Proceedings

Of the

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On

BRIDGING THE GAP BETWEEN ACADEMIA AND INDUSTRY IN NIGERIA – REFOCUSING THE ENGINEERING DISCIPLINE

Organised by

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Bayero University Kano

9th – 11th November, 2014.

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WELCOME ADDRESS FROM THE CHAIRMAN, CONFERENCE PLANNING COMMITTEE (ACICon 2014)

It gives me great pleasure to welcome you to the ancient city of Kano, the cross road of the ancient trans-Saharan trade, the current Centre of Commerce, and the venue of the Academia-Industry Conference 2014, tagged ACICon 2014. You are arriving Kano when the hamattan winds, the North-East Trade Winds, are taking over the landmass of the city. Although the weather might be a bit chilly in the early morning, it gradually heats up in the afternoon and mostly cools down towards evening. So please try to enjoy the little bit of each.

Nigeria has developed many visions and missions for development but the desired result is still only trickling in, if at all being achieved. The rising economies of the world such as the BRICS and the 'ASIAN Tigers' are miraculously making headways, even though we seem to have started together with most of them. Why? Many have since realized that it is their successful marriage of their Academia with their Industries. Both the Academia and the Industry in Nigeria have also realized this and are calling for linkage. The other question is 'How?'

Engineering and Technology has always been the causative agent of spectacular upsurge in development effort of any nation. Thus the development of engineering and technology must start from the academia and must be translated in to useful infrastructures/products/services in the industry so as to move the society forward. The participants assembled here are no doubt representative of both groups and would surely find a way of making this happen.

The Conference Organizing Committee has taken special care to ensure that the conference is stress free and enjoyable to all. Because of a number of constructions currently going on around Kano city, you may find some inconveniences to visit some areas, but the serene atmosphere of the conference venue could be a substitute.

I would like to thank our sponsors, donors, and collaborators in organizing this conference. I would like to particularly thank the National Office for Technology Acquisition and Promotion (NOTAP), the National Board for Technology Incubation (NBTI) and the National Agency for Science and Engineering Infrastructure (NASENI) for their support.

Finally, on behalf of the LOC, I warmly welcome you all, and wish you a wonderful and stress-free conference.

Prof. Mustapha Hassan Bichi, FNSE
Chairman, Conference Organizing Committee.

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CURRICULA DYNAMISM AND PARADIGM SHIFT IN PEDAGOGY FOR WORK- INTEGRATED LEARNING SYSTEM

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ABSTRACT

The Nigerian higher education system has not gone through substantial reforms and changes in engineering curriculum innovatively over decades. The same system of postgraduates' programmes in Engineering has been offered ever since inception, institutional practices related to teaching, structured learning, curricular and co-curricular initiative will be the forefront in leading the country's education system to excel to a global level. Focus should consider culturally based technologies for sustainable development coupled with bottoms-up innovations enhanced by top-down leadership support. The need for a paradigm shift from theoretical certification to a practical application of knowledge necessary for skill development and self-employment should be the cardinal objectives of our Engineering curriculum. Emphasis should be on the changing needs of the education system through reliance on the understanding and application of new curricula tailored toward work-integrated learning system and emerging technologies in fostering engineering education in Nigeria.

Keywords: *Curriculum Dynamism, Innovation, Practical, Restructure, Theoretical.*

SIGNIFICANCE: The Engineering education training need shift from sole theoretical background to work integrated learning system that will foster practical oriented learning system to bridge the gap between industry and the universities. Incorporating work-integrated learning system will upscale engineering profession in the face of fast technological global evolution and advancement. This will give engineering graduate a competitive advantage in technology development.

INTRODUCTION

Educational Curriculum of a subject is said to be the throbbing pulse of a nation. By looking at the curriculum one can judge the state of intellectual development and the state of progress of the nation. The world has turned into a global village; new ideas and information are pouring in like a stream. It is, therefore, imperative to update our curricula regularly by introducing the recent developments in the relevant fields of knowledge.

In the past, the term signified a course of studies followed by teachers and students in a teaching institution. Today, it means in general terms, the contract between society, the State and educational professionals with regard to the educational activities that learners should undergo during a certain phase of their lives to learn something desirable and productive.

According to Khwaja et al. (2000) curriculum is the formal and informal content and process by which learners gain knowledge and understanding, develop skills, and alter attitudes, appreciations, and values under the auspices of an academic institution. In other words, curriculum can be defined as the total experience. From this view point, Curriculum is not only the content selected and delivered, but also the planned and unplanned activities in which individuals' participate as students which consequently translate into the nation development.

The advent of internet which brings about globalisation has tremendous effects on the knowledge explosion which produce a vast amount of information, and these has given a new look to the components of curriculum. The urgent need of every nation nowadays to address their educational issues through constant modification of curriculum to keep pace with the modernization and global intricacies. The structure of a curriculum supposed to be built on demand driven by the society's developmental needs.

The Need to Restructure Engineering Curriculum

Nigerian higher educational system has not been proactive toward reforms and therefore is little or no substantial changes vis-à-vis curriculum innovation over the past several years despite globalisation. Public higher institution continue to offer same post-graduate programmes in Sciences and Engineering since decades with little or no new innovations in some areas which were in practice for decades in other countries, although few internal review and update within the schools has been carried out from time to time, yet it remain rigid enough to provide work-integrated learning system. Consequently, the curriculum has serious setbacks in innovations, dynamism, and flexibility; gradually degraded and failing to offer new programmes in tune with changing times and global trends.

For instance, the curriculum of engineering in Nigerian public universities still offer courses like Fortran, chain method of surveying using staff and tape. There are better alternative programmings languages such as Java, C++, Python, JavaScript etc., and for land surveying there are sophisticated tools with inbuilt GPS, GIS, AutoCAD with high precision and wireless access, just as an example but in every field there are innovations and new ways of delivery has been developed. Even though most of the University lecturers do studied abroad and might have experience these new changes yet upon returning home the rigidity of the curriculum and paucity of modern equipment force them into maintaining the status quo.

In order to make any meaningful advancement to become in tune with the global trends of educational system, a mid and long-term strategic orientation of our curriculum needs to be undertaken and some time-bound goals need to be fixed to achieve the desired results. Only few Private institutions offer multidisciplinary, innovative and modern courses to students. Non flexibility and total paralysis of the present course curriculum result to improper selection, organization, implementation and evaluation of curriculum content and its little relevance to the needs of our society.

Curriculum renovation that is realistic and quick in rejuvenating and revitalizing hope and passion for acquisition of broad-based knowledge that is worthwhile in a learner should be the focus of our higher education structure, the need for high committee of experts from diverse fields that will assume the responsibility of identification, design, restructuring and renovation of the curriculum offered at college and university level in a manner to make our courses learner-cantered, problem-based and research-driven.

In addition, methodology that will aid self-discovery and problem-solving ability which allows learners the opportunity for creativity should be entrenched in our curriculum. Quality, relevance and innovations are the key features that curriculum development in our University system need. Similarly, changes and innovations of our higher education system must involve the emergence of elastic curricula models and educational policies which emphasize interdisciplinary courses, open-ended systems, inter-generational, inter-professional and relationships sustainability.

The system of higher institution is characterised by low attitude toward initiative, innovation, skills, independent constructive mind-set and creative ideals. Urgent need for paradigm shift from a system that encourages cognitive learning processes and theoretical explanation to areas that need psychomotor application of practical illustration. Our present system favours cognitive development above other domains of learning. There is need to modify conventional teaching methodologies and introduce recent advances in technology into the teaching-learning process. The need for agility switch over from marker and talk to more interactive modes of teaching and learning by making use of audio-visual aids, e-contents, databases, e-learning objects and use of learning Modules. We should not lag behind in adopting the latest technology in every sphere of our education system, be it in teaching, devising syllabi, evaluation methods, creativity, analysis, certification and automation.

Nigerian engineering education system give rise to generalist professionals, according to Geer (2013) the role of a teacher in education should change from knowledge disseminator to knowledge creator. At all levels of higher institutions, innovation and greater diversification of subjects is the need at this point in time. Since inception same courses are being offered by colleges and universities with little scope for newer specializations and upcoming programmes. Therefore, there is a need to offer more specializations in all existing subjects and faculties and introduce new subjects wherever not available at present, so that a broader choice is made available to the students and they emerge as specialists in one specific area rather than ending up being generalists.

The basic aim of curriculum innovation is to serve as a key driver of growth based on knowledge inputs and to ensure quality knowledge output that translates into economic development of a nation. The call for reform for the existing universities to ensure frequent curricular revisions, introduction of new course systems, enhancing reliance on internal assessment, encouraging research, and reforming governance of institutions. The need for a paradigm shift from theoretical certification to a practical application of knowledge necessary for skill development and self-employment should be the cardinal objectives of our education. Emphasis should be on the changing needs of the society through reliance on the understanding and application of new pedagogies and emerging technologies.

Introduction of work-integrated learning system in engineering curriculum

Work-integrated learning system was defined by the National Commission for Cooperative Education, based in the United States of America as a structured educational strategy integrating classroom studies with learning through productive work experiences in a field related to a student's academic or career goals. It provides progressive experience in integrating theory and practice. It is a partnership among students, educational institutions and employers, with specified responsibilities for each party. Work-integrated learning is a process where students develop their skills, behaviour and self-awareness. A number of other terms also refer to work-integrated learning. These terms include experiential learning programs, externships, field-based learning, field placements, internships, practice-orientated education, professional practice, sandwich courses, work-based education and cooperative education. There are several means of addressing this method but all programs should possess four core elements and these are:

- A curriculum integrated with industry needs;
- Inclusion in the curriculum of a work component for the students in the curriculum to learn through experience;
- A group of workplaces offering appropriate placements for students to ensure that the tertiary course remains relevant by providing advice and input regarding the curriculum; and
- Well-defined logistics for the program to provide clear detail about organising, coordinating and assessing students.

Review of the literatures showed that an inappropriate curriculum has led to the production of graduates whose skills and specialisations do not reflect those needed in the labour market (Quinn et al., 2005; World Bank. (2000). Furthermore, It is also argued that the curriculum to be culturally relevant to support widening participation and to prepare graduates for living and working in a diverse society (Crosling et al., 2008). The views of Quinn et al (2005) and Heagney (2008) is typical for most engineering curriculum in Nigeria. However, Blackwell et al. (2001) argues that the higher education curriculum should offer students the opportunity to reflect on employment and other experiences to explore the learning and skills development relevant to the industry.

Constraints and Current Issues in Nigerian Higher Education System

One would expect knowledge explosion in Nigeria as it is happening even in some nearby African countries but instead, the universities are at loggerheads with its regulating body, NUC. When Universities were on strike seeking for education liberation, NUC was busy supporting the political powers. This sends a signal as to whether the country cares about the looming problems that may be borne out of the deteriorating system of education in Nigeria. Despite loud voice as the 'giant' of Africa, yet we are outrun educationally, which clearly shows the 'giant' is all about number.

The recent struggles by different associations of higher institutions have shown determination to put the country's educational system on track. Nigeria ranked 21st of the 54 African countries and 13th out of the 16 West African countries. The recently released United Nations Human Development Index (HDI), which is hinged on four critical macroeconomic variables of education, literacy, life expectancy, and standard of living, ranked Nigeria 156th out of the 187 countries that were surveyed. This demands for proactive measures rather than denial by the government of political leaders.

There is no doubt that the whole system of higher institutions needs review to establish new direction that will ultimately deliver our nation from the innovation dormancy and rigidity to openness and flexibility in this era. Ajayi and Ayodele (2002) reported that higher education in Nigeria today needs total overhauling and restructuring and reform becomes imperative to improve the performance of the system. The curriculum needs reform in content and in methodology to give room for the spirit of inquiry, discovery and experimentation. Ibukun (1997) suggested that there is the need to make plans and projections on the nation's manpower needs in a bid to integrate this into university programmes. The NUC and the Nigerian Manpower Board are in the position to alert universities on the future manpower requirements of the country.

The Need for Internationalization policy of Nigerian University

Internationalization is defined as the variety of policies and programs that universities and governments implement to respond to globalization. These typically include sending students to study abroad, setting up a branch campus overseas, or engaging in some type of inter-institutional partnership. Nigerian universities for example, have found it extremely challenging and complex to find their footing on the global higher education stage - they barely register on world institutional rankings and league tables and produce a tiny percentage of the world's functional research output.

For a country to achieve reform in its education system the need to invest heavily in education is paramount. Every reform in education must be back with sufficient funding in order to achieve the goal, it is no doubt that this may not be the first call to reform Nigerian education system and yield little results. In order to avoid such cases strong institution backed with monitoring and evaluation framework is to be installed. The importance of building and nurturing industry-university partnerships and the continuous quest for excellence through outcomes assessment and accreditation agrees with the bottoms-up innovations enhanced by top-down leadership support working in partnership with industry stakeholders.

CONCLUSIONS

Curriculum determines the extend of development of a nation. The rigidity of a curriculum closes the door to innovations and fails to service the labour market with professionals for industries, a well prepared human capital in science and technology is one of the key pillars that support knowledge based economies. In this sense, a well-educated engineering workforce is fundamental for innovation and entrepreneurship. Focus of the contemporary curriculum should be on the practical, facts and innovation rather than continuous theoretical drilling of the students. The bottoms-up innovations enhanced by top-down leadership support working in partnership with industry stakeholders should be the cardinal principle of the strategies for bridging up the gap between the Nigerian Universities and the industries.

Recommendations Curriculum Innovation toward work-integrated learning system

1. The study recommends that universities should consult industries in curriculum designing since this will curb the challenge of students not possessing the adequate hands on industrial training which has remained a far cry.
2. Time for attachment should be lengthened so that students leave the industry well equipped with relevant skills and knowledge.
3. There is need for the universities in liaison with industries to come up with policies that focus on student training so as to lessen the likelihood that students are left susceptible and at risk of being unattached to any industry when they are left to look for attachment places by themselves.
4. The need to introduce new courses cannot be overemphasized to accommodate the demand of the industries to be supported by government policies on industrialisation.
5. Ability to adapt to keep up with new developments i.e. ability to learn new models, techniques and technologies as they emerge and appreciate the necessity of such continuing professional development; appreciation of basic ethical and social responsibilities.

6. Nwadiani in Ochuba (2001) reported that the 60:40 Science: Humanities placement policy has not been implemented resulting in overproduction of humanities graduates while some areas of critical importance have been neglected. It has therefore become necessary to redesign the University education curriculum to become purely practical oriented for skill acquisition more especially in Engineering.

REFERENCES

Ajayi, I. A. and Ayodele, J. B. (2004). Fundamentals of Educational Management. Ado-Ekiti: Green-line publishers.

Blackwell, A, Bowes, L, Harvey, L,Hesketh, AJ & Knight, PT (2001) 'Transforming work experience in higher education', British Educational Research Journal,27.3, pp. 269–285.

Crosling, G, As-Saber, S & Rahman, N (2008), 'Postgraduate International Students and Independent Learning'. Paper presented at International Conference on Postgraduate Education, 16-17 December, Penang, Malaysia.

Federal Republic of Nigeria (2004) National Policy on Education. Government Press.

Federal Ministry of Education (2002).Communiqué: National Summit on Higher Education, March 11-16. Abuja, Nigeria.

Geer M.I. (2011) curricular innovation in higher education - need to renovate and restructure Higher education curriculum so as to meet the global challenges in terms of quality and Relevance http://www.greaterkashmir.com/news/2011/Dec/30/curricular-innovation-in-higher-education-12.asp.

Heagney, M. (2008). Student success and student diversity. Improving student retention in higher education: The role of teaching and learning, 17-28.

Ibukun, W. O. (1997).Educational Management: Theory and practice. Ado Ekiti. Green-line Publishers.

Khwaja, I. U., Shahnaz, A., & M, A. (2000). Module III : Curriculum Development, Assessment and Evaluation (pp. 1–117).

NUC (2004). Report on the performance of the Federal University system in 2002 presented at the special meeting convened by the Honourable Minister of Education on Thursday, December 12.

Okojie, J. A. (2007).Higher education in Nigeria. Being a paper presented at Education in Africa Day, held at House of commons Parlance of West Minister, London. Retrieved from http://www.nucnigeriainfo/es%20houseof commons.ppt

Quinn, J, Thomas, L, Slack, K, Casey, L, Thexton, W & Noble, J (2005), From Life Disaster to Lifelong Learning: Reframing Working Class 'Drop Out'. York: Joseph Rowntree Foundation.

Verspoor, M. A. (1994). Introduction, improvement and Innovation in Higher education. In J. Salmi and A. M. Verspoor (eds). Revitalising Higher Education. Oxford, New York.

World Bank (1994). Higher Education: The lesson of experience. Washington, D. C: The World Bank.

World Bank (2000). In Small states: Meeting challenges in the global economy.

EFFECT OF PROCESS VARIABLES ON BIODIESEL PRODUCTION FROM NEEM SEED OIL

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ABSTRACT

This work studied the effect of process variables on the production of biodiesel from Neem oil. Two-step transesterification was employed using potassium hydroxide as a homogeneous catalyst and methanol as alcohol. The effect of temperature (40 to 60 ^{O}C), reaction time (45 to 60 minutes), oil/methanol ratio (1:5 to 1:7) and catalyst concentrations (0.5 to 1.0 wt. %) was investigated. An optimum yield of 90 wt % of Neem oil methyl ester was obtained at a reaction time of 45 minutes, catalyst concentration of 1.0 wt %, temperature at 60 ^{O}C, and oil/methanol ratio of 1:7. The properties of the biodiesel produced were characterized and compare favourably with the ASTM standards for biodiesel signifying that the neem oil methyl ester could be used as an alternative to diesel.

KEYWORDS: Biodiesel, fossil fuel, transesterification, neem oil

1 INTRODUCTION

World energy needs are primarily fossil derived fuel (Mohammad *et al.,* 2010). Due to the current world energy usage, experts have reported that the fossil fuel reserve will be exhausted in few decades to come (Zadeh *et al*., 2011). More so, increase in emission of greenhouse gases, cost of processing crude oil, non-renewability and energy demand during the process which is arguably high is among the challenges of the continuous usage of this non-renewable source of energy. The challenges prompted a number of government, researchers and stakeholders in industries to develop alternative energy sources to consolidate the non-renewable fuels (Highina *et al.,* 2011). This alternative fuel must be technically feasible, economically competitive, environmentally friendly and readily available (Makama *et al.*, 2011).

Vegetable oils are perceived as a possible alternative to petroleum diesel. Generally, biodiesel is prepared from vegetable oils, animal fats, and waste greases such as yellow and brown greases (Lotero *et al.,* 2005). Various oils have been domesticated by different countries as raw materials for biodiesel production owing to its availability. Example includes soybean oil in United States, rapeseed oil in many European countries, coconut oil and palm oils in Malaysia and Indonesia. In India and Southeast Asia, Jatropha oil, Karanja oil and Mahua oil are used as a significant oil source for biodiesel production (Demirbas, 2009).

In nearly all part of Africa and Asia, edible vegetable oils are limited in supply and substantial quantities are been imported from developed nation to satisfy consumption demand. The author added the production of biodiesel in commercial quantity in Nigeria using common vegetable oil like palm oil and palm kernel oil is technically not feasible, since the Nigerian as nation at present cannot satisfy the food supplies of these oilsThe uses of non-edible oils are perceived as a possible feedstock for commercial biodiesel production in Nigeria. Non edible oils like rubber seed oil, Jatropha oil, castor oil, neem oil and waste cooking oil are therefore being considered as potential feed stocks (Musa *et al.*, 2014).

One of the promising sources oil seed for biodiesel production is the neem tree (*Azadirachta indica*). These trees produce the neem seeds which contained about 39.7 to 60 % (Aransiola *et al.*, 2012). A number of works have been reported on the biodiesel production from neem oil (Anya *et al.*, 2012; Aransiola *et al.*, 2012; Mohammed *et al.*, 2012). But as far as the author knowledge is concerned no attempt has been made to study the effect of process variable using factorial design. This work focused on optimizing the production of biodiesel by varying the factors that affect the production.

2.0 METHODOLOGY

The major material in this work is crude neem oil (CNO) purchased in NARICT, Zaria, Kaduna State, Nigeria. The chemicals used include analytical grade methanol and potassium hydroxide manufactured by Aldrich Chemicals Co. ltd, England.

2.1 Characterization of Crude Neem Oil

Characterization of the feedstock (CNO) was analysis for its chemical composition and physicochemical properties to ease comparison with standard level of purity of the material relative to using it for biodiesel production. Some of such properties include specific gravity (or density), flash point, kinematic viscosity, acid value, iodine value sulphur content, moisture or water content and were determined as reported by Musa *et al.*, 2014; Mohammed *et al.*, 2012; Tesfaye, 2009.

2.2 Production of Biodiesel from Crude Neem Oil using acid esterification and based transesterification

The crude neem oil was heated at 60 ^oC for about 10 mins and mixed with methanol (60 % w/w of oil). 0.75 % w/w of concentrated H_2SO_4 was added to the mixture and the mixture was stirred on a magnetic hot plate for 1hr at 60 ^oC, after which it was allowed to settle for 2 hrs. The pre-treated oil was separated from the methanol-water phase at the top (Aransiola *et al.*, 2012; Anya *et al.*, 2012). Production of biodiesel from neem oil was carried out in accordance with the experimental procedure reported by Musa *et al.*, 2014 and Berchmans and Hirata, 2008. A 2^4 Factorial design was employed. Methoxide was first prepared in a conical flask by dissolving potassium hydroxide in methanol; the mass of the catalyst dissolved and the ratio of the oil to methanol in each experiment is shown in Table 1. The reactor was filled with 50 grams of neem oil sample at 60 ^oC; the methoxide solution was then poured into the reactor containing the oil. The mixture was agitated vigorously for the giving reaction time and at a particular temperature as shown in Table 2. At the end of the reaction, the resulting mixture was cooled to room temperature and transferred into a separating funnel, allowed to settle (overnight) into a lighter coloured biodiesel on top of a layer of darker glycerine. Then separated, washed and dried as reported by Tesfaye, 2009. The methyl ester produced was then characterized as reported by Musa *et al.*, 2014

Plate 1: A water bath shaker

Plate 2: Biodiesel settling stage before glycerol removal

Plate 3: Washed biodiesel

3.0 *RESULTS AND DISCUSSIONS*

3.1 optimization of biodiesel production

Table 1: Variables and levels used for Neem oil Methyl ester (NOME) Synthesis

Variables	Symbols	Levels	
		Low level	High level
Temperature	A	40	60
Oïl/Méthanol ratio	B	1 : 5	1 : 7
Catalyst concentration	C	0.5	1.0
Reaction time	D	45	60

Table 2.0: Experimental Design for Alkali Transesterification

Run	**A**	**B**	**C**	**D**	**NOME Yield**
1	40	1.5	0.5	45	75.00
2	60	1,5	0.5	45	82.00
3	40	1:7	0.5	45	83.00
4	60	1:7	0.5	45	86.00
5	40	1:5	1.0	45	57.00
6	60	1:5	1.0	45	78.00
7	40	1:7	1.0	45	77.00
8	60	1:7	1.0	45	90.00
9	40	1:5	0.5	60	60.00
10	60	1:5	0.5	60	84.00
11	40	1:7	0.5	60	82.00
12	60	1:7	0.5	60	91.00
13	40	1:5	1.0	60	47.00
14	60	1:5	1.0	60	74.00
15	40	1:7	1.0	60	69.00
16	60	1:7	1.0	60	91.00

3.2 Effect of temperature

The effect of temperature on transesterification plays a vital role in both the quantity and quality of the methyl ester to be produced. As shown in Figure 1 the increase in temperature clearly influences the reaction rate and biodiesel yield in a positive manner. This is evident from the fact that from all experimental runs shown in Table 2, increase in temperature result into an increase in the biodiesel yield irrespective of other process conditions. The result obtained is in agreement with the report of Musa et al., 2014, and Patil and Deng (2009). The increase in the yield of NOME at higher reaction temperature is due to higher rate of reaction. According to Musa et al., 2014 Transesterification reaction is best performed at a temperature close to the boiling point of the alcohol used for alkaline transesterification. The high yield obtained in this study for all experimental run can be clearly attributed to appropriate choice of temperature.

3.3 Effect of Methanol-to-Oil Molar Ratio

The methanol-to-oil molar ratio is one of the important factors that affect the conversion of triglyceride to biodiesel. Stoichiometrically, three moles of methanol are required for each mole of triglyceride, but in practice, a higher molar ratio is required in order to drive the reaction towards completion (Patil and Deng, 2009). The presence of slight excess amount of alcohol during the transesterification reaction is essential to break the glycerine - fatty acid linkages. But excess of methanol should be avoided

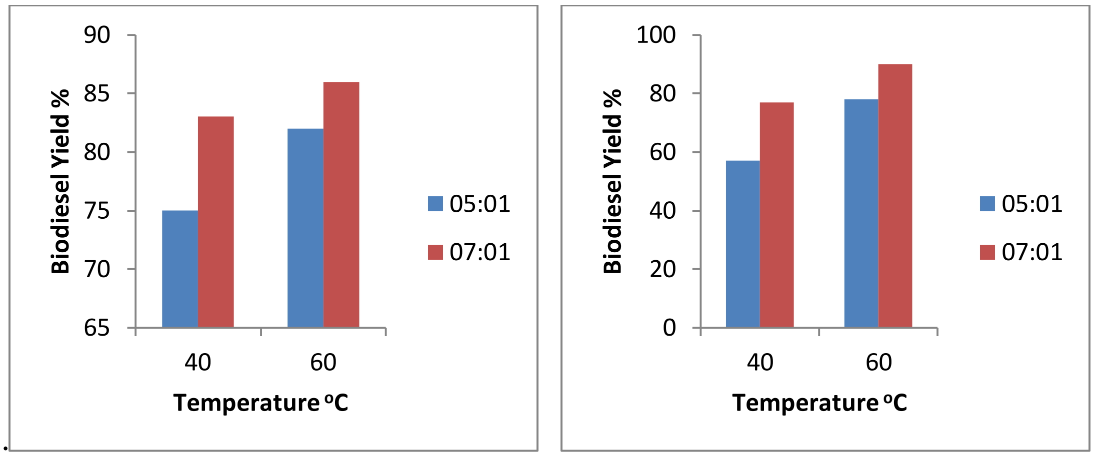

Figure 1: Effect of temperature and oil/methanol ratio on biodiesel yield at constant reaction time and catalyst concentration

As shown in Figure 1, the methanol to oil ratio of 7:1 from this work shows higher yield than methanol to oil ratio of 5:1. The result obtained shows close agreement with the work of Sulistyo *et al*. (2008) who stated a mole ratio of 7.5:1 to be optimum. It is important to add that increasing the alcohol content beyond this point (7:1) would lead to an increase the cost of alcohol recovery and complicate ester recovery.

3.4 Effect of Catalyst Concentration

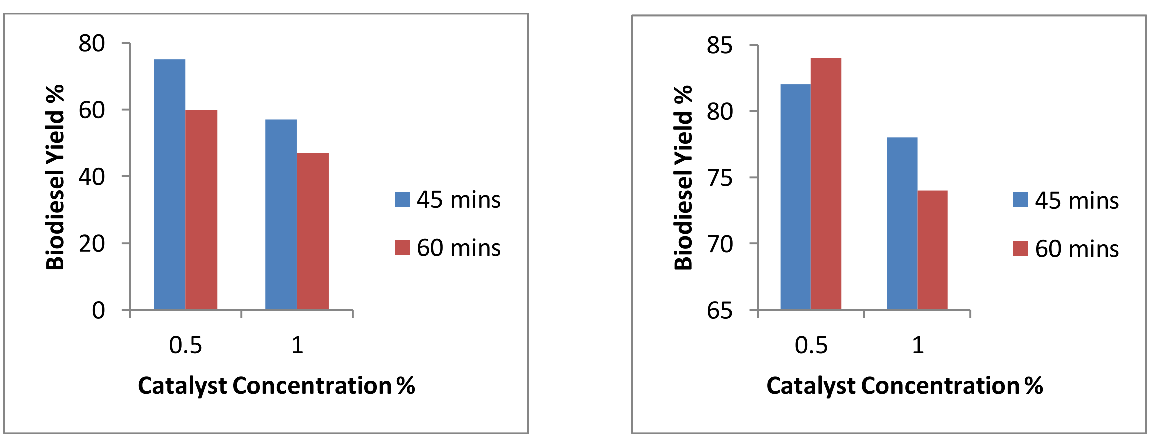

Figure 2: Effect of catalyst concentration and time on biodiesel yield at constant temperature and mole ratio

From Figure 2, it was rightly observed that the increase in catalyst concentration influenced the biodiesel yield in a negative way. This is in agreement with the report of Sulistyo *et al.* (2008); Lalita *et al.* (2004); and Refaat *et al.* (2008) who state the yield of methyl ester yield decreases with an increase catalyst concentration beyond 1 %. This is as result of soap formation by the side reaction between the vegetable oil and the excess catalyst concentration making separation difficult Effect of Reaction Time

Figure 2, shows that increase in reaction time had a negative impact on the NOME yield. This can be attributed to the high percentage of catalyst concentration but at same reaction time and catalyst concentration the percentage conversion have no significant impact. This report is in accordance with the work of Refaat *et al.* (2008) and Lalita *et al.* (2004).

4.0 CONCLUSIONS

The effect of process variable on biodiesel synthesis from neem seed oil was successfully carried out. Optimum condition for the synthesis was deduced to be a reaction time of 45 minutes, catalyst concentration of 1.0 wt %, temperature at 60 ^{O}C, and oil/methanol ratio of 1:7. The optimum yield at these conditions was 90 wt %.

REFERENCES

Anya, U.A., Nwobia, C.N. and Ofoegbu, O. (2012). Optimized Reduction of Free Fatty Acid Content on Neem Seed Oil for Biodiesel Production. *Journal of Basic and Applied Chemistry*.2(4): 21-2,.

Aransiola, E.F., Ojumu, T.V., Oyekola, O.O. and Ikhuomoregbe, D.I.O. (2012). A Study of Biodiesel Production from Non-edible Oil Seeds: A comparative Study. *The Open Proceedings Journal*,(3): 1-5.

Bajpai, D., & Tyagi, V. K (2006). Biodiesel:Sources, Production, Composition, Properties and its Benefits. *Journal of Oleo Science (JOS)*, ISSN 1345 – 8957 print/ ISSN 1347 – 3352 online, vol. 55, No. 10, 487 – 506.

Berchmas, J.H. and Hirata, S. (2008). Biodiesel Production from Crude Jatropha Curcas L. Seed Oil with a High Content of Free Fatty Acids. *Bioresource Technology*. (99): 1716-1721.

Demirbas, A. (2009). Progress and Recent Trends in Biodiesel Fuels. *Journal of Energy Conversion and Management*. (50): 14-34.

Devanesan, M. G., Viruthagiri, T., & Sugumar, N. (2007). Transesterification of Jatropha oil using immobilized *Pseudomonas fluorescens. African Journal of Biotechnology* Vol. 6 (21), pp. 2497-2501

Highina, B.K., Bagaje, I.M. and Umar, B. (2011). Biodiesel Production from Jatropha Caucus Oil in a Batch Reactor using Zinc Oxide as Catalyst. *Journal of Petroleum Technology and Alternative Fuel.* 2(9): 146-149.

Lalita, A., Sukunya, M., & Peesamai, J. (2004). Factors Affecting the Synthesis of Biodiesel from Crude Palm Kernel Oil. *The Joint International Conference on "Sustainable Energy and Environment (SEE)" Hua Hin, Thailand* 359 – 361.

Leung, D. Y. C., & Guo, Y. (2006). Transesterification of neat and used frying oil: optimization for biodiesel production. *Fuel Process Technology*; 87:883–90.

Lotero, E., Liu Y., Lopez, D.E., Suwannakarn, K., Bruce, D.A. and Goodwin, J.G. (2005). Systhesis of Biodiesel via Acid Catalysts. *Industrial Engineering and Chemical Resources Journal.* (44): 5353-5363.

Makama, B.Y., Banketa, T., Nwaebwu, C. and Linus, N.O. (2011). Synthesis and Calorific value of Biodiesel by Methanolysis of Castor and Olive Oils in Admixtures, *Australian Journal of Basic and Applied Sciences*, 5(11): 874 – 878.

Mohammad, F. Z., Amir, H.Z., Fahar, M. and Ghasem, N. (2010). Esterification of Free Fatty Acids by Rhizopus Oryzae as Cell Catalyzed from used Cooking Oil for Biodiesel Production. *World Applied Sciences Journal.* 8(6): 719-724.

Mohammed, J., Atuman, J. S., Ugwu, E. and Aboje, A.A. (2012). Production andCharacterization of Biodiesel from Jatropha Oil and Neem oil, *International \Journal of Emerging Trends in Engineering and Development*, 2(2), 313-320.

Musa U., Mohammed I. A., Sadiq M. M., Aliyu M. A., Suleiman B., and Talabi S. (2014), "*Production and Characterization of Biodiesel from Nigerian Mango Seed Oil*", Proceedings of the World Congress on Engineering 2014 Vol I, WCE 2014, July 2 - 4, 2014, London, U.K.

Musa. U, I.A. Mohammed, M.M. Sadiq, B. Suleiman,A.M. Aliyu, A.C. Umeji Experimental Determination of Fuel Properties of Waste Cooking Oil Biodiesel/Petrodiesel as Fuel For Diesel Engine. Proceedings of 7th International Conference on Sustainable Energy and Environmental Protection (SEEP 2014), 23-25 November 2014, Dubai-UAE

Patil, D.P., Gude, V.G., Cooke, P., Musou-mchee, S.,Nirmalakhadan N., Marharswany, A.,Peter, C. and Shuguang, D. (2010). Optimization of Microwave Assisted Transesterification of Dry Algal Biomass using Response Surface Methodology, *Bioresource Technology* (xxx). 1-7.

Refaat, A. A., Attia, N. K., Sibak, H. A., El Sheltawy, S. T., & El Diwani, G. I. (2008). Production Optimization and Quality assessment of Biodiesel from Waste Vegetable Oil. *International Journal of Environmental Science Technology*, 5 (1), 75 – 82, Sanford, D.S., White, J.M., Shah, P.S., Wee, C. Valverde, A.M. and Meier, R.G. (2009). Feedstock and Biodiesel Characteristics Report. *A Renewable Energy Group Incorporation Publication.*

Sulistyo, H., Rahayu, S. S., Winoto, G., & Suardjaja, I. M. (2008). Biodiesel Production from High Iodine Number Candlenut Oil. *World Academy of Science, Engineering and Technology*, 48

Tesfaye, K. (2009). Biodiesel Production from Wado Seed Oil. Published B.Sc. Thesis. Department of Chemical Engineering, Addis Ababa Institute of Technology, School of Graduate Studies, Addis Ababa University.

Zadeh, A.K.A., Almassi, M., Meighani, H.M., Ali, M.B., and Azizan, J. (2011). Suitability of Corthamus Oxyacantha Plant as Biodiesel Feedstock, *Australian Journal of Crop Science,* 5(12), 1639-1643.

PHOTOCATALYTIC DEGRADATION OF METHYLENE BLUE USING NIGERIAN SPHALERITE ORE

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ABSTRACT

Presently, there is a considerable interest in developing visible light active photocatalysts that can be activated by sunlight or ordinary lamps. This paper focuses on the evaluation of the visible light photo catalytic activity of sphalerite ore mined from a deposit in Abuni, Nasarawa State, Nigeria. The sphalerite ore powder has been characterized using XRF, XRD, UV-Vis spectroscopy and surface area analysis. The photocatalytic activity was evaluated using degradation of methylene blue as a model reaction. The sphalerite ore powder was found to be very active in the photocatalytic degradation of methylene blue under visible light illumination. Photocatalytic degradation of methylene blue was fitted to the pseudo-first order kinetic model. The photocatalytic efficiency was found to increase with increase in the intensity of the incident light.

INTRODUCTION

As the world's population continues to grow, more water will be needed for domestic, agricultural and industrial purposes. At the same time, more energy will be needed for various applications such as water treatment, transportation, production of various products, processing of agricultural products, street lightening, national security, household applications, etc. Solar energy has the highest potential of all the renewable energies especially in tropical Africa. Many developing countries including Nigeria have problems of steady supply of energy and pipe borne water. Fortunately, there are high levels of solar radiation in most of developing countries (Blanco *et al*, 2009). Therefore, it is very important to develop technologies based on locally available raw materials that can be used to harness solar energy and use it to solve some of the problems of sustainable energy and water supply.

Photo catalysis is a technique that utilizes light energy and semiconductors to drive various chemical processes which have very important applications in water and air purification, as well as renewable energy generation (Chong *et al*, 2010; Leung *et al*, 2007). Photo catalysis is usually performed under ambient operating temperature and pressure conditions using either sunlight or artificial sources of visible and/or ultraviolet light (lamps). Complete destruction of various water and air pollutants and pathogens can be achieved without generation of secondary pollutants. Two major steps are involved in heterogeneous photo catalysis: adsorption of the substrates on the photo catalyst surface and photo oxidation or photo reduction of the adsorbed substrates with the photo generated holes and hydroxyl radicals. Unlike ordinary adsorption process which merely concentrates pollutants on the surface of the adsorbent, photo catalysis leads to the destruction of the pollutants (Hoffman *et al*, 1995; Fujishima *et al*, 2007).

A wide range of semiconducting materials (such as TiO_2, ZnO, Fe_2O_3, CdS, GaP, ZnS, etc) have been applied to destroy various water and air pollutants and pathogens using simulated as well as real samples of polluted water and air. TiO_2 is the most widely used photocatalyst due to its non-toxicity, low cost, and good photocatalytic activity (Leung *et al,* 2007). However, TiO_2 is mostly active in the presence of UV light because of its large band gap of 3.2eV. UV light constitutes only about 5% of the solar radiation; about 50% of solar radiation is in the visible region (Casbeer *et al,* 2012). Hence, there is a considerable interest in developing visible light active photocatalysts which can be effectively activated by sunlight or ordinary lamps (Leung *et al,* 2007; Casbeer *et al,* 2012). Visible light active photocatalysts can be made by doping high band gap semiconductors with some metallic or nonmetallic elements, as well as by coupling two or more semiconductors to form composite photocatalysts (Casbeer *et al,* 2012; Lu *et al,* 2007). Synthesis of doped and composite photocatalysts can be very costly because high purity chemicals are often used, and the procedure for the synthesis may involve many steps and special conditions.

Recently, some naturally occurring mineral ores such as rutile (Lu *et al,* 2007) and sphalerite (Li *et al,* 2009; Yang *et al,* 2007; Chen *et al,* 2011) were found to behave like coupled semiconductors, exhibiting high visible light photocatalytic activity. For instance, natural sphalerite ores from some deposits in China were found to be very effective for the photocatalytic degradation of some dyes (Li *et al,* 2009) and carbon tetrachloride (Yang *et al,* 2007), as well as for photocatalytic bacterial disinfection (Chen *et al,* 2011).

Sphalerite is the major mineral ore from which zinc is produced commercially. Sphalerite is mostly composed of ZnS in association with other metal sulphide minerals (such as PbS, FeS_2 and $CuFeS_2$ etc) as well as some other other impurities. Nigeria is blessed over 100 million tonnes of complex zinc sulphide minerals (Olubambi *et al*, 2007). However, there is very scarce information in the literature about the quality and potential novel applications of the Nigerian zinc sulphide minerals. Therefore, present work focuses on the characterization of sphalerite samples obtained from Abuni deposit in Nasarawa State, Nigeria, using energy dispersive x-ray flourecence spectroscopy (XRF), X-ray diffraction (XRD), UV-Vis spectroscopy and specific surface area analysis. Photocatalytic degradation of methylene blue has been used as the model reaction to evaluate the photocatalytic activity of the sphalerite ore under visible light irradiation.

MATERIALS AND METHODS

Beneficiated samples of sphalerite were obtained from the National Metallurgical Development Center, Jos, Plateau State, Nigeria.

The sphalerite mineral ores were mined from a deposit in Abuni, Nasarawa State, Nigeria. The sphalerite sample was crushed into powder and then sieved to obtained fine powder with particle size below 106µm. Analytical grade methylene blue, sodium chloride and sodium hydroxide were used in the work.

X-ray diffraction (XRD) pattern of the sphalerite was recorded using a powder X-ray diffractometer (Shimadzu, model 6000) employing Cu Kα radiation source (λ=0.154nm). The chemical composition of the sphalerite samples was determined using energy dispersive X-ray florescence (EDXRF) spectrometer (Panalytical, Minipal 4 model). The UV-Vis absorption spectrum was recorded using a UV/Vis spectrophotometer (Jenway 6405 model).

The specific surface area of the sphalerite samples was measured using the Sear's method (Al-Degs *et al*, 2000). The latter method involves acidifying 1.5 g of a solid sample with dilute hydrochloric acid to a pH of 3 – 3.5. Then 30 g of sodium chloride is added with stirring, and the volume is brought to 150 ml with distilled water. The solution is then titrated with 0.10N sodium hydroxide. The Volume, V, needed to raise the pH from 4 to 9 is recorded. The specific surface area (S in m^2/g) is estimated using eq. 1.

$$S = 32V - 25 \qquad (1)$$

where V is the volume needed to raise the pH from 4 to 9.

Photocatalytic reactions were conducted at room temperature (30 ± 2^0C) and atmospheric pressure. 0.1g of sphalerite powder (photocatalyst) was dispersed by a magnetic stirrer in 100 ml of an aqueous solution of methylene blue (50mg/L). Before illumination, the suspension was stirred for one hour in the dark in order to establish adsorption-desorption equilibrium. Thereafter, the mixture was exposed to visible light irradiation supplied by a lamp placed 20cm away from the reactor. Four lamps of different power ratings (500W, 200W, 100W and 60W) were used in order to investigate the effect of lamp power on the photocatalytic process. Samples were periodically withdrawn from the reacting suspension and filtered to completely remove the photocatalyst particles. The obtained filtrates were then analyzed for the residual concentration of methylene blue using a UV – Vis spectrophotometer.

RESULTS AND DISCUSSION

The elemental composition of the sphalerite sample is presented in Table 1. Zinc, iron, sulfur, manganese, and molybdenum are major elements present. Shown in Figure 1 is the XRD pattern of the sphalerite. The pattern is characterized by sharp peaks at the Bragg angles of 28.4^o, 47.3^o and 56.1^o that can be assigned to a highly crystalline phase of ZnS (Li *et al*, 2009). The measured specific surface area of the sphalerite sample is $54m^2/g$ and the crystallite size of the sphalerite estimated using the Scherer's equation (eq. 2) is 6.0nm.

$$\tau = \frac{k\lambda}{\beta \cos\theta} \qquad (2)$$

The UV-Vis absorption spectrum of the sphalerite ore is shown in Figure 2. The sphalerite exhibit a broad absorption band up to 600nm. This indicates that the sphalerite ore can serve as a visible light-responsive photocatalyst (Casbeer *et al*, 2012).

The percentage of degradation of methylene blue was calculated using eq. 3.

$$Degradation = \frac{(C_0 - C_t)}{C_0} \times 100\% \qquad (3)$$

where Co and C_t are the initial concentration of methylene blue and the concentration of methylene blue after irradiation time (t) respectively. Table 2 shows the effect of irradiation time on the percentage photocatalytic degradation of methylene blue at various lamp powers. As apparent in the Figure, photocatalytic degradation of methylene blue increases with increase in the lamp power and irradiation time.

Photocatalytic processes are often described by the Langmuir-Hinshelwood kinetic model for heterogeneous catalysis (Sajjad *et al*, 2010). At low substrate concentration, the model can be approximated by the pseudo first order kinetic eq. (4) .

$$\ln\frac{C_0}{C} = k_{app}t \qquad (4)$$

where k_{app} and t are the apparent rate constant of the photocatalytic process and the irradiation time, respectively. The plots of $\ln(C_0/C)$ against irradiation times at various lamp powers are displayed in Figure 3. The plots were used to derive the values of k_{app} and the corresponding regression coefficients (R^2) that are listed in Table 3. As apparent in Table 3, a linear relationship (with $R^2 > 0.95$) exists between $-\ln(C_0/C)$ and irradiation times, t. Hence, the photocatalytic degradation of methylene blue using the sphalerite ore obeys pseudo-first order kinetics. As the lamp power (i.e. light intensity) increases, the rate of photocatalytic degradation of methylene blue increases. This is because as light intensity increases, the number of photons reaching the photocatalyst surface also increases; hence, the number of photogenerated holes and hydroxyl radicals increases. This leads to an increase in the rate of photocatalytic degradation of methylene blue (Sajjad *et al*, 2010; Ahmed *et al*, 2013).

The apparent rate constant is often used as the basic kinetic parameter for determining the activity of photocatalysts (Sajjad *et al*, 2010). The photocatalytic degradation of methylene blue using ilmenite ore and TiO_2 as the photocatalysts with 500W lamp as the source of visible light irradiation was studied by Hamza *et al.* (2011). The derived values of the apparent rate constant for the photocatalytic degradation of methylene blue on ilmenite and TiO_2 are 0.030 min^{-1} and 0.034 min^{-1}, respectively. Ahmed *et al.* (2013) reported an apparent rate constants 0.0134 min^{-1} for the photocatalytic degradation of methylene blue using TiO_2 photocatalyst and ultraviolet lamp. These values are substantially smaller than the apparent rate constant of 0.121 min^{-1} obtained in the present work using a 500W lamp. Therefore, the sphalerite ore used in this work is very effective for the photocatalytic degradation of methylene blue under visible light irradiation.

Table 1. Elemental composition of the sphalerite ore

Element	Al	Si	S	K	Ca	Mn	Fe	Ni	Cu	Zn	Mo	La
Conc. (% wt.)	0.5	0.75	6.6	0.05	1.07	4.14	38.16	0.02	0.057	44.5	3.9	0.06

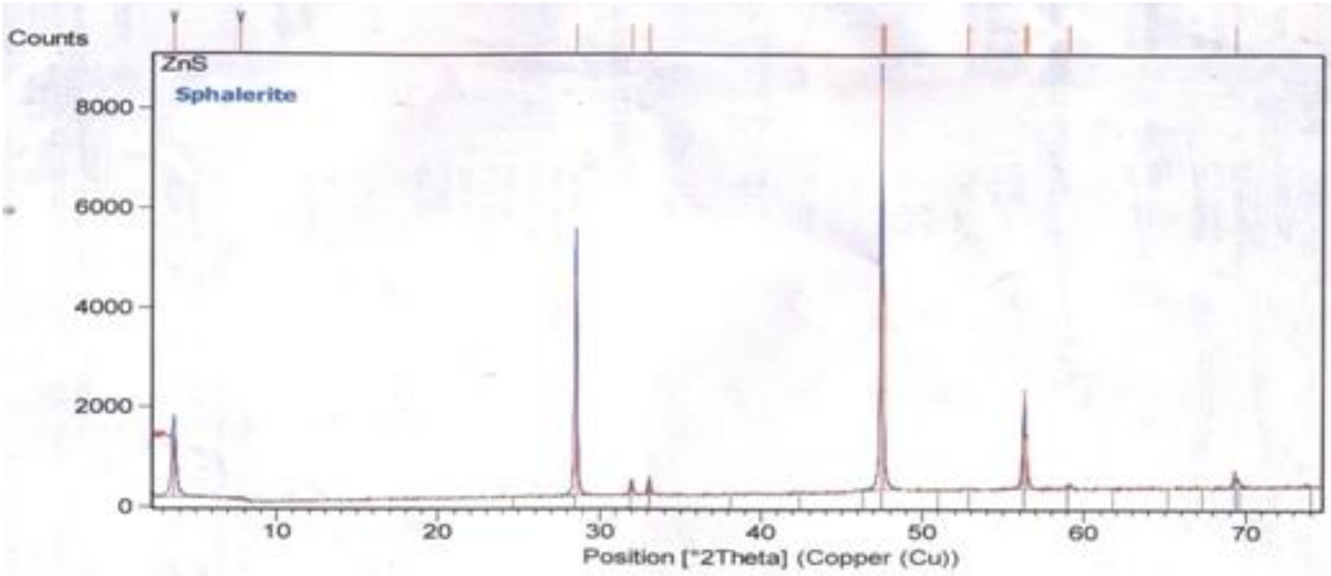

Figure 1. XRD pattern of the sphalerite ore

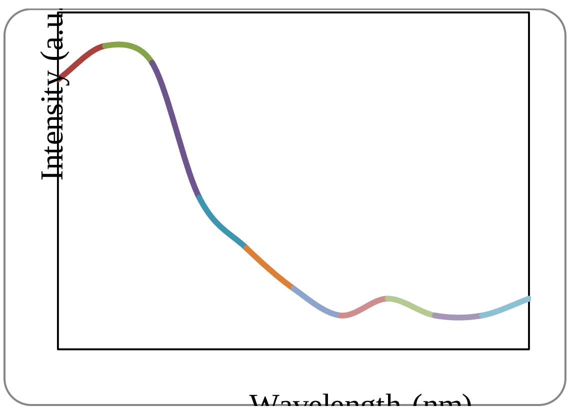

Figure 2. Absorption spectrum of the sphalerite ore

Irradiation Time	Degradation of methylene blue (%)			
	500W	200W	100W	60W
0	0	0	0	0
20	19	10	9	5
40	33	22	20	14
60	44	32	29	27

Table 2. Effect of irradiation time on the percentage photocatalytic degradation of methylene blue using sphalerite ore at various lamp powers

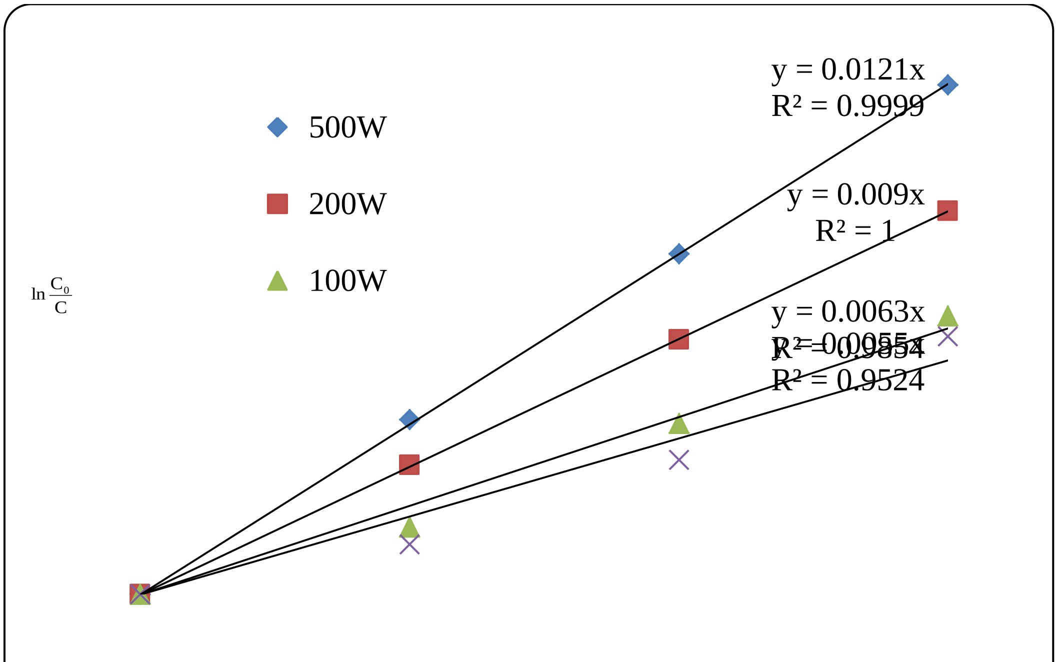

Figure 3. Pseudo first order kinetic plot for the photocatalytic degradation of methylene blue at various lamp powers

Table 3. Derived values of k_{app} at at various lamp powers

Lamp power	500W	200W	100W	60W
k_{app} (min^{-1})	0.121	0.0090	0.00063	0.0055
R^2	0.999	0.999	0.985	0.952

CONCLUSIONS

The sphalerite ore powder obtained from Abuni deposit, Nasarawa State, Nigeria has been characterized using XRF, XRD, UV-Vis spectroscopy and surface area analysis. The sphalerite ore powder was found to be very active in the photocatalytic degradation of methylene blue under visible light illumination. Photocatalytic degradation of methylene blue obeys pseudo first order kinetics. The photocatalytic efficiency was found to increase with increase in the intensity of the incident radiation.

REFERENCES

1. Ahmed, M.A., El-Katori, E. E. and Gharni, Z.H. (2013) Photocatalytic degradation of methylene blue using Fe_2O_3/TiO_2 nanoparticles prepared by sol–gel method. *Journal of Alloys and Compounds*, 553(1), pp. 19–29.
2. Al-Degs, Y. S., Tutunjureyad, M.F. and Shawabkeh, A. (2000). The feasibility of using diatomite and mn–diatomite for remediation of Pb^{+2}, Cu^{+2}, and Cd^{+2} from Water. *Separation Science and Technology,* 35(14), pp. 2299–2310.
3. Blanco, J., Malato, S., Fernandez, P., Gernjak, W. and Maldonado, M.I., (2009) Review of feasible solar energy applications to water processes. *Renewable and Sustainable Energy Reviews,* 13(1), pp. 1437–1445.
4. Casbeer, E., Sharma, V.K. and Li, X.I. (2012) Synthesis and photocatalytic activity of ferrites under visible light: A review. *Separation and Purification Technology*, 87 (5), pp. 1–14.
5. Chen, Y. M., Lu, A. H., Li, Y., Zhang, L. S., Yip, H. Y., Zhao, H. J., An, T. C. and Wong, P. K. (2011) Naturally occurring sphalerite as a novel cost-effective photocatalyst for bacterial disinfection under visible light. *Environmental Science and Technology*. 45(13), pp. 5689−5695.
6. Chong, M.N., Jin, B., Chow, C.W.K. and Saint, C. (2010) Recent developments in photocatalytic water treatment technology: A review. *Water Research*. 44 (1), pp. 2997-3027.
7. Fujishima, A., Zhang, X. and Tryk, D. A. (2007) Heterogeneous photocatalysis: From water photolysis to applications in environmental cleanup. *International Journal of Hydrogen Energy*. 32(14), pp. 2664–2672.
8. Hamza, A., Abdallah, N.M. and Aliyu, A. (2011) Photocatalytic activity of Nigerian ilmenite. *Nigerian Journal of Engineering,* 18, pp.111-114.
9. Hoffman, M.R., Martin, S., Choi, W. and Bahnemann, D.W. (1995) Environmental applications of semiconductor photocatalysis. *Chemical Reviews,* 95(1), pp. 69-96.
10. Leung, L. M., Leung, M.K. and Sumathy, K. (2007) A review and recent developments in photocatalytic water-splitting using TiO_2 for hydrogen production. *Renewable and Sustainable Energy Reviews*, 11, pp. 401-425.
11. Li, Y., Lu, A. H., Jin, S. and Wang, C. Q. (2009) Photo-reductive decolorization of an azo dye by natural sphalerite: Case study of a new type of visible light-sensitized photocatalyst. *Journal of Hazardous Materials*, 170 (1), pp. 479−486.
12. Lu, A., Lia, Y., Ming, L., Wang, C., Yang, L., Liu, J., Wang, Y., Wong, Y. and Wong, P. (2007) Photocatalytic oxidation of methyl orange by natural V-bearing rutile under visible light. *Solar Energy Materials and Solar Cells,* 91(1), pp. 1849–1855.

13. Olubambi, P. A., Ndlovu, S., Potgieter, J. H. and Borode, J. O. (2007) Effects of ore mineralogy on the microbial leaching of low grade complex sulphide ores. *Hydrometallurgy*, 86(1), pp. 96−104.
14. Sajjad, A.K., Shamaila, S., Tian, B.Z., Chen, F. and Zhang, J.L. (2010) Comparative studies of operational parameters of degradation of azo dyes in visible light by highly efficient WO_x/TiO_2 photocatalyst. *Journal of Hazardous Materials*, 177, pp. 781–791.
15. Yang, X. G., Li, Y., Lu, A. H., Yan, Y. H., Wang, C. Q. and Wong, P. K. (2007) Photocatalytic reduction of carbon tetrachloride by natural sphalerite under visible light irradiation. *Solar Energy Materials and Solar Cells,* 95(7), pp.1915−1921.

UTILIZATION OF MODIFIED SHEA BUTTER HUSK AS AN ADSORBENT FOR THE REMOVAL OF HEAVY METALS IN INDUSTRIAL EFFLUENTS

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ABSTRACT

Continuous adsorption of Nickel ions was studied in a glass column using modified shea butter husk. Characterisation of the husk revealed the presence of functional groups; –COOH, -OH and NH_2. The Scanning electron microscopy (SEM) indicated the pores and cavities of the husk, as well as the accumulated Ni (II) ions after sorption. The Brunaueur Emmet Teller (BET) test revealed the reduction in the surface area and pore volume from 5.493 m^2/g and 2.534 x 10^{-3} cc/g to 2.073 m^2/g and 1.067 x 10^{-3} cc/g respectively. The column parameters calculated showed the effectiveness of the column at flow rate of 0.5 ml/min, bed heights of 12 cm and concentrations of 250 mg/L. The percentage removal of the nickel ions at the optimum conditions was approximately 70% with about 77 mg of Ni (II) ions adsorbed out of a total of 112.5 mg sent into the column at an adsorption capacity of 4.018 mg/ wet bead.

KEYWORDS: adsorption, column, Ni (II) ions, shea butter husk

1.0 INTRODUCTION

Shea butter husk is an agricultural waste product of shea butter plant. The plant is found in about twenty countries in the world with large quantities in the dry Savannah regions in west Africa. Nigeria (latitude 10^{o} 0N longitude 18^{o} 0E) is the largest world producer of shea butter with capacity greater than 300,000 MT per annum (Osibo, 2013). Major states with high concentrations of this shea butter tree include: Niger, Kwara, Oyo, Kaduna, Osun, Kebbi and Zamfara (Warra, 2011). The current focus on small and medium scale enterprise has increased the search for alternative resources for economic growth and development. The shea butter production is an important aspect of income earnings for inhabitants in these regions and they are encouraged to focus upon it for exportation (Suleiman, 2008). This invariably has led to the generation of the waste matter, the shea butter husks which now litter the environment and aquatic habitats. This waste matter can be properly harnessed to serve a double benefit to host producing communities. This can be done through its utilization as an adsorbent for the removal of heavy metals ions in polluted effluents thereby sustaining the ecosystem and can also serve as an avenue for revenue generation.

Nickel (II) ion is a heavy metal commonly found in the effluent of electroplating waste water, mining activities, batteries production and in the alloy industries. This metal ion is dangerous to man, plants and the aquatic animals. The devastating effect is enormous as this metal ion is highly toxic, non-biodegradable and has bio-accumulation tendency. Prolonged exposure to oxides and sulphides of Ni is associated with risk to lung and nasal tumours.

This research seeks to use the shea butter husks by modifying it with a biological origin plant-alginate to remove the heavy metal ions- Ni (II) from a polluted wastewater in a continuous flow process. The alginate is used as an immobiliser so as to prevent clogging in the column and the leaching of the organic constituents contained in the husks. The use of column for the adsorption processes helps to give the dynamism of the husks at various stages in the column (Chen, 2013). The waste material used is eco-friendly, offers less cost, highly abundant and the process is easy to maintain and can be sustained over time for a cleaner and healthier environment.

2.0 MATERIALS AND METHODS

2.1 Shea butter husk

Shea butter husks collected in some farmland in Niger state, Nigeria, were thoroughly rinsed to remove impurities like sand, decayed leaves and inorganic matters from their surfaces. This was dried in an oven at 80 ^{o}C to remove excess water molecules and then crushed with jaw crusher (Retch RS200). It was sieved using an electrical sieve shaker to obtain a particle size in the range of 200-250 µm. The particles were then stored in a polyethene bag for further use. This sample shall be called the raw shea butter husks (RSBH).

2.2 Preparation of the modified shea butter husk beads

The modified shea butter husk (MSBH) was prepared by weighing 1 g of sodium alginate salt and dissolving it into 100 ml of distilled water kept on hotplate magnetic stirrer (model-Jenway 1000) at a temperature of 65 ^{o}C (Fiol *et al.*, 2006). The dissolved jelly-like solution was continuously stirred and then cooled down to a temperature of 25 ^{o}C. 2 g of RSBH (<250 µm) was added into the jelly-like solution under an agitation of 200 rpm to produce an homogeneous mixture of alginate and the husk particles. The mixture was carefully added drop wise through the nozzle of a syringe (Hypoject IV 110108) into a solution of 0.1 M calcium chloride dehydrate. The agitation was then reduced to 20 rpm so as to have uniform spherical beads. The entrapped RSBH with the calcium alginate (CA) beads were cured in the $CaCl_2$ solution for 24 hours. This was filtered and thoroughly rinsed with distilled water until the pH of the rinsed water is at neutral.

2.3 Preparation of stock solution

Nickel stock solution (1000 mg/L) of Ni (II) was prepared by dissolving approximately 4.0489 g of analytical grade nickel chloride hexa-hydrate $NiCl_2.6H_2O$ in 100 ml of deionized water and dilute to 1 litre in a volumetric flask with deionized water. 0.1 M of $CaCl_2$ was prepared by dissolving 11.1 g of $CaCl_2$ in 1000 ml of distilled water.

2.4 Characterisation of the adsorbents

Raw shea butter husk was characterized using several techniques. The functional group of the raw sorbents was characterized using the Fourier transform-infrared spectrophotometer (FT-IR-8400S, Schimadzu Japan). The spectral range varied from 4000 cm^{-1} to 400 cm^{-1} and samples were prepared using KBr disc. The surface morphology of the sorbent at the raw state and after adsorption with the modified sample was studied with High resolution scanning electron microscope (SEM EVO MA 10, Carl Zeiss). The BET test for RSBH and MSBH were done using the (NovaWin Quantachrome, 2013) for surface area and pore volume analysis.

2.5 Column Adsorption Procedure

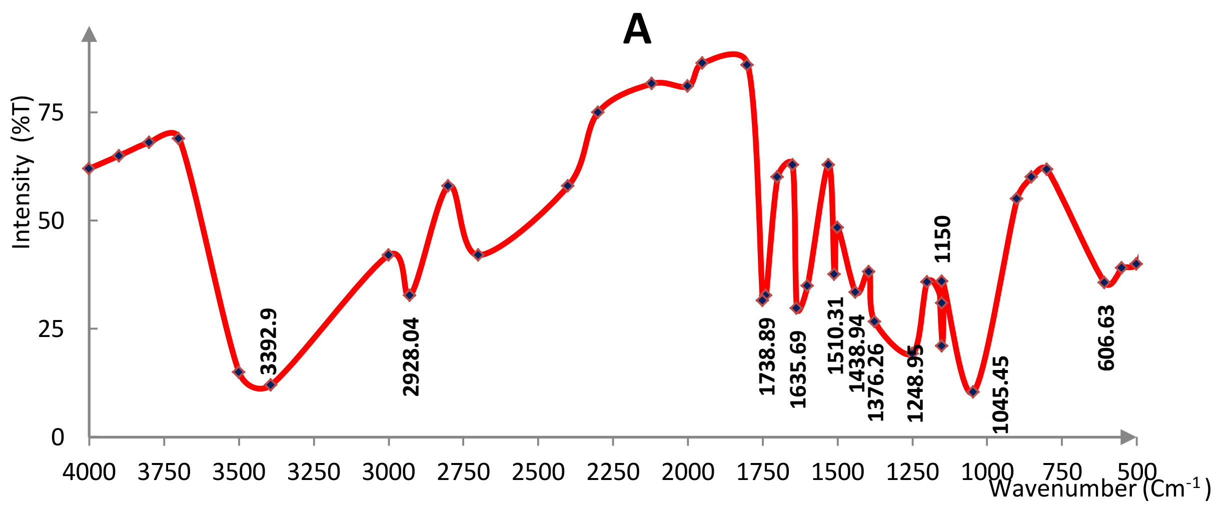
Fixed bed column adsorption experiments were conducted in a 1.8 cm diameter (I.D) glass column of length 25 cm. The column was filled to a height of 6 cm and 12 cm with the known weights of MSBH of approximately 1.56 mm $\pm$ 0.14 spherical shapes. This was supported over a glass wool and glass beads to prevent passage of some beads out of the specified range. The metal ion solution containing concentrations of 250 mg/L and 500 mg/L of adsorbates was fed to the column through a down flow at a varying flow rates of 0.5 ml/min to 5 ml/min using a 'drip bag flow set'. This was top-up periodically once solution is below marked points. The solution leaving the bottom of the column was collected at various time interval for analysis using fast sequential atomic absorption spectrophotometer (Varian SpectrAA 240FS). Flow continued until the concentration at the outlet of the column almost equals the concentration at the inlet.

2.0 RESULTS AND DISCUSSION

The FT-IR spectra (Figure 3.1) indicate that the raw husk has absorption above 3000 cm^{-1} which suggests that the husk may likely contains C=C. Absorption also occurred at the lower end of the range (i.e below 1700 cm^{-1}) and this is probably amide or carboxylate. There were some moderate band in the range of 1200 cm^{-1}-1000 cm^{-1} and 800 cm^{-1} - 600 cm^{-1} which may imply hydroxyl compound. A shift in the sharp peak at 1635.69 cm^{-1} for the raw husk to a flattened point at 1637.62 cm^{-1} of Ni-loaded and sorbent can be attributed to the stretching of C=O corresponding to carbonyls, olefinic C=C (Bansal *et al.*, 2009). The sharp peak observed at 1738.89 cm^{-1} for the raw husk is assigned to C-O bond of carboxylic or its ester and its complete disappearance on the Ni-loaded sorbent inferred that the metal bonded through interaction with active groups of OH, COOH on the raw husk (Minamisawa *et al.*, 2004).

The Brunaueur Emmet Teller (BET) test showed that the surface area obtained was 5.493 m^2/g at correlation coefficient, R^2 of 0.9999 and at pore volume of 2.534 x10^{-3}. There was a reduction in the area after adsorption with the Ni (II) ions to 2.033 m^2/g and the volume to 1.067 x 10^{-3} cm^3/g. This is as a result of the deposition and coverage of the sorptive sites of the husk by the Ni (II) ions.

The SEM micrographs of MSBH (see Figure 3.2) clearly depict images of the mixture of husk and alginate. Noticeable are the greyish white crystals well blended with the darkish alginates. The entrapment of the accumulated Ni (II) after the adsorption process as indicated by the red arrow in Figure 3.3 clearly indicate the adsorption and presence of the Ni (II) ions within the husk.



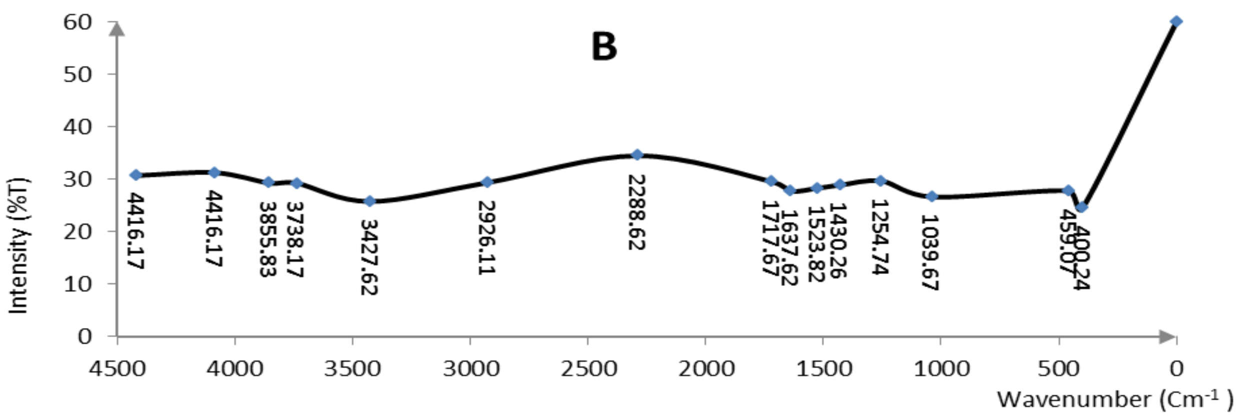


Fig. 3.1: FT-IR Spectra of raw shea butter husk (**A**) and Ni-loaded sorbent (**B**)

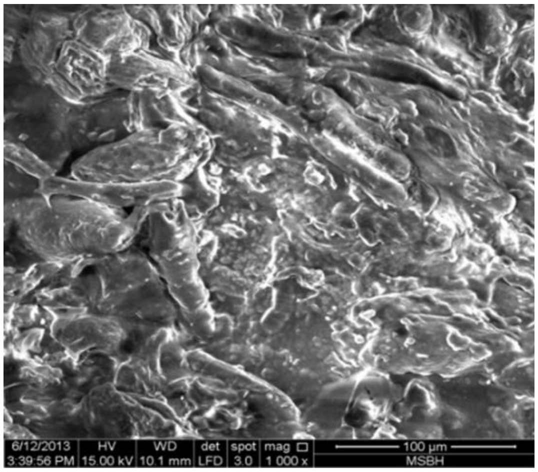


Fig. 3.2: SEM micrographs of MSBH

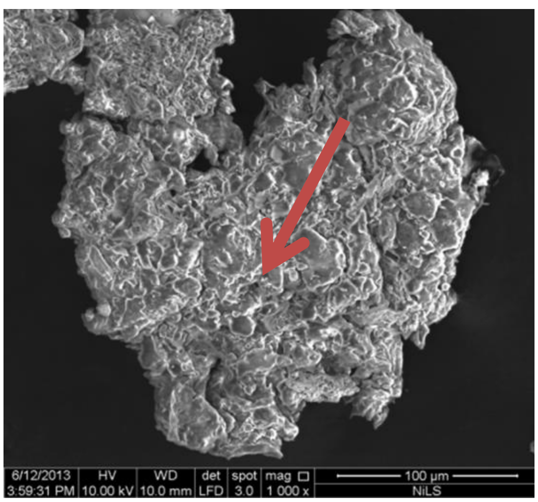


Fig. 3.3: SEM micrographs of Ni- MSBH

The dynamism of the effect of flow rate on Ni (II) sorption on MSBH in a continuous-flow packed bed was varied at 0.5 and 5 ml/min while the bed height and initial metal ion concentration were held constant at 12 cm and 250 mg/L respectively. The normalised plots of Ni (II) at these flow rates are shown in Figure 3.4.

The results showed that adsorption of the metal ions are strongly dependent on the flow rate. At lower flow rate of 0.5 ml/min, the sorption of Ni (II) increases gradually and there is delay in saturation of the sorbent. Saturation of the bed is easily attained at higher flow rate. To attain saturation at lower flow rate, the contact time must be prolonged (Calero, *et al*., 2009). This rapid sorption is as a result of availability of the sorption sites (Aksu *et al*., 2007) and delay in saturation offers more effective interaction between the sorbents and the adsorbates. As the influent flow continues, there is gradual saturation of the sites and thus less effectiveness in the uptake of the metal ions until a point is reached where the influent concentration equals effluent concentration which thus implies that the bed is fully saturated.

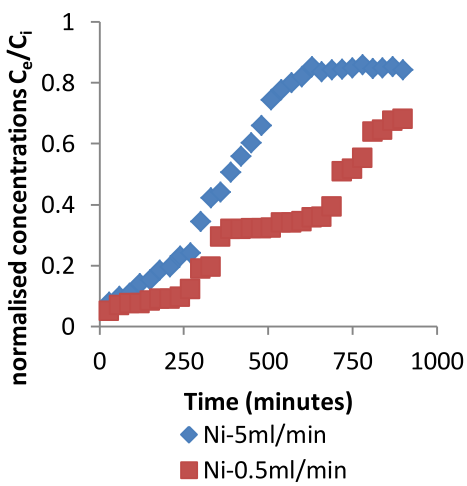


Fig. 3.4: Breakthrough curve for Ni (II) at flow rate of 0.5 ml/min and 5 ml/min, Ci= 250 mg/L and bed height of 12 cm

Ni (II) ions has maximum allowable limit of their concentration in electroplating effluent discharge as 0.5 mg/L (WHO, 1998) while for drinking water (WHO, 2008), it is 0.02 mg/L. Using a break through time at 0.2 ci (Bulgariu and Bulgariu, 2013), Ci is the initial concentration gives 330 minutes while at 5 ml/min, it was 210 minutes. Saturation time, ts at 0.95ci was yet to be achieved even after 900 minutes of continuous adsorption. This was quite remarkable as little as 2 g of the sorbent mass treated a volume of extremely polluted effluents. Evaluation of the column performance revealed the following parameters and their values are summarised on Table 3.1:

The total effluent volume V_{eff} (ml) treated according to Fiol *et al*. (2006) is evaluated as:

$$V_{eff} = Qt_{total} \qquad (3.1)$$

Where, Q is the volumetric flow rate (ml/min) and t_{total} is the total flow time in minutes

The area below the breakthrough curve is the total mass of heavy metals adsorbed, q_{total}, in mg, for a given feed concentration and flow rate (Calero, 2009). It is expressed as:

$$q_{total} = \frac{Q}{1000} \int_{t=0}^{t=t_{total}} C_R \, dt \qquad (3.2)$$

Where $C_{R,}$ is the concentration of metal removed in mg/L.

The total metal ions sent to the column, (mg) is deduced from Equation 3.3 (Blazquez, 2010).

$$m_{total} = \frac{CiQt_{total}}{1000} \qquad (3.3)$$

The percentage removal of the metal ions is evaluated as the ratio of mass of metal adsorbed (q_{total}) to the total mass of metal ions sent to the column (m_{total}) (Shahbazi, 2011),

$$\%R = \frac{q_{total}}{m_{total}} 100 \qquad (3.4)$$

The amount of metal adsorbed at equilibrium qe (mg/g), is expressed as:

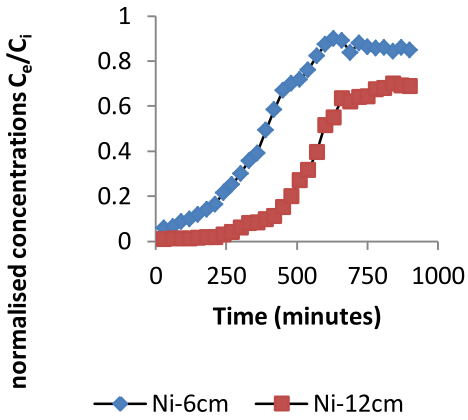
$$qe = \frac{q_{total}}{m} \qquad (3.5)$$

Where, m is the mass of adsorbent in (g).

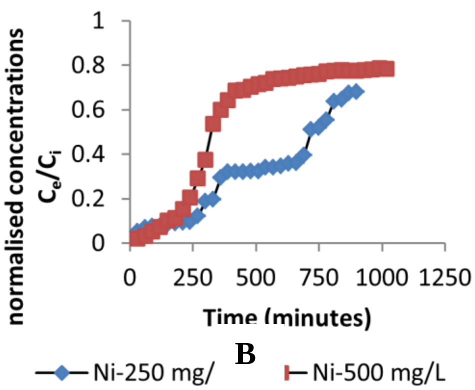
These gave rise to the following values obtained for the Ni (II) adsorption where: total metal ions sent to the column at 0.5 ml/min was 112.5 mg out of which 77.0 mg was adsorbed while at 5.0 ml/min, total metal sent was 1125 mg, out of which 503.13 mg was adsorbed. The percentage removal of the metal ions at 0.5 ml/min flow rate were much higher (68.45%) than at 5.0 ml/min which was 44.7 %. Amount adsorbed of metal in mg/wet bead is a function of total metal adsorbed which were higher at higher flow rate for the metal. This is so because the total metal sent to the column is a function of flow rate and time, although more metal ions were sent at higher flow rates, the amount of metals adsorbed is smaller when compared to saturation at lower flow rate.

3.2. **Effect of bed heights**

The amount of the adsorbed metals in the fixed bed column is dependent on the quantity of sorbent in the column (Qaiser *et al*., 2009). The experiment was performed at two different bed heights of 6 cm and 12 cm (see fig. 3.5A). The flow rate and initial metal concentration were kept at 0.5 ml/min and 250 mg/L respectively. The amount of metal ion adsorbed and percentage removal increased with increase in bed height. For Ni (II) adsorption, the amount adsorbed increases from 50.56 to 78.0 mg as the depth increases from 6 cm to 12 cm, while percentage removal increases from 44.9 % at 6 cm to 70.03 % at 12 cm bed height. Qaiser, *et al*., (2006) explained that at lower bed depth, the axial dispersion phenomenon predominates in mass transfer and this reduces the diffusion of the metal ions into the whole sorbent mass which consequently bring about the increase in breakthrough time. With increase in bed heights, the residence time is increased, allowing the metal ions to diffuse deeper inside the sorbent and hence reduction in breakthrough time. Similar results were obtained by Fiol *et al*., (2006); and Calero *et al*., (2009).



A



B

n of time at bed heights (**A**) of 6 cm and 12 cm and concentrations (**B**) of 250 and 500 mg/L for the adsorption of Ni (II).

3.3 Effect of initial metal ion concentration

The effect of concentration change was varied at 250 and 500 mg/L for Ni (II). At concentration of 250 mg/L, the breakthrough occurred lately because the smaller concentration gradient causes a slower mass transfer coefficient as a result of the decreased in diffusion coefficient (Aksu and Ferda, 2004). At normalised concentration of 0.2 mg/L, the breakthrough time was approximately 330 minutes at 250 mg/L and about 240 minutes at concentration of 500 mg/L (see Figure 3.5 B). A higher percentage of Ni (II) was however removed at higher concentration because of the increased driving force in the concentration gradients. These results demonstrated that the diffusion process of the metal ions into the sorbents is concentration dependent. The increase in adsorption capacity is as a result of more binding sites being covered from the increase in concentration of the metal ions.

4.0 **CONCLUSION**

1) The characterisation of the husk revealed the presence of functional groups such as; hydroxyl, carboxylic, carbonyls, and phenols groups as being responsible for the sorption process. The SEM-EDAX revealed the porosity and presence of the adsorbed Ni (II) in the sorbents. The BET test showed that raw husk is highly porous with a surface area of 5.493 m^2/g. which was reduced to 2.033 m^2/g after adsorption with the Ni (II).

2) Percentage removals of metal ions were higher at lower flow rate of 0.5 ml/min than at higher flow rate of 5.0 ml/min. As much as 68 % of the metal sent to the column had been adsorbed at flow rate of 0.5 ml/min as compared to 44.7 % at flow rate of 5.0 ml/min. The bed heights at 12 cm provided more binding sites for sorption. At lower inlet concentration of 250 mg/L, a steeper curve and slower break through time was achieved.

3) The MSBH has demonstrated a remarkable effectiveness in the removal of the Ni (II) ions in a wastewater. As little as 2g of the raw husks was able to treat 450 ml of polluted effluent at a flow rate of 0.5 ml/min; 12 cm bed heights and at concentrations of 250 mg/L.

Table 3.1: Summary Sorption characteristics for Ni (II) adsorption on MSBH at flow rate of 0.5 and 5.0 ml/min; bed heights of 6 and 12 cm; and at concentrations of 250 and 500 mg/L

Parameters	t_{total} (mins)	V_{eff} (ml)	m_{total} (mg)	q_{ads} (mg)	Removal (%)	Q (mg/wet bead)
Flow rates						
0.5 ml/min	900	450	112.5	77	68.45	4.018
5.0 ml/min	900	4500	1125	503.13	44.70	40.18
Bed Heights						
250 mg/L	900	450	112.5	77.0	68.45	8.04
500 mg/L	900	450	225	117.5	50.20	4.03

5.0 ACKNOWLEDGEMENT

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REFERENCES

Aksu, Z., Çağatay, Ş. Ş., & Gönen, F. (2007). Continuous fixed bed biosorption of reactive dyes by dried *Rhizopus arrhizus*: Determination of column capacity. *Journal of Hazardous Materials*, 143.362–371

Aksu, Z., & Ferda, G.F. (2004). Biosorption of phenol by immobilized activated sludge in a continuous packed bed: prediction of breakthrough curves. *Process Biochemistry*, 39 (5), 599–613.

.Blázquez, G., Calero, M., Hernáinz, F., Tenorio, G., Martin-Lara, M.A. (2010). Batch and column studies of chromium (III) biosorption by olive stone. *Environmental Progress & Sustainable Energy,* 30 (4) 576-585.

Bulgariu, D., & Bulgariu L. (2012). Equilibrium and kinetics studies of heavy metal ions biosorption on green algae waste biomass. *Bioresource Techn*ology, 103 489–493.Calero, M., Hernáinz1, F., Blázquez, G., Tenorio, G., & Martín-Lara, M.A. (2009). Study of Cr (III) biosorption in a fixed-bed column. *Journal of Hazardous Materials* 171 886–893.

Fiol, N., Escudero, C., Poch, J., & Villaescusa, I. (2006). Preliminary studies on Cr (VI) removal from aqueous solution using grape stalk wastes encapsulated in calcium alginate beads in a packed bed up-flow column. *Reactive & Functional Polymers,* 66 795–807

Minamisawa, M., Yoshida, S., & Takai, N. (2004). Determination of biologically active substances in roasted coffee using a diode-HPLC system. *Analytical Science and Technology*, 20: 325-328.
Osibo, O. (2013). Role of Nigerian Export Promotion Council in sheanut/butter developments. [PowerPoint slides]. at *Global Shea Alliance Conference*. Retrieved from http://www.globalshea.com//upload/files/conferencepresentation/osibo_nepc_shea2

Shahbazi, A. (2011). Functionalized SBA-15 mesoporous silica by melamine-based dendrimer amines for adsorptive characteristics of Pb (II), Cu (II) and Cd (II) heavy metals ions in batch and fixed bed column. *Chemical Engineering journal,* 168(2) 505-518.

Suleiman, M.A.T., (2008). Assessment of Potentials for Shea Nuts in selected Local Government Areas in Niger State

Warra A.A. (2011). Cosmestic potentials of African shea nut (Vitellaria paradoxa) butter. *Current Research in Chemistry,* 3 (2): 80-86

World Health Organization (Ed.). (2008). Guidelines for drinking-water quality. *World Health Organization*, ISBN 9241546743, Geneva.

World Bank. (1998). *Pollution prevention and abatement: Electroplating Industry*. Draft technical background document. Environment Department, Washington, D.C.

E-LEARNING IN ENGINEERING EDUCATION: THE NEED FOR IMPROVED FUNDING.

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ABSTRACT

E-learning or web-based instruction is being rapidly embraced by most universities across the world as such media of instruction are economical, convenient and disbursable to a larger audience. In engineering education, in particular, web-mediated techniques have been receiving more attention as various disciplines of engineering are receiving diverse models based on e-learning. A study was carried out in the faculty of engineering, Ahmadu Bello University Zaria, aimed at investigating the effect of certain variables such as gender, course of study, computer experience, and the percentage of internet usage on teaching and learning processes. Questionnaire was administered to a randomly selected five hundred (500) male and female students across the seven (7) departments of the faculty while about 85% were filled and returned. The study also examines the university management's perspectives and strategies to incorporate internet usage in teaching and learning processes especially in engineering, which further translates into the need for improved funding in that regard.

***Keywords**: Technology- based teaching, internet in engineering education, World Wide Web, user attitude.*

INTRODUCTION

The use of technology in the classroom has increasingly been the subject of many studies in recent years (Al-Habis and Al-Kandary, 2000). The world is witnessing an explosion of on-line and distance learning practices, which are attributed to a number of factors. These factors, which are largely valid in developing countries (such as Nigeria) as well as developed (advanced) countries, are recent advances in information technology, the declining cost of computers, impressive increase in access to the Internet, continuously improved quality of multimedia software, the need of corporations to maintain a competitive workforce in the globalized economy, the desire of non-traditional student's to eliminate the skill gap with traditional university students, and the tremendous increase in the magnitude of information (Jebreen and Jamal, 2008; Al-Najaar, 2001; Koohang, 2004; Al-Ani, 2000).

Engineering education, in particular, will need to use ICT to advance the learning process, make learning more effective, and more universal (Al-Ebaid, 2002; Bome'rafi, 2001).

The internet is considered to be the most prominent in modern technology and in the modern revolution of information and communication. Increasingly, students should make use of technology to acquire skills and knowledge. Furthermore literature on instructional technology shows that the use of internet in teaching has the potential to motivate both students and teachers, increase their participation and interaction in the classroom, provide students with a more active role in their learning, and help to facilitate cross-curricular work among other advantages (Ghandoor, 1999).

The use of internet in engineering education can achieve many advantages like: rapid understanding, flexibility in time and place, high speed in creating new programs compared to the systems of videos and CD-ROM, changing the style of the teacher from lecturing to guiding and monitoring, creating classes without walls, getting the study materials any time and from any location and getting the views of scientist and scholars in various fields (Madden *et al.,* 2005; Attwenger, 1997)

Currently, most universities are introducing a variety of internet services in their faculties in order to cope with new technology trends and to advance knowledge. Indeed, the internet service has become available to all teaching staff and to students in most of the world while studies have revealed low degree of internet usage in the universities for learning (Dutta and Taghaboni-Dutta, 2002; Fukumoto, 2002; Lo *et al.,* 2009; Moscinski, 2008; Peterson and Feisel, 2002).

Ahmadu Bello University has recommended that e-learning must be integrated with conventional method in an attempt to advance the learning process. However, this may pose a challenge to students who have different computer abilities, different degrees in internet usage, and different motivations for internet use. Moreover, there are no studies that address all the above variables altogether. It has been noticed that there are differences in terms of ability, training, and technical skill among students in their use of internet during their university studies. This is what gave rise to the present study, for it aims to study the nature, degree, and other factors that govern internet usage in university education.

Furthermore, this paper tries to reflect on the students' attitudes towards the use of internet in addition to the traditional learning process in engineering. Thus, an answer to the following question was sought: What is the real situation of the use of internet by the engineering students in Ahmadu Bello University Zaria in their education and how they feel about this issue? This question is divided into the following sub questions:

i. Are there any statistically significant difference at level (α= 0.05) in the percentage of internet usage among the students of the faculty of engineering according to the variables of the study?
ii. What is the degree of internet usage by the students in the university education?
iii. What do students feel about the incorporation of new technologies in the teaching process?
iv. Can a traditional learning system be substituted by another system that is based on e-learning methods?

Therefore, the objectives of this study include:

i. To examine the effect of internet usage on the university teaching and learning process, more importantly, engineering education,
ii. To study the relationship between internet usage in the learning process and the variables such as gender, course of study and computer experience among university engineering students, and
iii. To study the attitudes of the students towards such type of learning.
iv. To report some useful feedback for the Ahmadu Bello University in its pursuit to employ new technologies and establish the need for improved funding particularly in teaching engineering

2.0 METHODS AND PROCEDURES

The population consists of all the students of the faculty of engineering who were registered for the second semester of the academic year 2012/2013. A total of four thousand one hundred and eighteen (4,118) students at the B. Eng level were registered for that semester (Office of the Dean, Faculty of Engineering, Ahmadu Bello University, Zaria). Out of this number, sample of randomly chosen five hundred (500) students were approached and questionnaires were administered to them. Only four hundred and fourty eight (448) of the questionnaires were filled and returned at the time of compilation which represents 89.6% of the study population.

2.1 Methods and Instruments

As the case of many other studies, the descriptive survey method was used to study the variables. The method includes functions like the frequencies, the percentage, chi square analysis and post comparisons. Data were collected using a questionnaire prepared after critically review of literature related to this field. The study used the method of gathering personal data and questions that are related to the level and percentage of internet usage in university engineering education. The questionnaire composes of five (5) study sections as follows:

- General Information
- The level of students usage of internet and computer
- The degree of using internet in university education.
- The Internet topics in which students desire to develop their knowledge
- The attitude of using internet in engineering education.

2.2 Procedures

The following procedure was adopted for the study

- The total number of students who were registered for the second semester of year 2012/2013 was collected
- The questionnaires were distributed to the students during their classes and were collected after the class time.
- The data in the completed questionnaire were collated

- The questionnaire results were analyzed using SPSS.

2.3Variables

A. Independent variables:

1. Gender: male, female
2. Course of study

(Mechanical, Chemical, Agricultural, Civil, Electrical, Water resources and Metallurgical & Materials Engineering)

3. Level
4. Computer experience
   a. Low: less than two years.
   b. Moderate: 2-5 years.
   c. High: more than 5 years.

B. Dependent variable(s)

a. The percentage of internet usage which represent the internet usage in numbers depending on the above internal values. This can be classified into 3 main intervals (low, moderate, high).
b. The degree of using internet in university education.
c. The Internet topics in which students desire to develop their knowledge

The attitude of using internet in engineering education.

3.0 RESULTS AND DISCUSSION

The information gathered from the questionnaire are summarized in tables (see Appendix) while some are presented in figures. The analysis of these information using chi-square method show that all the dependent variables are significant at level $\alpha = 0.05$. This implies that all the variables are significant to this study. Figures 1-8 briefly analyzes responses from the questionnaire administered.

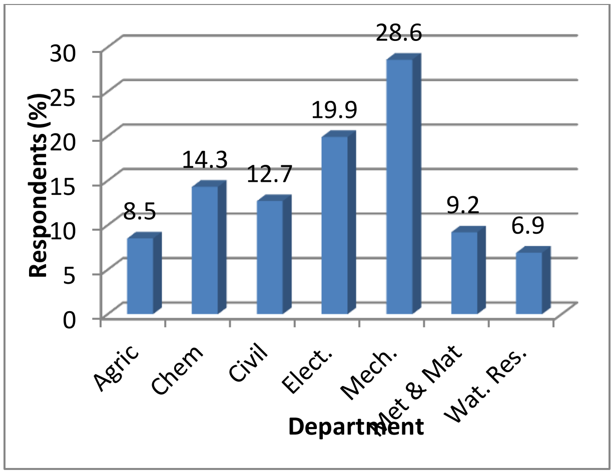


Fig. 1: Respondents According to Course of Study

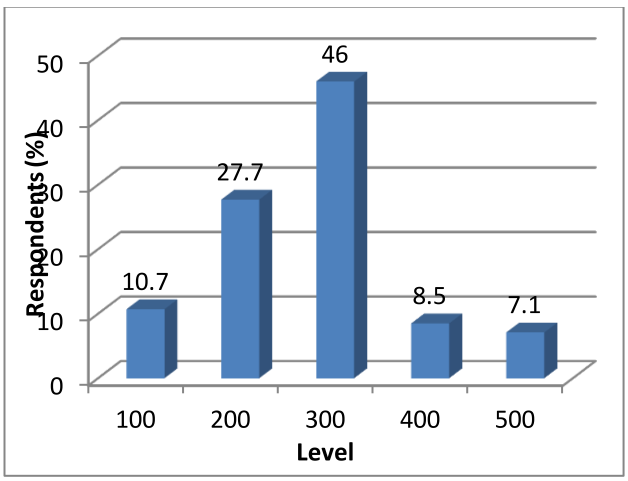


Fig. 2: Respondents According to Level

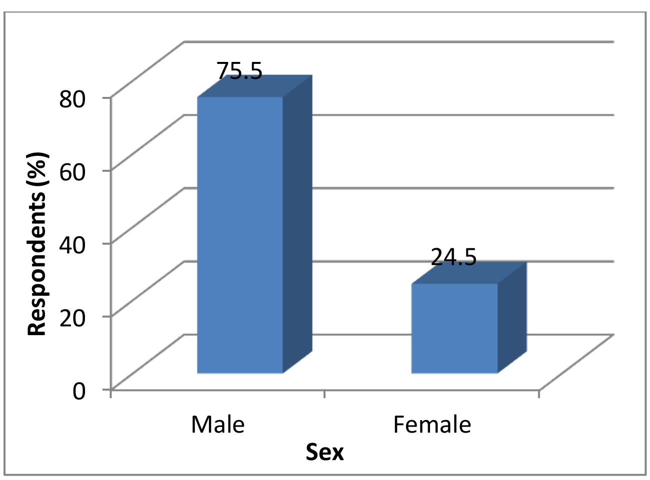


Fig. 3: Respondents According to Gender

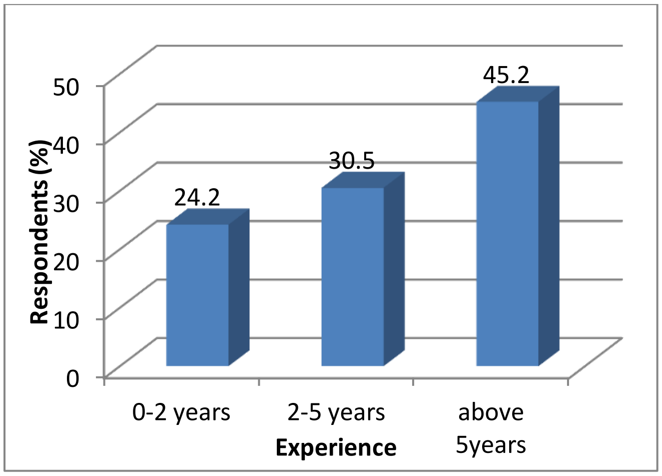


Fig. 4: Respondents According to Students' Computer Experience

From the results obtained from the analysis as presented in figures 1 - 4 above, it can be observed that students from the mechanical engineering department responded more to the questionnaire administered as compared to other students. This could be by virtue of their numerical advantage in terms of students in the various departments. Also larger percentages of the respondents are 300 level students; this can be associated to the level of commitment they have for activities happening on the campus, as intermediate students compared to those of higher or lower levels

From figure 3, male students are more than female students in the faculty. This can be associated to the phobia female students have towards studying engineering courses as non tradition courses for them. Figure 4 shows that 45.2% of the respondents have above 5years of computer usage experience while only 24.2% have below 2years of experience. This implies that majority of the students in the faculty have computer knowledge which is expected to aid their rate and interest in internet usage.

The level of internet usage for general purposes among students is presented in the figure below.

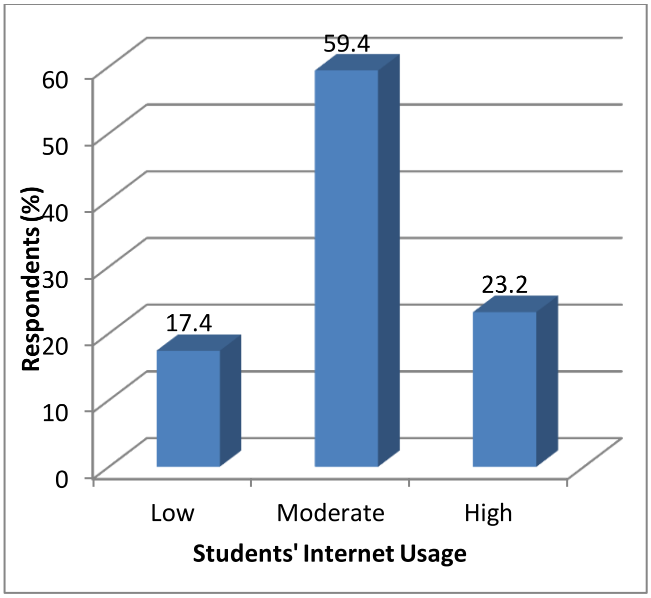
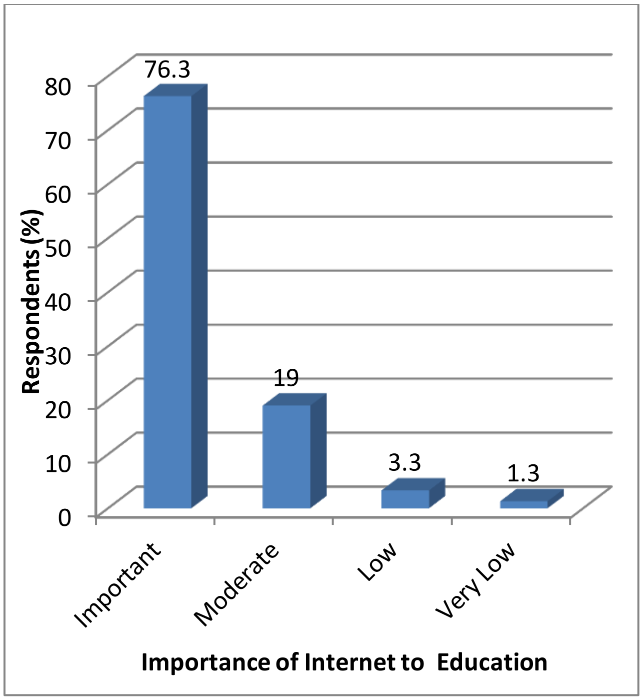


Fig. 5: Respondents According to Students' General Internet Usage

The analysis shows that 59.4% of students moderately use internet as compared to 23.2% and 17.4% of high and low usage respectively. Gender also plays a major role in the level of internet usage among students. This can be associated with dependency of the few female students on their male counterparts in solving problems given to them by their lecturers.

Generally, larger percentages of students use internet moderately, this implies that there is a reasonable rate of internet dependency by the students in gathering information or solving problems. Considering why moderate usage outwits high usage, one could argue that despite their level of experience in computer usage, the students still prefer other sources like text reading to internet facilities.

The perspective of students to the integration of internet to education system and their usage for educational purposes is presented in the figures 6-8 below.



Where Im represents Important, M represents Medium, L represents Low and Ve represents Very low.

Fig. 6: Respondents' Opinion on Importance of Internet to Education

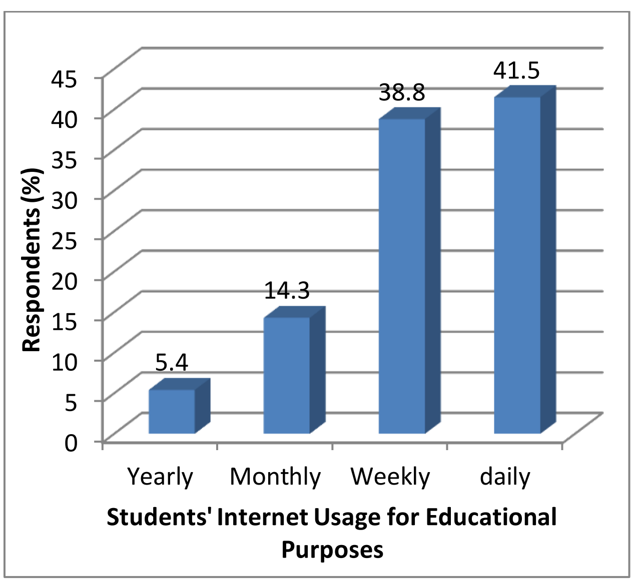


Fig. 7: Respondents Frequency of Internet Usage

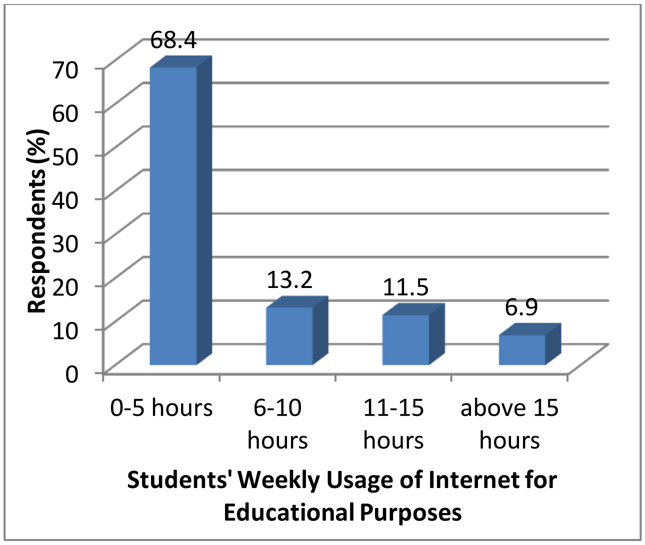


Fig. 8: Respondents According to Weekly Internet Usage

From the analysis, the students accord high level of importance to integration of internet into engineering education. This was deduced from responses as 76.3% agreed that the integration was important. This implies that the rate of inclusion of internet into engineering education is highly significant.

Also, 41.5% of the students access internet daily but 68.4% of the students access the internet for less than 5hours weekly; this represents larger percentages of the respondents. This is in agreement with early conclusions that the students depend less on internet for information gathering or other uses.

Table 1: Internet Topics

Internet Topics	**Great desire (frequency)**	**Great desire (%)**
1)Search data by index	155	**38.8**
2)Internet application	273	**63**
3)Search data by addresses	166	**41.5**
4)Chatting	134	**41.5**
5)E-mail	189	**44.9**
6)Games down load	116	**28.2**

7)Web browsing	282	**67**
8)Software Down Load	234	**54.3**
9)Designing web-based courses	187	**43.2**
10)Attending a course using internet and its applications in education	249	**56.7**

The results on table 1 show that the most important topics in ascending order were web browsing with 67% desire, internet application in checking relevant data in education with 63%, attending a course using internet and its application in education with 56.7% and software download with 54.3%. The rest of the percentages ranged from 44.49% for e-mail to 28.2% for electronic games downloading. These results indicate that although students wish to familiarize themselves with all the aspects of internet, effective web browsing was the most required part. Overall, these results indicate a strong desire among students to possess internet technology and use its applications in university education and in their public life. These results are in agreement with the studies of other researchers (Ghandoor, 1999) which empasizes the continous use of the internet techology for enhancement of ideas.

Table 2: Students' Attitude to Internet Usage

No	Students' Attitude to Internet Usage	Strongly Agree (frequency)	Strongly Agree (%)
1	Importance of internet as a source of information	176	39.6
2	Students dislike e-learning	69	15.8
3	These sites support reinforce the education process	178	40.6
4	Support positive effect of e-learning on the teaching environment	192	44.2
5	Access previous lecture notes on websites	134	30.2
6	Student do not favour the use of these sites	82	18.8
7	Students prefer to get the results of examination via websites	127	29

8	E-learning can totally substitute traditional learning.	106	24.5
9	Internet facilitate the learning process	152	34.4
10	Internet facilitate concept inventory	153	34.9
11	Students surf the internet for information	143	32.9
12	Technological advancements such as power point etc aids understanding	155	35.6
13	Special skills are not required in the use of the internet	112	25.7
14	Assisted learning internet sites are suitable for engineering courses	128	30
15	All universities present its courses via internet.	55	12.6

Table 2 presents result on the attitude of the students towards the use of e-learning as a substitute or partial substitute of the traditional learning. After careful review of the overall results in table 2, it was observed that the use of e-learning tools is important in two aspects. First, 44.2% of the students agreed that internet can serve as general informative resource that could impact positively on learning process while about 40.6% of the students believe that e-learning can act as a standalone teaching resource that would complement the traditional teaching methods. Finally most of the students believe that incorporating e-learning methods into the traditional system have a very positive effect on enhancing the outcome of the learning process on both technical depth and grades.

This indicates that student support the use of e- learning in the teaching process. However, the study results also shows that there is a negative aspect of e-learning as 15.8% of the students dislike it while 12.6% supports the presentation of courses via internet. This could be associated to lack of live interactivity between students and lecturers found in the real classrooms. Moreover, the students believe that some topics will require face to face dialogue which cannot be done by such kind of teaching method.

4.0 CONCLUSION.

This paper addressed the effect of integrating internet into the traditional teaching process along several aspects. The results of this study showed that there is necessity for using internet in all universities engineering’ faculties and students should be encouraged to use internet in order to enrich their learning outcomes and experience. The results also show that students are to be encouraged to use internet in engineering education and this should be done by the teacher and adopted as a university policy.

The authors believe that there is a great necessity to conduct more research related to internet usage that deal with other variables such as students academic and educational level and his/her culture in the field of internet, the relationship between students attitude toward using internet and their ability to use it.

APPENDIX

Study Questionnaire

1. **Introduction**

This questionnaire is designed to seek your opinion about the level of internet usage in the teaching and learning processes in the faculty of engineering. Any information provided will be treated confidentially and will be used for the purpose of recommending to relevant authorities after the completion of the study.

2. **General Information**

i. **Department**: [ ] Agric. [ ] Chem. [ ] Civil [ ] Elect. [ ] Mech. [ ] Met & Mat [ ] Wat. Res.
ii. **Level**: [ ] 100 [ ] 200 [ ] 300 [ ] 400 [ ] 500
iii. **Sex**: [ ] male [ ] female
iv. **Internet and Computer usage experience**: [ ] 0-2 years [ ] 2-5 years [ ] > 5 years.

3. **The level of internet and computer usage in university education and its variety.**

Your level of internet and computer usage in general [ ] Low [ ] Moderate [ ] High

4. **The degree of using internet in university education**

i. The importance of using internet in university education from your point of view:

[ ] Important [ ] Moderate [ ] Low [ ] Very low

ii. The degree of importance you accord to usage of internet for educational purposes.

[ ] Important [ ] Moderate [ ] Low [ ] Very low

iii. The number of times of your usage of internet for educational purposes.

[ ] yearly [ ] monthly [ ] weekly [ ] daily

iv. The number of hours of your usage of internet for educational purposes weekly:

[ ] < 5 hours [ ] 6-10 hours [ ] 11-15 hours [ ] >15 hours.

5. **The Internet Topics in which you desire to develop your knowledge (thick appropriately and as many sub-topics as required)**

No	Sub Topic	Great desire	Medium desire	Little desire	No desire
1	Search data by index				
2	Internet application in learning				
3	Search data by addresses				
4	Chatting				
5	E-mail				

6	Games Down Load
7	Web browsing
8	Software Down Load
9	Designing web-based courses
10	Attending a course in using internet and its applications in education

6. How do you feel about using internet in the learning process? (thick appropriately for ALL the sub-topics as required)

No	Sub Topic	Great desire	Strongly Agree	Agree	I don't know	Disagree	Strongly Disagree
1	Students consider the sites on internet as sources of information.						
2	Students hate e-learning because they cannot communicate directly with professors across these sites.						
3	Students believes that these sites support and reinforce the education process						
4	The use of these sites have impacted positively on my academic achievement.						
5	Students can access previous lectures notes or lecture content on the website of the course.						
6	Students do not favour the use of these sites for lack of the spirit of participation in the classroom.						
7	Students prefer to get the results of my examination via websites.						
8	Students use e-learning sites for the purposes of interaction with students.						
9	Students believe that interaction between each other across these sites facilitate the learning process						

	from their colleagues
10	Students feel that these sites encourage them and discuss ideas and concepts related to the courses.
11	Students use internet regularly to find information related to their lessons
12	Latest technological advancements such as (power point) are used in regularly engineering education as an aid in understanding the content of the course.
13	You believe that the use of these sites does not require the possession of special computer skills.
14	Students think that assisted learning Internet sites suitable for all engineering courses.
15	All universities present its courses via internet.

Please, give your view and recommendations on internet usage in this faculty.

INVESTIGATION ON THE EFFECTS OF AGRICULTURAL TRACTOR WHEEL (TYRE) INFLATION PRESSURE ON THE SOIL COMPACTION

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ABSTRACT

The impact of soil compaction from the wheel traffic of agricultural machines contributes to gradual alteration of soil properties which could reduce soil productivity and plant growth. Soil properties include soil type/texture, structure, porosity, soil bulk density, soil strength, mechanical impedance, and hydraulic properties (infiltration rate and hydraulic conductivity). These properties have an important influence on plant growth and development as they determine the ease of root penetration, water availability and gaseous exchange in the soil. This study investigates the effect of agricultural tyre inflation pressure on the soil compaction in the Agricultural Engineering Departmental Research Farm, Bayero University, Kano. The result obtained showed the mean values of soil moisture content were 19.3%, 21.2% and 20.6% at the depth of 0-15 cm from the soil surface and 16.4%, 17.6% and 18.6% at the depth 15-30 cm in the block A, B and C, respectively. Mean values of bulk density dry basis obtained were 1.55 g/cm^3, 1.54 g/cm^3 and 1.57 g/cm^3 at the depth of 0-15 cm from the soil surface and 1.76 g/cm^3, 1.83 g/cm^3 and 1.81 g/cm^3 at the depth of 15-30 cm in the block A, B and C, respectively. Results show that soil physical properties (soil bulk density, soil moisture content) increase as the agricultural tractor tyre inflation pressure increases. To reduce the problem of soil compaction, the tyre inflation pressure should be ranging between 50 and 100 kPa.

Keywords: Agricultural tractor, wheel, inflation pressure, soil compaction

1.0 INTRODUCTION

Soil compaction is a worldwide problem, especially with the adaption of mechanized agriculture. Soil compaction refers to the packing effect of a mechanical force on the soil. This packing effect decreases the volume occupied by pores and increases the density and strength of the soil mass. Bulk density and water infiltration are the indices of soil compaction Introduction of agricultural mechanization could result in soil compaction and cause soil degradation. This could be a serious problem in the future due to increase in size, weight and transportation frequency of machines used.

The introduction of agricultural mechanization has increased land to labour ratio in crop production, however machinery used in the field could have negative effects on the soil properties and hence crop productivity especially with the use of heavy machinery.

The effect of soil compaction cannot be over emphasized because many researchers have come up with various reports on how soil compaction affected the root development and yield of several crops adversely (Bekker, 1969; Hamza and Anderson, 2005). Andrian *et al.*, (2005) reported that even though the top soil is being relieved during tillage operation, the sub soil is correspondingly being compacted. Accordingly, inflation pressure has been set at the manufacturer's recommendation for the actual load on the tyre, which is the minimum acceptable inflation pressure for that load. Hamza and Anderson (2005) found that compaction induced by vehicle traffic has adverse effects on soil properties such as bulk density, soil strength, mechanical impedance, porosity and hydraulic properties (infiltration rate and hydraulic conductivity). Botto *et al.*, (2005) reported that the tractor drive wheel could support about 10 kN when the tyre inflation pressure is set at 138 kPa, however Burt *et al.*, (1983) reported that the best tyre inflation pressure suitable for tillage practices in Nigeria is 140 kPa but the tractor operators have been working below these pressures and the pressures that have been observed are as noted in this study. It was discovered that using the tractor at the tyre inflation pressure of about 100 kPa may be allowed depending on the soil type. However for effective tillage operation with minimum damage to the soil, tyre and implement, the operators should not operate the tractors below tyre inflation pressure of 100 kPa (Burt and Bailey, 1982). Inflation pressure determines tyre stiffness, which has a significant influence on the ground contact area of the tyre and the pressure distribution over the contact surface. Adjusting tyre inflation pressure has been used as a means of reducing soil compaction and improving the tractive performance of agricultural tractors (Boydas and Turgut, 2007). Bailey *et al.*, (1996) reported that at a tyre inflation pressure of 165 kPa, the tractive performance was poorest and quality of tillage operation was very poor. It was further reported that the soil bulk density increases with increase in soil compaction which invariably decreases the pore spaces in the soil. Burt *et al.*, (1983) also reported that most tyre inflation pressure specified for agricultural tractor tyre are not adhered to, thus the continual need to investigate the effect of tractor tyre inflation pressure on soil compaction. The effect of reducing the inflation pressure should be investigated further. For farmers and contractors, this is the easiest and cheapest way to reduce contact area pressure underneath the tyre. Bailey *et al.*, (1996) also reported an increase of contact area due to a reduction of the inflation pressure. The reduction of the contact pressure underneath the tyre achieved by reducing the inflation pressure has not been satisfactorily quantified so far. Different types of tyres reduce contact pressure and deformation differently as a result of decreasing inflation pressure. The study of deformations induced by inflation pressure could possibly lead to an improved tyre construction. Effects of inflation pressure on ground contact pressure, pressure beneath the tyre as well tractive efficiency, particularly for radial tyres, have recently been considered by many researchers (Eghball *et al.*, 1993; Bailey, 1996; Jun, 2004). The severity and the extent of soil compaction resulting from agricultural implement in Agricultural Engineering Departmental Research Farm has not been researched. Therefore, the objective of this study was to investigate the severity and effect agricultural tractor tyre inflation pressures on soil compaction on some soil properties.

2.0 MATERIALS AND METHODS

2.1 Experimental site

The experiment was conducted at the Agricultural Engineering Departmental Research Farm of Bayero University Kano.

2.2 Experimental procedure

The agricultural tractor used in this study was a 63.4 kW John Deere 6405 tractor (PTO power 51 kW). It has static weight distribution of 40% front and 60% rear with total mass of 3891 kg and 180 kg balancer (6×30 kg).The front tyres were radial 12.4-24 single operated at 220 kPa inflation pressure and the rear tyres were radial 18.4-34 single operated at 160 kPa inflation pressure and actual speed of 8 km hr^{-1}. The experiments were conducted during the May – June, 2013. Soil samples were collected at the depth of 0-30 cm to determine soil type/texture, soil moisture content, soil bulk density, soil porosity. The experimental site prior to this study was tilled and re-tilled before each experiment and the soil condition was assumed to be the same for all tests. Five different tyre inflation pressures (pi) of 50 kPa, 100 kPa, 150 kPa, 200 kPa and 250 kPa were selected for the experiment. Firstly all the tyres of the tractor were inflated up to 250 kPa. After the experiment at 250 kPa inflation pressure was performed, then tyre inflation pressure was reduced to 200 kPa, 150 kPa, 100 kPa, and 50 kPa. Each test was replicated three times.

2.3 Determination of Soil moisture content

The soil moisture content test is usually carried out in the laboratory by oven drying method. The moisture content (θ_w) of a soil sample is equal to the percentage ratio between the sample wet mass and dry mass (Cassel et al., 1995). The weight of water in a soil sample that was oven dried is the difference between the weight before drying and the weight of solids measured after drying. The water content (θ_w) of a soil expressed as a decimal or percent is defined from the equation below:

$$\theta_W = \frac{W_a - W_b}{W_b - W_r} \times 100 = \frac{W_w}{W_s} \times 100 \qquad (1)$$

where, θ_W is the water content on percentage; W_a is the weight of the soil and core ring before oven-drying (g); W_b is the weight of the soil and core ring after oven-drying (g); W_r is the weight of the core ring (g); W_w is the weight of water (g); W_s is the weight of solids (g).

2.4 Determination of Soil bulk density

Five undisturbed soil samples per four replicates treatments were randomly collected from (0–15 cm, and 15-30 cm) layers of the soil for laboratory determination, using 50 mm × 54 mm cylindrical cores then it was dried at 105℃ for 24 hours after the tillage. Bulk density is the ratio of a mass of dry soil (oven-dried at 105°C to constant weight) to its total volume. Soil bulk density was calculated by using the following Equation 1 below as reported by Cassel et al., (1995):

$$Bd = \frac{W_{dry}}{V} \qquad (2)$$

where, Bd is soil bulk density (dry basis), g/cm^3; W_{dry} is the weight of the dried soil sample, g; V is the total volume of the soil sample, cm^3.

2.5 Determination of Soil porosity

Soil porosity was derived mathematically from bulk density and particle density (Cassel et al., 1995).

$$e = 1 - \frac{\rho_b}{\rho_P} \qquad (3)$$

where, e is the porosity of the soil; ρ_b is the bulk density in g cm^{-3}; ρ_p is the particle density for most mineral soils equal to 2.56 g cm^{-3}.

2.6 Determination of Mean Weight Diameter (MWD)

Aggregate stability is expressed as the percentage of aggregates remaining larger than 0.2 mm. (Cassel et al., 1995). Aggregate size distribution after dry sieving can be expressed as a single empirical unit called mean weight diameter (MWD). Larger values of MWD denote higher proportions of larger aggregates in the soil sample. According to Cassel et al., (1995) the soil was sieved into the fractions > 64, 32, 16, 8, 4 and <4 mm, and 8.0, 4.76, 2.83, 2.0, 1.0, 0.5 and 0.3 mm in diameter respectively.

$$MWD = \frac{1}{W_t}\sum_{i=1}^{n} \bar{X}_i W_i \qquad (4)$$

where, MWD is a mean weight diameter in dry or wet basis; W_i is the weight of each size fraction in kg; W_t is the total weight of soil sample in kg; $\bar{X}_i$ is the mean diameter of each aggregate size fraction, cm.

2.7 Determination of Stress and strain of soil

Soil shear strength is the maximum resistance offered by soil to shearing stresses. The strength of a soil is often determined by its ability to withstand shearing stresses. Based on the Coulomb equation the soil shearing resistance is calculated from cohesive and frictional forces (Mc Kyes and Fan, 1985);

$$\tau = c + \sigma_n \tan\varphi \qquad (5)$$

where, τ is soil shearing resistance (kPa), σ_n is the normal stress on the shear plane (Pa), φ is soil friction angle (degrees), c is the cohesion (kPa).

3.0 RESULTS AND DISCUSSION

The experimental site's soil consisted of 90 % sand, 4 % Silt and 6 % clay by weight, this shows that soil textural class of loamy-sand. The result showed the obtained mean values of soil moisture content were 19.3%, 21.2% and 20.6% at the depth of 0-15 cm from the soil surface and 16.4%, 17.6% and 18.6% at the depth 15-30 cm in the block A, B and C, respectively. Mean values of bulk density dry basis obtained were 1.55 g/cm^3, 1.54 g/cm^3 and 1.57 g/cm^3 at the depth of 0-15 cm from the soil surface and 1.76 g/cm^3, 1.83 g/cm^3 and 1.81 g/cm^3 at the depth of 15-30 cm in the block A, B and C, respectively (Table 1).

Table 1 – Mean values of some soil properties of the experimental site before the experiment

Parameters	Block A		Block B		Block C	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Soil moisture content (%)	19.3	16.4	21.2	17.6	20.6	18.6
Soil bulk density (dry basis) (g cm^{-3})	1.55	1.76	1.54	1.83	1.57	1.81
Soil penetration resistance (N cm^{-2})	320		300		310	
Maximum shear stress (kN m^{-2})	40.16		38.75		35.25	

Table 2 – Mean values of some soil properties of the experimental site after the experiment in Block A

Parameters	**Block A**									
	0-15 cm					**15-30 cm**				
	Tyre pressure (kPa)					**Tyre pressure (kPa)**				
	50	**100**	**150**	**200**	**250**	**50**	**100**	**150**	**200**	**250**
Soil Moisture Content (%)	1.62	18.5	19.1	19.8	20.2	16.6	17.8	18.7	19.4	19.9
Soil bulk density (dry basis) (g cm^{-3})	0.95	1.55	1.62	1.69	1.76	0.89	0.99	1.10	1.16	1.19
+Soil porosity (%)	61.5	58.7	56.2	53.1	52.9	64.4	62.8	60.2	58.1	56.7
Soil penetration resistance (N cm^{-2})	299	310	315	320	322	291	307	311	318	320

Table 3 – Mean values of some soil properties of the experimental site after the experiment in Block B

Parameters	**Block B**									
	0-15 cm					**15-30 cm**				
	Tyre pressure (kPa)					**Tyre pressure (kPa)**				
	50	**100**	**150**	**200**	**250**	**50**	**100**	**150**	**200**	**250**

Soil Moisture Content (%)	1.64	17.9	18.4	20.8	21.1	16.9	17.1	18.2	19.1	20.2
Soil bulk density (dry basis) (g cm^{-3})	0.97	1.52	1.69	1.73	1.79	0.90	0.98	1.12	1.15	1.17
Soil porosity (%)	62.1	59.6	55.7	54.5	53.8	65.9	63.6	59.9	57.3	55.2
Soil penetration resistance (N cm^{-2})	295	312	317	319	321	293	310	312	319	322

Table 4 – Mean values of some soil properties of the experimental site after the experiment in Block C

Parameters	**Block C**									
	0-15 cm					**15-30 cm**				
	Tyre pressure (kPa)					**Tyre pressure (kPa)**				
	50	**100**	**150**	**200**	**250**	**50**	**100**	**150**	**200**	**250**
Soil Moisture Content (%)	1.61	18.2	19.7	20.3	20.9	16.1	17.1	18.2	19.1	19.7
Soil bulk density (dry basis) (g cm^{-3})	0.90	1.51	1.59	1.70	1.72	0.82	0.95	1.10	1.14	1.16
Soil porosity (%)	63.1	59.2	58.1	54.7	53.0	63.1	62.2	60.1	58.9	56.9
Soil penetration resistance (N cm^{-2})	292	308	310	318	320	296	302	309	320	321

During the study, it was observed that the soil properties that were used to describe the soil, increases with increasing in the tyre inflation pressure. The results showed that the mean soil bulk density dry basis increased and the porosity decreased. Also the mean soil bulk density decreased with increasing soil depth, but porosity and available water increased with soil depth (Tables 2-4). Also, it was observed that the higher the tyre inflation pressure, the lower the soil contact area of the tyre thus the higher the soil penetration resistance. This could be due to the fact that when area of pressure distribution is small, as such, the tyre pressure is acting on a small area thereby increasing the point pressure on the soil. Therefore, the contact area of the

driving wheel is a function of the tyre inflation pressure and this further affected the soil compaction, the soil cone index, bulk density and soil shear strength. It was further observed that the mean soil bulk density increases with increase in soil compaction which invariably decreases the pore spaces (porosity) in the soil. The results agree with those of Meek *et al.,* (1992) who reported an increase in soil bulk density from 1.67-1.92 t m^{-3} with a tyre pressure of 408 kPa and wheel weight of 2724 kg at moisture contents near field capacity. Similar results were also reported by Cassel *et al.,* (1995) who found an increase in soil bulk density for tracked inter-row areas of a controlled traffic area. Boydas and Turgut (2007) in their study also showed that values of bulk density of soil increased with increasing level of compaction by 8 and 10 tons of farm machinery which is in agreement with this study.

4.0 CONCLUSION

4.1 Conclusion

The following conclusions were drawn from the study;

i. It was observed that the soil properties that were used to describe the soil, increases with increasing in the tyre inflation pressure.
ii. It was further observed that the mean soil bulk density increases with increase in soil compaction which invariably decreases the pore spaces (porosity) in the soil.

REFERENCE

Andrian, A., Thomas, A. T., Richard, E. M., Harry, W. A., and Barry, L. F. (2005). Ground-based forest harvesting effects on soil physical properties and douglas-fir growth. *Soil Science Society of American Journal, 69,* 1822-1832.

Bailey, A. C., Raper, R. L., Way, T. R., Burt, E. C., and Johnson, C. E. (1996). Soil stresses under a tractor tire at various loads and inflation pressures. *Journal of Terramechanics, 33*, 1-11.

Bekker, M. G. (Ed.). (1969). *Introduction to Terrain-Vehicle Systems*. USA: The University of Michigan Press.

Botto, G. F., Jorajuria, D., and Graghi, L. M. (2005). Influence of the axle load, tyre size and configuration on the compaction of a freshly tilled clayey soil. *Journal of Terramechanics, 21*, 15-22.

Boydas, M. G., and Turgut, N. (2007). Effect of tillage implements and operating speeds on soil physical properties and wheat emergence. *Turkish Journal of Agriculture and Forestry, 31*, 399-412.

Burt, E. C., and Bailey, A. C. (1982). Load and inflation pressure effects on tires. *Transaction of American Society of Agricultural Engineers, 25*, 881-884.

Burt, E. C., Lyne, P. W., Meiring, P., and Keen, J. F. (1983). Ballast and inflation effects on tire efficiency. *Transaction of American Society of Agricultural Engineers, 26*, 1352-1354.

Cassel, D. K., Razkowski, C. W., and Denton, H. P. (1995). Tillage effects on corn production and soil physical properties. *Journal of Agricultural Science 59*, 1436-1443.

Eghball, B., Mielke, L. N., Calvo, G. A., and Wilhelm, W. W. (1993). Fractal description of soil fragmentation for various tillage methods and crop sequences. *Soil Science Society of American Journal, 57*, 1337-1341.

Hamza, M. A., and Anderson, W. K. (2005). Soil compaction in cropping system: A review of the nature, causes and possible solutions. *Soil Tillage Research, 82,* 121-145.

Jun, H., Way, T. R., Björn, L., Mats, L., Bailey, A. C., Burt, A. D., and McDonald, T. P. (2004). Dynamic load and inflation pressure effects on contact pressures of a forestry forwarder tire. *Journal of Terramechanics, 41*, 209-222.

Mc Kyes, E., and Fan, T. (1985). Multiplate penetration tests to determine soil stiffness moduli. *Journal of Terramechanics, 22*, 157-162.

Meek, B. D., Rechel, E. R., Carter, L. M., and DeTar, W. R. (1992). Bulk density of a sandy loam: Traffic, tillage, and irrigation-method Effects. *Soil Science Society of American Journal, 56*, 562-565.

ORGANIZATIONAL ASPECT OF WATER MANAGEMENT IN WATARI IRRIGATION PROJECT, KANO: PROBLEMS, CHALLENGES AND SOLUTIONS

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ABSTRACT

This study reviewed the organizational aspect of water management in Watari Irrigation Project (WIP) to identify the problems and challenges facing the scheme and to suggest a way out. Three approaches (Questionnaires, Reconnaissance survey and Verbal interviews) were adopted for this research. Some of the identified problems and challenges encroaching the scheme were; excessive conveyance losses in the canals (116 breaches per km), canals were silted up and infested with weeds (reduction in rate of flow), Farmers illegally break the main canal to siphon water into their farm plot considered non-irrigable area (27 breakages per km), farmers at upstream over-irrigate their plots (water logged and inadequate supply to farmers at downstream), Faulty water allocation system (continues flow allocation system), irrigating in the night (20% of farmers at downstream), some farmers at downstream abandoned their farming activities due to inadequate supply of water (4.5% of the total developed irrigable area = 48.3ha), absence of institutional regulations , misunderstandings between farmers and agency staff, group of farmers and another group of different blocks and between individual farmers, lack of participatory maintenance culture among farmers among others. In view of the above problems three major solutions were suggested; 1) Institutionalizing the project management through participatory irrigation management (Water users association-WUAs, Government-Agency and representatives of other bodies-traditional rulers, NGOs among others). 2) Appropriate water management strategy (Basic scheme data, Planning procedures, Budgeting procedures and Implementation). 3) Manpower development and training. Finally, the adopted water allocation system (continues flow allocation system) should be changed; rotation allocation system is recommended.

Keywords: Irrigation, Water Management, Problems, Solutions

1.0 INTRODUCTION

The success of any irrigation project depends to a large extent on the proper functioning of its water conveyance and distributions system. The water management office for WIP is responsible for the release of water from the Dam through its primary, secondary, and tertiary conveyance systems. The fundamental objective of any irrigation system is to control water in such a way that it increases agricultural production (Sarojini et al., 2012). Water releases have to be such that all farmers are assured to receive sufficient supplies of irrigation water and water losses and waste should be kept to a minimum (Haskoning, 1995). Proper functioning of an irrigation scheme is essentially identified with proper operation of the system to ensure reliable and equitable distribution of irrigation water among water users. The conveyance of water with minimum losses at all irrigation levels; primary, secondary and tertiary (Kazaure, 2003). Decision must be made at all levels as to the optimum distribution of the irrigation water supply. At primary level water must be conveyed from storage (reservoir) via the main canal (MC), at secondary level water is diverted from sector turnout (STO) via distributary canals (DCs) and at tertiary level water is diverted from field turnout (FTO) via field channels (FCs) and distributed to various farms. Finally, at on-farm level the farmer has to decide how to distribute the water over the farm plot (Kazaure, 2003).

This paper focus on the organizational aspect of water management in watari irrigation project and to come up with clear picture of what are the current situation, challenges and to suggest the way forward.

2.0 MATERIALS AND METHODS

2.1 Project Description

WIP is located in Bagwai Local Government Kano State, Nigeria. The project is situated along Bichi to Gwarzo road north-western part of Kano about 50 km from Kano city. It is located within latitude of $12^{o}6'$ – $12^{o}10'$N, and longitude 8^{o} 09' - 8^{0} 16'E and an approximate elevation of 490m in a valley of the Watari River, a tributary of Challawa River which is also a tributary of Kano River (Karaye, 2002). The project was initiated and constructed from 1987 to 1991 by Kano State Water Resources and Engineering Agency (WRECA) under Kano State Ministry of Agricultural and Natural Resources, sponsored by Kano State Government. The project was handed over to Kano State Agricultural and Rural Development Authority (KNARDA) by Ministry of Agricultural and Natural Resources in 1991. WIP has an area of 4,575ha of which only 2,601ha is suitable for irrigation out of which 1073ha has been developed. The project developed area is intersected by eight tributaries which created major obstacles for the construction of the irrigation main canal. Therefore, the main canal was crossed over the tributaries through inverted siphons and bridges (Hasconing, 1991).

WIP is located in the Sudan savannah belt of Northern Nigeria, and has three distinct seasons; the cool dry season from October to February, the hot dry season from March to May and the worm rainy season from June to September inclusive. The meteorological data obtained from the area indicated an average maximum temperature of 38.2 ^{0}C and an average minimum temperature of 14 ^{0}C. It has an average relative humidity of 74.5 % during wet season, and 33.5 % for the dry season. It also has an average annual rainfall of 813 mm and an average monthly precipitation of 66.5 mm during the worm-wet season (Haskoning, 1991). Figure 1 shows general layout of watari irrigation project.

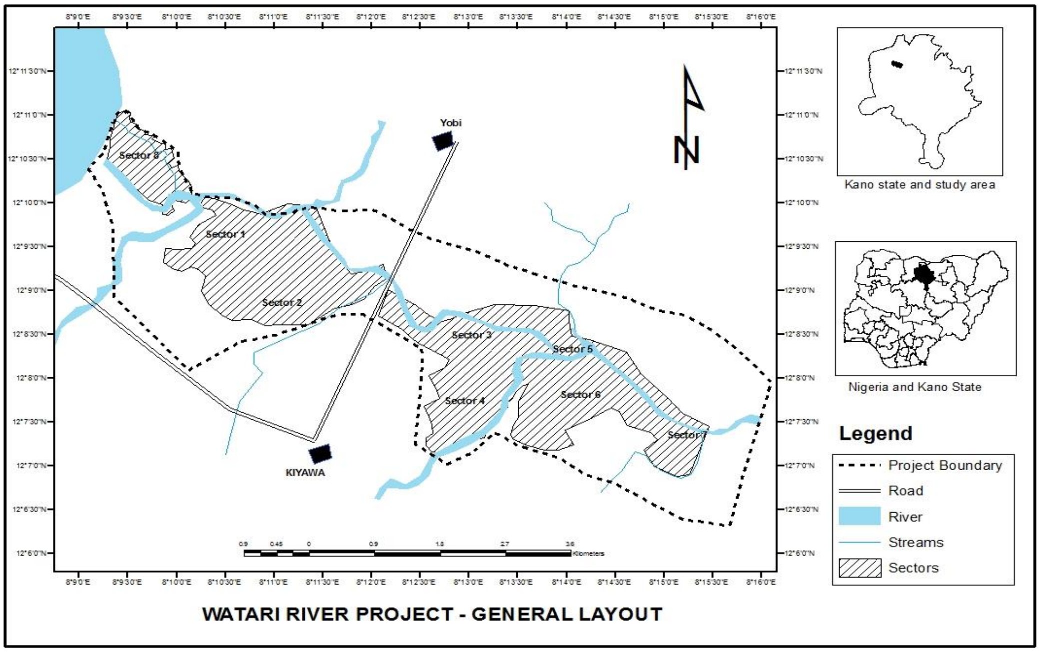

Figure .1: Watari Irrigation Project General Layout

2.2 Hydraulic System of WIP

2.2.1 Water storage (Dam)

The project has a dam located upstream, which serves as the source of irrigation water. The Dam has a total design storage capacity of 105.1 million m^3, it has active storage capacity of 93 million m^3, and the reservoir surface area is 1,959 ha. It has a drainage catchment area of 653 km^2 with an outlet at the southern part of the dam of 1m-diameter orifice in which water flow into the main canal. The southern reservoir outlet comprises of hydraulic system (Howell Bunger Valve) which is used to control the amount of irrigation water to be applied (Haskoning, 1991).

2.2.2 Primary level (Main Canal)

The main canal is initially 12 km long with distributaries canals branching out to convey water to four sectors (sector 1; 159 ha, 2; 168 ha, 3; 216 ha and 4; 72 ha). There is also a northern reservoir outlet supplying irrigation water to sector 8; (72 ha) using a distributary canal of about 0.8 km. There is also an overlapped area of 112.5 ha. Shanono et al., (2012) reported that in 2010 the main canal was increased by 4 km and sector 5; (273 ha) was developed making main canal to be 16 km and six sectors out of eight sectors and 1,072.5 ha out of 2691 ha that are initially intended to be developed. Surface irrigation method is practiced in the developed area. Irrigation season at WIP last for about 16 weeks between (January – May) and categorized into three stages. Early stage, middle stage and late stage with water releases from release gate of 40, 80 and 60% respectively (Haskoning, 1991).

2.2.3 Secondary level (Distributaries canals)

The main canal is branches to distributaries canals through sector turnouts (STOs) diverting irrigation water to various sectors. The system has two night storage reservoirs located at sector 1 and 3 which are opened to collect and store the irrigation water at night from DC1 and DC3 for use by the farmers in the daytime. The irrigation water is slowly released at the beginning of the irrigation season because most of the farmers are yet to prepare their plots for irrigation. At the middle of the irrigation, water is released at the highest peak, and at the end of the irrigation toward the start of the wet season the irrigation water is reduced gradually (Haskoning, 1991).

2.2.4 Tertiary level (Field channels)

Water is diverted from field turnout (FTO) via field channels (FCs) and distributed to various farms. Each field has its own field turn out structure (FTO) receiving water from the distribution canal and releasing into the field channel. Each farmer's plot receives water directly from the field channel by means of a plastic siphon (Haskoning, 1991).

2.3 Field Work

Three methods were adopted in order to investigate the present situation related to organizational aspect of water management at WIP.

2.3.1 Questionnaire

100 questionnaires were design and administered to farmers and agency staff to assess how irrigation water has been managed in the project area. This is to come up with clear picture of what is the current situation and the challenges facing the project area related to water management.

2.3.2 Reconnaissance survey

A reconnaissance survey was conducted, this was to observe the physical condition of the whole irrigation system, especially the hydraulic structures of the project area and manner at which the system was operated. Some of the things considered were percentage of release gate at different irrigation stage, condition of the main canal (MC), Sector turnout (STO), distributaries canal (DC), field channel turnout (FTO), field channels (FC) and type of water allocation (among water users) system adopted in the area among others.

2.3.3 Interview

Farmers and agency staff were also interviewed verbally, this was aimed at identifying their challenges in water management activities and to find out what contribution were they rendering to the successful operation, management and maintenance of the system. To identify weather water users associations (WUAs) are contributing to the betterment of the system, what is the relationship between project operators/managers, WUAs, and individual farmer and to find out any other challenge(s) hindering the successful system operation.

3.0 RESULTS AND DISCUSSION

3.1 Present Situation and challenges

The results obtained from all the three approaches (Questionnaire, Reconnaissance survey and Verbal interview) adopted in this study showed that, the system performance in terms of water management reduced drastically. The identified problems in WIP related to water management are the problems which often lead to unreliable and inequitable sharing of water among water users such as:-

i) Excessive conveyance losses in the canals as a result of breaches, which covers an average of 116 breaches per km.

ii) Improper maintenance of the canals, which resulted into heavy siltation and weed infestation which reduce their capacities and increase their retardance coefficient hence reduce the rate of flow in the canals.
iii) Farmers illegally break the main canal to siphon water into their farm plot considered non-irrigable area for an average 27 breakages per km.
iv) Ineffective and inefficient use of water by the farmers due to inappropriate on-farm water management. Most of the farmers at upstream over-irrigate their crops which consequently caused their farm plots to be water logged and on the other hand it affects the downstream farmers negatively.
v) The present adopted water allocation system (continues flow allocation system) is faulty which permitted the farmers at upstream to ignorantly misuses the irrigation water.
vi) The result of preliminary field survey shows that, about 20% of farmers at downstream irrigate their crop at night.
vii) About 30% (amount to 4.5% of the total developed irrigable area = 48.3 ha) of the farmers at downstream abandoned their farm activities due to inadequate supply of water as a result of inappropriate water allocation among water users. The most devastating aspect of it is that, the loss of irrigable land due to inadequate supply at downstream is continues at high rate.
viii) Absence of institutional regulation, most of the farmers misbehave and disregards other users.
ix) Farmers do not participated in the system maintenance. They always think that it is Government responsibility.

Generally, such problems causes poor system performance of irrigation infrastructure and improper system maintenance and operation.

3.2 Suggested Solutions

3.2.1 Institutionalizing the project management

Water management in an irrigation scheme is not an activity which is carried out in isolation, it requires holistic approach. Participatory irrigation management (PIM) must be put in place to overcome or reduced these problems and challenges. PIM is an institutionalized arrangement by establishing a formal mechanism for interaction between farmers (through WUAs), government (irrigation agency) and representatives of other bodies (traditional rulers, Agricultural extension, NGOs among others) viz. figure 3.1. The idea of PIM is aimed at enhancing capacity building or local empowerment of the irrigation users, it will also promote sustainable management of irrigation system.

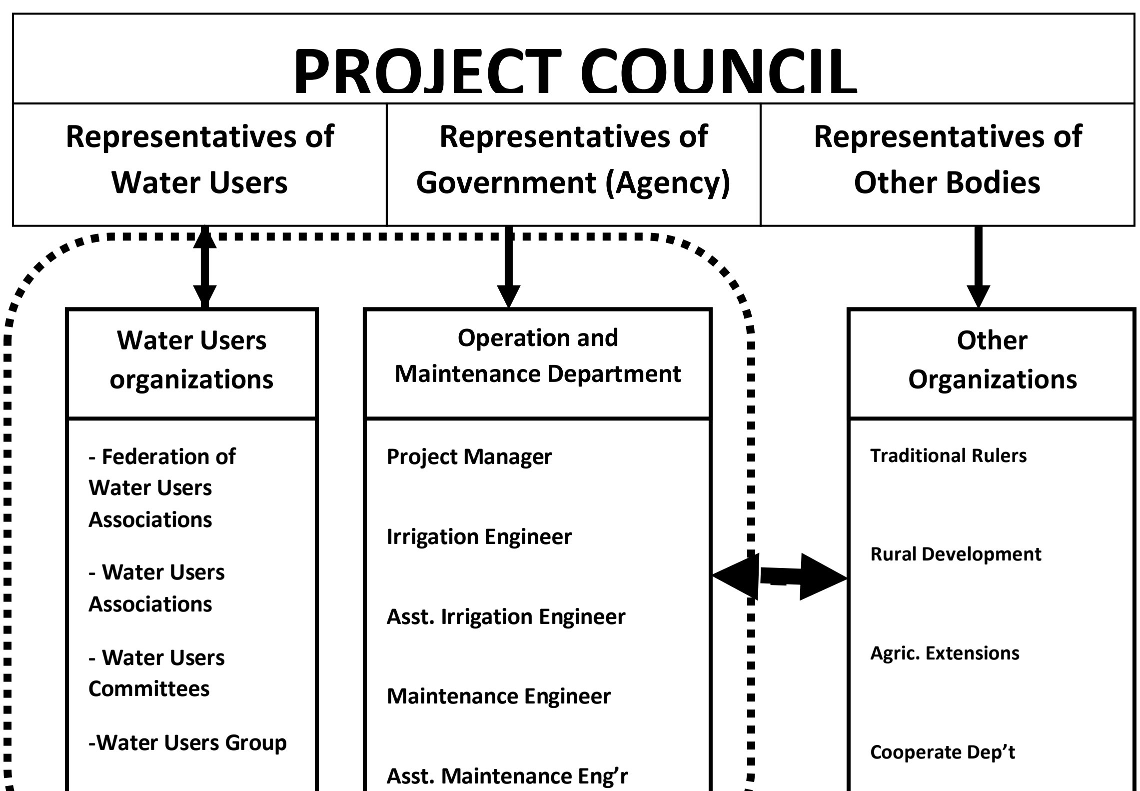

Figure 2: Institutional framework for water management

3.2.2 Appropriate water management strategy

The appropriate process of water management comprises of four items as presented in Figure 3.2

1 Basic scheme data

This is to have a basic scheme data which were known to be dynamic (changes with time) such as maps, hydrologic data, meteorological data, cropping pattern of each year, staffing among others.

2 Planning procedures

Having known the basic data, it will help in planning the operation and maintenance activities of the system.

3 Budgeting procedures

Based on the initial plans for maintenance and operation and all kind of information on record in the basic scheme data, the amount of water to be delivered to various sectors can be budgeted so as to achieve a fair share of irrigation water among water users.

4 Implementation

This is to implement the planned and budgeted distribution of irrigation water. Implementation includes the supervision and adjustment of the operation when the need arises.

<u>WATER MANAGEMENT</u>

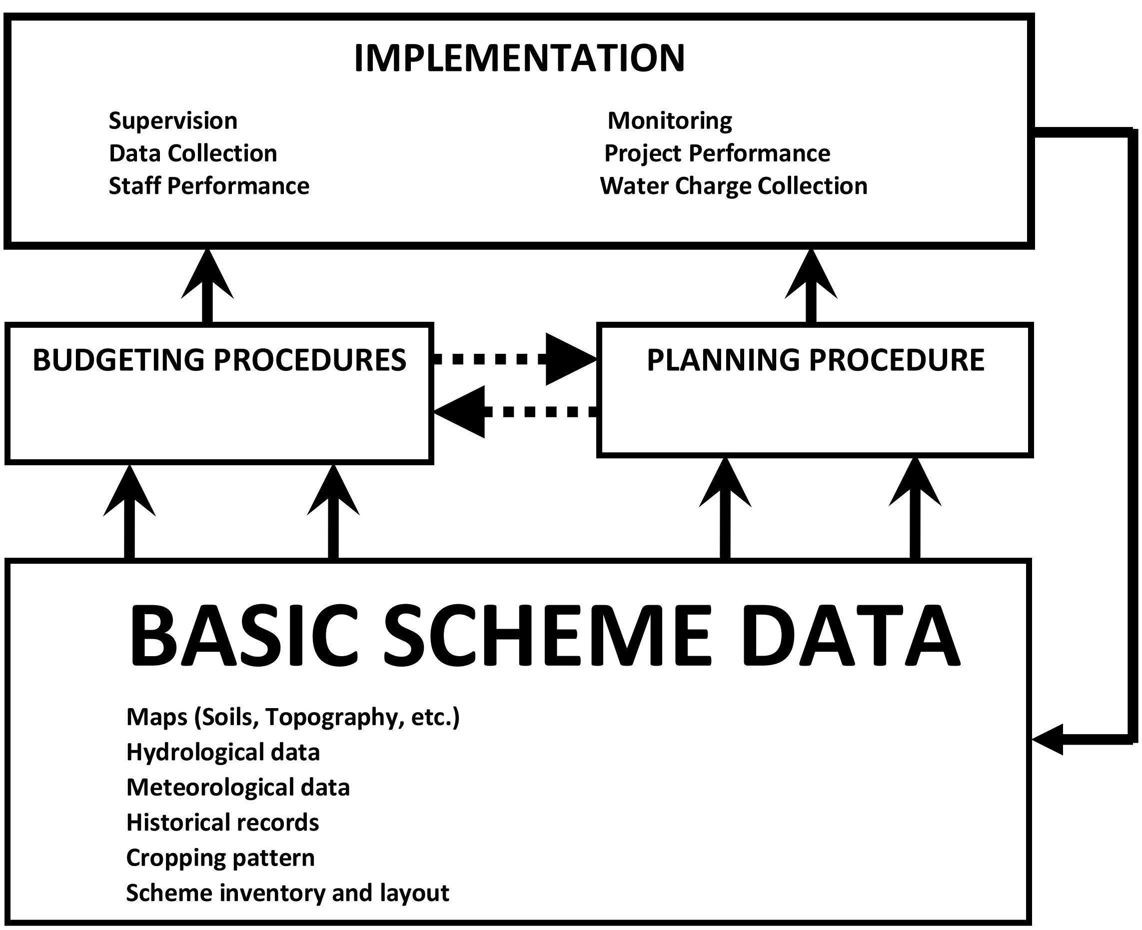

Figure3: Water Management strategy

3.2.3 Manpower development and training

There is need for manpower development and training, this is to identify the manpower requirements necessary for the management and operation of the project and the related training needs. Due to a widespread shortage of experience with gravity irrigation in the project area and within the agency. Continued training of staff and farmers is most important for the success of the scheme. The water management office should be responsible for the operation of the primary and secondary levels, while farmers should be train to take over the water management from field turnouts up to their respective farm plots. Each staff should know and perform his duties to the best of his capability. This will ensure division of responsibilities as shown in figure 3.3.

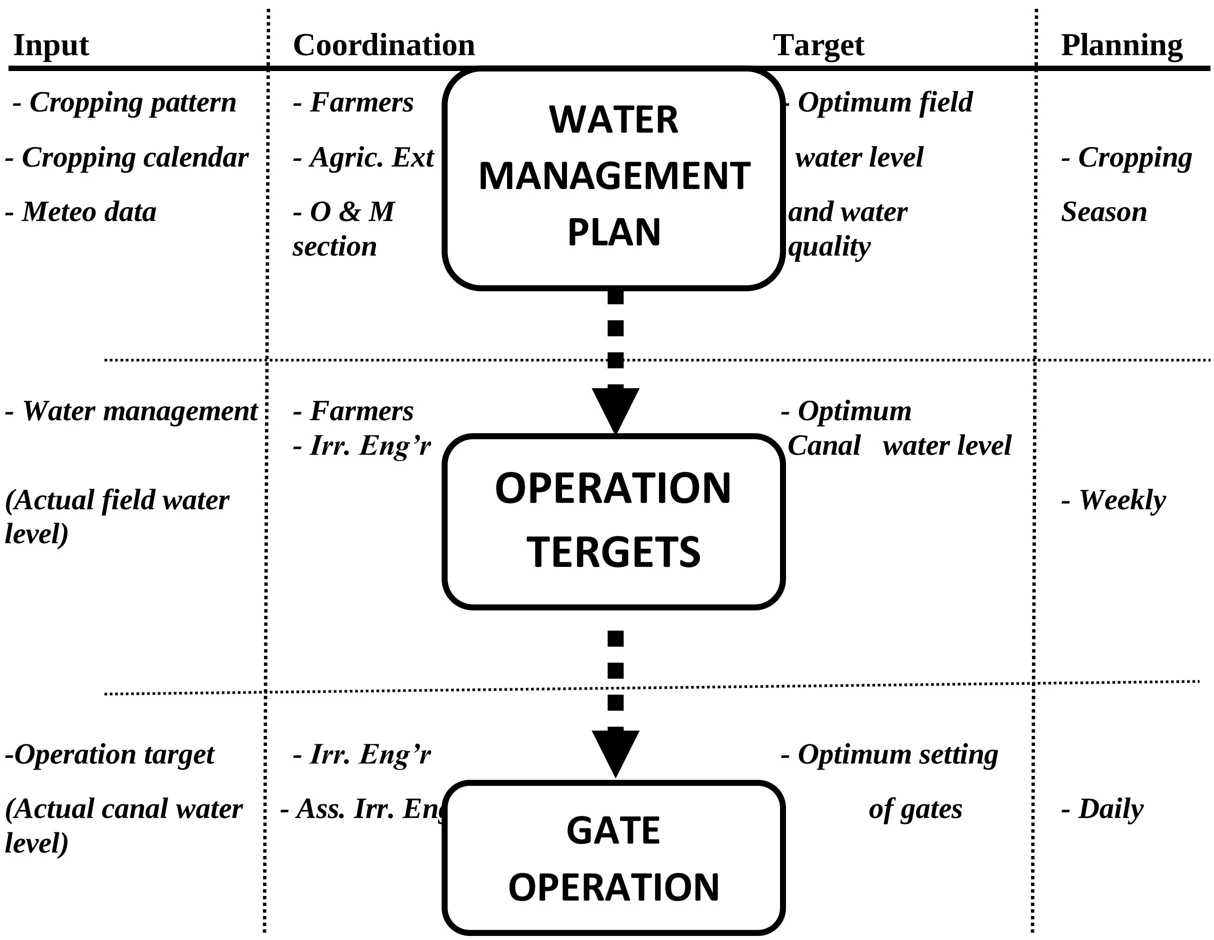

Figure 4: Operational planning

4.0 CONCLUSION

The study reviewed the organizational aspect of water management at WIP to identify the problems and challenges facing the scheme and to suggest a way out. Based on the results obtained there were existed problems and challenges hindering the success of water distribution among water users. Some of the identified problems and challenges attacking the scheme were conveyance losses, canals were silted up and infested with weeds, Farmers illegally break the main canal to siphon water into their farm plot considered non-irrigable area, farmers at upstream over-irrigate their plots, Faulty water allocation system, farmers at downstream abandoned their farming activities due to inadequate supply of water, absent of law and order, misunderstandings between farmers and agency staff, group of farmers and another group of different block and between individual farmers, lack of commitments from the farmers in maintenance of the system among others. Three major solutions were suggested; Institutionalization Project Management through Participatory irrigation management, Water Management strategy and Manpower Development and Training. Finally, the adopted water allocation system (continues flow allocation system) should be changed; rotation allocation system is recommended.

REFERENCES

Haskoning, (1991). Preliminary/Reconnaissance Survey, Haskoning Engineering Consultants (Nigeria) ltd in coorperation with Haskoning Royal Dutch Consulting Engineers and Architects. A feasibility study report.

Haskoning, (1995). Final Engineering Report. Haskoning Engineering Consultants (Nigeria) ltd in coorperation with Haskoning Royal Dutch Consulting Engineers and Architects. A feasibility study report.

Karaye, M. I. (2002). Evaluation of Soil Erosion in Watari Irrigation Project, Bagwai – Kano, Nigeria. A post graduate Diploma in Agricultural Engineering Thesis, Submitted to Department of Agricultural Engineering, University of Agriculture Makurdi-Nigeria.

Kazaure, Y.D. (2003). Participatory Irrigation Management: Lessons Learnt from Kano River Irrigation Project Phase I *Proceedings of International Seminar of Large and Small Scale Irrigation Schemes in Africa, 374-388 ICID Abuja Nigeria.*

Sarojini, B.D., M.V. Ranghaswami and C. Mayilswami (2012). Performance Evaluation of Water Delivery System in Canal Command Area of Pap Basin, Tamilnadu. India Water Week 2012 – Water, Energy and Food Security: Call for Solutions, 10-14 April 2012, New Delhi.

Shanono, N.J., M.K. Othman, N.M. Nasidi and H. Isma'il (2012). Evaluation of Soil and Water Quality of Watari Irrigation Project in Semi-Arid Region, Kano, Nigeria. Proceedings of the 33rd National Conference and Annual General Meeting of the Nigerian Institute of Agricultural Engineers (NIAE) Bauchi. pp. 181 – 186.

SELECTION OF ROTARY STEERABLE SYSTEM (RSS) FOR EXTENDED REACH DRILLING (ERD) USING ANALYTIC HIERARCHY PROCESS (AHP)

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ABSTRACT

Analytic Hierarchy Process (AHP) is a decision making algorithm developed in the 90s. It has many applications as documented in Decision Support System literature. This approach allows the decision makers to model a problem in a hierarchical structure showing the relationship of the goal, objectives (criteria), sub-objectives and alternatives. Decision making within the oil and gas industry is a complex process involving extensive analysis of multiple objectives based on diverse criteria variety. This paper proposes AHP as a tool used in selecting RSS for Extended Reach Drilling (ERD). Three different rotary steerable systems (RSS) (PowerDrivevorteX962, Geo-Pilot GXT and AutoTrack G3) were considered. The selection was based on the Tool Average Diameter; Flow rate range; Maximum torque; Max WOB; Maximum temperature; Sand content; Maximum rotary speed; MWD/LWD; Measurement accuracy; and Maximum DLS. The overall relative rating was found to be 0.24, 0.33 and 0.24. With (Geo-Pilot GXT) having 0.33 as the highest.

Key words: *AHP, ERD, RSS, Oil and Gas Drilling*

1.0 INTRODUCTION

A great deal of the world's undeveloped oil and gas resources are located in deep and ultra deep water, and pose a great challenge for future technology (Øyvind O. B., 2012). But it is a necessity to get a hold of these resources as the easily accessible fields are depleting while the world still demand larger amounts of these non renewable resources. In order to do so efficiently the industry must keep evolving and pushing available equipment to its limits to reach greater depths. Drilling in deep water is changing from mainly vertical wells, to highly deviated ones (ERD) as well. This might help increase recovery factor, but it will most certainly be more challenging. Drilling in this environment will push equipment to its absolute limits, increasing the possibilities for failure and leaving no room for error (Øyvind O. B., 2012). Decision making within the oil and gas industry is a complex process involving extensive analysis of multiple objectives based on diverse criteria variety. So the use of Multi Criteria Decision Making (MCDM) methods is required for making decisions that satisfy all the relevant criteria for all levels. Although numerous organizations in both the private and public sectors have already benefited from the use of AHP, there are far more organizations still unaware of a process such as AHP that is theoretically sound, understandable, and matches their expectations (Forman E.H et al. 2001).

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making approach and was introduced by Saaty (1994). The AHP has attracted the interest of many researchers mainly due to the nice mathematical properties of the method and the fact that the required input data are rather easy to obtain. The AHP is a decision support tool which can be used to solve complex decision problems. It uses a multi-level hierarchical structure of objectives, criteria, sub-criteria, sub-sub-criteria and alternatives. The pertinent data are derived by using a set of pair-wise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion.

1.1 An Overview of AHP

1.1.1 Foundation of AHP:

The foundation of the Analytic Hierarchy Process (AHP) is a set of axioms that carefully delimits the scope of the problem environment (Saaty 1986). It is based on the well-defined mathematical structure of consistent matrices and their associated right Eigen vector's ability to generate true or approximate weights (Saaty1980, 1994). The AHP methodology compares criteria, or alternatives with respect to a criterion, in a natural, pair-wise mode. To do so, the AHP uses a fundamental scale of absolute numbers (Table 1) that has been proven in practice and validated by physical and decision problem experiments. The fundamental scale has been shown to be a scale that captures individual preferences with respect to quantitative and qualitative attributes just as well or better than other scales (Saaty 1980, 1994). It converts individual preferences into ratio scale weights that can be combined into a linear additive weight w(a) for each alternative a. The resultant w(a) can be used to compare and rank the alternatives and, hence, assist the decision maker in making a choice. Given that the three basic steps are reasonable descriptors of how an individual comes naturally to resolving a multi-criteria decision problem, then the AHP can be considered to be both a descriptive and prescriptive model of decision making. The AHP is perhaps, the most widely used decision making approach in the world today. Its validity is based on the many hundreds (now thousands)of actual applications in which the AHP results were accepted and used by the cognizant decision makers (DMs), Saaty (1994b).

1.1.2 Principles of AHP:

Basic principles of AHP: decomposition, comparative judgments, and hierarchic composition or synthesis of priorities (Saaty 1994). The decomposition principle is applied to structure a complex problem into a hierarchy of clusters, sub-clusters and so on. The principle of comparative judgments is applied to construct pair-wise comparisons of all combinations of elements in a cluster with respect to the parent of the cluster. These pair-wise comparisons are used to derive 'local' priorities of the elements in a cluster with respect to their parent. The principle of hierarchic composition or synthesis is applied to multiply the local priorities of the elements in a cluster by the 'global' priority of the parent element, producing global priorities throughout the hierarchy and then adding the global priorities for the lowest level elements (usually the alternatives).

1.1.3 Extended Reach Drilling (ERD)

Extended Reach Drilling (ERD) is the key technology for enabling multi-well pad sites and thereby reducing what otherwise would be a larger number of individual well pads (Wells, G. 2011).

"The aim of ERD is either to reach a larger area from one surface drilling location, or to keep a well for a longer distance in a reservoir in order to maximize its productivity and drainage capability while at the same time reducing environmental footprints" (Agbaji, 2010). There are two common ways to technically describe what constitutes an ERD well. First, if the length of the departure is two times or more than that of the true vertical depth then it is considered to be an ERD. Second, it is considered ERD if the measured depth is a minimum of two times the true vertical depth. Advanced equipment for an ERD well may include wider diameter drill pipe, additional mud pumps, enhanced solids control, higher capacity top-drive motors, more generated power, and oil-based drilling fluids (Judzis et al. 1997).

1.1.4 Rotary steerable system (RSS)

RSS was first introduced in the late 1990s, and the technology continues to evolve. The impact of the technology to the drilling process has been recognized within the industry. Rotary Steerable System (RSS) is a tool that allows the driller to guide the drill bit in the right direction with the rotation of the drill string in parallel. The system is found a little bit behind the drill bit, and is designed to enhance or direct the BHA to the right direction. This control processes are usually pre- planned and monitored by a directional drilling Engineer in place for monitoring and adjusting the drilling process.

2.0 METHODOLOGY

Ten selection criteria were considered and grouped into B1-Technological, B2-Operational reliability and B3-Telemetry/ sensors group, as shown in Figure 1 and Table 2. Having defined the selection criteria, the next step is the pair-wise comparison of the importance of the criteria. This is done by assigning a weight between 1 (equal importance) and 9 (absolutely more important) to the more important criterion, and the reciprocal of this value is then assigned to the other criterion in the pair (Table 1). Each potential choice were then rated relative to each other choice on the basis of each selection criterion- this is achieved by performing pair-wise comparisons of the choices. The ratings derived in the steps above were combined to obtain an overall relative rating for each potential choice. The overall relative rating is calculated using equation 2.

Table 1: Scale of Relative Importance for criteria rating

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong Importance	Experience and judgment strongly favor one activity over another
7	Demonstrated Importance	An activity is strongly favored and its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals of above nonzero	If activity i has oneof the above nonzeronumbers assigned to itwhen compared withactivity j, then j has the reciprocal valuewhen compared with i.	

Sourcse: Saaty (1980)

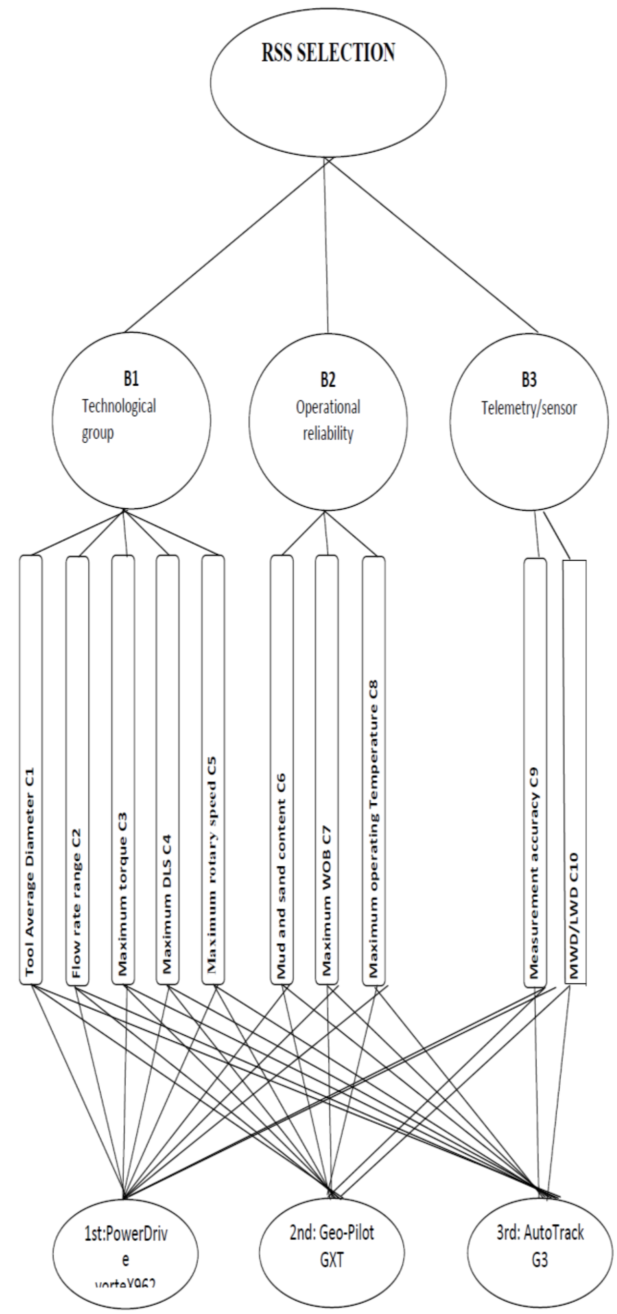

Fig. 1: Representation of Hierarchy

Table 2: AHP Steps and Levels in the selection of RSS

Level	**Process**
0 (Point A)-Objectives	Selection of RSS
1 Level(Bi)-Grouping the criteria	B1-Technological group B2-Operational reliability B3-Telemetry/ sensors
2 Level (C_i)-Grouping the sub-criteria	***Technological Group*** C1- Tool Average Diameter; C2- Flow rate range C3-MaximumTorque C4- Maximum SLD C5- Maximum Rotary Speed ***Operational reliability Group*** C6- Sand Content C7- Maximum WOB C8- Maximum Temperature ***Telemetry Group***

	C9- Measurement Accuracy C10- MWD/LWD
3 (Di)- Alternatives	D1, D2, D3 - Types of RSS

3.0 RESULTS AND DISCUSSION

The results obtained are presented in the Tables below. Table 3 illustrates the results obtained from Pair-wise comparison matrix of criteria, while Tables 3.1, 3.2 and 3.3 reveals the results obtained from the Pair-wise comparison matrices for Technological group, Reliability group and Telemetry group respectively. Similarly, Tables 4.1C1- 4.10C10 presents the matrices for each criterion. From the results it can be seen that the extent to which the groups and sub-groups satisfy the criteria are weighted according to the relative importance of the criteria.

Table 3: Pair-wise comparison matrix of criteria:

A	AB1	AB2	AB3	Σ=	Vi
AB1	1.00	3.00	2.00	6.00	0.43
AB2	0.33	1.00	0.20	1.53	0.11
AB3	0.50	5.00	1.00	6.50	0.46
				14.03	

Where Vi – "Relative Weight" of specific criteria.

Consistency Index (CI):

$CI = \frac{\lambda_{max} - n}{n-1}$, where n – size of matrix;
λ_{Max} – maximum Eigen value.

λ_{max}=(1+0.33+0.50)·0.43+(3+1+5.00)·0.11+(2+0.2+1.00)·0.46=3.25

Then: $CI = \frac{3,25-3}{3-1} = 0.12$

Table 3.1: Pair-wise comparison matrix for Technological group:

B	B1C1	B1C2	B1C3	B1C4	B1C5	Σ=	Vi
B1C1	100	2.00	3.00	2.00	1.00	9.00	0.30
B1C2	0.50	1.00	3.00	2.00	1.00	7.50	0.25
B1C3	0.33	0.33	1.00	2.00	1.00	4.67	0.16
B1C4	0.50	0.50	0.50	1.00	1.00	3.50	0.12
B1C5	1.00	1.00	1.00	1.00	1.00	5.00	0.17
						29.67	

$\lambda_{\text{мах}}$=5.36; $CI = \frac{5{,}36-5}{5-1} = 0.09.$

Table 3.2: Pair-wise comparison matrix for Reliability group:

B	B2C6	B2C7	B2C8	Σ=	Vi
B2C6	1.00	2.00	3.00	6.00	0.55
B2C7	0.50	1.00	1.00	2.50	0.23
B2C8	0.33	1.00	1.00	2.33	0.22
				10.83	

λ_{Max}=3.02; $CI = \frac{3{,}02-3}{3-1} = 0.01$

Table 3.3: Pair-wise comparison matrix for Telemetry group:

B	B3C9	B3C10	Σ=	Vi
B3C9	1.00	1.00	2.00	0.50
B3C10	1.00	1.00	2.00	0.50
			4.00	

λ_{Max}=1; $CI = \frac{2-2}{2-1} = 0$

To calculate the Priority vector, the Relative weight of the pair-wise comparison matrix for the 3-groups is multiplied by the "Relative Weight" of Pair-wise comparison matrix of criteria

$$\begin{vmatrix} 0.30 & 0 & 0 \\ 0.25 & 0 & 0 \\ 0.16 & 0 & 0 \\ 0.12 & 0 & 0 \\ 0.17 & 0 & 0 \\ 0 & 0.55 & 0 \\ 0 & 0.23 & 0 \\ 0 & 0.22 & 0 \\ 0 & 0 & 0.5 \end{vmatrix} * \begin{vmatrix} 0.43 \\ 0.11 \\ 0.46 \end{vmatrix} = \begin{vmatrix} 0.13 \\ 0.11 \\ 0.07 \\ 0.05 \\ 0.07 \\ 0.06 \\ 0.03 \\ 0.02 \\ 0.23 \end{vmatrix} \text{..............Eq. 1.}$$

Table 4.1C1: Matrices for each criterion:

C1	C1D1	C1D2	C1D3	Σ=	Vi
C1D1	1.00	0.70	2.00	3.70	0.34
C1D2	1.43	1.00	3.00	5.43	0.50
C1D3	0.50	0.33	1.00	1.83	0.17
				10.96	

λmax= 3.00 CI=0.00

Table 4.2C2:

C2	C2D1	C2D2	C2D3	Σ=	Vi
C2D1	1.00	0.95	0.45	2.40	0.24
C2D2	1.05	1.00	0.50	2.55	0.25
C2D3	2.22	2.00	1.00	5.22	0.51
				10.17	

Table 4.3C3:

C3	C3D1	C3D2	C3D3	Σ=	Vi
C3D1	1.00	0.85	2.00	3.85	0.35
C3D2	1.18	1.00	3.00	5.18	0.48
C3D3	0.50	0.33	1.00	1.83	0.17
				10.86	

λmax
= 3.00 CI=0.00

Table 4.4C4:

C4	C4D1	C4D2	C4D2	Σ=	Vi
C4D1	1.00	0.50	3.00	4.50	0.40
C4D2	2.00	1.00	2.00	5.00	0.44
C4D3	0.33	0.50	1.00	1.83	0.16
				11.33	

λmax
= 3.18 CI=0.09

Table 4.5C5:

C5	C5D1	C5D2	C5D3	Σ=	Vi
C5D1	1.00	0.90	0.25	2.15	0.17
C5D2	1.11	1.00	0.30	2.41	0.19
C5D3	4.00	3.33	1.00	8.33	0.65
				12.89	

λmax = 3.00 CI=0.00

Table4.6C6:

C6	C6D1	C6D2	C6D3	Σ=	Vi
C6D1	1.00	1.00	1.00	3.00	0.33
C6D2	1.00	1.00	1.00	3.00	0.33
C6D3	1.00	1.00	1.00	3.00	0.33
				9.00	

λmax = 3.00 CI=0.00

Table 4.7C7:

C7	C7D1	C7D2	C7D3	Σ=	Vi
C7D1	1.00	0.50	0.25	1.75	0.15
C7D2	2.00	1.00	0.80	3.80	0.32
C7D3	4.00	1.25	1.00	6.25	0.53
				11.80	

Table 4.8C8:

C8	C8D1	C8D2	C8D3	Σ=	Vi
C8D1	1.00	0.40	0.85	2.25	0.22
C8D2	2.50	1.00	2.00	5.50	0.53
C8D3	1.18	0.50	1.00	2.68	0.26
				10.43	

Table 4.9C9:

C9	C9D1	C9D2	C9D3	Σ=	Vi
C9D1	1.00	2.00	0.90	3.90	0.36
C9D2	0.50	1.00	3.00	4.50	0.41
C9D3	1.11	0.33	1.00	2.44	0.23
				10.84	

Table 4.10C10:

C10	C10D1	C10D2	C10D3	Σ=	Vi
C10D1	1.00	1.00	1.00	3.00	0.33
C10D2	1.00	1.00	1.00	3.00	0.33
C10D3	1.00	1.00	1.00	3.00	0.33
				9.00	

To get the overall relative rating, the "Relative weight" of Matrices for each criterion is multiplied by Priority vector obtained in (Eq.1.)

$$\begin{pmatrix} 0.34 & 0.24 & 0.36 & 0.40 & 0.17 & 0.33 & 0.15 & 0.22 & 0.36 \\ 0.50 & 0.25 & 0.48 & 0.44 & 0.19 & 0.33 & 0.32 & 0.53 & 0.41 \\ 0.17 & 0.52 & 0.17 & 0.16 & 0.65 & 0.33 & 0.53 & 0.26 & 0.23 \end{pmatrix} * \begin{pmatrix} 0.13 \\ 0.11 \\ 0.07 \\ 0.05 \\ 0.07 \\ 0.06 \\ 0.03 \\ 0.02 \\ 0.23 \end{pmatrix} = \begin{pmatrix} 0.24 \\ 0.33 \\ 0.24 \end{pmatrix} \text{.........Eq.2.}$$

4.0 CONCLUSIONS

1. It can be seen from the overall relative rating obtained in (Eq.2) that the Geo-Pilot GXT can be recommended for the considered ERD.
2. From the CI and the λmax values obtained, it can be inferred that the pair-wise comparisons were highly consisted.
3. The AHP provides a convenient approach for solving complex MCDM problems and the method is quite transparent.
4. The proposed hierarchy can be applied (or any other proper modification of it), as a Tool for RSS selection.
5. The AHP has proved to be useful in many different types of industries and applications.

5.0 REFERENCES

Agbaji, A.L. (2010) Optimizing the Planning, Design And Drilling Of Extended Reach and Complex Wells *(SPE 136901). Abu Dhabi International Petroleum Exhibition and Conference, Abu Dhabi, UAE, November 1-4, 2010.*

Forman, E.H. and Gass, S.I. (2001) The analytic hierarchy process—an exposition. Operations Research;49(4):469–86

Judzis, A., K. Jardaneh and C. Bowes (1997) Extended-Reach Drilling: Managing, networking, guidelines, and lessons learned. *SPE Paper 37573 presented at the 1997 SPE/IADC Drilling Conference, Amsterdam. March 4-6, 1997.*

Øyvind, O. B. (2012) *A Study in Limiting Factors for Extended Reach Drilling of Highly Deviated Wells in Deep Waters.* A Thesis Submitted in partial fulfilment of the Requirements of Norwegian University of Science and Technology for the Degree of Master of Science. Norway: Norwegian University of Science and Technology

Saaty, T. L. (1986) Axiomatic Foundation of the Analytic Hierarchy Process, *Management Science*, 32, 841-855.

Saaty, T. L. (1990) An Exposition of the AHP in Reply to the Paper "Remarks on the Analytic HierarchyProcess", *Management Science*, Vol. 36, No. 3, 259-268.

Saaty, T. L. (1994a) How to Make a Decision: The Analytic Hierarchy Process, *Interfaces*, 24, 19-43.

Saaty, T. L. (1994b) Fundamentals of Decision Making. *RWS Publications, Pittsburgh, PA*
Saaty,T.L. (1980) The Analytic Hierarchy Process. *McGraw-Hill, New York.*

Wells, Gas (2011) "Sustainable Drilling of Onshore oil and gas wells." *Paper №2-23.*

MULTIPLE REGRESSION MODELS FOR STRENGTH PREDICTION OF GROUNDNUT SHELL ASH (GSA)-RICE HUSK ASH (RHA) CONCRETE

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ABSTRACT

This paper presents the effect of Groundnut Shell Ash (GSA) blended with Rice Husk Ash (RHA) on the strengths of concrete and strength prediction models of the concrete. The GSA and RHA used were obtained by controlled burning of groundnut shell and rice husk, respectively in a kiln to a temperature of 600 ^oC, and after allowing cooling, sieved through sieve 75 µm. The compressive, splitting tensile and flexural strengths of GSA-RHA-Concrete grade 20 were investigated at replacement levels of 0, 10, 20, 30 and 40 %, respectively, at curing ages of 3, 7, 28, 60 and 90 days in accordance with standard procedures. The strengths of GSA-RHA-Concrete were also modeled using Minitab statistical software to establish regression models. The result of the investigations showed that the compressive, splitting tensile and flexural strengths of concrete decreased with increase in GSA-RHA content. However 15 % replacement with GSA-RHA was considered as optimum for structural concrete. The regression models of GSA-RHA-Concrete for compressive, splitting tensile and flexural strengths were developed with R^2 values of 0.817, 0.844 and 0.931, respectively which are considered to be good for prediction of concrete strengths.

Keywords: Concrete, GSA, RHA, Strength models

1. INTRODUCTION

In many developing countries, Ordinary Portland cement is an expensive and sometimes scarce commodity and this has contributed to limit the construction of adequate housing in most of these countries. According to Alabadan *et al*. (2005), the high cost of Ordinary Portland cement is largely due to the high cost of plant and high energy required in the production. Supplementary cementing materials such as pozzolanas have been identified in literature as alternatives to Ordinary Portland cement and fundamental to advancing low cost construction materials with the main benefits of saving natural resources and energy as well as protecting the environment through the use of the main mineral admixtures (Elinwa and Mahmood, 2002).

In construction industry, strength is a primary criterion in selecting a concrete for a particular application. The effect of supplementary cementing materials on strength of concrete depends on the pozzolana content and the pozzolanic activity of the material during hydration. Concrete used for construction gain strength over a long period of time after casting. Therefore, reliable prediction for the strength of concrete would be of significance, for it will provide a chance to do the necessary adjustment on the mix proportion used to avoid situation where concrete does not reach the required design strength or for more economic use of raw materials and fewer construction failures, hence reducing construction cost (Kheder *et al*., 2003).

Prediction of concrete strength has been an active area of research and a considerable number of studies have been conducted on prediction of strength of concrete at various ages with high level of accuracy. These include studies conducted by Kheder *et al.*(2003), Popovics and Ujhelyi (2008), Zain and Abd (2009), Deepa *et al.* (2010), Ramadoss (2012), just to name a few. A number of researches, including Ogork et *al.* (2014) have also reported on use of multivariable regression models for strength prediction of concrete strengths. Zain and Abd (2009) reported that statistical models have the advantage over other modeling techniques of being mathematically rigorous and can be used to perform predictions much more quickly as well as provide insight into the key factors influencing strength. It is on this premise that this research aimed to model the strength properties of GSA-RHA-Concrete for design prediction.

2. MATERIALS AND METHODS

2.1 Materials

Ordinary Portland cement manufactured in Nigeria as Dangote brand, with a specific gravity of 3.14 was used. The oxide composition of the cement is shown in Table 1. Sharp sand from River Challawa, Kano, Nigeria, with a specific gravity of 2.62, bulk density of 1899.50 kg/m^3 and moisture content of 2.50 % was used. The particle size distribution of the sand shown in Fig. 1, indicate that the sand used was classified as zone -1 based on BS 882 (1992) grading limits for fine aggregates. The coarse aggregate is crushed granite of nominal size of 20 mm with a specific gravity of 2.7, moisture content of 1.30 percent and bulk density of 1500.0 kg/m^3. The particle size distribution is also shown in Fig. 1.

Groundnut shell of SAMNUT 10 specie and rice husk were obtained from Yakasai village and Bunkure town, respectively, Kano State, Nigeria. The Groundnut Shell Ash (GSA) and rice husk ash (RHA) were obtained by a two-step burning method (Sugita, 1993), where the shell and husk were burnt to ash and further heating the ash to a temperature of about 600 ^oC in a kiln and controlling the firing at that temperature for about two and five hours, for GSA and RHA respectively, and the ashes were allowed to cool before sieving through 75 µm sieve. The GSA is of specific gravity of 2.12, bulk density of 835 kg/m^3 and moisture content of 1.60 %, while the RHA is of specific gravity of 2.03, bulk density of 368.50 kg/m^3 and moisture content of 2.0 %. The grain size distributions of GSA and RHA is shown in Fig. 1. The oxide composition of GSA and RHA was conducted using X-Ray Flouresence (XRF) and the result is shown in Table 1.

Table 1: Oxide Composition of OPC (Dangote Brand), GSA and RHA

Oxide (%)	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**K_2O**	**Na_2O**	**SO_3**	**TiO_2**	**MnO**	**BaO**
OPC	18.0	3.10	4.82	68.37	1.48	0.35	0.32	1.82	0.35	0.03	0.16
GSA	20.03	2.00	4.03	13.19	1.82	38.80	-	1.08	0.68	0.20	0.31
RHA	75.30	2.73	2.30	2.34	0.37	4.70	0.53	0.63	0.16	0.37	0.10
Oxide (%)	**V_2O_5**	**P_2O_5**	**ZnO**	**Cr_2O_3**	**NiO**	**CuO**	**SrO**	**ZrO_2**	**Cl**	**L.o.I**	
OPC	0.03	-	-	-	-	-	-	-	-	1.27	
GSA	0.03	1.90	0.08	0.03	0.01	0.10	0.20	0.22	0.26	8.02	
RHA	-	9.87	0.48	-	-	-	-	-	-	3.41	

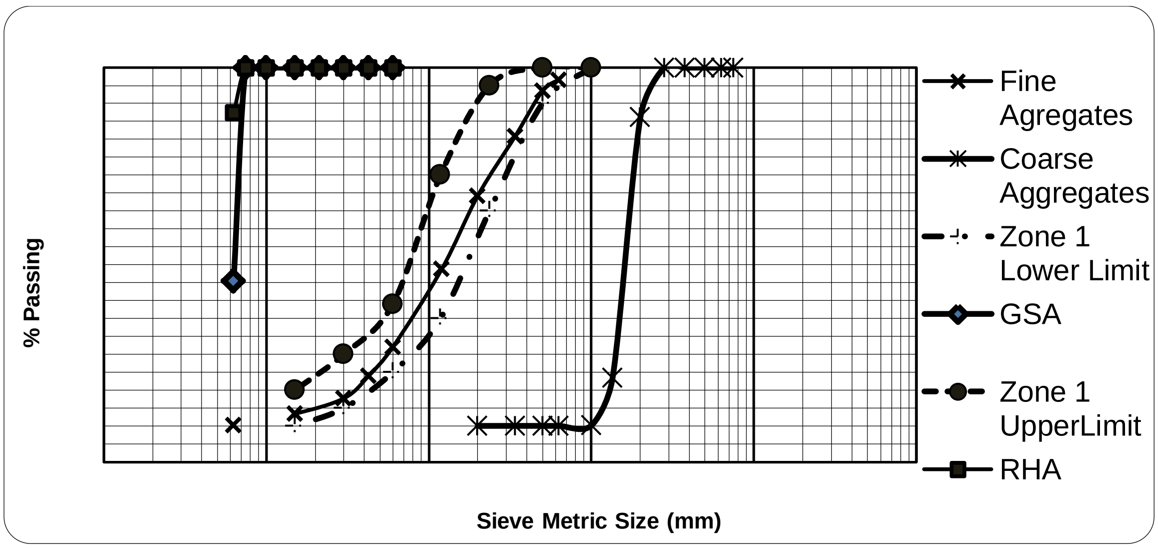

Fig. 1: Particle Size Distribution of GSA, RHA, Fine Aggregates and Coarse Aggregates

2.2 Methods

2.2.1 Concrete Mix Design

Concrete grade 20 was designed with a target mean strength of 33 N/mm^2, slump range of 10-30 mm, and a water-cement ratio of 0.55. Five mixes as shown in Table 2 were used, CMI-00 is the control mix and CMI-10, CMI-20, CMI-30 and CMI-40 are mixes containing GSA blended with 10 % RHA at combined replacement levels of 10, 20, 30, and 40 %, respectively.

Table 2: Mix Proportions for Grade 20 GSA-RHA-Concrete

Mix No.	GSA (%)	RHA (%)	Cement (kg/m^3)	GSA (kg/m^3)	RHA (kg/m^3)	Aggregates		Water (kg/m^3)	w/c
						Fine (kg/m^3)	Coarse (kg/m^3)		
CMI-00	0	0	318.2	0	0	704.5	1252.4	175.0	0.55
CMI-10	0	10	286.4	0	31.8	704.5	1252.4	175.0	0.55
CMI-20	10	10	254.6	31.8	31.8	704.5	1252.4	175.0	0.55
CMI-30	20	10	222.8	63.6	31.8	704.5	1252.4	175.0	0.55
CMI-40	30	10	191.0	95.4	31.8	704.5	1252.4	175.0	0.55

2.2.2 Compressive strength, splitting tensile strength and flexural strength tests on GSA-RHA-Concrete

The compressive, splitting tensile and flexural strengths of GSA-RHA-Concrete were carried out in accordance with BS 1881 Part 116 (1983), BS 1881 Part 117 (1983) and ASTM C293-94 (1994), respectively using the mixes in Table 2. Samples were cast in steel moulds of 150 mm cubes, 150 mm diameter by 300 mm long cylinders and 150 mm x 150 mm x 750 mm long beams, for compressive, splitting tensile and flexural strength tests respectively, and cured in water for 3, 7, 28, 60 and 90 days, respectively. A total of seventy five (75) samples were tested for each test and at the end of every curing regime, three samples were crushed using the Avery Denison Compression Machine of 2000 kN load capacity and at constant rate of 15 kN/s for the compression test and the Universal Testing Machine of 600 kN load capacity for splitting tensile and flexural strength tests, and the average taken. The results of compressive, splitting tensile and flexural strengths are shown in Fig. 2, 3 and 4, respectively.

2.2.3 Statisical Modeling of the GSA-RHA-Concrete Mixtures

Statistical models were developed from experimental data using MINITAB 11 software to predict strength behavior of GSA-RHA-Concrete. In developing the compressive strength, splitting tensile strength and flexural strength prediction models of the pozzolanic concrete, two effects were considered; (i) influence of ash content and (ii) influence of curing on the concrete strength. The software generates model equations and graphs that would best fit the experimental data. A comparison is then made between the experimental data and data generated by the models and the error difference evaluated.

3. ANALYSIS AND DISCUSSION OF RESULTS3.1 Compressive, Splitting Tensile and Flexural Strengths of GSA-RHA-Concrete

The compressive strength of GSA-RHA-Concrete shown in Fig. 2 indicated that compressive strength increase with curing age and decreased with increase in blended GSA- RHA content. The compressive strength of control samples was higher than that of samples containing combined GSA-RHA at all ages. The 28 days compressive strength of GSA-RHA-Concrete ranged from 11.9 N/mm^2 – 21.9 N/mm^2 (46.0 – 84.6 % of control) at GSA-RHA content of 10 – 40 %, with least compressive strength occurring at 40 % GSA-RHA content. It was however observed that the 28 days compressive strength of concrete with about up to 15 % GSA-RHA content exceeded the design characteristic strength of 20 N/mm^2 and was considered as optimum percentage replacement.

The decrease in compressive strength of concrete with increase in GSA-RHA content would be due to dilution effect of Ordinary Portland cement in the mix available for the hydration process and hence a reduction in the formation of the stable strength producing cementitious compounds and weaker formation of C-S-H gel as a result of pozzolanic reaction of GSA-RHA. This is consistent with works done by Prasanphan *et al.* (2010), Oyekan and Kamiyo (2011) and Parande *et al.* (2011).

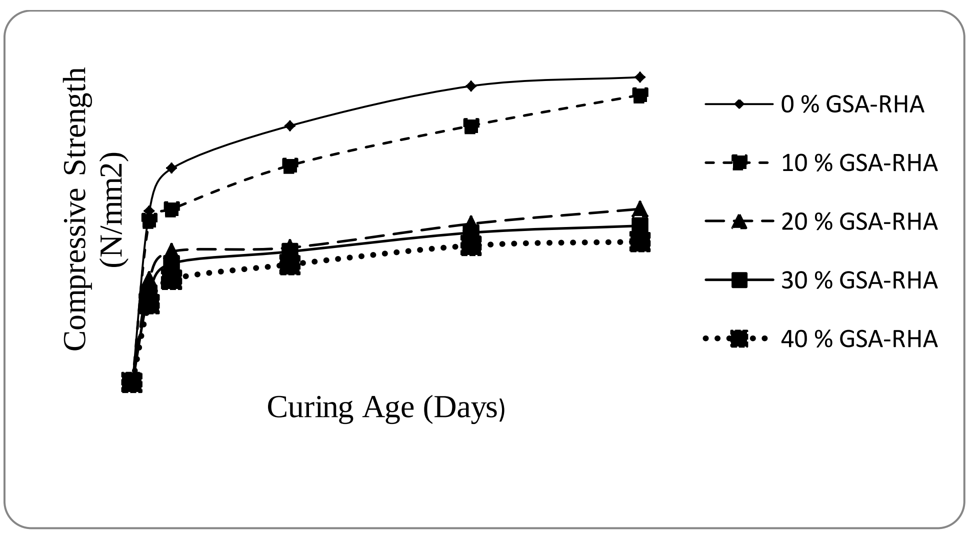

Fig. 2: Compressive Strength Development of GSA-RHA-Concrete Grade 20

Fig. 3 and 4 showed that the splitting tensile strength and flexural strength of GSA-RHA-Concrete grade 20 increased with curing age but decreased with increase in percentage of combined GSA-RHA content. However, the tensile strength of concrete at 10 % GSA-RHA content was higher than control at curing age of 28 days and above.

The decrease in splitting tensile strength with increase in GSA-RHA content may be attributed to dilution effect of Portland cement and weaker formation of C-S-H gel as a result of pozzolanic reaction of GSA-RHA (Oyekan and Kamiyo, 2011). However, the enhancement in tensile strength at low level of GSA-RHA substitution may be due to increased pozzolanic reaction and the packing ability of the fine particles of RHA (Habeeb and Fayyadh, 2009). The flexural strength behavior was similar to splitting tensile strength but with slightly higher values.

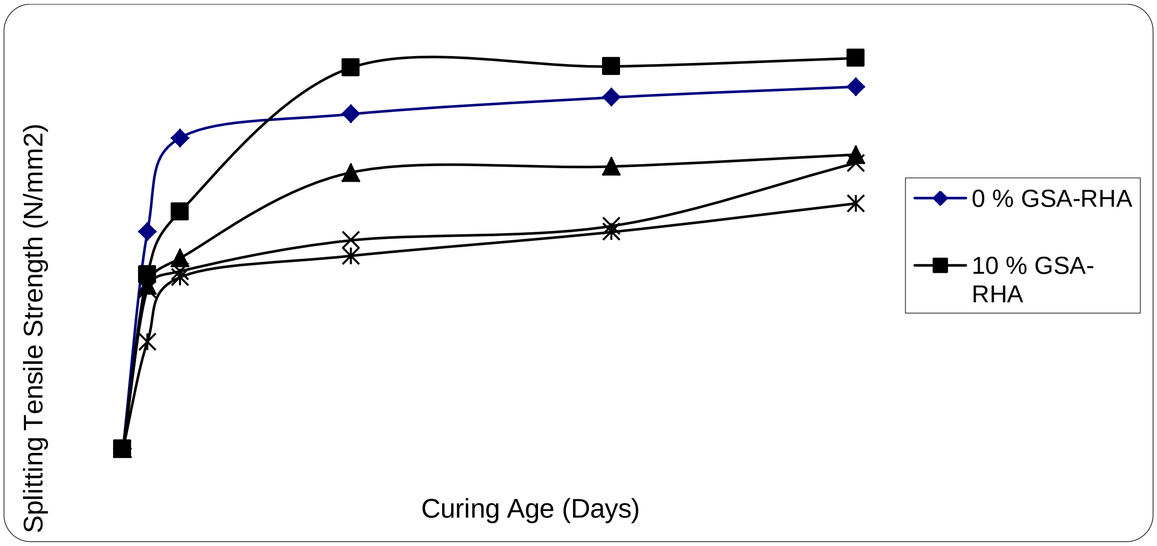

Fig. 3: Tensile Strength Development of GSA-RHA-Concrete Grade 20

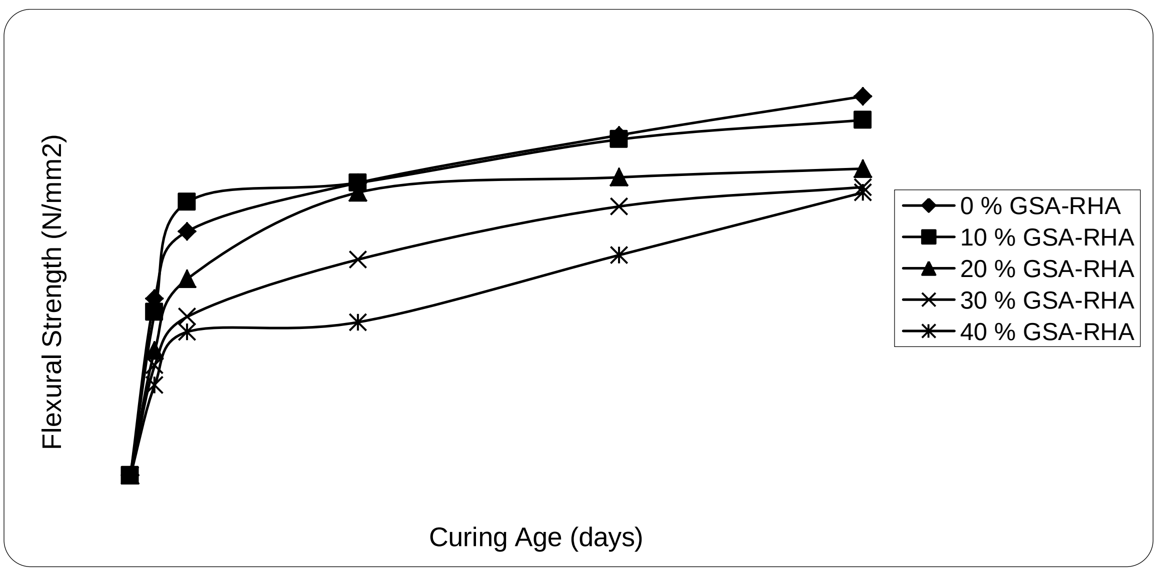

Fig. 4: Flexural Strength Development of GSA-RHA-Concrete Grade 20

3.2 Regression Models for GSA-RHA-Concrete

The regression equations generated for compressive, splitting tensile and flexural strengths of GSA-RHA-Concrete models are given in equations 1 - 3, respectively.

f_{cc} = 17.10 - 3.26 GR + 2.09 A …………….(1)

f_{tc} = 1.88 - 0.35 GR + 0.33 A ………………(2)

f_{bc} = 1.67 - 0.33 GR + 0.43 A ……………..(3)

Where; f_{cc} is concrete compressive strength, f_{tc} is concrete splitting tensile strength, f_{bc} is concrete flexural strength, GR and A are percentage replacement of cement by GSA-RHA and curing age of samples, respectively.

At 0.05 level of significance, from the regression analysis, P-value = 0.000 for both GSA-RHA content and age of curing of concrete, and shows that both variables are highly significant ($P < 0.05$) signifying that the variation in the concrete compressive, splitting tensile and flexural strengths is caused by GSA-RHA content and age of curing. The coefficient of determination, (R^2) is 0.817, 0.844 and 0.931, respectively and indicates that the variation of concrete strengths is significantly dependent on the variations of GSA-RHA content and age of curing. The residual and normality plots (Fig. 5 and 6; 7 and 8; 9 and 10) were drawn for the compressive, splitting tensile and flexural strengths of concrete to further examine how well the models fit the data used. It was observed that there were few large residuals (Field, 2002; Elinwa and Abdulkadir, 2011) and limited apparent out-lier (Razak and Wong, 2004). This confirms that the models are adequate for design prediction.

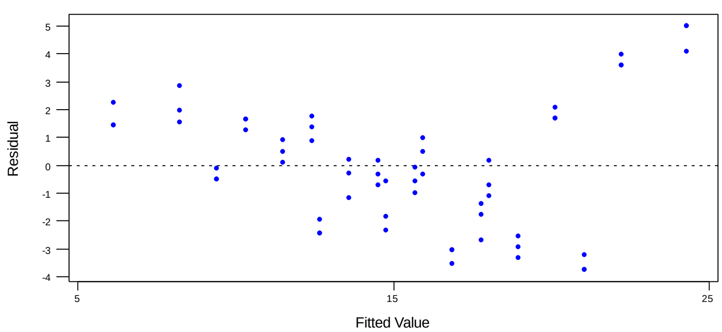

Fig. 5: Residual Versus Fitted values for Compressive Strength of GSA-RHA-Concrete

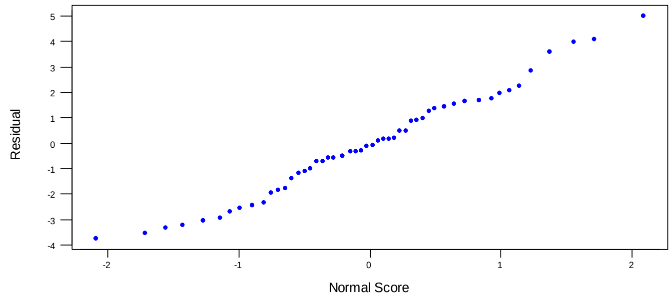

Fig. 6: Normal Probability of Residuals for Compressive Strength of GSA-RHA-Concrete

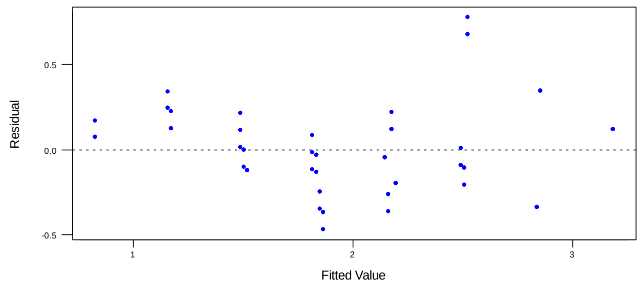

Fig. 7: Residual Versus Fitted values for Splitting Tensile Strength of GSA-RHA-Concrete

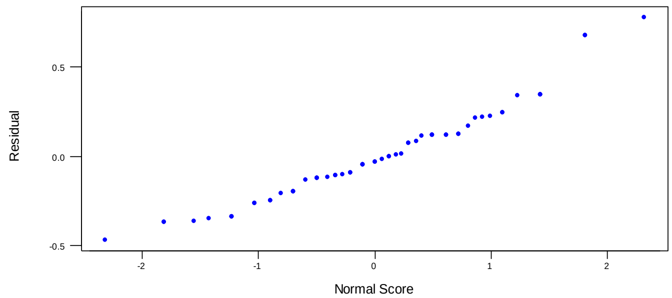

Fig. 8: Normal Probability of Residuals for Splitting Tensile Strength of GSA-RHA-Concrete

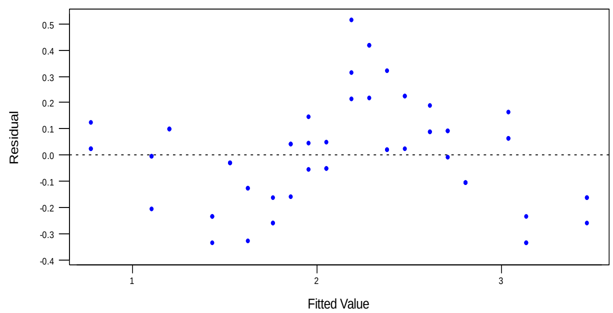

Fig. 9: Residual Versus Fitted values for Flexural Strength of GSA-RHA-Concrete

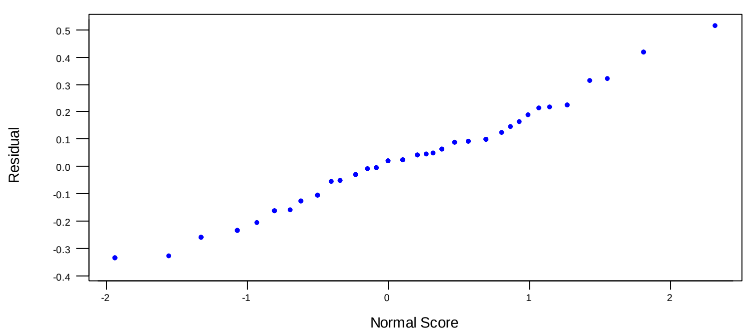

Fig. 10: Normal Probability of Residuals for Flexural Strength of GSA-RHA-Concrete

4. CONCLUSIONS

i) The compressive strength, splitting tensile strength and flexural strength of concrete decreased with increase in GSA-RHA content. However, 15 % would be considered as the optimum percentage replacement to act as a retarder suitable for hot weather concreting, mass concrete and long haulage of ready mixed concrete.

ii) The regression models for GSA-RHA-Concrete with R^2 values of 0.817, 0.844 and 0.931, respectively were good for prediction of concrete strengths.

REFERENCES

Alabadan, B.A; Olutoye, M.A; Abolarin, M.S. and Zakariya, M. (2005): Partial replacement of Ordinary Portland cement (OPC) with Bambara groundnut shell ash (BGSA) in concrete. *Leonardo Electronic Journal of Practices and Technologies*, 6: 43-48

ASTM C 293-94 (1994): Method of determination of flexural strength of concrete beams. Annual book of ASTM Standards, vol. 4, West Conshecken, U.S.A.

BS 882, Part 2 (1992): Grading limits for fine aggregates. British Standard Institution, London

BS 1881, Part 116 (1983): Method of determination of compressive strength of concrete cubes. British Standard Institution, London

BS 1881, Part 117 (1983): Method of determination of tensile splitting strength of concrete cylinders. British Standard Institution, London

Deepa, C; Sathiyakumari, K. and Sudha, V.P. (2010): Prediction of the compressive strength of high performance concrete mix using tree based modeling. *International Journal of Computer Applications*, 6(5): 18-24

Elinwa, A.U. and Mahmood, Y.A. (2002): Ash from Timber Waste as Cement Replacement Material. *Cement and Concrete Composites*, 24(2): 219-222.

Elinwa, A.U. and Abdulkadir, S. (2011): Characterizing Sawdust-Ash for Use as an Inhibitor for Reinforcement Corrosion. *New Clues in Sciences*, 1: 1-10.

Field, A. (2002): Discovering Statistics using SPSS for windows. Sage publication, London: 492.

Habeeb, G.A. and Fayyadh, M.M. (2009): Rice Husk Ash Concrete: The effect of RHA average particle size on mechanical properties and drying shrinkage. *Australian Journal of Basic and Applied Science*, 3(3): 1616-1622

Kheder, G.F; Al-Gabban, A.M. and Suhad, M.A. (2003): Mathematical model for the prediction of cement compressive strength at the ages of 7 and 28 days within 24 hours. *Mater. Struct*., 36: 693-701

Ogork, E.N; Uche, O.A.U. and Elinwa, A.U. (2014): Strength Prediction Models of Groundnut Husk Ash (GHA) Concrete. *American Journal of Civil and Structural Engineering*, 1(4): 104-110. DOI: 10.12966/ ajcse.10.03.2014

Oyekan, G.L. and Kamiyo, O.M. (2011): A study on the Engineering Properties of Sandcrete blocks produced with rice husk ash blended cement. *Journal of Engineering and Technology Research*, 3(3): 88-98

Parande, A.K; Stalin, K; Thangarajan, R.K. and Karthikeyan, M.S. (2011): Utilization of Agroresidual waste in effective blending in Portland cement. *International Scholarly Research Network, ISRN Civil Engineering*, 2011, article ID 701862: 1-12

Popovics, S. and Ujhelyi, J. (2008): Contribution to the concrete strength versus water-cement ratio relationship. *Journal of Materials in Civil Engineering*, 20: 459-463

Prasanphan, S; Sanguanpak, S; Wansom, S. and Panyathanmaporn, T. (2010): Effect of ash content and curing time on compressive strength of cement paste with rice husk ash. *Suranaee Journal of Science and Technology*, 17(3): 293-302.

Ramadoss, P. (2012): Modeling for the evaluation of strength and toughness of high performance fiber reinforced concrete. *Journal of Engineering Science and Technology*, 7(3): 280-291

Razak, H.A. and Wong, H.S. (2004): Strength estimation model for high-strength concrete incorporating Metakaolin and silica fume. *Cement and Concrete Research*, 35: 688-695.

Sugita, S. (1993): 'On the Economical Production of large Quantities of Active RHA'. *International Symposium on Innovative World of Concrete*, 2: 3-71

Zain, M.F.M. and Abd, S.M. (2009): Multiple regression model for compressive strength prediction of high performance concrete. *Journal of Applied Sciences*, 9(1): 155-160.

STRENGTH PROPERTIES OF CONCRETE CONTAINING SCRAP TYRE AS FINE AND COARSE AGGREGATE

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ABSTRACT

This paper discussed the possibility of using scrap-tyre as replacement in concrete. Grade 30 concrete with slump between 30 - 60 mm was made using DoE mix design. 0%, 5%, 10% and 15% replacements of both the fine and coarse aggregates were made with tyre particles of size 1 – 4 mm and 5 – 8 mm. The properties of fresh and hardened concrete such as slump, mechanical test were measured based on short-term investigation according to BS and BS EN standard. Laboratory results revealed that the workability of 5% and 10% replacement were higher than the control mix, while 15% decrease workability significantly. There was also decrease in compressive strength, splitting tensile strength and flexural strength. The compressive strength of 5% replacement was found to be approximately the same as the design strength of 30 MPa.

KEYWORDS: Scrap tyre, flexural strength, splitting tensile strength, compressive strength.

1.0 INTRODUCTION

A tyre is a composite of complex steel/fiber cords. Tyres are made of plies of reinforcing cords extending transversely from bead to bead, on top of which a belt is located below the thread. Over the years, disposal of tyres has become one of the serious problems in environments. Land filling is becoming unacceptable because of the rapid depletion of available sites for waste disposal. France which produces over 10 million scrap-tyres per year will have a dwindling supply of landfills starting from July 2002, due to a new law that forbids any new landfill in the country. Used tyres are required to be shredded before land filling (Siddique and Naik, 2004). Innovative solutions to meet the challenge of tyre disposal problem have long been in development, the promising options are: use of tyre rubber in asphaltic concrete mixtures; incineration of tyres for the production of steam and reuse of ground tyre rubber in a number of plastic and rubber products (Siddique and Naik, 2004).

Modification of concrete properties by the addition of appropriate materials is a popular field of concrete research. The brittle nature of concrete and its low loading toughness compared to other materials, has prompted the use of waste particles as a concrete aggregate to possibly remedy or reduce these negative attributes. Elastic and deformable tyre-rubber particles could improve concrete properties (Khaloo, *et.al*, 2008).

Khaloo, *et al*, (2008) investigated the mechanical properties of concrete containing high volume of tyre particles. They observed that the slump of concrete increases with tyre aggregate concentration lower than 15% and reaches its maximum when the tyre concentration was 15%, the tyre aggregate concentration exceeding 15% reduced the slump. They concluded that rubberized concrete with fine rubber particles exhibits an acceptable workability with respect to plain concrete.

According to Wang, *et al*, (2013), the workability of concrete containing chipped tyres was generally lower than that of the control concrete showing a range of 35 – 55mm slump, the slump value was found to decrease as the size and proportion of chipped tyres increased. They observed that increased chipped content would increase the consumption of mixing water and cement paste for coating the surface area of the shreds, which thus decreased the workability.

Indeed, many researchers have studied properties of scrap tyre containing concrete. They mostly used scrap tyre as fine aggregate replacement in form of crumb rubber, coarse aggregate replacement in form of chipped tyre, or cement replacement in form of scrap tyre powder. Most authors have identified a decline in the overall quality of concrete mechanical properties. Research on incorporating both crumb rubber and chipped rubber as fine aggregate and coarse aggregate in concrete is very scarce, and the study of the durability-related properties of concrete containing scrap tyre is very few and mostly neglected.

In this study, the effect of replacing 5, 10, and 15% by weight of fine aggregate and coarse aggregate with fine scrap tyre and coarse scrap tyre were investigated. The properties of concrete studied both at fresh and hardened state includes: workability, compressive strength, splitting tensile strength and flexural strength,

2.0 MATERIALS AND METHODS

2.1 Materials

In this study, scrap tyres were obtained from Yong Fong Rubber Industries Sdn Bhd Malaysia. Two forms of tyre particles were used; the crumb rubber particles of size ranging from 1mm to 4 mm was used as fine aggregate replacement in concrete. While tyre chips ranging in size between 5 mm to 8 mm was used as coarse aggregate replacement concrete. This particle sizes for both the crumb rubber and for the tyre chips were obtained from sieve analysis of the scrap tyre particles.

2.2 Preparation of Samples and test procedures

The concrete mix consists of cement, fine aggregate, coarse aggregate, water, crumb rubber particles, and chip rubber particles. Concrete mix was designed based on the DOE method of mix design for normal concrete was used. The targeted characteristic strength was 30 MPa at 28 days with 5% defectives. The aggregate types were uncrushed for fine aggregate and crushed for coarse aggregate. The maximum W/C ratio was 0.65, the maximum cement content was 550 kg/m^3, the minimum cement content was 260 kg/m^3. The specific gravity of aggregate used was 2.6, and the percentage of fine aggregate passing 600 µm sieves was 60%. 1% super-plasticizer was added to improve the workability of the mix. Fine aggregate was replaced by 5, 10 and 15% crumb rubber while coarse aggregate was replaced by 5, 10 and 15% tyre chips in different mixes. Table 1 shows the mix proportions of the various concrete constituent used.
For the fresh concrete properties, the workability of each concrete mix was determined according to BS EN 12350 (2009) Part 2"Testing fresh concrete: Slump test".

Compressive strength test was done according to BS EN 12390 (2009) Part 3: "Compressive Strength of test specimens". Concrete specimens of size 100 mm × 100 mm x 100 mm cubes were casted, after 24 hours the cubes were demolded and stored in water for 3,7, 28 and 60 days before testing. Twelve similar samples were prepared for each mix proportion, i.e. 3 for each testing day. A total of 48 cubes were tested for compressive strength.

The flexural strength test was done according to BS EN 12390 (2009): Part 5: "Flexural strength of test specimens". Beam samples measuring 500 mm×100 mm ×100 mm were casted and after 24 hours of casting, were demoulded and stored in water for 3, 7 and 28 days before test for flexural strength. Nine similar samples were prepared for each mix proportion, i.e. 3 samples for each testing day. A total of 36 prisms were tested for flexural strength.

The splitting tensile strength test was done according to BS EN 12390 (2009): Part 6: "Tensile splitting strength of test specimens". Cylindrical concrete specimens of size 100 mm diameter × 200 mm long were casted and after 24 hours, were demolded and stored in water for 3,7,28 and 60 days before testing for tensile splitting strength. Twelve similar samples were prepared for each mix proportion i.e. three samples for each testing day. A total of 48 cylinders were tested for splitting tensile strength.

3.0 RESULTS AND DISCUSSIONS

3.1 Workability

The results of the workability which was done using slump test method are shown in Figure 1. There was an increase in workability with increase in percentage replacement. At 5% and 10% replacement of fine aggregate/coarse aggregate FA/CA with fine tyre/coarse tyre FT/CT there was an increase in workability compared to the control mix. As the percentage replacement was increased to 15%, a sudden decrease in workability was noticed. When smaller particles of tyre rubber is used in concrete, there is an increase in workability up to a certain percentage replacement of aggregate, then further increase in replacement will result in decrease in workability as was shown in Figure 1, where there was increment in slump up to 10% replacement, then at 15% replacement there was a sudden decrease in slump. In general, the rubberized concrete specimens have acceptable workability in terms of ease of handling, placement, and finishing.

3.2 Compressive Strength

The results of compressive strength of all the concrete mixes were shown in Figure 2 and Table 2. As expected, increasing the rubber content in the concrete decreases the compressive strength of the concrete. Also, as expected, the concrete compressive strength increases with days of curing. This is due to the continues hydration process taking place in the cement in the concrete in presence of moisture, which produces more gel, the gel results to a stronger bond between the aggregate and the cement paste, thereby increasing the compressive strength. Comparing with the results obtained from Table 2, the target strength for the concrete was 30 MPa, at 5% replacement, strength of 29.5 MPa was found which is approximately same as the target strength. Therefore, replacing fine aggregate and coarse aggregate in concrete with smaller size fine tyre particles and smaller size coarse tyre particles can achieve the desired strength but at a lower percentage replacement

3.3 Splitting Tensile Strength

The result of splitting tensile test was shown in Figure 3; it was shown that increasing the rubber content in the concrete decreases the splitting strength of the concrete. Also, as expected, the concrete splitting tensile strength increases with days of curing. This is due to the continues hydration process taking place in the cement in the concrete in presence of moisture, which produces more gel, the gel results to a stronger bond between the aggregate and the cement paste, which makes the concrete more difficult to split or break. From Table 3, replacing 5% of FA/CA with 5% FT/CT results to a decrease in compressive strength by11.7%, 10% replacement reduces strength by 19.4%, and 15% replacement reduces strength by 31.4%. The rubberized concrete mixtures demonstrated a ductile failure and had the ability to absorb a large amount of energy under compressive and tensile loads than the control mix. This was noticed by the mode of failure of the samples. Comparing the reduction of splitting tensile strength with that of compressive strength, it was found that at the same percentage replacement, the percentage reduction of compressive strength was higher than that of splitting tensile strength. Therefore, tyre rubber has more negative effect in terms of strength of concrete in compressive strength than in splitting tensile strength.

3.4 Flexural Strength

The result of flexural strength was shown in Figure 4. It was shown that increasing the rubber content in the concrete decreases the flexural strength of the concrete. Also, as expected, the concrete flexural tensile strength increases with days of curing. This is due to the continues hydration process taking place in the cement in the concrete in presence of moisture, which produces more gel, the gel results to a stronger bond between the aggregate and the cement paste, which makes the concrete more resistant to bending. From Table 4, replacing 5% of FA/CA with 5% FT/CT results to a decrease in compressive strength by 19%, 10% replacement reduces strength by 13.8%, and 15% replacement reduces strength by 16.7%. The reduction of strength for 5% was found to be higher than that of 10% and 15% from Table 4 This is because as flexural strength is also dependent on fibre if present in concrete or any fibre shaped material, the 10% and 15% replacement contains more fibre-like aggregate which reduces the loss of flexural strength compared to the control mix. The rubberized concrete mixtures demonstrated a ductile failure and had the ability to absorb a large amount of energy under compressive and tensile loads than the control mix. This was noticed by the mode of failure of the samples.

4 CONCLUSION

Based on the findings of this research, it can be concluded that

1) The workability of the concrete increase with increase in percentage replacement of FA/CA with FT/CT particles for 5% and 10% replacement, then a sudden decrease in workability for 15% replacement
2) The compressive strength of the concrete decrease with increase in percentage replacement of FA/CA with FT/CT particles, but the compressive strength of the 5% replacement was found be almost equal to the design strength of the concrete i.e. 30 MPa at 28 days.
3) The splitting tensile strength of concrete decreases with increase in percentage replacement of FA/CA with FT/CT particles, but the percentage decrease was less than that of the compressive strength; and the rubberized concrete demonstrated a ductile failure and had the ability to absorb a large amount of energy under compressive and tensile loads than the control mix.
4) The flexural strength of concrete decreases with increase in percentage replacement of FA/CA with FT/CT particles, but the percentage decrease was less than that of the compressive strength. The 5% replacement was found to have more reduced flexural Strength than the 10% and 15% replacements compared to the control mix.

REFERENCES

Bravo, M., and De Brito, J., (2012). Concrete made with used tyre aggregate: durability-related performance. Journal of Cleaner Production, Vol25: 42-50

BS 1881-122, (2011), "Method for determination of water absorption".

BS EN 12350-2, (2009), "Testing of fresh concrete: Slump test".

BS EN 12390-3, (2009), "Compressive strength of test specimens".

BS EN 12390-5, (2009), “Flexural strength of test specimens”.

BS EN 12390-6, (2009), “Tensile splitting strength of test specimens”.

BS ISO 1920-8, (2009), “Determination of drying shrinkage of concrete for samples prepared in the field and in the laboratory”.

Ganjian, E., Khorami.M, and Maghsoudi,A,A., (2009). Scrap tyre replacement for aggregate and filler in concrete. Construction and Building materials, vol 23: 1828-1836

Khaloo. A., Dehestani.M, and Rahmatabadi.P, (2008). Mechanical Properties of Concrete containing high volume of tyre rubber particles. Waste Management, Vol 28: 2472-2482.

Mohammed, BS., Hossain, AMK, Swee, ETJ, Wong, G., and Abdullahi, M., (2012). Properties of crumb rubber hollow concrete block. Journal of cleaner production, Vol 23: 57-67

Neville, AM., (2003).Properties of Concrete. Longman Scientific and Technical

Siddique, R., Naik, T.R., (2004), “Properties of concrete containing scrap-tyre rubber –An overview”, Waste Management, 24: 563–569.

Tang, W., Cui, H., and Lo.Y, (2012). Properties of concrete containing scrap tyre chips. Advanced Materials Research, Vol 399-401: pp1252-1256.

Wang, X., Li, W., Wang, J., and Wang, C., (2013). Experimental study on the properties of the crumb rubber concrete. Advanced Materials Research, Vol 645: 172-175.

Yung, WH., Yung, LC, and Hua, LH., (2013). A study of the durability properties of waste tyre rubber applied to self compacting concrete. Construction and Building materials, vol 41: 665-672.

Table 1: The mix proportions of the concrete constituent

Material	Type of Samples			
	Control (kg/m3)	Concrete + 5% Fine TR + 5% Coarse TR (kg/m^3)	Concrete + 10% Fine TR + 10% Coarse TR (kg/m^3)	Concrete + 15% Fine TR + 15% Coarse TR (kg/m^3)
cement	340	340	340	340
Fine Aggregate	700	665	630	595

Coarse Aggregate	1140	1083	1026	969
water	190	190	190	190
Fine TR	0	35	70	105
Coarse TR	0	57	114	171
SP (0.5% of cement)	1.7	1.7	1.7	1.7
Reduction in water (12%)	23	23	23	23
Reduced Water	167	167	167	167

Table 2: **Percentage gain/loss of Compressive Strength at 28 days**

% Replacement	Compressive Strength at 28 Days (MPa)	% Gain/loss of Compressive Strength
0 Control	35.02	(35.02-35.02)/35.02 x 100 = 0
5	29.52	(28.74-35.02)/35.02 x 100 = -15.71
10	24.44	(24.44-35.02)/35.02 x 100 = -30.21
15	21.63	(21.63-35.02)/35.02 x 100 = -38.23

Table 3: **Percentage gain/loss of Splitting Tensile Strength at 28 days**

% Replacement	Splitting Tensile Strength at 28 Days (MPa)	% Gain/loss of Splitting Tensile Strength (%)
0	4.94	(4.94-4.94)/4.94 x 100 = 0
5	4.36	(4.36-4.94)/ 4.94x 100 = -11.74
10	3.98	(3.98-4.94)/ 4.94x 100 = -19.43
15	3.39	(3.39-4.94)/ 4.94x 100 = -31.38

Table 4: **Percentage gain/loss of Flexural Strength at 28 days**

% Replacement	Flexural Strength at 28 Days (MPa)	% Gain/loss of Flexural Strength (%)
0	6.59	(6.59-6.59)/ 6.59x 100 = 0
5	5.34	(5.34-6.59)/ 6.59x 100 = -18.97
10	5.68	(5.68-6.59)/ 6.59x 100 = -13.81
15	5.47	(5.47-6.59)/ 6.59x 100 = -16.70

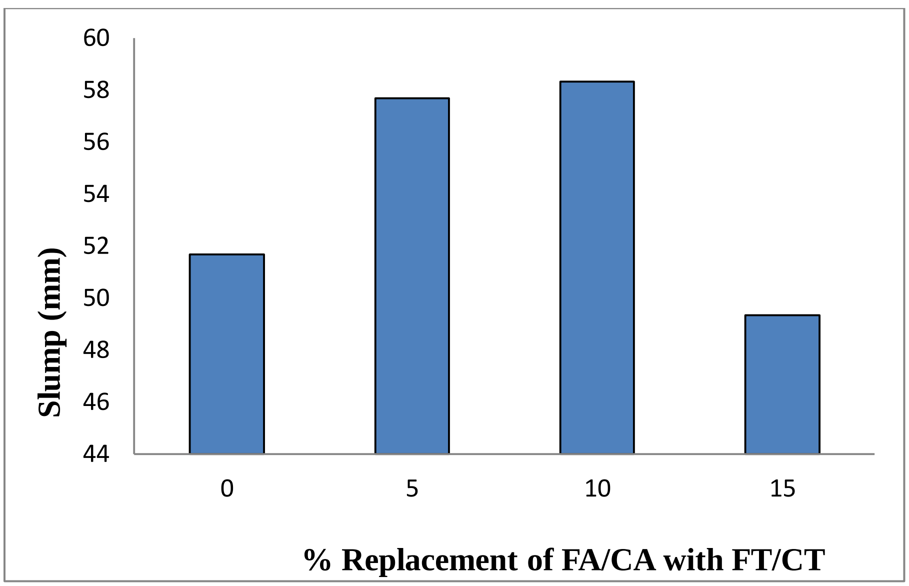

Figure 1: **Workability of Concrete**

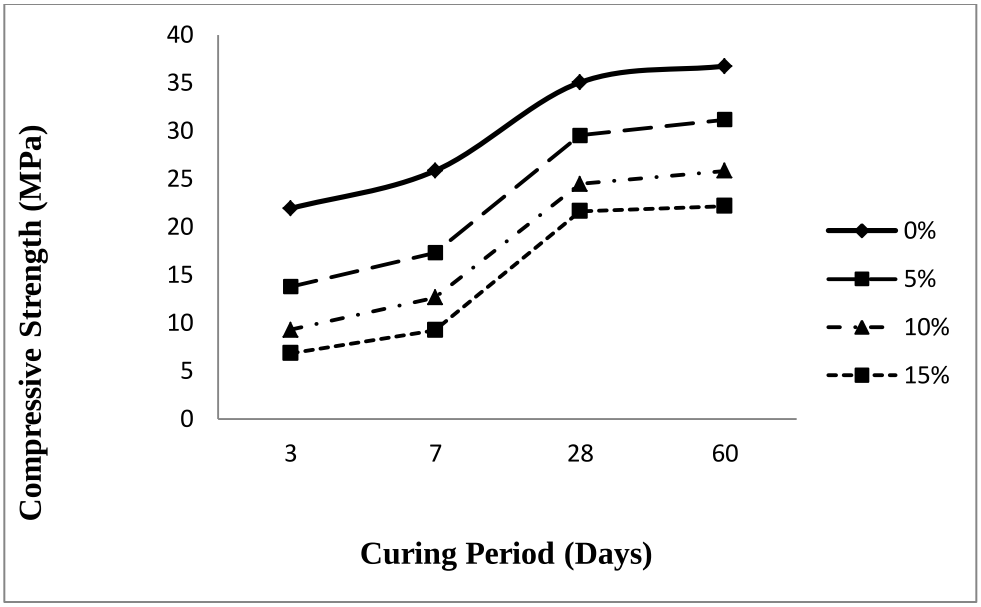

Figure 2: Variation of Compressive strength with time

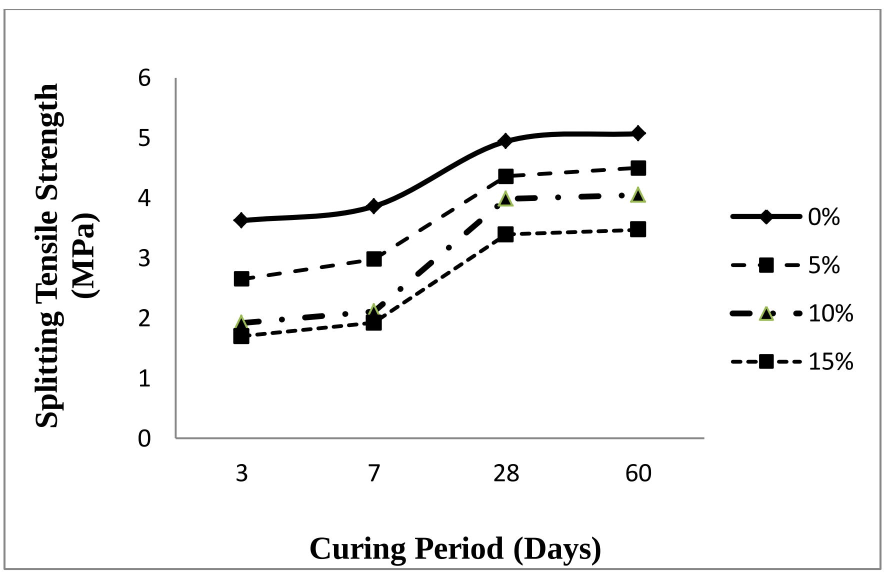

Figure 3: Variation of Splitting Strength with time

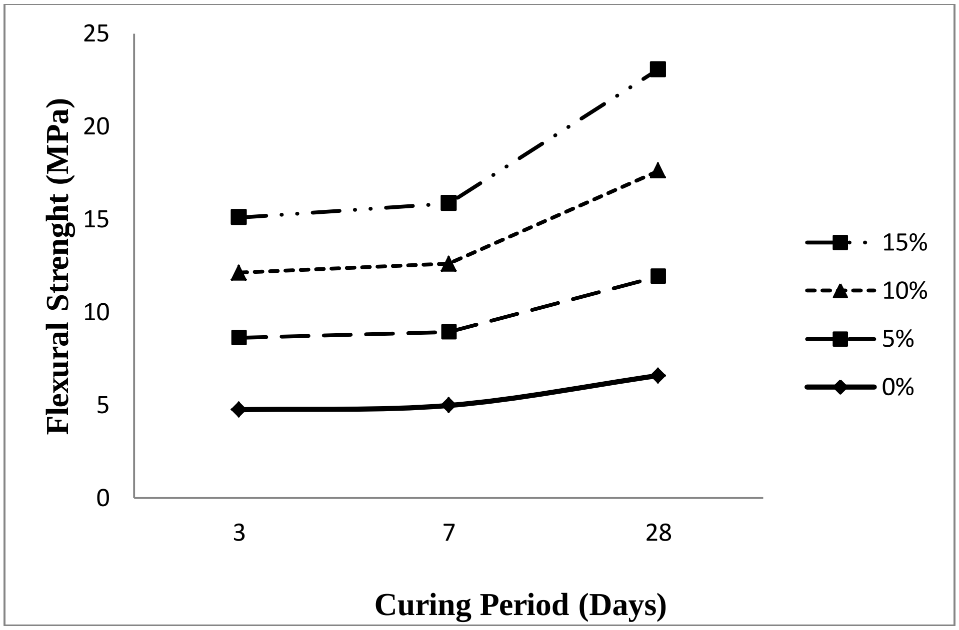

Figure 4: **Variation of flexural strength with ti me**

ENRICHING ENGINEERING CURRICULUM WITH THE USE OF SPECIALIZED SOFTWARE PACKAGES USING *COMSOL MULTIPHYSICS*

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ABSTRACT

This paper presents the work on simulation of three cases using the specialized software package COMSOL Multiphysics to advocate the enrichment of Tertiary Education curricular with the teaching and use of software packages in order to make the process of acquisition of knowledge easier and more functional. In doing this, the results obtained from the software on heat conduction, central deflection of the Euler-Bernoulli beam, magnetic flux density and force on the plunger of a Solenoid Actuator were compared with those obtained from the traditional methods of solution like the analytical method which can be tedious, complex, and more error-prone. The results show that with meticulous modeling technique and proper choice of software packages, the error in results from simulation studies could be as low as 0.001% in the case of good modeling technique and as high as 16.44% for poor choice of software, thus showing that enriching the curriculum with the use of the software would engender the processed of teaching and learning that could otherwise be very complex and often lead to complications in comprehension.

KEYWORDS: Software; curriculum; temperature gradient; beam deflection; magnetic flux density.

1.0 INTRODUCTION

1.1 Curriculum

Curriculum is a term that varies in definition; depending upon from what angle it is viewed: development, research, planning. According to Oje (1998), while it can be defined as a structured series of intended learning experiences – the instrument by which educational institutions seek to translate the hope of society into concrete reality – the sum total of all the means applied by these institutions to promote what society and educators consider as desirable learning. Others like Ali (1990), view curriculum as a formwork or guide, consisting essentially of topics concepts, ideas, etc, which students are expected to be taught, using specific methods, materials and activities at specified class levels, following from which it is expected that the student would have by and large, attained the objectives or goals for which teaching was done in the first place.

According to Oroge (1998), the varying definitions are attributed to the changing nature of knowledge, the learner, the learning process as well as the widening expectation of the roles and functions of the school within the larger society.

Still yet, Ukeje (1986) is of the view that in order to promote social change, the school curriculum must be functional. That is, it should be so designed as to prepare the youth for specific problems they will meet after they leave school both in terms of their job and in terms of social living. According to Oje (1998), curriculum must be characterized by having definite and dynamic objectives, must be flexible and must have built into it a process of constant evaluation. This, according to her, will help in determining the extent to which the educational process is meeting the stated goals.

It is in view of this functionality and dynamic change – a process of being able to apply acquired knowledge to solving the ever-changing problems of society – that tertiary institutions must equally enrich their curriculum not only to enhance student understanding of the subject matter but also to be able to meet the challenges of a changing world. One such way that is fast gaining momentum the word over but which is only slowly catching up here is the use of specialized software packages to solve problems.

1.2 Software Packages

More often than not, students encounter very complicated computations when solving problems. These include, but not limited to, such partial differential equations as the Navier Stokes Equation, Heat conduction, Laplace and Wave equations, and others like the Dirac-delta functions in complicated Euler-Bernoulli Equations, and complicated Optimization of Processes. Granted, solutions to these equations and problems exist by way of analytical and numerical methods. However, taking the partial differential equations for a case study, the analytical methods on the one hand, can become tedious, often containing many summation terms and thereby lending the method of implementing them error-prone and time-consuming. In addition, the student has to be very skilled in the implementation of the solution, say on a spreadsheet. On the other hand, the numerical solutions usually involve very large systems of equations that the same arguments could also be made as in the case of the analytical solution. For example a 10 by 10 grid involves 100 linear algebraic equations, and this could be much larger with practical problems involving very large domains.

On the other hand many programmes (like *MS Excel*), programming languages (like *FORTRAN*, *BASIC*), and special software packages (like Matlab *COMSOL Multiphysics*) are available, which could be used to solve these problems. Even though Programs like the *MS-Excel*, and *FORTRAN/BASIC* do not presently posses direct capabilities to directly solve PDE's/ODE's, they can be used as powerful tools to implement them using the analytical and numerical methods mentioned above, but, as mentioned earlier, this requires a very thorough understanding of *Excel* and programming languages. On the other hand, specialized packages (programs) like *MATLAB/COMSOL Multiphysics*, with a meticulous choice of model, and boundary and initial conditions, could be used to solve them directly in all dimension (One-, Two-, and Three-dimensions).

It is thus seen that incorporating the teaching of the use of these packages in the curriculum, will go a long way in not only aiding the understanding of the problem to be solved, but also be in tune with the dynamic requirement of problem solving. This paper seeks to demonstrate this using the *COMSOL Multiphysics* package as a case study for solving problems.

1.3 The *COMSOL Multiphysics* Software

COMSOL Multiphysics (CMP) is a powerful interactive environment for modeling and solving all kinds of scientific and engineering problems based on partial differential equations (PDEs). The CMP can easily extend conventional models for one type of physics into multiphysics models that solve coupled physics phenomena—and do so simultaneously. Thanks to the built-in *physics modes* it is possible to build models by defining the relevant physical quantities—such as material properties, loads, constraints, sources, and fluxes—rather than by defining the underlying equations. CMP then internally compiles a set of PDEs representing the entire model. The software can be used as a standalone product through a flexible graphical user interface, or by script programming in the MATLAB language.
To solve the PDEs, the *COMSOL Multiphysics* uses the proven *finite element method (FEM)*. The software runs the finite element analysis together with adaptive meshing and error control using a variety of numerical solvers.

2.0 MATERIALS AND METHODS

This work used three case studies to present how software packages could be used to enrich the curriculum in the tertiary institutions. The first is heat transfer by conduction through a body, using 1-. 2-, and 3-Dimensions. The second is a case of a body traversing a simply-supported beam with a constant velocity – a typical Euler-Bernoulli equation. The third is the modeling of a Solenoid Actuator. In all cases except the last one, the analytical solution was implemented on *MS Excel*/*Matlab* and then the numerical solution on *COMSOL Multiphysics*.

2.1 Heat Conduction

A case study of heat conduction is now undertaken for a steel rod of radius r = 5 mm, and length L = 100 mm, having thermal conductivity k = 14.4 W/m K, with a volumetric heat generation G = 10 MW/m^3, (Figure 1) insulated at one end while the other end is maintained at constant temperature T_0 = 200 °C, while the cylindrical surface is exposed to the surrounding so that heat is transferred by convection with a convective heat transfer coefficient of h = 57.6 W/m^{2}K at a surrounding temperature T_∞ = 30 °C.
In order to demonstrate the importance of enriching tertiary education curriculum with special software packages, various methods of solution were used to find the temperature gradient in this rod.

2.1.1 Analytical Solutions

The 1D steady-state axial temperature distribution (temperature gradient) equation is (Chapra and Canale, 2006):

$$\frac{d^2T}{dx^2} + G = 0 \qquad (1)$$

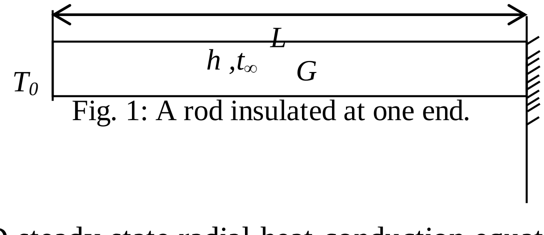


Fig. 1: A rod insulated at one end.

While the 1D steady-state radial heat conduction equation is (Lewis, Nithiarasu, and Seetharmu, 2004):

$$k\left(\frac{d^2T}{dr^2} + \frac{1}{r}\frac{dT}{dr}\right) + G = 0 \qquad (2)$$

The analytical (or 'exact') solution for Equation (1) is easy enough to implement. This is done by assuming a solution of the form (Chapra and Canale, 2006):

$$T = ax^2 + bx + c \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_} (3),$$

– which can then be solved by differentiating twice to give $T'' = 2a$. Substituting this result into the differential equation gives the value of a, and, by applying the boundary conditions, the values of the remaining coefficients, b and c can be obtained. However, this solution is limited to only the axial temperature distribution along the centre-line (or axis) of the cylindrical rod; it does not give axial temperature distribution away from the centre-line.

The analytical solution of Equation (2) is given by Lewis, Nithiarasu, and Seetharmu, (2004) as:

$$\frac{T(r)-T_\infty}{T_c-T_\infty} = 1 - \left(\frac{r}{r_0}\right)^2 \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_} (4),$$

where:

$$T_c = T_\infty + \frac{Gr_0^2}{4k} \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_} (5),$$

and where: T_c is the temperature at the centre of the rod.

Using this solution and the analytical solution for Equation (3) by Martinez, (2012) a 1D analytical solution is obtained for the axial temperature distribution at any position, thus:

$$\frac{T(x)-T_\infty}{T_0-T_\infty} = \frac{cosh[m(L-x)]}{cosh(mL)} + \frac{G\left(1-\frac{cosh[m(L-x)]}{cosh(mL)}\right)}{km^2(T_0-T_\infty)} \quad \text{\_\_\_\_\_\_\_\_\_\_} (6)$$

– for axial temperature distribution at the surface of the rod, and

$$\frac{T(x)-T_c}{T_0-T_\infty} = \frac{cosh[m(L-x)]}{cosh(mL)} + \frac{G\left(1-\frac{cosh[m(L-x)]}{cosh(mL)}\right)}{km^2(T_0-T_\infty)} \quad \text{\_\_\_\_\_\_\_\_\_\_} (7)$$

– for axial temperature distribution at the centre line and at any radius r_i, substituting $r_i = r_o$ in Equation (5) for any radial position r_i. Where $m = \sqrt{\frac{h\rho}{kA}}$ and ρ is the density of the rod material.

Consider now the 2D analytical solution given by VanSant (1980) into which the internal heating term given by Martinez (2012) is substituted:

$$T(x) = T_0 + \left\{(T_0 - T_\infty)Q + \left[\frac{G(1-Q)}{km^2(T_0-T_\infty)}\right]\right\} \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_} (8), \text{ where:}$$

$$Q = 2\sum_{n=1}^{\infty}\left\{\frac{[B_i J_o(R\lambda_n)cosh(L\lambda_n(1-X))]}{[(\lambda_n^2+B_i^2)J_o(\lambda_n)cosh(L\lambda_n)]}\right\} - 2\pi\sum_{m=0}^{\infty}\sum_{n=1}^{\infty}\left\{\frac{(2m+1)B_i J_o(R\lambda_n)cos\left(\frac{2m-1}{2}(1-x)\pi\right)}{L^2\left[\lambda_n^2+\frac{(2m+1)^2\pi^2}{4L^2}\right](\lambda_n^2+B_i^2)J_o(\lambda_n)}\right\} \quad \text{\_\_\_}(9)$$

and: J_0 and λ_n are, respectively, zero order Bessel function and the nth root of the characteristic equation; B_i is the Biot modulus = hL/k; while here $m = \sqrt{\frac{hC}{kA}}$ (and C is the circumference of the rod, $R = r/r_0$; and $X = x/L$

Equations (7) and (8) were implemented on *MS Excel* and temperature distributions at the centre-line and at the surface of the rod were determined.

The complicated nature of implementing analytical solutions can be gleaned from the last two Equations, as implementing them either on *spreadsheet* or 'manually' can become tedious and error-prone. And this is for only 2D. The analytical solution in 3D for any Partial Differential Equation (where available), would of course be much more complicated! The use of special software packages to solve these problems (in all dimensions) lessens not only the complications but also minimize errors. This is one reason why there is the need to enrich tertiary institutions' curriculum with the use of special. This study would be limited to the 1D and 2D solutions for both analytical and numerical solution.

2.1.2 Numerical Solution by Finite Element Method (FEM)

The numerical solution by Finite Element Method (FEM) is implemented here using *MS Excel* only to show and emphasis how tedious doing so could be, compared to special software packages like the *COMSOL Multiphysics*, which also uses FEM.
As in the preceding section, the FEM solution is limited to only the axial temperature distribution at the centre-line of the rod and at the surface.
The 1D Quadratic Element FEM solution for axial temperature distribution as given by Lewis, Nithiarasu, and Seetharmu, (2004) resulted in the following:
Stiffness Matrix:

$$[K] = \frac{Ak}{6l}\begin{bmatrix} 14 & -16 & 2 \\ -16 & 32 & -16 \\ 2 & -16 & 14 \end{bmatrix} + Ah\begin{bmatrix} 0 & 0 & 0 \\ 0 & 2 & 1 \\ 0 & 1 & 2 \end{bmatrix} \_\_\_\_\_\_\_\_\_\_\_\_\_\_ (10)$$

Forcing Vector:

$$\{f\} = \frac{AGL}{6}\begin{Bmatrix} 1 \\ 4 \\ 1 \end{Bmatrix} + AhT_\infty \begin{Bmatrix} 0 \\ 1 \\ 1 \end{Bmatrix} \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (11)$$

These Equations were assembled for temperature distribution at the centre-line and at the surface for 21 nodes along the length of the rod. This resulted in a 21 × 21 system of equation, which was solved on *MS Excel* using the *Gauss Elimination Method*.
The 2D FEM solution by Galerkin's method for linear triangular axisymmetric elements given by Lewis, Nithiarasu, and Seetharmu, (2004) as resulted in the following:
At the centre-line, the stiffness matrix and the loading vector were obtained as in Equations (12) and (13), respectively:

$$[K] = \frac{2\pi\bar{r}k}{4A}\begin{bmatrix} 1.06E-04 & -6.25E-06 & -1.00E-04 \\ -6.25E-06 & 6.25E-06 & 0 \\ -1.00E-04 & 0 & 1.00E-04 \end{bmatrix} \_\_\_\_\_\_\_\_\_\_ (12)$$

$$\{f\} = \frac{2\pi GA}{12}\begin{Bmatrix} 2.5E-03 \\ 2.5E-03 \\ 5.00E-03 \end{Bmatrix} \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (13)$$

At the surface of the rod the stiffness matrix and the loading vector were obtained as in Equations (14) and (15), respectively:
Theses matrices and vectors were also assembled on *MS Excel*, resulting in a 22 × 22 system of equations and which was also solved using the *Gauss Elimination Method*.

$$[K] = \frac{2\pi\bar{r}k}{4A}\begin{bmatrix} 1.00E-04 & -1.00E-04 & 0 \\ -1.00E-04 & 1.06E-04 & -6.25E-06 \\ 0 & -6.25E-06 & 6.25E-06 \end{bmatrix} + \frac{2\pi hl}{12}\begin{bmatrix} 2.50E-03 & 2.50E-03 & 0 \\ 2.5E-03 & 7.50E-03 & 0 \\ 0 & 0 & 0 \end{bmatrix} \_\_\_\_\_\_\_\_\_\_ (14)$$

$$\{f\} = \frac{2\pi GA}{12}\begin{Bmatrix} 5.00E-03 \\ 7.50E-03 \\ 7.50E-03 \end{Bmatrix} + \frac{2\pi T_\infty l}{6}\begin{Bmatrix} 2.50E-03 \\ 5.00E-03 \\ 0 \end{Bmatrix} \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (15)$$

Where: l = length of an element; and $\bar{r} = r_i + r_j r_k/3$; and i = j = k = 1, 2, ….elements.

2.1.3 Implementation on *COMSOL Multiphysics*

Using the chosen geometry, the model was drawn on the GUI of the software for 1D, 2D and 3D (see Appendix A for the subdomain plots of the 3D). The boundary conditions of temperatures, thermal insulation, heat transfer coefficient, etc were then specified and a solution obtained for each of the dimensions.

2.2 Dynamic Response of a Beam under a Moving Load

The second case study in this work is that of central beam deflection of a simply supported beam when a load moves over it with a constant speed. A beam of height h = 0.02 m, width of b = 2.4 m, and length L = 20 m was used for the model. The load of P = 6.25 N travelling across the length of the beam with a speed of v = 2.296 m/s was chosen. The deflections at various time intervals for specified positions along the beam were then computed by analytical method and by FEM using *COMSOL Multiphysics*.

The beam and its load just described is the Euler-Bernoulli beam and the equation of motion is the classical Euler-Bernoulli equation for beam displacement given by Sethi (2012) as:

$$\rho A \frac{\partial^2 U_z}{\partial t^2} + EI_y \frac{\partial^4 U_z}{\partial x^4} = \delta(x - vt)P \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (16).}$$

Where ρ is the density of the beam material, A is the cross-sectional area, t is time, EI is the flexural rigidity of the beam, x is any position along the length of the beam, $U_z = U_z(x,t)$ is the beam deflection for $0 \le x \le L$ and $0 \le t \le L/v$, and δ is the Dirac-Delta function.

2.2.1 Analytical Solution

Sethi (2012) also gave the analytical solution for Equation (16) is as:

$$U_z(x,t) = U_{zs}(L/2)\frac{96}{\pi^4}\sum_{n=1}^{\infty}\left[\frac{1}{n^2(n^2-\alpha^2)}\left\{sin(n\pi t/\tau) - \frac{\alpha}{n}sin\left(\frac{n^2}{\alpha\tau}\right)\right\}sin(n\pi x/L)\right] \quad \text{\_\_\_\_\_\_\_\_ (17)}$$

for α ≠ n and:

$$\begin{aligned} U_z(x,t) = {} & U_{zs}(L/2)\frac{96}{\pi^4}\sum_{n=1, n\neq\alpha}^{\infty}\left[\frac{1}{n^2(n^2-\alpha^2)}\left\{sin(n\pi t/\tau) - \frac{\alpha}{n}sin\left(\frac{n^2}{\alpha\tau}\right)\right\}sin(n\pi x/L)\right] \\ & + U_{zs}(L/2)\frac{96}{\pi^4}\left[\frac{1}{2\alpha^2}\left\{sin(n\pi t/\tau) - \frac{\alpha\pi t}{\tau}cos\left(\frac{\alpha\pi t}{\tau}\right)\right\}sin(n\pi x/L)\right] \quad \text{\_\_\_\_\_\_\_ (18),} \end{aligned}$$

for α =n

where: $U_{zs}(L/2) = \frac{PL^3}{48EI}$ is the static mid-span displacement for force P at the mid-point of the beam; τ = L/v is the traversing time for the moving load and α is a non-dimensional parameter which varies from 0 to 1.

A program to implement this analytical solution on *Matlab* was written by Forbes (2008) was modified to suit the present study and was run on *Matlab*.

2.2.2 FEM Solution by *COMSOL Multiphysics*

Here, too, the Euler-Bernoulli beam was modeled on *COMSOL Multiphysics*. The result was also extracted in a graphical plot and saved. It must however, be mentioned here that, *COMSOL Multiphysics* Version 3.5a (used in this study) and up to Version 4.3, does not presently have the capability for a moving load (the Dirac-Delta function). However, the nearest approximation to this is the use of both the *test* function and the *Gaussian* function (better known as the Normal distribution), COMSOL Multiphysics (2012).

2.3 The Solenoid Actuator

The last case study in this work is the Solenoid actuator. The problem to be solved for was taken from Bargallo (2006) as follows:

Given a Solenoid Actuator with relative permeability of air and coil, $\mu = 1$; current density in the coil, $J = 1{,}000{,}000$ A/m^2, and with a B – H curve for the core and plunger as follows:

Table 2.1: B – H values of a Solenoid Switch

H (A/m)	460	640	720	890	1280	1900	3400	6000
B (T)	0.80	0.95	1.00	1.10	1.25	1.40	1.55	1.65

Source: Bargallo, (2006)

To obtain the magnetic field in the solenoid and the force applied to the plunger.

This problem was modeled on the *COMSOL Multiphysics* using the dimensions given for the problem.

Here, no analytical solution is attempted and the results given by the author (from softwares *ANSYS* and *QuickField*) *was* used as a basis for comparison.

3.0 RESULTS AND DISCUSSION

3.1 Heat Conduction

Table 2 below shows the results obtained from the analytical solution and FEM by *MS Excel* in juxtaposition with those from *COMSOL Multiphysics* (CMP). In Table 2(a), which shows the axial temperature distribution at the surface of the rod, using the analytical solution for basis of comparison for the result from CMP, the maximum and minimum absolute errors are 0.005 and 0.001 % respectively. The corresponding figures for the centre-line temperature distribution (Table 2(b)) are 0.53 % and 0.02%.

Table 2(a): Axial temperature distribution at the surface

SURFACE TEMPERATURE DISTRIBUTION (°C)							
Axial position, x (m)	1D (Analytical)	1D (FEM Excel)	1D (FEM CMP)	2D (Analytical)	2D (FEM Excel)	2D (FEM CMP)	3D (FEM CMP)
0.00	200.00	200.00	200.00	200.18	200.00	200.00	200.00
0.01	286.97	292.26	287.02	287.68	286.53	286.24	286.21

0.02	345.24	340.58	345.31	345.59	344.66	344.61	344.60
0.03	384.24	378.76	384.31	384.39	383.69	383.74	383.71
0.04	410.30	408.22	410.37	410.35	409.87	409.91	409.88
0.05	427.65	430.04	427.71	427.65	427.38	427.35	427.31
0.06	439.11	439.36	439.15	439.07	439.02	438.87	438.84
0.07	446.52	446.10	446.56	446.48	446.67	446.33	446.30
0.08	451.10	451.44	451.13	451.05	451.53	450.94	450.90
0.09	453.58	454.80	453.61	453.53	454.40	453.44	453.41
0.10	454.36	454.86	454.39	454.31	455.73	454.23	454.19

Table 2(a): Axial temperature distribution at the centre-line

SURFACE TEMPERATURE DISTRIBUTION (°C)							
Axial position, x (m)	1D (Analytical)	1D (FEM Excel)	1D (FEM CMP)	2D (Analytical)	2D (FEM Excel)	2D (FEM CMP)	3D (FEM CMP)
0.00	200.00	200.00	200.00	200.06	200.00	200.00	200
0.01	288.40	293.53	288.46	287.31	287.95	288.83	288.777
0.02	347.62	342.50	347.70	346.77	347.04	347.73	347.746
0.03	387.27	381.21	387.34	386.61	386.71	387.28	387.255
0.04	413.76	411.07	413.82	413.26	413.32	413.69	413.686
0.05	431.40	433.18	431.45	431.02	431.11	431.32	431.297
0.06	443.04	442.62	443.09	442.75	442.95	442.95	442.934
0.07	450.57	449.45	450.61	450.35	450.72	450.49	450.471
0.08	455.22	454.85	455.26	455.04	455.67	455.15	455.126
0.09	457.74	458.25	457.77	457.59	458.58	457.67	457.649
0.10	458.54	458.29	458.57	458.39	459.93	458.47	458.446

3.2 Central Deflection of the Euler-Bernoulli Beam

Figure 3(a) shows a chart of the beam deflections at axial distances along the beam using analytical method, while Figure 3(b) shows the corresponding deflections from CMP. It is seen from the Figures that the CMP models the central deflection well, with an absolute error of about 4.15 % for the middle time span of (4.35 second). For all other time spans the error ranges from a minimum of 0.21 % to a maximum of 16.44 %, except at the second and the last but one time steps (0.871 and 7.84 seconds, respectively) where large departures are observed up to an error of about 80 %. However, remembering that the CMP uses the Gaussian function in place of the Dirac-Delta function, this result is not so bad in the light of the central deflection of all other time-steps.

Further, it is emphasized here that the results for this case (beam deflection) can be improved upon with better modeling technique than was done in this work. This result also, does not in any way mean better results cannot be obtained using other softwares; like *ANSYS*, *SAP200*, to mention but a few, which has the capability to directly model moving loads. This is also the more reason why this paper advocates for enrichment of the university curricular with the teaching and use of special software packages.

Fig. 3(b): Beam deflection by CMP

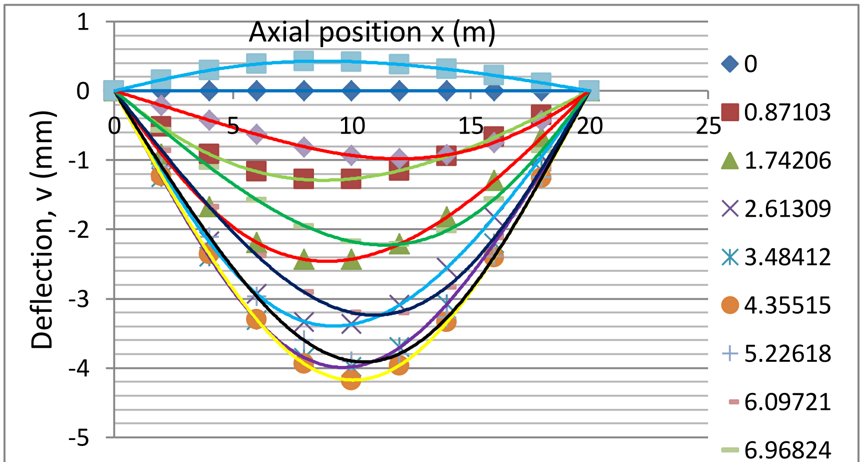
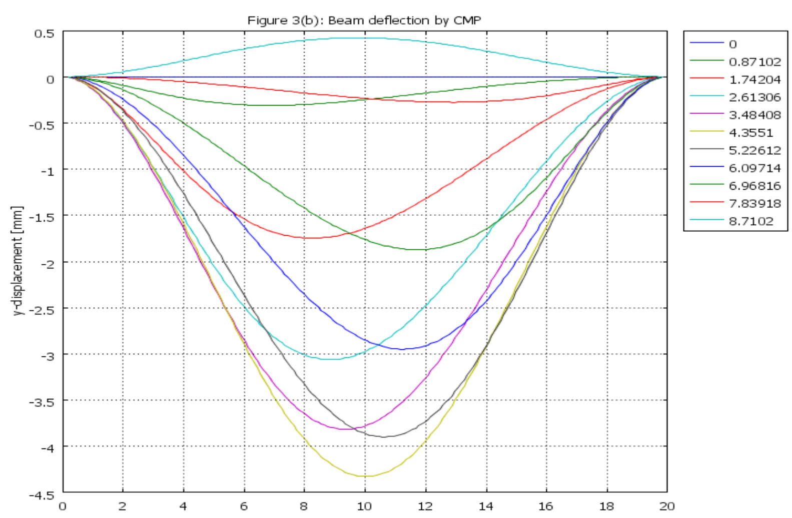


Fig. 3(a): Beam deflection by analytical method

3.3 The Solenoid Actuator



Tables 3(a) and 3(b) show the results of simulation of a Solenoid Actuator by CMP, and other methods. The force obtained from simulation by CMP, compared to the calculated one has an absolute error of 1.74 %, and using the *ANSYS* and then the *QuickField* as basis the errors in the computed maximum magnetic flux density are, respectively 7.8 % and 1.2 %.

Table 3(a): Force applied to the plunger of the modeled Solenoid Actuator.

Force on Plunger (N)	
Calculated (Bargallo, 2006)	374.1
COMSOL Multiphysics	380.6

Table 3(b): The maximum magnetic Flux Density in the solenoid of the modeled Solenoid Actuator.

Magnetic Flux Density B (T)	
ANSYS	0.933
QuickField	1.0183
COMSL Multiphysics	1.006

In summary, the point of what has been presented and discussed here is that many of the complex and often time-consuming problems Engineering students in particular and Engineers in general, are required to solve can be done using specialized software packages with very minimal errors and within very little time and with even an added advantage of visualizing the problem-solving process, thus engendering understanding. Therefore, enshrining the use of software in the Engineering curriculum would go a long way to improve quality of teaching, learning and research. This is not, of course, advocating the elimination of solving problems the conventional way – as a matter of fact, the conventional way is part and parcel of simulation methods, as fully understanding the conventional method is, in fact, the basis of properly modeling a problem in the first place, and, in fact, next to experiments, the traditional way of solving problems is next!

4.0 CONCLUSION AND RECOMMENDATION

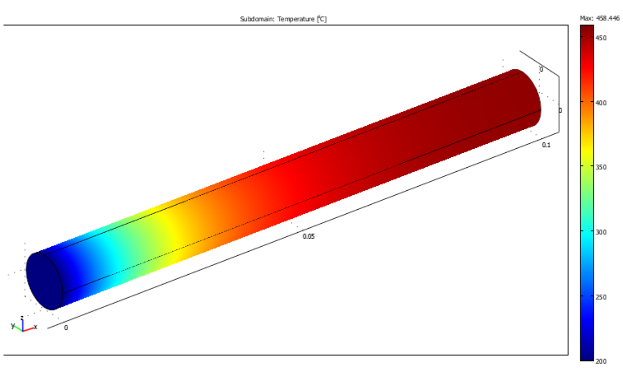
Using special software packages lessen the time spent on solving problems and minimize errors in the course of solving them in the traditional method. The use also enhances understanding of the basis of the problem itself. There is very little disparity between results obtained by all the traditional methods on the one hand and those by software packages. A thorough understanding of the traditional methods of problem-solving leads to a much better modeling of the problem on software. Thus, enriching tertiary education curricular by incorporating the teaching and learning of the use of software packages is necessary for a more robust educational system geared towards solving the problems of the society.

It is therefore, recommended that the curricular of Engineering, and, in fact, all Science-related disciplines be enriched with the teaching and use of software packages, and that more emphasis should be placed on experiments as this serves as the basis of validating both analytical and numerical methods of problem solving. In this light, further work on the case studies presented here should focus on experiments to validate results from any software used.

REFERENCE

1. Ali, A. (1990). *Problems of Curriculum Development, Implementation and Evaluation and Preferred Solutions.* Conference of the Curriculum Organization of Nigeria.
2. Bargallo, R. (2006). Finite Elements for Electrical Engineering. UPC. Pp 248 – 249.
3. Chapra, S. C. and Canale, R. P. (2006). Numerical Methods for Engineers. McGraw-Hill, London. Pp 862 -871.
4. COMSOL Inc (2014): http//www.comsol.com/bogs. Accessed 30 – 08 – 2014.
5. Lewis, R. W. , Nithiarasu, P., and Seetharamu, K. N. (2004). Fundamentals of the Finite Element Method for Heat and Fluid Flow. John Wiley & Sons, Ltd, England. Pp 115 – 146.
6. Martinez, I. (2006). Heat Conduction. *Unknown Publishers*.
7. Oje, F. U. (1998). *The Role of the Teacher in Curriculum Planning for Academic Excellence*. Jos Journal of Education, No. 1, Vol 3. Pp 36 – 39.
8. Oroge, S. A. (1998). *Enriching the Tertiary Curriculum for Relevance and Functionality*. Journal of the World Council for Curriculum and Instruction. WCCI, Region 2, Vol 2. Pp 23 – 27.
9. Sethi, M. C. (2012). Dynamic Response of Beam under Moving Mass. B. Tech Thesis. National Institute of Technology, Roukela. Pp 21 – 23.
10. Ukeje, N. O. (1986). School and Society in Nigeria. Fourth Dimension Co. Ltd. Enugu.
11. vanSant, J. H. (1980). Conduction Heat Transfer Solutions. Lawrence Livemore National Laboratory. Pp 308.

APPENDIX: Subdomain Plots by *COMSOL Multiiphysics*



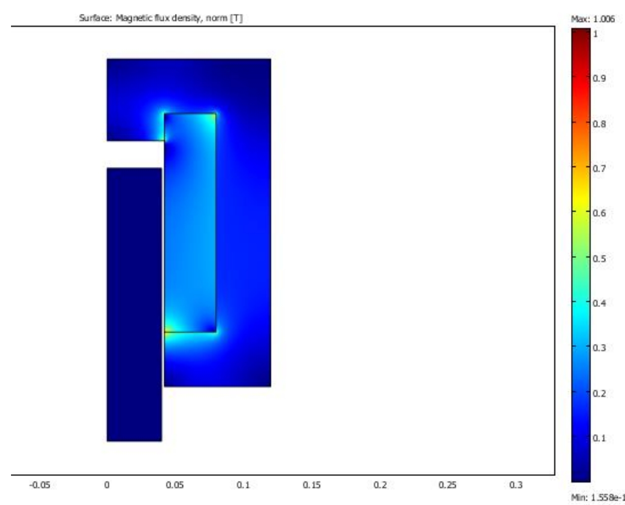


Fig. A1: Subdomain plots of solution of heat conduction through a rod.

Fig. A1: Subdomain plots of solution of Surface Magnetic Flux.

DEVELOPMENT OF AN EMBEDDED LIGHT ACTIVATED REMOTE FOR FAN REGULATOR

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ABSTRACT

This paper focus on the design of a simple and sufficiently sensitive light beam detector via remote, which can function properly and reliably in all indoors ambient lighting conditions. The remote control signal detector compares the luminous intensity on a light beam detector with that on of an ambient luminous intensity detector and given a sufficient difference, initiates a cyclic controller output sequence. The output cycles, changing the state of the controlled fitting from OFF to ON (at different ON states if applicable) and back OFF. The luminous intensity difference detector designed uses two light dependent resistors (LDRs) in special enclosures which increased their sensitivity to a focused light beam in high levels of ambient illumination. A UA741C Op-Amp IC based comparator is used to detect a difference in illuminance between the ambient illumination and the extra illuminance as a result of a focused light beam on the light beam detector. The light remote controlled ceiling fan regulator realized using the luminous intensity difference detector has a control range, which competes favorably with infra-red remote controlled systems. The following features was observed; Successfully detects the difference between the ambient illumination and the illumination as a result of a focused beam of light, from the controller, on the detector LDR in a very wide range of ambient illumination. The system maintains the state of its output in the presence of all ambient lighting conditions. The reliability of the system always detects the luminous intensity difference, provided the luminous intensity at the beam detector LDR is sufficiently higher than that on the reference LDR

KEY WORDS: LDR, Illuminance, luminous intensity and remote control.

1.0 INTRODUCTION

Electrical devices and systems can be remote control by means of wireless handheld controllers. These controllers make use of electromagnetic waves of different spectra. Usually the frequency of the electromagnetic waves used for control is selected from the ranges of frequencies that are not generated internally by the controlled device or externally in the ambient surroundings of the target environment where the controlled device is to be used (Jibrin and Ahmad, 2010).

The control signals are restricted to narrow bandwidths and are expected to be of very specific format at the receiver of the controlled device. These measures are taken to ensure that the controlled device does not respond to random electromagnetic phenomena, to ensure reliability in operation of the controlled system and for control instruction differentiation (William, 2003). The most popular and widely used spectrum for remote control systems today is the infrared range of frequencies. Most consumer electronics and electrical devices in use today are of the infrared type. Infrared signals are invisible to the naked eyes and so the signals are not focused into a narrow beam when used in remote control systems. Therefore accurate pointing of the remote controller to the detector of the controlled device is not necessary, making them easier and more convenient to use (Tocci and Widmer, 1998). Electrical products (systems) comes with their own specific remote controller. It is not uncommon to have up to five different remote controllers in a residential sitting room alone.

Electromagnetic waves of the visible light spectrum is generally not used for remote control systems for several obvious reasons which include the high possibility of interference from natural and man-made light sources which exist in almost all environments where electrical equipment are deployed, the higher power for visible light generation and preference for unobtrusive, discrete and invisible control signals. However, a small niche exists for the use of visible light for the remote control of electrical and electronics systems, this includes simple power “on” and “off” operations, speed or intensity control of multiple home electrical fittings using a single controller (Roll and Joines, 2001).

2.0 LIGHT SENSOR

Light Dependent Resistor (LDR) was chosen because; its sensitivity was deemed to be sufficient to detect the light intensity differences expected in the proposed application, its response time is adequate for the intended application, it is the most suitable for use in a voltage divider network at the input to a voltage comparator circuit, it is cheaper and more readily available than other light sensitive devices (Theraja and Theraja, 1995). Packaged in either hermetically sealed cans, plastic case or coated in moisture resistant epoxy, LDRs are ideal for daylight sensing and switching applications. They can also be used in position sensing applications. The LDR chosen for this work is the SILONEX MPY54C569, Cadmium Sulphide (CdS) photoconductive cell in epoxy coated package, by Farnell® Electronic Components (Van, 2007).

3.0 METHODOLOGY

The methodology adopted are thus:

i. Design of the light intensity difference detector;
ii. Determination of the input bias resistors values;
iii. Circuit analysis; and
iv. Results analysis

i. DESIGN OF THE LIGHT INTENSITY DIFFERENCE DETECTOR

Of the several alternatives, the basic circuit configuration of the detector circuit decided upon is shown in Figure 3.1.

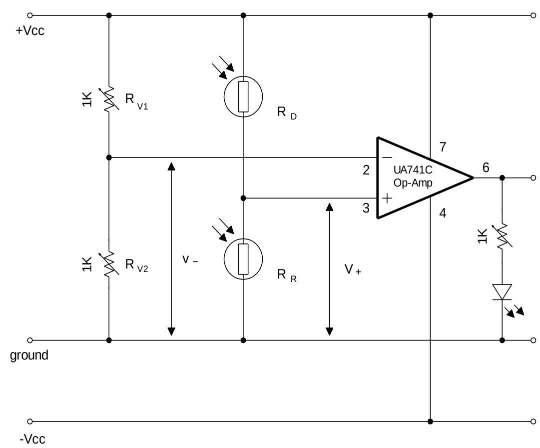

Figure 3.1: Basic Configuration of the Ideal Light Beam Detector

R_D (Detector) and R_R (Reference) are LDRs; R_R is positioned to receive ambient illumination and is not intended as the control signal detector, R_D is positioned as close to R_R to receive approximately the same amount of ambient radiation, but far enough to be separately illuminated by the flashlight's light beam from at least 4.0m away. The LDRs are both of the same make in order to have similar electrical characteristics.

When R_D and R_R are exposed to equal amounts of light intensities, the voltage input to the non-inverting input of the Op-Amp, *V+* would be approximately equal to *Vcc/2*. Resistances of two identical LDRs at equal levels of illumination are not exactly equal. The voltage at the inverting input, V-, can be varied between *Vcc* and ground by adjusting variable resistors R_{V1} and R_{V2}. Resistors R_{V1} and R_{V2} are both 0–1kΩ variable. Ideally, in order to preserve power, they should be much higher values say 0–500kΩ since their voltage divider action is all that is required. All they need is to divide the voltage to provide the required adjustable voltage level to the inverting input and supply the minimum input bias current. However, the higher there value the less precisely adjustable they become. Fine adjustment is required to control the sensitivity of the comparator to the beam of light. *V-* is adjusted to be slightly higher (more positive) than *V+*, to an extent of which to determine the sensitivity of the comparator. With *V-* slightly higher than *V+*, the output of the Op-Amp comparator, measured between pin 6 of the IC and ground, is LOW. LOW here refers to a negative voltage approximately equal to *–Vcc*.

When the illumination on R_D is greater than that on R_R, as a result of say a focused beam of light, its resistance will fall and as a result, the voltage on the non-inverting terminal *V+* would rise. From the voltage divider rule, *V+* can be calculated as (Ramamurthy et al, 2006):

$$v+ = \frac{R_R}{R_R + R_D} \times V_{CC} \qquad \textbf{\textit{(3.1)}}$$

From equation (3.1), it can be readily seen that if $R_R = R_D$ (at equal levels of illumination),

$$v+ = \frac{V_{CC}}{2} \qquad \textbf{\textit{(3.2)}}$$

But if $R_R > R_D$ (When R_D is at a higher illumination than R_R) then,

$$v+ > \frac{V_{CC}}{2} \qquad \textbf{\textit{(3.3)}}$$

Consequently, when the illumination of R_D is sufficient to make *V+* greater than *V-*, the output of the comparator becomes HIGH. HIGH here refers to a positive voltage approximately equal to *+Vcc*. However, immediately the illumination of R_D returns to same level as that on R_R, as a result of retracting the beam of light focused on R_D, the output from the Op-Amp comparator will go back LOW. Thus the basic circuit which can detect the control signal, a focused beam of light on the detector, differentiate it from the ambient lighting conditions and produce an output which can be used to initiate the control action in the controlled device has been designed.

In reality however, the circuit designed here is ideal and impractical because of some drawbacks. Perfecting the detector circuit by studying these drawbacks and modifying the design accordingly will form the main focus of this work.

ii. DETERMINATION OF THE INPUT BIAS RESISTORS VALUES.

In order for the light intensity difference detector to function properly both in the light and in the dark, a means by which the non-inverting input to the Op-Amp would always be supplied with sufficient input bias current had to be found. The circuit was modified to include two biasing resistors, R_B, in parallel with the LDRs as shown in Figure 4.1. For symmetry and maximum sensitivity, both biasing resistors were chosen to be the same value and were designated R_{B1} (in parallel with R_D) and R_{B2} (in parallel with R_R). The value of R_{B1} and R_{B2}, which are equal, will be referred to as R_B.

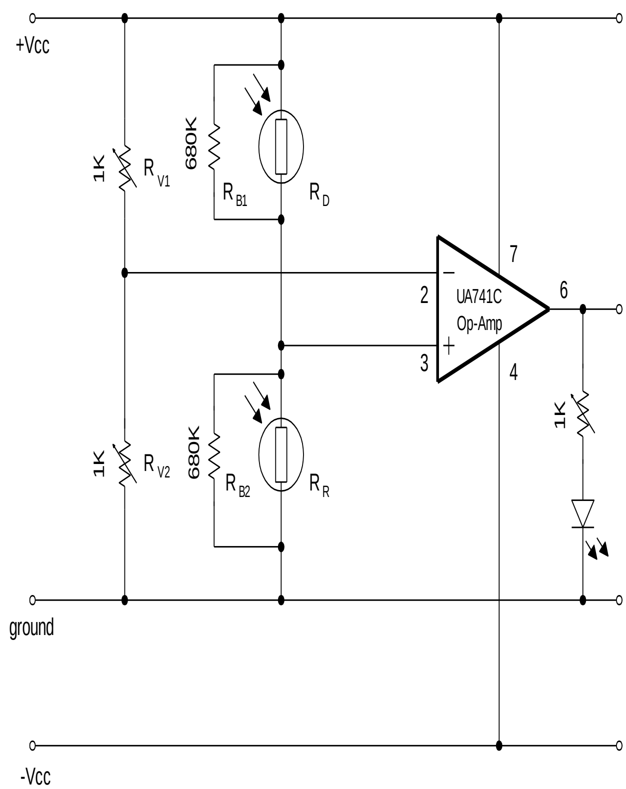

Figure 4.1: Light Beam Detector Circuit with Biasing Resistors

The experimentally determined value of the resistance of the LDRs when the detector resumed proper operation, 690kΩ, is obviously the maximum value that can be used as the biasing resistors. Recall that in complete darkness the LDRs have infinite resistance. In absolute darkness the bias current will be supplied through these resistors.

Lower resistance values can be used to supply the input bias current, but as can be seen from Figure 4.1 the biasing resistors are placed each in parallel with one LDR, since the circuit is to be activated or deactivated by varying the effective resistance of R_D in parallel R_{B1} with respect to R_R in parallel with R_{B2}, the value of the biasing resistors have to be chosen carefully.

If a smaller value of resistance say 10kΩ is chosen for R_B, the effective change of resistance from the parallel arrangement as a result of the illumination of the LDRs will be less than if a higher value of R_B, say 680kΩ, is chosen. As an illustration, Figure 4.2 shows a fixed resistor connected in parallel with an LDR. For different values of the fixed resistance, the effective value of the parallel arrangement will vary for a fixed range of LDR resistance variation.

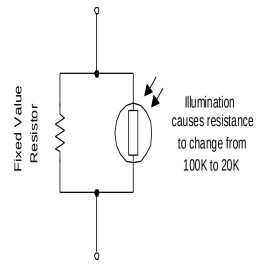

Figure 4.2: Parallel Arrangement of Fixed Resistor and LDR.

iii. CIRCUIT ANALYSIS

Three main parts of the electronic ceiling fan regulator system, namely the light beam detector, the clock pulse generator and the timer IC based speed-switching circuit. The sensitivity of the light beam detector is set indoors under normal lighting conditions. Initially, the two encased LDRs R_D and R_R are placed in complete darkness. The voltage across the ground terminal and the non-inverting input is measured and compared to that across the positive power supply rail and ground.

If the voltage at the non-inverting input is less than half the value of the positive power supply, variable resistor R_{V1} is set at its maximum value of 1kΩ and variable resistor R_{V2} will be used for sensitivity adjustment. Alternatively, if the voltage at the non-inverting input is more than half the value of the positive power supply voltage, R_{V2} is set at its maximum value of 1kΩ and R_{V1} will be used for sensitivity adjustment. This is done to ensure that when the light beam detector's sensitivity is finally set, the series arrangement of R_{V1} and R_{V2} will drain as little current as possible from the power supply. This is so because one of them is always set at its maximum value. It is possible to adjust the two variable resistors to provide the inverting input with the required voltage for optimum sensitivity at an infinite range of values, as long as their resistances are at the same proportion with respect to each other. However, to set the current drain to the least possible value the procedure of always setting one to the maximum value is mandatory.

With the two LDRs placed in complete darkness, the variable resistor designated for sensitivity adjustment is slowly varied to the position where the output of the comparator just switches from the HIGH state to the LOW state. This can be observed from relay RLD's switching action, or during construction by inserting a 1kΩ resistor in series with an LED between the comparator's output and the ground terminal. After the state where the output just goes LOW when the two LDRs are in complete darkness, the detector LDR, R_D, should be exposed to the ambient lighting conditions; this should cause the output to go HIGH since the other is in complete darkness. The detector LDR should now be replaced in complete darkness, if the comparator's output doesn't immediately return to the LOW state, as is usually the case; the variable resistor designated for sensitivity adjustment should be further adjusted in the direction that turns the output back LOW.

This process of exposing the detector LDR, R_D, to ambient light, replacing it in complete darkness, and tweaking the value of the sensitivity adjustment resistor should be repeated until such the state when the output from the comparator immediately returns to LOW whenever the detector LDR is exposed to ambient light and is replaced in complete darkness.

At this point the light beam detector circuit is at its most reliable sensitivity setting. It may be more sensitive at the previous settings, but the fact that the output doesn't immediately return to the LOW state immediately the detector LDR is replaced in darkness makes it unreliable for control purposes.

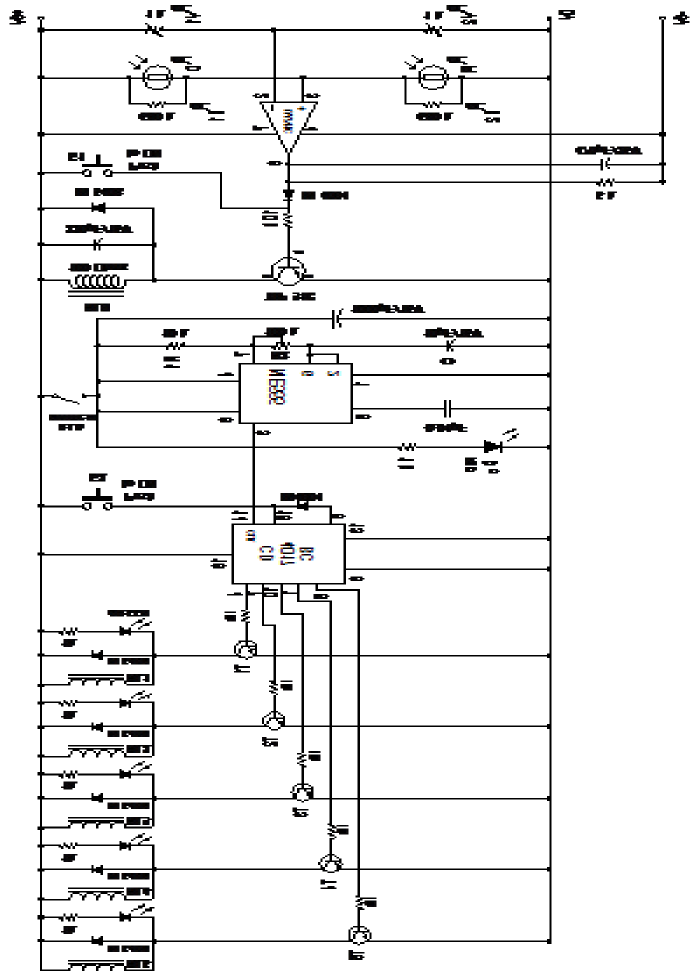

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Figure 5.1: Complete Circuit of the Design

The output from the comparator assumes one of two states HIGH or LOW. Recall that a comparator acts like a single bit analog-digital-converter. The HIGH state refers to an output voltage equal to or slightly less than the positive power supply voltage, in this circuit that is *+6V*. At the LOW state the output voltage is equal to or slightly higher (more positive) than the negative power supply voltage, *-6V*.

In the LOW state, the 470µF, 25V capacitor and 5kΩ resistor connected across the comparator's output and the negative power supply lines have virtually 0V across them and serve no purpose. The IN4001 diode is reverse biased and no current flows through. Switch S_1 may be used to manually activate the subsequent circuitry to change the speed of the fan or switch it off. When the manual control switch S_1 is pushed down, the base of the TIP31C power transistor is connected to the positive power rail, *+Vcc* through a 10kΩ resistor. This activates the subsequent stages. With S_1 pushed down, the IN4001 diode protects the output of the Op-Amp which is in the LOW state from being forced to the high state and potentially creating a short across the positive and negative supply rails.

When the control light beam is detected, to transit to the HIGH state the output of the detector's comparator must first charge the 470Mf, 25V capacitor this creates a very short delay and when charged the capacitor helps filter out any transient state changes that may occur to cause instability in the switching of the next stage. The 5kΩ resistor serves as a pull-down resistor to enable the output return to the LOW state quickly whenever the control beam is withdrawn. It provides a path for the capacitor in parallel with it to discharge. When in the output is HIGH the IN4001 diode conducts and turns the TIP31C switching transistor on through a 10kΩ resistor.

The TIP31C, when on, is operating in the saturated region of its operational characteristics and consequently its V_{CE} is approximately equal to zero. The collector terminal is virtually grounded and relay's (RLD) coil is supplied with the right voltage *+6V* to turn on. It however only comes on after a very short delay as the 220μF, 16V capacitor charges across it. The IN5408 diode, in parallel with the relay coil and the 220μF, 16V capacitor, is connected in reverse bias as a free-wheeling diode to drain the high current that is created when the energy stored in the magnetic field of the relay coil returns to the circuit whenever the transistor switches off.

The combination of the 470μF, 25V capacitor at the output of the comparator and the 220μF, 16V across the relay RLD coil help to filter out detection transients and cause a delay to ensure reliability of detection in the light beam detector system.

Whenever the control light beam is detected the TIP31C transistor switches on and Relay RLD is powered, this causes its contacts RLD Switch to close. The closing of switch RLD causes the NE555 Timer IC based clock pulse generator circuit to be powered.

When RLD switch is closed, power is suddenly applied to the NE555 Timer clock pulse generator; this causes undesirable transients in its output before its steady state operation is attained. The undesirable transients on the CLK input to the 4017 Counter/Divider IC clocks the IC a random number of times causing an unpredictable state of its outputs. To avoid this initial random state of the controllers output whenever the control beam is detected, a high value capacitor 1000μF, 16V is used to force the power to the clock pulse generator to rise slowly to the positive power supply voltage, *+6V*. The inclusion of this capacitor completely eliminates the transients in the output of the NE555 Timer based clock pulse generator and allows a smooth clocking of the CD4017BC in order to have a predictable transition of the output of the ceiling fan regulator from one state to another. When the 555 Timer is used in the astable multivibrator circuit configuration, the values of three components R_1, R_2, and C determine the frequency of the clock pulses generated. In this work R_1 is 10kΩ, R_2 is a pre-settable 100kΩ resistor and C is 10μF, 16V. The pre-settable 100kΩ is adjusted near its maximum value to give an output frequency of approximately 1Hz. As long as the circuit is powered it continues to generate square wave clock pulses indefinitely.

A red LED D_O in series with a 1kΩ resistor is used to indicate whenever the control beam is detected and the clock pulse generator circuit turns on. The LED however, doesn't accurately indicate when the control light beam is retracted because when RLD switch opens, the clock pulse generator circuit goes off much slower than the beam detector as a result of the need for the 1000µF, 16V to discharge which it does mainly through the series arrangement of the 1kΩ resistor and the red LED, D_O.

The CD4017BC IC is used to set the output of the ceiling fan regulator at the desired states. The IC is powered by connecting pin 16 to the positive power supply rail and pin 8 to the ground terminal. Pin 13, the Clock Enable input is active-low and is also connected to the ground rail. The Clock Enable input is tied to the ground rail to permit the CLK input at pin 14 to trigger the IC whenever a positive transition is detected. The clock input to the IC at pin 14 is triggered on the rising edge of the clock pulse, which is why the power to the 555 Timer stage is controlled at the positive terminal and not the ground. If the clock signal is at the HIGH state when the power to the 555 Timer is disconnected, it goes LOW and falling edge of the clock pulse doesn't further trigger the Counter/Divider IC. If the clock signal is at the LOW state when the power to the 555 Timer is disconnected, it remains LOW and doesn't trigger the Counter/Divider either.

Whenever the 555 Timer based clock pulse generator IC is powered on the detection of the continued presence of the control beam, the 4017 continues to respond to the positive transition of the clock input at pin 14. At any point in time, unless when reset at pin 15, one of its ten decoded outputs Q_0, Q_1, Q_2, Q_3, Q_4, Q_5, Q_6, Q_7, Q_8, Q_9 at pins 3, 2, 4, 7, 10, 1, 5, 6, 9 and 11 respectively is in the HIGH state. Q_0 and Q_1 at pins 3 and 2 respectively are not used and serve as delay before an output from the regulator is observed. Outputs Q_2, Q_3, Q_4, Q_5, and Q_6 at pins 4, 7, 10, 1, and 5 respectively are used to set the regulator at a particular speed setting. Output Q_7 at pin 6 is used to reset the count of the IC by connecting it to the RESET input at pin 15. Whenever the Q_7 output goes HIGH, all the Q outputs are set LOW and on the next positive transition of the clock pulse the count restarts at Q0 at pin 3. This cycle continues and only terminates when the control light beam is withdrawn. When the control beam is withdrawn the detector output goes LOW, transistor TIP31C and Relay RLD both turn off, disconnecting the power to the clock pulse generator. When the clock pulse generator turns off the input to the 4017 IC becomes a steady LOW signal, and its outputs remain at the state they were before the withdrawal of the control signal.

A means by which the electronic ceiling fan regulator's output can be reset to the off state without turning off the regulator's power supply is provided via switch S_2. Whenever S_2 is pressed the RESET input at pin 15 of the 4017 IC, which is an active-high input is temporarily connected to the positive power rail. To prevent harm to the IC through pin 6, which is also used to reset the count, pin 6 is connected to pin 15 through and IN4001 diode. This diode ensures that during manual resetting of the IC the pin 6 outputs is protected from damage by a direct connection to the positive power rail, which can cause excessive current flow due to short-circuiting of the power line when the output is LOW.

For each speed output of the regulator, the HIGH state either of the Q_2, Q_3, Q_4, Q_5, or Q_6 decoded outputs at pins 4, 7, 10, 1, or 5 respectively of the 4017 Decade Counter/Divider IC is used to turn on the corresponding switching transistor T_1, T_2, T_3, T_4, *or* T_5 respectively through 10kΩ current limiting resistors. Whenever either of these transistors is on, the corresponding relay coil RL_1, RL_2, RL_3, RL_4, *or* RL_5 is powered across the *+6V* and ground power supply terminals. A freewheeling diode is used across each of the five relay coils to protect the switching transistors from damage as a result of the high current created by the collapse of the magnetic fields of the relay coils whenever the transistors turn off. To indicate the particular speed at which the output from the electronic ceiling fan regulator has been set, a green LED in series with a 1kΩ resistor is also connected across each relay coil to indicate when the coil, which controls a particular output speed, is powered.

Recall that only one of the 4017 IC's decoded outputs should be in the HIGH state at any point in time; this implies that the regulator cannot be set at more than one speed at a time.

The schematic showing how the relays switches control the speed of the fan, by selecting the particular output from the manual regulator's inductive coil to connect to the ceiling fan or opening the circuit by connecting to none has been illustrated in Figure 5.1.

iv. RESULTS ANALYSIS

The Luminous Intensity Difference Detector designed and constructed in this paper has the following features:-

i) Successfully detects the difference between the ambient illumination and the illumination as a result of a focused beam of light, from the controller, on the detector LDR in a very wide range of ambient illumination.

ii) Responds only to a sustained beam of light that is focused on the detector LDR, which has intensity, which is higher than the ambient to a preset extent. Such a beam is not normally obtainable by random light sources or phenomena.

iii) Does not respond to luminous intensity differences caused by shadows (steady or passing) or light beams of a short duration.

iv) Maintains the state of its output in the presence of all ambient lighting conditions.

v) Simple in design and cheap to implement, making it an attractive solution for the remote control of electrical fittings.

vi) Reliability. Always detects the luminous intensity difference, provided the luminous intensity at the beam detector LDR is sufficiently higher than that on the reference LDR.

vii) Free from output state changes due to power fluctuations or LDR resistance change transients.

4.0 CONCLUSIONS

It was clearly seen that the designed system was successfully achieved by detecting the difference between the ambient illumination and the illumination of a focused beam of light, on the detector LDR, and does not respond to luminous intensity differences caused by shadows or light beams of a short duration. The system also maintains the state of its operation at ambient lighting conditions. Simple in design and cheap to implement, making it an attractive solution for the remote control of electrical fittings.

REFERENCES

Jibrin, M.M. and Ahmad, K. (2010) "Development of a GSM-Based SMS Remote Controller for Home Appliances" Nigerian Journal of Engineering, Faculty of Engineering Ahmadu Bello University Zaria., Vol. 17 No.1. ISSN: 0794-4756. PP 99-105

Ramamurthy, H; Prabhu B.S. and Gadh, R. (2006) "Application of generic reconfigurbale wireless interface for industrial automation scenarios", US Patent Disclosure, UCLA Case No. 2006-002-1

Roll, W. G., and Joines, W. T. (2001). *RSPK and consciousness.* Paper presented at the Proceedings of Presented Papers: The Parapsychological Association 44th Annual Convention, 267–284.

Theraja B.L. and Theraja A.K., (1995) "A Text-book of Electrical Technology" S. Chand & Company LTD, New Delhi, India, pp. 1753-1761

Tocci R.J. and Widmer N.S., (1998) Digital Systems: Principles and Applications, Prentice Hall International (UK) Limited, United Kingdom, pp. 240, 490.

Van, R.T., (2007) 'Dark/Light Activated Relay' http://www.uoguelph.ca/~antoon/circ/actrelay.htm, 2007

William G. R (2003) Poltergeists, Electromagnetism and Consciousness *Journal of Scientific Exploration*, Vol. 17, No. 1, 0892-3310/03. PP. 75-86

MICROCONTROLLER BASED ELECTRONIC VOTING MACHINE FOR FREE AND FAIR ELECTION IN NIGERIA

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ABSTRACT

Since independence, Nigeria has failed to conduct a fully free and fair election due to socio-political and sometimes religious factors. Elections are always rigged and destabilized using thugs and other rigging techniques. Paper or ballot voting and corruption are the main causative agents for this failure of free and fair election. Electronic voting could prevent election rigging and minimise it to a greater extent if the government and the people will be committed towards solving the nation's problems. Thus the best election method for Nigeria is an electronic voting This paper presents the design and implementation of an electronic voting machine designed with Unified Modelling Language (UML) and then Simulated in Proteus ISIS using PIC18F4520 Microcontroller. The microcontroller program was written in C in MPLAB IDE. The system enables voters cast their votes electronically. The system ensures only the valid voter votes and only once. This could be achieved by identifying the voter's finger print in addition to the use of the Radio frequency identification (RFID) identity added on the voter's card to enhance the system security. The system automatically sends each vote casted to the INEC database where a program developed counts the votes for each party and provides the results at the end of the election to the INEC officials and to the other national and international observers and media. The electronic voting machine was designed and simulated successfully

Keywords: Electronic voting machine, rigging, Radio frequency identification (RFID), Unified Modelling Language (UML), MPLAB IDE and Proteus ISIS.

1.0 INTRODUCTION

According to the Law Dictionary (1910) "an Election is an act of choosing or selecting one or more from a greater number of persons, things, courses, or rights". It is the formal way of selecting a leader in a democratic state. Nigeria is been plague by un-free and fair elections. Corruption and the primitive paper ballot used are the main hurdles for free and fair elections in the country (Awopeju 2011). The Nigerian electorate system is purely unjustifiable having the election commission been inaugurated by the government in power, corruption in politics and use of thugs to disrupt elections has been a daily rigging technique in the Country. Electronic voting was considered to be the best voting system for Nigeria as it can overcomes most of the problems encountered by the ballot voting (Kuye C.O et al 2003). However, this won't be achieved until the government and the people are so committed.

Qadah and Taha (2006) developed an electronic voting machine set for university student's elections. It used mobile network communication for the students to cast their votes. A simple electronic voting machine was designed using switches, gates and other discrete electronic components. It uses seven segment display to display the results (Hoque 2014). Carson et al (1987) patented electronic voting machine using a motor driven mechanism for a ballot paper while Thomas E. et al (1975) patented microprocessor controlled buttons, buffers and displays.

This paper presents a design and simulation of an electronic voting machine that could be used for free and fair election in Nigeria. The work has the following objectives:

- To understand the problem and generate the project background.
- To gather and analyze the requirements of the system
- To produce the system design using UML
- To implement the system
- To test and evaluate the system

The electronic voting machine presented in this paper is cost efficient and more user- friendly. The object oriented design used made the system more robust, qualitative and reliable (Douglass 2004).The system only focuses on the design and simulation of the electronic voting machine. The INEC server application was developed for the simulation and testing purpose. The system is not concerned about the encryption of data over network. The data was encrypted only for simulation purpose. The system can detect when someone votes already and when unregistered voter wanted to vote. Both attempts would be denied by the system.

2.0 METHODOLOGY

Spiral model life span was chosen for this system for its lesser problems than waterfall model **(**O'Docherty 2005). The requirements of the system were elicited from interviews and background reading out of the requirement gathering methods (Bennett, McRobb, Farmer 2006). The requirements were then analysed using Unified Modelling Language (UML). The system was also designed using Object Oriented approach with the UML diagrams. It was implemented as a real time embedded system using PIC microcontroller, finger print sensor, RFID reader and the other electronic components. The program for the microcontroller was written in C programming language using C18 compiler in MPLAB IDE and then included into the microcontroller during the simulation. Below block diagram of the system below describes the various units of the system. The system was simulated using Proteus ISIS and a visual Basic application developed to serve as the INEC server. The application verifies voters, saves the records of votes and finally provides the election results based on the votes cast.

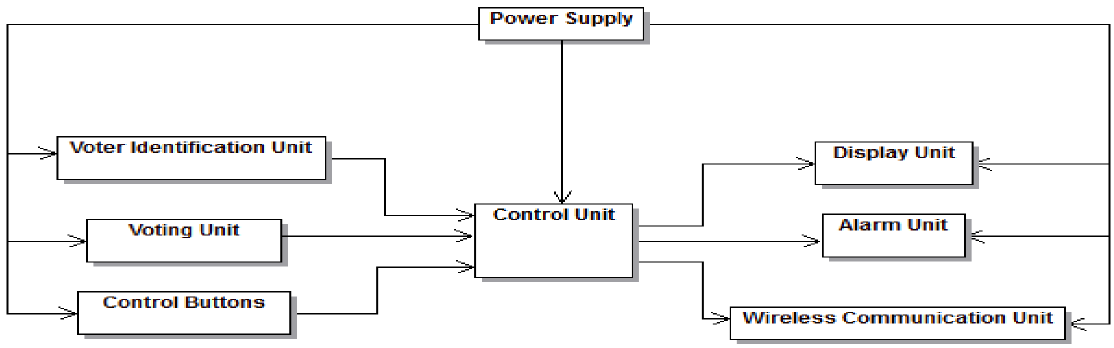

Fig1: System Block Diagram

3.0 REQUIREMENTS GATHERING AND ANALYSIS

Existing voting systems in some developed countries were observed to elicit the requirements of this voting machine. Background reading was also conducted. Hence the system shall statement was derived as detailed below. The Console, context and use case diagrams were drawn for the system analysis.

3.1 CONSOLE DIAGRAM

Console diagram gives the physical view of the expected system after development. The Figure below shows the system's console diagram

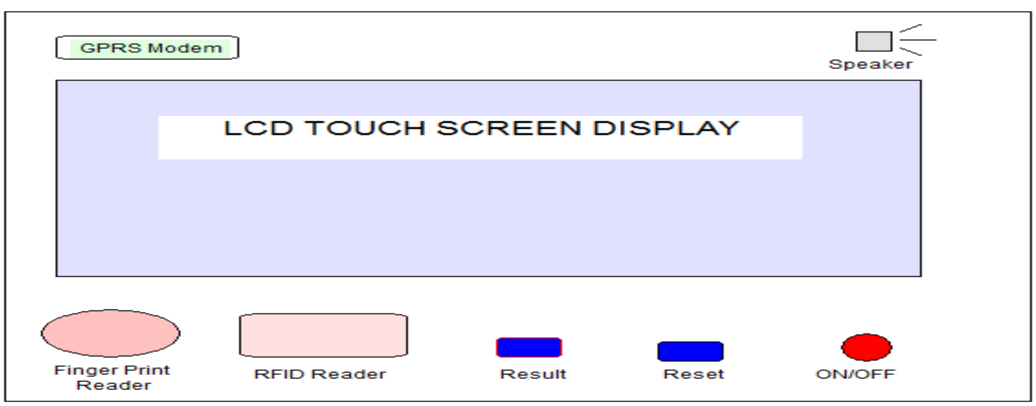

Fig 2: System Console Diagram

3.2 CONTEXT DIAGRAM

Context diagram shows the input process output of a system. It depicts the whole system as a single block showing its inputs, processing and outputs units. This is to know what the system takes in as an input, what it processes and what the system outputs to the user or an actor (Lutowski 2005). Below is the context diagram for the system.

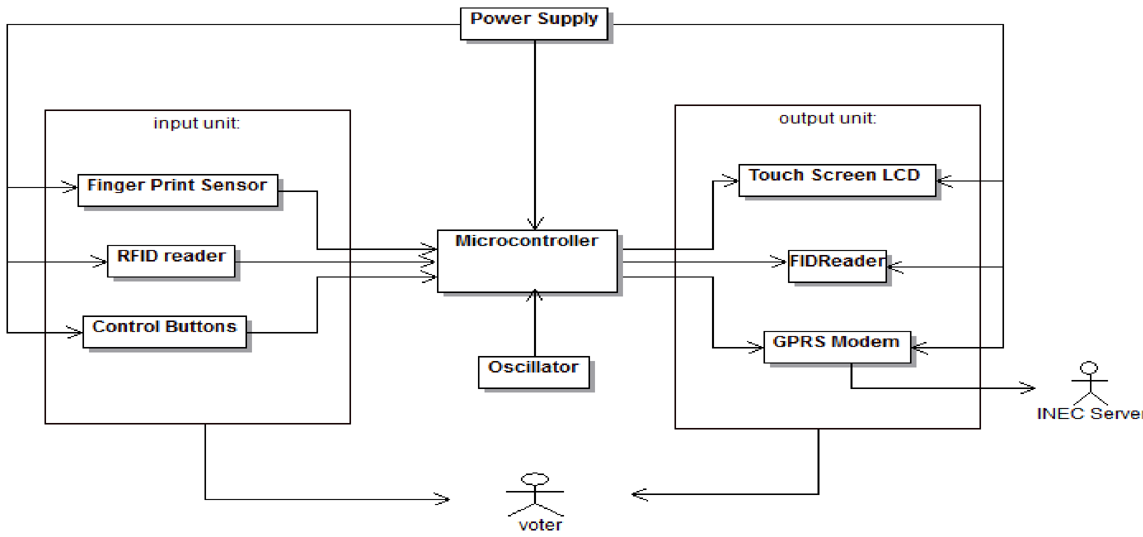

Figure 3: System Context Diagram

3.3 USE CASE DIAGRAM

A use case shows the functions of a system from the client's perspective. It also shows the interaction between the system and the actors using the system (Bennett, McRobb, Farmer 2006). Below is the use case diagram for this system

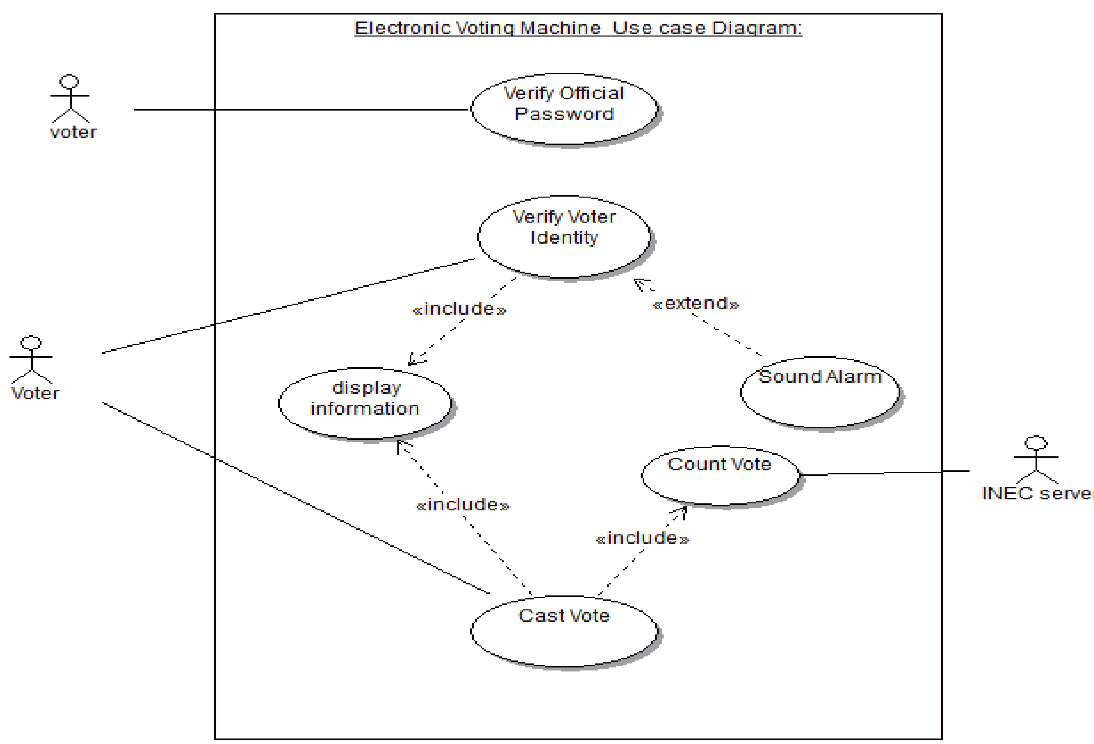

Fig 4: System Use-case Diagram

4.0 *DESIGN*

4.1 Hardware design

The system consists of microcontroller, power supply, input/output, display and alarm units. Each unit was designed separately. The microcontroller selected was PIC18F4520.The selection depends on the system requirements (Bates 2008). The PIC has 40 pins which are enough for all connections to other hardware (Microchip 2008). It also has adequate memory and features for this system development. It has enough technical support and popularity for embedded system development (Huang, 2005). Serial RFID Reader and biometric Finger Print sensors where selected to connect to the microcontroller using UART and USART respectively. Touch Screen LCD was selected to facilitate easy voting. Below is the circuit diagram for the system designed

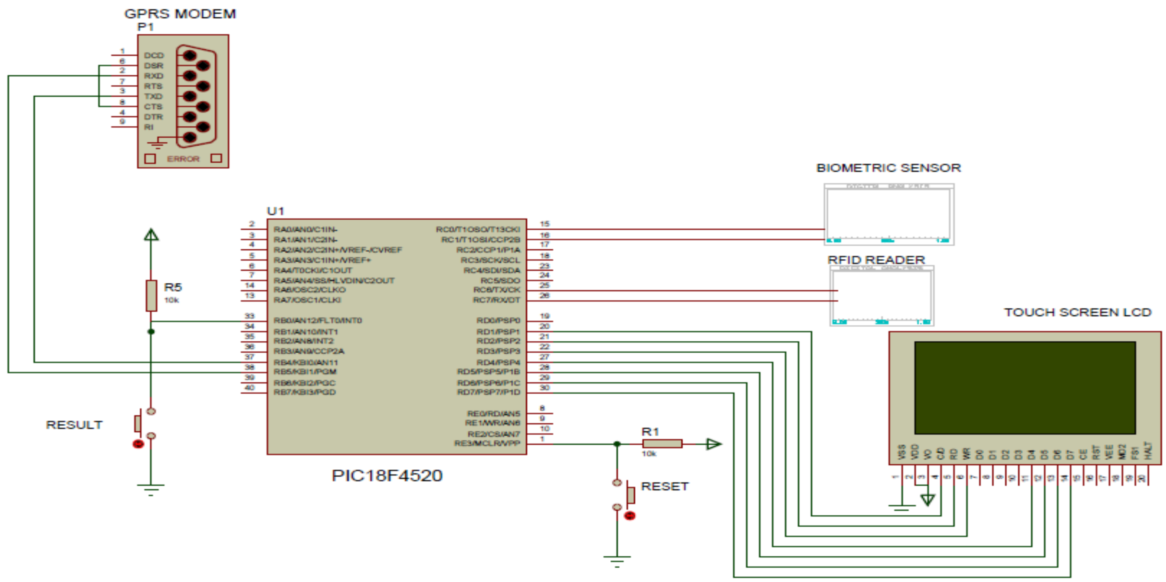

Fig 5: The system circuit diagram

4.2 Software design

Since Object-Oriented approach provides more robust and qualitative software, the system was designed with UML diagrams (O'Docherty 2005). The Activity, sequence, association and class diagrams were drawn for the system using UML studio.

4.2.1 ACTIVITY DIAGRAM

Activity diagram like the flow chart shows the flow of communications between objects and series of operations and decisions taken by the objects to achieve a certain task. Below is the activity for this system.

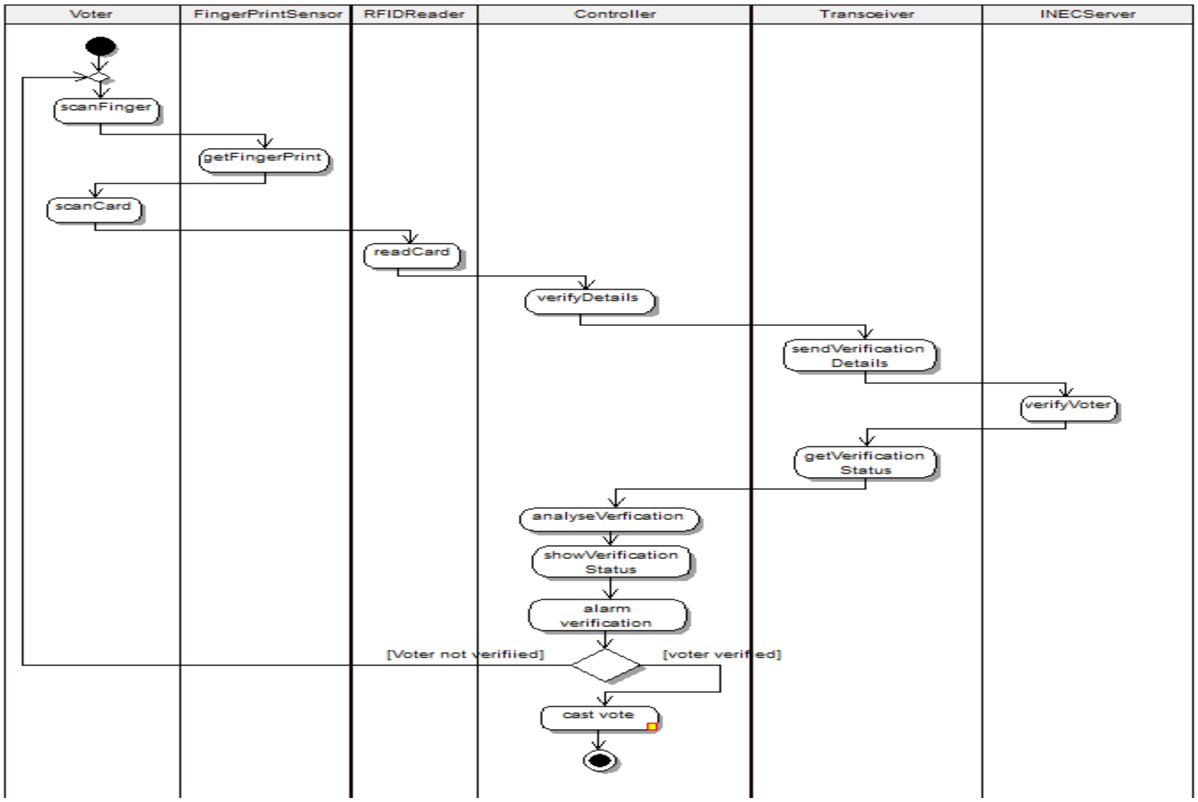

Fig 6: The activity diagram

4.2.2 SEQUENCE DIAGRAM

The sequence diagram gives details of information interchange, operations and decisions between the objects and actors with respect to the time reference. Below is the sequence diagram of the system.

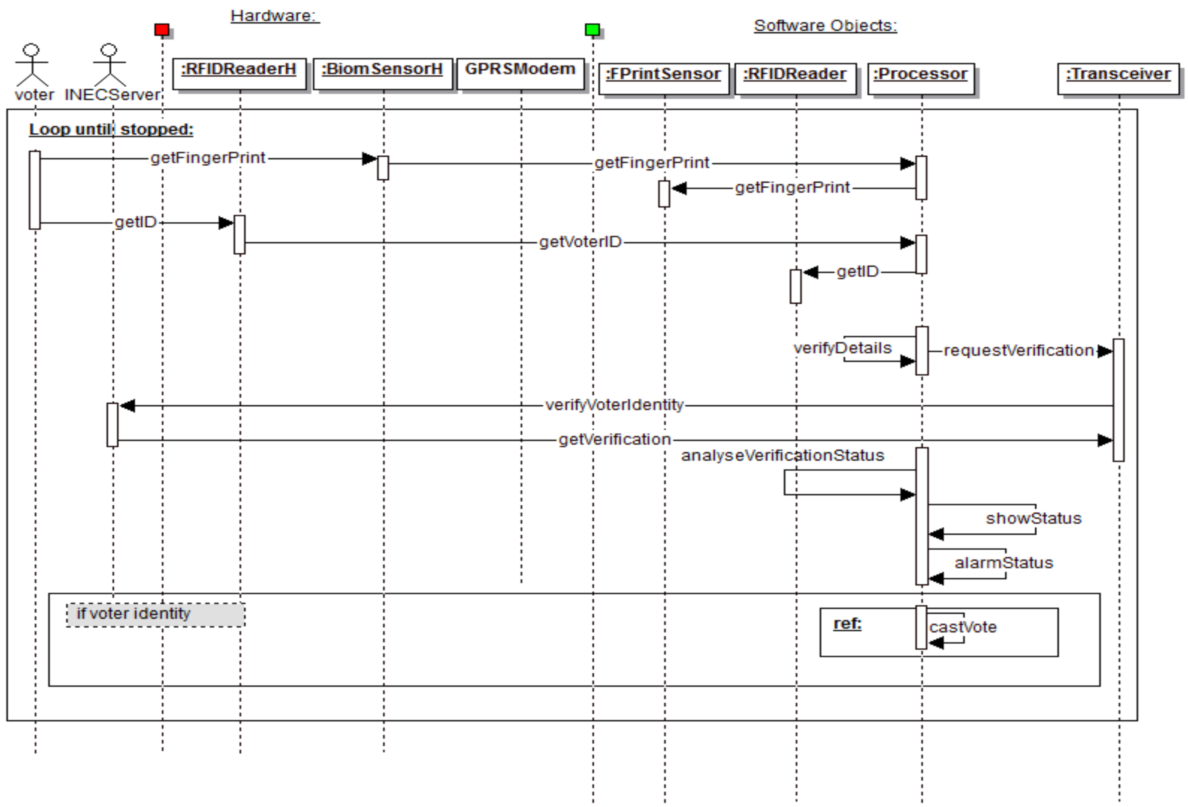

Fig 7: The sequence diagram

4.2.3 ASSOCIATION DIAGRAM

This diagram shows the relationship between the various classes of the software objects. Below is the association diagram for this system.

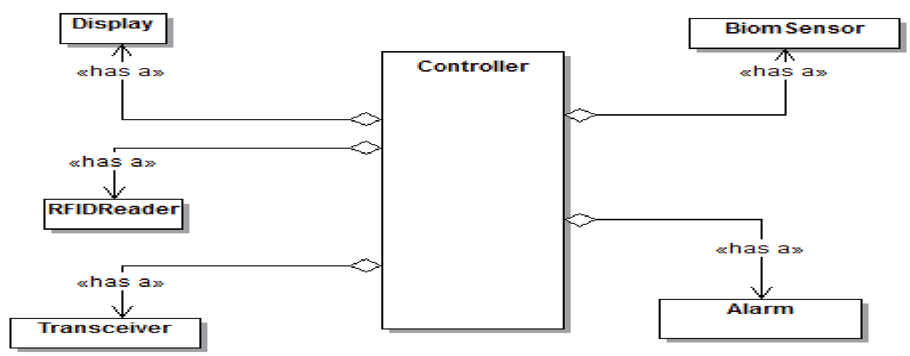

Fig 8: The association diagram

4.2.4 CLASS DIAGRAM

This diagram shows the relationship between the various classes of the software objects .It also shows the attributes and methods belonging to each class. Below is the class diagram for this system.

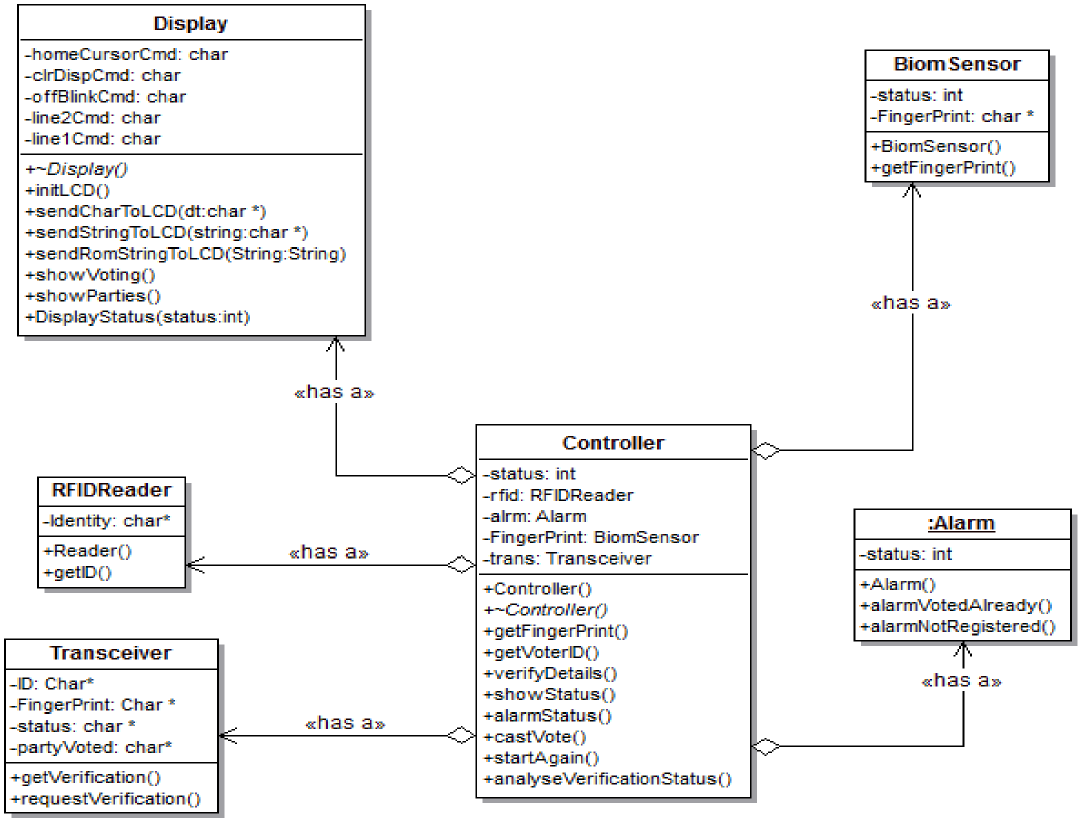

Fig 9: The class diagram

5.0 IMPLEMENTATION

The system was simulated in Proteus ISIS. For this purpose, the RFID reader was replaced with a keypad so that the identities would be entered manually. COMPIM was used to serve as the GPRS

Modem. It provides the connection between the system and the INEC server application. The INEC server application was also developed with Visual Basic 2010. Below is the simulated system.

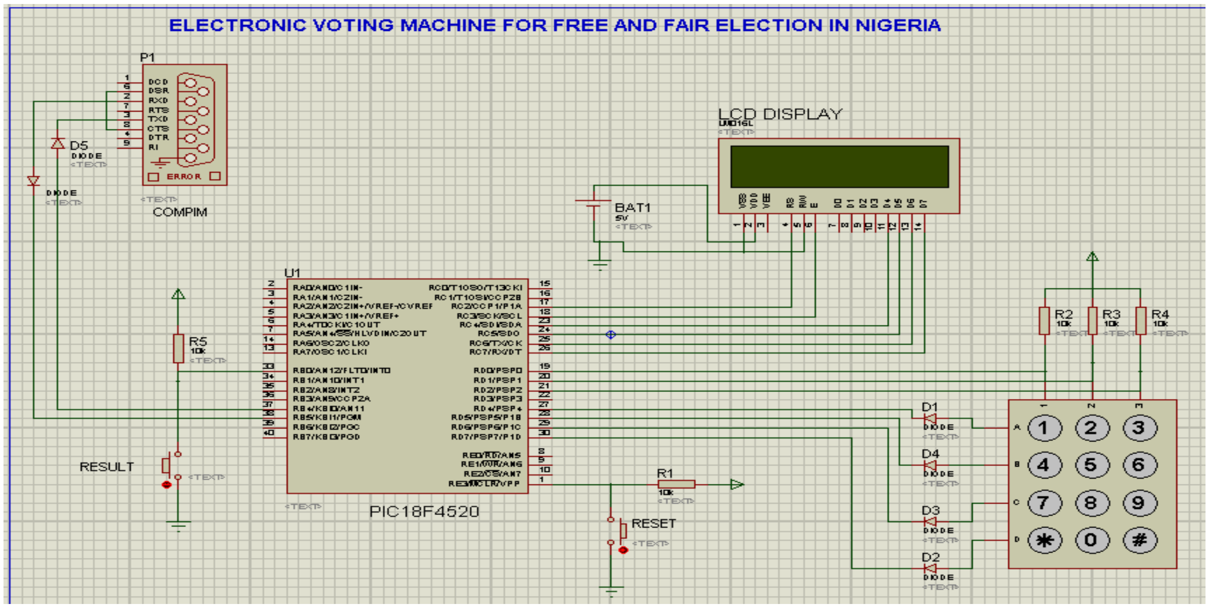

Fig10: Simulated Circuit

5.0 RESULTS AND EVALUATION

After the system was designed and implemented in Proteus ISIS, it was tested with the aid of a Visual Basic application developed to serve as the INEC server. The application verifies voter's identities from pre-recorded database. It saves all the records of the voting for each voter. It also provides the final results including the total number of votes casted and the positions of the political parties. The system was tested and found working successfully. Below is the result obtained from the simulation.

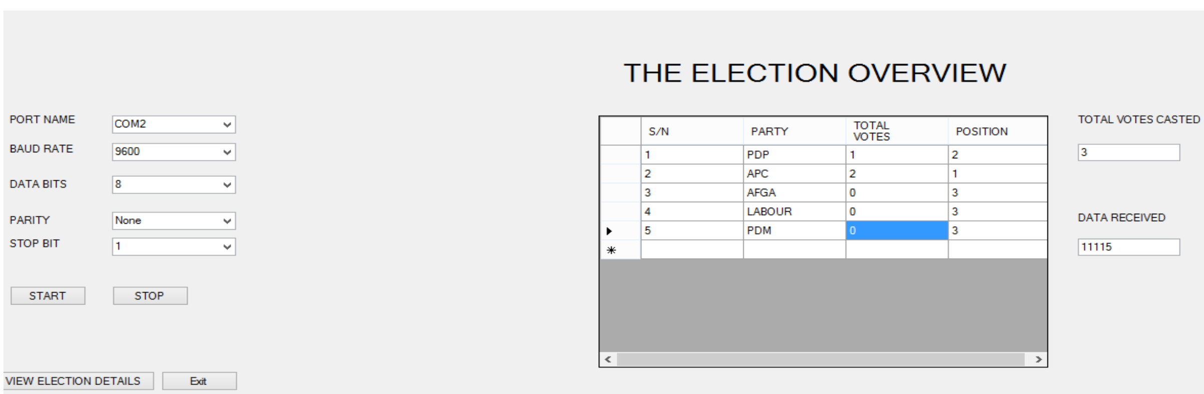

Fig11: Result of the Simulated System

7.0 DISCUSSIONS AND CONCLUSION

Ballot paper election gives room for rigging elections especially in country with high level of corruption and illiteracy like Nigeria. Electronic voting is the hope for free and fair election in Nigeria. This paper presents a microcontroller based electronic voting machine designed in Object Oriented Approach using Unified Modelling Language (UML). It was simulated with Proteus ISIS and a Visual Basic 2010 application developed serving as INEC server. The system was designed and simulated successfully. It was found working as specified by its requirements. With this system, election rigging could be reduced to a minimum.

8.0 RECOMMENDATIONS FOR FUTURE WORK

To further enhance this system in future work, the following were recommended:

- A strong and power encryption should be used for the data communication.
- Voter's picture should be shown on the machine when verified.

REFERENCES

Awopeju A (2011) *Election Rigging and the Problems of Electoral Act in Nigeria*. Afro Asian Journal of Social Sciences Volume 2, No. 2.4 Quarter IV 2011 ISSN 2229 - 53131

Bennett, S., McRobb S., Farmer, R. (2006) *Object-Oriented Systems Analysis and Design Using UML*. 3rd edition.UK: McGraw-Hill Education Limited

Bates M.P (2008) *Programming 8-bit PIC microcontrollers in C: with Interactive Hardware Simulation.* Oxford UK: Elsevier

Carson H., Indianapolis, Ind. (1987) *ELECTRONIC VOTING MACHINE*. [Online]Available from <http://www.google.com/patents/US4649264> Access [12/11/2014]

Douglass, B. P. (2004) *Real Time UML: Advances in the UML for Real-Time Systems*. 3rd edition. Boston: Pearson Education Inc.

Hoque Md. (2014) A *Simplified Electronic Voting Machine System*. International Journal of Advanced Science and Technology Vol.62, (2014), pp.97-102.

Huang H. (2005) *PIC Microcontroller: An introduction to Software and Hardware Interfacing*. U.S.A: Thomson Delmar Learning Inc.

Kuye C.O et al (2003) *Design and Analysis of Electronic Voting System in Nigeria*. International Archive of Applied Sciences and Technology: IAAST; Vol 4 [2] June 2013: 15-20. Society of Education, India

Law Dictionary (1910) *what is an election*. [Online]: Available from <http://thelawdictionary.org/election/ >Accessed [13/11/2014]

Microchip Inc. (2008) *PIC18F4520 datasheet* U.S.A: Microchip Technology Inc.

O'Docherty M. (2005) *Object –Oriented Analysis and Design: Understanding System – Development with UML 2.0*. West Sussex: John Wiley and Sons Limited

Qadah Z., Taha R. (2006) *Electronic voting systems: Requirements, design, and implementation.* Computer Standards & Interfaces 29 (2007) 376–386. Elsevier Ltd.

Lutowski, R. (2005) *Software requirements : encapsulation, quality, and reuse*. New York: Taylor & Francis Group, LLC

Thomas E. et al (1975) *ELECTRONIC VOTING MACHINE*. [Online]: Available from <http://www.google.com/patents/US4015106> Accessed [12/11/2014]

RESEARCH COMMERCILIZATION THROUGH UNIVERSITY-BASED BUSINESS INCUBATOR

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ABSTRACT

Technology commercialization is growing in many parts of the world. Recently, the role that universities play in this process has gained particular attention. Industry has largely being carrying the role of technology commercialization. However, universities are now playing a more positive role, especially in advanced nations including the United States and European countries, in commercializing the research results from university laboratories. From this perspective, Nigerian universities can also play the key role at very early stages of technology commercialization. Measures have to be put in place to manage the early stages of the commercialization processes for university technologies and researches, especially engineering researches. These include technology transfer offices, technology incubators and gap funding. Educational courses to assist technology commercialization have not been developed in Nigerian universities. If these courses can be developed in appropriate ways at the universities, they may accelerate technology commercialization. This study seeks to show the features and the effects of technology incubators on the commercialization of university developed technologies. Business incubation is an efficient tool that maximizes the success of emerging companies. It creates jobs, revitalizes communities, and commercializes new technology thereby enhancing economic development. Interest in business incubation comes from a variety of sources which include local and regional governments, universities, chambers of commerce, science parks, private companies, private real-estate developers and non-profit organizations. In this age of knowledge-based and technological drive of economy, innovation and entrepreneurship have become the prime drivers of economic growth. Technology-based incubators are envisioned by many countries as an effective instrument for local development, technology transfers, stimulation of innovation and the cross-fertilization of ideas between researchers and entrepreneurs to spin-off companies.

Keywords: Business Incubation, University, Technology commercialization,

1. INTRODUCTION

Responding to the educational and social challenges of rapidly growing emerging economies requires a new type of university, cantered not only on educating individuals and producing intellectual capital but on educating organizations to be able to transform their research into profitable products and services for local and global markets, creating sustainable jobs for their graduates and communities.

The development of vibrant and self-renewing innovation and commercialization culture is the desire of virtually all leading universities and companies who seek to not become stagnant and drive growing value to customers and shareholders. Business Incubators are intended to link technology, resources and know-how to entrepreneurial talent for the purposes of accelerating the development of new companies, and thus speeding up the commercialization of technology (Minshall et al, 2005; Markman *et al*, 2008; Peters *et al*, 2004).

Business incubation is an efficient tool that maximizes the success of emerging companies. It creates jobs, revitalizes communities, and commercializes new technology thereby enhancing economic development. Business incubation is not a new phenomenon. It has been around since 1942 in schools and universities where students and professors were given the opportunity to test and employ their knowledge and research to start up new companies. In 1942 Student Agencies Inc. located in Ithaca, New York was created to incubate student companies. In 1946, Massachusetts Institute of Technology (MIT) President, Karl Compton and other alumni founded the American Research Development (ARD) incubator. The first known incubator outside of the academic environment was the Batavia Industrial Centre (BIC) located in Batavia, New York in 1959 and the formal concept of business incubation had been developed ever since. The UK and Europe developed later during the 1980s through various related forms such as innovation centres, technopoles centre, science parks, etc. The concept of business incubation was introduced to Nigeria in the 1990s by the UNDP. Business incubators have become increasingly important for economic development, especially in relation to small business creation and to employment opportunities. Interest in business incubation comes from a variety of sources which include local and regional governments, universities, chambers of commerce, science parks, private companies, private real-estate developers and non-profit organizations.

Universities and research centres can help form so-called systems and networks of innovation. Small and Medum Enterprise (SMEs) collaborate with systems of innovation on regional, national or even international levels, dependant on their knowledge and competence needs. SMEs that innovate through science-driven R&D tend to collaborate with partners across the world in search for new and unique knowledge. SMEs that innovate through engineering based user-producer learning tend to collaborate with nearby partner. Here, innovation often involves the application of existing knowledge or new combinations of knowledge. Knowledge Transfer from a university generally takes the form of collaboration with an industrial partner or contracted research or a start-up or a licensing agreement.

Technology commercialization is growing in many parts of the world. Universities play a very important role in the process of commercializing R&D results especially in advanced nations of the world such as USA and European countries. In view of the above Nigerian universities can also play a key role in technology commercialization, therefore, measures have to be put in place in our universities to manage the commercialization of their R&D results. These measures include Technology Transfer Office, Technology Incubator and Gap funding. This paper attempt to show how University-based Business Incubators (UBIs) can assist in commercialization of R&D results.

2. CHALLENGES OF R&D COMMERCIALIZATION IN DEVELOPING COUNTRIES

Commercialisation is a new culture among most researchers as most feel that their tasks are mainly to generate and transmit knowledge through research conducted. However, commercialisation is now seen in many countries as an important contributor to universities to achieve financial independent now that the government had reduced allocation to the Universities in Nigeria. (Martin and Etzkowitz, 2000). The challenges of R&D commercialization in developing nation (Chandran, 2010) are:

- Lack of funding and incentives to support private sectors research commercialization
- Lack of pre-seed and seed funding, market funding, prototype funding
- No angel investors
- Poor venture capital availability (no active involvement of private VC companies)
- No strategic map for VC industry
- Poor financing by banking sectors for start-ups and new ventures
- Difficulties in accessing funds at expansion phase especially through soft loans, equity arrangements, and expansion funds
- Limited university-industry linkages
- Limited industry sponsored research activities
- Limited R&D activities especially among SMEs
- Lack of coordination between government-university-industry
- Poor R&D management practices in public and private sectors
- Lack of structural and systems flexibility in universities/research institutions/private sectors
- Poor or absence of technology transfer office within universities and research institutions
- Not enough champions and leaders
- Inadequate organizational culture
- Poor communication systems
- Lack of income generating agendas within universities and research institutions
- Overlapping roles of agencies causing lack of focussed efforts
- Lack of agencies in managing and assessing the impact of R&D funding and management of various government funds
- Troublesome procedures in filling grants/funds (no support agencies)
- Lacking technical support by incubators - most incubators only provide facilities and commercial incubation (e.g the Technology Incubation Centres [TICs] in Nigeria) etc.

The key areas of challenges identified in order to improve the commercialisation rate are mainly in the areas of funding, industry link, incentive mechanism, manpower and technology transfer infrastructure.

3. ROLE OF TECHNOLOGY BUSINESS INCUBATION IN COMMERCIALIZATION OF ENGINEEIRING RESEARCH IN THE UNIVERSITIS

It is estimated that there are 7500 incubators worldwide growing at an annual rate 33% and that approximately 2500 are connected with universities (Knopp, 2010), (Monkman, 2010). Furthermore, the university incubators foster technological innovation and industrial renewal (Allen and Rahman, 1985; Smilor and Gill, 1986; Allen and McCluskey, 1990; Mian, 1996). Establishing business incubation programme in the Universities will lead to:

- Establishment of strong University Industry Linkage through Business Incubators
- Successful development of entrepreneurial companies through an array of business support resources and services
- Production of successful firms
- Incubator graduates have the potential to:–create jobs–commercialize critical technologies–strengthen local and national economies
- Technology Business Incubator promotes University Industry Relationship through the establishment of the following sub offices:
  –Intellectual Property Rights Office
  –Transfer of Technology Office
  –Entrepreneurship Development Centre
  –Establishment of a Technology Park

3.1 BUSINESS INCUBATION

"Business incubation is a unique and highly flexible combination of business development processes, infrastructure and people designed to nurture new and small businesses by helping them to survive and grow through the difficult and vulnerable early stages of development." (UKBI)

Business Incubation is a unique and highly flexible combination of business development processes, infrastructure and people, designed to support entrepreneurs and grow new and small businesses, products and innovations through the early stages of development and/or change (Paul H and Paul C, 2002). In other words, business incubators provide start-up companies with a range of support measures, including physical space within the incubator building, training and coaching, business contacts, access to finance etc

Business incubation is different to other forms of business support in that it provides a complete, tailored, ‘hands-on’ business support environment. The business development resources made available through an incubation environment are provided by both an on-site incubation team as well as ‘brought in’ from a network of external contacts. Incubation is a resource-intensive activity therefore most incubation has to be selective. The purpose of incubation is not to provide support indefinitely, so most incubation environments will set a limit on the time that they will work with client ventures before they are encouraged to move on.

Note that business incubators are distinct from science parks, according to the definition by United Kingdom Science Park Association (UKSPA), science parks represent a cluster of knowledge-based businesses, where support and advice are supplied to assist in the growth of the companies. The most important distinguishing feature is that science parks are not restricted to start-up companies and as a result may also host relatively large and well-established companies (Christian, 2010)

3.1.2 Objectives of Business Incubators

The typical objectives of business incubators are usually the following:

- Economic and socio-economic development
- New entrepreneur creation
- Reduction of business failure
- Employment and wealth creation
- Transfer of technology
- Intellectual property and research/technology commercialization
- Stimulation of technology enterprises
- International competitiveness
- Import replacement
- Business cluster development

3.1.3 Types of Business Incubators

There is no unique type of business incubator. The focus of business incubators varies greatly from country to country and even within individual country. The incubation type has been adapted to meet a variety of needs. They vary between economies and regions depending on the local conditions, culture, business development services and economic development policy. In legal forms, the classification of business incubators has the following organizational patterns (OECD, 1999.):

- **Not-for-profit based incubators**
    1. ***Public incubators*** run by government and non-profit organizations are objectively to promote economic development.
    2. ***Academic-related incubators*** usually located in the university or research institutions are for facilitating technology transfers and for stimulating innovation through the interaction of ideas between researchers and entrepreneurs on creating spin-off companies.
    3. ***Joint Public/private incubators*** are joint efforts or a partnership programs between government and private/not-for-profit organizations to encourage the creation of new entrepreneurs by combining the expertise of the private sector and the use of public funding.

- **Profit based incubators**

    Profit-based incubators are usually owned by the private sector and seed capital investment groups that are generally seeking a profit return on their investment.

3.1.4 Business incubation process model

A model of business incubation process where the incubator serves as a SME development tool and consisting of three main stages and one small pre-stage (germination) is shown in **Figure 1**. The Entrepreneur passes through four stages: idea germination, startup (pre-incubation), expansion (incubation) and maturity (post-incubation). (InfoDev, 2009)

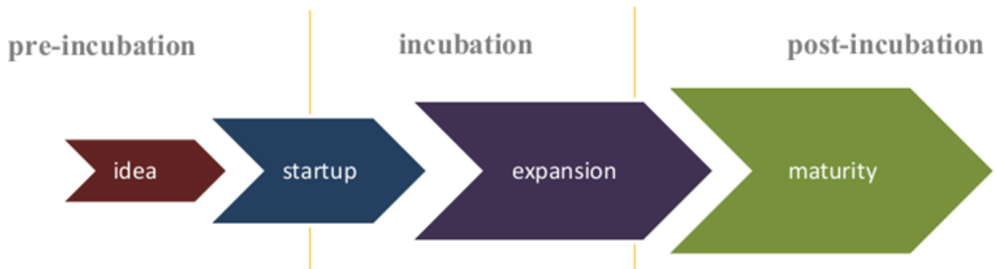

Figure 1: Business incubation process model (InfoDev, 2009)

1. **Germination stage:** This is the very earliest stage of intervention, where you entrepreneurial ideas come. This is also the most risky part of the venture because high uncertainty exists. Moreover, due to lack of knowledge, capabilities, etc. this is the most expansive part for entrepreneur and business incubator. They should invest time and effort mostly.
2. **Pre-incubation stage.** The main goal of the stage is to help an individual with an idea. This is the most riskiest and expensive stage of the process. Very few incubators can afford this kind of activity where they can access public support or private risk capital. This is often required in high-tech innovation industries and with incubators closely attached to universities. Authors believe that this innovation comes out of need.
3. **Incubation stage.** An idea has graduated to a plan, with a team, and operations have begun. Consequently startup started scaling and expansion. Risks are still high, investments here are expensive and still don't bring any profit. Incubators help in a search of business model, provide business assistance, build the team, provide resources, access to networks, and capital sources. Some incubators invest in the companies.
4. **Post-incubation stage. "**This is where a profitable company merely seeks a particular type of facility." There is basically no need of intervention by an incubator, but experience shows that incubators still help companies. For instance, many companies continue to rent spaces in an incubator. As authors accentuate for some incubators "this relationship with mature companies can be a crucial strategy to assist with and subsidize their other programs." Companies are mature, and safe.

3.2 UNIVERSITY-BASED BUSINESS INCUBATOR (UBI)

The development of new research/technology-based firms has become increasingly important in today's competitive economies. Faced with this challenge, several governments, local businesses and some universities are collaborating to promote the development of Technology Businesses in their regions (Mian, 1994). One mechanism used for this purpose is the establishment of technology incubators in or around the university campuses. Interest in the university sponsored technology incubator stems from the significant potential of the concept. The concept holds out the possibility of linking talent, technology, capital, and know-how to leverage entrepreneurial talent, accelerate the development of new technology-based firms, and speed the commercialization of technology (Smilor and Gill, 1986). Practitioners whether government and policymaker academia, researchers and experts concentrate on the role of business incubation program as an active role in the employment to support economic growth (Allen and Levine, 1986; Thierstein and Wilhelm, 2001, Roper, 1999) and technology commercialization and transfer (Mian, 1994; Phillips, 2002; McAdam et al, 2008, Kathleen, 2012). Many scholarly articles discussed the importance of incubators as a value added vital tool for developed and developing countries. (Sweeney, 1987; Allen and McCluskey, 1990; McAdam, et al., 2006; Hansen, et al., 2000; Hughes, et al., 2007). In addition, incubators are goals for technology commercialization and transfer (Mian, 1997; Phillips, 2002; Rothaermel and Thursby, 2005; McAdam et al, 2008; Akçomak and Taymaz, 2007). Moreover, incubators act as a tool for jobs creation (Thierstein and Wilhelm, 2001; Frenkel et al., 2008; Roper, 1999; Abetti, 2004). Finally, incubators are used to support a startup with several services (Smilor and Gill, 1986; Allen and Rahman, 1985; Allen and McCluskey, 1990; Lalkaka, 2002; Hannon, 2005; Mian, 1997; Adegbite, 2001).

3.2.1 What is UBI?

University-based Business Incubator (UBI) is an office or unit in the University which provides services, supports, guidance as well as promotion of new business based on technology, innovation, creation or knowledge.

University incubators are established in or by university campuses. There are different models, sizes and nuances regarding these kinds of initiatives. The common factor is that these incubators generally promote the development of new research/technology-based firms inside their own facilities. The role played by universities consists of linking research, technology, capital and know-how to leverage entrepreneurial talent, accelerate the development of new technology-based firms, and speed up the commercialization of technology**.** Their success is considerably tied to the capacity of linking research with industry.

3.2.2 Why UBI?

This is the question that may likely be asked within the university and in the society. The answer is certainly in the following reasons;

1. The lack of research commercialization within the universities
2. The low entrepreneurial spirit of students and alumni
3. The missing link between new business and technology

However, these are not the separate causes and effects but rather related to one another.

3.2.3 Missions of UBI

A complete UBI should be able to link technology and intellectual property created by students, researchers and staffs, with business incubation process through the proper means such as licensing or joint venture. UBI does not focus only on business incubation but also coordination with other related organization or departments i.e. Research and Development Office, Technology Transfer Office, etc.

3.2.4 Goals & Objectives of UBI

- To help potential entrepreneurs such as students, staff and general public to incubate their technology based businesses
- To provide support for patenting research and development work of university staff and students
- To liaise with private/public sector enterprises and funding sources, govt. agencies, industrial associations, chambers of commerce to provide facilitation and networking for Incubatee companies

3.2.5 Benefits of UBI

University incubators have the additional advantage that they can draw upon the resources available at the university, including academic support, access to research facilities, as well as easy access to the student pool to recruit employees.

- ***University***
  The benefits of university involvement include the students' involvement in entrepreneurship and the potential positive connections that could be formed between local entrepreneurs and students as well as between the universities. University involvement will not only open students up to the idea of creating their own business, but it will also connect entrepreneurs to students who may possess skills that they do not have (such as finance, accounting, engineering design, etc). This would benefit the entrepreneur because the service would be free and the student because they would be getting hands on experience in their field (Liss 2011). University involvement in student entrepreneurship also provides a unique environment that could potentially attract new applicants (students and professors), research opportunities, and business ventures within the university. It creates an opportunity to draw the 'creative classes to one particular area where collaboration can occur. This could also provide a needed opportunity to commercialize a university's research and further distinguish a university from others.

- ***Surrounding areas***
  Entrepreneurship is a major force of economic growth that is necessary for a country. There is a strong correlation between entrepreneurship and the local development of an area (Rasmussen and Sorheim, 2006). Implementing an incubator in a university could lead to start-up companies beginning in the areas, creating jobs and therefore increasing the value of the areas. These businesses will employ and generate wealth.

- ***University Industry Linkages***
  - In a knowledge-based economy, university based technology venturing is a key factor of internationally comparative advantage in industry
  - Technology venturing through university incubator activity is emerging

- Technology Business incubator become an important instrument in the creation of new enterprises and jobs
- Technology Incubators' contribution to high-tech start-ups in the newly industrializing economies

- ***Positive Impact on Entrepreneurship and Launch of Companies***
  Many young students have the motivation to start their own business; however, they lack the resources necessary. Students will not only be attracted to the independence and innovative atmosphere of the business incubator, but also to the aspect of passion for creating something new and different. The sooner universities tap into this student resource in entrepreneurship, the easier it will be for students to begin start-up companies because they will feel supported not only by the incubator, but by the university as well. A business incubator allows students the opportunity to gain experience through workshops and seminars as well as work in an atmosphere with other entrepreneurs. It also offers the physical means for them to launch their business. The end goal of the incubator environment is to "develop student entrepreneurs in an environment that allows them to learn and grow throughout the process and to ultimately launch their ventures in the real world" (Linebarger, 2010).

3.2.5 UBI Structure

There are a few types of UBI structure depending on the policy and management of each university. However, the suitable structure of UBI should at least have the following characteristics;

- Clear organization structure and formally established under the university administration
- Independent both structurally and financially which means the UBI might consider having its own guidelines, practices, rules and regulations.

3.3 TECHNOLOGY COMMERCIALIZATION

This is the process of converting knowledge into products & services. It moves ideas from the concept to the laboratory model and onto the market place. It creates a National Innovation System through University Knowledge Base. Commercialization of technology involves any possible configuration or scheme that allows those who invest in technological innovation (inventors, research systems, private firms and others) to capture some of the economic benefits generated by their innovation. Patent licensing, research grants and contracts, R&D joint ventures, and technical services for a fee, are all examples of commercialization schemes. (Nicholas, 1997).

3.3.1 Process of Technology Commercialization

Jolly tried to show the processes that should initially be put in place for technology commercialization (Jolly, 2008). He shows five independent sub-processes and bridges between them for a start-up as shown in Figure 2 below:

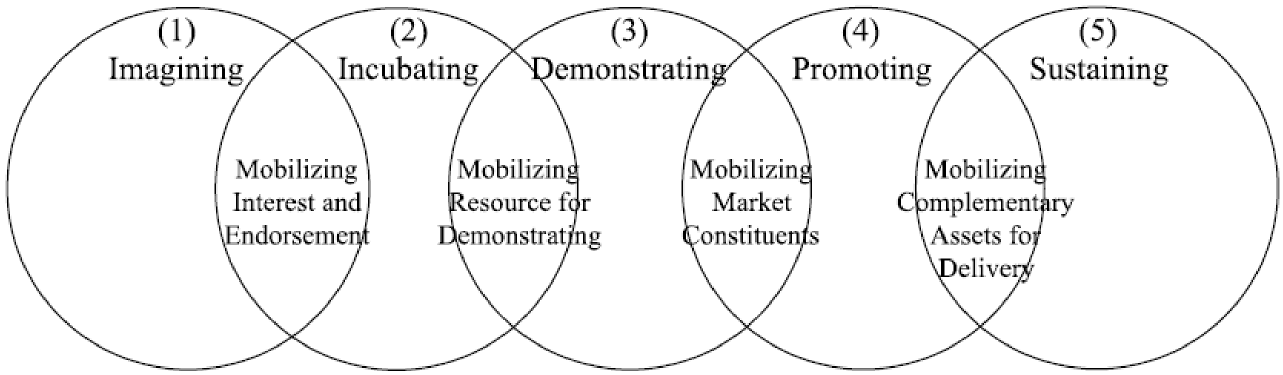

Figure 2: Process of technology commercialization (Jolly's model)

- ***Imagining:*** At this stage the application idea based on the technology is developed, the principle ad mechanisms of the technology are clarified, the potential patentable area is researched and the market application for the technology is explored.
- ***Incubating:*** At this stage the feasibility of the technology meeting the market need based on the market analysis is evaluated. At this stage, the specific use and customers are identified. Making a prototype enables evaluation of the reliability of the technology. This activities create awareness about the technology
- ***Demonstrating***: At this stage the prototype is constructed to test the market's reaction. The market requires proof of an improvement in performance or cost reduction. The prototype is given to the customer to check its performance for a certain period.
- ***Promoting:*** This is the stage when the product is put on to the market with endorsement from customer following testing and evaluation. At this point the first sales income is generated and planned sales is set and targeted.
- ***Sustaining:*** This is the stage where the market is extended into new areas and expanded in the original market.

3.3.2 University Technology Commercialization Model

The challenge in the technology commercialization process above is when and how to move the students and researches from the imagining stage to the incubating stage. In order to proffer solution this problem, the following 4 models were proposed. (Etzkowitz, 2008):

- ***Researcher model:*** In this model, the research results are disseminated to the society through the publication of research papers. This is the most traditional method and a general type of promotion. In this model, it is not easy to examine whether the technology meets the market demand because the spread of technical information on the technology tends to be limited to academics. Another problem is making the technical information accessible to the customer. (Etzkowitz, 2008)

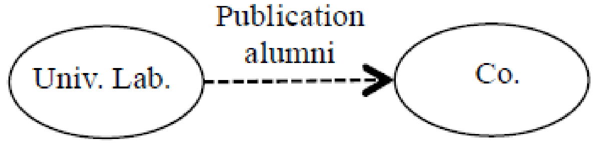

Figure 3: Researcher model (Etzkowitz, 2008)

3. ***Liaison office model (LO model):*** The university creates a liaison office contact point for industry and contribute to technology transfer through contract research. In this model, the number of number of corporate are limited and the intention of the partners determines whether commercialization will happen or not. (Etzkowitz, 2008)

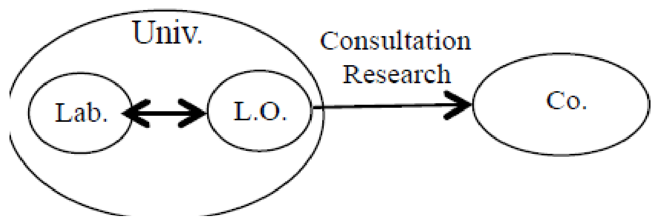

Figure 4: Liaison office model (Etzkowitz, 2008).

4. ***Technology transfer Office model (TTO model):*** The university becomes the owner of the intellectual property invented in the university and technology transfer office becomes the contact point for technology licensing. This model is better than the Researcher model because the TTO staffs actively examines the potential licenses and seek opportunity for commercialization. However the budget and number of staff may not be there or may be insufficient at many universities. (Etzkowitz, 2008)

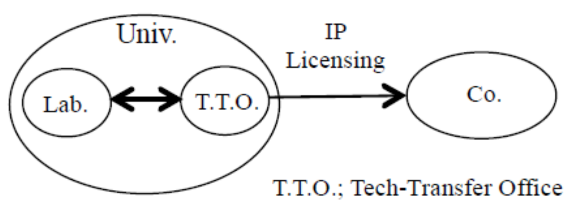

Figure 5. Technology transfer Office model (Etzkowitz, 2008).

5. ***Incubator model:*** In the incubator model, the university researchers and students who do not have much business experience work with local entrepreneurs to do the technology development, marketing, creating the business plan and finding investors and business partners. Incubator staff and manager support them in these activities. (Etzkowitz, 2008)

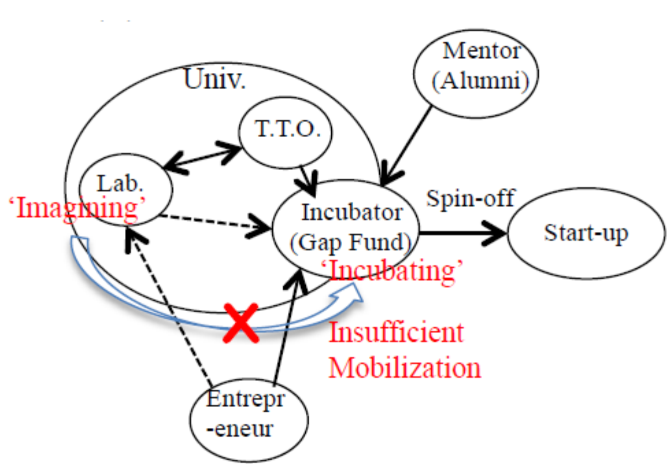

Figure 6. Incubator model (Etzkowitz, 2008).

3.4 COMMERCIALIZATION OF ENGINEERING RESEARCHES USING THE INCUBATOR MODEL (UBI).

Eztkowitz noted the importance of the university incubator as a support function for the university researchers and the students to set up start-up companies. (Eztkowitz, 2008). He defines the basic elements of the university incubator model as follows:

6. Selection processes which prompt improvement of business ideas at the onset
7. Availability of space that can be used for a limited period
8. Being able to outsource business support services
9. Availability of mentoring and advice to improve business skills
10. Networking opportunities as a means of introducing potential partners and investors.

3.4.1 Stages in the University-based Business Incubation Process

In the UBI model for commercialization of R&D, the following three stages will be used in the incubation process:

- ***Ideation stage.*** It is the process of generating, exploring and evaluating new technology/business ideas that can give the business proposed by the student or researcher a competitive advantage. An expert committee will be formed for the evaluation of the ideas through interview of each applicant and analysis of the. business potential and feasibility of the proposed technology
- ***Team and Enterprise formation* stage**. Team formation is the key for an entrepreneur in commencing a business. The team should ideally have a mix of co-founder with complementary skills. The team can register the enterprise as a private limited company or limited liability partnership or any legally recognized entity.
- ***Prototype /business started stage.*** Here the working model or prototype of the technology is developed and certified by experts for commercialization or technology transfer. But if it is a business service idea, the enterprise can start the business operations as per the business plan and start generating revenue.

3.4.2 Services to be Provided in the UBI.

The UBI will assist in engineering research commercialization by providing the following services and facilities:

- ***Office Space for Incubator and Incubatee***
  1. Infrastructures
  2. Telephone & Fax
  3. Meeting room
  4. Library
  5. Internet
- ***Business Consultation***
  1. Entrepreneurship development
  2. Business plan
  3. Business development
  4. Business matching
  5. Access to finance and funding
- ***Other Consultation***
  1. Industrial management
  2. Human resources development
  3. Product development
  4. Marketing
  5. Finance and Accounting
  6. Technology development
- ***Liaison for Activities***
- ***Entrepreneurial Development***
  1. Entrepreneurial club setting up
  2. Business plan competition
- ***Supports for setting up business as well as intellectual Property.***
- ***Other related services depending on the need and availability of the students or clients such as:***
  1. Innovation fair
  2. Start-up fund
  3. Venture capital
  - ***Intellectual Propety services***
    1. Training
    2. IP management
    3. IP Law
    4. Patent drafting and filing
    5. IP evaluation
  - ***Protection and Management***
    1. Patent database searching and mapping
    2. Patent examination
    3. Patent filing
    4. Licensing and other forms of technology transfer

5. TECHNOLOGY COMMERCIALIZATION AND UBIs INITIATIVES.

Below are some of the initiatives of technology commercialization and university business incubation programmes and projects in Nigeria and in some countries.

- The National Board for Technology Incubation (NBTI) had signed Memorandum of Understanding (MoU) with the National Board for Technical Education (NBTE) and the National Universities Council (NUC) on the establishment of Business incubation facility (Institutional-based Technology Incubation Centre) in the Polytechnics and Universities across Nigeria. The Technology Incubation Programme (TIP) is a programme run by NBTI in the Federal Ministry of Science and Technology (FMST) is a unique and highly flexible combination of business development process, infrastructure and people designed to nurture and grow new and small businesses, products, innovations and entrepreneurs by supporting them through the early stages of development. It is an integrated support programme provided by the Governments, Academic institutions and Private sector, either individually or in partnership with the intention of creating and nurturing of budding value-added and technology-based enterprise (FMST, 2005).

- Technology commercialization programme at the University of Texas USA. The programme is an academic Master of Science in Technology commercialization. It is a one year programme and it deals on the knowledge base and skills set needed to get technology into the market as quick as possible. The programme is focused on science and technology commercialization, assessment of technology, technology transfer, technology enterprises and intrapreneurship. The curriculum includes the following courses: converting technology to wealth, marketing technological innovations, the art and science of market driven entrepreneurship, commercialization strategy, technology enterprise design and innovation management (MSTC, 2014)

- The establishment of University Business Incubators (UBIs) in Thailand is the beginning of awareness and understanding of universities' role in the socio-economic development of the nation-beside teaching, research, academic services and supporting cultures. Business incubation is the extension of all those key functions of university i.e. commercialization of research and innovation, entrepreneurial development of university alumni as well as other new entrepreneurs in the region. Previously, the concepts of entrepreneurship and research commercialization were not very well taken among Thai universities due to the misunderstanding and lack of information. The establishment of UBI, therefore, significantly and effectively promotes and facilitates these two processes during the recently years. With the initiation of the Commission on Higher Education (CHE), many public universities have begun to setup the UBI with the better understanding and clearer missions in order to link between existing resources and organizations within the university and the UBI. CHE has funded at least 45 UBIs in the universities throughout the country (Chachanat T and Rom H, 2007).

- University of Dar es Salaam Business/Technology Incubation Project**.** College of Engineering and Technology Development and Transfer Center. The proposed National Business/Technology Incubation Programme (NBTIP), which is expected to provide business/technology incubation services in Tanzania, has the purpose of assisting the new venture creation process. Having recognized the significance of technological innovation and entrepreneurship in shaping the future, the University of Dar es Salaam (UDSM) has decided to establish the business and technology incubation project as a means of commercializing technologies developed at the UDSM so as to enable SMEs to develop high value-added products, processes and services, and hence the project could become key implementation measure of the National SME Development Policy (UDSM, 2014)

- In Tunisia, the Investment Promotion Agency (API) is responsible for the implementation of a business incubation management programme to generate synergies between academic institutions and enterprises:
    - Six universities provide the facilities required for business incubation
    - API contributes the know-how (training of future entrepreneurs, market feasibility studies, fund raising)

6. CONCLUSION

The paper presented an overview of how university-based business incubators can facilitate the commercialization of R&D results or technology. University based business incubators are not only useful in developed nations but also in developing nations such as Nigeria. They play a significant role in job and wealth creation through the service and facilities they provide to their clients. The Nigerian government should encouraged the universities to set-up technology commercialization outfits such as the business incubator using initiatives such as public-private partnership so that researches lying down in the universities can be transferred from the university laboratories to the market.

REFERENCES

1. Abetti, P.A. (2004), ‘Government-Supported Incubators in the Helsinki Region, Finland: Infrastructure, Results, and Best Practices’, Journal of Technology Transfer, 29 (1): 19–40.
2. Adegbite, O. (2001), ‘Business Incubators and Small Enterprise Development: The Nigerian Experience’, Small Business Economics, 17 (3): 157–66.
3. Akçomak, I. S., and Taymaz E (2007). ‘Assessing the Effectiveness of Incubators: The Case of Turkey’. In V. V. Ramani, and A. V. Bala Krishna (eds), *Business Incubation: An Introduction*. Hyderabad: Icfai University Press, 234–64.
4. Allen, D and McCluskey A (1990),‘Structure, Policy, Services, and Performance in the Business Incubator Industry’, Entrepreneurship Theory and Practice vol.15, no.2, pp. 61–77
5. Allen, D and Rahman, S (1985), ‘Small Business Incubators: A Positive Environment for Entrepreneurship’, Journal of Small Business Management, vol. 23 (July), pp. 12–22.
6. Chachanat T and Rom H, (2007) Development and Future Challenges of Business Incubators in Thailand, National Science and Technology Development Agency (NSTDA), 111 Thaialnd Science Park, Phetkasem Printing Group Co.,Ltd.

7. Chandran G (2010), R&D commercialization challenges for developing countries The case of Malaysia, Tech Monitor, Nov-Dec 2010
8. Christian H (2010), The Effect of Market Entry on Innovation: Evidence from UK University Incubators_ University of Oxford job market paper, January 2010
9. Etzkowitz H. (2008), The Trilpe Helix, University-Industry-Government innovation in action, Routledge, 2008:55.
10. FMST (2005), Policy functions structure and operational guidelines of Technology Incubation Programme in Nigeria. Federal Ministry of Science and Technology (FMST), Abuja
11. Frenkel, A., Shefer D, and Miller M (2008). 'Public versus Private Technological Incubator Programmes: Privatizing the Technological Incubators in Israel'. *European Planning Studies*, 16 (2): 189–210.
12. Hannon, P. D. (2005). 'Incubation Policy and Practice: Building Practitioner and Professional Capability'. *Journal of Small Business and Enterprise Development*, 12 (1): 57–78.
13. Hansen, M. T., Chesbrough H. W., Nohria N. and Sull D (2000). 'Networked Incubators. Hothouses of the New Economy'. *Harvard Business Review*, September– October: 74–84.
14. Hughes M., Ireland R. D. and Morgan R. E. (2007). 'Stimulating Dynamic Value: Social Capital and Business Incubation as Pathway to Competitive Success'. *Long Range Planning*, 40: 154–77.
15. InfoDev (2009), Review of 20 business incubation models – InfoDev process model 2009, available online at http://worldbusinessincubation.wordpress.com/business-incubation-models/.
16. Jolly V K (1997), Commercilalizing new technologies, getting from mind to market, Havard Business School Press, 1997:18.
17. Kathleen R. A (2012), Technology Commercialization: Have We Learned Anything? The Journal of Engineering Entrepreneurship, Volume 3, Number 1, 2012
18. Knopp, L (2010), Incubation industry compensation survey. Athens, OH: NBIA Publications.
19. Lalkaka, R. (2002). 'Technology Business Incubators to Help Build an Innovationbased
20. Linebarger M.(2011) "University Venture Incubators: Empowering Entrepreneurs Across
21. Liss, Kenneth (2010), "Incubators: The New Venture Capitalists?". Harvard Business School.
    London: Francis Pinter.
22. Markman, G., Siegel, D., and Wright, M. (2008), 'Research and technology commercialization', Journal of Management Studies, Vol 45, No 8, pp 1401–1423.
23. Martin, B. R. and Etzkowitz, H. (2000). The origin and evolution of the university species. Science and Technology Policy Research Unit (STPRU), Electronic Working Paper Series, Sussex University.
24. McAdam, M. and McAdam, R. (2008), "High Tech Start-ups in University Science Park Incubators: The Relationship between the Start-Up's Lifecycle Progression and use of the Incubator's Resources", *Technovation*, Vol. 28 No. 5, pp. 277-90.
25. McAdam, M., B. Galbraith, R. McAdam, and P. Humphreys (2006). 'Business Processes and Networks in University Incubators: A Review and Research Agendas'. *Technology Analysis and Strategic Management*, 18 (5): 451–72.

26. Mian S A (1997), Assessing and managing the university technology business incubator: an intergrative framework. J Business Venturing, 12:251-285
27. Mian, S.A. (1994), 'The University Business Incubator: a Strategy For Developing New Research/Technology- Based Firms', The Journal of High Technology Management Research, 7: 191–208.
28. Minshall, T., and Wicksteed, B. (2005), University Spin-Out Companies: Starting to Fill the Evidence Gap, a report on a pilot research project commissioned by the Gatsby Charitable Foundation, St John's College Centre, Cambridge
29. Monkman, D (2010), 'Business Incubators and their Role in Job Creation', President& CEO National Business Incubation Association (NBIA), Athens, Ohio. June 30, 2010, <www.nbia.org>.
30. MSTC (2014), Master of science in Technology commercialization website, The University of Texas at Austin, http://www.mccombs.utexas.edu/MSTC (Accessed October 2014)
31. Nicholas G. K, (1977), Commercialization of Research and Technology, Productive Sector Growth and Environment Division Office of Sustainable Development Bureau for Africa, U.S. Agency for International Development
32. OECD (2012), Promoting graduate entrepreneurship in Tunisian universities, http://www.oecd.org/cfe/leed/OECD%20Tunisia_UniversityEntrepreneurshipReport_FINAL.pdf (Accessed November 2014)
33. OECD, (1999), Business Incubation: international case studies. OECD Publications, Paris.
34. Paul H and Paul C (2002), UK Incubators: Identifying Best Practice : Ukbi National Incubator Study 2000/2001
35. Phillips, R. G. (2002). Technology business incubators: how effective as technology transfer mechanisms? Technology in Society Vol: 24, No: 3: 299-316.
36. ***Rasmussen, E.A.*** and R. Sorheim (2006), '***Action-based entrepreneurship education***', Technovation, 26 (2), 185–94
37. ***Roper, S. (1999), 'Israel's Technology Incubators: Repeatable Success or Costly Failures',*** Regional Studies, 33. (2): 175–80
38. Rothaermel F T and Thursby M (2005), Incubator firm failure or graduation? The role of university linkages. Research Policy, 34, 1076-1090
39. Smilor, RW and Gill, MD (1986), the New Business Incubator: Linking Talent, Technology, Capital, and Know-How, Massachusetts, Lexington Books, New York.
40. ***Sweeney, G. P. (1987) Innovation, Entrepreneurs and Regional Development,*** Journal of Economic Behaviour and Organization 3: ***39***–63.
41. Thierstein, A. and Wilhelm, B. (2001), Incubator, Technology and Innovation Centres in Switzerland: Features and Policy Implications, Entrepreneurship and Regional Development, Taylor & Francis Journals, vol. 13(4), pages 315-331, October.
42. UDSM (2014), University of Dar es Salaam Business/Technology Incubation Project website, http://www.coet.usdm.ac.tz/incubation/udsm_business_incubation project.pdf (Accessed November 2014)
43. UNESCO-UIS (2010), Challenges Faced by Developing Countries. UNESCO Institute for Statistics, Succursale Centre-Ville Montreal, Quebec H3C 3J7 Canada

COMPARATIVE ANALYSIS ON THE EFFECT OF POLYMER SOLUTION AND OIL QUENCH ON CONDIMENT GRINDING DISC

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ABSTRACT

A Comparative analysis on the effect of polymeric quenchant - poly ethylene glycol, PEG - and used-automobile lubricating oil on hardening condiment grinding discs was conducted. Samples from condiment grinding disc were prepared for various tests before and after heat treatment (hardening) followed by subsequent quenching in polymer solution and oil. The tests conducted on the samples were hardness test, tensile strength test and impact test. The test results revealed that the sample quenched in oil produced a better result as compared with polymeric quenchant.

Keywords: Quench, Hardness, Tensile, Grinding disc, Polymer

1.0 INTRODUCTION

Grinding disc made of cast iron is sensitive to crack and distortion during quenching. To avoid distortion and crack during quenching there is need for controlled and uniform quenching. Factor affecting quench uniformity is the design of the quench system. Agitation, quenching medium temperature, quenchant concentration and type of medium are the most important parameters affecting the quench uniformity in the design of quench system. The effect of agitation on the performance of various quench oils has been studied in details. It has been reported that the ability to thoroughly harden in conventional quenching increases with increasing agitation(Ahmed, 2011), studies of both agitation and temperature on the distortion of carbon steel show that, agitation of quench oil is necessary to remove film boiling processes, if uniform heat transfer throughout the quenching operation is to be achieved(Ahmed, 2011).

Polymer solutions have been widely substituted for oil quenching; aqueous solutions of polymer are used to improve the cooling characteristics of the quenching media. Polymer concentration varies from 30% - 40% depending on the type of product being processed (Ahmed, 2011).

The problem of condiment contamination due to high wear rate which lead to ill health may sometimes be associated with the condiment grinding mill. Locally fabricated mills are double discs mill type with two discs rotating and robbing each other. therefore Foods ground by these mills were sometimes found to be contaminated with the disc's small particles, paints, corroded products and lubricants; other contaminants are iron calcium and magnesium if found in large quantities (Yahaya et al., 2012). The contaminants usually originate, from ageing and wearing of grinding discs, metal components, bearings, bushes and grinding chamber. Metal contaminants are noted to be inorganic elements, which may be present in ground foods. These may have toxicological effects to human beings. The study by (Yahaya et al., 2012) recommended the heat treatment of such discs to reduce the wearing of the grinding disc and hence reduce contamination. This study deals with the comparative analysis of the hardness of quenched condiment grinding disc in used automobile oil and polymer solutions with the main aim at improving quality of the disc so as to address the mentioned problems. Heat treatment is the process of controlled heating and cooling metals in its solid state in order to obtain the desired change in physical and mechanical properties. One of the most important mechanical properties of steel is its ability to be hardened to resist wear and abrasion or be softened to improve ductility and machinability. (Davies et al, 1983) Quenching is the process of rapid cooling of materials to room temperature. It is done to preserve the solute in the solid solution. During this operation (on carbon steels) the austenite is transferred into martensite (a hard brittle metal). Liquid quenching is performed in water, oil and more recently in aqueous polymer solution, water and oil quenching have the higher rate of cooling with water being the fastest.

Polymers are complex and giant molecules made up of smaller molecules; the small molecules which combine to form the polymers can be of one or more chemical compounds. Polymers are formed by a process called polymerization (Gowariker et al 2007). There are several commercial polymers that are readily accepted and used as quenchant such as polyacrylate polyvinyl alcohol polyvinylpyrrolidone polyethylene glycol and polyalkylene glycol etc (www. Amazon.com, 14/8/14).

Research on the quench media have been conducted on various metals. Of recent, the effects of polymer solution and oil quenchant on hardening automobile camshaft have been studied. It is shown that the hardness of the camshaft after quenching in polymer and oil are 420BHN and 320BHN respectively (Ahmad, 2011) this indicated polymer as better quenchant if higher hardness is to be achieved. Studies have been conducted using vegetable oil as quenchant. Hardening characteristic of plain carbon steels and ductile cast iron using neem oil as quenchant have been studied; it is found that the sample quenched in neem oil has high hardness than that of mineral oil (Hassan et al, 2011).

2.0 MATERIALS AND METHODS

This section presents the various experiments conducted on the samples. These include heat treatment, hardness test, tensile strength test and impact strength test.

2.1Materials

2.1.1 Heat Treatment. Materials and equipment used for heat treatment are. Samples cut from the grinding discs twelve for each test, a muffler furnace and quenching media (oil and polymer solution).

2.1.2 Hardness testing. Material and equipment used for hardness testing are Rockwell testing machine BS 891 manufactured by Avery Denison Limited, England. The machine has nine different scales, selection is made based on the material type. 150kgf and Brale diamond as load and indenter was used. Hardness test was conducted on the samples cut and heat treated for hardness testing.

2.1.3 Tensile Strength Test. This test was conducted to determine the strength and elongation of the samples. The test was conducted using universal testing machine (UTM) Serial number 500-10074 manufacture by CUSSON LIMITED, ENGLAND and the material tested are sample cut from the disc and heat treated for tensile test.2.1.4

2.1.4 Impact test. This test was conducted using Avery Denison England. Seal No 063363 set on 170Joules.

2.2 Methods

2.2.1 Heat *Treatment*

Heat treatment was conducted, on 27 prepared samples intended for various mechanical properties tests, in a muffle furnace SXL Series. The samples were placed in the heating chamber and the muffle cover was closed, the power supply was switch on and using the controller the muffle furnace was programmed at 900°C, 30 minute raising time and 60 minutes soaking time. The furnace reached the set temperature in 30 minutes. The samples were soaked at that temperature for one hour to allow it homogenize.

Quenching

After soaking the samples were quenched in various Medias, this involved putting the red hot sample into a liquid media. Used-automobile oil and polymer solutions in various concentration were maintained at room temperature, 9 samples (i.e. three for each mechanical properties tests) were quenched in oil, 30% polymer solutions and 20% polymer solutions accordingly, this was followed by tempering.

Tempering

This is done to induce some softness in the unready hardened cast material to reduce internal stresses by heating to temperature bellow lower critical point. The samples were heated to 450°C and maintained at that temperature for one hour and then brought out from the furnace to cool in air.

2.2.2 Hardness test.

Hardness is very important in disc mill; a disc mill must possess enough hardness to resist wear and abrasion due to rubbing and at the same time withstand shear and compressive strength because of tightening and crushing action of the mill. Hardness tests were conducted before and after the heat treatment to determine the improvement achieved.

The Rockwell hardness tester was used; it is the most common and easiest. It require no special skills, usually hardness of a material indicates the materials resistance to scratch, indentation and penetration of its surface.

Procedure: - Rockwell testing machine BS 891 manufactured by Avery Denison Limited, England, was used. The machine has nine different scales, selection is made based on the material type, harder material require higher load and harder indenter e.g. hard steel, hard cast irons, pearlitic malleable iron, titanium, deep case hardened steels and other harder material require 150kgf and Brale diamond as load and indenter respectively (www.hardnesstesters.com). The test was conducted by placing the sample on an anvil supported by screw shaft that raises or lowers the anvil. The screw shaft is driven by a handle located at bottom of the shaft, when the sample is placed on the anvil the handle is then rotated via the handle in clockwise direction to raise the anvil toward the indenter. On contact with the indenter the dial indicator starts moving in clockwise direction. The handle was rotated slowly until the indicators point at a zero on the display, when the two indicators are on zero the load lever is triggered. The indenter penetrates into the sample, this could be noticed when the pointer is moving in anticlockwise direction, after about 30 second the pointer stops and the reading was taken from the position of the long indicator. The procedure was repeated for all the samples.

2.2.3 Tensile Strength test**:** - this was conducted to determine the tensile strength of the sample

Sample preparation: - The surface of the purchased disc, from Yankura market, was ground to remove the grooves. Portable grinder was used, the disc was then cut to size (9×9)mm using cutting disc, the cut sample was made to size and gauge length was prepared using surface grinder, the gauge length is (50mm) and the sample length is 120mm. Axis of tension was made along the axis of the sample and the gripped end was made plain to suit the holders of the testing machine. The gauge length was marked; the gauge length is the section where the extension is measured during or after the test (measuring about 50mm).

Tensile test procedure: - The machine was put on and the screen was turn on, after waiting for few second the computer finished booting to display the interface, software (win test analysis) was lunched and test type was selected. Load and speed was set at 100KN and 100mm/min respectively

The identity of each sample was verified. AC, QL, QP20, AND QP30, are used for As-received, Quenched in Oil, Quenched in 20% polymer solution and Quenched in 30% polymer solution accordingly. The dimension needed to calculate the cross sectional area of the elongated section was measured and recorded. The load and elongation-at-break indicators were reset to zero. The specimen was placed in the grips and was secured by closing the grips, and the test was started. The procedure was repeated for each sample.

2.2.4 Pendulum Impact Test

This test was conducted to determine the impact strength of the sample before and after heat treatment. Charpy *V*-Notch bar test method was adopted for its simplicity; uniformity in loading; reasonable velocity of impact and easy to adapt in different testing temperature. The result is usually reported in energy absorbed or energy per unit area below the notch.

Procedure: The samples was cut to standard, according to Tweeddale (1964), 55mm long, the cross sectional area was (9×9) mm and a 45°*V*-notch was produced 2mm deep at the middle of 55mm long bar. The test piece was arranged on the machine by setting notch end against a stop. The 27kg (weight) hammer was raised to 1 meter above the striking position and released. The energy absorbed was recorded from the scale. The procedure was repeated for all samples.

3.0 RESULTS, ANALYSIS AND DISCUSSION

The results obtained from the hardness, impact and tensile strength tests are presented and discussed in this section.

3.1 Results

3.1.1 Hardness result

The results of the hardness test conducted are shown in table 1 below.

Table 1: Hardness Test Results of Specimens Tested.

SPECIMENS TREATMENT	HARDNESS OF SAMPLES (HRC)			
	1	2	3	AVERAGE
AS-CAST	46	50	50	48.7
OIL QUENCHED	65	62	65	64
30% POLYMER Q	66	71	81	72.7
20% POLYMER Q	68	67	75	70

3.1.2 Tensile Strength Results:

The results of the tensile test conducted are shown in the table 2,3,4 and 5 below

Table 2: Force and elongation results

Sample	1	2	3	AVERAGE
Force(Kgf)	1228	2233	2007	1822.67
Force(N)	12047	21908	19688	17881
Elongation (mm)	2.883	4.153	4.245	3.76

Table 3: Sample Quenched in Oil (Q-O).

Sample	1	2	3	AVERAGE
Force(Kgf)	1786	1775	2388	1983
Force(N)	17520.66	17412.75	23426	19453.14
Elongation (mm)	3.736	4.539	3.936	4.070

Table 4: Samples Quenched in 30%Polymer (Q30%P) Solution

Sample	1	2	3	AVERAGE
Force(Kgf)	660	667	680	669
Force(N)	6474.60	6543.27	6670.80	6562.89
Elongation (mm)	2.038	1.657	1.712	1.802

Table 5: Sample Quenched in 20% Polymer Solution (Q20%P)

Sample	1	2	3	AVERAGE
Force(Kgf)	676	685	780	713
Force(N)	6631.56	6719.85	7651.80	7001.07
Elongation (mm)	5.083	4.07	3.95	4.367

Figure1. Below show the results of hardness test conducted, sample quenched in 30% polymer solution recorded higher hardness Value.

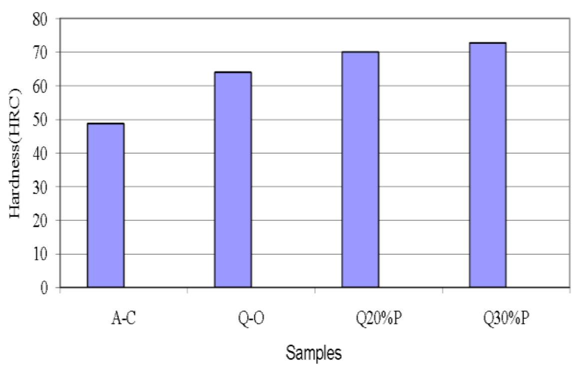

Fig 1: Hardness Test Results

Figure 2. Below shows the result of tensile test conducted, sample quenched in oil recorded higher tensile strength.

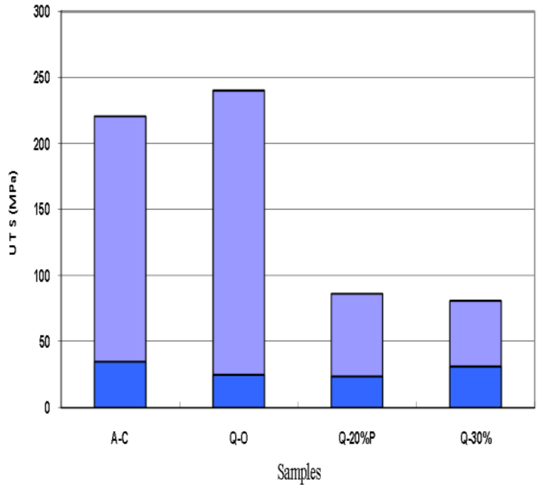

Fig. 2.Tensile Test Results of Specimens

Figure3. Below shows the result of Impact test conducted, As-Cast Sample recorded higher impact strength.

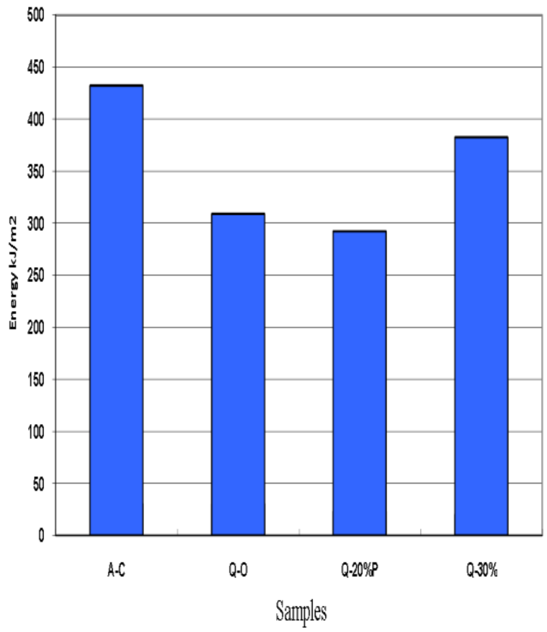

Fig 3. Impact Strength Test Results

3.2 Results Analysis and Evaluation

3.2.1Tensile Strength Test Analysis

The results of the tensile test are expressed as follows:

The cross sectional area of the sample can be given as;

$$\text{CSA} = B * W ------------------------------(1)$$

Where CSA = cross sectional area

B = breadth

W = width

The ultimate tensile strength of the sample can be given as;

$$(\text{UTS}) = \frac{M_L}{C\,SA} ------------------------------(2)$$

Where UTS = Ultimate tensile strength

M_L = Maximum load

CSA = Cross sectional area

The percentage elongation can be given as;

$$(\%e) = \frac{\Delta L}{Lo} * 100 ------------------------------(3)$$

Where %e= percentage elongation

ΔL = change in length

Lo= original length

Tensile strength and percentage elongation of each sample can be computed using equation (1) – (3)

Example; for the sample Quenched in Oil:

B = 9mm

W=9mm

M_L = 19453.14N

L_F = 54.074mm

ΔL = 54.074 – 50.00 = 4.074mm

$$\text{CSA} = 9 \times 9 = 81mm^2 \ or\ 0.081m^2$$

(i) UTS $= \frac{19453.14}{81} = 240.16kN/m^2$

(ii) (%e) = $\frac{4.074}{50} X\ 100 = 8.15\%$

4.2.2 Impact Test Analysis

The cross sectional area of the sample can be given as;

$$\text{CSA} = B * W ---------------------------------(4)$$

The Impact strength of the sample can be given as;

$$A_K = \frac{a_k}{C\ SA} ---------------------------------(5)$$

Cross Sectional Area and Impact Strength of each sample can be calculated using equations (4) and (5)

Example; for the sample quenched in oil

B = 9mm

W = 9mm

a_k = 25J

$$\text{CSA} = 9 \times 9 = 81mm^2 \; or \; 0.000081m^2$$

$$A_K = \frac{25J}{0.000081m^2} = 308.6kJ/m^2$$

Table 6: Ultimate tensile strength

Sample Treatment	LOAD (N)	Cross sectional area (mm²)	Initial length (mm)	Elongation (mm)	Ultimate tensile strength (MPa)	% Elongation
AS-CAST	17881.00	81	50	3.76	220.75	7.52
Q- OIL	19453.14	81	50	4.074	240.16	8.15
Q -30% P	6562.89	81	50	1.82	81.02	3.64
Q- 20%P	7001.07	81	50	3.03	86.43	6.06

3.3 Discussion of Results

3.3.1 Hardness

The Hardness results obtained before and after heat treatment showed that as-cast sample had a hardness of 48.7HRC. After heat treatment sample quenched in 30% polymer solution recorded higher hardness 72.7HRC followed by the samples quenched in 20% Polymer solution (70HRC). Samples quenched in oil after austenization recorded 64HRC this shows that there is improvement in hardness on the all samples, with the sample quenched in 30% polymer solution recording highest and oil quenched samples recording lowest. The values are represented in Fig.2 above.

3.3.2 Tensile Strength

The average values obtained for the Ultimate Tensile Strength test for the samples before and after heat treatment were 220.75 MPa, 240.16 MPa, 81.02 MPa, and 86.07 MPa for as-cast, quenched in oil, quenched in 20% polymer solution and quench in 30% polymer solution respectively. The results show that all samples recorded decrease in tensile strength after heat treatment with exception of samples quenched in oil. The values are represented in Fig 3.

3.3.3 Impact Strength

The average values obtained for the Impact Strength test for the samples before and after heat treatment were 432.2 kJ/m^2, 308.8 kJ/m^2, 382.8 kJ/m^2 and 292.3 kJ/m^2 for as-cast, quenched in oil, quenched in 20% polymer solution and quenched in 30% polymer solution respectively. The results show that all samples recorded decrease in impact strength after heat treatment. For heat treated Samples, sample quenched in 30% polymer solution recorded lowest impact strength while sample quenched in oil indicated higher impact strength. The values are presented in fig.3.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The results of the various tests conducted on the grinding disc revealed That both hardness and tensile strength of the disc mill improved after heating to austenizing temperature and quenching in oil as shown in Table 4 and 5. This indicates that used automobile oil is more suitable media of quenching condiment grinding disc as compared to Polymeric quenchant.

4.2 Recommendations

Based on findings of this work the following recommendations are made:

- That oil quenching can be used as quenching medium for improving the hardness of condiment grinding disc.
- Researches on the effect of various polymer concentration and/or type of polymer on cast iron or any other metal can be carried out.

REFERENCES

1. Davies, D.J and Oelmann, L. A. (1983). "The structure, properties and heat treatment of metals", Pitman publishing New Zealand LTD, Wallington.
2. George, A. "Quenchant and Quenchant Technology". http:/www.amazon.com. Accessed August, 2014.
3. Ahmed, O. J. (2011) "Study the effect of polymer solution and oil Quenchant on Hardening Automotive camshaft". Journal of Thi-Qar University, Vol. 6, Pp. 134-146.
4. Yahaya, D.B Abdullahi, I and Aremu, D.A (2012). Investigation of Metal Contaminants in locally Ground Foods. Journal of Emerging dreads in Engineering and Applied Sciences 3(1) PP, 340-342.
5. Goweriker,V. R.; Viswannathan, N.V.; and Sreedha J. (2007). "Polymer Science" Published By New Age International (P) LTD New Delhi India.
6. Hassan, S. B, Agboola. J.B, Aigbodion, V.S. and Williams, E.J, (2011). "Hardening Characteristics of Plain Carbon Steel and Ductile Cast Iron Using Neem Oil as Quenchant", Journal of Minerals & Materials Characterization & Engineering, Vol. 10, No.2, pp.161.
7. Tweeddale, J.G. (1964). The Mechanical Properties of Metal: Assessment and Significance. George Allen and Unwin Ltd, London.

MULTIPLE STUDENTS' INSTITUTION BASED LEARNING BY EXPERIENCE PROGRAMS: SOLUTION FROM THE SCRATCH FOR BETTER INDUSTRY AND RESEARCH INTEGRATION

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ABSTRACT

The purpose of this paper is geared towards information gathering on the existing relationship between engineering students and the practical courses offered to them, and possibility of introducing new more students' experience enhancement programs to tackle the problem from its root and preparing students /engineers for industry with a view to enhancing their research and industrial practice ability through more in house experimental and working experience programs that will prepare them well on graduation. Experiential learning is also referred to as learning through action, learning by doing, learning through experience, and learning through discovery and exploration as a goal for narrowing the existing gap is considered. First of all data were taken in form of semi structured questionnaire from engineering academicians, students from a federal university and a federal polytechnic and also from engineers outside the academic institutions for assessing the level in which the students gain and will gain their practical knowledge and the extent to which it will prepare them for industry. Also this research paper has studied the level and frequency at which the students experience programs will be conducted suggested by academicians, students, laboratory Technologist and technicians and has also shown a low level of industry related researches carried out at the research institutions for the students and also show a low participations from students.

KEYWORDS: Practice, Assessments, Academia Research.

1. INTRODUCTION

In the book, *Teaching for Experiential Learning by,* Wurdinger and Carlson (2010) has found that most of college faculties teach by lecturing as few of them learnt how to teach that way.

Although a good lecturing should be part of an educator's teaching repertoire, faculties should actively involve their students in the learning process through a discussion, group works, practical hands-on participations, and applying information outside the classroom.

This process is referred to as experiential learning as students are involved in a learning content in which they have a peculiar interest and need. Learning through practical experience has not been a new concept for the higher college classrooms. Renowned educational psychologists such as John Dewey (1859-1952), Carl Rogers (1902-1987), and David Kolb (b. 1939) have worked out the groundwork of learning theories that focus on "learning through experience or "learning by doing." Dewey had popularized the concept of Experiential Education which focuses on problem solving and critical thinking rather than memorization and rote learning. Rogers considered experiential learning "important and significant" as compared to what he called "meaningless" cognitive learning. Kolb also had noted that concrete learning experiences are more critical to meaningful learning and is well known for his Learning Style Inventory (LSI) which has been widely used in many fields of studies and disciplines today to help in identifying some preferred forms of learning. A key element of experiential learning is the student, and that learning happens (the knowledge gained) as a result of being personally involved in this pedagogical approaches.

1.1 Experiential Learning Principles

The list of experiential learning principles as noted from the (Association for Experiential Education, 2011, para 4): is as follows

1. Experiential learning happens when carefully chosen practical experiences are supported by reflection, critical analysis and synthesis.
2. Experiences are structured to prepare the students to take initiative, make decisions and be responsible for results.
3. Throughout the experiential learning process, the student should be actively engaged in posing questions, making investigations and experimentations, be curious, solve problems, assume responsibility, be creative and constructive.
4. Students should engage intellectually, emotionally, socially and physically. This involvement producing a perception that the learning task is genuine.
5. The results of the learning form the basis for future experience and learning.
6. Relationships are developed and nurtured: student to self, student to others and student to the world at large.
7. The instructor and student may see success, failure, adventure, risk-taking and uncertainty, because the outcomes of the experience could be a positive or negative.

1.2 Instructors' role in experiential learning

The instructor's basic roles includes setting suitable experiences, bringing up problems, setting up boundaries, support to students, insure physical and emotional safety, and facilitating the practical learning process.

Also instructor should recognize and motivate students for spontaneous opportunities of learning and has to strive to be aware of their interests, judgments and ideas and how it influences the student. The design of the practical learning experience should include the possibility to learn from the natural consequences, natural mistakes and successes. In experiential learning, the instructor should guide rather than directing the learning processes where students are naturally interested in learning. The instructor assumes the role of facilitator and is guided by a number of steps crucial to experiential learning as noted by (Wurdinger & Carlson, 2010, p. 13).

1. Be willing to accept a less teacher-centric role in the classroom.
2. Approach the learning experience in a positive, non-dominating way.
3. Identify an experience in which students will find interest and be personally committed.
4. Explain the purpose of the experiential learning situation to the students.
5. Share your feelings and thoughts with your students and let them know that you are learning from the experience too.
6. Tie the course learning objectives to course activities and direct experiences so students know what they are supposed to do.
7. Provide relevant and meaningful resources to help students succeed.
8. Allow students to experiment and discover solutions on their own.
9. Find a sense of balance between the academic and nurturing aspects of teaching.
10. Clarify students‟ and instructor roles.

1.3 Student Roles in Experiential Learning

Qualities of experiential learning are those in which students decide themselves to be personally involved in the learning experience (students are actively participating in their own learning and have a personal role in the direction of learning). Students are not completely left to teach themselves; however, the instructor assumes the role of guide and facilitates the learning process. The following list of student roles has been adapted from (UC-Davis, 2011 and Wurdinger & Carlson, 2010).

1. Students will be involved in problems which are practical, social and personal.
2. Students will be allowed freedom in the classroom as long as they make headway in the learning process.
3. Students often will need to be involved with difficult and challenging situations while discovering.
4. Students will self-evaluate their own progression or success in the learning process which becomes the primary means of assessment.
5. Students will learn from the learning process and become open to change. This change includes less reliance on the instructor and more on fellow peers, the development of skills to investigate (research) and learn from an authentic experience, and the ability to objectively self - evaluate one's performance.

1.4 Integrating Experiential Learning (EL) in Teaching

As previously noted, a primary role for instructors is to identify a situation which challenges students through problem-solving, cooperation, collaboration, self-discovery and self-reflection. At the same time, decide what the students should learn or gain from the learning experience. Below are some primary points to consider when integrating experiential learning in your own teaching.

Plan. Once the EL experience has been decided upon, plan the experience by tying it to the course learning objectives and determine what students will need to successfully complete the exercise (resources such as readings and

Worksheets, research, rubrics, supplies and directions to off-campus locations, etc.). Also, determine the logistics: how much time will be allotted for the students to complete the experience (a complete class session, one week or more)? Will students need to work outside of class? How will the experience end? What forms of assessment will you employ? Will you use ongoing assessments such as observations and journals (called formative assessment), end of experience assessments such as written reports and projects, self and/or peer assessments, or a combination of all three?

Prepare. After the planning has been completed, prepare materials, rubrics, and assessment tools and ensure that everything is ready before the experience begins.

Facilitate. As with most instructional strategies, the instructor should commence the experience. Once begun, you should refrain from providing students with all of the content and information and complete answers to their questions. Instead, guide students through the process of finding and determining solutions for themselves.

Evaluate. Success of an experiential learning activity can be determined during discussions, reflections and a debriefing session. Debriefing, as a culminating experience, can help to reinforce and extend the learning process. In addition, make use of the assessment strategies previously planned.

1.5 Experiential Learning Opportunities in Higher Education

There are numerous experiential learning opportunities in higher education that can be found in most disciplines. The following is a list of these experiences as noted by (George Mason University, 2011; Loretto, 2011; Northern Illinois University OTC, 2011).

A. **Apprenticeship Experiences** provide students an opportunity to try out a job usually with an experienced professional in the field to act as a mentor. Apprenticeships are a type of on the job training which may lead to certification. Many skilled laborers learn their trade by doing an apprenticeship.
B. **Clinical Experiences** are hands-on experiences of a pre-determined duration directly tied to an area of study such as nursing students participating in a hospital-based experience or child development and teacher education students participating in day care and classroom settings.
C. **Cooperative Education Experiences** are more extensive than internships and will usually span two or more semesters of work. Co-ops are paid professional work experiences and are tied very closely to the student's academic work. During the co-op experience students will receive ongoing advising and the co-op will be structured to meet the student's academic and/or career goals. Co-op experience usually is included on a student's transcript in addition to being awarded designated credit hours for its completion.

D. **Fellowship Experiences** provide tuition or aid to support the training of students for a period of time, usually between 6 months to one year. They are usually made by educational institutions, corporations, or foundations to assist individuals pursuing a course of study or research. Post-graduate fellowships assist students at the graduate level while post-doctorate fellowships provide monies for those who have already achieved their doctorate degree.

E. **Field Work Experiences** allow students to explore and apply content learned in the classroom in a specified field experience away from the classroom. Field work experiences bridge educational experiences with an outside community which can range from neighborhoods and schools to anthropological dig sites and laboratory settings.

F. **Internship Experiences** are job-related and provide students and job changers with an opportunity to test the waters in a career field and also gain some valuable work experience. Internships can be for credit, not for credit, paid or unpaid**.**

G. **Practicum Experiences** are often a required component of a course of study and place students in a supervised and often paid situation. Students develop competencies and apply previously studied theory and content such as school library media students working in a high school library or marketing majors working in a marketing research firm. Practicum experiences also allow students to design and develop a project in which they apply knowledge and develop skills such as a doctoral student preparing the components of an online course.

H. **Service Learning Experiences** are distinguished by being mutually beneficial for both student and community. Service learning is growing rapidly and is considered a part of experiential education by its very nature of learning, performing a job within the community, and serious reflection by the student. Service learning involves solving some of society's issues; such as, homelessness, poverty, lack of quality education, pollution, etc. One of the goals of service learning is to help students become aware of these issues and develop good citizenship in learning how to help solve some of these problems.

I. **Student Teaching Experiences** provides student candidates with an opportunity to put into practice the knowledge and skills he or she has been developing in the preparation program. Student teaching typically involves an on-site experience in a partner school and opportunities for formal and informal candidate reflection on their teaching experience, the on-site teaching portion of this experience can range from ten to sixteen weeks, depending on the program

J. **Study Abroad Experiences** offer students a unique opportunity to learn in another culture, within the security of a host family and a host institution carefully chosen to allow the transfer of credit to a student's degree program. Students studying a foreign language will perfect the accent and greatly expand their vocabulary--a skill retained for life. Making new friends, and travel and decision making, are also key parts of the study abroad experience.

K. **Volunteer Experiences** allow students to serve in a community primarily because they choose to do so. Many serve through a non-profit organization – sometimes referred to as formal volunteering, but a significant number also serve less formally, either individually or as part of a group. Because these informal volunteers are much harder to identify, they may not be included in research and statistics on volunteering.

2. METHODOLOGY

2.1 Sample

A questionnaire based method was used and the data were obtained from two institutions that: Bayero University and Hussaini Adamu Federal polytechnic Lecturers, Technologist, Technicians, Engineers (working within the institutions and outsiders) and students. No gender was considered in both. Comparisons between participants from both program viewpoints formed the framework for the data sampling, analysis and interpretation Shkedi, I.A. (2003). Sixty three (63) Lecturers ranging from Graduate Assistant to professors in university and Assistant Lecturers to level chief lecturer as the case in polytechnic system. 21% of the sample was university lectures while 20% of it was polytechnic lecturers, 21% Technologist, 9% Technicians, and 21% students.

All the students were fully engineering students that have started full faculty core course and practical, meaning they have little knowledge on what engineering practical they are offered while some are fresh engineering graduate and engineers who had completed all required undergraduate practical and industrial trainings with full undergraduate academic requirements.

2.2 Data Collection

Data collection involved a systematic process of accessing a number of information in form of a questionnaire from number of sources: engineering academicians, engineers and students as reflective questionnaire. Students 'practice concern and interest, academician and engineers' practice concern, industry contacts and consultancy at all level of educations and fields of engineering were assessed and considered as follows:

1. Nature of Job
   Here nature of the job is assed whether they are academicians, government, private, self or even unemployed.
2. Level Of Education
   Under this part level of education were assessed which included undergraduate, graduate and post graduate
3. Field Of Engineering
4. Do you support The Introduction of more in house Student Experience programs to acquire more hands on practical experience for all Engineering Students, a practical such as electric motor winding and rewinding, Electronics Repairs such as T.V , Radio ,Hand set repairs e.t.c , Hands on electric circuit constructions and maintenance for instance for electrical Students at all school time level and how often
5. Nature of the student experience course if introduced**,** Compulsory with 70% attendance or Optional
6. Do you think this new practical course will make most of the student able to construct their projects themselves when they reach their final year?
7. Do you think the new practical course will prepare and encourage them well to/ for industry?
8. Do you think a Research Seminar course should be introduced?
9. Research Publication
   Total No. Of Research Publications Industry Inclined/Based Ones that are applied in industry and Non Industry Inclined/ Based Ones
10. Practicing: Engineering practice status (industry consultancy services and industry contacts) was accessed

Practical experiences, how they value and appreciate it, if they are really practicing the engineering or not

11. Research Laboratory Contacts: The abilities and research skills

2.3 Data analysis

The use of inclusive analysis helped illuminate the research model of the engineering practice assessment. The data from all sources were aggregated into categories that emerged from content analysis. The categories were integrated into a chart with different sectional parts that reflected the results as feelings, beliefs, and knowledge of the participants.

The use of different sources of data enabled us to represent the participants' authentic voices, experiences, and insights and to reinforce our confidence in the credibility of the data.

3 RESULTS AND DISCUSSION

The idea of incooperating the forty nine(49) lecturers , twenty one (21) technologist, nine (9) technicians and twenty one 21 students has revealed the level of practice and research skills interest among students and engineers, 96% of the participants that is academicians, students and engineers have shown a great support for the introduction of the new suggested in house experience program with a supported frequency as 39% recommended the program to be for every academic year then followed by 29% that suggested it to be for three academic sessions, 10 for four sessions, 15 persons suggested it to be for two sessions while 8 persons for a single year the engineering program.

This study has shown that most of the participants **(96%)** believe the program will help in enhancing students' ability to have a good practical education knowledge and research skills that will increase the level of students’ participation in practice on graduation in a professional and guided ways which is the major educational goal in engineering, bridging the gap between theory and practice, research and **98%** believed it will prepare them well for future research and developments between them in the industry and the research institutions. Majority(85%) from fig.1-6. of the teachers involved in research teachings that is academicians and practical teachings (technologist and technicians) suggested the program to be a compulsory course for every engineering students and will help them gain insight into how they are working presently while looking forward to improve for their future practice. The focus of the current research was to develop a Students’ Institution based Learning by Experience Programs in preparing Student and Engineers from scratch for better Research –Industry Integration.

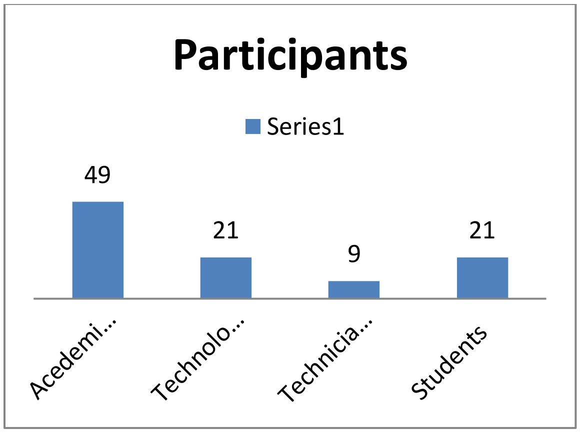

Fig. 1Participants (respondents)

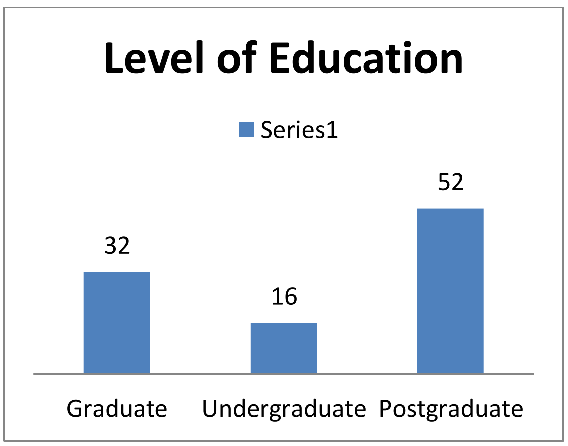

Fig.2 Participants ‘Level of Education

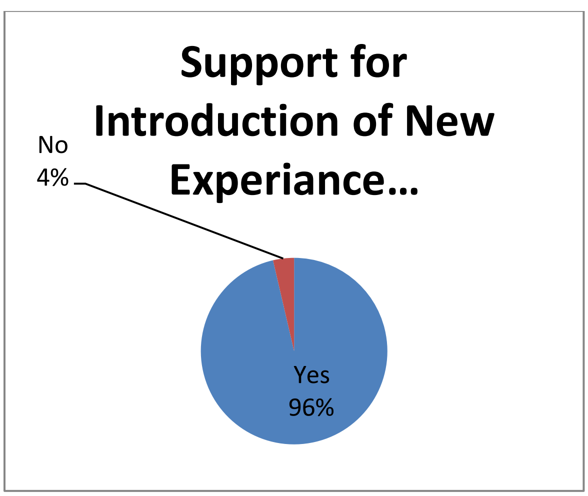

Fig.3 Support for the Program

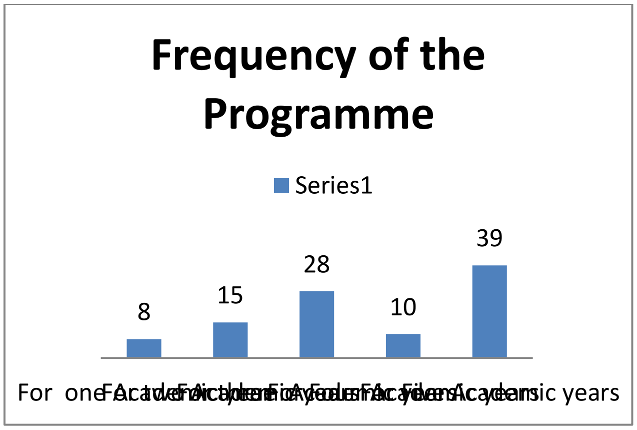

Fig.4 Frequency of the program (Year)

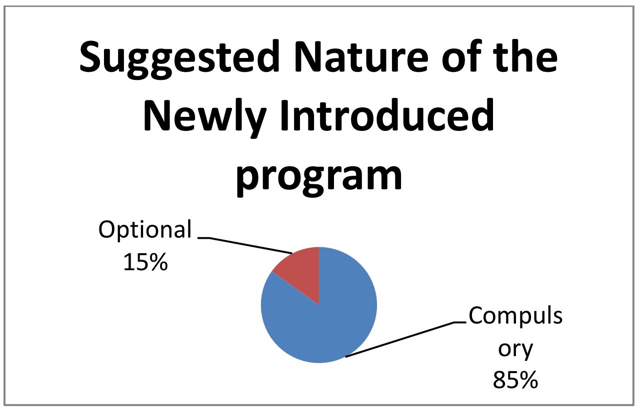

Fig.5 Nature of the Program

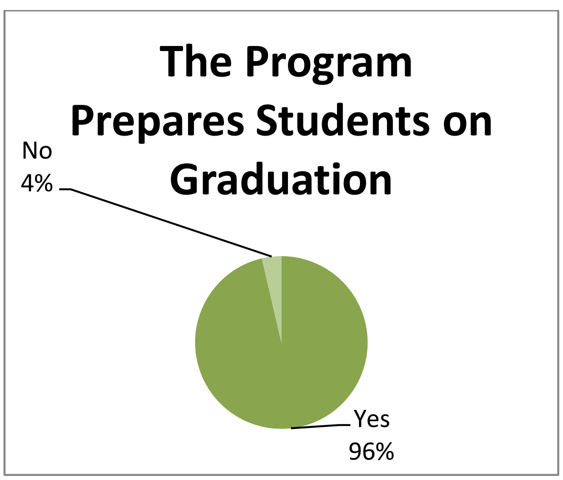

Fig.6 Program prepares Students on Graduation

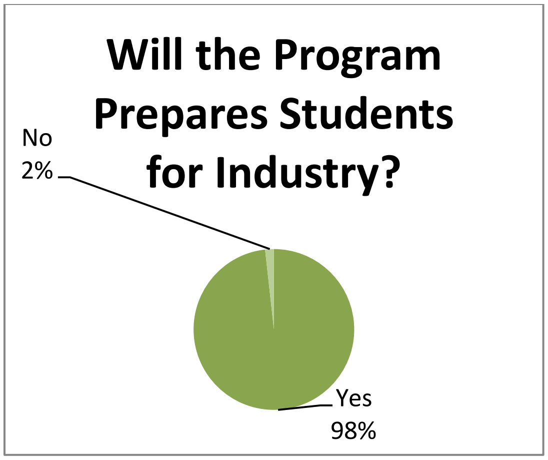

Fig.7 Program prepares Students for Industry

4 CONCLUSION

The idea of incorporating the lecturers, engineers and students of the engineering has revealed the level of practice and research skills interest among the fellow engineers, Most academicians, students and engineers have shown a great support for the introduction of the new suggested in-house experience program and have supported mainly its frequency to be more than one program in the engineering program, which means the educational curriculum is suggested to be adjusted.

Also the study has shown that most of the participants believed the program will help in enhancing students' ability to recall practical education knowledge, research skills and will increase the level of students' participation in practice on and after graduation that can be applied in professional situations which is a major educational goal, bridging the gap between theory, practice, research and prepare them well for future research and developments.

Findings suggested that more practical and research-oriented teaching Programmes should be introduced to students in targeting them from the scratch and preparing them for industry as next generation engineers and Future studies and teaching practices should explore more on the teaching of research skills and their actual implementation in the educational field.

REFERENCES

[1] Association for Experiential Education http://www.aee.org/

[2] George Mason University. Center for Teaching Excellence (2011). *About teaching: Experiential learning*. http://cte.gmu.edu/Teaching/experiental_learning.html

[3] Haynes, C. (2007). *Experiential learning: Learning by doing*http://adulteducation.wikibook.us/index.php?title=Experi

[4] Loretto, P. (2011). Experimental_Learning_learning_by_Doing,*Learningbyexperience*.tp://internships.about.com/od/internships101/p/TypesExperEd.htm

[[5] ELC, (2011) (ELC Northern Illinois University, College of Business Experiential Learning Center). http://www.cob.niu.edu/elc/

[6] OSEEL (2011). Northern Illinois University, Office of Student Engagement and Experiential Learning *About the office of student engagement and experiential learning(2011)*.http://www.niu.edu/teachercertification/teachercert/tcp_st.shtml

[7] OTC (2011) Northern Illinois University, Office of TeacherCertification).*Studentteaching*.http://www.niu.edu/teachercertification/teachercert/tcp_st.shtml

[8] SAP (2011) Northern Illinois University, Study Abroad Program. *A parent's guide to study abroad programs.* http://www.niu.edu/studyabroad/audiences/parents.shtml

[9] UC Davis etal . (2011) University of California Davis (). *5-step experiential learning cycle definitions.* http://www.experientiallearning.ucdavis.edu/module1/el1_40-5step-definitions.pdf

[10] Wurdinger, S. D., & Carlson, J. A. (2010). *Teaching for experiential learning: Five approaches that work.* Lanham, MD: Rowman & Littlefield Education.

[11] Shkedi, I.A. (2003). Words that are trying to touch: Qualitative research,theory and practice. Tel-Aviv: Ramot. (Shkedi, 2005).

ASSESSMENT OF THE QUALITY OF MATERIALS AND WORKMANSHIP FOR BUILDING PROJECTS IN LOKOJA.

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ABSTRACT

This paper focus on the assessment of quality of material and workmanship for building projects in Lokoja. The objectives include: 1. to assess the quality of building materials and workmanship for building project in Lokoja. 2. To assess the effect of the quality of building materials and workmen trades on the quality of building projects in the study area. These were achieved by assessing some basic building material and workmanship used for building projects. In keeping up with the aim of the research work, 40 structured close ended questionnaires were administered to the respondent and retrieved using stratified random sampling using builders, architects, engineers, quantity surveyors, contractors and Artisans as the respondents. Data collected were presented and analysed using tables and Relative Importance Index (RII). It was found that out of the 19 building materials investigated, 14 were of good quality with cement ranking highest while 5 were of low quality with laterite ranking lowest. On the rating of quality of trades of workmen in Lokoja results reveals that painters, electrician and carpenters produce the most satisfactory quality of work with relative Importance Index (RII) of 3.90, 3.7, and 3.4 respectively. The workmen trades who specialized in the actual construction process were ranked low, and this calls for concern. Further findings indicate that cement, Reinforcements, Granite and sharp sands were ranked as the materials with most impact on the quality of building projects in Lokoja. Plaster sand was ranked lowest owing to the fact that it is only used for finish and hence does not have direct impact on the structural stability of the building.

Keywords: Assessment, Building, Lokoja, Materials, Projects, Quality, Workmanship

1. INTRODUCTION

Building is an enclosure for spaces designed for specific use, meant to control local climate, distribute services and evacuate waste. It is a structural entity capable of securing self by transmitting weights to the ground (Fadamiro, 2002). More so, building is a structure for human activities, which must be safe for the occupants. However, these same buildings have been posing treats and dangers to people either during or after construction as a result of its collapse due to poor quality of material and workmanship (Odulami, 2002).

Quality has become a very popular subject in recent years due to conceptual changes in the industry. It is playing a pivot role during the construction phase of the project. The definition of quality in the past as "compliance to standards" is now found to be inadequate and replaced with the current definition as "customer satisfaction" (Abdel-Razek, et al., 2001). Quality is an outcome of engineering and manufacturing process. It is a conformance to agree and fully understood requirements. It is believed that quality is not comparative, and there is no such thing as high quality or low quality. A product or service either conforms to requirements or it does not (McCabe, 1998).

In Nigeria, materials and components are displayed in the market without Standard Organization of Nigeria (SON) quality certification number. It is also noted that quality continues to decline (Akingboungbe, 2002). More so, there are insufficient testing laboratories where most

building materials and components are tested before standard are established for good practice and use. Sometimes, specimens of materials sent to the laboratories have better strength than those on production sites (Odulami, 2002). Odulami further stated that a bag of cement should weigh 50kg on arrival at the site. Also, sand and aggregate brought to production sites sometimes come with certain percentage of impurities which may be injurious to cement and the reinforcing rod. This will lower the strength of concrete made of this type of materials. The various reinforcing rods come to site with varying diameters and strength. This affects the strength of structural members of buildings where they are used. The production of undersized and unseasoned timber that is mostly taken for granted may lead to deflection of beams and slab made from such materials. The interaction of problems resulting from the above will lead to building failure and eventual collapse.

Additionally, poor quality of workmanship makes it difficult or impossible for workers to perceive and apply the concepts of quality control and limits of tolerance for building production thereby, resulting in poor construction which may finally lead to building collapse (Ogunsemi, 2002). The site of building collapse scattered across the length and breadth of Nigeria is quite alarming that it is unimaginable what effects it will have on the building industry and Nigeria economy as a whole.

This incidence of building collapse therefore called for a need to study the competency and effectiveness of construction sites workers in Nigeria and also to investigate the quality, durability, performance and other quality assurance criteria of building materials and components used for building construction. The aim of this paper is to investigate the relationship between poor quality of materials and workmanship and building collapse in Nigeria.

Majority of building projects (both ongoing and completed) in Lokoja are often characterized by noticeable defects. This defect causes rapid deterioration of the building elements, serviceability problems and sometimes structural failure of the building. Against this backdrop, informed assessments of the quality of material and workmanship to be used for building projects are needed if functionality and serviceability of a building is to be sustained.

The aim is of this research work is to assess the quality of material and workmanship used for building projects in Lokoja. The following objectives are to be achieved: **A**ssessment of the quality of building materials and workmanship and the effect of the quality of workmen trades on the quality of building projects in lokoja.

2. OVERVIEW AND REFERENCE TO RELATED WORKS

Quality can be defined as "the total conformance of a product to standard and specification i.e. the product must be able to meet client's requirements and specification and must be fit for its purpose (Olusola et al., 2002). He further said that the absence or lack of quality is easily recognized in faulty product that create problems for users and generally fail to achieve user's satisfaction.

In most buildings, materials that are primarily used on site (referred to as "star" materials by Odulami (2002)) are cement, sand, and aggregate (of various classes). Iron rods, water and timber (hard or soft wood). These materials are usually mixed together to give different components and elements found in the erection of any building structures. For a good structure, these components must be of some specific ultimate strength, which must have been tested and trusted.

However, materials of secondary importance and application are glass, aluminum and ceramics. Due care must be taken in the selection of materials as the two of them i.e. primary and secondary, are not separable (Bolaji, 2002). It is on record that, good building techniques are enhanced by building materials of good quality (Adebayo, 2000). Building materials, no matter how good they may be (whether primary or secondary), can be seriously vulnerable if not properly handled and stored.

In 2007, a building collapsed in Nigeria during construction and it was attributed to the use of sub-standard materials especially the sandcrete block used in the construction (Olusola, Ata & Ayangade, 2002). Quality of concrete, for instance, has been badly affected as a result of sub-standard and poor material and this is the reason why many buildings of reinforced concrete members collapse with loss of lives and injuries (Olusola, Ata & Ayangade, 2002). The issue of confirmation of quality of building materials when used in the construction process must be taken serious so as to avoid situations where majority of buildings fail in meeting safety obligations to the general public which may finally result into building collapse. Before any material should be incorporated into building works, there is a need to establish its quality through quality control (QC), quality assurance (QA) and quality level (QL).

The quality, cost and timely delivery of products in the construction industry very much depends on workmanship (The Hindu, 2006). The skill, experience and personal ability of the workmen go a long way in determining the quality of the workmen, which is a measure of their effectiveness and efficiency. Workmanship is "skill in an occupation or trade of different workmen based on their training or profession" (Adetayo, 1995).

Workmen in the building industry could be classified into professional skilled and unskilled labour. Professionals in the building industry include architect, quantity surveyor, Engineers, land surveyor, builder and estate surveyors. Skilled labourers are those who overtime have been trained in their specific trades and have experience that is needed to do their various works well. They range from general foreman and to other skilled craftsmen such as carpenters, bricklayers, plumbers, iron binders, etc.

The unskilled labourers do not have any skill in any trade. They are usually on site to give assistance to the skilled labourers and usually come in two forms – those learning to become skilled in their chosen trade and those that are not learning any trade i.e., they only render assistance. Skilled labourers are those that are directly involved in the building process.

3. RESEARCH METHODOLOGY

The data used in this research were collected via the administration of well-structured questionnaires to professionals and workmen trades in the construction industry. The data were used to assess the quality of material and workmanship for building projects in Lokoja.

The sampling frame for this research was fragmented amongst the following institutions of professionals in the construction industry; Nigerian Institute of Building (NIOB); Nigerian Institute of Architect (NIA); Nigerian Institute of Quantity Surveyors (NIQS) ; Nigerian society of Engineers (NSE) which constitute the target population. Since the population of study for this research is clearly defined, every respondent in the defined population was given equal chance during the administration of the questionnaire.

The structured questionnaire was designed to have multiple-choice type of different tables and checkboxes. The preliminary section of the questionnaire dwells on background information from the professionals in the industry, which was designed to collect data on the general characteristics of the respondents in order to check for the quality of the data in readiness for analysis and interpretation. The historical data gotten were collected from NIOB, NSE, NIA, NIQS journals, The Journal of the Federation of Construction Industry in Nigeria, and newspaper dailies, publications on building collapse and through the website.

Tables were used for data presentations. The analysis of the collected data was carried out using the following descriptive and analytical scientific methods. Nominal data were used as a scale of measurement to differentiate the parameters being measured after the variables have been converted into numbers.

The questions in the administered questionnaires were structured and ranked using Likert Scale and the responses were analysed with the use of Relative Important Index (RII). This can be expressed as thus:

$$RII = \frac{\Sigma P U_i}{N}$$

Where RII= Relative Importance Index, p = employment rating/ranking (5, 4, 3, 2 and 1), U= premium (5) and N= no. of samples (40)

Two different legends are used for analyzing this research. They are;

Extremely Satisfactory (E.S) ------------- 5

Very Satisfactory (V.S) ------------------- 4

Satisfactory (S) ---------------------------- 3

Slightly Satisfactory (S.S) ---------------- 2

Not Satisfactory (N.S) --------------------- 1

The interpretation of the above legend is that, factors ranked from; 1-1.99 are not satisfactory, 2-2.99 are slightly satisfactory, 3-3.99 are satisfactory, 4-4.99 are very satisfactory and 5 and above are Extremely satisfactory.

The second legend is;

Extremely High Effect (E.H. E) ---------- 5

Very High Effect (V.H.E) ------------------ 4

High Effect (H.E) ---------------------------- 3

Low Effect (L.E) ---------------- ------------ 2

Very Low Effect (V.L.E) ------------------- 1

The interpretation of the above legend is that, factors ranked from; 1-1.99 have very low effect, 2-2.99 have low effect, 3-3.99 have high effect, 4-4.99 have very high effect and 5 and above have extremely high effect. The above rankings were used to achieve objectives one, two and three. Forty questionnaires were randomly administered to the target group. All the administered questionnaires were retrieved, representing 100% effective response rate.

4. RESULTS AND DISCUSSION

4.1 Presentation and Analysis of Respondents Information

Background information of the respondents were collected and analysed. This was necessary in order to validate the acceptability of their opinion and knowledge of information sought by the researchers. The result of their responses are presented and analysed below

4.1.1 Respondent's Professional Training

The result of the respondent's professional training is presented in Table 1. It can be seen from the table that 40% of the respondents were Artisans trained in different building trades such as electrician, mason, carpenters, plumbers, painters etc. The research allocated this per cent to the respondents because they are saddle with the responsibility of actual translation of materials and drawings to the real structure. Hence their knowledge of quality material usage and workmanship is very vital for the validity of the research. More so, 20% was also allocated to the Architect and Quantity Surveyors because drawings are made by Architect while the Architect and the Quantity Surveyor carry out the material and workmanship specifications. Builder, Architect, Electrical Engineer and Mechanical Engineers were allocated 5% each.

Table 1 Respondent's Professional Training

Profession	Frequency	Percentage
Builder	2	5
Architect	8	20
Electrical Engineer	2	5
Mechanical Engineer	2	5
Civil Engineer	2	5
Quantity surveyor	8	20
Artisan	16	40
Total	45	100.0

Source: Field survey, 2014

4.1.2 Respondent Years of Experience in the Construction Industry

Table 2 shows the respondents' years of experience in the construction industry. From the analysis, 50% of the respondents have 10 to 15 years of the construction experience while 20% have between 1-5 years and another 20% have between 5-10 years of working experience in their various training and professions. 5% of the respondents each have between 15-20 years and above 20 years respectively. It can therefore be concluded that the majority of respondents possess the prerequisite experience to order quality material and workmanship.

Table 2 Respondent years of Experience in the Construction industry

Years of experience	Frequency	Percentage
1-5years	8	20
5-10years	8	20
10-15years	20	50
15- 20 years	2	5
20 years and above	2	5
Total	40	100.0

Source: Field survey, 2014

4.1.3 Training on Quality Control and Quality Control Management

Table 3 shows the training on quality control and quality management. It is seen from the table that majority of the respondent (80%) had undergone training on quality control and quality control management. Quality control involves carrying out the work to standards and specification and discarding such if not up to while quality control management deals with getting it right at first time. This means that majority of the respondents have undergone one training or the other in respect of quality management and control.

Table 3 Training on Quality Control and Quality Control Management

S/N	Training on Quality control and quality control management	Frequency	Percentage
1	Yes	32	80
2	No	8	20
	Total	40	100

Source: Field survey, 2014

4.2 Assessment of the Quality of Some Basic Building Materials used in Lokoja

The result in table 4 shows that cement used in the area (with RII= 4.92), sharp sand (with RII= 4.40), and granite (with RII = 4.35) were the locally made material that was ranked highest with the grade points above '4' meaning they are very satisfactory. The following materials were ranked satisfactory in terms of quality in the ranking order presented, nails; ceiling boards, plaster sand; reinforcing bars (high yield); wall tiles; glazed windows; metal windows; timber; floor tiles; sanitary appliances; and wooden windows.

Further Investigation reveals that cements used in Lokoja are produce from neighboring community (Obajana cement factory), sharp sand readily available along most riverine communities and vast granite resources in Ajaokuta.

Electrical fittings, wooden doors, metal doors, glazed doors, and laterite were ranked slightly satisfactory with laterite ranking lowest (with RII of 2.15 and SDV of 7.87). Investigation and physical assessment reveals that major laterite in Lokoja are mix with clay. This is not good for building as it may result to drying shrinkage which may lead to cracks in the building.

Table 4 Assessment of the Quality of Some Basic Building Materials

S/N	Building materials	E.S	V.S	S	S.S	N.S	% Scores	RII	ST. DEV	Rank
		5	4	3	2	1				
1.1	Cement used in the area.	25	12	8	0	0	197	4.92	10.34	1st
1.2	Sharp sand	21	14	5	0	0	176	4.40	9.24	2nd
1.3	Granite	18	18	4	0	0	174	4.35	9.27	3rd
1.4	Nails	10	15	14	1	0	154	3.85	7.10	4th
1.5	Ceiling board	6	14	16	4	0	142	3.55	6.78	5th
1.6	Plaster sand	5	14	16	5	0	139	3.47	6.74	6th
1.7	Reinforcement Bar (high Yield)	2	13	23	2	0	135	3.37	9.82	7th
1.8	Wall tile	2	13	23	2	0	135	3.37	9.82	7th
1.9	Glaze windows	5	8	23	4	0	134	3.35	8.86	9th
1.10	Metal windows	6	7	18	9	0	130	3.25	6.51	10th
1.11	Timber	3	4	30	3	0	127	3.17	12.38	11th
1.12	Floor tile	3	4	30	3	0	127	3.17	12.38	11th
1.13	Sanitary appliances	0	7	26	10	0	126	3.15	10.66	13th
1.14	Wooden windows	1	9	20	10	0	121	3.02	8.09	14th
1.15	Electrical fittings	0	5	28	5	2	116	2.90	11.37	15th
1.16	Wooden doors	0	2	30	8	0	114	2.85	12.72	16th
1.17	Metal doors	1	8	18	11	1	114	2.85	7.19	16th
1.18	Glaze doors	0	7	19	14	0	113	2.82	8.45	18th
1.19	Laterite	0	2	10	20	8	86	2.15	7.87	19th

Legend: E.S = Extremely Satisfactory (5), V.S= Very satisfactory (4), S= Satisfactory (3), S.S = Slightly Satisfactory (2), N.S = Not Satisfactory (1)
Source: **Field survey, 2014**

4.3 Assessment of the Quality of Building Trades of Workmen for Building Project in Lokoja

The result in table 5 on the rating of quality of trades of workmen in Lokoja reveals that painters, electrician and carpenters produce the most satisfactory quality of work having RII of 3.90, 3.7, 3.4 respectively which are slightly satisfactory. This call for concern as it reveals that trade workmen who specialized in the actual construction process are ranked low.

Table 5 Assessment of the quality of trades of workmen for building project in Lokoja

S/N	CONSTRUCTION TRADE	E.S	V.S	S	S.S	N.S	% Scores	RII	ST. DEV	Rank
2		5	4	3	2	1				
2.1	House painters	12	10	16	4	0	156	3.90	6.38	1st
2.2	Electrician	13	13	4	10	0	149	3.72	5.78	2nd
2.3	Carpenters	6	10	20	4	0	138	3.45	7.61	3rd
2.4	Landscaper	8	12	10	10	0	138	3.45	4.69	3rd
2.5	Plumber	8	12	8	12	0	136	3.40	4.89	5th
2.6	Glazier	4	8	25	3	0	133	3.32	9.92	6th
2.7	Iron benders	3	10	20	7	0	129	3.22	7.71	7th
2.8	Welders	9	10	8	8	3	128	3.20	2.70	8th
2.9	Cladders	8	10	8	6	8	124	3.10	1.41	9th
2.1	Mason	2	8	16	14	0	118	2.95	7.07	10th

Legend: E.S = Extremely Satisfactory (5), V.S= Very satisfactory (4), S= Satisfactory (3), S.S = Slightly Satisfactory (2), N.S = Not Satisfactory (1)
Source: Field survey, 2014

4.4 Assessment of Effect of the Quality of Material and Workmen Trades on the Quality of Building Projects in Lokoja

Table 6 ranked the effects of quality of material on the quality of building projects in Lokoja. From the table, it is seen that Cement, Granite, sharp sands, laterite, electrical fittings and timber have very high effect while nails, sanitary appliances, and plaster sand have high effect on the quality of building projects in Lokoja with cement ranking highest and plaster sand ranking lowest. Plaster sand was ranked lowest owing to the fact that it is only used for finish and hence does not have direct impact on the structural stability of the building.

Table 6 Assessment of Effect of the Quality of Material and Workmen Trades on the Quality of Building Projects in Lokoja

S/N	Building materials	E.H.E	V.H.E	H.E	L.E	V.L.E	% Scores	RII	ST. DEV	Rank
		5	**4**	**3**	**2**	**1**				
1	Cement	25	12	8	0	0	197	4.92	10.34	1st
2	Reinforcement Bar	23	10	7	0	0	176	4.40	9.46	2nd
3	Granite	14	25	2	0	0	176	4.40	11.05	2nd
4	Sharp sand	14	25	2	0	0	174	4.40	11.05	2nd
5	Laterite	18	18	4	0	0	174	4.33	9.27	5th
6	Electrical fittings	18	16	6	0	0	172	4.30	8.60	6th
7	Timber	19	14	7	0	0	172	4.30	8.45	6th
8	Nails	3	7	24	7	2	131	3.27	8.90	8th
9	Sanitary appliances	3	13	16	8	0	131	3.27	6.67	8th
10	Plaster sand	5	10	15	9	1	129	3.22	5.29	10th

5-Extremely High Effect, 4- Very High Effect, 3- High Effect, 2- Low Effect, 1-Very Low Effect

Source: Field survey, 2014

4.5 Assessment of Effect of the Quality Workmen Trades on the Quality of Building Projects in Lokoja

The result in table 7 showed that Iron benders, Carpenters, Electricians, masons and plumbers have very high effect while Glaciers, Welders, Cladders and House painters have high effect and Landscapers have low effect on the quality of building projects in Lokoja with Iron benders ranking highest and landscapers ranking lowest

Table 7 Assessment of Impact of the Quality of Trades' Workmen on the Quality of Building Projects in the Area

S/N	Workmen trades	E.H.E	V.H.E	H.E	L.E	V.L.E	% Scores	RII	ST. DEV	Rank
2		5	4	3	2	1				
2.1	Iron benders	40	0	0	0	0	200	5.00	17.88	1st
2.2	Carpenter	29	11	0	0	0	189	4.72	12.66	2nd
2.3	Electrician	25	10	5	0	0	180	4.50	10.36	3rd
2.4	Mason	16	20	4	0	0	172	4.30	9.38	4th
2.5	Plumber	17	10	11	2	0	162	4.05	6.96	5th
2.6	Glazier	11	10	11	9	0	146	3.65	4.65	6th
2.7	Welders	4	10	18	8	0	130	3.25	6.78	7th
2.8	Cladders	8	5	10	17	0	124	3.10	6.28	8th
2.9	House painters	2	12	14	10	2	122	3.05	5.65	9th
2.10	Landscaper	0	6	16	4	14	94	2.35	6.78	10th

Legend: 5-Extremely High Effect, 4- Very High Effect, 3- High Effect, 2- Low Effect, 1- Very Low Effect
Source: Field survey, 2014

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In line with the objectives of this research, it was found that the quality of the following materials, cement, sharp sand and granite is very satisfactory while nails, ceiling boards, plaster sand, reinforcing bars (high yield), wall tiles, glazed windows, metal windows, timber, floor tiles, sanitary appliances, and wooden windows is satisfactory and electrical fittings, wooden doors, metal doors, glazed doors, and laterite is slightly satisfactory with cement having the highest ranking and laterite the lowest.

It was also found that quality of work done by the following trade workmen ranked in descending order, painters, electrician, carpenters, plumbers, glaciers, iron benders, welders and cladders and produce work which is rated satisfactory while that of masons is rated slightly satisfactory. This rating of trade workmen call for concern as it reveals that trade workmen who specialized in the actual construction process are ranked low.

In terms of trade workmen, Iron benders, Carpenters, Electricians, Masons and plumbers have very high effect while Glaciers, Welders, Cladders and House painters have high effect and Landscapers have low effect on the quality of building projects in Lokoja with Iron benders ranking highest and landscapers ranking lowest.

The research also discovered that cement, granite, sharp sands, laterite, electrical fittings and timber have very high effect while nails, sanitary appliances, and plaster sand have high effect on the quality of building projects in Lokoja with cement ranking highest and plaster sand ranking lowest.

5.2 Recommendation

Based on the findings in this research, the following recommendations are made:

a) Quality control and quality control managements of material and workmen in construction work must be critically appraised if functionality and serviceability of a building is to be sustained.

b) Policy should be put in place to discourage the use of substandard quality materials and workmen for building project executions.

c) Nigeria Industrial Standard (NIS) and Standard organization of Nigeria (SON) should be re-organized to implements and enforce quality adherence

d) Nigeria Industrial Standard (NIS) and Standard organization of Nigeria (SON) should from time to time carry out sensitization, training and workshops for construction Artisans and professionals in the built environments on quality control and quality control managements.

e) Care should be exercised by project design team in material selection and specifications. This can be achieved through proper assessment of materials constituents, choice of manufactures with a system in placed to check for their conformity to specification.

f) Workmen with the appropriate training should be employed for building works especially those working on the structural members.

g) Clients need to be educated on the need to snub quacks; it is a principal crime for non-professionals to handle any construction project.

h) Building professionals should also ensure proper and efficient supervision of workmen as well as efficient checking of materials before incorporation into building works.

REFERENCES

Abdel-Razek, et al., 2001, A Proposed Method to Measure Quality of the Construction Project, *International Exhibition Conference for Building & Construction, Egypt.*

Adebayo, S. O. 2000, Improving building techniques. Proceedings of a workshop on Building Collapse: Causes, prevention and remedies. The Nigerian institute of building, Lagos State.

Adetayo, M. T. 1995, Workmanship in Nigeria Construction Industry. *The Construction, Journal of the Federation of Building and Civil Engineering Contractors in Nigeria*,

Akindoyeni, A. 2002, Professionalism in building design and construction. In D. R. Ogunsemi (Ed.), Building Collapse: Causes, prevention and remedies. The Nigerian Institute of Building, Ondo State.

Bolaji, E. O. (2002). Building materials specification and enforcement on site. In D. R.Chinwokwu, G. 2000, The role of professionals in averting building collapse. Proceedings of a workshop on Building collapse: Causes, prevention and remedies (pp.12-28). The Nigerian Institute of Building, Lagos State.

Fadamiro, J. A. 2002, An assessment of building regulations and standards and the implication for building collapse in Nigeria.

McCabe,S. 1998, Quality Improvement Techniques in Construction, Addison Wesley Longman Limited.

Odulami, A. A. 2002, Building materials specification and enforcement on site. In D. R.

Ogunlana, S. O. 1993, Quality management in Construction: The years ahead. *The Construction, Journal of The Federation of Building and Civil Engineering Contractors in Nigeria*,

Ogunsemi, D. R. 2002, Building Collapse: Causes, prevention and remedies (pp. 28-39). The Nigerian Institute of Building, Ondo State.

Olusola, K. O. 2002, Structural stability of building structures. In Ogunsemi, D. R. (Ed.), Buildin Collapse: Causes, prevention and remedies (pp. 50-73), The Nigerian Institute of Building, Ondo State.

MODELLING OF VEGETABLE OIL HYDRO PROCESSING FOR BIOFUEL PRODUCTION

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ABSTRACT

Production of biofuels from biomass needs to be seriously considered to reduce our reliance on petroleum. This work focuses on the modelling of vegetable oil hydro processing reaction pathways and simulation frame work developed in Aspen Plus version 2006.5, to produce Green diesel and Gasoline biofuels. Twenty one hypothetical reaction steps or pathways have been modelled and the overall stoichiometric hydrogen consumption was found to be 169 moles with hydro deoxygenation route consuming more hydrogen (61moles) and is much favoured than decarboxylation/decarbonylation route. The quality specifications of the simulated Green diesel with Cetane number 75 fall within acceptable range and met the United State diesel standard ASTM D975. A complete disappearance of triglycerides in the product mixture at the hydro treating temperature of 360 °C and pressure of 50 bar was observed. Sensitivity analysis conducted shows that Jatropha oil conversion efficiency to C_{15}-C_{18} hydrocarbon decreases with increase in H_2/oil ratio. Therefore, hydro processing of vegetable oil has a prospective to become a vital process for the production of biofuels.

Keywords — Biofuel, Green diesel, Hydro processing, Vegetable oil, Modelling,Simulations

1. INTRODUCTION

Renewable and clean fuel sources are being aggressively desired due to increased demand, environmental concerns and depleting petroleum reserves coupled with deteriorating quality of the crude oil (Kumar et al. 2010). One of the renewable sources is biofuels from plant-derived oils, specifically, non-edible and used oils such as waste restaurant oil, Jatropha oil, algae oil, etc. Prior to use in engines, these oils originating from plants and animals need to be converted into suitable fuels by processes that can lower their viscosity and oxygen content, and improve their atomization and lubricity (Donnis, 2009). The European Union (EU) target for biofuels is to account for 10 per cent of all automotive fuel consumption by energy content by 2020 (U.S., 2002).

Existing technology for producing diesel fuel from plant oils such as rapeseed, soybean and palm has largely centred on trans esterification of oils with methanol to produce fatty acid methyl esters (FAME) or biodiesel(Kent et al. 2009). However, there is quality issues associated with its widespread use which include; poor storage stability, low value by-product glycerol, saponification reaction with the caustic present as a catalyst etc. Thus, another option of biofuel production is a direct hydro treating of non-food triglyceride resources or vegetable oil to form C_{15}-C_{18} hydrocarbons. These processes can be performed using existing petroleum refineries (Marker, 2005). Hydro processing involves hydro treating to remove heteroatoms (sulphur, nitrogen, oxygen) and hydrocracking to saturate and break C–C bonds by reacting oil with hydrogen in the presence of catalyst so as to produce high quality diesel and gasoline molecules (Scherzer and Gruia, 1996).

Several works proposed the reaction pathways for hydro processing vegetable oils. George & Corma (2007) proposed that, the first step is the hydrogenation of the C=C bonds of the vegetable oils. The hydrogenated vegetable oils then form free fatty acids, di-glycerides, and mono-glycerides. At lower space velocities and temperatures these compounds undergo two different pathways to produce normal alkanes. The first is decarboxylation/decarbonylation, which produces normal liquid alkanes (C_{17} if from a C_{18} free fatty acid), CO or CO_2, and propane. This pathway requires the least amount of hydrogen. Alternatively, triglycerides undergo a dehydration/hydrogenation pathway to produce a liquid *n*-alkane (if from a C_{18} acid) and propane. The straight chain alkanes can undergo isomerization and cracking to produce lighter and isomerized alkanes. Yanyong et al. (2009) studied the hydro treatment of Jatropha oil to produce green diesel over tri-functional Ni–Mo/SiO_2–Al_2O_3, Ni–Mo/SiO_2 and Ni–Mo/γ-Al_2O_3 catalysts at 623 K, 4 MPa, 7.6 h^{-1} LHSV and 800 mL/mL H_2/oil in feed. The best route of deoxygenation was found to be over Ni–Mo/SiO_2–Al_2O_3 catalyst. Kumar et al. (2010) elucidated the extent of hydro processing pathways and the effect of reaction conditions on them, from the liquid hydrocarbon distributions. C_{17} and C_{18} hydrocarbons make up more than 85% of total n-alkanes from triglycerides.

This paper developed more fundamental hydro processing reaction pathways for conversion of vegetable oil to biofuels by considering the full reaction mechanism and then simulates the model using all available data in Aspen Plus version 2006.5

2 METHODOLOGY

To enable us develop reaction pathways for vegetable oil (triglyceride) conversion to biofuel, we assumed hydro treatment of Jatropha oil. The scope will be limited to the use of the software to demonstrate how a hydro processing unit can be created and tested virtually, based on the data obtained from experiments published in the literature. Aspen Plus was used for the simulation to run and test the proposed hydro processing reactions. The major fatty acids in Jatropha oil are Oleic, Linoleic, Palmitic and Stearic acid which are shown in Table **6A** in appendix. However, we approximated the Triacylglycerol's (TAGs) content to reflect only the major fatty acids found in Jatropha oil in order to allow us get their exact chemical properties for simulation purpose.

2.1 Reaction Pathways Strategy

The deoxygenation of triglycerides can follow three different reaction pathways – hydro deoxgenation, decarboxylation and decarbonylation. The distribution of hydrocarbons in the products is affected by the oxygen elimination route according to the following reactions:

1. Saturation or hydrogenation of double bonds (chemical stability)
2. Hydro treating (Heteroatom removal for clean combustion)
   - deoxygenation
     - hydro deoxygenation (HDO)
     - decarboxylation
     - decarbonylation
3. Different side reactions:
   - hydrocracking of fatty acid chain of triglycerides
   - Water-gas-shift, Methanisation
4. Isomerisation of produced normal paraffin from deoxygenation (cold flow properties)

Figure 1 shows hydro deoxygenation reaction (exemplified by the unbroken red lines) that removes oxygen in the form of water and by this mechanism, the products are water, propane and three normal alkanes of the full length of the fatty acid chains. Decarboxylation or CO_2-elimination is the oxygen removal in the form of CO_2 where the triglyceride is broken down into propane, carbon dioxide and into an *n*-alkane one C-atom shorter than the total length of the fatty acid (exemplified by the blue lines.) Decarbonylation produces hydrocarbon with an odd carbon number plus water and CO.

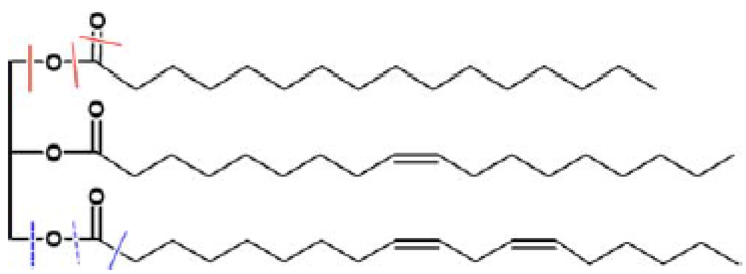

Figure1 Schematic representation of the three different reaction pathways for the removal of triglyceride- oxygen by hydro treating **(Donnis, 2009)**

2.1.1 Model Hydro deoxygenation Reaction Pathways

The proposed hydro deoxygenation reactions of Trioleic, Trilinoleic, Tripalmitic, Tristreatic and free fatty acids where oxygen is removed in the form of water are as follows:

1. Trioleic acid glyceride (18:1)
   $C_{57}H_{104}O_6 + 15H_2 \rightarrow 3n\text{-}C_{18}H_{38} + C_3H_8 + 6H_2O$
2. Trilinoleic acid glyceride (18:2)
   $C_{57}H_{98}O_6 + 18H_2 \rightarrow 3n\text{-}C_{18}H_{38} + C_3H_8 + 6H_2O$
3. Tristearic acid glyceride (18:0)
   $C_{57}H_{110}O_6 + 12H_2 \rightarrow 3n\text{-}C_{18}H_{38} + C_3H_8 + 6H_2O$

4. Tripalmitic acid glyceride (16:0)
   $C_{51}H_{98}O_6 + 12H_2 \rightarrow 3n\text{-}C_{16}H_{34} + C_3H_8 + 6H_2O$
5. Free fatty acid as oleic acid
   $C_{18}H_{34}O_2 + 4H_2 \rightarrow n\text{-}C_{18}H_{38} + 2H_2O$

2.1.2 Model Decarboxylation Reaction Pathways

The decarboxylation reactions of trioleic, trilinoleic, tripalmitic, tristreatic and free fatty acids, where oxygen is removed in the form of carbon dioxide (CO_2), are as follows:

6. Trioleic acid glyceride (18:1)
   $C_{57}H_{104}O_6 + 6H_2 \rightarrow 3n\text{-}C_{17}H_{36} + C_3H_8 + 3CO_2$
7. Trilinoleic acid glyceride (18:2)
   $C_{57}H_{98}O_6 + 9H_2 \rightarrow 3n\text{-}C_{17}H_{36} + C_3H_8 + 3CO_2$
8. Tristearic acid glyceride (18:0)
   $C_{57}H_{110}O_6 + 3H_2 \rightarrow 3n\text{-}C_{17}H_{36} + C_3H_8 + 3CO_2$
9. Tripalmitic acid glyceride (16:0)
   $C_{51}H_{98}O_6 + 3H_2 \rightarrow 3n\text{-}C_{15}H_{32} + C_3H_8 + 3CO_2$
10. Free fatty acid as oleic acid
   $C_{18}H_{34}O_2 + H_2 \rightarrow n\text{-}C_{17}H_{36} + CO_2$

2.1.3 Model Decarbonylation Reaction Pathways

The decarbonylation reactions of trioleic, trilinoleic, tripalmitic, tristreatic and free fatty acids where oxygen is removed in the form of carbon monoxide (CO) and water are:

11. Trioleic acid glyceride (18:0)
   $C_{57}H_{104}O_6 + 9H_2 \rightarrow 3n\text{-}C_{17}H_{36} + C_3H_8 + 3CO + 3H_2O$
12. Trilinoleic acids glyceride (18:2)
   $C_{57}H_{98}O_6 + 12H_2 \rightarrow 3n\text{-}C_{17}H_{36} + C_3H_8 + 3CO + 3H_2O$
13. Tristearic acids glyceride (18:0)
   $C_{57}H_{110}O_6 + 6H_2 \rightarrow 3n\text{-}C_{17}H_{36} + C_3H_8 + 3CO + 3H_2O$
14. Tripalmitic acids glyceride (16:0)
   $C_{51}H_{98}O_6 + 6H_2 \rightarrow 3n\text{-}C_{15}H_{32} + C_3H_8 + 3CO + 3H_2O$
15. Free fatty acid as oleic acid
   $C_{18}H_{34}O_2 + 2H_2 \rightarrow n\text{-}C_{17}H_{36} + CO + H_2O$

2.1.4 Model Water-gas shift Reaction

In a series reaction, the carbon four oxides formed via decarboxylation of triglycerides react further with hydrogen to form carbon monoxide and water through water-gas shift reaction. The reaction is shown below: 16. $12CO_2 + 12H_2 \leftrightarrow 12CO + 12H_2O$

2.1.5 Model Methanization reaction

This is another reaction in series with decarbonylation and water-gas shift reactions. The carbon monoxides formed react with hydrogen in the ratio 1:3 to produce methane and water. The reaction is depicted below: 17. $12CO + 36H_2 \leftrightarrow 12CH_4 + 12H_2O$

2.1.6 Model Hydrocracking reactions

18. n- $C_{18}H_{38} + H_2 \rightarrow C_8H_{18} + C_{10}H_{22}$
19. n- $C_{17}H_{36} + H_2 \rightarrow C_5H_{12} + C_{12}H_{26}$
20. n- $C_{16}H_{34} + H_2 \rightarrow C_7H_{16} + C_9H_{20}$
21. n- $C_{15}H_{32} + H_2 \rightarrow C_4H_{10} + C_{11}H_{24}$

2.1.7 Hydrogen consumption

From the above reaction pathways, twenty one hypothetical hydro processing reaction steps have been modelled and the overall stoichiometric hydrogen consumption is found to be 169 moles as shown below. Hydro deoxygenation consumed more hydrogen compared to decarboxylation and decarbonylation. However, if side reactions are considered, decarboxylation consumed more hydrogen through water-gas-shift and methanisation reactions. To improve the blend stock quality of green diesel, hydro isomerization/hydrocracking reactions were proposed, even though, this reduced the yield of C_{15}-C_{18} alkanes. These modelled reactions were used in the Aspen Plus hydro processing simulation.

Hydrodeoxygenation	=	61 moles H_2
Decarboxylation	=	21 moles H_2
Decarbonylation	=	35 moles H_2
Water-gas shift	=	12 moles H_2
Methanization	=	36 moles H_2
Hydrocracking	=	4 moles H_2
Total	**=**	**169 moles H_2**

2.2 Preparation of Data

A continuous flow stoichiometric reactor was used and the following parameters were obtained from the published literature:

1. Total pressure of the reactor; 40-60 bar
2. Hydrogen partial pressure; 800 Nm^3/m^3
3. Fatty acid composition of Jatropha Curcas oil (Table 6A in Appendix)
4. Reactor temperature; 340-380 °C
5. Total conversion of each deoxygenation route: 0.7 for hydro deoxygenation, 0.2 for decarboxylation and 0.1 for decarbonylation.

2.3 Aspen Plus hydro processing Simulation Model

Process simulation allows us to predict the behaviour of a process by using basic engineering relationships, such as mass and energy balances as well as phase and chemical equilibrium (Aspen, 2009). Given reliable thermodynamic data, realistic operating conditions, and rigorous equipment models, we can simulate actual plant behaviour. Process simulation enabled us to run many cases, conduct "what if" analyses, and performed sensitivity studies and optimization runs. With simulation, we can design better plants and increase profitability in existing plants. Process simulation is useful throughout the entire lifecycle of a process, from research and development through process design to production. Aspen Plus makes it easy to build and run a process model by providing a comprehensive system of online prompts, hypertext help, and expert system guidance at every step. Aspen Plus was used to simulate the hydro processing model for conversion of Jatropha oil to biofuel. The simulation is divided into four sections: building the process model, adding data to the process model, running the simulation and sensitivity analysis.

1. Building the process model

The process model was built by building the process flow sheet which involved selecting the reactors, material streams and other equipment from the model library.

2. Adding data to the process model

Now that we have created the process flow sheet, components (Hydrogen, Propane, etc.) were entered in the model. For the non-data bank components; trioleic, linolein, palmitoleic and stearic glycerides, on-line Chemical book was used to download their mole files comprising of molecular structure, molecular weight and boiling range. The thermodynamic property selected was Redlich-Kwong-Soave coefficient method. Jatropha oil flow rate was specified as 10,000 kg/hr and Hydrogen flow rate 4550.84 kg/hr. Reactions stoichiometries as well as the conversions were specified as 0.7 for hydro deoxygenaton, 0.2 for decarboxylation and 0.1 for decarbonylation.

3. Running the simulation

After all required inputs were completed, the simulation run begun and later completed. Hence, the results of the simulation can now be examined.

4. Sensitivity analysis

The hydrogen-to-oil ratio was varied to see its effect on the hydrocarbon (C_{15}-C_{18}) yield. The hydrogen flow rate was defined to vary from 4550.84 kg/hr. to 10550.84 kg/hr. in increments of 1000 kg/hr. Table 5 shows the result.

2.4 Process Description

The vegetable oil hydro processing flow diagram simulated using Aspen Plus is shown in **Figure 2**. Jatropha oil (JATROOIL) is combined with hydrogen (HYDROGEN), brought to reaction temperature (350- 400 °C), and is then routed to the HYDROTR1 (a combination of hydrotreater and hydrocracker) which is a catalytic reactor section where it is converted by a series of optimized hydrodeoxygenation, decarboxylation and decarbonylation reactions to a rich diesel fuel (green diesel), gasoline and light ends. The products from HYDROTR1 are then passed through stream 1 to HYDROTR2, another catalytic reactor for optimized hydro isomerization reactions to branched paraffin rich diesel fuel or green diesel to achieve better cold flow properties in the green diesel product. Both reactors were modelled as stoichiometric reactors in Aspen Plus. Due to the exothermic reaction inside the reactors, the product exits the reactor in a mixed gas–liquid phase and is cooled from 360°C to 100°C before it enters a high pressure –low temperature separator, where the gas and liquid phase separate.

The water and CO_2 formed by the deoxygenation reactions are separated from the fully deoxygenated hydrocarbon product. Water is recovered from WATERSEP (a decanter) into steam; while CO_2 and the off-gases are recovered from the flash drums, FLASH1 and FLASH2. The deoxygenated liquid product is then fractionated to remove the small amount of light fuel by-product through the separation columns; debutaniser (DEBUTANE) and diesel splitter (DIESELSP). The fractionation columns produce propane, naphtha and diesel products. The excess hydrogen provided to the reactor is recovered through pressure swing adsorption (PSA) and then recycled back to the reactor to maintain a minimum required hydrogen partial pressure. Make-up hydrogen is added to the process to balance both chemical consumption and solution losses (Kalnes, 2007). Parametric specifications of vegetable oil hydro processing simulation in Aspen Plus are presented in Table 1.

Table 1 Parametric specification of hydro processing simulation

Unit names	**Aspen model**	**Exit temperature °C**	**Pressure bar**
HYDROTR1	Stoichiometric reactor	360	50
HYDROTR2	Stoichiometric reactor	380	50
DEBUTANE	RadFrac distillation: reboiler	226.6	1
DIESELSP	RadFrac distillation: reboiler	294.2	1
FLASH1 & 2	Flash 2 column	88.7	1

3 RESULTS AND DISCUSSION

3.1 Hydro processing Simulation Result

The hydro processing model and simulation framework developed in Aspen-plus version 2006.5 was used to upgrade Jatropha oil to green diesel and gasoline by fitting the reaction parameters obtained from the literature. Table 2 shows the results of analysis of main streams in vegetable oil hydro processing. Column one and two shows 23 components used and their chemical formulae respectively. Column three shows Hydrogen stream with a total flow of 4550.84 kg/hr and column four displays Jatropha oil (JATOIL) stream with a flow rate of 10,000 kg/hr together with the fractional flow of the different triglycerides. Column 5 – 10 show diesel stream (DIESEL), gasoline stream (GASOLINE), stream 1, 2, 4 and 14 respectively and a complete disappearance of the triglycerides in the product mixture as well as fractional distribution of different hydrocarbons spread across the streams can be observed. Green diesel is the major product formed with a total flow of 67,627 kg/hr and the straight chain alkanes ranging from C_5 to C_{18} are the majority of products produced during hydro processing reaction. Form Table 2, the biofuel fractions produced includes; Diesel, Gasoline and light ends (Methane, Propane) in descending order.

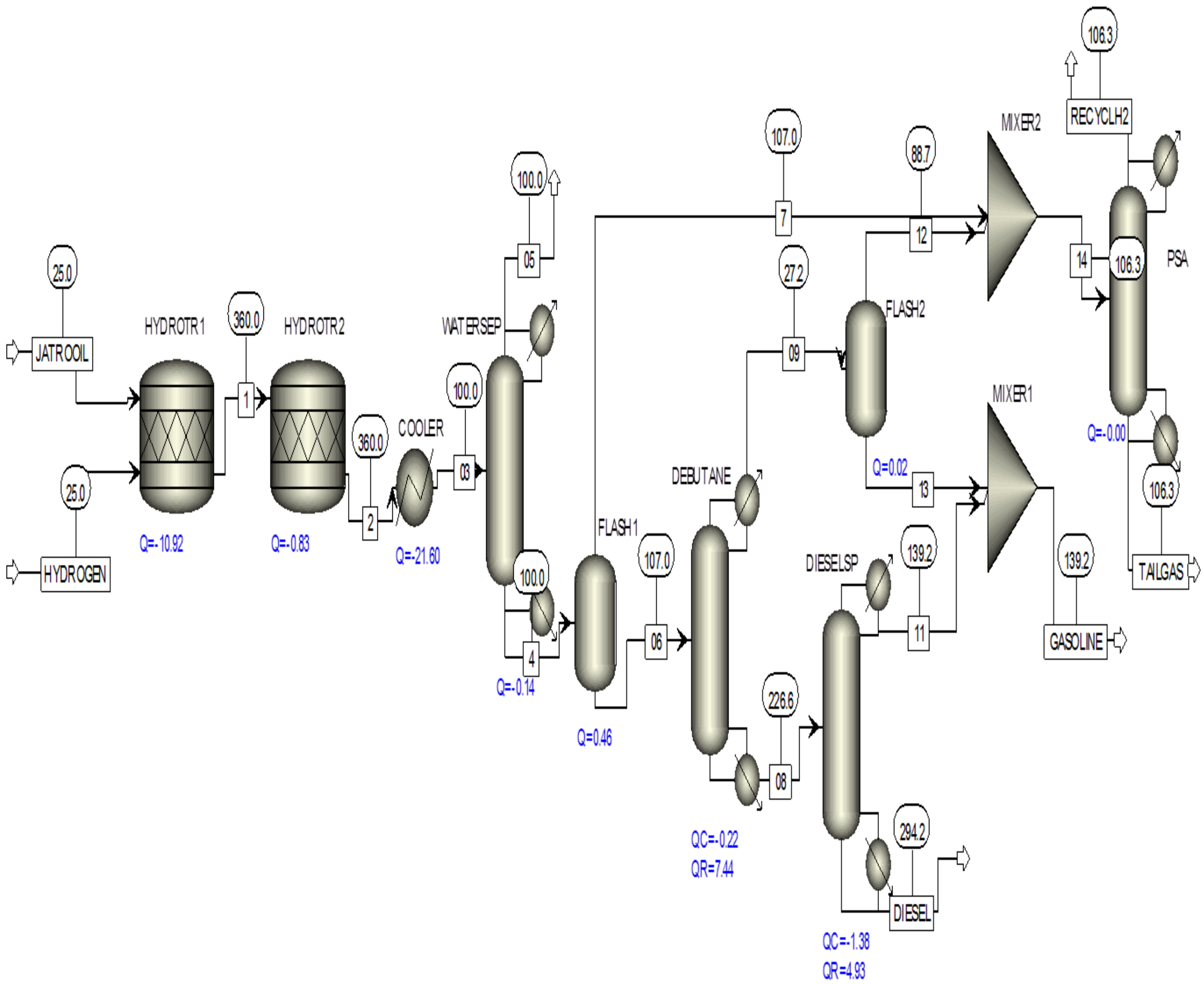

Figure 2 Vegetable oil hydro processing flow diagram

Table 2 Results of analysis of main streams in vegetable oil hydro processing Aspen simulation

COMPONENT NAME	FORMULA	HYDROGEN	JATOIL	DIESEL	GASOLINE	1	2	4	14
Trioleic	C57H104O6	0	45000	0	0	0	0	0	0
Tripalmitic	C51H98O6	0	11400	0	0	0	0	0	0
Trilinolein	C57H98O6	0	40300	0	0	0	0	0	0
Tristearic	C57H110O6	0	2270	0	0	0	0	0	0
Oleic	C18H34O2	0	1030	0	0	0	0	0	0
Water	H2O	0	0	2.82E-21	5.89E-06	9285.06	10189	203.77	203.77
Hydrogen	H2	4550.84	0	0	0	1472.69	1204.28	1192.2	1192.2
N-Octadecane	C18H38	0	0	42659	232.16	53665	42932	42932	40.99
N-Heptadecane	C17H36	0	0	16833	519.27	21732	17385	17385	32.91
N-Hexadecane	C16H34	0	0	5882.44	471.61	6714.95	6379.21	6379.2	25.14
N-Pentadecane	C15H32	0	0	2187.77	356.18	2699.57	2564.59	2564.6	20.62
Propane	C3H8	0	0	1.06E-18	9.82E-05	4996.91	4996.91	4996.9	4996.9
Carbon monoxide	CO	0	0	0	0	962.44	1790.13	1790.1	1790.1
Carbon dioxide	CO2	0	0	6.93E-34	4.11E-09	3024.34	1270.23	1257.5	1257.5
Methane	CH4	0	0	0	0	0	165.37	165.36	165.36
N-Octane	C8H18	0	0	8.85E-06	7.71E+02	0	4817.48	4817.5	4046.4
N-Decane	C10H22-1	0	0	0.1155	4590.62	0	6000.59	6000.6	1409.9
N-Pentane	C5H12-1	0	0	2.61E-13	2.48E-02	0	1304.06	1304.1	1304
N-Dudecane	C12H26-1	0	0	63.91	2809.98	0	3078.73	3078.7	204.83
N-Heptane	C7H16-1	0	0	3.11E-08	7.88E+00	0	148.57	148.57	140.68
N-Nonane	C9H20-1	0	0	9.61E-05	1.15E+02	0	190.16	190.16	74.92
N-Butane	C4H10-1	0	0	6.19E-18	1.89E-05	0	36.93	36.93	36.93
N-Undecane	C11H24	0	0	6.78E-02	86.45	0	99.32	99.32	12.8
	Total Flow KG/HR	**4550.84**	**100000**	**67627**	**9960.55**	**104550**	**104550**	**94543**	**16956**
	CETANENO	**12.73**	**85.19**	**75.25**	**123.43**	**215.31**	**189.23**	**243.26**	**12.79**
	SG	**0.3**	**0.91**	**0.78**	**0.73**	**0.71**	**0.71**	**0.69**	**0.47**
	APISTD	**340**		**49.1**	**59.95**	**65.49**	**65.49**	**71.28**	**0.47**
	Q VALUE MJ/KG	**119.9**	**72.3**	**43.9**	**44.1**	**39.61**	**39.57**	**43.75**	**166.4**

The Green diesel characterization properties equivalent to petroleum diesel, such as, API gravity, Specific gravity, Flash point, Heating value and Cetane number derived using Aspen Plus properties (Prop-Sets), APISTD, SGSTD, FLPT-API, QVALNET and CETANENO, respectively are presented in Table 3. The quality specifications of simulated Green diesel as compared to standard Green diesel and Petro diesel fall within acceptable range. Therefore, from a refiner's perspective, this simulated green diesel could be considered a premium diesel blending component. The boiling range (294°C) is comparable to typical diesel with substantially higher Cetane (75) and lower density. These are very valuable properties that enable refiners to optimize the amount of lower value refinery streams that can be blended into refinery diesel pool while meeting the United State diesel standard ASTM D975 (No. 2, boiling range 180 –340°C.)

Table 3 Diesel fuel properties (ULSD is ultra-low sulphur diesel)

Fuel properties	Petroleum diesel (ULSD)	Green diesel (Standard)	Green diesel (Simulated)
% Oxygen	0	0	0
Specific Gravity: SGSTD	0.84	0.78	0.78
Heating Value (MJ/kg) QVALNET	43	44	44
Cetane: CETANENO	40	70-90	75
Cloud point (°C)	-5	-5 to +10	-2
Flash point °C: FLPT-API	60-80	100-170	123
Distillation (°C)	200-350	265-320	294

APISTD	41.1	45-60	49.1
Stability	Good	Good	Good

3.2 Analysis of Oxygen Removal Pathways

It is necessary to analyse the effect of reaction conditions (360 °C, 50 bar and 4550.84 kg/hr hydrogen), on the relative rate of different oxygen removal pathways over commercial Ni-Mo/SiO_2-Al_2O_3 catalyst. Results from Table 2 proved that deoxygenation of triglycerides followed three different reaction pathways – hydro deoxygenation, decarboxylation and decarbonylation. The distribution of hydrocarbons in the products is affected by the oxygen elimination route. C_{15} and C_{17} alkanes are the product of oxygen removal from triglyceride by decarboxylation + decarbonylation (with CO and CO_2 the side-products), while C_{18} and C_{16} alkane hydrocarbon, are the products of hydro deoxygenation reaction (with water as the side product). The extent of both pathways and the effect of reaction conditions on them can be consequently elucidated from the liquid hydrocarbon distributions shown in Table 4. C_{17} and C_{18} hydrocarbons make up more than 85% of total n- C_{17}/ C_{18} ratio of major product alkanes i.e. n-heptadecane (C_{17}) and n-octadecane (C_{18}) alkanes from triglycerides (15.3% C_{16}:0, 6.6% C_{18}:0, 41.5% C_{18}:1, 35.3% C_{18}: 2) in Table 6A. We have taken (C_{18}), as a measure of relative ratio of decarboxylation + decarbonylation versus hydro deoxygenation. Table 4 shows that the C_{17}/ C_{18} ratio is about 0.4 and C_{18} hydrocarbon yield is 2 to 2.5 times more than C_{17} hydrocarbon yield. This indicates that hydro deoxygenation route (which forms C_{18} hydrocarbon) is much favoured than decarboxylation/decarbonylation route (which forms C_{17} hydrocarbon.)

Table 4 Hydrocarbon distribution of liquid products at 360 °C, 50 bar and 4550.84 kg/hr. H2

Hydrocarbon products	Flow rate (kg/hr.)	Vol. (%)
C_{15}	2187.55	3.2
C_{16}	5882.44	8.7
C_{17}	16833.0	25.0
C_{18}	42659.0	63.1
C_{17}/ C_{18}	0.4	

3.3 Sensitivity Analysis Result

The Aspen Plus was used to study the sensitivity of hydro processing process performance – hydrocarbon products yield to changes in hydrogen flow rate and the result is shown in Table 5. This is a very important parameter for hydro treating processes i.e., the hydrogen (gas feed) to oil (liquid feed) ratio or H_2/oil ratio which is deemed to have a main impact on hydrogenation and cracking reactions efficiency. In this case the H_2/oil represents the ratio of hydrogen feed over the Jatropha oil.

Table 5 Sensitivity analysis results

Runs	Hydrogen flow rate (kg/hr)	$C_{15}H_{32}$ (kg/hr)	$C_{16}H_{34}$ (kg/hr)	$C_{17}H_{36}$ (kg/hr)	$C_{18}H_{38}$ (kg/hr)	QCOND (MW)	QREB (MW)
1	4550.84	2187.748	5882.418	16833.26	42659.15	-1.703	4.213
2	5550.84	1793.171	5412.389	16128.24	41788.8	-1.926	3.641
3	6550.84	1587.457	5113.611	15643.53	41081.31	-2.018	3.321
4	7550.84	1443.31	4891.829	15278.96	40537.07	-2.087	3.15
5	8550.84	1350.153	4724.344	14983.4	40070.93	-2.121	2.999

6	9550.84	1285.697	4592.565	14736.26	39663.14	-2.133	2.866
7	10550.84	1239.799	4486.153	14524.7	39299.25	-2.131	2.745

Table 5 shows that as hydrogen flow rate is increased, the liquid hydrocarbon products flow decreased. This result revealed that Jatropha oil conversion efficiency decreases with H_2/oil ratio, which is expected as increasing H_2/oil ratio favours the undesirable cracking and hydrogenation reactions competing with the desirable hydro treatment reactions. This trend is clearly observed in Figure 3 which shows the effect of H_2/oil ratio on the C_{15}-C_{18} paraffin yield. The yield of Octadecane ($C_{18}H_{38}$) is highest for all five different hydrogen flows and decreases from 42.7 to 39.1% with hydrogen flow. Next is Heptadecane ($C_{17}H_{36}$) with yield from 16.8 to 14.9%, then Hexadecane 5.9 to 4.7% and finally, Pentadecane 2.2 to 1.3%.

Figure 4 shows that biofuel products are mainly green diesel, while a small percentage of bio gasoline was also present. For this reason, the primary product is considered the green diesel. The yields are calculated from the simulated distillation data of the total liquid product of each hydro treatment H_2/oil ratio. At 0.46 H_2/oil ratio the diesel yield is about 84.6% and 9.1% gasoline. A further increase in the hydrogen flow decreases the diesel yield to 82.1% but increases the gasoline yield to 11.5%. So, we can deduce that increase in hydrogen flow will decrease diesel yield and increase gasoline yield simultaneously. Thus, a trade-off exists when attempting to change hydrogen flow. Therefore, it is necessary we analysed the effect of reaction conditions, on the relative rate of different oxygen removal pathways for optimum yield of desired transportation fuel such as diesel or gasoline.

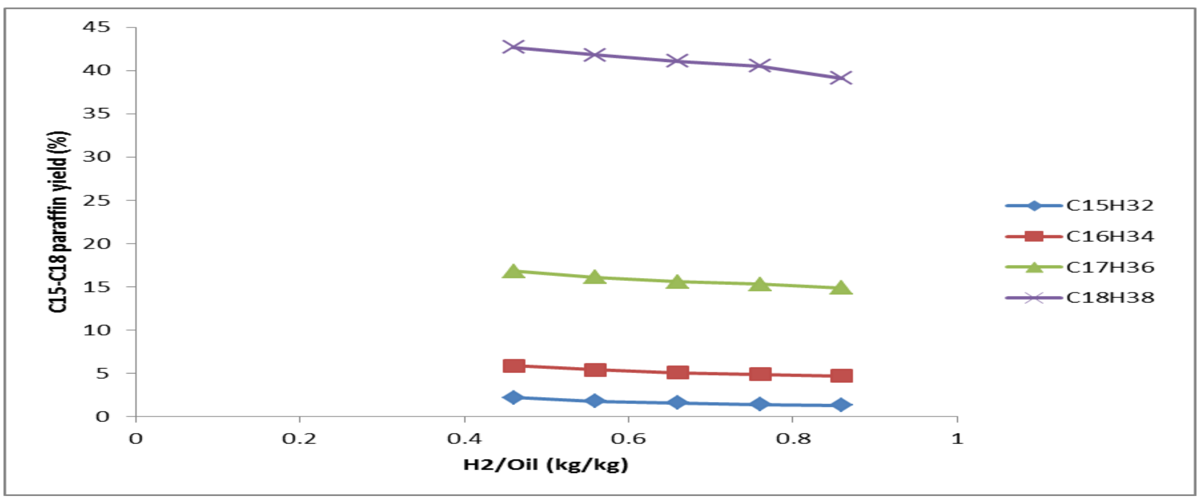

Figure 3 C15-C18 paraffin yield of hydro treated Jatropha oil at different hydrogen flows

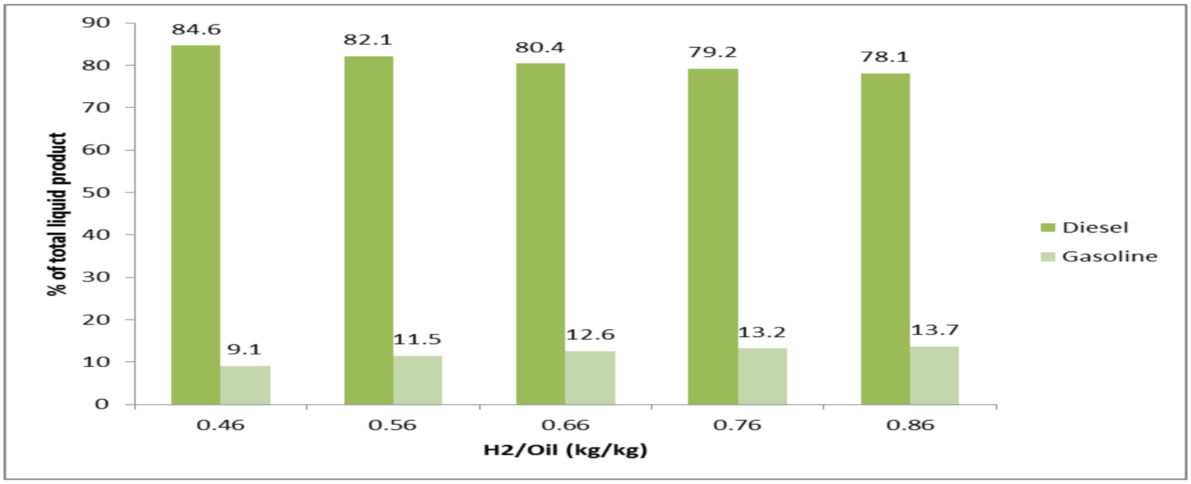

Figure 4 Green diesel and Gasoline product yields (wt. %) at different hydro treatment H_2/oil ratio

4 SUMMARY AND CONCLUSIONS

In this work, twenty one hypothetical hydro processing reaction steps or pathways have been modelled and the overall stoichiometric hydrogen consumption was found to be 169 moles. Hydro deoxygenation consumed more hydrogen (61moles) compared to decarboxylation (21 moles) and decarbonylation (35 moles). However, if side reactions are considered, decarboxylation consumed more hydrogen through water-gas-shift (12 moles) and methanisation reactions (36 moles). C_{17} and C_{18} hydrocarbons make up more than 85% of total major product alkanes and C_{18} hydrocarbon yield is 2.5 times more than C_{17} hydrocarbon yield. This indicates that hydro deoxygenation route (which forms C_{18} hydrocarbon) is much favoured than decarboxylation/decarbonylation route (which forms C_{17} hydrocarbon.) Green diesel is the major product formed with a total flow of 67,627 kg/hr and the straight chain alkanes ranging from C_5 to C_{18} are the majority of products produced during hydro processing reaction. The quality specifications of the simulated green diesel with Cetane number 75, oxygen content 0%, heating value 44 MJ/kg, boiling range 294°C as compared to standard green diesel and petro diesel with Cetane number 40, oxygen content 0%, and heating value 43 MJ/kg fall within acceptable range. These are very valuable properties that enable refiners to optimize the amount of lower value refinery streams that can be blended into refinery diesel pool while meeting the United State diesel standard ASTM D975 (No. 2, boiling range 180 –340°C.) Therefore, from a refiner's perspective, this simulated green diesel could be considered a premium diesel blending component. The use of Aspen-Plus as a simulation software package has been tested by studying the effect of the process variables on product yields or throughput and found to be effective. Sensibility analysis result revealed that Jatropha oil conversion efficiency decreases with increase in H_2/oil ratio, which is expected as increasing H_2/oil ratio favours the undesirable cracking and hydrogenation reactions competing with the desirable hydro treatment reactions. Hence, hydro processing of vegetable oil (triglyceride) has a prospective to become a vital process for the production of biofuels since it offers high-quality hydrocarbon-based fuels. It is recommended to test the process at a pilot plant to better simulate real-plant conditions.

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[1] Aspen, P. (2009). *Getting started Building and Running a Process Model.* Burlington: Aspen Technology.
[2] Donnis, B. (2009). Hydro processing of bio-oils and oxygenates to hydrocarbons: understanding the reaction routes. *Chemistry and Material Science*, vol. 52, no. 3, pp. 229-240.
[3] George, W. H., & Corma, A. (2007). Synergies between bio- and oil refineries for the production of fuels from biomass. *Angewandte Chemie International Edition*, vol. 46, issue 38, pp. 7184-7201.
[4] Kent Hoekman, S. K., Gertler, A., Broch, A., & Robbins, C. (2009). *Investigation of bio distillates as potential blend stocks for transportation fuels.* Alpharetta: Coordinating Research Council, Inc.
[5] Kumar, R., Rana, B., Tiwari, R., & Verma, D. (2010). Hydro processing of Jatropha oil and its mixtures with gas oil. *Green Chemistry*, no. 12, pp. 2232-2239.
[6] Marker, T. (2005). *Opportunities for bio renewables in oil refineries.* Illinois: U.S. Department of Energy.
[7] Stumborga, M., Wongb, A., & Hogan, E. (1996). Hydro processed vegetable oils for diesel fuel improvement. *Bio resource Technology*, vol. 56, issue 1, pp. 13-18.
[8] U.S. (2002). Vision for Bioenergy and Bio based Products in the U.S. *Biomass Technical Advisory Committee*, 101en, *Linear Networks and Systems.* Belmont, Calif.: Wadsworth, pp. 123-135, 1993. (Book style)
[9] Yanyong, L. (2009). Hydro treatment of Jatropha oil to produce green diesel over trifunctional Ni–Mo/SiO2–Al2O3 catalyst. *Chemistry Letters*, vol.38, no.6, pp. 53-66.

APPENDIX

Table 6A Fatty acid composition of toxic and non-toxic *Jatropha Curcas* oil **(Becker & Makkar, 2008)**

Molecular formula	**Scientific Name**	**Systematic Name**	**Non-toxic (%)**	**Toxic**
14:0	Tetradecanoic	myristic	0.2	0.1
16:0	Hexadecanoic	palmitic	13.4	15.3
17:0	Heptadecanoic	heptadecanoic	0.1	0.1
18:0	Octadecanoic	stearic	6.4	6.6
20:0	Eicosanoic	arachidic	0.2	0.2
22:0	Docosanoic	behenic	tr	tr
24:0	Tetracosanoic	lignoceric	tr	0.1
Total saturated			**20.3**	**22.3**
16:1 n-7	9-hexadecenoic	palmitoleic	0.8	0.9
18:1 n-9	cis-9-octadenoic	oleic	36.5	41
20:1 n-9	cis-11-eicosenoic	eicosenoic	0.1	0.1
Total monounsaturated			**37.3**	**42**
18:2 n-6	cis-9, 12-octadecadienoic	linoleic	42.1	35.3
18:3 n-3	9, 12, 15-octadecatrienoic	α-linolenic (ALA)	0.2	0.3
Total PUPA			**42.3**	**35.7**

Results are presented as per cent values of reported fatty acids. tr = traces

LAND FILL GAS ENERGY GENERATION POTENTIAL FROM MUNICIPAL SOLID WASTE DISPOSAL SITES IN KANO, NIGERIA.

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ABSTRACT

The potentials for generation of electricity from landfill gas emissions of four major municipal solid waste disposal sites in Kano metropolis from the years 2012 -2040 were determined. The methane generation potential of the dumpsites were determined using U.S. EPA LandGEM model. The results show that maximum annual potential electricity that can be generated from court road dumpsite is 3,635.329 MWh/yr by the year 2016 which would decline to 1,394.779 MWh/yr by the year 2040, while for Hajj camp dumpsite the maximum is 2,338.949 MWh/yr by the year 2018 which would decline to 948MWh/yr by the year 2040. The maximum potential for Maimalari dumpsite is 3,263 MWh/yr by the year 2024 which would decline to 1,722.779 MWh/yr by the year 2040 while for Ubagama dumpsite generation would rise from 277.628 MWh/yr in 2015 to 469.664 MWh/yr.

KEYWORDS: Landfill gas, Methane, municipal solid waste, Incineration, Energy, electricity

1.0 INTRODUCTION

There are various processes of energy recovery from municipal solid waste such as incineration (combustion), pyrolysis, gasification , refuse derived fuel (RDF) and through anaerobic digestion or landfill gas generation (Moh'd. Abu-Qudais et al 2000; Ebru et al 2009). Anaerobic reaction within solid waste disposal sites generates various gases (landfill gas) mainly methane and carbon dioxide. In addition other non methane volatile organic compounds are also produced (IPCC, 1996, Weitz et al., 2006). The exact percentage distribution of gases in landfill varies, but typical constitutions found in municipal solid waste disposal sites are methane 45 - 60 % , carbon dioxide 40 – 60% (Cheema, 1997). According to Intergovernmental Panel on Climate Change (IPCC, 1996), the gases produced in solid waste disposal sites, particularly methane, can be a local environmental hazard if precaution are not taken to prevent uncontrolled emissions or migration into surrounding lands. Landfill gas is produced both in landfills (properly managed solid waste disposal sites) and open dumps (unmanaged waste disposal sites) and are both considered solid waste disposal sites (IPCC, 1996).

Both of the two primary constituents of the landfill gas (methane and carbon dioxide) are considered green house gases, which contribute to global warming, but IPCC does not considers carbon dioxide present in raw landfill gas to be a green house gas (GHG) because it considers landfill gas carbon dioxide as biogenic and thus part of the carbon cycle, therefore only the methane content in landfill gas is considered as GHG.

Methane is more potent green house gas than carbon dioxide, with global potential of over 21 times that of carbon dioxide (Montserrat et al, 2007). Solid waste disposal sites comprises the principal sources of anthropogenic methane emissions, and are estimated to account for 5 – 20% of anthropogenic methane emissions globally (IPCC,1996). The atmospheric concentration of methane has increased by 151% since 1750 and its concentration continues to increase (Chalvatzaki and Lazaridis, 2010). Globally efforts are being made to control green house gas emission from various sources, waste sector inclusive. Therefore utilizing landfill gas from solid waste disposal sites as energy contribute to stabilizing green house gas concentration in the atmosphere that would prevent the dangerous anthropogenic interference with the climate system. Landfill gas can have concentration of more than 50% by volume and this means that the calorific value of landfill gas can be 18,000-22000 KJ/ m^3 (Umberto et al, 2003; Spokas et al 2006). For these reasons landfill gas energy potential is being exploited as fuel for energy conversion process.

It has been estimated that Kano Metropolis generates about 156,676 tonnes of solid waste per month and with a population of about 3,248,700 the per capita solid waste generation is about 0.56 kg/capita day(Ogwueleka, 2009), this makes Kano city the second to Lagos in terms of waste generation in Nigeria. Most of the waste generated which consists of plastics, paper wood, glass, metal and food remnants (Diso et al, 1995) are dumped in an open uncontrolled waste disposal sites scattered within the urban areas of the city which is typical of most developing countries where the dominant disposal method is open dumping compared to the wide use of sanitary landfills in western countries (Visvanathan, 2006). The waste disposal sites in Kano are characterized by odour and smoke coming from spontaneous fires (due to the presence of methane gas), which causes pollution problems to the environment and can lead to serious health hazards. According to Intergovernmental Panel on Climate Change(IPCC), gaseous emissions from solid waste disposal sites particularly methane can be a local hazard and is considered a green house gas(GHG) that contribute to global warming (IPCC,1996).

The aim of this paper is to determine the waste composition, estimate methane emissions and determine the electrical energy generation potential of these emissions from four major municipal solid waste disposal sites in Kano metropolis.

2.0 METHODOLOGY

The four dumpsites namely, Court road, Maimalari, Hajj camp and Ubagama are located within Kano municipality.

2.1 Waste characterization/ physical composition

Characterization of waste at the disposal sites were carried out according to the American Society for Testing and Materials (ASTM D5231). The procedure involved random collection of waste from trucks loads in the amount of 15 to 20kg per unit. About 100 kg sample of solid waste was collected per day in each of the four dumpsites. At each dumpsite the collected sample waste was then spread on a polythene sheet and sorted into different categories of plastics, paper, textile material, glass, vegetable /Agricultural waste, metal and earth/ decayed matter. The categorized wastes were then weighted using a weighting scale and their percentage weight recorded. This procedure was conducted in the months of October, March and August (2012-2013) to cater for seasonal variations.

2.2 Dumpsites capacity

The years of opening of the dumpsites (t) were obtained from Kano State Refuse management and sanitation Board (REMASAB). As the dumpsites have not reached their full capacity, the expected year of closure of the dumpsites are determined based on the capacity and rate of waste disposal at the dumpsites. The capacities of the waste dumps were determined based on waste dump area, average depth and density of the waste. The dumpsites areas were obtained using Google Map and Esri Arcgis software program (Google Map, 2013, ArcGIS, 2003). Satellite image of the dumpsites were obtained and the area determined using the program. Record of average depths of the dumpsites and estimated amount of waste in the dumpsites as of 2012 were obtained from REMASAB. The density of waste were determined by placing the samples of waste collected in a 250 ml beaker, shaking and slightly dropping and then weighting. The waste density is then calculated by dividing the weight of the waste by its volume (Kian-Ghee Tiew, 2009).

2.3 Methane generation potential of the solid waste disposal sites

Landfill gas generation can be modeled using zero-order, first-order, and/or second-order generation models. Studies have shown that first-order models provide more reliable outcomes in comparison to the zero-order models and are not as complicated as the second-order or multi-phase models (Oonk et al, 1994; Debra, 2009). Methane generation from the solid waste dumpsites were estimated using the LandGEM model equation which is based on first order decay reaction and is consistent with the approach of Intergovernmental Panel on Climate change (IPCC, 1996).

$$Q_{CH4}=\sum_{i=1}^{n}\sum_{j=0.1}^{1} kL_o \left[\frac{M_i}{10}\right]\left(e^{-kt_{ij}}\right) \qquad (1)$$

Where:

Q_{CH4} = Annual methane generation in the year of calculation (m^3 yr-1)
i = The yearly time increment
n = Difference : (year of the calculation) – (initial year of waste acceptance)
j = 0.1 year increment
L0 = Methane generation potential (m^3/Mg)
Mi= Mass of waste accepted in the ith year (Mg)
k = Methane generation rate (yr-1)
tij = Age of jth section of waste mass Mi accepted in the ith year.

The important parameters of the LandGEM equation for the generation of methane gas are Lo (methane generation potential) and k (methane generation rate)(Debra, 2009).

2.3.1 Methane generation potential (L_O)

The methane generation potential is determined from the equation (IPCC,1996);

$$L_O = DOC \times DOC_f \times F \times {}^{16}/_{12} \times MCF \qquad (2)$$

$$DOC = (0.4 \times A) + (0.17 \times B) + (0.15 \times C) + (0.3 \times D) \qquad (3)$$

Where:
DOC = degradable organic carbon
A= fraction of MSW that is paper and textiles wastes, B = fraction of MSW that is garden park waste, C= fraction of MSW that is food waste and D= fraction of MSW that is wood or straw.
DOCf = fraction of assimilated degradable organic carbon(DOC)is obtained from the IPCC default value of 0.77 (IPCC, 1996).
MCF = Methane correction factor. This is based on the category of the solid waste disposal site (SWDS) management as presented by IPCC:
Managed sites MCF = 1.0
Unmanaged, deep sites (≥ 5m) MCF = 0.8 Unmanaged, shallow sites (< 5m) MCF = 0.4
Unspecified SWDS - default value: MCF = 0.6
F = fraction of methane in landfill gas (0.5 default)
16/12 = stoichiometric factor.

2.3.2 Methane generation rate constant

The methane generation rate constant or decay rate k, is determined based on US EPA(2005);

$$k = 3.2 \times 10^{-5}(x) + 0.01 \qquad (4)$$

Where x is annual average precipitation.

2.4 Energy generation potential of methane gas

The power potential of the methane gas is computed using equation (5), also the annual electricity generation potential is computed using equation (6).

$$P = methane\ gas\ flow\left(\frac{m^3}{day}\right) X\ Enegy\ content\left(\frac{J}{m^3}\right)$$

$$X\ Ɽ\ X\left({}^{1}\Big/_{Heat\ rate\left({}^{J}/_{kWh}\right)}\right) X\ {}^{1}/_{24} \qquad (5)$$

Where: P = Power (kW), Ɽ is the recovery rate with a value of 75% – 85% (US EPA, 2006), a value of 80% is used in this computation.
The annual electrical generation is expressed as:

Annual electricity (kWh) = generation potential (kW) x 24hr/day x 365 days/year
(6)

3.0 RESULTS AND DISCUSSIONS

3.1 Waste composition

The result of the composition analysis of the solid waste at the four dumpsites conducted in the months of October, March and August (2012-2013) are shown in table 1.

Table1: Average% of waste composition

Category	Court road (%wt)	Maiamalari (%wt)	Hajj camp (%wt)	Ubagama (%wt)
Plastics	27.88	28.34	29.14	29.22
Paper	7.60	4.70	12.68	8.31
Textiles	11.48	5.13	8.41	10.18
Glass	1.87	3.63	1.57	2.94
Agricultural	21.78	15.54	18.69	17.58
Earth/ garbage	21.65	34.27	28.20	30.97
Metals	0.19	0.06	0.00	0.12
Food waste	7.49	8.33	1.32	0.67

3.2 Dumpsites capacity

The capacities of the waste dumps were determined based on waste dump area, average depth and density of the waste. The dumpsites areas were obtained using Google Map and Esri Arcgis software program (Google Map, 2013, ArcGIS, 2003). Satellite image of the dumpsites were obtained and the area determined using the program. Table 2 shows the density of the solid waste in the dumpsites, average depth and areas of the dumpsites.

Table2: Dumpsites densities and areas

Dumpsite	Density of solid waste (kg/m^3)	Average depth (m)	Area (m^2)
Court Road	276.00	20.00	43,337.93
Hajj Camp	321.60	10.00	41,855.16
Maimalari	255.00	13.50	92,832.31

Ubagama	234.00	8.00	28,867.84

The density of the solid waste from the four dumpsites varies from 321.60 kg/m^3 – 234.00 kg/m^3, while average depth and area of the dumpsites ranges from 20.0m - 8.00m and 92,832.31 m^2 – 28,867.84m^2 respectively. Table 3 shows the estimated capacities of the four dumpsites.

Table 3: Estimated capacities of the dumpsites

Dumpsite	Estimated capacity (m^3)	Estimated capacity (tons)
Court Road	866,788.60	239,233.65
Hajj Camp	418,551.60	134,606.20
Maimalari	1,253,236.19	319,575.23
Ubagama	230,942.72	54,040.60

The amounts of waste in place as of year 2012 in the four dumpsites are shown in table 4.
Table 4: Waste in place as of year 2012.

Dumpsite	Initial year of waste disposal (year)	Waste in place as of 2012 (Mg)	Average annual waste disposal (Mg/year)
Court Road	1991	188,304.60	9415.23
Hajj Camp	2003	72,203.40	9025.43
Maimalari	2003	120,395.29	15049.41
Ubagama	1999	13,693.38	1,141.12

3.3 Methane generation

The important parameters in the LandGEM equation (1), methane generation potential (L_o) and methane generation rate constant (k) were computed from equations (2) and (4) respectively.
The DOC values of the waste in the four dumpsites were computed using the waste compositions in table 1.
DOCf = fraction of assimilated degradable organic carbon(DOC)is obtained from the IPCC default value of 0.77 (IPCC, 1996). As all the four dumpsites fall within the category of unmanaged , deep dumpsites (≥ 5m, from table 2) their MCF value is therefore 0.8. Default value of 0.5 (IPCC, 1996) for fraction of methane in the landfills is assigned.
The methane generation rate or decay rate k, is determined using the annual average precipitation of Kano which has the value of 873mm (Kano climate, kano.gov.ng,). Table 5 shows the computed parameters.

Table5: Methane generation potential

Dumpsite	k(y-1)	L_o (m^3 /Mg)
Court Road	0.041	76.94
Hajj Camp	0.041	48.01
Maimalari	0.041	72.63
Ubagama	0.041	64.63

The annual methane generation potential power and annual electricity generation for the four dumpsites are shown in tables, 6- 8 (Appendix I) and figures 1-3.

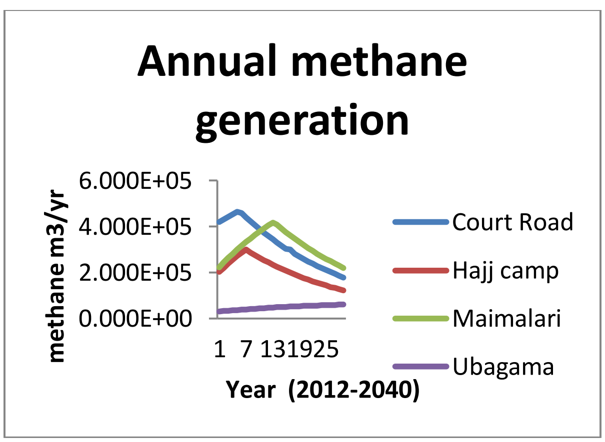

Figure1 1: Methane generation of the four dumpsites

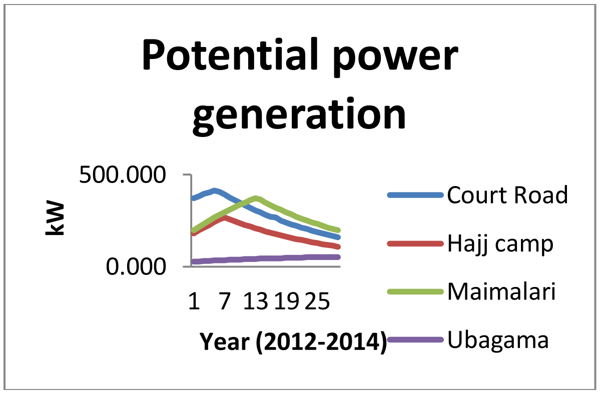

Figure 2: Potential power generation of the four dumpsites

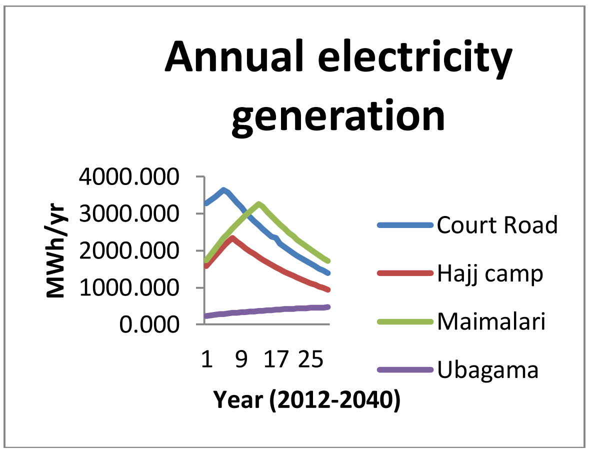

Figure 3: Annual electricity generation of the four dumpsites

The maximum annual potential electricity generation from court road dumpsite is 3,635.329 MWh/yr by the year 2016 which would decline to 1,394.779 MWh/yr by the year 2040, while for Hajj camp dumpsite the maximum is 2,338.949 MWh/yr by the year 2018 which would decline to 948MWh/yr by the year 2040. The maximum potential for Maimalari dumpsite is 3,263 MWh/yr by the year 2024 which would decline to 1,722.779 MWh/yr by the year 2040 while for Ubagama dumpsite generation would rise from 277.628 MWh/yr in 2015 to 469.664 MWh/yr.

4.0 CONCLUSION AND RECOMMENDATIONS

Landfill gas emissions from waste disposal sites are considered green house gases which contribute to global warming due to presence of methane gas. Therefore utilization of landfill gas for electricity generation would reduce the green house gas emission from waste disposal sites. The analysis of the result show the annual electricity generation potentials of methane gas emission from four major dumpsites in Kano between 2012-2040. The results show that substantial electricity can be generated especially from methane emissions in Court road, Hajj camp and Maimalari dumpsites within the period 2012-2040. It is therefore recommended that the authority concern should consider the possibility of electricity generation from methane emissions in these waste disposal sites as this would augment the increasing demand of electricity supply in Kano.

REFERENCES

Cheema, C. (1997) *Evaluation of gas migration and methane oxidation in domestic solid waste landfill*. Master of Engineering thesis. Asian Institute of Technology, School of Environment, Resource and Development. Bangkok, Thailand. August, 1997. 1-139.

Debra, R. (2009) *Landfill Gas to Energy: Incentives and Benefits*. Annual Report, October, 2009, University of Central Florida.

Diso, I.S., (1995), *Waste Management Survey in Kano*. The Energy Team, Bayero University Kano

Ebru, A., Ahmet, D. (2009). *Energy content Estimation of municipal solid waste by multiple regression analysis*. 9th International Advanced Technologies Symposium (IATS). May, 13-15, 2009, Karabuk, Turkey.

IPCC(1996). Revised 1996 IPCC Guidelines for National Greenhouse gas Inventories. *Reference manual*. 2.2-2.22.

Kian-Ghee Tiew, (2009). *Solid waste Characterization at Chacellery and Tun Seri Lanang Libraray building*, University Kebangsaan Malaysia.

Moh'd Abu-Qudais, Hani A. Abu-Qudais, (2000). Energy content of Municipal soild waste in Jordan and its potential utilization. *Energy Conversion & Management*. 41; 983-991.

Montserrat, Z., Jorge, I.P.P., Ignacio,A.P. and Angel, R.R. (2007). Study of the energy potential of the biogas produced by an urban waste landfill in southern Spain. *Renewable and Sustainable Energy Reviews*, 11(2007): 909-922.

Ogwueleka, T. Ch. (2009). Municipal solid waste characteristics and management in Nigeria. *Iran Journal of Environment, Health, Science and Engineering*, 6(3): 173-180.

Oonk, H., A. Weenk, O. Coops, L. Luning (1994). *"Validation of landfill gas formation models,"* TNO Institute of Environmental and Energy Technology Report, Grontmij, December 1994

Spokas, K., Bogner, J., Chanton, P., Morcet, M., Aran, C., Graft, Y., Moreu-k, G., Hebe, I., (2006). Methane mass balance at three landfill sites: What is the efficiency of capture by gas collection systems. *Waste management* , 26: 516-525.

Umberto, D., Francesco Di Maria, Daniela, L. and Stefania, P. (2003). Sanitary lnadfill energetic potential analysis: A real case study. *Energy Conservation and Management*, 44(2003): 1969-1981.

Visvanathan, C. (2006). Solid waste management in Asian perspectives. School of Environment, Resources and Development, Asian Institute of Technology.http://www.swlf.ait.ac.th/newinterface/research% 20reports.html

Weitz, M., Jeffery, B.C. and Edger, S. (2006). *Estimating National landfill methane emissions: An application of the 2006 IPCC waste model in Panama.* US EPA, 6207- J, 1-8.

HOT SECTION CREEP LIFE ESTIMATION OF A MEDIUM SIZE GAS TURBINE ENGINE

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ABSTRACT

This paper investigates the effect of creep life consumption of stationary gas turbine. The LMP is the method used to estimate the engine creep life, the creep life of the blade at mean was found to be 29 years at ISA clean condition and reduce to 17 years at 42 ^{0}C of the Northern part of Nigerian temperature for a period of one year with a percentage decrease of 41% due to effect of ambient temperature and sandy environment. Due to compressor fouling the firing temperature has to be increase to maintain constant power output of 27.6MW which results to a reduction in engine creep life. To maintain a constant power output TET has increased to 1615 K. The result also shows that an increase in TET will leads to an increase in metal temperature from 1049K to 1127K which result in high stress. The turbine blade can also be affected by the gas flow around the blades, inlet and outlet cooling temperature, and cooling effectiveness of blade. The conventional ways of solving the problem is by introduction of inlet filtration system together with the compressor cleaning.

KEYWORDS: Creep Life, Turbine Entry Temperature (TET), Larson Miller Parameter (LMP), Low Pressure Turbine (LPT), Gas Turbine

SIGNIFICANCE: The significance of the study is to calculate the blade creep life of the HP Turbine at 42^{0}C and to maintain a constant power output of 26.7MW engine which results to a reduction in engine creep life and the cost.

1.0 INTRODUCTION

During the operation of an industrial Gas Turbine, GT components undergo various types of degradation due to high temperatures and mechanical loading. These conditions make the components to have failure mechanisms such as creep (Weber *et al*, 2005). Creep is one of the most common failure mechanisms that reduce the components creep life. The creep effect depends on the operating conditions of the engine, mode of operation and the design parameters. The Larson Miller Parameter (LMP) is the method used to estimate the HPT rotor blade creep life for different ambient temperature for a period of one year. Even with the advanced cooling technology the performance degradation results to an increase in TET and the metal temperature as well since they are directly proportional to each other. This result to high stress due to increase in aerodynamic load and leading to early creep life failure.

Creep is the plastic deformation which increases over time due to influence of stresses and temperatures. Creep normally occurs at temperature above the absolute melting temperature of turbine materials (Viswanathan, 1998; Reimer, 1997).
Eshati (2010) investigated the effects of the design parameters and the operating conditions on the turbine blade creep life. The effects of using different radial temperature distribution factor (RTDF), cooling effectiveness, TET and blade turbine materials on the blade creep life were investigated. For both the materials (A and B), changing the value of the RTDF led to a change in the location of maximum and minimum temperatures along the span of the blade. At the lower RTDF the temperatures at the tip and root for both materials were seen to be higher than at the higher RTDF. The maximum metal temperature which is at 75% of the span of the blade increased with the increase in RTDF. For lower RTDF the lowest creep life was located at the lower section of the blade whereas at higher RTDF it was at around 75% of the span of the blade.

2.0 MATERIALS AND METHODS

2.1 Engine Technical Specification

The engine consists of 19- stages compressor with a pressure ratio of 23.1:1 and has an annular combustor with externally mounted fuel nozzles. A 2-stage air cooled HPT which drives the compressor and auxiliary drive gear box, and a 6-stage aerodynamically coupled low pressure power turbine which is driven the gas generator (www.gaviation.com). The engine model of 27.6MW GT engine was simulated using TURBOMACH software at DP, off design point for both the clean engine and degraded engine. The design point calculations have been carried out and presented in Table 1.

Table 1 : Design Point Results of 27.6MW Engine

S/N	Engine Parameters	Values
1	Power Output (MW)	27.6
2	Fuel Flow (kg/s)	1.63
3	SFC (mg/kWs)	59.01
4	Exhaust Temperature (^{0}F)	965
5	Thermal Efficiency	39.4
6	Inlet Mass Flow (kg/s)	80.5
7	TET (K)	1505
8	Ambient pressure (KPa)	101.325
9	Ambient temperature (K)	288

2.2 Blade Geometry Specification

The HP turbine is a two stage turbine, for the design process the first stage of the blade was considered.

Table 2: Blade Geometry Specification at the Mean Height (Eshati et al, 2010)

Geometrical Parameter at Mean Height	Value	Unit
Stage loading	1.48	
Stage Reaction	50%	
Flow Coefficient	0.40	
Height to Chord Ratio	1.46	
LE/TE Radius	0.3889	M
Inlet Annulus Area	0.1038	m^2
Blade Chord	2.909	Cm
Stagger Angle	35	^0C
Rotational Speed	10050	Rpm
Density of Material	8180	Kg/m^3
Blade thickness	0.002	M

2.3 Thermal Model

To calculate the blade section metal temperature, it is necessary to treat the blade as individual where the metal temperature is assumed to be constant at both span and chord wise. The cooling effectiveness is assumed to be the same for all the blade section, and the coolant inlet temperature for the blade section is taken from the exit of the compressor (Haslam, 2011). The section metal temperature can be calculated using the formula below (Eshati et al, 2010).

$$T_{MSec} = T_{GSec} - \varepsilon(T_{GSec} - T_{Cisec}) \quad \ldots \quad (1)$$

Where;

$T_{GSec} = section\ gas\ temperature, T_{Cisec} = section\ coolant\ inlet\ temperature$

$T_{MSec} = section\ metal\ temperature, \varepsilon = rotor\ cooling\ effectiveness$

2.4 Stress Model

To calculate the creep life of a blade, the stresses from the root to tip were considered. To perform the stress model calculation, there are some parameters to be used such as pressure, rotational speed and temperature and were generated using the Cranfield University software called TURBOMATCH. It is assumed that the axial velocity remains constant along the span of the blade and the forces on the blade act at the blade section centre of gravity (Haslam, 2011). The centrifugal force was calculated at each section (Eshati et al, 2010).

$$CF_{Sec} = \rho \times A_{AvCs} \times h_{sec} \times \omega^2 \times d_{CG} \quad \ldots \quad (2)$$

Where;

$CF_{Sec} = Centrifugal\ force\ at\ each\ section, \rho = blade\ density, \omega = angular\ speed$

d_{CG} = *the distance between the rotation axis & the section centre of gravity,* h_{sec} = *blade section height*

In order to calculate the average cross section area, section height and distance CG to rotation axis from root to mean and mean to tip in Table 3 is used together with the formula;

$$A_{AVCs} = \frac{cross\ section\ area\ TDS + cross\ section\ area\ \frac{1}{2}H}{2} \quad \ldots \quad (3)$$

$$h_{sec} = mean\ radius\ TDS - mean\ radius\ ^1/_2\,H \quad \ldots \quad (4)$$

$$d_{CGSec} = mean\ radius\ ^1/_2\,H + {}^1/_2 \times section\ height\ ^1/_2\,TDS \quad \ldots \quad (5)$$

(Eshati et al, 2010)

Table 3: Blade Specification for the Area and Radius *(Eshati et al, 2010)*

	TDS	½ H	RDS
Mean Blade Cross Section Area (m2)	5.96×10^{-5}	6.71×10^{-5}	7.94×10^{-5}
Mean Blade Radius (m)	0.41	0.39	0.37

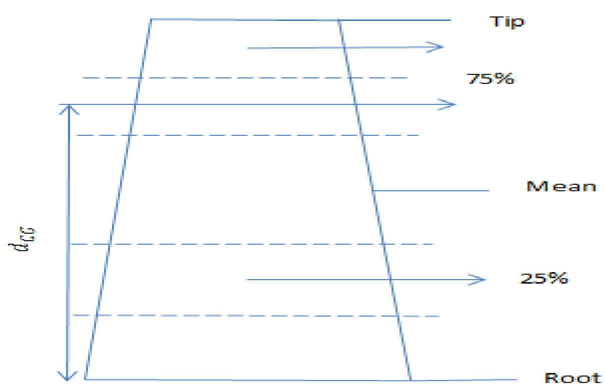

Figure 1: Centrifugal Stress at Root

The centrifugal stress at each section can be calculated using the formula as follows;

$$\sigma_{CFSec} = \frac{\sum CF_{Sec}}{A_{cs}} \quad \ldots \quad (6)$$

Where;

σ_{CFSec} = *centrifugal stress at each section,* A_{cs} = *cross section area of the section*

2.5 HP Turbine Blades – Estimation of Creep Life

The creep life of the blade at each section can be calculated once the blade section stress and the T_{msec} are known. To find the LMP at each section the formula can be represented as follows.

$$LMP = \frac{T}{1000}\left(\log t_f + C\right) \qquad \ldots \qquad (7)$$

Where;

$T = temperature\ {}^{0}K,\ C = constant,\ t_f\ = time\ to\ failure$

2.6 COST OF INCREASING FUEL FLOW

Compressor fouling has leads to an increase in fuel flow. The price of the fuel gas was obtained from NYMEX Natural Gas Features website for a period of 6 years from January 2006 to December 2011, but the analysis will focused on the year 2006 since it is the year that can give a clear effect of changing the fuel price.

During the period of 2006 price have gone down from $11.43/MMBTU to $8.32/MMBTU and the average being about $7.23/MMBTU. The following are some of the information used in calculating the fuel cost;

Natural gas density (NGD) = 1.14 kg/m3 (Nafoora Chemical Laboratory)

Natural gas lower heat value = 37456 BTU/m3 (NCL)

Engine operating hour = 8760 hours

Fuel flow increase = 0.042 kg/s

Since the quantity of the fuel has been found it is now easier to find the volume of the fuel using the formula as follows.

$$Fuel\ gas\ flow = \frac{fuel\ flow\ increase}{density} \qquad \ldots \qquad (8)$$

2.7 YEARLY EXTRA FUEL COST

The following formulas are used in calculating the yearly extra fuel cost;

Yearly$Increasing\ fuel\ flow = fuel\ gas\ flow \times operating\ hour \times NGHV \times 60$ (9)

$Yearly\ Increasing\ fuel\ flow = 0.037 \times 8760 \times 37456 \times 60 = 728.41\ MBTU$

$Yearly\ Cost\ of\ extra\ fuel = average\ cost \times yaerly\ increase\ fuel\ flow$ (10)

3.0 RESULTS AND DISCUSSION

3.1 Effect of Increasing TET on Ambient Temperature

This investigation was carried out to see how firing temperature affects engine performance when it is increased. It shows that an increase in ambient temperature to a target temperature of 42^{0}C will lead to an increase in TET. The design point TET was 1505K at ISA clean condition and increases to 1615K at 42^{0}C. The graph in figure 2 is linear which shows that TET is directly proportional to the ambient temperature, which results to a decrease in creep life of the blade as the temperature on the hot section increases.

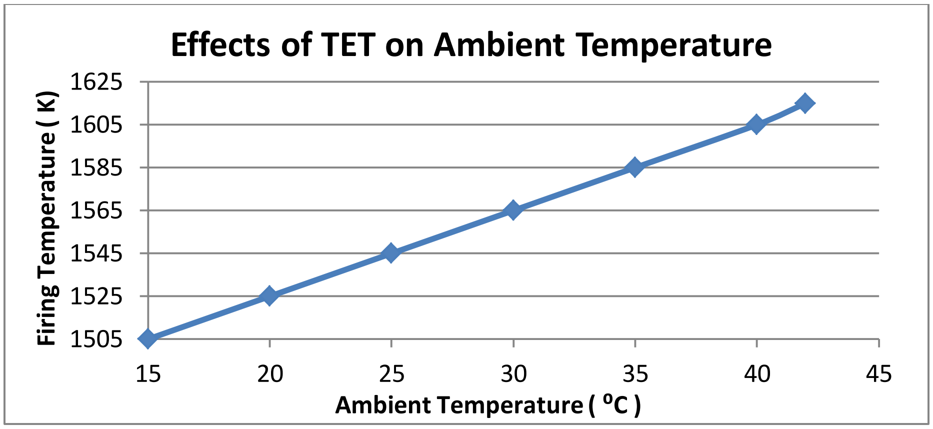

Figure 2: Effects of TET on Ambient Temperature

3.2 Effect of Fouling on Fuel Flow

The result shows the effects of increasing TET to restore power will increase the fuel flow. In order to achieve the power output of 27.6MW, the TET of the fouled engine has to be increased to 1615K. However, fuel flow increases from 1.63kg/s to 1.67kg/s with a percentage increase of approximately 3% due to compressor fouling, and the power output has been restored from 21.51MW to 27.6MW.

3.3 Thermal Model

The section gas temperature is the TET at the design point which is T_{GSec} = 1505K, the section coolant inlet temperature is the compressor outlet temperature which is equal to 745.1K while ε is constant and has a value of 0.60. Using all values the section metal temperature was found to be T_{msec} = 1049 K. From the Figure 3 above it shows that an increase in firing temperature from 1505K to 1615K of the target temperature will lead to an increase in metal temperature from 1049K to 1127K for a period of one year to maintain constant power. Thus, leading to compressor fouling which reduces the blade creep life. The metal temperature has to be increased by 6.9% in order to recover the power output of the engine. Since the graph is linear it shows that TET is directly proportional to metal temperature, which results to a decrease in blade creep life.

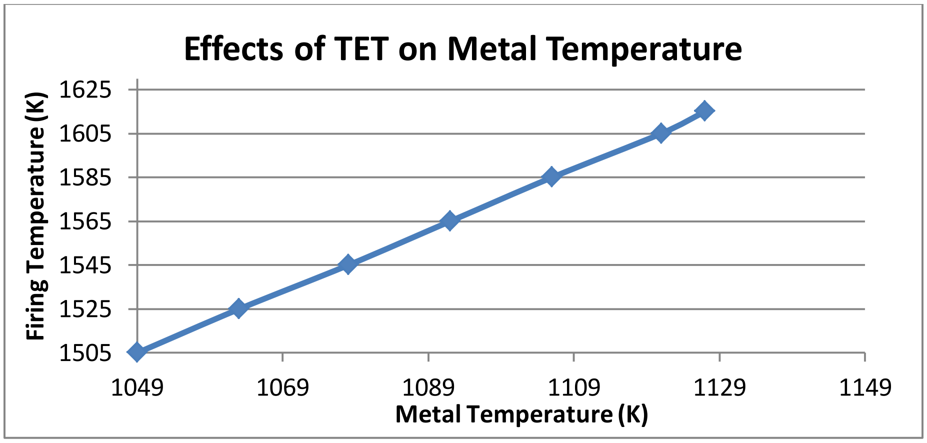

Figure 3: Effects of TET on Metal Temperature

3.4 Stress Model

In order to calculate the average cross section area, section height and distance CG to rotation axis from root to mean and mean to tip in Table 3 is used together with the formula;

Since the shroud centrifugal force is zero now the centrifugal force at each section was calculated, example CF from mean to tip can be calculated using the values below; where the density of a material = 8180 kg/m^3 (Eshati *et al*, 2010), Section height = 0.02122 m, Average cross section TDS = $6.34 \times 10^{-5}\ m^2$, Angular velocity = 1052.43 rad/s and distance CG to rotation axis = 0.39953 m. The assumed blade material is NIMONIC ALLOY 90, before calculating creep life of a blade using Larson Miller Parameter (LMP), a centrifugal stress were calculated at each section. The centrifugal stress from mean to tip was found to be $CF_{Sec} = 4.87\ kN$ and the cross section area of the corresponding section is 6.71×10^{-5} m^2 presented in Table 3. The centrifugal stress is $\sigma_{\mathrm{CFSec}} =\ 72.53$ MPa. The same procedure was applied from root to mean.

3.5 HP Turbine Blades – Estimation of Creep Life

The creep life of the blade at each section can be calculated once the blade section stress and the T_{msec} are known. The constant C is equal to 20 for an industrial applications but it can vary according to conditions stated (Haslam, 2011). At ISA design point clean condition when TET = 1505K, the section metal temperature is 1049K and the stress at the mean blade was found to be 72.53MPa. Using a graph the LMP can be obtained at blade stress = 72.53MPa and the result found to be LMP = 26.65. The HP turbine blades creep life was found to be $t_f = 29\ years$. Assuming a factor of safety 60% (Haslam, 2011) at all temperatures, therefore the value of t_f has changed to 17.4 years at 42^{0}C. The temperature across each stage is assumed to be the same. Since the stress at shroud is zero and the creep life was found to be very small, so it is assumed to be negligible.

3.6 Effects of Creep Life on Metal Temperature

An increase in metal temperature from 1049K to 1127K will lead to a decrease in creep life of the blade at mean from 29 years at ISA to 17 years at 42^{0}C of the Northern part of Nigerian temperature for a period of one year. This shows about 41% decrease in creep life of the blade in order to maintain a constant power there is need to increase the TET which will also decrease the blade creep life to about 6 months.

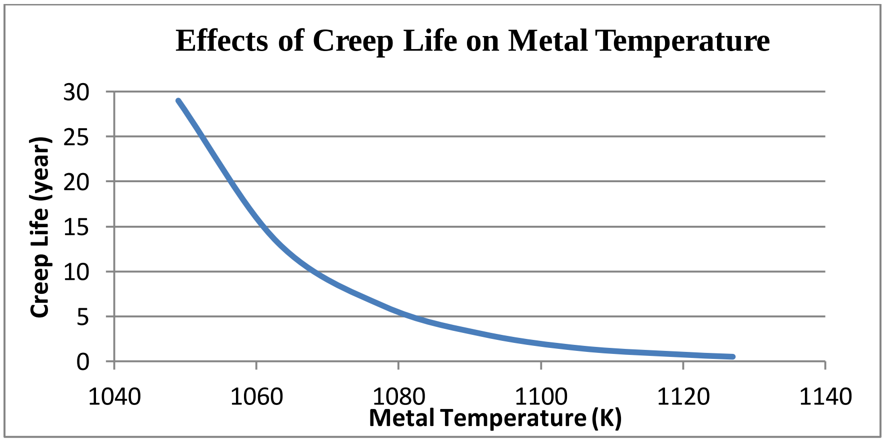

Figure 4: Effects of Creep Life on Metal Temperature

The blade creep life decreases proportionally with an increase in TET, the results is the same since the metal temperature is proportional to the turbine entry temperature.

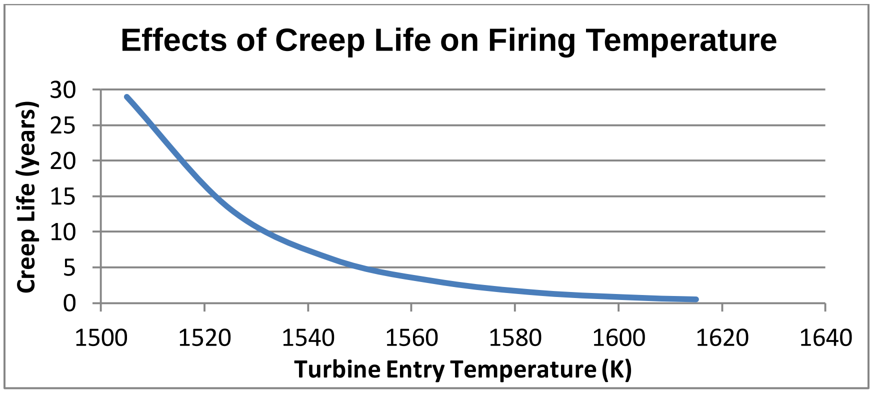

Figure 5: Effects of Creep Life on Firing Temperature

The fuel gas flow was found to be $0.037m^3/s$. The operating cost increases from $6060.37 to $8325.73 due to the effect of changing the fuel price at 8760 operating hours which is equivalent to one year of operation without compressor cleaning. The result also shows that an increase in fuel price has great effect on operating a gas turbine engines. The operating cost will increase significantly if there is no compressor cleaning.

Table 4: Effect of Changing Fuel Price

Operating Hours	NYMEX Natural Gas Price	
	Minimum $8.32/MMBTU	Maximum $11.43/MMBTU
8760	$6060.37	$8325.73
17520	$12120.74	$16651.46
26280	$18181.11	$24977.18

4.0 CONCLUSION

During the operation of an industrial Gas Turbine, GT components undergo various types of degradation due to high temperatures and mechanical loading. These conditions make the components to have failure mechanisms. The LMP was the method used to calculate the engine creep life. The creep life of the blade at mean was estimated to be 29 years at ISA and reduced to 17 years at target temperature of 42^0C with a percentage decrease of 41% due to effect of T_a and sandy environment. To maintain a constant power output TET has increased from 1505K to 1615 K. The result shows that an increase in TET leads to an increase in metal temperature from 1049K to 1127K which results in high stress. The turbine blade can also be affected by the gas flow around the blades, inlet and outlet cooling temperature, and cooling effectiveness of blade. The variation of blade metal temperature and maximum stress along the span of the blade has a strong influence on the blade's creep life.

5.0 REFERENCES

Eshati, S., Abdul Ghafir, M. F., Li, Y. G., and Laskaridis, P., (2010). "Impact of Operating Conditions and Design Parameters on Gas Turbine Hot Section Creep Life" School of Engineering, Cranfield University, Bedford MK43 0Al, UK. Proceedings of ASME Turbo Expo 2010: Power for Land, Sea and Air. GT2010.

Haslam, A. S., Cookson, R. A., (2011). "Mechanical Design of Turbomachinery" Department of Power and Propulsion, School of Engineering, Cranfield university.

http://www.business.scotsman.com/energyutilities/British-Energy-estimates-cost- of 3690260.jp. Accessed on 23rd December 2011 by 11:30pm

http://www.gaviation.com/engines/marine/lm2500plusg4.html. GE Aviation LM2500+ accessed on 18 Nov.2011 by 10:00 pm

http://www.gsfi.net/common/NYMEXSettlementHistory.pdf "NYMEX - Natural Gas Contract Settlement Price" accessed on 6th December 2011 by 10:00 pm.

Reimer, M. M., (1997). "Stress and Strain" in Edward, P. J. (ed.) Rules of Thumb for Mechanical Engineers, Gulf Publishing Company.

Viswanathan, R., (1998). "Damage Mechanisms & Life Assessment of High-Temperature Components" ASME international, Metals Park, Ohio.

Weber, B., Jin, H., Pistor, R. And Lowden, P. (2005). "Application of an Integrated Engineering Approach for LM1600 Blade Life On-line Assessment", 16th symposium on industrial application of gas turbines (IAGT), 12-14, October, Canada.

DETERMINATION OF LIFT/DRAG CHARACTERISTICS OF THERMO SET CAST AIRFOILS AT LOW REYNOLDS NUMBER

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ABSTRACT

The main objective of this investigation is to determine the lift/ drag characteristics of some selected airfoils favored by many wind turbine manufacturers at low Reynolds number. NACA 4415, 2412 and 0015 were cast using thermo set material (fibre glass and polyester resin). Wind tunnel experiments were performed to obtain the lift and drag forces. The size of the cast airfoil is such that it can be mounted in the test section of the wind tunnel. Using the wind speeds of 3.0 m/s to 7.0 m/s at intervals of 1 m/s, the lift and drag forces were measured at seventeen different angles of attack. The Reynolds number corresponding to each wind speeds was obtained using the wind tunnel data management system. The lift and drag characteristics of NACA 0015 were considered as a case study and Corrections were made on the data which account for Solid and Wake blockage. The characteristics of NACA 0015 airfoil represented on charts showing the amount of lift and drag obtained at various angle of attack. As expected with low Reynolds number, the airfoils generate lesser lift and encounter higher drag, bringing down the performance of the airfoil.

KEYWORDS; NACA Airfoils, Wind Tunnel, Reynolds number, Lift/drag characteristics.

1.0 INTRODUCTION

The performance of airfoils at low Reynolds numbers has been of interest in connection with a wide range of applications, including the operation of aircraft at low speeds and the design of micro air vehicles, compressor blades, wind turbines, and inboard sections of helicopter rotors. Several investigators have studied airfoil Performance in the low Reynolds number regime. Their findings indicate that serious aerodynamic problems occur below Reynolds number of about 200,000. Specifically, the laminar boundary layer on the upper surface of the airfoil is subjected to an adverse pressure gradient, even at low angles of attack. This often results in laminar boundary-layer separation and formation of a shear layer. At lower Reynolds numbers, the separated shear layer does not reattach to the airfoil surface, and a large wake is formed. In contrast, at higher Reynolds numbers, the separated shear layer may reattach to the airfoil surface, resulting in the formation of a separation bubble. It should be stressed that, in both cases, laminar separation has a significant detrimental effect on airfoil lift and drag. Therefore, it is of interest in any investigative work into the aerodynamics of wind turbines, a most important requirement is the lift/drag characteristics of the airfoil cross-section used for the blades at the set of Reynolds Number at which the wind turbine is expected to operate. According to Vermeer, Sorensen, and Crespo (2003) in a review, most experiments have been performed at rather low Reynolds numbers (as related to blade chord and rotational speed). They stated that only three cases with Reynolds numbers exceeding 300,000 are known and that running a test at low Reynolds numbers shouldn't be much of a problem as long as an appropriate aerofoil section is chosen, of which the characteristics are known for that particular Reynolds range. In this way, the model test does not resemble a full-scale turbine, but is still suitable for comparison and verification with numerical models.

Now, research into aerodynamic characteristics at relevant ultra-low chord-based Reynolds numbers – as would be expected in low wind speed regimes such as at Classes 1 and 2, prevalent in most parts of Nigeria (Adamu, 2012) – has been severely limited. According to Adamu (2012) there is a dearth of lift/drag data needed for wind turbine aerodynamics research at these ultra-low Reynolds numbers for Nigerian wind speed Classes.

1.1 AIM AND OBJECTIVES

The aim of this study is to determine the lift/drag characteristics of NACA 4415, 2412 and 4415 airfoils at low Reynolds number. The objectives are to:

I. Cast airfoils using thermo set material (NACA 0015,2412 and 4415)
II. Measure the lift and drag forces on a NACA 4415, 2412 and 0015 airfoils at different angles of attack and varying Reynolds number.
III. To correct the data obtained

2.0 MATERIALS AND METHODS

2.1 AIRFOIL MODELS

The airfoil used are NACA 4415, 2412 and 0015 which falls under the NACA Four-Digit Series. According to this approach the first digit specifies the maximum camber (m) in percentage of the chord (airfoil length), the second indicates the position of the maximum camber (p) in tenths of chord, and the last two numbers provide the maximum thickness (t) of the airfoil in percentage of chord. For example, the NACA 4415 airfoil has a maximum thickness of 15% with a camber of 4% located 40% back from the airfoil leading edge (or 0.4c).

The airfoil models:- NACA 4415, 2412 and 0015 were made of thermo set material, each airfoil has a chord length of 100mm and a span of 150mm

Specifications of the fabricated airfoil:

NACA Airfoil Number	**0015**	**2412**	**4415**
Chord	**100mm**	**100mm**	**100mm**
Length	**150mm**	**150mm**	**150mm**

Maximum chamber	**0**	**2%**	**4%**
Position of maximum chamber on chord	**0**	**0.4mm**	**0.4mm**
Maximum thickness	**0.15**	**0.12**	**0.15**

2.2 PRODUCTION PROCESS MATERIALS

1 Card board paper
2 Masking tape
3 Polyester resin (Type R10- 03)
4 Cobalt
5 Fibre glass
6 Car body filler
7 Durawax
8 Sand paper
9 Hardener

2.3 THE PRODUCTION PROCESS

1 Using the airfoils coordinates the original airfoils (NACA 4415, 2412 and 0015) were produced using cardboard paper.
2 A fibre glass female mould is then taken from the original. This mould is in two halves. Durawax is applied to the mould to ensure that the item produced does not stick to the mould. This mould can be used a number of times.
3 The two halves are then filled with chopped fibre glass mat mixed with resin. Hardener and cobalt (accelerator that speed the hardening process) are added to the resin to start the curing process, once it is added it must be worked quickly as the resin will solidify quickly.
4 The two halves filled with the mix are then matched together and hold firmly for some few minutes. This solidifies and the mould is carefully removed.
5 The airfoils produced are then filled with good quality body filler for imperfection and sanded to get a smooth finish.

2.4 EXPERIMENTATION

1. The wind tunnel was calibrated on installation and the k factor =0.1
2. Before starting the wind tunnel, the zeroing of the Digital Micro-manometer and zeroing of the 3 balance outputs (lift, drag and pitching moment) was performed.
3. For each model, the following were measured and inputted in the wind tunnel data management system:
    a. airfoil span;
    b. airfoil chord;
4. The barometric pressure was recorded at approximately 1 and inputted in the wind data management system
5. The tunnel was turned on the speed was adjusted to the desired value(3m/s to 7m/s at intervals of about 1m/s)

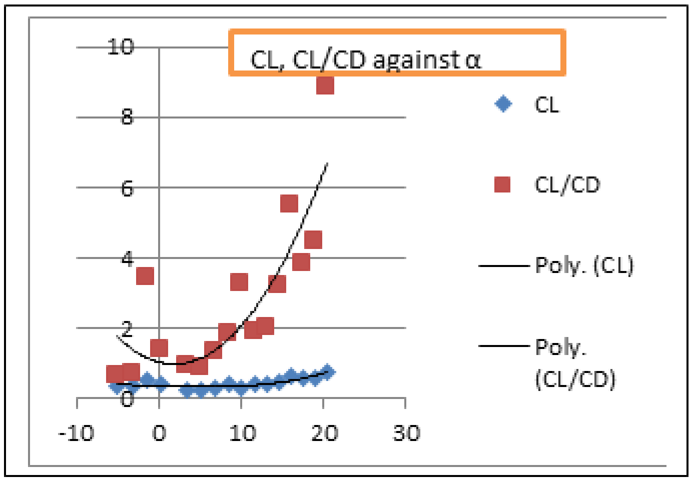
For each configuration, the data was taken via the wind data system management at angles of attack from -5° to +20.5° at about 2° increments.

3.0 DISCUSSION OF RESULTS

The tables and the charts below shows the Coefficient of lift (C_L), the ratio ${C_L}/{(C_D)}$ at different angles of attack For NACA 0015

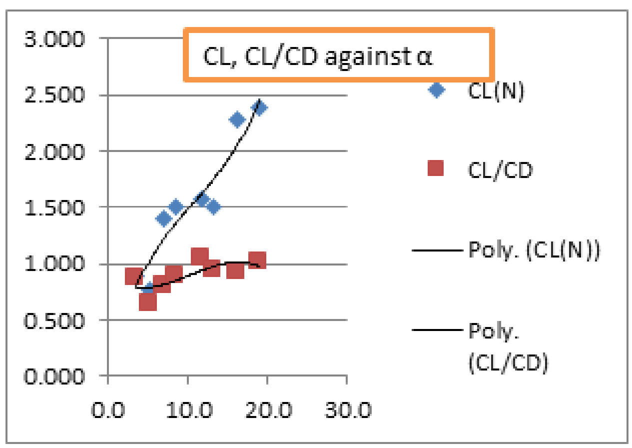
Re=6,019

A0A	CL	CL/CD
-5.0	2.392	3.272
-3.2	2.181	2.600
-1.4	3.078	0.897
0.2	1.319	1.222
3.6	1.668	1.000
5.3	1.409	0.916
6.9	1.989	0.826
8.6	2.025	1.000
10.1	0.978	0.208
13.2	1.741	1.049
17.7	3.282	1.096
20.5	3.475	0.886



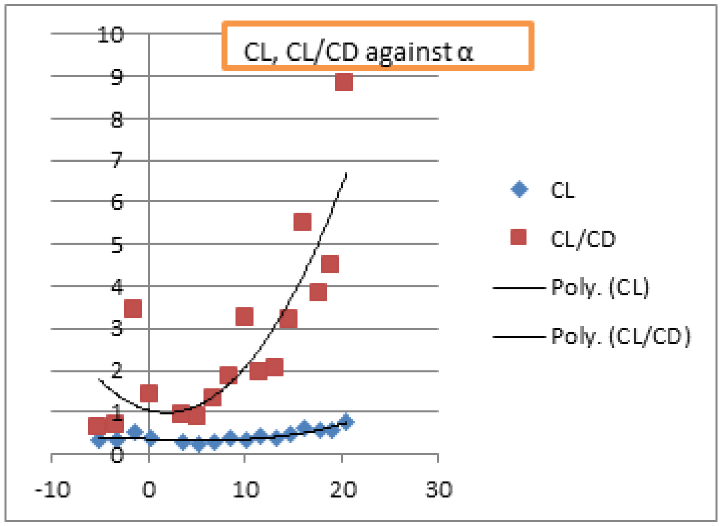
Re=8,424

A0A	CL(N)	CL/CD
-5.0	1.578	2.778
-3.2	1.599	2.866
-1.4	2.490	1.031
0.2	1.567	1.624
3.6	0.882	0.866
5.3	0.762	0.647
6.9	1.394	0.796
8.6	1.499	0.888
10.1	1.017	0.312
11.7	1.576	1.052
13.2	1.498	0.934
16.2	2.275	0.929
19.1	2.390	1.011



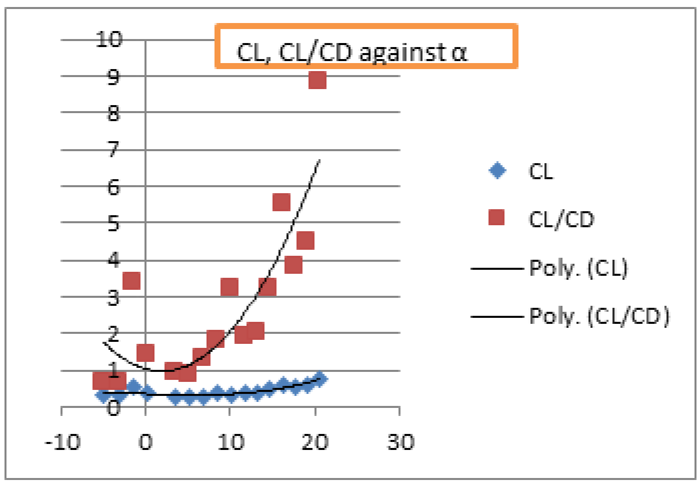
Re=10,612

A0A	CL(N)	CL/CD
-5.0	1.182	2.801
-3.2	1.157	2.565
-1.4	1.780	1.049
0.2	1.348	1.407
3.6	0.917	0.982
5.3	0.863	0.905
6.9	0.931	0.723
8.6	1.367	1.107
10.1	1.078	0.448
11.7	1.393	1.096
13.2	1.355	0.988
16.2	2.084	0.953
17.7	1.872	1.046



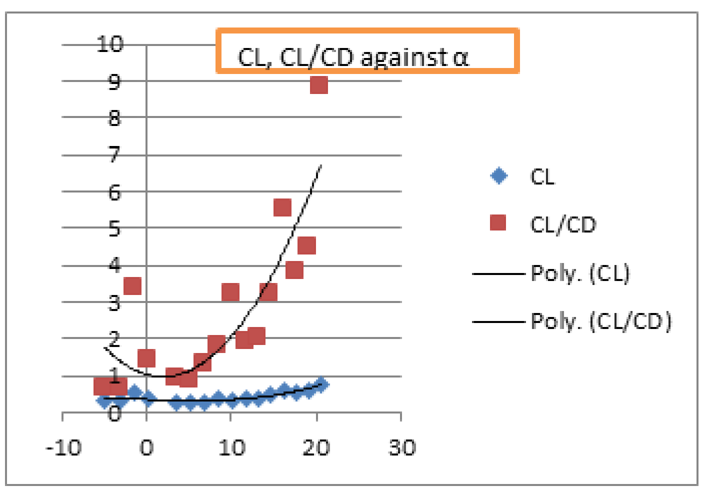
Re=12,888

A0A	CL(N)	CL/CD
-5.0	1.554	2.225
-3.2	1.231	2.457
-1.4	1.662	1.303
0.2	1.272	1.559
3.6	1.033	1.105
5.3	0.821	0.883
6.9	1.048	0.910
8.6	1.300	1.082
10.1	1.069	0.506
11.7	1.454	1.215
13.2	1.170	1.140
16.2	1.847	0.963
17.7	1.773	1.022



Re=14,920

A0A	CL(N)	CL/CD
-5.0	1.461	2.559
-3.2	1.266	2.951
-1.4	1.603	1.447
0.2	1.173	1.659
3.6	1.043	1.209
5.3	0.886	1.106
6.9	0.990	0.943
8.6	1.371	1.192
10.1	0.972	0.575
11.7	1.247	1.117
13.2	1.427	1.178
14.7	1.415	0.955
17.7	2.014	1.064
19.1	1.921	0.936



3.1 WIND-TUNNEL BOUNDARY CORRECTIONS

In general, the aim of wind tunnel test is to make measurements of aerodynamic quantities under strictly controlled and defined conditions in such a way that despite the presence of the tunnel walls, the data can applied to unconstrained flow. The existence of spatial variation in the wall induces velocities means that this equivalent cannot be obtained precisely and some corrections for these variations are needed.

The presence of the wind-tunnel walls increases the measured lift, drag and pitching moment due to an increase in velocity at the model. More specifically, the lateral boundaries in a two-dimensional testing context cause the following phenomena to occur.

• Buoyancy: Buoyancy is an additional drag force that results from a decrease in static pressure along the test section due to the growth of the boundary layer at the walls. Though buoyancy effects are usually insignificant.

• Solid Blockage: The physical presence of a model within a test section is known as solid blockage, which produces a decrease in the effective area. The velocity of the air must increase as it flows over the model, increasing all aerodynamic forces and moments at a given angle of attack. Solid blockage is a function of the model size and test section dimensions.

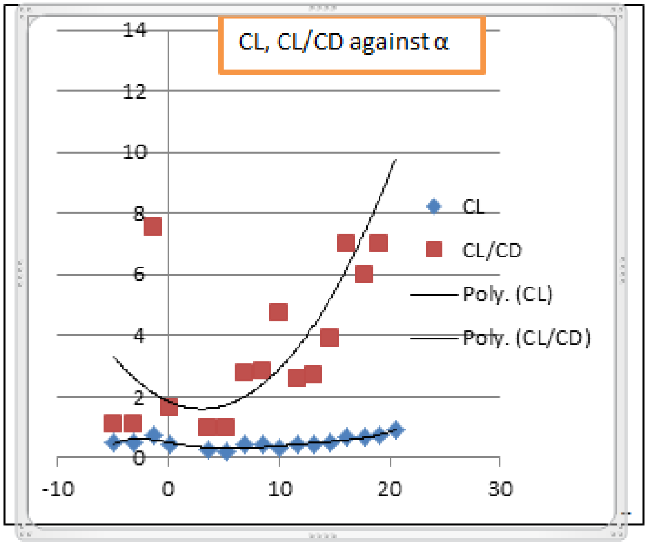
$$\epsilon_{sb}=\frac{K_1 M_v}{A^{3/2}}$$

• Wake Blockage: This results from a velocity within the airfoil wake that is compared than the free stream velocity. The effect of wake blockage is proportional to the wake size and thus to the measured drag force on the model.

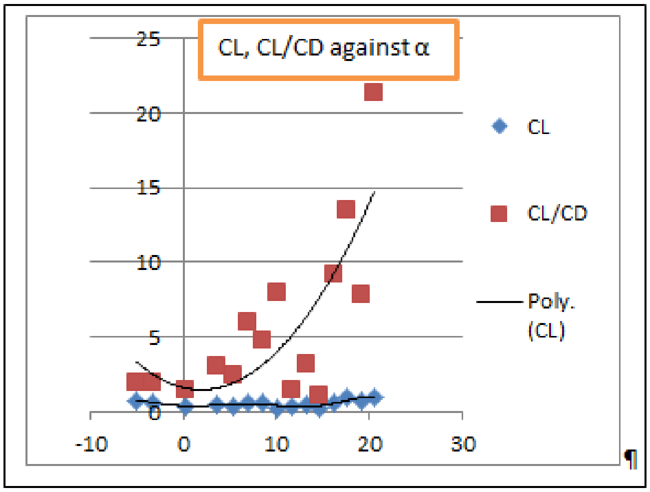
$$\epsilon_{wb}=\left(\frac{c}{2h}\right)$$

The tables and the charts below shows the corrected Coefficient of lift (C_L), the ratio ${C_L}/{(C_D)}$ at different angles of attack For NACA 0015

RE=6,019		
AOA	CL	CL/CD
-5.0	0.7176	1.9725
-3.2	0.6543	2.0157
0.2	0.3957	1.5373
3.6	0.5004	3.1314
5.3	0.4227	2.4044
6.9	0.5967	5.985
8.6	0.6075	4.8406
10.1	0.2934	7.9946
11.7	0.3492	1.4642
13.2	0.5223	3.2461
14.7	0.2022	1.1019
16.2	0.663	9.2083
17.7	0.9846	13.4325
19.1	0.7494	7.9051
20.5	1.0425	21.3627

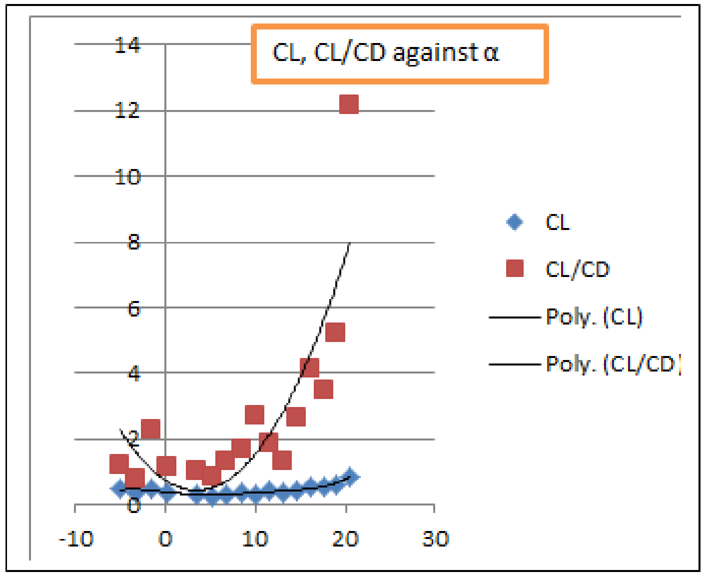


RE=8424		
AOA	CL	CL/CD
-5.0	0.4734	1.0811
-3.2	0.4797	1.0826
-1.4	0.747	7.5227
0.2	0.4701	1.6414
3.6	0.2646	0.9717
5.3	0.2286	0.9703
6.9	0.4182	2.7769
8.6	0.4497	2.8534
10.1	0.3051	4.7156
11.7	0.4728	2.6064
13.2	0.4494	2.6814
14.7	0.4791	3.8856
16.2	0.6825	7.0072
17.7	0.6612	5.9729
19.1	0.717	7.0157
20.5	0.9285	12.986



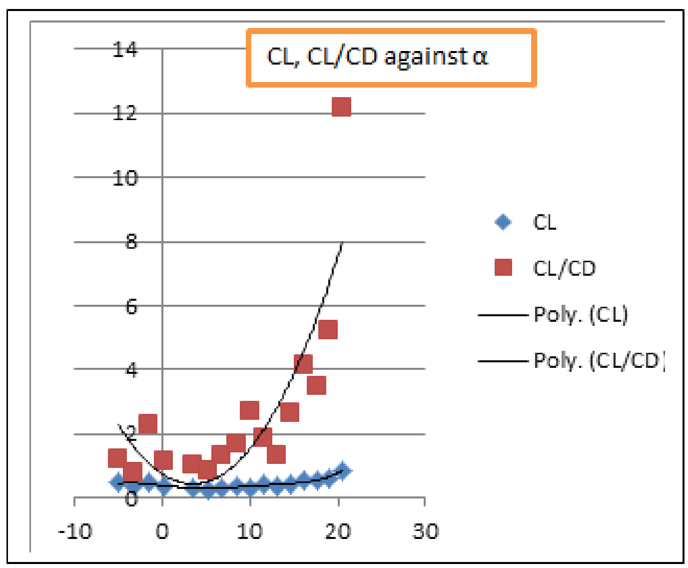
RE=12,888

AOA	CL	CL/CD
-5.0	0.4662	1.2236
-3.2	0.3693	0.7775
-1.4	0.4986	2.3009
0.2	0.3816	1.148
3.6	0.3099	1.0509
5.3	0.2463	0.8313
6.9	0.3144	1.3046
8.6	0.39	1.6905
10.1	0.3207	2.6995
11.7	0.4362	1.8826
13.2	0.351	1.2986
14.7	0.4488	2.6307
16.2	0.5541	4.1166
17.7	0.5319	3.4902
19.1	0.6318	5.2172
20.5	0.8736	12.1333



RE=14,920

AOA	CL	CL/CD
-5.0	0.4383	1.0046
-3.2	0.3798	0.7297
-1.4	0.4809	1.9182
0.2	0.3519	0.9422
3.6	0.3129	0.9877
5.3	0.2658	0.7871
6.9	0.297	1.1237
8.6	0.4113	1.7031
10.1	0.2916	1.8514
11.7	0.3741	1.503
13.2	0.4281	1.8694
14.7	0.4245	2.3108
16.2	0.3897	1.9954
17.7	0.6042	4.4167
19.1	0.5763	4.6702
20.5	0.7884	9.3191



4.0 CONCLUSIONS

The results of the analysis based on the graph for NACA 0015, as the amount of lift varies with the angle of attack so does the drag. The lift curve reaches its maximum at 17.7 degrees angle of attack at Reynolds number 10,612. As expected with low Reynolds number regime, the drag experienced by the airfoil is high with the varying Reynolds number. This is more pronounced with graph obtained from the corrected data. Corrections were made on the data which account for Solid and Wake blockage. Making this data available, several and different methods can be proposed to tackle the challenges of low lift generated and high drag experienced in low Reynolds number regime.

REFERENCES

Adamu, A. A. (2012). Experimental Investigation of the Wake of a Wind Turbine with a Convergent Nozzle. Energy Technology and Management Conference, ETMCon, 2012, Ibadan

Dr.D.Ravindran; Computational fluid dynamics of wind turbine blade at various Angles of attack and low Reynolds number. S.Rajakumar. et. al. / International Journal of Engineering Science and Technology Vol. 2(11), 2010, 6474-6484.

Jacobs, E. N. and Sherman, A. (1937). Airfoil Section Characteristics as affected by Variations of the Reynolds Numbers. NACA Technical Report No. 586. http://www.naca.larc.nasa.org Accessed February, 2011.

Katam, V. (2005). Simulation of Low RE Flow over a Modified NACA 4415 Airfoil with Oscillating Camber. M. Sc. Thesis, University of Kentucky. http://www.uky.edu/gradschool_theses/339 Accessed February, 2011.

Lissaman, P.B.S. "Low Reyn olds Number Air foils", Annual Review of Fluid Mechanics, Palo Alto, California: Annual Reviews, Inc., Vol.15 , pp . 223 - 23 9 ,1983
Marchman, J.F. "Aerodynamic Testing at Low Reynolds Numbers", Journal of Aircraft, Vol.24, No.2, February 1987.

Mueller, T.J."Low Reynolds number Vehicles" AGARDOgraph No.288, February1985.

Miklosovic, D. S., Schultz, M. P. and Esquivel, C. (2004). Effects of Surface Finish on Aerodynamic Performance of Sailboat Centreboard. Journal of Aircraft. Vol. 41 No. 5, p 1 – 9.

Mueller, T.J., Jansen, B.J.Jr."Aerodynamic Measurements at Low Reynolds Numbers", AIAA paper No. 82-0598, 1982.

Ostowari, C. and Naik, D (1984). Post Stall Studies of Untwisted Varying Aspect Ratio Blades with an NACA 4415 Airfoil Section. Part I, Wind Engineering Vol. 8, No. 3 p 1 – 19

Reuss, R. L., Hoffman, M. J. and Gregorek, G. M. (1995). Effects of Surface Roughness and Vortex Generators on the NACA 4415 Airfoil. NREL/TP – 44 – 6472, p 1 – 103.

Saliveros, E. (1988). The Aerodynamics Performance of the NACA 4415 at Low Reynolds numbers. M. Sc. Thesis, University of Glasgow, UK.

Vermeer, L. J., Sorensen, J. N., and Crespo, A. (2003). Wind Turbine Wake Aerodynamics. Progress in Aerospace Sciences, Vol. 39, p457 – 510.

GAS TURBINE PERFORMANCE ENHANCEMENT WITH ON-LINE COMPRESSOR CLEANING

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ABSTRACT

During the operation of an industrial Gas Turbine airborne particles are ingested and affect the engine performance which causes performance degradation in the compressor. A 27.6 Megawatt is a two-shaft engine designed for use in the Northern part of Nigeria where the temperature is very high at approximately 42 ^{0}C in June. When the engine operates at 42 ^{0}C it produces a power output of 21.51MW which causes a power loss of 22%. However, SFC increases from the design point value of 59.01kg/Ns to a value 62.33kg/Ns representing a 6% increase. In order to recover the power output it is possible to increase the TET to 1615K which leads to an increase in metal temperature from 1049K to 1127K. This would result in an increase in fuel flow consumption which of course leads to loss of blade creep life. The benefit of on-line compressor cleaning is to maintain the performance of an engine at constant TET. This can reduce the cost of fuel consumption and cost of operating the GT engine. On-line washing is one of the valuable tools that prevent engines from fouling. From the results obtained at different frequency of wash schedule, the cost of power loss for 10 days was found to be US$3800. It shows that washing every 10 days is more effective compared with 20 days and 30 days. The total cost of washing for 10 days interval was found to be US$162000 with a net profit of US$8800000 over one year of operation.

KEYWORDS: Fouling, High Pressure Turbine, On-line washing, Degradation, Wash Fluid

SIGNIFICANCE: The research conducted provides the most economical solution for on-line compressor washing at different intervals based on industrial gas turbine engine with a shaft power of 27.6MW.

1.0 INTRODUCTION

Gas Turbine (GT) engine was designed originally for aircraft. Due to its weight and small size, the GT has become an appreciated machine for other applications such as industrial and power generation. The use of GT in power generation and industrial applications has grown up significantly in the last two decades. The emphasis on environmental protection and influence of higher fuel prices, industry privatization and market deregulation demand higher operating efficiencies and reduced emission levels (Hamed *et al*. 2006).

Stalder (2001) performed on-line washings at time intervals in the range between 700, 350 and 120 operating hours. It showed that plant performance is significantly higher at shorter on line washing intervals, which prevent incremental power degradation. The combination of both washing methods is the most effective and economical. Based on the operating hours of 8000, it was estimated that improved performance equivalent to approximate $450,000 per year can be achieved with the combination of both on line and off line compressor washing methods on one 30MW gas turbine.

Boyce (2007) investigated the proper combination of on-line water wash and crank wash will vary from location to location. By monitoring the performance, any site can determine the best water wash combination. The result of the tests indicated that under most operating conditions, the demineralized water wash done twice weekly is as effective as water-soap mixtures.

Schneider (2010) investigated that, compressor off-line washing should be performed if the gas turbine has more than 2% power loss. If the gas turbine has a high fouling rate, a daily compressor on-line washing schedule should be considered to reduce the power degradation in the interval between inspections.

2.0 MATERIALS AND METHODS

2.1 Design Point Simulation of a Medium Size Engine

Design Point (DP) of an engine is a point in the operating range of a GT when the engine is running at the particular speed, PR and MF for which the engine components were designed (Paul *et al*, 2003). The engine model of 27.6MW GT engine was simulated using TURBOMACH software at DP, off design point for both the clean engine and degraded engine. The design point calculations have been carried out using the following information; Inlet mass flow = 80.5kg/s, TET = 1505K, Ambient pressure = 101.325KPa, Ambient temperature = 288K. The other value for the design point is shown in Table 1.

Table 1 : Design Point Results of 27.6MW Engine

S/N	Engine Parameters	Values
1	Power Output (MW)	27.6
2	Fuel Flow (kg/s)	1.63
3	SFC (mg/kWs)	59.01
4	Exhaust Temperature (^{0}F)	965
5	Thermal Efficiency	39.4

6	Pressure Ratio	23:1

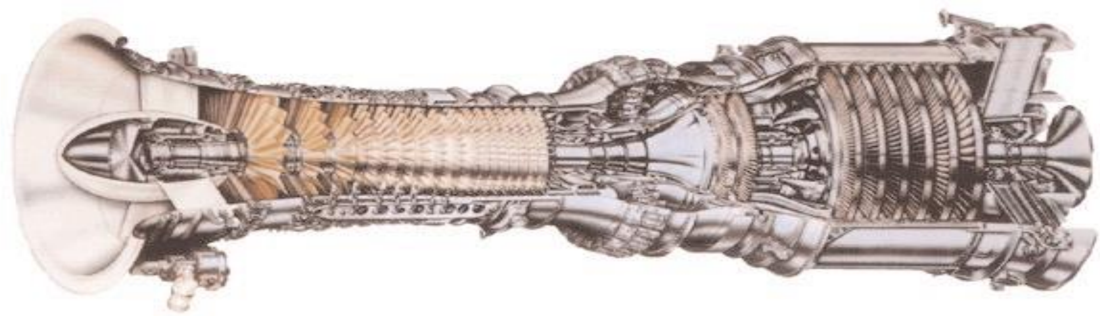

Figure 1: Medium Size Twin Shaft Engine (www.gaviation.com, 2011)

2.2 Frequency of Washing

The performance of a GT engine has been affected due to fouling which leads to loss of power production and increased revenue to the user. To recover the power output due to degradation it is necessary to undergo a regular on-line cleaning which will partially or completely recover the power loss. Since the on-line washing can be perform at different intervals during the operation of an industrial GT engine, different frequency of washing interval were investigated for a period of twelve month in order to find the most effective and economically cheap. They are categorised into three as follows:

- On-line washing once every one month
- On-line washing every twenty days
- On-line washing every ten days

2.3 Power Loss after 10 Days

Power loss for washing

$$= \% \text{ power loss} \times \text{power output} \times \text{operating hour} \quad \ldots \qquad (1)$$

Cost of power loss

$$= \text{power loss for washing after 10 days} \times \text{cost of power} \quad \ldots \qquad (2)$$

2.4 Comparison at Different Frequencies of Wash Schedule

$\text{Frequency of washing after every 10 days} =$

$\text{cost of power loss without washing for one year} -$

$\text{cost of power loss for washing after every 10 days for one year} \quad \ldots$

(3)

3.0 RESULTS AND DISCUSSION

The effects of varying ambient temperature at constant TET, effects of compressor efficiency reduction and mass flow drop are taken into investigation for the off- design point simulation.

3.1 Effects of Ambient Temperatures

The off-design simulations were carried out by varying the ambient temperature from -10^{0}C to 30^{0}C at constant TET. This task was carried out to know the effects of ambient temperature on engine shaft power. The result shows that a decrease in ambient temperature results in an optimum engine performance, however when the engine inlet temperature is at 30^{0}C the compression work increases. This means the compressor needs more power to compress the hot air due to high inlet temperature. This results to a drop in thermal efficiency and power output. At datum point where the temperature is 315K gives a power output of 21.51MW with a percentage drop of 22%.

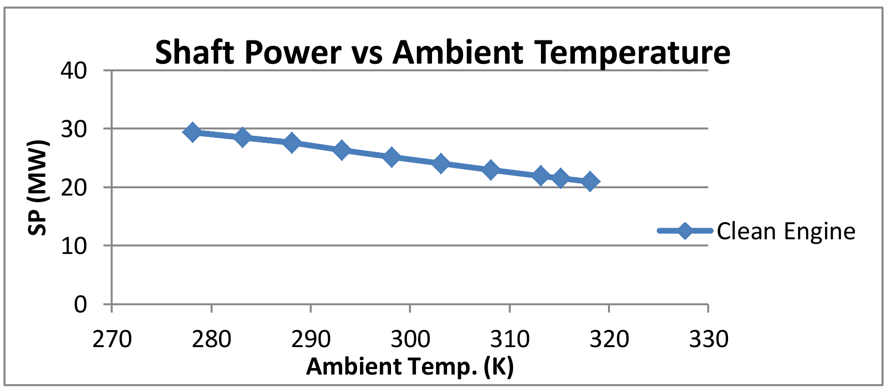

Figure 2: Effect of Ambient Temperature on Shaft Power

However SFC increases from the design point value of 59.01kg/Ns to a datum point value of 62.33kg/Ns with a percentage increase of approximately 6%.

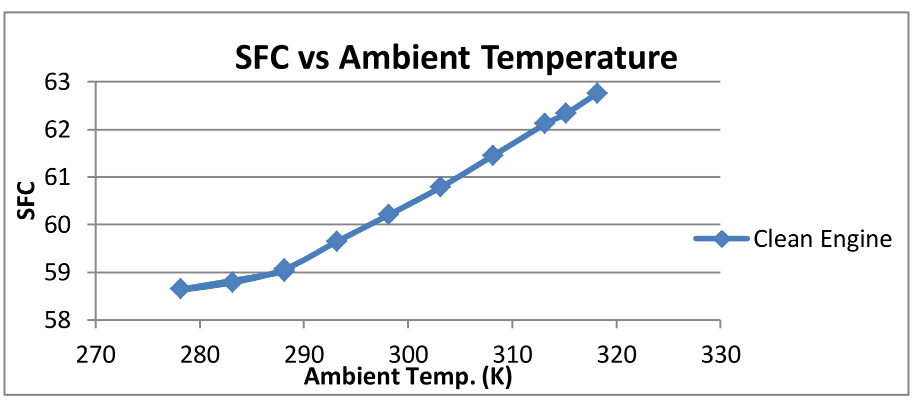

Figure 3: Effects of Ambient Temperature on SFC

When the ambient temperature increases to a datum temperature of 315K in Figure 4, it gives a power output drop by 22%, PR=15.7% , mass flow=16% , thermal efficiency of 5.6% and increase SFC by 5.6%. During the hot day the ambient temperature is high which cause a reduction in mass flow and density and results to drop in power output. However during the cold day the density increases and causes an increase in mass flow and results to increase in power output.

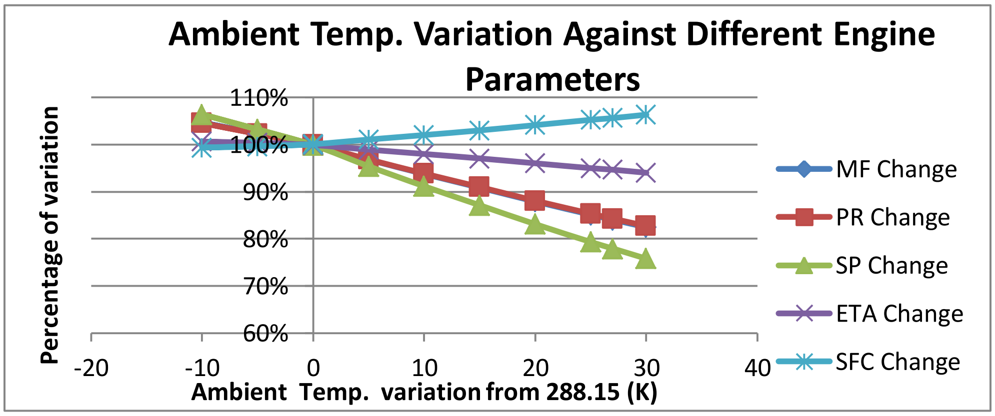

Figure 4: Ambient Temperature Effects on Different Engine Parameters

The clean engine line is above the fouled line which indicates 22.1% drop in power output while 28.3% drop for the fouled engine as shown in Figure 5. At higher ambient temperature, it is more severe as there is a combined reduction of mass flow due to fouling and density reduction of ambient air. This leads to higher losses in power output. At the lowest ambient temperature the effect of fouling is relatively smaller since the mass flow reduction due to fouling is less than the increase the mass flow increase due to ambient temperature. The Figure 6 shows the effect of SFC against ambient temperature for both clean and fouled engine, the clean engine line is now below the degraded line which indicates an increase in SFC of 5.6% for the clean engine while 14.4% for the fouled engine.

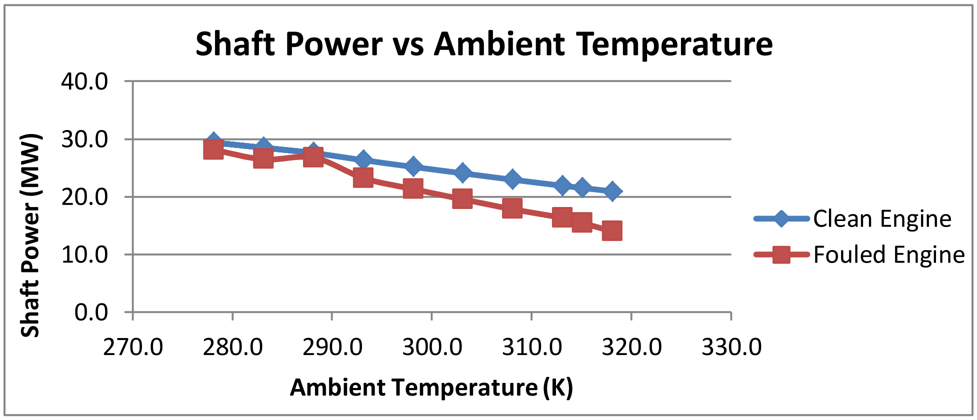

Figure 5: Clean and Fouled Engine Shaft Power

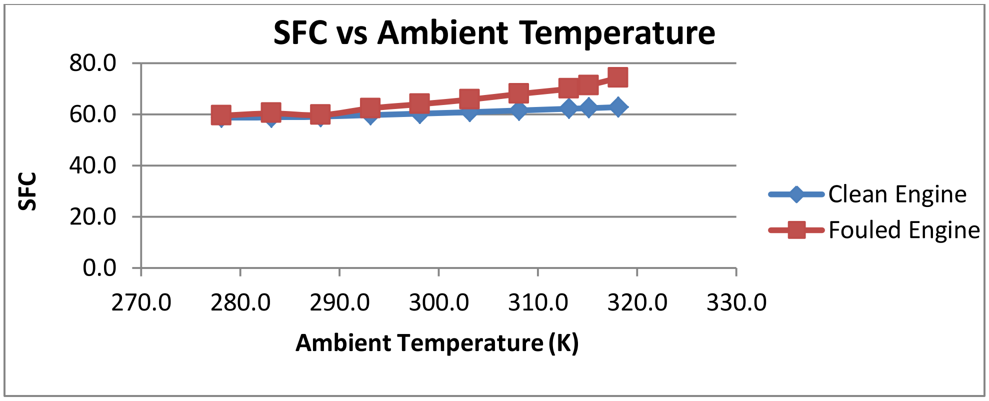

Figure 6: Clean and Fouled Engine SFC

3.2 Effects of Mass Flow (MF) Reduction

Simulation of an engine was carried out to see the effects of MF drop ranging from 1% to 5%. For the two shaft engine a drop in MF produces an effect which reduces the performance of the engine. Due to variable rotational speed the engine counterbalances the drop in mass flow which automatically increases its velocity. Since there is no change in TET the compressor will operates at constant pressure ratio mass relationship, and is determined by the turbine hot section (Cyrus and Andrew, 2004). Due to drop in flow capacity the non-dimensional velocity line moved towards the left side of the compressor map, the compressor run faster due to degraded operating point which is positioned on the high non-dimensional speed line.

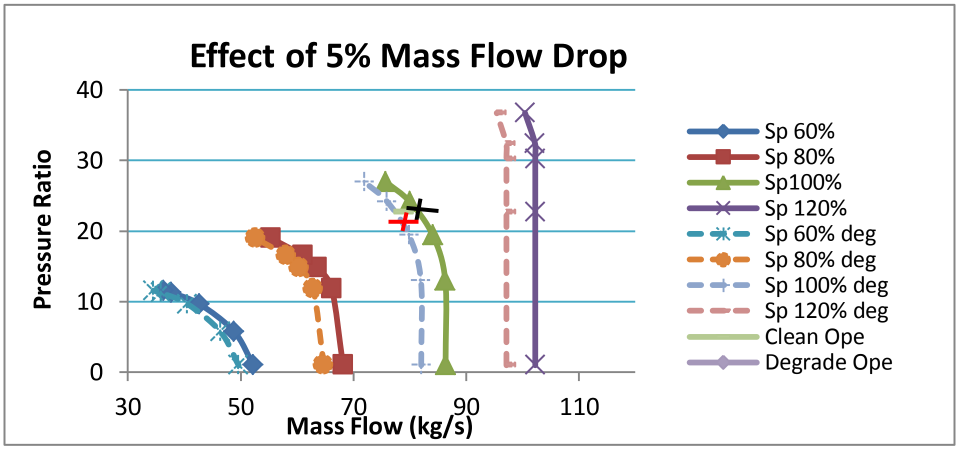

Figure 7: Effects of 5% MF for 26.7MW engine

3.3 Effects of Compressor Efficiency Reduction

Simulation of an engine was carried out to see the effects of compressor efficiency drop ranging from 1 to 5%. It can be noticed that, the reduction in power output is greater for compressor efficiency than MF as well as PR. The two shaft engine changes its velocity which causes a large reduction in power output. It can be noticed the reduction in power output is greater when combined (compressor efficiency and MF) than when treated separately. The alternative method to restore the power output is by compressor cleaning.

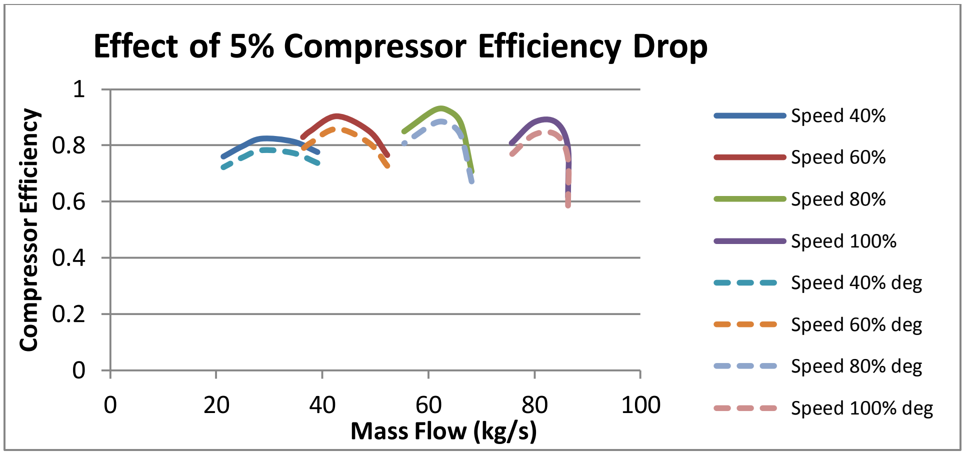

Figure 8: Effects of Compressor Efficiency reduction on 27.6MW Engine

3.4 On-line Washing Every Ten Days

Based on the data obtained, when the engine operates for ten days without cleaning then power output drops from 27.6MW to 27.59MW with a percentage reduction of 0.0074%. When the engine operates for 9000 hours without washing the power reduces to 26.86 MW with a percentage reduction of 2.69%. Assuming no recovery due to compressor washing and no pressure drop effects, the engine will behave like this under fouling effects without cleaning system.

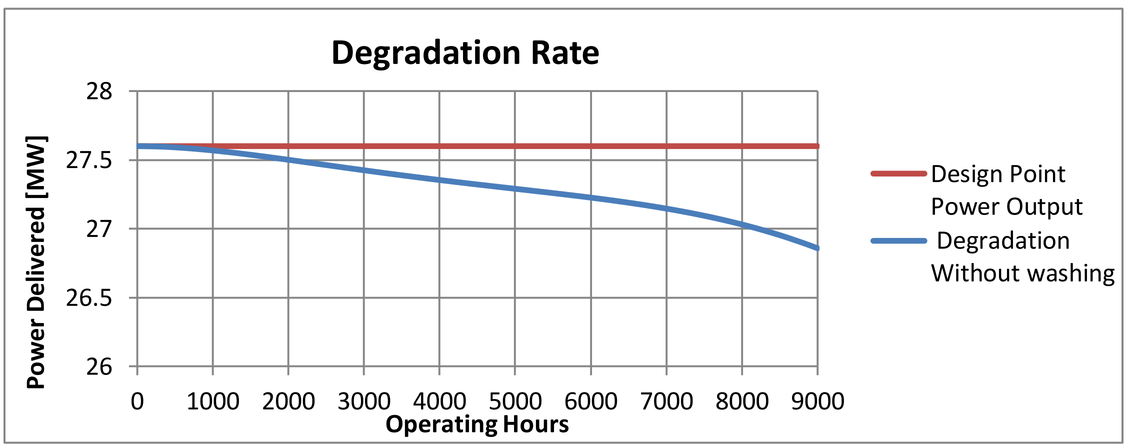

Figure 9: Degradation Rate for 10 days

Figure 10 shows a curve for an on-line cleaning for 10 days interval for a period of 9000 hours of operation assuming a power recovery rate of 50%. Due to on-line washing of a compressor the power can be recovered by 1.3% thus from 26.86MW to 27.22MW shown in figure

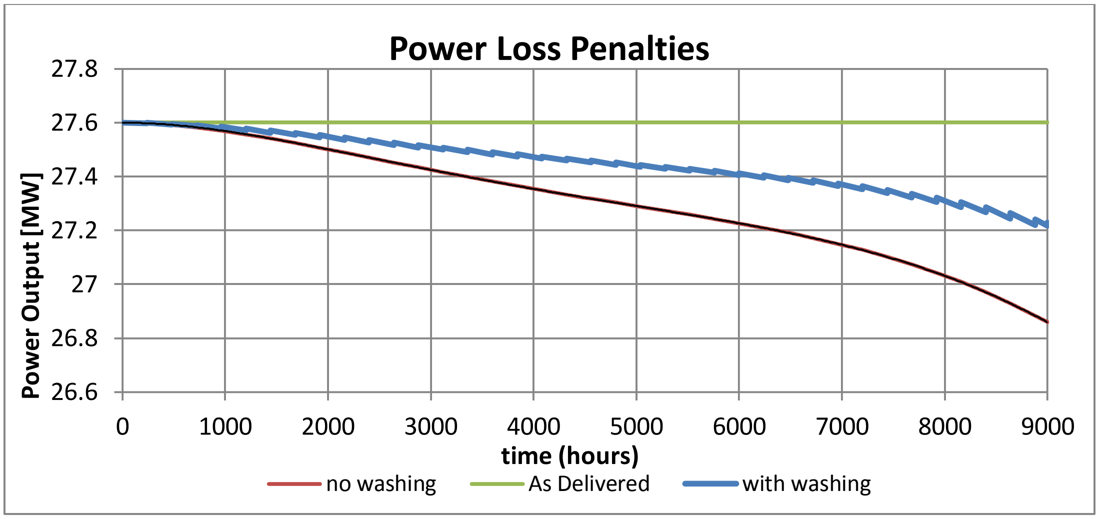

Figure 10: On-line Washing every 10 Days

Based on the results obtained in **Error! Not a valid bookmark self-reference.**2, the power loss and cost of power for 10 days is less than the 20 and 30 days. It shows that the 10 days intervals is more profitable compared to 20 and 30 days.
The cost of power per MWh = £50 = $78 (www.business.scotsman.com)

Table 2: Cost Analysis of Power Loss

Frequency of Washing	Power Loss (MWh)	Cost of Power Loss ($)
10 Days	49	3800
20 Days	384	30000
30 Days	1232	96000
One Year	116053	9050000

4.0 CONCLUSION

The design point of a typical 27.6 Megawatt GT engine model was created using the TURBOMATCH software. The off-design simulations were carried out by varying the ambient temperature from -10^{0}C to 30^{0}C at constant TET. The performance has been estimated over an ambient temperature range from -10^{0}C to 30^{0}C at constant TET. A decrease in ambient temperature tends to obtain an optimum engine performance, however the high temperature of northern Nigeria made it necessary to go on-line compressor cleaning. At a temperature of 42^{0}C in northern Nigeria produces a power output of 21.51MW. The effect of ambient temperature increases and causes a reduced power of 22%. However, SFC increases from the design point value of 59.01kg/Ns to a datum point value of 62.33kg/Ns representing a 6% increase. In order to recover the power output it is possible to increase the TET to 1615K which leads to an increase in metal temperature from 1049K to 1127K. This would result in an increase in fuel flow consumption which of course leads to loss of blade creep life

From the results at different frequency of wash schedule, the cost of power loss for 10 days was found to be US$3800. It shows that washing every 10 days is more effective compared with 20 days and 30 days. The benefit of on-line compressor cleaning over a complete one year is to maintain the performance of an engine at constant TET, which reduces the cost of fuel consumption and cost of operating the GT engine. The total cost of washing for 10 days interval was found to be US$162000 with a net profit of US$8800000 over one year of operation.

5.0 REFERENCES

Boyce, M. P., (2003). "Gas Turbine Engineering Handbook" 2nd Ed., Butter worth – Heinemann, Boston. ASME paper No 114 / Vol 129, January 2007.

Boyce, M. P. (2003). "Handbook for Cogeneration and Combined Cycle Power Plants" ASME, New York. ASME paper No 114 / Vol 129, January 2007.

Boyce, M. P. and Gonzalez F., (2007). "A Study of On-line and Off-line Turbine Washing to Optimize the Operation of a Gas Turbine". ASME paper No 114/Vol 129.

Boyce, M. P. and Latcovich, J. A., (2002). "Condition Monitoring and its Effect on the Life of New Advanced Gas Turbines." Gas Turbine Users Association Conference, Houston, Tx, April 21 – 25.

Diakunchark, I. S, (1992). "Performance Deterioration in Industrial Gas Turbines" ASME Journal Engineering Gas Turbines Power, 114 pp 161 – 168.

Hamed, A., Tabakoff, W., and Wenglarz, R., (2006). "Erosion and Deposition in Turbomachinery" J. Propul. Power, 22(2), pp 350 – 360.

http://www.business.scotsman.com/energyutilities/British-Energy-estimates-cost-of.3690260.jp. Accessed on 23rd December 2011 by 11:30pm.

http://www.gaviation.com/engines/marine/lm2500plusg4.html. GE Aviation LM2500+ accessed on 18 Nov.2011 by 10:00 pm.

J. P. Stalder, (2001), "Gas Turbine Compressor Washing State of the Art Field Experiences" Journal of Engineering for Gas Turbines and Power. ASME 2001. Vol 123/363

Musa, G. H., (2012). "Gas Turbine Performance Enhancement with On-line Compressor Cleaning" Msc. Thesis, School of Engineering, Department of Power and Propulsion, Cranfield University.

Pachidis, V. A.,(2011). "Gas Turbine Performance Simulation" School of Engineering, Department of Power Propulsion and Aerospace Engineering. Paul, L., Russ, G., and Mark, B., (2003), "Development in On-line Gas Turbine Compressor Cleaning"

Pilidis, P., and Palmer, J. R., (2011). "Gas Turbine Theory and Performance" Cranfield University, School of Engineering, Department of Power and Propulsion.

Schneider E, (2010). "Analysis of Compressor On-line Washing to Optimize Gas Turbine Power Plant Performance." A Journal of Engineering for Gas Turbines and Power. ASME 2010 by ALSTOM Vol 132/ 062001-1

EFFECTIVENESS OF ENGINEERING STUDENTS INDUSTRIAL WORK EXPERIENCE SCHEME (SIWES) PROGRAM INMANUFACTURING INDUSTRIES OF KANO STATE

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ABSTRACT

The engineering Students Industrial Work Experience Scheme (SIWES) program is a very important part of the training that provides practical skill acquisition through training in relevant industries. This training serves as an effective instrument for exposing student to the real working environment in Nigeria at the same time serves as link between the industries and the academic institution for the purpose of grooming engineers that are going to become the employees of the industries. This paper examines the schemes' trend for engineering students in Bayero University Kano for past years by administering questioners to students involved in the scheme. At the same time other stakeholders like Coordinator, Industry based supervisors, Lecturers and ITF SIWES schedule officer were also interviewed. The main finding is that students' placements into relevant industries has been a major challenge that hinders the effectiveness of the scheme especially with the closure of over 400 manufacturing companies in the commercial city of Kano. The paper also point out its shortfalls and then proffer solutions towards its improvement and bridging of the gap between academia and industries.

1.0 INTRODUCTION

1.1

1.2 The Students Industrial Work Experience Scheme (SIWES) is an effective instrument for exposing students to the realities of work situation in their chosen professions. It is designed to acquaint students with the industry while still undergoing academic training with the sole aim of supplementing the laboratory practicals and preparing them for industrial challenges.It is a skill training programme designed to expose and prepare Students of engineering of tertiary institutions for the industrial work situation they are likely to meet after graduation [1]. Prior to the introduction of the Scheme, industries were seriously complaining about the lack of adequate practical background experience of graduates from universities and that the theoretical education provided alone is making them not to respond to the need of the economy. It was due to this growing concernthat the SIWES was introduced to provide students with the opportunity of exposure to handle equipment and machinery in Industry to enable them acquires prerequisite practical and skills [2]. Since the inception of the scheme 1974 the programme has been experiencing exponential increase in the number of participating institutions, courses and students.

However, this exponential growth and expansion of SIWES, has taken place against the backdrop of successive economic crises which have affected the smooth operation of the Scheme. Mostindustries in Nigeria today, areoperating below installed capacity while others are completely shut down. In Kano city of the northern part of Nigeria alone, over 400, 000 workers have lost their jobs, while over 400 companies have closed down, following epileptic power supply in the city, preference given to foreign investors, lack of support to indigenous enterprises and lack of protectionfor locally manufactured goods by the government [3-6].

This has impacted negatively on the Scheme as institutions of higher learning find it increasingly difficult to secure placement in Organisations where they could acquire the much needed practical experience. Other issues that have impact on the smooth operation of the scheme are the lack of proper monitoring and supervision by the industries and institutions. The Students Industrial Work Experience Scheme has been reviewed frequently in terms of scope, operations and guidelines. Such efforts at reviewing the Scheme have been documented in reports of the Industrial Training Fund (ITF) which include; Biennial SIWES National Conference, Students Industrial Work Experience Scheme in Human Resource Development in Nigeria (ITF 2003) and the Annual Chief Executives' Forum of SIWES Regulatory Agencies with other Stakeholders [7-13]. Similarly, the SIWES Handbook which provides information on the concept, objectives, scope and operational process is reviewed and updated regularly to reflect necessary changes. Three of such reviews have so far been produced since the first issue in 1974.

In view of the challenges, study on the effectiveness of the scheme that has existed for more three decades in the faculty of engineering Bayero University, Kano becomes necessary and faculty of engineering is considered as a case study in order to evaluate the impact on students training program. At the same time it is an avenue for getting feedbacks from the captains of industries on our students' performance generally. The information is going to assist the faculty and the university towards the future preparation of the scheme.

The study, therefore, takes a look at problems militating against the smooth operation of the scheme and ways of enhancing its effectiveness for attainment of desirable outcome or target irrespective of current situation of industries in Kano.

3.0 METHODOLOGY

3.1 Research Design

The study focused on examining the challenges faced by students during SIWES and its adequacy towards the achievement of the desired objectives.

At the same time other stakeholders like Coordinator, Industry based supervisors, Lecturers and ITF SIWES schedule officer were also interviewed.

3.2 Background of the Case study population

The faculty of Engineering Bayero University Kano which is the target case study was established in 1978 as faculty of Technology until September 2011, when the name was changed to faculty of Engineering. Since establishment the vision and mission of the faculty is to provide a world-class center of engineering training that meets the growing need for expertise in engineering field. The expertise the faculty provides in the engineering profession includes civil, Electrical, mechanical, Agricultural, Irrigation, computer and recently introduced mechatronics engineering. The faculty offers five years degree programmes which are interposed by SIWES programme in the third and fourth year of student's course duration. It is one of the highest credits –carrying course that requires a minimum of 8 weeks and 24 weeks at the third and fourth level respectively.

Generally, based on employers rating of students from this faculty, the students are doing well and have very good theoretical background [14]. The sound theoretical background requires some practical skills and abilities in order to actualize the set vision of the University of producing well polished students in this great field of engineering. The faculty and the university authority have places much emphasis on the programme by establishing a SIWES unit directly under the Vice Chancellor's office that is charged with the responsibility of liaising with the Industrial Training fund (ITF) and industries. As a result of the difficulty associated with getting placement for student due to the closure of many industries in the northern part of the country, students are now directly involved in finding places by themselves.

The industries range from small scale to medium scale within and outside Kano that posse the adequate facilities for such training. This is due to the limited placement opportunities around. Other options for placements are the public organizations which are most of the time doing little or no activities that pertains the core engineering works.

The basic exposure the students require during the training are but not limited to the following;

- Creation of useful contacts with the captains of industries in order to have a general feel of the industries.
- Hands –on practical training, project-based/reports, special assignments and activities by employer.
- Leadership, communication and general business entrepreneurial skills

The faculty in collaboration with university SIWES unit has developed a set of assessment tools that involves the lecturers, technologist and the host company for evaluation on students' performance during the programme. It is the responsibility of the employer to give an overall summary of the student's performance while the lecturer/technologist visits the industry for students supervision and gives an assessment of the students final technical report on his/her activities during the programme.

3.3 Data collection and Analysis

Questionners were served to some four hundred level students that have participated in the scheme with the aim of getting vital information for the research. Basically, the questioner centrally enquires from the students information about their personal experiences and challenges faced when exposed to the real working environment of industries were optimal production output is the target of all concern. Approximately a total of 200 questioners were distributed across all the programmes of all the departments. A total of about 150 questioners were returned fully completed.

Based on the information provided by students, a statistical package for social science (SPSS) software was employed for the analysis. The software is good for the analysis of survey data which allows researchers to do their own statistical analysis and data documentation as well as management. The response of the students was analyzed and recommendations were deduced based on the results.

4.0 RESULTS AND DISCUSSIONS

The analysis of the students responses based the questionners served is as shown in Table 1.0. The questionnner requires a yes or no answer was and an elaboration is required if a yes answer is given. Response of the students shows that out of 150 students only 22 (14.7%) indicated that they were not happy with the SIWES due to the fact that the routine is the same throughout the period and apart from that the work is not core to their course of study. The other 128 students were happy and their responses were “yes”. The following were the main reasons for them accepting that there was value to the learning process.

- The theory was applied to practice by 104 students
- The communication skills was enhanced for 4 students
- The confidence was boosted for 19 students

It is interesting to note that most of the students were able to marry theory to practice and at the same time the course covered in school were very relevant to the industrial activities.

Table 1.0 Students response on personal experience

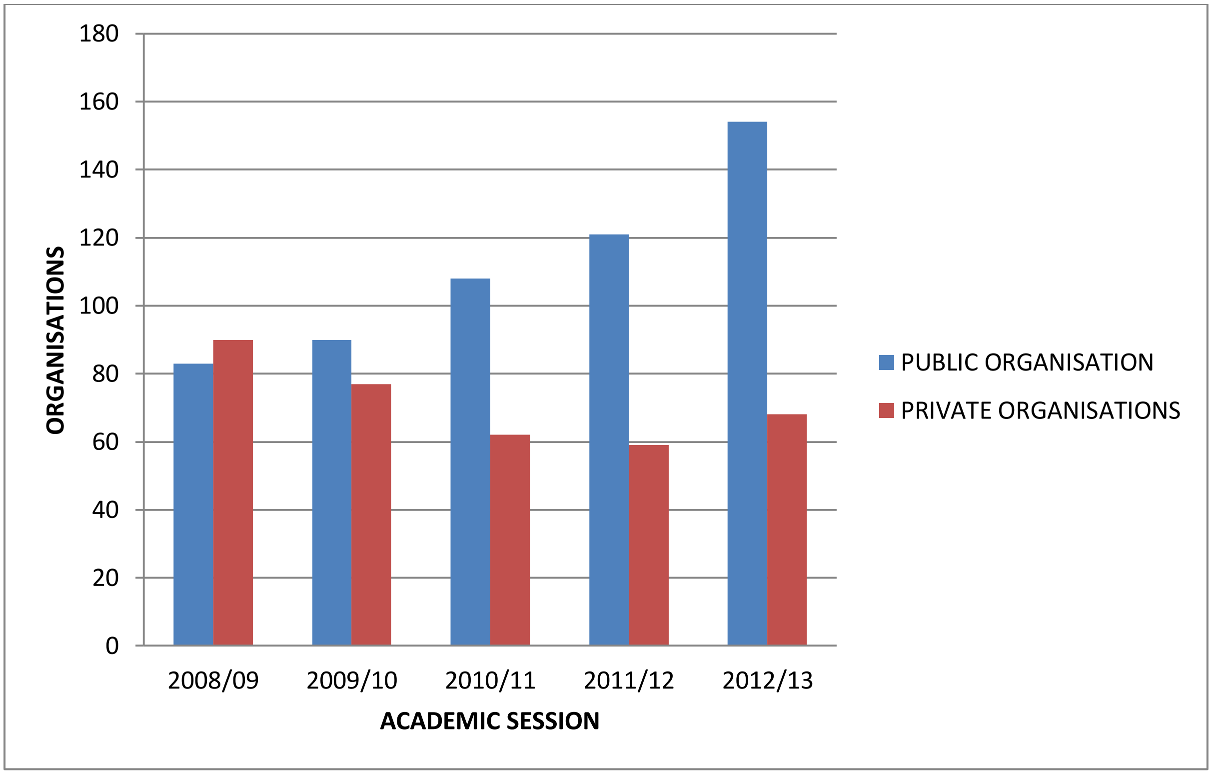
RESEARCH QUESTIONS	STUDENTS’ RESPONSES IN PERCENTAGE (%)	
	YES	NO
Did SIWES added value to your learning process	85.30	14.7
Did you put your theory into practice	81.25	18.75
Has your confidence boosted up after the SIWES	19	81
Did your communication skill improved	4	96

On other aspect of the questionner students were asked about challenges faced during the SIWES and their response is reported as shown in Table 2.0. More that 74% (112) students have experienced difficulty with getting a quality place while some were forced go to public organization where the core engineering activities are not much and the number students participating in the programme are much more when compared to private organization.

Table 2.0 Challenges faced

Placement	74.67% (yes)
Redundancy	24.00%
Others	12%

The effect of lack of places for placement in private organizations is as shown in Fig. 1.0 where for the span of five years the public organization placements keeps increasing while private organizations keeps decreasing every year. Redundancy was also experienced by about 36 students and of them were those that did their programme with public organizations. The others that are about 17 in number are students that have problems with either accommodation or lack of money for transportation and delay of payment of allowance by ITF.



Source; BUK SIWES Unit [15]

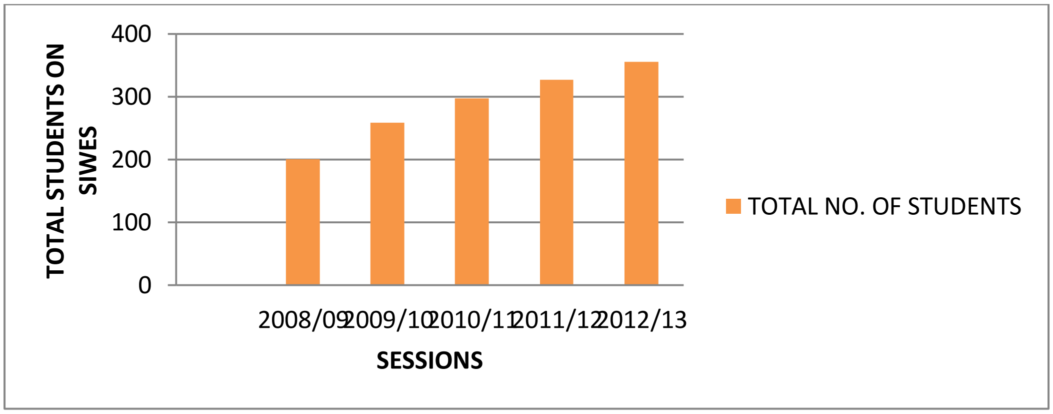
Fig. 1.0 Students placement in private and public organizations

Another very important question raised in the questionnaire is that of recommendations to the University for the Improvement of the scheme as indicated in Table 3.0. About 144 students suggested that the university through the SIWES unit should liaise with industries and seek places for students. Out of the 144 students, 64 of them are of the opinion that many of the industries have space for takingmore students but are always restricting the number to very few students. Other factor also consider is the frequent visit by the institutions as better means of evaluating student involvement in the programme and can also serve as a way bridging the gap between academia and industries.

Table 3.0 Suggestions to the university

University to seek placements for students	96%
Frequent visit by university lecturer/technologist	67%
University to design specifications handbook	75%

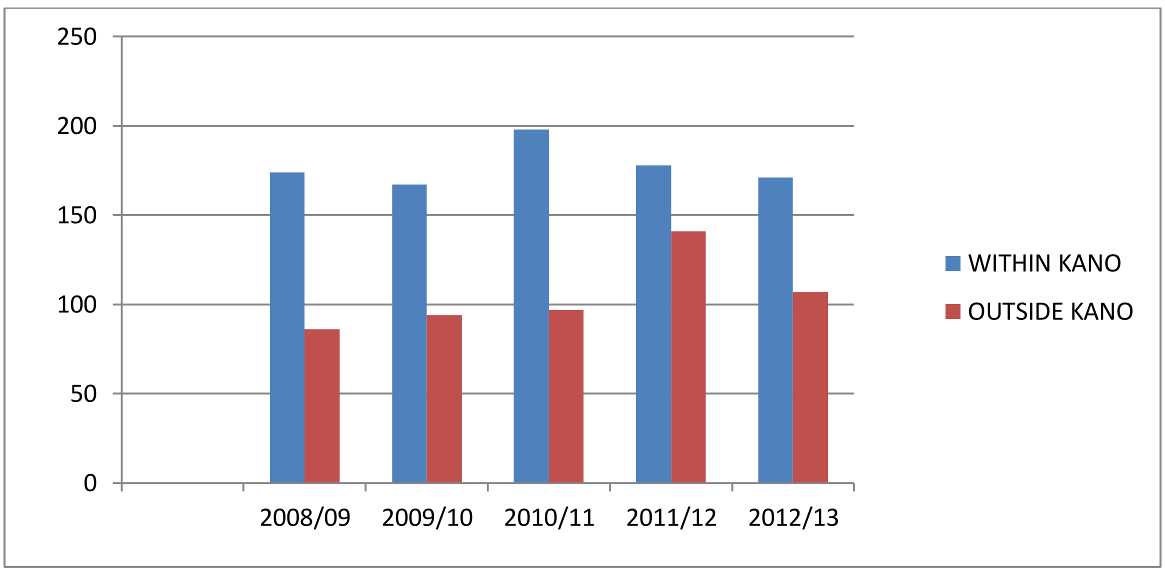
The based on the analysis conducted on placement data obtained from the SIWES Unit for the period of last five years, it shows that an increase of 80% is attained over the period as indicated in fig. 2.0. Going by the trend the growth of students participating in the scheme is expected to increase with the addition of more departments, Federal Universities and Private Universities as well as other higher institutions.



Source; BUK SIWES Unit [15]

Fig. 2.0 Growth of Students on SIWES for the last five years in faculty of Engineering.

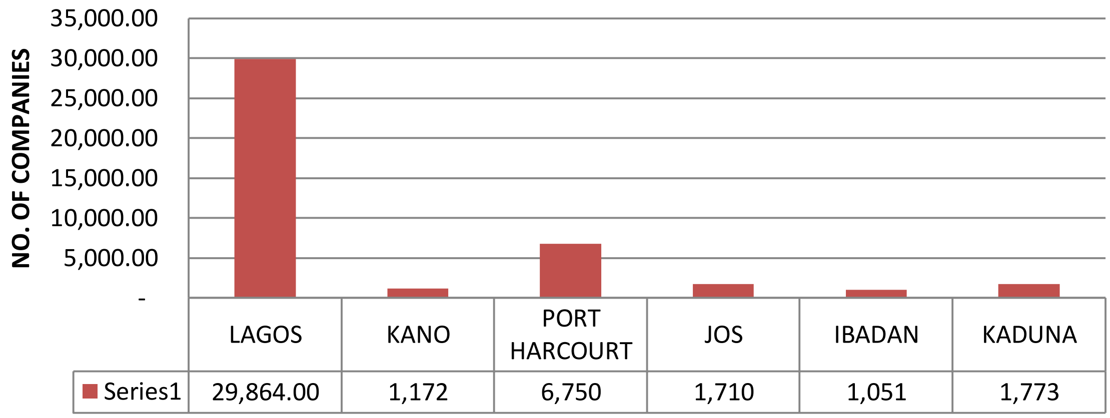
Further analysis of the placement data is also shown in fig.3.0 which shows the distribution of students placement within and outside Kano environment. It can be observed that the number of students that did their programme within kano are always more than those that did outside kano durng the same period of five years. The pattern is also in close agreement with answers provided by the students in the questionners and response of lecturers interviewed.



Source; BUK SIWES Unit [15]

Fig. 3.0 Student placement within and outside kano for the last five years

The lack of industies in the northern part of the country is clearly shown in fig. 4.0 based on the analysis carried out for the distribution of industries in major cities of Nigeria. From the analysis it can be observed that more than 80% of the companies are now located in lagos and Port harcourt.



Source; https://companylist.org/ [6]

Fig. 4.0 Number of companies for some industrial cities of Nigeria

It can also be observed that Kano is having the list number of indusries apart of Ibadan. Further more, based on analysis of current data obtained from ITF Kano office, up to 75% of the industries have closed down which is about 400 companies currently in operation in Kano.

5.0 CONCLUSIONS

This paper attempted to establish whether the SIWES programme for students of faculty of engineering Bayero University Kano is effective considering the rampant closure of many factories in Kano state which has caused serious problem of quality places for students' placements. SIWES is definitely important for the enhancement of the technical skills of our students and the attainment of its goal will only be achieved in relevant industries that have the adequate equipment and manpower. However, its success is hindered by the lack of quality industries in this part of the country where 75% of the industries have closed down. This is very alarming and requires the full attention of all concern. The university and the few industries that are still surviving need to come together and find means of getting the desired exposure for students in their training as future engineering professionals.

6.0 Recommendations

The recommendations that can be put forward from the study on the effectiveness of SIWES in achieving the desired objective of producing competent engineers that can directly fit into our industries are summarized as follows.

- **Through supervision of students during the period of the programme by all stakeholders is necessary for quality assurance.**

- **Employers' cooperation in providing places for students and at the same time providing meaningful training will encourage the students.**

- **The SIWES unit should prepare an orientation program before students are allowed to start the program so that the student can comprehend that the programme is designed to enhance their skills and employability after graduation.**

- **Due to lack of quality places for students' placements, use of two or more small scale industries is recommended during the period of the attachment.**

- **The faculty should developed a SIWES portal in order to enhance the manual task of carrying out SIWES activities and supervision/assessment by lecturers and industry based supervisors.**

REFERENCES

[1] Alabi, S.A. (2005). A comparison of SIWES and Cooperative Education.10th Biennial SIWES National Confernece held at the Confluence Beach Hotel, Lokoja, 5th - 6th July, 2006.

[2] ITF (1973).The Students Industrial Work Experience Scheme (SIWES).

[3] (2006) MAN economic review 2003-2006. Manufacturing Association of Nigeria

[4] www.buk.edu.ng/bulletin_list. Vol xxxii Bulletin Friday 20th December, 2013 NO. 49

[5] Imhonlele, A. (2009). Nigeria's Manufacturing Sector and the Activities of Political Entrepreneurs. Business day, Friday 04 September. [Online] Available: www.businessday.com

[6] https://companylist.org/ accessed 20th November, 2014.

[7] ITF (2002).*Proceedings and Resolutions* of the 8 Biennial SIWES National Conference, held at the Hill Station Hotel, Jos, 5-6th June, 2002.

[8] ITF (2003). *Students Industrial Work Experience Scheme in human resource Development in Nigeria. Jos:* Industrial Training Fund (ITF).

[9] ITF (2004).*Proceedings and Resolutions* of the 9 biennial SIWES National Conference, held at the Hill Station Hotel, Jos, 13-14th July, 2004.

[10] ITF(2004). *Students Industrial Work Experience Scheme*: *Information and guideline for Student Industrial Work Experience Scheme (*Reviewed). Jos: Ruche Press.

[11] ITF (2004). *Minutes and Resolutions* of the 5 Chief Executives' Forum of SIWES Supervising Agencies held on 2nd December, 2004 in the Office of the Executive Secretary, National Commission for Colleges of Education, Abuja

[12] ITF (2006).*Proceedings and Resolutions o*f the 10 Biennial SIWES National Conference, held at the Confluence Beach Hotel, Lokoja, 5-6th July, 2006.

[13] ITF (2008).*Minutes* of the inaugural meeting of the Sub-Committee of the Chief Executives' Forum on SIWES Funding held on 15th April, 2008 at the National Virtual Library NUC, Abuja.

[14] COREN (2013) Accreditation Documents for Electrical Engineering Bayero University, Kano

[15] Bayero University, Kano SIWES placement lists for 2008-2013

DETERMINATION OF DISTRIBUTION GENERATION PLACEMENT IN A DISTRIBUTION NETWORK CONSIDERING STABILITY INDEX

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ABSTRACT

This paper present an approach to determining the most sensitive bus for distributed generation placement in a typical radial distribution network. The approach determined the most sensitive node using a stability index known as apparent power loss. In addition the effect of distributed generation placement on the system security is investigated. Simulation was carried out using a Matlab Script and was tested on a 33-Bus IEEE distribution network. Based on the result obtained distributed generation placement on a network reduces the tendency voltage instability, due to an improvement in active transfer loss of 8.1%, 14.26% and 18.15% when a DG was placed at locations 18, 33 and 32 as compared to the active transfer loss of 0.6667p.u prior to DG placement. While a minimum voltages of 0.9212, 0.9342 and 0.9421p.u was recorded, with DG placed at bus 18, 32 and 33 respectively as compared to minimal voltage of 0.9125p.u prior to DG placement

Keywords: System Security, Stability Index, Distributed Generation (DG), Active Power transfer

INTRODUCTION

With increasing growth in customer demand and consistent exploitation of the existing distribution network, the tendency of occurrence of voltage collapse or voltage instability has become more pronounced. Also, the high possibility of voltage instability in distribution network, has facilitated the need to control both active and reactive power, so as to mitigate the consequences arising from voltage collapse. Thus the need to identify the most sensitive node susceptible to the problem of voltage instability has become critical (Cutsem and Vournas, 1998). As a way of mitigating the problem of voltage instability, distributed generation is used to offer voltage support. However for the solution to be effective, there is need for identifying the most sensitive node susceptible to the problem of voltage instability.

The problem of voltage instability is characterized in such a way that the voltage magnitude of the system decreases gradually until the system reaches near the collapsing point. At this point the system reaches some maximum admissible load beyond which a power flow solution no longer exists (Eminoglu and Hacaoglu, 2007). For efficient operation and management of distribution networks, there is need to adequately prevent the occurrence of voltage collapse. Increasing connection of distributed energy source in the distribution network, the need to ascertain the effect of such distributed energy source in minimizing the problem of voltage collapse.

Earlier work on determining the voltage stability index as contained in (Venikov *et al.*, 1995), was based on performing load flow analysis. The major problem with this approach, is that it relied heavily on the need for convergence of the load flow solution, without necessarily acknowledging that divergence might not signify instability. In work of (Chebbo and Irwing, 1992), a bus stability indicator is presented by computing the ratio of thevenin equivalent impedance to the load impedance at a given bus. The work failed to acknowledge that computing the bus impedance matrix for a distribution network may not be obtained due to singularity of the admittance matrix. This approach in determining voltage stability is not suited for a distribution network. The work of (Gubbina and Strmcnik, 1997) formulated the problem of voltage stability using Jacobian matrix of the reduced system. The work of (Eminoglu and Hacaoglu 2007), formulated the use of transferred active and reactive power of the distribution line in a reduced form. Although, the work considered the effect of different static loads, but this added to the computational complexity of their approach. (Ettehedi and Vaez-Zadeh, 2012), presented the use of distributed generation placement to solve the problem of instability. The work of (Subramanyam, 2009), adopted the use of distributed generation penetration level to solve the problem of voltage stability index. This approach ranked the respective buses based on the computed voltage index to identify appropriate location for siting distributed generation. The problem with (Subramanyam, 2009), was its failure to identify heavily loaded bus. The main focus of this paper is to identify the most susceptible bus to voltage instability for distributed generation placement for mitigating the problem of voltage collapse using an index known as apparent power loss.

The rest of this paper is organized as follows: the next section explain the problem of voltage instability. Section III, present the fundamental derivation of apparent power. Section IV, gives a detail of the developed algorithm. Section V detail the analysis and result obtained from the test system.

II. Problem of Voltage Instability of a Distribution Network

The problem of voltage collapse occurs in a heavily loaded system that lacks sufficient reactive power sources and cannot provide adequate voltage profile to maintain the system. The shortage of reactive power often leads to wide area black out and voltage instability in the network (Ettehedi and Vaez-Zadeh, 2012). With increasing awareness and the use of distributed generation such as solar photovoltaic cell, other renewable energy source in distribution network, the problem of voltage instability can be reduced and enhance improve the performance of the network (system security).

III. Mathematical Model of the Stability Index

Consider a single-line model of a 2-bus distribution system as in Figure 1.

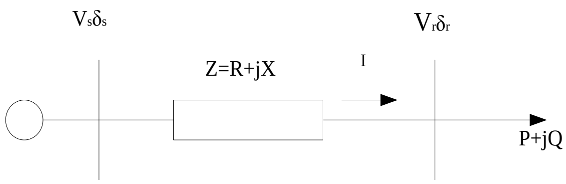

Figure 1. Shows a Single Line of a Two Bus network Distribution System

By applying Kirchhoff's voltage law

$$|V_r| \angle\delta_r = |V_s| \angle\delta_s - |I| Z \quad (1)$$

$$|V_r|(\cos\delta_r + j\sin\delta_r) = |V_s|(\cos\delta_s + j\sin\delta_s) - |I|(\cos\theta + j\sin\theta)(R + jX) \quad (2)$$

$$|V_r|\cos\delta_r + j|V_r|\sin\delta_r = |V_s|\cos\delta_s - |I|(R\cos\theta + X\sin\theta) + j[|V_s|\sin\delta_s - |I|(X\cos\theta - R\sin\theta)] \quad (3)$$

$$|V_r|\cos\delta_r = |V_s|\cos\delta_s - |I|(R\cos\theta + X\sin\theta) \quad (4)$$

$$|V_r|\sin\delta_r = |V_s|\cos\delta_s - |I|(R\cos\theta + X\sin\theta) \quad (5)$$

Taking the square of equations (4) and (5), to obtain the magnitude of V_r

$$|V_r|^2\cos^2\delta_r = |V_s|^2\cos^2\delta_s - 2|I||V_s|\cos\delta_s(R\cos\theta + X\sin\theta) + |I|^2(R\cos\theta + X\sin\theta)^2 \quad (6)$$

$$|V_r|^2\sin^2\delta_r = |V_s|^2\sin^2\delta_s - 2|I||V_s|\sin\delta_s(R\cos\theta - X\sin\theta) + |I|^2(R\cos\theta - X\sin\theta)^2 \quad (7)$$

Adding equations (6) and (7)

$$|V_r|^2 = |V_s|^2 - 2|I||V_s|\cos\delta_s(R\cos\theta + X\sin\theta) - 2|I||V_s|\sin\delta_s(X\cos\theta - R\sin\theta) + |I|^2(R^2 + X^2) \quad (8)$$

$$|V_r|^2 = |V_s|^2 - 2|V_s||I|R(\cos\delta_s\cos\theta - \sin\delta_s\sin\theta) + X(\cos\delta_s\cos\theta + \sin\delta_s\sin\theta) + |I|^2(R^2 + X^2) \quad (9)$$

$$|V_r|^2 = |V_s|^2 - 2|V_s||I|[R\cos(\delta_s + \theta) + X\sin(\delta_s + \theta) + |I|^2 Z^2 \quad (10)$$

$$|V_r|^2 = |V_s|^2 - 2|V_s||I||Z|[\cos\phi\cos(\delta_s + \theta) + \sin\phi\sin(\delta_s + \theta)] + |I|^2 Z^2 \quad (11)$$

$$|V_r|^2 = |V_s|^2 - 2|V_s||I||Z|\cos(\phi - \delta_s - \theta) + |I|^2|Z|^2 \quad (12)$$

Substituting the trigonometric function

$$\cos(\phi - \delta_s - \theta) \approx 1 \quad (13)$$

Upon substituting |I| and simplifying the expression

$$|V_r|^4 + 2|V_r|^2 (PR + QX) - |V_s^2||V_r^2| + (P^2 + Q^2)|Z|^2 = 0 \quad (14)$$

The line receiving end active and reactive power, can be obtained from Equation (13)

$$P = |Z|^{-1}[-V_r^2\cos\theta. \pm\sqrt{\cos^2\theta.V_r^4 - V_r^4 - |Z|^2 Q - 2V_r^2QX + V_r^2V_s^2}] \quad (15)$$

$$Q = |Z|^{-1}[-V_r^2\sin\theta. \pm\sqrt{\sin^2\theta.V_r^4 - V_r^4 - |Z|^2 Q - 2V_r^2QX + V_r^2V_s^2}] \quad (16)$$

From equations (14) and (15), for the value of active and reactive power to be real

$$\cos^2(\theta).V_r^4 - V_r^4 - |Z|^2 Q - 2V_r^2QX + |V_r^2||V_s^2| \geq 0 \quad (17)$$

$$\sin^2(\theta).V_r^4 - V_r^4 - |Z|^2 Q - 2V_r^2QX + |V_r^2||V_s^2| \geq 0 \quad (18)$$

Adding equations (17) and (18) to obtain transfer active and reactive power

$$2|V_r^2||V_s^2| - |V_r^4| - 2|V_r^2|(PR + QX) - |Z|^2 (P^2 + Q^2) \geq 0 \quad (19)$$

The bus stability index can be computed using equation (19)

$$SI = 2|V_r^2||V_s^2| - |V_r^4| - 2|V_r^2|(PR + QX) - |Z|^2 (P^2 + Q^2) \quad (20)$$

IV. Distributed Generation placement Algorithm

The problem of distributed energy placement can be formulated as an optimization function with aim of minimizing loss, improving voltage profile, reliability etc. In this section, the problem is solved using successive power flow and stability index based on apparent power to identify the bus susceptible to voltage collapse (Ettehedi and Vaez-Zadeh, 2012). The most vulnerable node is regarded as a suitable position for distributed generation placement due to its high tendency of voltage instability. The developed algorithm for distributed generation placement is shown in Figure (2).

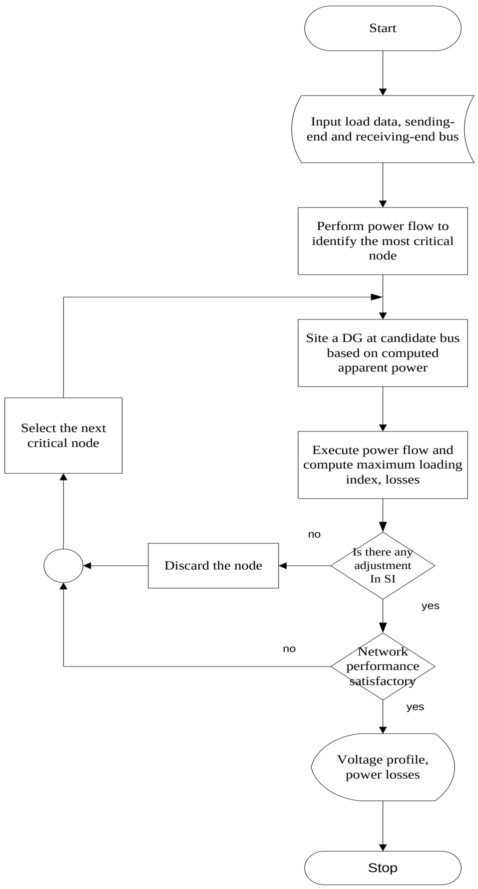

Figure 2. Algorithm for Distribution Placement Using Apparent Power Loss

V. Analysis and Result

The developed algorithm for distributed generation placement and the corresponding stability index is implemented using the IEEE 33-bus test system shown in Figure (3), with data as contained in (Srinivisa and Narasimham, 2009). Based on the result of simulation obtained as shown in Figure (4), the most critical node was identify to be buses 16, 17, 18, 32 and 33 with bus 18 being the bus with the lowest value of the stability index. With a distributed generation of 200kW, installed at the bus 18, an improvement in the active transfer loss (stability index) was recorded. With 200kW DG installed at node 33, an improvement in the stability index and voltage profile was also recorded and so on. Table 1 shows the summary of the result obtained for the standard 33-Bus IEEE Distribution network.

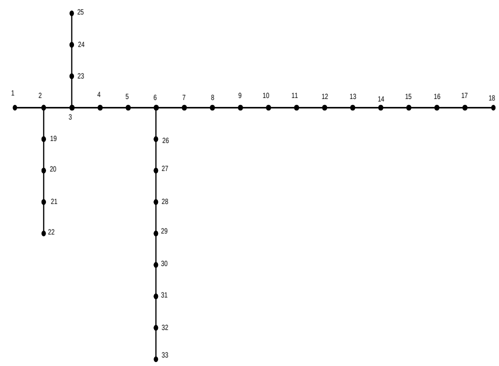

Figure 3. Single-Line Diagram of a 33-Bus IEEE Distribution Network

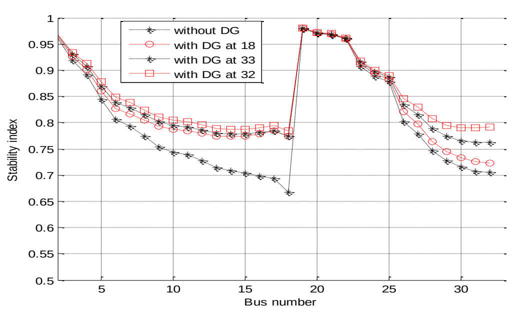

Figure 4. Shows the Variation of the Stability Index as a Function of Bus Number

Table 1. Summary of the Results Obtained

Case	Without DG	With DG at 18	With DG at 33	With DG at 32
Active power (kW)	202.2	166.95	136.04	118.23
Reactive power (kVAR)	135.02	110.25	89.64	77.36

Minimal Voltage (p.u)	0.9125	0.9212	0.9342	0.9421
Active Transfer Lossr (p.u)	0.6667	0.7207	0.7618	0.7877
% Active Transfer Loss		8.1	14.26	18.15

CONCLUSION

In this paper, a voltage stability index, was developed to determine the most critical node for distributed generation placement, within a distribution network. A continuous power flow was used to determine the best location for DG placement, so as to mitigate the consequence of voltage collapse or voltage instability. The placement algorithm was tested using an IEEE 33bus test feeder. The results reveals with distributed generation placed at node 32, a better performance was achieved with a minimal voltage of 0.9421p.u and active power transfer of 0.7877p.u. The improvement in voltage profile was as result of reduction in active and reactive power loss.

REFERENCES

CUTSEM T. V AND VOURNAS. C, 1998. *Voltage stability of Electric Power System, Power Electronics and Power system series Kluwer.*

EMINOGLU. U & HOCAOGLU. M. H 2007, *A Voltage Stability Index for Radial Distribution Network*, Gebze Institute of Technology, 408-413, 2007.

VENIKOV V. A., STROEV V. A., IDELCHICK V. I & TARASOV V. I, *Estimation of Electrical power system steady state stability in load flow calculation*, IEEE transaction, power Apparatus System PAS94,1034-1041. 1995.

CHEBBO. A. M., IRWING M. R., & STERLING M. J. H, *Voltage Collapse Proximity Indicator and Implications*, IEEE proceeding Vol 139(3), 241-252, 1992.

GUBBINA F & STRMCNIK B., *A Simple Approach to Voltage Stability Assessment in Radial Networks*. IEEE transaction on power system stability Vol 12(3), 1121-1128. 1997.

ETTEHADI. M & VAEZ- ZADEH. S, *DG placement in Distribution Networks Considering Voltage Stability*, IEEE transaction Vol 8(2),1-6, 2012.

SUBRAHMANYAM. J. B. V, *Distributed generator placement and sizing in Unbalanced Radial distribution system*, Journal of Theoretical and Applied Information Technology, Vol 13(2), 746-753. 2009.

SRINIVASA. R & NARASIMHAM . S. V. L 2009. *A New heuristic Approach for optimal reconfiguration in distribution system,* international journal of engineering and applied science. Vol 5(1), 18. 2009.

REVIEW ON POWER HARVESTING TECHNIQUES AND APPLICATIONS

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ABSTRACT

Technological advancement has led to the decrease in size and power requirements for sensors and complex digital systems. The power supply commonly employed in many of such systems use batteries. However, conventional batteries have short lifespan after which they must be physically replaced by human intervention; otherwise the system cannot function efficiently. To overcome this problem a more efficient technique that provides almost unlimited power supply for such electronic devices is to extract energy (harvest) from the environment to charge batteries increasing its life span or supply power directly to the system. Power harvesting have application where battery replacement is difficult or impractical. The paper present short history of power harvesting, followed by potential energy harvesting sources, power harvesting, conversion, power management and battery charging techniques.

Keywords: Autonomous micro-systems; Energy scavenging ;Power harvesting; Power management;

INTRODUCTION

Reduction in size and increase in functionality is the present trend in electronic equipments technology. The size of such devices is becoming so small that instead of portable devices they are becoming wearable devices that can be integrated in everyday use objects like watches (Billinghurst and Starner, 1999). It also has opened up many new opportunities for low power wireless sensor networks. Such networks have significant potential in a variety of environmental, structural, medical, and military applications (Chris *et.al.*,2008), (Nicholas and Glenn, 2005).

All those units, based on today's microelectronic technology, need an external power supply, these poses a number of new challenges. The power supply commonly employed in many systems uses batteries (Marzencki, 2005), hence for remote systems and in sensor networks, replacement of batteries becomes difficult, time consuming and wasteful. Additionally, a battery that is large enough to last the longer at sensor node would dominate the overall size of the node, and thus would not be very attractive or practical. Also, the battery chemistries often involve toxic heavy metals, and present disposal issues, regardless of rechargeable technology (Chris *et.al.*,2008).

Therefore, there is need to explore alternatives ways to power such systems, as existing battery technology brought some inefficiency and difficulties in such systems. Harvesting energy from their local environment, to minimize the maintenance and the cost of operation (Faruk 2009). Power scavenging may enable wireless and portable electronic devices to be completely self-sustaining.

Energy harvesting can be obtained from different energy sources, such as mechanical vibrations, electromagnetic sources, acoustic, airflow, heat, and temperature variations. Energy harvesting, in general, is the conversion of ambient energy into usable electrical energy. When compared with energy stored in common storage elements, such as batteries, capacitors, and the like, the environment represents a relatively infinite source of available energy (Billinghurst and Starner, 1999).The obtained energy can then be used to recharge a secondary battery or, in some cases, to power directly the electronic system.

The paper is aimed to tackle issues as follows: First, part 2 Brief history of power harvesting, part 3 energy harvesting devices classification according to source and type of energy. Part 3 review the principles behind different types of energy conversion. Part 4 discussed the power conditioning needed by electronic devices relying on energy harvesting, Finally, part 5, the conclusions of the work are presented.

A. Brief history of harvesting power

The first observation of harvesting energy in form of current from natural source was in 1826. Thomas Johann Seebeck found that a current would flow in a closed circuit made of two dissimilar metals when they are maintained at different temperatures (Justin, 2007). Edmund Becquerel In 1839, was experimenting with an electrolytic cell composed of two metal electrodes, discovered the photovoltaic effect (Mah,1998). The first large area solar cell was constructed in 1894 by Charles Fritts who coated a layer of selenium with a thin layer of gold (Damaschke,1997).

While the photovoltaic effect was first observed by Edmund Becquerel, it became fully comprehensible only after developing the quantum theory of light and solid state physics in the early 1900s (Myers 2009). Joseph Henry and Michael Faraday independently discovered the principle of producing electricity from magnetism, known as electromagnetic induction, in 1831. In October of the same year, Faraday invented the first direct-current generator consisting of a copper plate rotating between magnetic poles (Harb,2010). The first observation of harvesting energy in form of charge was in 1880. Pierre and Jacques Curie successfully predicted and proved experimentally that certain crystals would exhibit a surface charge when subject to mechanical stress, a phenomenon known as piezoelectricity (Justin, 2007).

B. Power harvesting sources and classification

Power harvesting is a process whereby electrical energy can be generated from the surroundings using some method of what as called in the literature Direct Energy Conversion techniques (Angrist, 1982). A device that executes this procedure is called energy harvesting device. Such devices do not consume any fuel or substance, hence is maintenance free. In a broader perspective, the ambient energy sources suitable for harvesting can be grouped as summarized below according to their characteristics (James and Farooq, 2008):

- Natural Energy: Wind, water flow, ocean waves, and solar energy can provide limitless energy availability from the environment
- Mechanical Energy: motion, Vibrations from machines, mechanical stress, strain from high-pressure motors, object movement, etc. the electromechanical transducer can be electromagnetic, electrostatic, or piezoelectric (Harb,2010).
- Thermal Energy: Waste heat energy variations from furnaces, heaters, and friction sources
- Electromagnetic Energy: Solar and light source can be divided into two categories of energy: indoor room light and outdoor sunlight energy. Light energy can be captured via photo sensors, photo diodes, and solar photovoltaic (PV) panels, Electromagnetic radio frequency (RF): Base stations, wireless internet, satellite communication, radio, TV, digital multimedia broadcasting, etc.
- Pressure gradients: Micro water flow (e.g. faucet).
- Acoustic

Another classification scheme may consider who or what provides the energy for conversion: the first kind is called the human energy source. The energy is provided by the activity of human beings or animals. The second kind is the energy harvesting source that gets its energy from the environment (Starner and Paradiso, 2004).

C. Power harvesting system components

There are three components or stages in any power harvesting device; Energy conversion, Harvesting and Conditioning Circuit and Energy Storage as shown in Figure (1).

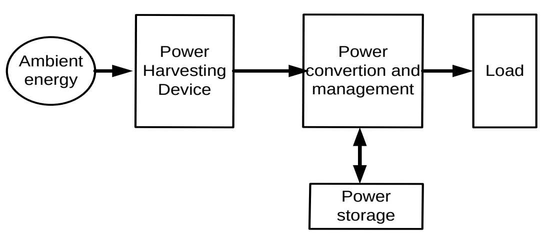


Figure 1 : A generic power harvesting unit components

a. Principles and application of power harvesting review

In this section we discuss the most common harvesting principles and their applications.

i. Mechanical vibration

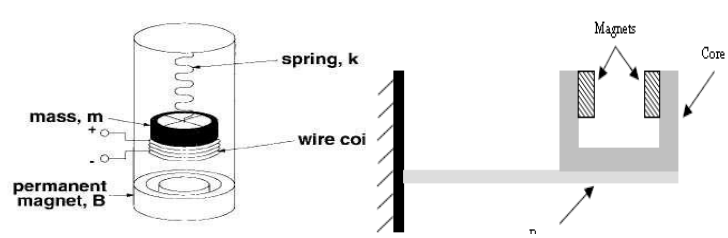
Mechanical vibration or kinetic energy harvesting as referred to by (Beeby *et al* 2006), is a Vibration-based power generators that convert mechanical energy of vibrating or any motion based surface into electrical energy, it is motion driven. The Ambient vibrations are present in many environments, such as automotive, buildings, structures (bridges, railways), industrial machines, household appliances, etc. The energy present in the vibrations can be extracted using a suitable mechanical-to-electrical energy nverter or generator.

The generator requires mechanical system that couples environmental displacements to the transduction mechanism. The design of the mechanical system should maximize the coupling between the kinetic energy source and the transduction mechanism which depend entirely upon the characteristics of the environmental motion. Generators in this category, proposed to-date used electromagnetic, electrostatic or piezoelectric principles (Amirtharajah and Chandrakasan1998, Cian´O *et al* 2008).

- **Electromagnetic harvesting**

Electromagnetic energy harvesting can be achieved by the principle of electromagnetic induction, employing Faradays law of electromagnetic induction. One of the most effective ways of producing electromagnetic induction for energy harvesting is with the help of permanent magnets and a coil or a resonating cantilever beam (Damaschke 1997). It can be built from discrete components, which has a fixed magnet and a moving coil. As shown in Figure (2). Vibration-based electromechanical power generator described by (Amirtharajah and Chandrakasan1998) consists of a cantilever beam and a pair of magnets as shown.

Since the late 1990s, various researchers (Amirtharajah and Chandrakasan1997, Amirtharajah 1999, Kulah and Najafi 2004, Umeda *et al* 1996) have identified the techniques employed to generate power from electromagnetic resources. Some of which does not take the form of a cantilever. The designs utilize a spring-mass-damper arranged so that the magnet and coil move with respect to each other under the influence of an external vibration (Scherrer *et al* 2005) as shown in Figure (3) where m is the mass, and k is the spring constant (or stiffness constant). A seismic mass is suspended within the outer case and the entire device moves relative to the inertial frame with the position of the case at time t described by u (t). The position of the seismic mass relative to its equilibrium position in this case is x (t). The damper represents losses within the system and energy extracted. If assumed that the damping force is proportional to velocity $\dot{x}(t)$ with viscous damping coefficient c, then the equations of motion may be written as below (Faruk 2009):



a b

Figure 2: Electromagnetic generator design a) using coil and permanent magnet b) Cantilever (Amirtharajah and Chandrakasan1997, Amirtharajah 1999).

$$m\ddot{x}(t) + c\dot{x}(t) + kx(t) = -m\ddot{u}(t) \qquad (1)$$

For these types of devices, maximum power is achieved when at resonance, i.e., the input vibration frequency matches the mechanical resonant frequency. Generally this type of configuration relies on relatively small displacements between a PM and coil to harness power from environmental vibrations.

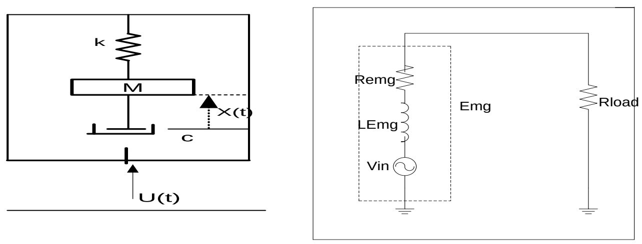
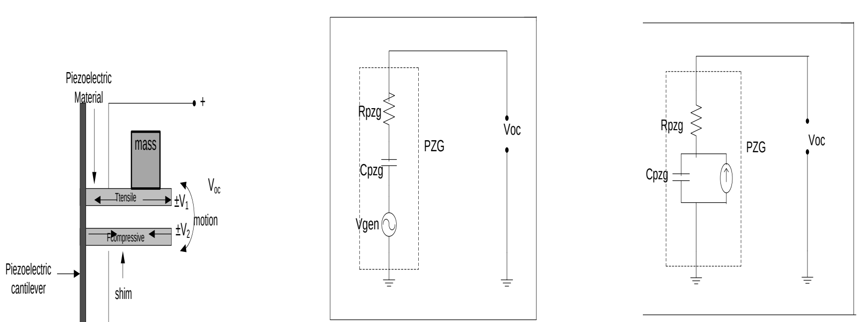


Figure 3: Electromagnetic harvesting a) mass–spring-damper configuration, b) model

The electromagnetic generators design have the advantage of being enclosed and can be protected from the outside environment. Electromagnetic induction provides the advantage of improved reliability and reduced mechanical damping as there would not be any mechanical contact between any parts; also, no separate voltage source is required (Roundy 2003). However, electromagnetic materials are bulky in size and are complicated to integrate with Micro Electro Mechanical Systems (MEMs) (Wang and Yuan 2007).

- **Piezoelectric conversion**

Piezoelectric conversion use materials called piezoelectric materials, which convert mechanical energy from vibration, pressure or force into electricity. Conversely, when electric field is applied, the material undergoes strain. This property of piezoelectric materials is considered by the researchers to develop various piezoelectric harvesters in order to power different applications. The piezoelectric generator is a non-linear device, as such functions differently in various situations. A number of equivalent circuits to model piezoelectric generation have been proposed and used (Tan 2008). The piezoelectric bimorph cantilever beam generator shown in figure 2.2(a) can be modeled in either the Thevenin equivalent circuit model or Norton equivalent circuit model as illustrated in Figure 2.2(b)



b c

a

Figure 4: a) Piezoelectric bimorph cantilever beam generator, (b) Thevenin, (c) Norton equivalent model of piezoelectric generator.

The open circuit voltage equation is derived in (Roundy *et al* 2003)as:

$$V_{oc} = \frac{dt}{\varepsilon}\sigma \qquad (2)$$

where; ε is the dielectric displacement of the piezoelectric material, σ is the mechanical strain, d is the piezoelectric strain coefficient and t is the thickness of the piezoelectric material.

This principle have been used to sense wind speed in remote areas (Wang and Yuan 2007), to generate power for sensor in pipeline system (Mah 1998), and for wireless radio frequency transmitter (Tan 2008). A cantilever based structure with piezoelectric material attached to the top and bottom surfaces is a good arrangement for harvesting energy from vibrations. This geometry was developed by (Roundy *et al* 2003, Roundy and Wright 2004), using composite piezoelectric cantilever beam as shown in figure 5.

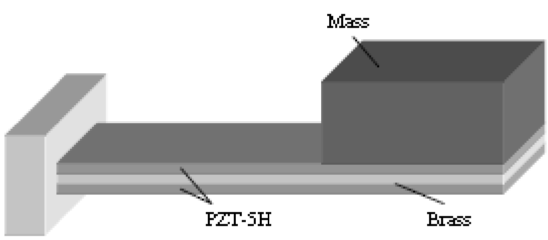


Figure 5: Schematic of cantilever piezoelectric generator developed (Roundy *et al* 2003)

- **Electrostatic energy harvesting**

This type of harvesting is based on the changing capacitance of vibration-dependent variable capacitor. Vibrations separate the plates of an initially charged variable capacitor, and mechanical energy is converted into electrical energy. Electrostatic generators are mechanical devices that produce electricity by using manual power (Cian´O *et al* 2008). The basic operation was explained by (Beeby *et al* 2006) where the harvested energy is provided with work done against the electrostatic force between the plates of the capacitor. Electrostatic generators are classified into three types: in-plane overlap, in-plane gap closing and out-of-plane gap closing (Chalasani and Conrad 2008). A lot of research work were carried out by (Beeby *et al* 2006), Chalasani and Conrad 2008, Sterken 2002), discuss electrostatic generators using charged electrets. The important advantage of using the electrostatic converters is their ability to integrate with microelectronics and they do not need any smart material. One of the disadvantages of using electrostatic converters is that they need an additional voltage source to initially charge the capacitor.

A simplified equivalent circuit for an electrostatic generator using charge-constrained conversion is shown in Figure (6). This circuit demonstrates the basic function of energy conversion in electrostatic energy harvesting (Tashiro *et al* 2002). A pre-charged reservoir, which could be a capacitor or rechargeable battery is represented as the input voltage source V_{in}. The variable capacitor C_S is the variable capacitance structure, and C_{par} is the parasitic capacitance associated with the variable capacitance structure and any interconnections. When C_S is at its maximum capacitance state (C_{max}), switch S_{w1} closes, and charge is transferred from the input to the variable capacitor. The capacitive structure then moves from its maximum capacitance position to the minimum capacitance position (C_{min}) with both switches open. The result is that the energy stored on C_S increases. At minimum capacitance, switch S_{w2} closes and the charge stored on C_S (now in a higher energy state) is transferred onto the storage capacitor C_{stor}. The mechanical vibrations have done work on the variable capacitor causing an increase in the total energy stored in the system.

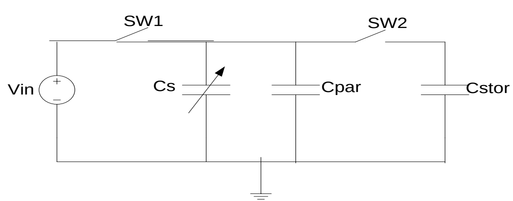


Figure 6 : Electrostatic energy harvesting equivalent circuit

The increase in energy stored in the variable capacitor per cycle is given by the following equations:

$$E = \frac{1}{2} V_{in}^2 \left[C_{\max} - C_{\min} \right] \left[\frac{C_{\max} + C_{par}}{C_{\min} + C_{par}} \right] \qquad (3)$$

$$E = \frac{1}{2} V_{\max} V_{in} \left[C_{\max} - C_{\min} \right] \qquad (4)$$

Piezoelectric materials have been stated to be the best transduction mechanism for microgenerators by (Roundy *et al)*, because they can have the highest energy storage density of the three transduction mechanisms.

ii. Harvesting energy from temperature differences

Thermal energy harvesters are based on the Seebeck effect: when two junctions, made of two dissimilar conductors, are kept at a different temperature an open circuit voltage develops between them. Figure (7), shows the schematics of a thermocouple, the simplest voltage generator based on the Seebeck effect. Distinguish are two pillars, made of two different materials and a metallic interconnect. When a temperature difference ΔT is established between the bottom and the top of the pillars a voltage V develops between the points A and B. This voltage is given by

$$V_{Seebech} = (\alpha_1 - \alpha_2).(\Delta T_{hot} - \Delta T_{cold}) = \alpha_{Seebech} .\Delta T \qquad (5)$$

where α_1 and α_2 are material dependent quantities, known as Seebeck coefficients. Typically semiconductors are used as pillars, as their Seebeck coefficient is large. Furthermore the sign of the Seebeck coefficient is opposite for p-type and n-type semiconductors, so that the contribution of the two pillars to the voltage adds up if semiconductors of opposite doping are used.

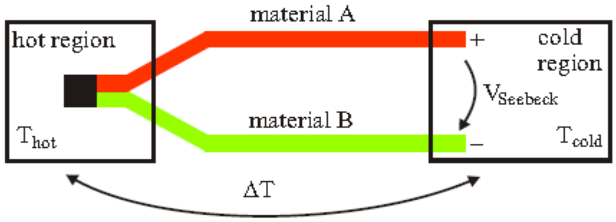


Figure 7 : Schematic layout of a Seebeck sensor consisting of two different materials A and B (Lawreence and Snyder 2002).

Here, the thermal energy is scavenged to obtain electrical energy to power the electronic devices. Thermoelectric devices are primarily used in space and terrestrial applications. A method to generate electrical energy using thermoelectric generators was described by (Lawreence and Snyder 2002). The temperature difference was obtained naturally between the air and soil is used. The design reported by, (Sodano *et al* 2007, Sodano *et al* 2004) used a seebeck heat pump that helps to convert the ambient temperature difference into electrical power. This temperature gradient is generated by waste heat and solar radiation.

iii. Harvesting electromagnetic radiation

Another source of energy present in the environment is electromagnetic radiation, either in the form of light (known as solar energy), or lower frequency Radio Frequency (RF) radiation. Both methods are extensively used in many present devices.

- **Solar energy**

Solar energy is a mature technology for large scale energy generation. Photovoltaic systems are found from the Megawatt to the milliwatt range producing electricity for a wide range of applications: from wristwatch to grid-connected PV systems. Here, a photocell is used to convert the light energy into electrical power. A photovoltaic cell is a device that converts light energy into electrical energy. The power available from solar cells varies widely depending on the illumination level (e.g. indoors or outdoors) and on the solar cell technology. The efficiencies of various solar cell technologies at different illumination levels have been reported in (Randall 2005).

The application of photovoltaic in portable products is a valid option under the appropriate circumstances (Chalasani and Conrad 2008). An array of 100 solar cells is used to produce power to supply Micro Eelectro Mechanical system (MEMs) electrostatic actuators implemention (Randall 2005, Lee *et al* 1995). The project successfully produce voltage of about 150V. Studies on delivering power to a remote system with an optical fiber are also deliberated in (Gross 1991, Chalasani and Conrad 2008). While designing sources which scavenge solar energy, factors such as availability of day light, periods of dense cloud and snow cover, effects of operation at higher latitudes, characteristics of the photovoltaic cell used, the intensity of the incident light and power supply requirements are to be considered (Myers 2009, Raghunathan *et al* 2005).

- **RF energy harvesting**

Ambient RF energy is also a possible source for energy harvesting. Ambient RF energy refers to RF energy available through public telecommunication services (e.g. GSM, WLAN frequencies). The power is generated elsewhere and delivered to the devices by some form of electromagnetic waves of RF radiation as shown in figure (8). There are two types of energy sources for RF radiation: controlled RF or ambient RF.The controlled RF sources technology received more attention, it is also called beamed RF sources. This way, an emitter sends microwaves across the atmosphere within a particular bandwidth and a maximum emission power, so the receiver can convert such microwaves into available power supply for the electronic circuits. This principle is well-known as RFID systems based on passive tags (Alvarado *et al* 2012). An energy harvesting system performance using multiple RF sources was demonstrated in (Harb,2010).

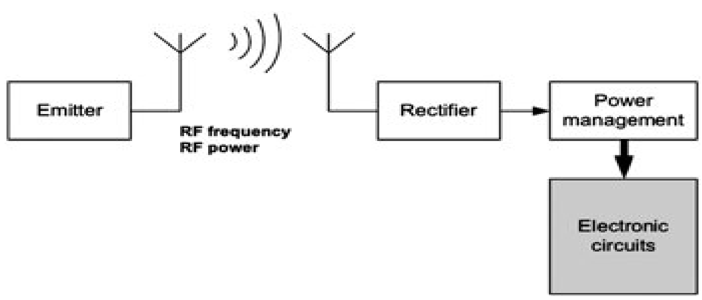


Figure 8 : Block diagram of radiofrequency energy harvesting principle (Alvarado *et al* 2012).

IV. Acoustic energy harvesting

Energy can also be extracted from sound waves as is the case for acoustic energy harvesting. In acoustic energy harvesting, an acoustic transducer or resonator is used to convert acoustic energy to electrical energy. In general, acoustic power can only be harvested in very noisy environments. A study has been conducted using incident sounds as a source of excitation for piezoelectric materials to power an ultra-low power processing circuit and it was found that the system can only operate at very high noise, i.e., 114 dB (Amirtharajah and Chandrakasan1997). In the ambient environment, energy from acoustic noise is very low, hence energy harvesting from sound wave 20dB is very inefficient. From theoretical results, acoustic energy harvesting can only yield 0.96 μW/cm3, much lower than other methods of energy harvesting.

On examining the literature on electromagnetic harvesters, it appears that a great number of them are configured as a cantilever beam. Nevertheless, this method produces less power than that will produce by piezoelectric and electrostatic methods. Electromagnetic harvesting provides the advantage of improved reliability and reduced mechanical damping as there would not be any mechanical contact between any parts; also it does not require a separate voltage source. However, electromagnetic materials are bulky in size. The major drawback concerning the use of electromagnetic harvesters is that the power output is lower compared to the piezoelectric and electrostatic methods (Worthington 2010). Power harvesting generally depends on the environment where the application will be used and the availability and nature of the ambient energy to be scavenged.

D. Power conditioning, managements and storage

The energy present in the environment that can potentially be harvested is discontinuous in nature. Therefore, not only the voltage level must be adjusted, but, because at times there is no energy at all, there must be some way to store the energy for use at a convenient time. Power electronic circuits form key interfaces in energy harvesting systems. As the ambient energy sources are much diversified (vibrations, RF, thermal, etc.), and the transducers are available in several types, many techniques are published, ranging from simple passive diode rectification circuit to efficient active converter circuits with intelligent control, and power conditioning that maximizes energy harvesting system efficiency as a function of operating conditions(Worthington 2010).

Therefore, power electronics concepts (control, devices, circuit topologies) reported in the energy harvesting literature are subject to design tradeoffs (Szarka 2012). The output voltage of the interface circuitry must comply with the requirements of the load electronics. The required voltage rectification, conversion, and regulation can be achieved by using one of two approaches (Guan and Liao 2007), either by using single-stage circuits, or by connecting separate rectification and DC-DC converter stages. Some generic topologies of passive power rectification used in power harvesting are shown in Figure (9). Full-bridge rectification is the most common circuit reported in the energy harvesting literature (Szarka 2012).

In order to improve the harvesting efficiency of passive rectifier technique, researchers have added a dc-dc converter, as shown in Figure (10). By controlling the switching duty cycle of the dc-dc converter via a control algorithm. The harvesting efficiencies (i.e. mechanical-to-electrical conversion) was reported to increased (Worthington 2010). Active or synchronous rectifier designs can be used to further increase the efficiency by reducing the conduction losses. The switching devices in synchronous designs are referred to as “active diodes”, consisting of a MOSFET driven by a comparator that monitors the transistor’s source-drain voltage (Clare and Burrow 2008). However, the control circuitry of active topologies presents additional power consumption and may require conditioned supply.

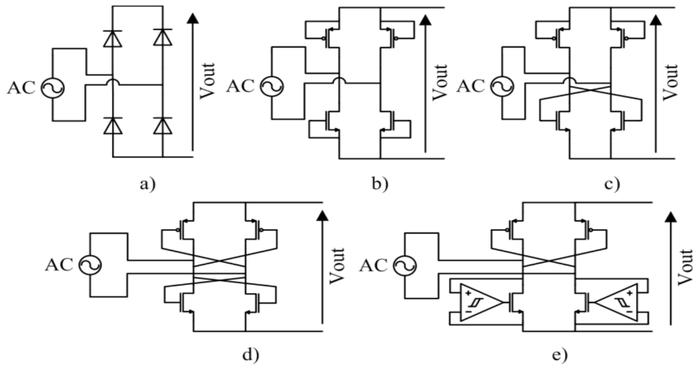


Figure 9: Full-wave rectifier topologies: a) diode rectifier, b) diode-tied MOS rectifier, c) gate cross-coupled NMOS rectifier, d) cross-coupled rectifier, and e) active rectifier with cross-coupled PMOS switches (Szarka 2012)

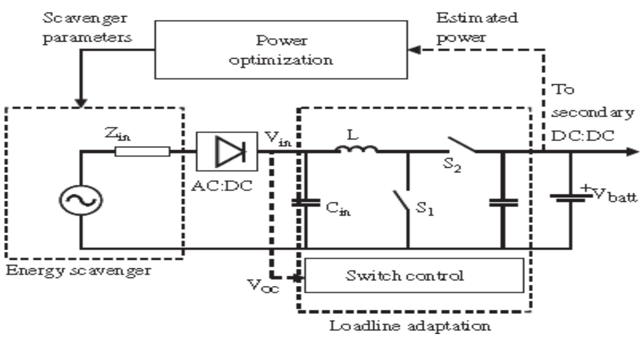


Figure 10: Power management architecture for an autonomous microsensor powered by an energy scavenger with passive rectifier, dc-dc converter circuit and storage battery (Clare and Burrow 2008).

Direct AC-DC converters for power harvesting circuits are also reported (Szarka 2012), they comprise of switch-mode converters that require no separate rectification stage . These topologies usually contain one or more switched inductors. They can operate with very low input voltages and offer more effective current and voltage regulation than switched-capacitor converter topologies. Figure (11) shows four example converter topologies, Circuits (a) and (b) are single-inductor topologies proposed by (Dwari *et al* 2008).

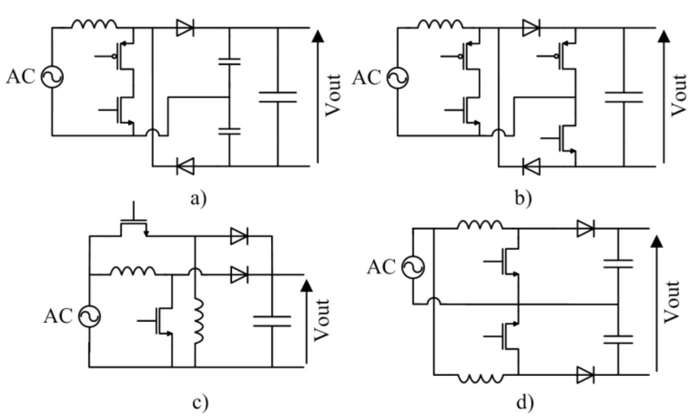


Figure 11: Direct AC-DC converter topologies; a) single inductor with split capacitor, b) single inductor with secondary side switches (Worthington 2010), c) combined boost – buck-boost (Dwari and Parsa 2010), and d) dual boost converter (Szarka 2012).

Energy storage unit also form key component in the power harvesting system, it provides a temporarily storage for the harvested energy to be used at convenient time. Super-capacitor and thin film solid state battery are used for power storage in power harvesting circuit as proposed (Clare and Burrow 2008). The block diagram in Figure. 10 presents a power management architecture suitable for autonomous microsensors. The energy produced by the scavenger is first rectified (in the case of vibration scavengers). Then a dedicated DC–DC converter (loadline adaptation) regulates the load offered to the scavenger so that it matches the electric impedance of the generator to realize maximum power transfer. The same circuit transfers the power to an energy storage element, for instance a secondary battery, matching the voltage level Vin at the scavenger output with the voltage level needed to charge the battery Vbatt.

E. CONCLUSION

In this paper, described are several energy Harvesting technology and their application. Energy conversion techniques, and power management in harvesting technologies are briefly presented. Energy harvesting techniques and their applications are expanding and becoming more attractive especially with advance in microelectronics and MEMs. Power management allows for from multiple sources, which, depending on the application, can lead to directly power the application circuit with or without using battery.

REFERENCES

(Billinghurst and Starner, 1999) Billinghurst M.and Starner, T., 1999. Wearable devices: new ways to manage information, *IEEE Computer* 32, p. 57–64.

(Chris *et.al.*,2008) Chris, K. Joshua, D. and Sam, B. 2008. *Review:* Energy Options for Wireless Sensor Nodes, *Sensors*.

(Nicholas and Glenn, 2005) Nicholas, S. H. and Glenn, G. A., 2008, Small-scale Energy Harvesting through Thermoelectric, Vibration, and Radiofrequency Power Conversion, *Journal of Applied Physics*.

(Marzencki, 2005) Marzencki, M., Vibration Energy Scavenging, *European Commission Research Project VIBES of the 6th STREP Framework Program*.

(Faruk 2009) Faruk Yildiz, 2009, Potential Ambient Energy Harvesting Sources and Techniques, The Journal of Technology Studies, v 35, Fall.

(Justin, 2007) Justin R. F.,2007. A comparison of power harvesting techniques and related energy storage issues M.S Thesis. Dept. Mech. Eng., Virginia Polytechnic Institute and State Univ. Blacksburg.

(Mah,1998) Mah, O.,1998. Fundamentals of photovoltaic materials, National Solar Power Research Institute, Inc.

(Damaschke,1997) Damaschke, J.M.,1997. Design of a low-input voltage converter for thermoelectric generator. *IEEE Transactions on Industry Application.* 33(5):1203.

(Myers, 2009) Myers, R.L., 2009, The basics of physics. Greenwood Press,Westport, Conn., 2006.

(Harb,2010) Harb, A., 2010. Energy harvesting: State-of-the-art, Renewable Energy, Elsevier.

(Stanley, 1982) Stanley, W.A., S. , 1982. *Direct Energy Conversion*, Allyn & Bacon.

(James and Farooq, 2008) James, M. G. and Farooq, B., 2008. Comparison of Energy Harvesting Systems for Wireless Sensor Networks. *International Journal of Automation and Computing*, 05(4), p.334-347.

(Starner and Paradiso, 2004) Starner, T. and Paradiso, J.,2004. Human Generated Power For Mobile Electronics, in *Low Power Electronics Design*, C. Piguet, ed., ch. 45, CRC Press.

(Mateu and Francesc, 2005) Mateu, L. and Francesc, M.,2005. Review of Energy Harvesting Techniques and Applications for Microelectronics. Proceedings of the SPIE Micro-Technologies for the New Millennium.
(Beeby *et al* 2006) Beeby, S. P., Tudor, M. J., White, N. M.,2006. Energy harvesting vibration sources for microsystems applications, REVIEW ARTICLE, Meas. Sci. Technol. 17, R175–R195.

(Amirtharajah and Chandrakasan1998) Amirtharajah, R. and Chandrakasan, A. P. 1998. Self-powered signal processing using vibration-based power generation, *IEEE Journal of Solid-Stage Circuits*, v 33 n 5, May 1998, p. 687–695.

(Cian´O *et al* 2008) Cian´O M., Terence O., Rafael V., Martinez-Catala, J. R., Brendan, O.,2008. Review Energy scavenging for long-term deployable wireless sensor networks, Talanta 75 p. 613–623.

(Amirtharajah and Chandrakasan1997) Amirtharajah, R. and Chandrakasan, A. P. 1997., .Self-Powered Low Power Signal Processing,. In *VLSI Circuits, Digest of Technical Papers, 1997 Symposium on* pp. 25.26.

(Amirtharajah 1999) Amirtharajah, R., Design of Low-Power
VLSI Systems Powered by Ambient Vibration, Ph.D. Dissertation, Massachusetts Institute of Technology, June 1999.

(Kulah and Najafi 2004) Kulah, H and Najafi, K., 2004, An electromagnetic micro power generator for low-frequency environmental vibrations, *Micro Electro Mechanical Systems—17th IEEE Conference on MEMS (Maastricht),* p .237–240.

(Umeda *et al* 1996) Umeda M., Nakamura, K. and Ueha, S.,1996, Analysis of the Transformation Of Mechanical Impact Energy To Electric Energy Using Piezoelectric Vibrator, *Japan, Journal of Applied Physics,* v 35, p 3267–3273.

(Gross 1991) Gross, W., 1991, Optical Power Supply For Fibre-Optic Hybrid Sensors, *Journal of Sensors and Actuators A,* 1991, v 25-27, pp 475-480.

(Scherrer *et al* 2005) Scherrer, S., Plumlee, D.G. and Moll, A.J., 2005, Energy scavenging device in LTCC materials. In: *IEEE workshop on microelectronics and electron devices (WMED '05)*, Boise, ID, USA, p.77-78.

(Roundy 2003) Roundy, S. J., 2003, Energy Scavenging for Wireless Sensor Nodes with a Focus on Vibration to Electricity Conversion, Ph.D Thesis.

(Wang and Yuan 2007) Wang, L. and Yuan, F. G.,2007, Energy Harvesting by Magnetostrictive Material (MsM) for Powering wireless sensors in SHM, *SPIE Smart Structures and Materials & NDE and Health Monitoring, 14th International Symposium (SSN07)*.

(Tan, 2008) Tan, Y.K., Lee, J.Y., Panda, S.K., 2008, Maximize Piezoelectric Energy Harvesting Using Synchronous Charge Extraction Technique For Powering Autonomous Wireless Transmitter, *Sustainable Energy Technologies, 2008. ICSET 2008. IEEE International Conference on* , vol., no., p.1123-1128.

(Roundy *et al* 2003) Roundy, S., Wright, P. K. and Rabaye, J. 2003, A study of low level vibrations as a power source for wireless sensornodes *Comput. Commun.* 26 1131–44.

(Roundy and Wright 2004) Roundy, S. and Wright, P. K., 2004, A piezoelectric vibration based generator for wireless electronics *Smart Mater. Struct. Vol.*13, 1131–42.

(Beeby *et al* 2006) Beeby, S. P., Tudor, M. J., and White, N. M.,2006, Energy Harvesting Vibration Sources For Microsystems Applications, *Journal of Measurement Science and Technology*, 2006, v 17, p. 175-195.

(Chalasani and Conrad 2008) Chalasani, S., Conrad, J.M., 2008, A survey Of Energy Harvesting Sources For Embedded Systems, *Southeastcon, IEEE*, pp.442-447.

(Sterken 2002) Sterken, T., Baert, K., Puers, R. and Borghs, S., 2002, Power Extraction From Ambient Vibration, *Proceedings of 3rd Workshop on Semiconductor Sensors and Actuators*, p. 680–683.

(Tashiro *et al* 2002) Tashiro, R., Kabei, N., Katayama, K., Tsuboi, E., Tsuchiya, K., 2002, Development of an Electrostatic Generator for a Cardiac Pacemaker that Harnesses the Ventricular Wall Motion. *Journal of Artificial Organs*, vol. 5, no. 4, p. 239–245.

(Lawreence and Snyder 2002) Lawreence, E. E. and Snyder, G. J., A Study of Heat Sink Performance in Air and Soil for Use in a Thermoelectric Energy Harvesting Device, *Proceedings of the 21st International Conference on Thermoelectronics*, Portland, OR, p. 446–449.

(Sodano *et al* 2007) Sodano, H. A., Simmers, G. E., Dereux, R., and Inman, D.J., 2007, Recharging Batteries using Energy Harvested from Thermal Gradients, *Journal of Intelligent Material Systems and Structures*, v 18, p. 3 -10.

Sodano *et al* 2004) Sodano, H. A., Simmers, G. E., Dereux, R., and Inman, D. J., 2004, Power Harvesting Using Thermal Gradients for Recharging Batteries, *Proceedings of 15th International Conference on Adaptive Structures and Technologies*, Bar Harbor, ME, October 25–27 2004.

(Randall 2005) Randall, J.F., 2005, Designing Indoor Solar Products: Photovoltaic Technologies for AES, John Wiley & Sons, 2005 (Chapter 5).

(Lee *et al* 1995) Lee, J. B., Chen, Z., Allen, M. G., Rohatgi, A. and Arya, R., 2005, A miniaturized high-voltage solar cell array as an electrostatic MEMS power supply, *Journal of Microelectromechanical Systems*, v 4, p. 102-108

(Raghunathan *et al* 2005) Raghunathan, V., Kansal, A., Hsu, J., Friedman, J. and Srivastava, M.,2005, Design Considerations for Solar Energy Harvesting Wireless Embedded Systems, *Fourth IEEE/ACM International Conference on Information Processing in Sensor Networks*.

(Alvarado *et al* 2012) Alvarado, U., Juanicorena, A., Adin, I., Sedano, B., Gutiérrez , I. and de Nóm, J., 2012 RESEARCH ARTICLE Energy harvesting technologies for low-power electronics. Trans. Emerging Tech., v 23, p.728–741

(Worthington 2010) Worthington, E.L., 2010, Piezoelectric Energy Harvesting: Enhancing Power Output by Device Optimisation and Circuit Techniques. PhD Thesis.

(Dwari *et al* 2008) Dwari, S., Dayal, R., Parsa, L., 2008, A Novel Direct AC/DC Converter for Efficient low Voltage Energy Harvesting, *Industrial Electronics, 2008. IECON 2008. 34th Annual Conference of IEEE* , vol., no., p.484-488.

(Triet 2008) Triet, T. L., 2008, Efficient Power Conversion Interface Circuits for Energy Harvesting Applications, PhD. Dissertation, Oregon State University.

(Szarka 2012) Szarka, G.D., Stark, B. H. and Burrow, S. G., 2012, Review of Power Conditioning for Kinetic Energy Harvesting Systems, *Power electronics, IEEE transaction on*, Vol.27, no2, p.803-815.

(Guan and Liao 2007) Guan, M. J. and Liao, W. H., 2007, On the Efficiencies of Piezoelectric Energy Harvesting Circuits towards Storage Device Voltages, *Smart Mater. Struct.*, vol. 16, p. 498-505.

(Clare and Burrow 2008) Clare, L. R., and Burrow, S. G.,2008, Power Conditioning for Energy Harvesting, in *Proc. SPIE Active and Passive Smart Structures and Integrated Systems*, San Diego, pp. 69280A-13.

(Dwari and Parsa 2010) S. Dwari and L. Parsa, 2010, An Efficient AC–DC Step-Up Converter for Low-Voltage Energy Harvesting, *IEEE Trans. Power Electron.*, vol. 25, p. 2188-2199.

THE CONCEPT OF MINI OFF-GRID, DISTRIBUTED RENEWABLE ENERGY SYSTEM FOR RURAL AND REMOTE ELECTRIFICATION IN NIGERIA

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ABSTRACT

Today, there is a tendency to forget that there are still many locations in the world which do not have an electrical connection to a central utility network. Furthermore, in many places due to remoteness and cost, it is unlikely that a main grid connection will ever be established. However the need for power still exists. However, many of them are also fortunate enough to live in the proximity to potential indigenous renewable energy sources such as hydro, solar, wind, biomass etc. This paper presents the concept of using renewable energy sources/technologies in solving the energy problem of rural or remote centers using mini-grid, especially in a region with renewable energy potential.

Keywords: component; Developing countries, rural/remote electricity,Mini grid, Renewable energy resources/technology.

I. INTRODUCTION

Eighty percent of Nigeria’s approximately 170 million citizens reside in rural communities. Most of this populace is plagued with the ills of hunger and poverty. One of the ways we can begin to combat this ailment is by increasing the income earning power of residents of rural regions. The inaccessibility of energy aggravated by the nonexistence of socio-economic prospects in rural communities has resulted in the escalation of hunger, poverty and poor health. The provision of adequate, affordable, accessible and sustainable electricity supply is critical to the attainment of the broad goals of high and sustainable human development. Electricity interacts with human development at different levels. It helps to facilitate economic development and poverty reduction by underpinning industrial growth and enhancing productivity. It contributes to social development by helping to fulfill the basic human needs of nutrition, warmth and lighting, in addition to education and public health (UNDP 2005).

At present, in Nigeria, a very large number of people do not have access to the share of electrical energy necessary for their subsistence and their development. They have legitimate aspiration for electrical energy security, just as they have for food security.

It is absolute certain that any form of electrical energy obtained from natural sources like the sun, wind, waves, water or other natural sources, will provide a series of answers in the areas of water pumping, lighting, telecommunications, medical, food preservation and motive power (REAP 2006).

Centralized power generation has been the dominant approach to electrification in developed countries over the last century since the development of improved generation technologies such as large-scale steam turbines; the introduction of transformers and high voltage lines using alternating current (Maxwell 2009). A similar centralized approach has been followed in many developing countries. In post World War 2 Africa, for example, centralized electricity generation was seen as a precondition for development, with the delivery of electricity and infrastructure paving way for economic growth. This approach overlooked constraints such as dispersed population, low purchasing power and limited potential for load growth (Kirubi et al. 2008). The main key variables in determining the cost of grid extension-comprising installation of high or medium-voltage lines, substation(s) and a low-voltage distribution are;

- the size of the load to be electrified,
- the distance of the load from an existing transmission line, and
- the type of terrain to be crossed.

Due to the lack of critical mass, the low potential electricity demand and the, usually, long distances between the existing grid and the rural area, the costs of electrifying small communities through grid extension are very high and therefore, not economically viable. The lack of local technical and management personnel and the high transmission losses are also deterring factors playing against this solution (Belfikra et al. 2008).

II. BRIEF OVERVIEW OF NIGERIA ENERGY RESOURCES

Nigeria with a land mass of about 924,000km^2 and an Atlantic shoreline of about 1000km is one of few developing countries blessed with sizeable primary energy resources, as indicated in Table 1. She is endowed with significant renewable energy resources including large and small hydroelectric power resources, solar energy, biomass, wind and potentials for hydrogen utilization; and development of geothermal and ocean energy. Table 1 presents some of Nigeria Energy Reserves/ Potential.

However, the country's current power sector planning process mainly favors conventional centralized gas fired generation. By 2020, this is set to comprise 74% of the country's total electricity output.

Any positive result from the current geological surveys of the country will hopefully reinforce the sufficiency of these reserves for meeting the Nigerian domestic energy requirements (Energy in Developing Countries, World Bank 2003).

Table 1: NIGERIA ENERGY RESERVES/ POTENTIAL (OPEC 1980)

Resource	Reserves	Reserves Billion toe	% Fossil
Crude oil	33 billion bbl	4.488	31.1
Natural gas	4502.4 billion m^3 (159 trillion cubic feet)	3.859	26.7
Coal & Lignite	2.7 billion tons	1.882	13.0
Tar Sands	31 billion bbl oil equivalent.	4.216	29.2
Sub-Total (Fossil Fuels)		**14.445**	**100.0**
Large scale hydro	10,000 MW		
Small scale hydro	734 MW	Provisional	
Fuel wood	13,071,464 has (forest land 1981)	Estimate	
Animal waste	61 million tons/yr	" "	
Crop Residue	83 million tons/yr	" "	
Solar Radiation	(3.5-7.0) kWh/m^2-/day		
Wind	(2-4) m/s (annual average)		

III. EXPLOITING RENEWABLE ENERGY RESOURCES

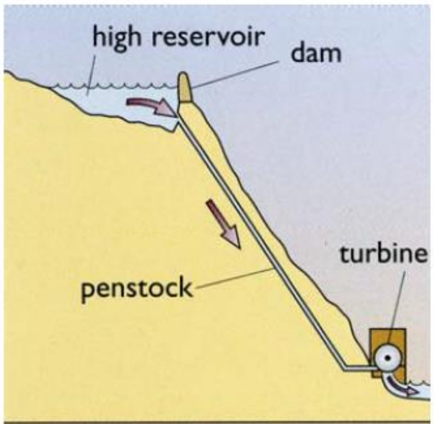
One way to increase the power generation and per capita consumption of Nigeria is by installation of small or mini-grids for rural or remote areas since they are very far from the central utility. This can be achieved by using the available alternative resources of energy at the disposal of such centers, which are numerous. These alternative sources of generating electrical energy are called *Renewable Electrical Energy* and it refer to electric energy sources that do not result in the depletion of the earth's resources. The technologies involved in generating electricity from these natural sources are called *Renewable Energy Technologies (RETs).*

There are three main attributes of RES: free availability, allowance for modular technology and emission free. Therefore, developing countries must open a wide access to technology for the utilization of their indigenous RES .One of the greatest problems in utilizing renewable energy sources is their low density of power and intermittent nature depending largely upon local site and unpredictable weather conditions (Keinkauf and Raptis 1997). We will have a brief overview of the popular RES and RETs.

A. *Hydropower*

According to the latest report, the global installed hydropower capacity increased from 896.9 Gigawatts (GW) in 2006 to 1,072.1 GW in 2011, and is expected to climb to 1,443 GW by 2020, thanks to support from governments around the world. Small hydro power, SHP has emerged as one of the most favored and promising solutions due to its reliability and affordability. Small and mini hydro facilities are gaining importance as their effect on the environment, and national budgets, is less substantial. The construction of SHP plants does not disturb the local habitat and the building of large dams and reservoirs is unnecessary, thereby avoiding issues of deforestation and submergence.

Figure 1: Typical Hydro power installation (Pfeiffer 2009)



SHP plants are consequently much quicker to construct and also offer higher rates of return due to the low capital investment and operational and maintenance costs. Their implementation also carries positive social benefits as they encourage community participation and capitalize on local skills for plant construction. China is the biggest SHP market globally, accounting for 55.3% of the cumulative installed capacity in 2011. China has installed 59 GW of small hydro and is expected to take the lead among small hydro countries. China is followed by India and the US, with 9% and 6.9% of the SHP installations, respectively (Renewable Energy Magazine Jan 30.2013).

Although there may not be any international consensus on the definition of small hydropower, an upper limit of 30 MW has been considered. Thus, 30 MW has been adopted as the maximum rating under this dispensation. Small hydro can further be subdivided into mini hydro (<1 MW) and micro hydro (<100 kW). Thus both mini and micro hydro schemes are subunits of the SHP classification.

To determine the potential power of water in a river it is necessary to know the flow rate (Q) in the river and the available head (H) in meters. The flow of the river (m^3/s) is the amount of volume of water (m^3) which passes a cross section of the river in a given time (s).
The head is the vertical difference, in meters (m) in level the water falls down.
The potential power (P) available is given by the expression below:

$$P = Q * H * \rho * g \qquad (1)$$

Where ρ is the density of water, measured in $kg/m^3$and g is the acceleration due to gravity in ms^{-2}.
Equation (1) can be re-written as:

$$P = Q * H * 1000 * 9.8 Watts \qquad (2)$$

B. Solar and photovoltaic technology

Here, electricity is generated from solar energy (Sun) through photovoltaic materials (cells or modules) that convert sunlight directly into electricity. The knowledge of the amount of solar radiation in a given location (area) is essential in the field of solar energy physics. This in effect helps one to have a fair knowledge (idea) of the insolation power potential over the location (Craddock 2008). Figure 2 shows the solar radiation in Southern Nigeria.

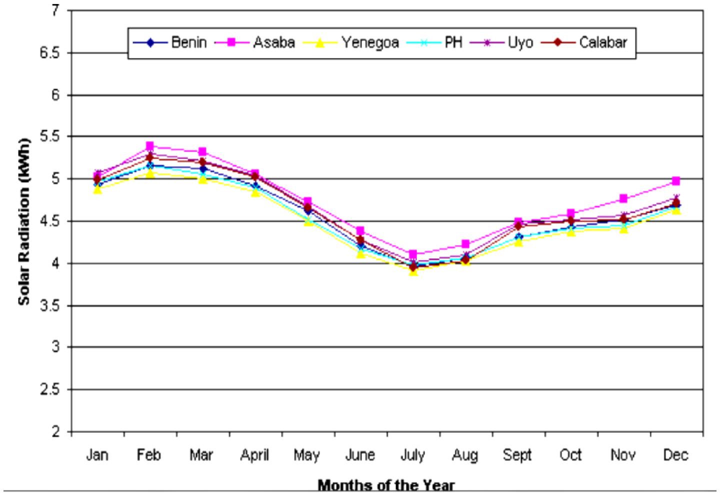


Figure 2: Monthly solar radiation in Southern Nigeria (Dike et al. 2011).

A photovoltaic system consists basically of the module which converts the solar energy to direct current (DC) electricity, the battery which stores the DC electricity for use when the solar radiation is either poor or non-existent, the charge controller which regulates the charging and discharging of the battery to preserve its life, the inverter which converts the DC from the modules or battery into alternating current (AC), wires, switches, relays mounting structures etc are all important in PV installation.

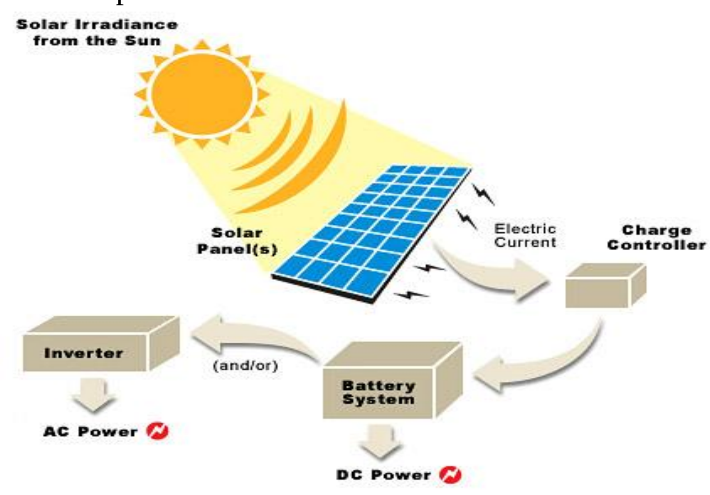


Figure 3: Solar power November 15 2014 (http://www.alternative-energy-news.info/technology/solar-power)

Table 2: Field of Application of Photovoltaic (Pfeiffer, 2009)

[1] **Application**	[2] **Typical PV capacity**	[3] **Examples**
[4] Satellites	[5] (1…20)kW	[6] Satellites for TV weather, space probes , space stations
[7] Small applications	[8] < 1 W	[9] Measuring devices, pocket calculators
[10] Solar household system (SHS)	[11] < 100W	[12] Basic load covering of household (lighting, telecommunication)
[13] Commercial Isolated system	[14] 50….10kW	[15] Rural area without grid access
[16] Decentralized grid connected PV-installation	[17] (1…30)kW	[18] Private homes, public buildings, demonstration installations
[19] PV Plants	[20] >30kW	[21] Pilot plants, demonstration installations

The expected energy consumption in Watt-hour per day of the location is derived using the following expressions:

$$E = n * P * T(Wh) \quad (3)$$

Where:
E = Energy demand per day
n = Number of appliances
P = Power rating [W]
T = Duty cycle [h]

The PV in-feed from the installation is determined using the expression below

$$P_{mpp} = A * G_{stc} * \mu_{stc} Watts \quad (4)$$

Where μ_{stc} = PV Efficiency at standard test conditions,
G_{stc} =Radiation Intensity at standard test conditions, in Watts per square meter
P_{mpp} =Maximum Power Point, in Watts,
A= PV Area in m^2.

The radiation intensity is the only parameter that varies depending on the period of the day (Pfeiffer, 2009).

C. Wind Energy

Wind energy has been used for pumping water and milling grain for hundreds of years. More recently, wind energy has also been used for electricity generation. Wind turbines are now used for large-scale energy delivery, and can also be effective as small-scale remote applications. Developing countries can take advantage of wind power on a small scale, both for irrigation (wind pumps) and for generation of electricity (PATC 2008).

Unlike the trend toward large-scale grid connected wind turbines seen in the West, the more immediate demand for rural energy supply in developing countries is for smaller machines of up to about 60 kW. These can be connected to small, localized micro-grid systems and used in conjunction with diesel generating sets and/or solar photo-voltaic systems. Currently, the use of wind power for electricity production in developing countries is small, the main area of growth being for very small battery charging wind turbines (50 – 500 Watts). Other applications for small wind machines include water pumping, telecommunication power supplies and irrigation (Spera 1994).

The power in the wind is proportional to the cube of wind velocity. If the wind speed doubles, therefore, the power in the wind will increase by a factor of eight.

$$P = \frac{\rho * A * V^3}{2} Watts / m^2 \qquad (5)$$

Where P is the power, ρ is density of air (kg/m^3), A is the swept area (m^2). If V is the wind velocity (m/s), then at sea level (where the density of air is $1.2 kg/m^3$) then the power will be:

$$P = 0.6V^3 Watts / m^2 \qquad (6)$$

This means that the power in the wind will range from $10 W/m^2$ at 2.5m/s (a light breeze) to $41{,}000 W/m^2$ at 40m/s (a hurricane).

Such variability of the wind affects nearly all aspects of wind energy system design, construction, citing, use and economy.

TABLE 3: Categorization of wind power (Pfeiffer 2009).

Installed Power	**Categorization**	**Wind Turbine Capacity Range**
< 1 kW	Micro systems	<1 kW
1-100 kW	Wind home systems, hybrid systems	1-50 kW
100-10 MW	Isolated power systems and decentralized generation	100 kW-1 MW
>10 MW	Wind power plants-on shore wind farms	>500 kW
>100 MW	Wind Power plants-off shore	>2000 kW

IV. RENEWABLE LOCAL MINI-GRIDS

Mini-grids can be an important alternative to or enhance the effectiveness of central grid extension to increase access to reliable electricity services in developing economies. Mini-grids are defined as one or more local generation units supplying electricity to domestic, commercial, or institutional consumers over a local distribution grid. They can operate in a standalone mode and can also interconnect with the central grid when available.

Although mini-grids can use diesel generators, renewable energy-based mini-grids (henceforth referred to as RE mini-grids) use electricity generation technologies that utilize locally available renewable energy sources like solar, wind, biomass, and run-of-river hydro, thus avoiding local and global pollution. These generation technologies include solar photovoltaic and wind turbines with battery storage, biomass gasifiers and biogas digesters with internal combustion engines, micro and mini-hydro turbines, and hybrid systems (a combination of more than one generation technology). Due to their low or often zero fuel costs (except potentially in the case of biomass-based systems), RE mini-grids can be more cost effective than those utilizing diesel generators or kerosene based lighting. The latter have little capital expenditure, but have relatively high fuel costs, volatile prices, and logistic limitations. RE mini-grids have distinct advantages over central grid extension and other decentralized energy options in providing access to reliable and affordable electricity.

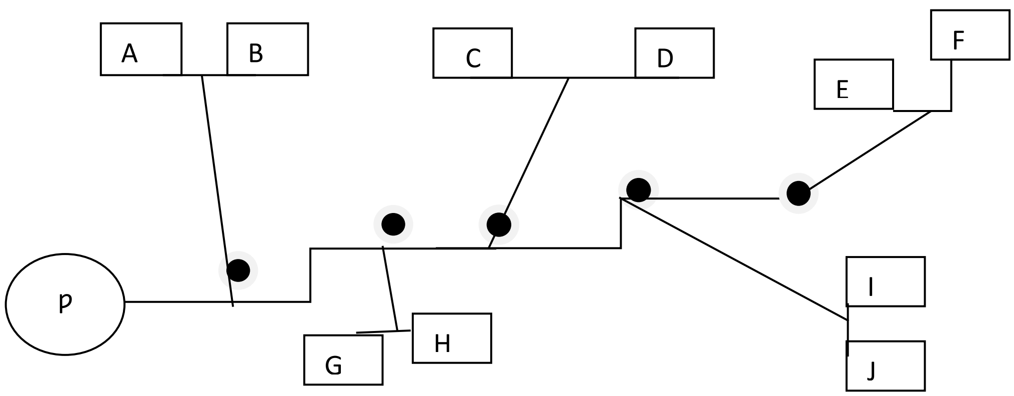


Figure 4: A typical mini-grid outlay showing a portion of village to be electrified.

P is the power house with RES, A-I are the different consumers at different point on the distribution system.

RE mini-grids have distinct advantages over central grid extension and other decentralized energy options in providing access to reliable and affordable electricity.

1. Compared to central grid extension, RE mini-grids can be less expensive due to lower capital cost of infrastructure (depending on distance) and lower cost of operation by avoiding transmission and distribution losses (Cust et al. 2007).
2. In countries with power shortages, electricity supply through the central grid, especially in rural areas, may not be reliable. In such regions, RE mini-grids that can be designed and operated effectively, can be more reliable than the central grid in providing electricity access and can ensure local energy security.
3. Mini-grid developers have the potential to access capital beyond the traditional power sector, and may be able to provide quicker access to electricity than central grid extension that may be prone to bureaucratic hurdles and slow implementation.

4. Unlike other decentralized energy options like solar home lighting systems and off-grid lighting products, mini-grids (depending on their size) can provide electricity to not only residential loads like lighting and phone charging, but also to commercial loads like mills and oil presses.
5. RE mini-grid developers have strong incentives to pursue demand-side management, to keep capital cost of generation equipment low.
6. Development and operation of mini-grids can create local jobs.

However, it is important to note that the design of a local mini-grid system requires the services of specialist who are capable, first of all, of estimating overall demand and how it will evolve, the local energy sources, and the future user's ability to pay. Then they must define all the components of the system, production, transport, distribution and use (Gouwello 2002).

V. VARIOUS LOADS

Since the power demand of a house or a village or even a remote urban area is different at different time span, guaranteed power supply from a single decentralized power system may not be economical because of high initial investment and low load factor. Figure x shows a typical electric demand load curve in a village in developing countries. Most villages are characteristically agriculture oriented and have little or no commercial and industrial activities.

Energy consumption, particularly electrical energy, is very low. The base load is therefore, relatively little as compared with intermediate load and peak load. The peak load is mostly for lighting purpose and last only for maximum 2-3 hours in the evening The energy consumption/needs of the rural community are categorized into three groups; household, commercial and community conveniences (social services) consumption. Household energy consumption in most rural communities is mainly used for the basic functions of the home: lighting, entertainment (radio, video player and television).

The previously mentioned end users-lighting and entertainment- are very attractive and are most popular initial uses of electricity in most rural settings. However, if a mini-grid project is to pay for itself and to bring increased socio-economic benefits to the community, it often is necessary to judiciously incorporate productive, income-generating uses in the load mix. Many such uses, such as agro-processing equipment, refrigerators, water pumps, and metal working equipment require motors as the source of motive power (Maskey and Nestmann 2008).

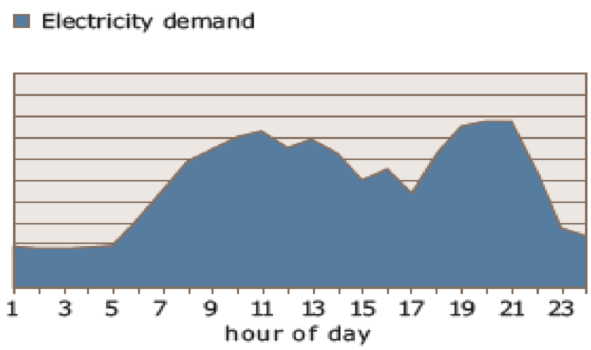


Figure 5: Typical load profile for rural setting (Alliance for Rural Electrification 2010).

VI. CONCLUSION

Consistent, economical, affordable and clean supply of energy in Nigeria is a must for a sustained national development and is indeed vital in the fight against hunger and poverty. A large number of Nigeria's citizens are presently denied access to energy. Coincidently, most of these people are residents of rural communities which also happen to be the poorest regions of the country. In the pursuit to eliminate poverty and attain a sustained national development, we must address issues of rural, economic and social development. In other words, we must improve the quality of life of the inhabitants of the rural community by increasing access to food, industrial output (especially agriculture), healthcare, education, information, transportation and entertainment.

One of the ways to achieve this is through consistent, economical and cleaner sources of energy such as renewable energy by installation of mini-grids that will cater for the needs of the people in these regions. This will be the driving force to attaining rural community development and indeed a sustained national development.

Mini-grids with distributed renewable energy system will be an important option to increase the access to reliable electricity for rural and remote area applications.

VII. REFERENCES

Alliance for rural electrification; hybrid power systems based on renewable energies: a suitable and cost-competitive solution for rural electrification, 2010.

Belfikra R, Nichita, C, Reghem P and Barakat G,2008 'Modeling and Optimal Sizing of Hybrid Renewable energy System', *Power Electronics and Motion Control Conference,. EPÉE-PEMC* pp 1834-1839.

Christophe de Gouwello 2002, 'Technological *Configurations of Decentralized Energy Supply, Decentralized Rural Electrification, An Opportunity for the Planet'*. System Solaires Paris

Craddock, D 2008, *Renewable Energy Made Easy: Free energy from solar, wind, hydropower and other alternative energy resources*. Atlantic Publishing, Florida.

Cust J, Singh A, and Neuhoff K, 2007 'Rural Electrification in India: Economic and Institutional aspects of Renewable', *Faculty of Economics, University of Cambridge, Cambridge Working Papers in Economics*

Dike V.N, Chineke T.C, Nwofor O.K and Okoro U.K 2011, 'Evaluation of horizontal surface solar radiation levels in Southern Nigeria, *Journal of renewable and sustainable energy*

Energy in Developing Countries, World Bank, 2003.

http://www.alternative-energy-news.info/technology/solar-power. November 2014.

Keinkauf, W and Raptis F, 1997 'Elektrifizerung mit erneueurbaren Energien-Hybridanlangen-technik zur dezentralen, netzkompatiblen Stromversogung Forschungsverbund Sonnenergie',

Kirubi C, Arne J, Daniel M.K.and Mills A 2009 'Community- Based Electric Micro-Grids Can Contribute to Rural Development: Evidence from Kenya' *World Development* pp 1200-1221.

Maskey R.K and Nestmsnn F 2008, 'Hydro-based renewable power system for rural electrification' *Institute of Water resources management, hydraulics and rural engineering,* University of Karlsruhe, Germany.

Maxwell, C.J 2009, 'Distributed generation: options and approaches', *Sustainable Energy Regulation and Policy making for Africa Vienna, Austria*. Renewable Energy and Energy Efficiency Partnership, REEP, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford, 1892, pp.68–73.

Organization of the Petroleum Exporting Countries, OPEC, Annual Statistical Bulletin, Federal Republic of Nigeria Energy for the 4th Plan, 1980.

Pfeiffer, K, *Renewable Generation and Storage of Electrical Energy* at Brandenburg University of Technology, Cottbus, Germany, on December 2009.

Renewable Energy Action Plan, Federal Ministry of Power and Steel, Federal Republic of Nigeria, December 2006.

Renewable Energy Magazine, Jan 30.2013.

Spera, D.A 1994, 'Fundamental Concepts of Wind Turbine Engineering, *Wind Turbine Technology*.

United Nation Development Programme, UNDP Human Development Report, 2005.

Wind for Electricity Generation Technical Brief by Practical Action, Technology Challenging Poverty, 2008.

ENGINEERING PRACTICE INDUSTRY CONTACTS AND RESEARCH ASSESSMENTS FOR ACADEMIA –INDUSTRY RESEARCH INTEGRATION

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ABSTRACT

This paper focuses on information gathering on the existing relationship between engineering academicians,, engineers and industries with a view to enhancing their relationship and bridging the existing gab in between, First of all data were taken from engineering academicians, students, Engineers that are working class either government employed, self-employed, private employed and non-employed across a federal university and a federal polytechnic environments, (Bayero university kano and Hussaini Adamu Federal Polytechnic) in order to assess the level in which they participate in an industrial Engineering practices and direct consultancies which help develops the industry sector, Also level of industry related researches carried out at the research institutions and their participations were studied. A questionnaire based research approach was used in this paper and from the data gathered it is clearly understood that more need to be done from both side of academia and industries in making the industries recognize the importance of academic researches for building their industry sector.

Result show a very big gap between industry and academia in terms of industry contacts, researches and consultancy and it is suggested in this paper that more Research and Development (R&D) units if there is any that will create Practices with proper instructions, formal guidance, continual training and educations should be created in both institutions and industries; also for academia each faculty should have a R&D unit with every PhD. Holder in that faculty as a member with a position of Research Officer which will bring about more industry contacts, consultancy, industry based researches especially for higher degree holders with a view to narrowing the existing gap.

Keywords: Practice, Assessments, Academia Research.

I. INTRODUCTION

Collaborative projects, when run effectively, can serve to give immediate feedback from industry to academia and vice-versa as it gives, engineers and engineering academicians and students direct contact with companies in the industry, they gain the immediate exposure to abilities and skills that will be expected of them in industry and are exposed to the socio-commercial realities which lie behind their designs. The consequent benefits to the confidence of engineering graduates are obvious. It has been known that the engineering undergraduate learning experiences could be greatly improved from being put in a situation which more closely simulates the industrial environment if not a collaborative project. From the higher institute's point of view, collaborative projects can enable timely feedbacks from industry on the engineering students' abilities, which can be very useful in curriculum evaluation and teachers awareness on areas of lapses.

The industry collaboration enables them to stay in touch with the latest and current abilities of designs and gain positive exposure both within and outside their institutions, no doubts these approach is greatly beneficial for all three parties (academicians, engineers and students) when managed correctly.

It is acknowledged that so many good designers have come out from the shop floors and streets, some starting with an apprenticeship, road site trainings etc. and move up through the academic levels through night courses. Though this pattern of skills developments has greatly declined due to the increasing availability of university grants and the reduced availability of the apprenticeship system. Salter [1] seriously mourns the loss of this route of education and the consequent loss of skills, he believes that in many ways the old Apprenticeship has provided a more complete preparations for a good career as a designer than the current university based education. He also believes there could be several areas in which the old system was superior: apprentices were continuously occupied and surrounded by technology of their industry and openly exposed to a very wide range of industrial activities and technological developments. Plus being exposed to the entire world of production processes and consistently confronted with the results of their own designs mistakes, seeing the physical applications of their ingenuity and ideas. In today's modern university environment, this is an aspect of engineering knowledge getting too often neglected in favor of computer simulations, which are much simpler, cheaper, and safer for students and academic researchers to use.

Salter also believed that is possible to transfer the best features of the classical apprenticeship

into a university system environment and compress it into a shorter period, projects in which students are exposed to real industry feedbacks and are expected to produce a good working prototypes better than the computer models, the importance of combining students' natural creativity on product designs with instructions and guidance has been clarified by, among others, Kurowski and Knopf [2]:

A good and successful product designer has to combine the natural creativity with the systematic use of structured design methodology and modern computer-aided design tools, simulations inclusive. Practices

without the proper instructions and a proper formal guidance have failed to recognize the vast knowledge of the design process developed by experts and successful professionals, design of a product solely based on theory without the knowledge or technical know-how derive from practice is ineffective as many exceptions are learned by working on actual design project.

The usefulness of professional development for design lecturers by close contact with professional designers and outside agencies has been stresses by Butterworth [3] as he says:

A revised design curriculum needs to inspire a passion for making things and a curiosity about how they could be made better, for hand, body and spirit; and to factor in a sense of the expectations of the new consumer.

It also has increasingly been supported by increased development professionals and teachers involved in professional making and designs from a wide range of practice and by organizations representing creative and cultural industries.

This shows another benefit of outside partnership, that of continual development for lecturers. Those days when academic lecturers would gain an expertise in a topic and subject, had a set of notes that could be spent for a forty-year career delivering the same materials to successive coming groups of students are no more, this is peculiar especially in science and engineering which are supposed to be the tools for advancement but is still continued, it is critical for t academic teachers to ensure their expertise and contribution remain a vogue and relevant to the industry, and there will be no better way of achieving this than working on collaborative projects with industry.

It is been described by Steiner [4] the experience and contribution of Swanson Multidisciplinary Design Laboratory for providing the real-world experience for students.

Industrial companies willing to sponsor projects are required to bring up open-ended, challenging design technical problems which are intended towards preparation of students for entering the workplace through institution R&D unit, such an effort and exercise can improve the students' employability after graduation. In addition many of these projects are multidisciplinary in nature and will require the students to work alongside students and professionals from other disciplines in finding the solution, they represent the nature kind of student that industry is in need of to be cultivated as next generation of engineers.

Research and Development (R&D) has proven importance in bridging and narrowing the gap between academia and engineering industries especially in developed parts of world where it is given more importance and has shown its effectiveness in achieving a small gap in industry academia relationship.

Dublin Institute of Technology (DIT) has a proud history of collaboration with industry [6]. In its strategic plan, the institute states the enhancement of the industry collaboration as a strategic objective with a view to extending DIT's academicians' contribution in narrowing the academia- industry gap and introduces students' research based programmes for the employability of its graduates, and to ensure the

effective participation of DIT with industry in supporting economic development. One of the goals identified by the Institute, through which it aims to pursue this objective, is to develop industry links in programme development and delivery. Projects similar to the one described in this paper form part of DIT's effort to reach that goal.

II. METHODOLOGY

1. Sample

A questionnaire based method was used and the data were obtained from two institutions that is Bayero, University and Hussaini Adamu Federal polytechnic for Lecturers, privately employed postgraduate students, self-employed, unemployed graduates, and government. employed that are working at Bayero university works department. All the respondents were from different fields of engineering that **46%** of the sample was Electrical, **4%** Civil, Mechanical **20%, 14%** Computer, **8%**Agric and **8%** other Engineering.

Also **66%** of the respondents were practicing **34%** Non-practicing, no gender was considered and the only 2 undergraduate students were considered as the research mainly focuses on research and developments between industry and academia. Comparisons between participants' viewpoints formed the framework for the data sampling, analysis and interpretation [5]

36 Academic lecturers ranging from Graduate Assistant/Assistant Lectures as the case in polytechnic system to level of professors and chief lecturers as the case in polytechnic system were questioned

22 of the sample was government employed while

8 was privately employed. Also **14** of it was self-employed and **20** fresh but unemployed.

All the students were fully engineering students are fresh engineering graduate and engineers who had completed all required undergraduate practical and industrial trainings.

2. Data Collection

Data collection involved a systematic process of

accessing a number of information in form of a questionnaire from number of sources :Engineering Academicians, Engineers and students as reflective questionnaire, Students 'practice concern and interest, Academician and Engineers' practice concern, industry contacts and consultancy at all level of educations and fields of engineering were considered and assessed as follows:

12. Nature of Job
    Here nature of the job is assed whether they are academicians, government, private, self or even unemployed.
13. Level Of Education
    Under this part level of education were assed which included undergraduate, graduate and post graduate
14. Field Of Engineering
15. Research Publication
    Total No. of Research Publications Industry Inclined/Based ones that are applied in industry and Non Industry Inclined/ Based Ones

16. Practicing
    Engineering practice status was checked
17. Industry Consultancy Services and Industry Contacts
    Practical experiences, how they value and appreciate it, if they are really practicing the engineering or not
18. Research Laboratory Contacts
    The abilities and research skills

3. Data analysis

The use of inclusive analysis helped illuminate the research model of the engineering practice assessment. The data from all sources were aggregated into categories that emerged from content analysis. The categories were integrated into a chart with different sectional parts that reflected the results as feelings, beliefs, and knowledge of the participants.

The use of different sources of data enabled us to represent the participants' authentic voices, experiences, and insights and to reinforce our confidence in the credibility of the data.

III. RESULTS AND DISCUSSION

The idea of in cooperating the lecturers, engineers and a few students of the engineering has revealed the level of practice and research skills among the fellow engineers , Most academicians, students and engineers have shown in adequate effort in real industry contacts ,researches and developments but shown a level of participation of practice. Also substantial amount of the response (88%) (from figure 1-6) has recognized importance of practice that will help in bridging the gap between the academia, engineers and industry at very important level while a few considered it important and less important

IV. CONCLUSION

This research paper has shown a very low level of participation in industry based researches from academicians, engineers and students-: it also exposed the inadequate laboratory and industry contacts and industry consultancy services from engineers, engineering academicians and students. Therefore, this study recommends establishing research and developments centres at institutions such as university, polytechnic e.tc and industries such as manufacturing, services industries e.tc will really improve level of engineers, academicians and students participation in industry related researches and will narrow the existing gaps between academia and industry. Also for academia each faculty should have a R&D unit with every PhD. Holder in that faculty as a member with a position of Research Officer which will bring about more industry contacts, consultancy, industry based researches especially for higher degree holders with a view to narrowing the gap.

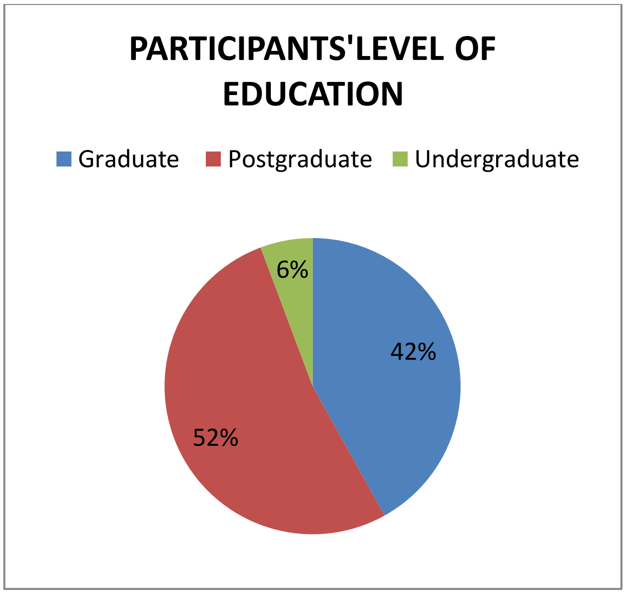

Fig. 1 **Participants' level of Education**

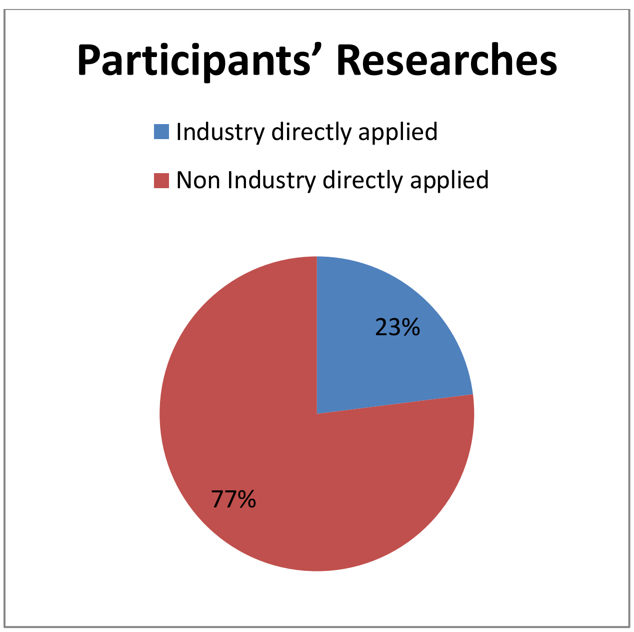

Fig. 2 participants' Researches

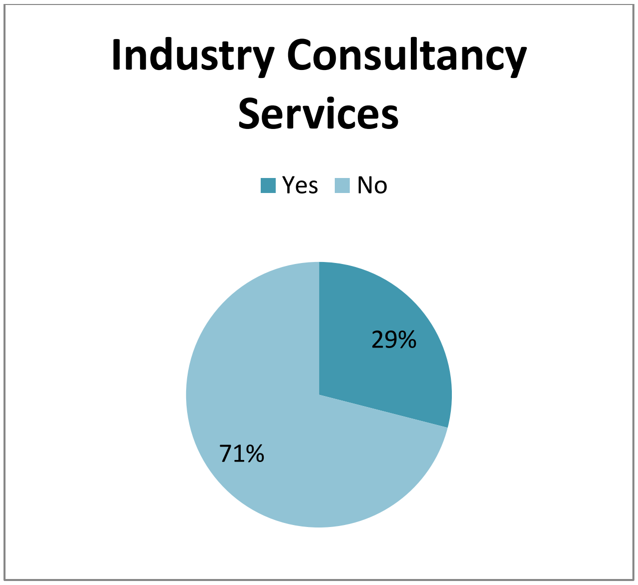

Fig.3 Participants' Industry Consultancy Service Rendering

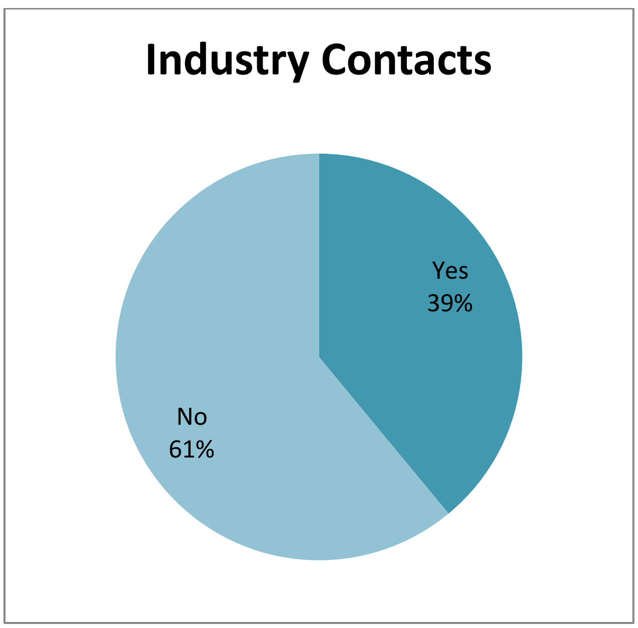

Fig.4 Participants’ Industry Contacts

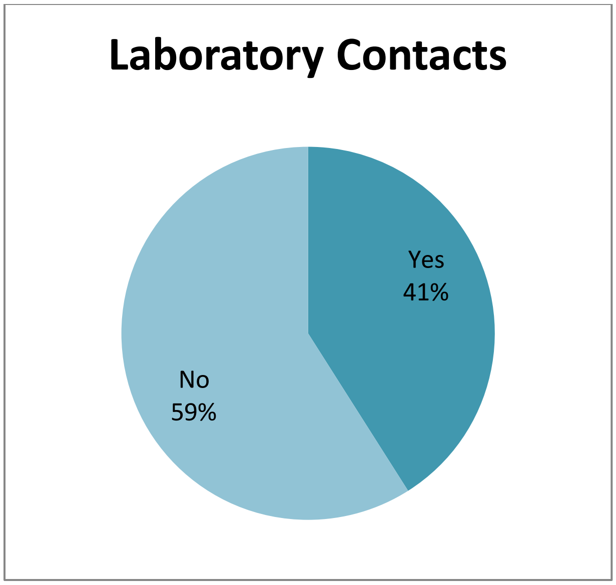

Fig.5 Participants' Laboratory Contacts

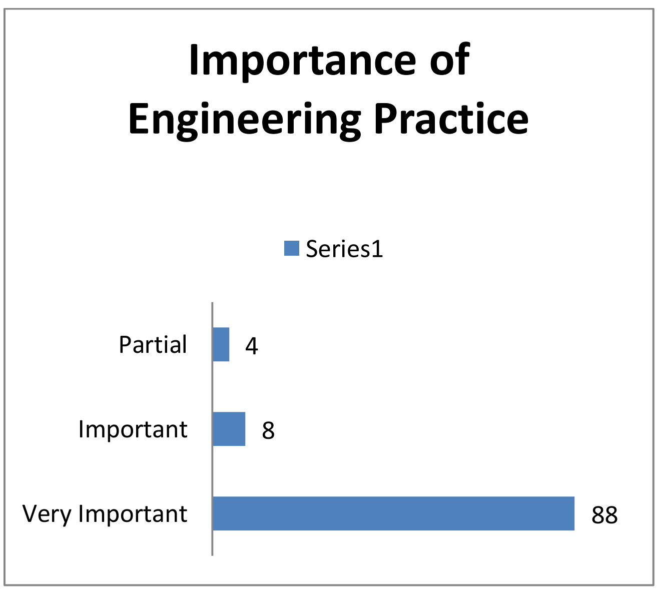

Fig.6 Participants' Perception on Importance of Engineering Practice

REFERENCES

[1] Salter, S.H., "Some new Heresies on the training of Engineers". IEE Colloquium on Design Education, Institution of Electrical Engineers Digest No: 1994/116

[2] Kurowski, P. and Knopf, G "Educating Engineers about Product Design Methodology".

proceedings of 3rd CDEN/RCCI International Design Conference. University of Toronto, Ontario, Canada, 2006

[3] Butterworth, L "The role of craft in reshaping design education", in DESIGN EDUCATION: NOW YOU SEE IT, NOW YOU DON'T. Report of a Seminar organised by the National Society for Education in Art and Design (NSEAD) and the Design & Technology Association (DATA) with the support of the Department for Education and Skills (DfES) at the Royal College of Art on Tuesday 11 July 2006

[4] Steiner, M. "Using Real-World Multidisciplinary Design Exercises to prepare young engineers to enter Today's Workforce". International Engineering and Product Design Education conference, 2-3 September 2004, Delft, The Netherlands.

004269

[5] Shkedi, I.A. (2003). Words that are trying to touch: Qualitative research, theory and practice. Tel-Aviv: Ramot. (Shkedi, 2005).

ESTABLISMENT OF COMMUNICATION LINK BETWEEN MICRO-COAXIAL HELICOPTER AND GROUND CONTROL STATION USING WI-FI TECHNOLOGY

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Abstract

This paper presents the development of communication link between a modified micro-coaxial helicopter and the ground control station of an unmanned aerial vehicle UAV system using a Wi-Fi technology. The communication link between the prototype micro-UAV and the ground control station was established via an Arduino uno platform by configuring the Wi-Fi shield to a dedicated router access point (which was encrypted to prevent unauthorized access) and a visual ground control station window was developed using a program written in visual C# programming language. This was tested in an indoor based environment within the Control Laboratory of Department of Electrical and Computer Engineering, Ahmadu Bello University Zaria. The global positioning system (GPS) data of longitude, latitude, time stamp and speed at which these data were transmitted from the micro-UAV were monitored at the ground station (a laptop PC with GUI developed program) with the aid of the GPS module, Ardiuno micro-controller and Ardiuno Wi-Fi shield. The received signal strength indicator (RSSI) of the link is within the acceptable specification range of -60dBm to -41dBm operating at a frequency of 2.4GHz and data rate of 5.4Mbit/s.

KEYWORDS

FXD: Fei Xaing Da GCS: Ground Control Station, RC: Radio Controlled UAV: Unmanned Aerial Vehicle, H_∞: H-Infinity

1. INTRODUCTION

Unmanned Aerial Vehicle (UAV) is an aircraft system with the absence of human pilot and is rather replaced with other computer and other forms of wireless facilities onboard (Austin, 2011). The UAV in this case is a modified radio controlled (RC) FXD based coaxial helicopter as shown in Fig 1. In this paper, the communication link established finds application in the area of remote sensing of an unmanned aerial vehicle from a base station.

Fig 1: Modified RC based FXD coaxial helicopter.

Most research works have been carried out in the area of modelling and stability analyses of the aerodynamics of a micro coaxial helicopter. By developing different models based on the different configurations. For instance (Seisan, 2012) considered a coaxial system with the absence of stabilizing bar, vertical and horizontal fins and tail rotor. The work employed a non-linear feedback stabilizing controller and the lyaponuv's stability criterion to analyse the stability of the model. The works of (Thien *et al*., 2012), (Schafroth, 2010), (Allan, 2010, Chen and McKerrow, 2007), (Wang *et al*., 2012) and (Muresan *et al.*, 2011) considered a coaxial system without analysing the effect of vertical fin, horizontal fin and tail rotor in their model analysis. In addition, (Cai *et al*., 2011) used single rotor helicopters and considered all the vital parts in its model analysis but had less emphasis on the communication link of its UAV setup. Still on single rotor, however, based on (Yamaha R-50 helicopter model), the works of (Hald *et al.*, 2005) investigated the stability of helicopter using optimal Turning Kalman Predicator with less emphasis on the communication link. On the other hand, authors (Thien et al., 2012) and (Yuan and Katupitiya, 2012) estimated the system parameters of the helicopter using identification toolboxes but did not analyse the communication link in its analysis. Also, most of the single rotor helicopter did not consider the effect of upper rotor and upper rotor flapping angles in the non-linear model derivation of the coaxial helicopter system model.

The works of (Okafor, 2014) provides a complete mathematical modelling of the FXD RC based coaxial helicopter by considering the effect of vertical fin, horizontal fin, tail rotor, upper rotor blade and upper rotor flapping angles in their model analysis, however the effect of communication link setup was not discussed. Moreover, all the reviewed works had not considered the communication link of the modified FXD RC based coaxial helicopter which is open to literatures.

The aim of this paper is to extend the scope of (Okafor *et al.,* 2014) by analysing the procedures required in setting up a communication link between a modified FXD RC based coaxial helicopter which was achieved by incorporating payloads such as: Ardiuno Uno microcontroller, Ardiuno Uno Wi-Fi shield, GPS module and external voltage supply. The remaining parts of this paper are divided into Sections: description of the various kinds of UAV systems are discussed in Section II. The procedures required in setting up the communication link are presented in Section III. Section IV discusses the results and provides the applications of the UAV system. Finally, Section V concludes the work and recommends areas for further work.

2. CLASSIFICATION OF THE VARIOUS KINDS OF UAV

UAVs can be classified based on their endurance and altitudes (Austin, 2011). Furthermore, the classification can be extended based on rotor configuration and nature of its wings.

A. Classification based on Endurance and Altitude

According to (Austin, 2011), the following are the classifications of the UAVs according to endurance and altitude:

1) HALE – High altitude long endurance UAV is characterized by an altitude of over 15000m and endurance duration above 24hours. It is basically used for extremely long-range reconnaissance and surveillance missions. They are usually utilized by Air Forces from fixed bases.
2) MALE – Medium altitude long endurance UAV operates at an altitude between the range 5000–15000m over endurance duration of 24hours, their roles are similar to the HALE systems but they operate at somewhat shorter ranges.
3) TUAV – Medium Range or Tactical UAV operates between the ranges of 100 - 300km. These aircrafts are smaller when compared to HALE or MALE and are mostly operated by the Army and Naval forces.
4) Close-Range UAV is used by mobile army battle groups, military/naval operations and for diverse civilian purposes. These UAVs operate at ranges of up to 100km and find application in diverse areas such as: reconnaissance, ship-to-shore surveillance, crop-spraying and traffic monitoring, etc.
5) Mini UAV is a UAV system below a certain mass (20 kg), but larger in size than a micro-UAV (MAV). It is capable of being hand-launched and operates at a range of up to 30km and are, mostly used by mobile battle groups and for diverse civilian purposes.
6) Micro UAV, also termed as MAV, is characterized by a rotor blade with a radius below 30cm. Micro-UAVs find applications in urban environments especially within buildings. A micro-UAV is basically used to carry out indoor experiments and is attributed with the least altitude of less than 50m and endurance capability of less than 12 minutes.

B. Classification based on Rotor Configuration

Micro-UAV can also be classified according to the rotor configuration as follows:

1) Single Rotor: A single rotor is a kind of UAV that utilizes only a single rotor blade.
2) Coaxial Rotor: A coaxial rotor is a kind of UAV that utilizes two rotor blades. (Christoph, 2011) suggested that coaxial UAVs can further be classified as:

i) Full-Scale coaxial helicopter: it is a UAV with fixed revolutions per minute (rpm) and dual swash plate.

ii) Miniature-Scale coaxial helicopter:
This kind of UAV has a varying rpm, single swash plate and stabilizer and has no collective pitch. Miniature scale coaxial helicopter is termed as a micro-UAV.

3) Quad-Rotor: A quad-rotor is a kind of UAV system that utilizes four rotors blade.

C. Fixed Wing Airplane: This kind of UAV has two fixed wings with a single rotor propeller at the front tip of an aeroplane. **Basic Concept of Wireless Technology**

Most UAVs use Wi-Fi technology for the transmission and reception of data using any of the IEEE802.11a/b/g/n standards. According to (Zaloker, 2003) and (Mammadov, 2013), these standards have theoretical indoor and outdoor ranges of between 35 to 250m. Practical ranges that can be obtained are subject to physical and environmental constraints. An abridged summary of the 802.11 wireless network standards is shown in Table 1. This table illustrates the IEEE802.11b/g protocol standard required in setting up a communication link for data transfer between the micro-UAV and the ground control station. They are both operating at the unlicensed frequency of 2.4GHz. Based on this standard, data transfer rate between 4.5Mbps and 54Mbps (Zaloker, 2003) can be achieved within an allowable distance of 38m indoors. With these specifications, it is expected that the modified micro-UAV can operate in most indoor environments. It is worth noting, however, that the data rates and coverage distance will be affected if there are walls and other forms of obstacles between the ground control station and the micro-UAV (Zaloker, 2003) Also, the joystick transmitter transmits at a frequency of 45MHz. The signal received will determine the navigational control of the helicopter and the level in which the location data (longitude and latitude information) from the air vehicle will be returned back to the ground control station**Table 1: 802.11 Network Standards(**Zaloker, 2003**)**

802.11 Network Standards					
802.11 Protocol	Frequency (GHz)	Data Rate		Approximation Indoor Range	Approximation Outdoor Range
		Typical	Maximum	Meters	Meters
a	5	23Mbit/s	54Mbit/s	35	120
b	2.4	4.5Mbit/s	11Mbit/s	38	140
g	2.4	19Mbit/s	54Mbit/s	38	140
n	2.4/5	74Mbit/s	300Mbit/s	70	250

DEVELOPMENT OF THE COMMUNICATION LINK

A program was developed in Arduino platform in order to configure the Wi-Fi shield to a dedicated router access point which would create a network interface and is expected to show network strength of the communication link via the ground control station (GCS). A program was written into a GPS module with the expectation of returning the longitude and latitude positioning and speed of data transmission from the micro-UAV via the serial monitor of the ground control station (A Visual C# application). The flow chart which shows the program sequence required for establishing a communication link between the micro-UAV and the ground control station is shown in Fig 2. A schematic block diagram was used to illustrate the wireless communication setup between the micro-UAV and the ground control station, which is shown in Fig 3.

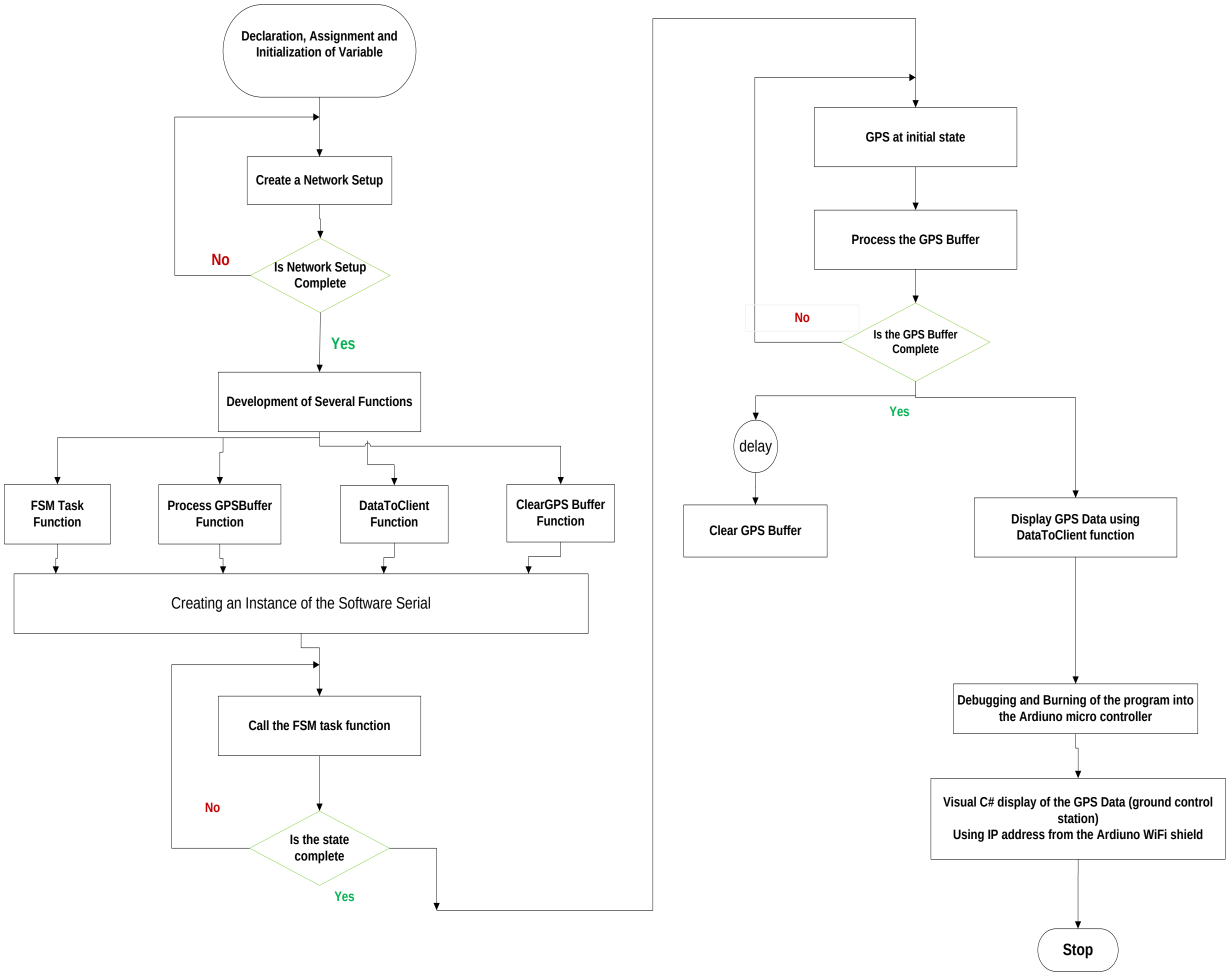

Fig 2: Flow Chart of the Communication Link between the Micro-UAV and the GCS

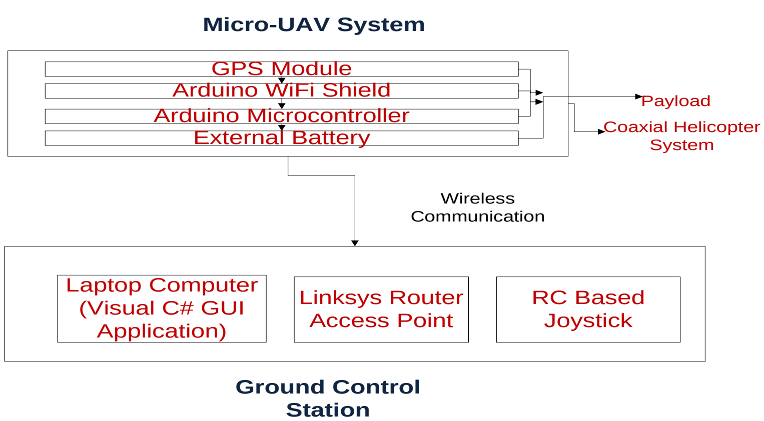

Fig 3: Schematic Block Diagram of the Communication Setup between the Micro-UAV System and Ground Control Station

The steps required for developing the communication link, were discussed as follows:

A. Declaration, Assignment and Initialization of Variables

1) Declaration of directories such as: SPI.h, WiFi.h, WiFiClient.h, WiFiServer.h, WiFiUdp.h, and SoftwareSerial.h to have access to the various libraries associated with the above mentioned directories.

2) Defining the state based on the GPRMC (Recommended Minimum Specific GPS/TRANSIT Data) data of the GPS and allocation of the GPS Buffer_Size to 100, Lat_Buffer size to 13, PORT to 5000

3) Initializing the network name (SSID) and password of the network, this is because the Wi-Fi security is based on a WPA2 (WiFi Protected Access 2)

4) Initializing the dates and the WiFi Server on the basis of the assigned port and creation of a Client that would aid in publishing the GPS data wirelessly.

B. Creating a Network Setup

The following steps are employed in obtaining the network connection.

1) Initializing the Arduino WiFi shield IDE board (WL_IDLE_STATUS)
2) Initializing a serial communication
3) Carrying out a check to determine whether a WiFi-status is equal to WL_NO_SHIELD, if true WiFi shield is not present
4) While if the status is not WL_CONNECTED, the WiFi shield search for the network based on the assigned network name (SSID) and password for every 10 seconds.
5) Immediately a network connection is established, communication can be achieved via a web server over a defined PORT

C. Development of the Various Functions

The following functions were created to facilitate in the process of transmitting of GPS location data:

i) Finite State Machine (FSM_Task) function

ii) ProcessGPSBuffer function

iii) DataToClient function

iv) ClearGPSBuffer function

D. Development of the Main Program for Obtaining the GPS Data

The main program was developed by calling in functions which is presented as follows:

1) Creating an instance of the SoftwareSerial for the transmission and reception of serial gps data if available, this was achieved by using serial port on pins 2 and 3. The data are treated as character.
2) The character is further processed into the FSM_Task function, the processed character is transformed to various states based on the GPRMC.

3) The states in step (2) are set to attain to a COMPLETE STATE with the view of transmitting all the required states else, a loop sequence continues

4) A ProcessGPSBuffer function is called in order to process the "gpsSentenceBuffer", hence DataToClient function is called to publish the clients which are initialized as dates and time, gps location data with direction, speed of transmission and the RSSI. After every display a ClearGPSBuffer function is used to reset the state to the initial status, this is achieved by clearing the Buffer data.

5) The program was debugged in order to correct any form of errors before burning the program into the micro-controller.

6) A visual C# program was developed to stream out wireless information (GPS data) from the micro-UAV back to the ground control station; this was achieved by searching for the IP address of the Ardiuno WiFi Shield using PSCAN application and inserting the IP into the developed Visual C# window in Fig 4.

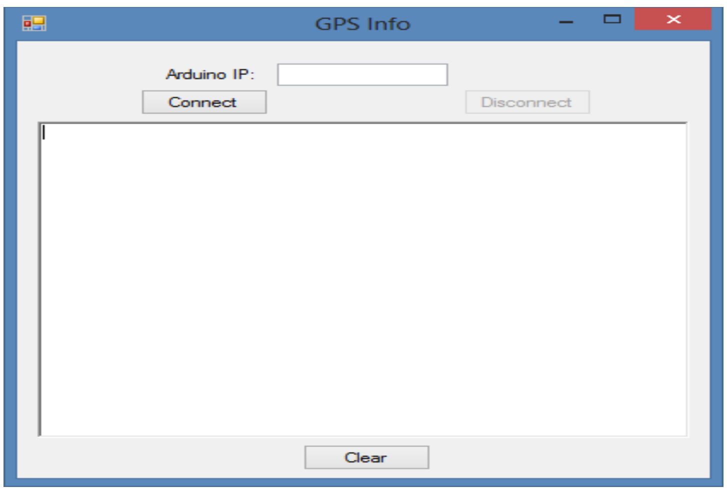

Fig 4 Ground Control Station Window

3. RESULT ANALYSIS

The IP address enables the micro-UAV to transmit GPS data either at stationary position or in motion via the ground control station. The search action is shown in Fig 5.

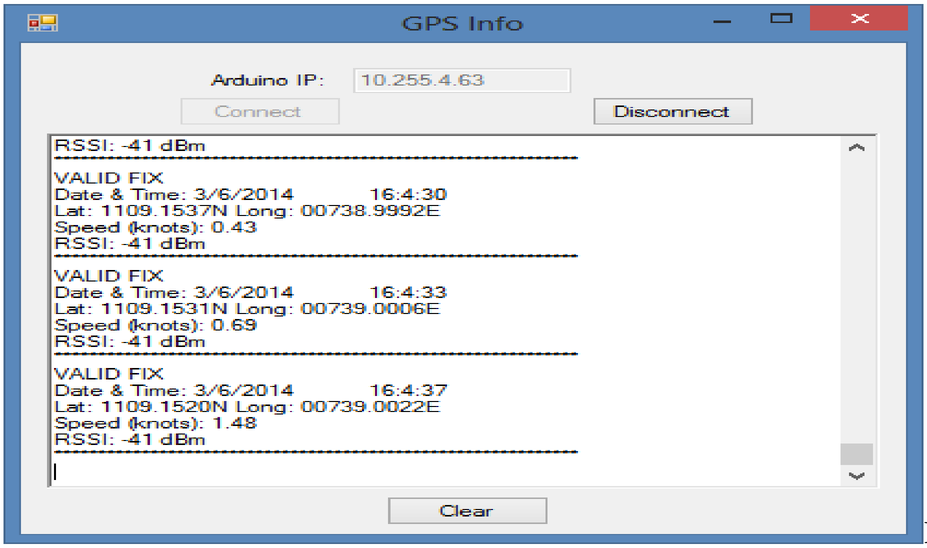

Fig 5: Micro-UAV Data at Ground Control Station

A schematic map of the Control Laboratory is shown in Fig 6

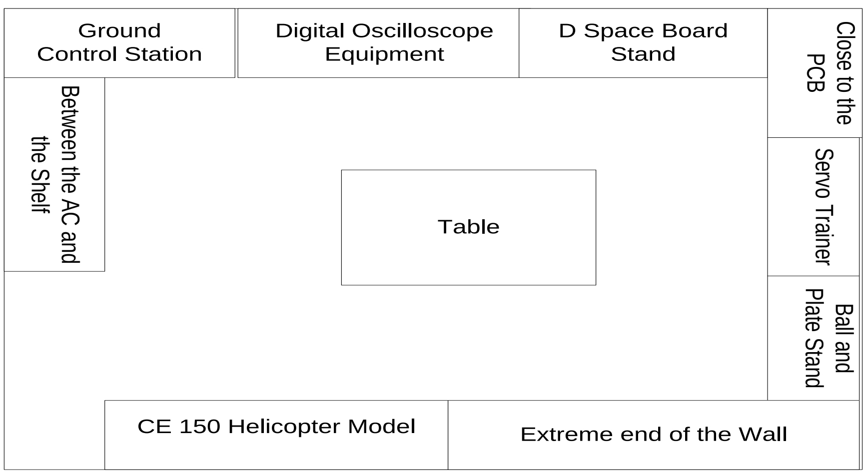

Fig 6: Schematic Map of the Control Laboratory

A. Result Obtained from the micro-UAV system

The global location data and the network information obtained from the micro-UAV via the ground control station indicate the positioning of the micro-UAV at different location within the control laboratory. These information's tell the accurate positioning of the micro-UAV, the network strength between the micro-UAV and the ground control station and finally the speed at which these data are transmitted which was converted to m/s. Table 2 shows the mapped positioning of micro-UAV and its corresponding GPS data which tells at any instance of time the exact location of the micro-UAV system.

These global location data of the micro-UAV positioning were obtained within the Control Laboratory in the Department of Electrical and Computer Engineering, ABU Zaria, although these location data can vary based on the following factors:

The number of satellite the micro-UAV can sense: The number of satellite sensed by the micro-UAV determines the nature of the global location data that will be returned. It was observed that for an effective data to be transmitted, minimum of 3 satellites ought to be sensed. The micro-UAV was able to sense 3 to 6 satellites before transmitting the location data via the ground control station monitor.

i) Speed of data transmission: The speed of the GPS data transmission is within the range 0.16m/s to 0.855m/s. Although the initial reading obtained was in knots and was converted to m/s (1 knot is 0.514m/s).

ii) The received signal strength indicator (RSSI) identified within the range -60dB to -41dB which reflects a good signal level expected to establish effective communication and an electromagnetic wavelength of 0.125m and frequency of 2.4GHz. The data rate of transmission 5.4Mbp.

Table 2 Location of the micro-UAV within the Control Laboratory

Location of the micro-UAV	**Network Strength (RSSI) /** dBm	**Global Positioning System Data**		**Speed of Transmission (m/s)**	**Time (H:M:S)**
		Longitude (E)	Latitude (N)		
Close to the ground control station	-41	7.38992	11.091537	0.215	16:4:30
Close to the digital oscilloscope equipment	-60	7.39011	11.09144	0.245	16:43:57
D Space Board	-60	7.390092	11.091603	0.405	16:54:14
Close to the PCB	-60	7.390143	11.091523	0.63	16:55:47
Servo Trainer	-60	7.390179	11.09148	0.855	16:59:09
Ball Plate Model Stand	-60	7.390093	11.091507	0.675	17:04:07
Endpoint of the wall opposite the door	-60	7.390062	11.091512	0.23	17:5:25

Close to the CE 150 Helicopter Model	-60	7.39003	11.091573	0.59	17:08:02
Between the AC and the Shelf	-60	7.390048	11.091449	0.16	17:09:04

CONCLUSION

The communication link between the micro-UAV and the ground control station was established via an encrypted router accessed point. Sets of programs were developed and burned into the Arduino micro-controller. The global location data of the Control Laboratory in Department of Electrical and Computer Engineering ABU Zaria that were sensed form the satellite was returned effectively to the ground control station via Wi-Fi medium. GPS data obtained tells the exact location of the micro-UAV within the Control Laboratory. The communication link established in this work, finds application in remote sensing of micro UAV system from a given base station, which is relevant to the transportation industry.

Moreover, further works should explore new approaches to auto-control vehicle from a base station, path planning trajectory, collision avoidance, remote sensing and climatic sensing from a very high altitude.

REFERENCE

ALLAN, L. 2010. *Stabilizing Yaw in a Miniature Coaxial Helicopter.* Thesis Report: , University of Queensland, Austrialia

AUSTIN, R. 2011. *Unmanned aircraft systems: UAVs design, development and deployment*, John Wiley & Sons.

CAI, G., CHEN, B. M., DONG, X. & LEE, T. H. 2011. Design and implementation of a robust and nonlinear flight control system for an unmanned helicopter. *Mechatronics,* 21**,** 803-820.

CHEN, L. & MCKERROW, P. J. 2007. Modelling the lama coaxial helicopter. *Faculty of Informatics-Papers***,** 731.

CHRISTOPH, H. 2011. Unmanned Aircraft Design, Modeling and Control. *ETH Swiss Federal Institute of Technology Zurich,***,** 1-24.

HALD, U. B., HESSELBÆK, M. V., HOLMGAARD, J. T., JENSEN, C. S., JAKOBSEN, S. L., SIEGUMFELDT, M., LA COUR-HARBO, A. & THOMSEN, J. S. 2005. Autonomous helicopter-modelling and control. *Report, Aalborg university*.

MAMMADOV, E. 2013. *Long-range Communication Framework for Autonomous UAVs.* University of Ottawa.

MURESAN, B., POP, C., NASCU, I. & CRISAN, R. Nonlinear neuro-predictive control of a miniature coaxial helicopter. Control & Automation (MED), 2011 19th Mediterranean Conference on, 2011. IEEE, 1271-1276.

OKAFOR, E., MU'AZU, B. M., & AKINSANMI., O. 2014. Modeling and Linearization of a Modified RC Based Micro-Coaxial Helicopter Using Small Perturbation Technique. *Zaria Journal of Electrical Engineering Technology,* , Vol.2 No2**,** 34-36.

SCHAFROTH, D. M. 2010. *Aerodynamics, modeling and control of an autonomous micro helicopter.* Diss., Eidgenössische Technische Hochschule ETH Zürich, Nr. 18901, 2010.

SEISAN, F. Z. 2012. *Modeling and Control of a Co-axial Helicopter.* University of Toronto.

THIEN, H. P., MULYANTO, T., MUHAMMAD, H. & SUZUKI, S. 2012. Mathematical Modeling and Experimental Identification of Micro Coaxial Helicopter Dynamics. *International Journal of Basic & Applied Sciences,* 12.

WANG, F., PHANG, S. K., CUI, J., CAI, G., CHEN, B. M. & LEE, T. H. Nonlinear modeling of a miniature fixed-pitch coaxial UAV. American Control Conference (ACC), 2012, 2012. IEEE, 3863-3870.

YUAN, W. & KATUPITIYA, J. A GREY-BOX SYSTEM IDENTIFICATION PROCEDURE FOR SCALE MODEL HELICOPTERS BASED ON FREQUENCY-DOMAIN ESTIMATION METHODS. Proceedings of the 28th Congress of the International Council of the Aeronautical Sciences, Brisbane, Australia, 2012.

ZALOKER, J., & WEERES. S. 2003. Wi-Fi Technical Document. *http://www.arrownac.com/solutions-applications/machine-to-machine/files/atd-wifi.pdf* . **,** 1-5.

PERFORMANCE ANALYSIS OF MINIMUM RECEIVER CONFIGURATION FOR A 3D SOURCE LOCALIZATION USING MATLAB.

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ABSTRACT

Source localization based on time difference of arrival (TDOA) can provide three dimensional (3D) source locations. The performance of source localization based on TDOA depends on the arrangement of the receivers and distance between them. This paper investigates the effect of antenna separation on the performance of 3D source localization using the minimum number of antennas for 3D source localization and evaluates the effects of TDOA on position estimation. The simulation was performed for 2m, 4m and 10m to ascertain the impact of TDOA errors on the source position error (SPE) at low, moderate and high altitude. At a low TDOA error value of 0.005ns, the SPEs are 0.0002m, 0.004m, and 0.0130m for antenna separations of 10m, 4m and 2m respectively. At the moderate TDOA error of 0.015ns, the SPEs are 0.005m, 0.012m and 0.042m for antenna separations of 10m, 4m and 2m respectively. At the high TDOA error of 0.003ns, the SPEs are 0.009m, 0.02m and 0.08m for antenna separations of 10m, 4m and 2m respectively. The evaluation shows that there is a linear relationship between the SPE and TDOA errors but at higher receiver separation the system produces low position errors resulting to higher accuracy in source localization.

Key Words: *TDOA, Three-dimension (3D), SPE and Receiver separation.***1.0**

INTRODUCTION

Source localization is the task of locating an emitting signal source. Among its application includes multilateration which is a type of surveillance technology that determine the position of aircraft by receiving transponder transmission from multiple receiving station antennas [ICAO, 2007]. Other applications include sonar and seismology [Lu et al, 2013]. There are many approaches to source localization, but the most studied and widely used technique is the Time Delay of Arrival (TDOA). TDOA involves finding the time difference between the signals received by two or more receiving antennas. Depending on the number of antennas used, 2D or 3D source localization can be obtained [Neven et al, 2004]. For a 3D source localization, a minimum of 3 receiving antennas are used which are connected to a central processing system where the computation processes are done.

Many articles describe source localization. A group of signal processing algorithm and a kind of multichannel miniature sound intensity sensors were used to realize a practical concept and application of passive acoustic radar for automatic localization [Kotus, 2010]. Using a centralized generalized likelihood ratio test (GRLT), the detection benefit provided by PMR is source localization was derived [Hack, (2012]. The novel bounds on the performance of any source localization algorithm were determined by examining the underwater acoustic source localization problem as an unorthodox communication problem [Buck, 2002]. The algorithm for position estimation was presented in [Ralph and Misra, 2002] and a synthesizable VHDL model of 3D hyperbolic positioning system algorithm was implemented and simulated using IEEE numerical standard (numerical_std) package.

Beside source localization, many article focus on TDOA application in source localization [Lu and Wu 2012, Yong and Florencio 2003, Yong and Florencio 2003, Jean-Marc 2003, Kirkwood 2003, and Yu 2012]. By considering the effect of noise as a function of source to sensor distances, the problems of source localization using TDOA measurements in both 2D and 3D dimensional spaces were considered [Baoqi and Yang, 2013].

A solution for locating a moving source using time difference of arrival and frequency difference of arrival was determined in the presence of random errors in receiver locations [Ho et al, 2007]. The Signal to Noise Ratio (SNR) is used as a benchmark to compare the performance of five different Time Delay Estimation (TDE) techniques [Yushi and Abdulla, 2005].

A comparison is made between the different generalized cross correlation methods for TDE at different observation intervals to determine the accuracy and speed of estimation [Kobra and Seghaleh, 2013].

2.0 SOURCE LOCALIZATION SYSTEM STRUCTURE

A typical source localization system consists of multiple antennas which are spatially located and connected to a processing. The processing unit is where the entire complex computations are performed which involves down converting the received signals received by the antennas and performing TDOA estimations to determine the position of the emitting signal source. The ability of the system to resolve a 2D or 3D emitting signal source location depends on the number of receivers deployed. For a 3D emitting signal source location, a minimum of 4 receiving antennas are used. More receiving antennas result to improved emitter source location which is achieved through averaging.

An emitting source can emit signal from any direction as such 360 degree coverage is necessary. There are possible antenna configurations that can provide 360 degree coverage but in this work a Y-antenna configuration is adopted as the one of the aim of the project to determine the effect of receiver separation on the emitter source locating performance. By adopting the Y-shaped antenna configuration, the distance between the reference antenna and the other receiving antennas can be the same and varied simultaneously.

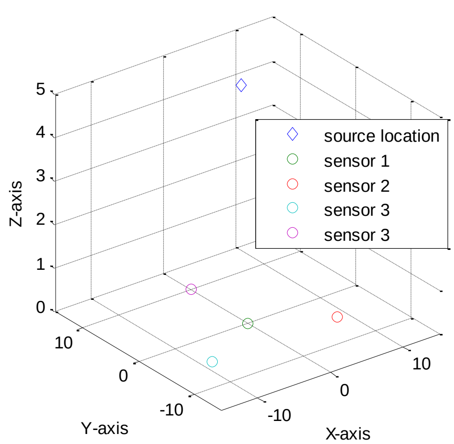

Figure 1: Y-shaped antenna configuration

3.0 SOURCE LOCALIZATION METHODOLOGY

Source localization using TDOA involves finding the time delay between signals received by pair of antennas which is then use to estimate the signal source. The discrete representation of each signal received by each antenna is obtained by converting from radio frequency to intermediate frequency and sample at Nyquist rate. There are several methods of obtaining time delay [Yushi and Abdulla, 2005] but this paper focus attention on the errors obtained from Time Delay Estimation (TDE) which has a direct relationship to the path difference error and its relationship to the signal source position estimation error. Using 1^{st} antenna as reference and a k-th antenna, the path difference obtained from time delay of the signals received by these two antennas is:

$$\Delta d_{1,k} = \Delta t_{1,k} \times c \qquad (1)$$

Where c is the speed of light $3 \times 10^8 m/s$ and $\Delta t_{1,k}$ is the time delay obtained from any of the TDE techniques.

For a four receiver configuration system, the time delay estimates obtained from Eq.(1) are $\Delta d_{1,2}$, $\Delta d_{1,3}$ and $\Delta d_{1,4}$.

Given the position of the signal source in the Cartesian coordinate as (x, y, z), the distance d_k from the signal source to the k-th antenna can be calculated using the Euclidean distance.

$$d_k = \sqrt{(-x_k)^2 + (y - y_k)^2 + (z - z_k)^2} \quad (2)$$

Where (x_k, y_k, z_k) is the Cartesian coordinate of the k-th antenna.

For each antenna pair formed by the reference antenna (k=1) and the k^{th} antenna (2, 3 and 4), the path difference obtained from Euclidean distance is

$$\Delta d_{1,k} = d_1 - d_k \qquad (3)$$

Equation of the path difference obtained from TDE in Eq.(1) and the one obtained from Euclidean distance in Eq.(3) forms the following relationship

$$\Delta t_{1,k} \times c = \sqrt{(x-x_1)^2+(y-y_1)^2+(z-z_1)^2} - \sqrt{(x-x_k)^2+(y-y_k)^2+(z-z_k)^2} \quad (4)$$

By generating a set equations for k=2 to 4, the signal source (x, y, z) can be estimated by solving a set of 3 simultaneous equations with 3 unknowns.

4.0 SIMULATION, RESULTS AND DISCUSSION

Using the system configuration and setup discussed in section 2, a Gaussian random variable with zero mean and standard deviation is introduced in the k^{th} path difference and the SPE is then determined. The TDOA error is included to consider the effect of signal attenuation, quantization error and so on. 100 trails Monte Carlo simulation were conducted for various TDOA errors at antenna separation of 2m, 4m and 10m to ascertain the impact of TDOA errors on the source position error (SPE).

a. Antenna separation of 2 meters

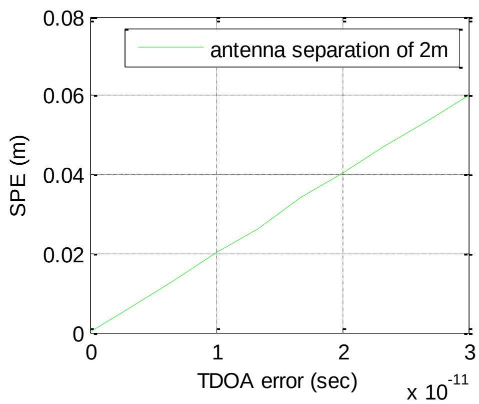

Figure 2: SPE versus TDE error for antenna separation of 2m

Figure 2 shows SPE for various TDE errors at an antenna separation of 2m. From the plot, it can be seen that there is a linear relation between the SPE and the TDOA errors. At a low TDOA error of 0.005ns, moderate TDOA error of 0.015ns and high TDOA errors of 0.03ns the SPEs are 0.01m, 0.03m and 0.06m respectively.

b. Antenna separation of 4 meters

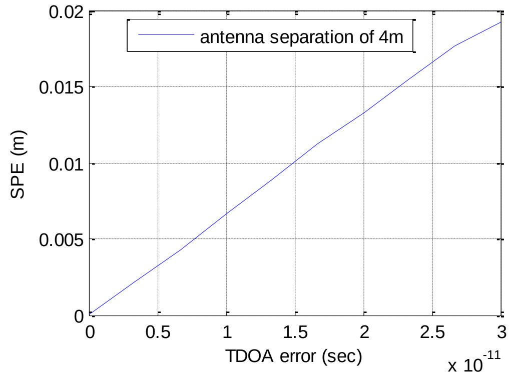

Figure 3: SPE versus TDOA error for antenna separation of 4m

Figure 3 shows the SPE versus TDOA error for an antenna separation of 4m. From the plot at a low TDOA error of 0.005ns, moderate TDOA error of 0.015ns and high TDOA error of 0.03ns the SPEs are 0.003m, 0.01m and 0.02m respectively.

c. Antenna separation of 10 meters

Figure 4 shows the SPE versus TDOA error for an antenna separation of 10m. From the plot at a low TDOA error of 0.005ns, moderate TDOA error of 0.015ns and high TDOA error of 0.03ns the SPEs are 0.0015m, 0.005m and 0.009m respectively.

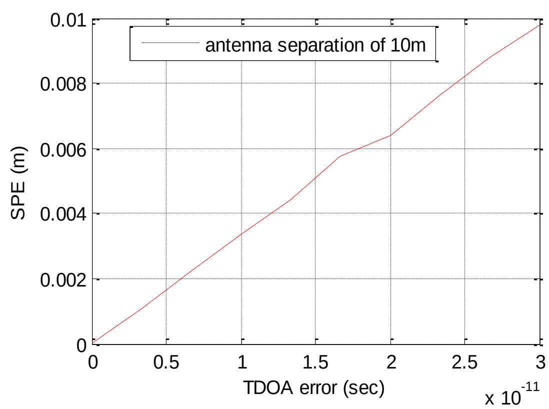

Figure 4: SPE versus TDOA error for antenna separation of 10m

d. SPE and TDOA error comparison for antenna separation of 2m, 4m, and 10m

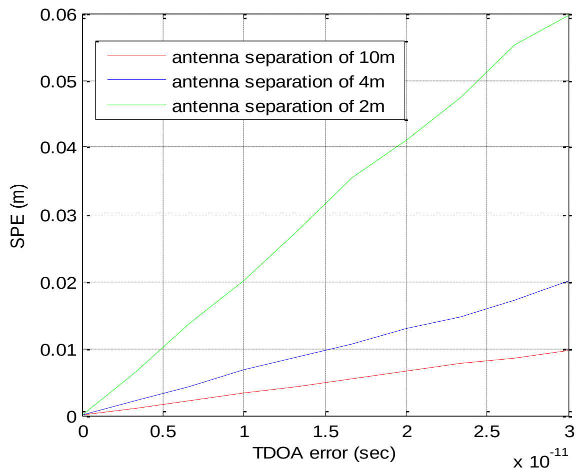

Figure 5: SPE and TDOA error comparison for antenna separation of 2m, 4m and 10m.

Figure 5 show a comparison of SPE and TDOA error of the three antenna separations. From the figure, it can be seen that for all values of TDOA error greater than 0 sec, the SPE error produced by antenna separation of 10 m is low compared to that of 4m and 2m. This means that the system resolves position error at high accuracy when the antenna separation is 10 m compared to the lower antenna separation.

5.0 CONCLUSION

In this work, source localization based on TDOA is implemented using MATLAB and the effect of TDOA error on SPE was determined by varying the distance between the antennas. From the results obtained, for all values of antenna separation there is a linear relationship between the SPE and TDOA error. As the antenna separation increases, the SPE error produced by the system is low resulting to higher accuracy in source localization.

REFERENCES

Baoqi H., Xie L., and Yang Z., (2013), "TDOA-based Source Localization with Distance-dependent Noises.".

Buck, J. R., (2002), "Information theoretic bounds on source localization performance". Sensor Array and Multichannel Signal Processing Workshop Proceedings.

Hack D. E., (2012), "On the applicability of source localization techniques to passive multistatic radar". ASILOMAR Signals, Systems and Computers Conference.

Ho K. C., Xiaoning L., and La K., (2007), "Source localization using TDOA and FDOA measurements in the presence of receiver location errors: analysis and solution". Signal Processing, IEEE Transactions on 55.2: pp 684-696.

International Civil Aviation Organization Asia and Pacific (ICAO) (2007), "Guidance Material on Comparison of Surveillance Technologies (GMST)". Edition 1.0.

Jean-Marc V. (2003), "Robust sound source localization using a microphone array on a mobile robot." IEEE/RSJ International Conference Proceedings on Intelligent Robots and Systems, (IROS). Vol. 2.

Kirkwood B. C. (2003), "Acoustic source localization using time-delay estimation". Technical University of Denmark.

Kobra M., and Seghaleh M. Z., (2013), "Implementation of Time Delay Estimation Using different Weighted Generalized Cross Correlation in Room Acoustic Environments". Life Science Journal, vol 10.no 6.

Kotus, J., (2010). "Application of passive acoustic radar to automatic localization, tracking and classification of sound sources".), 2010 2nd IEEE International Conference on Information Technology (ICIT).

Lu L., and Wu H-C., (2012), "Novel robust direction-of-arrival-based source localization algorithm for wideband signals." Wireless Communications, IEEE Transactions: pp 3850-3859.

Lu Z.; Deng L. K., Wang H., and Luo M., (2013), "Time-delay estimation of multiple targets with wavelet based phase-only matched filter". International Journal of Electronics: pp 1-13.

Neven W.H.L., Quilter T.J., Weedon R. and Hogendoorn R.A., (2004). "Surveillance report on Wide Area Multilateration (WAM)". National Aerospace Laboratory (NLR).

Ralph B., and Misra D., (2002), "A synthesizable VHDL model of the exact solution for three-dimensional hyperbolic positioning system". VLSI Design 15, no. 2: pp 507-520.

Xiaomei Q., and Xie L., (2012), "Source localization by TDOA with random sensor position errors—part I: static sensors". 15th IEEE Conference on Information Fusion (FUSION).

Yu H., (2012), "Approximate Maximum Likelihood Algorithm for Moving Source Localization Using TDOA and FDOA Measurements". Chinese Journal of Aeronautics 25.4: pp 593-597.

Yong R., and Florencio D., (2003), "New direct approaches to robust sound source localization". IEEE International Conference Proceedings on Multimedia and Expo, ICME'03. Vol. 1.

Yushi Z., and Abdulla W. H., (2005) "A comparative study of time-delay estimation techniques using microphone arrays." Department of Electrical and Computer Engineering, the University of Auckland, School of Engineering Report 619 (2005).

A DIRECT FUZZY PID SPEED CONTROLLER FOR DC MOTORS

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ABSTRACT

This work involves design and performance evaluation of a direct fuzzy PD controller for dc motor speed control and a critical comparison with a classical PID controller. One of the characteristics of fuzzy controllers is their capability to be used for the control of processes whose mathematical models are not available. The classical PID controllers also are widely used for industrial processes whose analytical models are difficult or impossible to procure. The fuzzy controller input and output variables are chosen and the universes of discourse are chosen for the inputs and the outputs. The controller rules-base for the P and PD are then developed. Thereafter Matlab/Simulink motor model and fuzzy inference system model are integrated to give a complete fuzzy control system model. The model is then configured as fuzzy, P and PD control systems for dc motors. Simulation and tuning of the modeled control system are carried out concurrently to achieve the specified performance criteria. The fuzzy controllers of P and PD type are shown to be capable of giving zero steady-state error, in contrast to the classical controller for which pure P control could not achieve steady-state error elimination. The P fuzzy controller was tuned to achieve a Rise-time (0-100%) = 0.0244 seconds, overshoot=9.56%, settling-time (2% set-value) = 0.05 seconds and steady-state error = 0. Furthermore, the fuzzy controller performance has been shown to be less stringent in terms of controller parameter settings.

Keywords: DC motor, speed control, fuzzy logic, PID

1.0 INTRODUCTION Although the concept of fuzzy logic could be traced to ancient times (Altrock C.V., 1995) the first publication on the subject was by Lotfi Zadeh in 1965, and the first industrial applications were made after the 1970s (Altroct C.V., 1995),. Ibrahim Mamdani used fuzzy logic to control a steam plant that he could not get under control with conventional techniques (Altroct C.V., 1995). After the first applications the growth of fuzzy logic applications has been fast.

Why are fuzzy controllers needed when there are already other types of controllers available Fuzzy controllers have the following advantages; they are robust, cheaper than conventional proportional, integral and derivative (PID) controllers because they can cover a much wider range of operating conditions than a PID controller, and can operate with noise and disturbances of different natures (Reznik L., 1997). They are also easily reconfigured (Reznik L., 1997).

One of the most common uses of feedback control is to position an inertia load. The inertia load may consist of a very large, massive object such as a radar antenna or a small object such as a precision instrument (Gopal, M., 2002). Electric motors are the commonly used positioning devices in servo systems. In fact electric motors are almost the most widely used actuators in servo systems requiring speed control of inertia loads.
The dc motors are generally used for large-power applications such as in machine tools and robotics. Also in steel rolling plants were precise speed control is needed dc motors find extensive use. The control of dc motors is therefore a very interesting and useful area

Although the advantages of fuzzy controllers are becoming clearer, the actual implementation of the controllers is usually hampered by the dearth of systematic tuning methods. The tuning of the fuzzy controller parameters is treated as a two-level exercise in (Mann G.K.I., et al, 1999); a low-level tuning and a high-level tuning. The high-level tuning is achieved by varying the fuzzy knowledge base parameters (rules, membership functions or universe of discourse. The low-level tuning is described by the apparent linear gains (ALG). The ALG terms adjust the overall magnifications, similar to a conventional linear PID controller (Mann G.K.I., et al, 1999). The controller design was primarily fuzzy PI controller in which an integrator is added in the fuzzy controller output stage. In this paper the design is of a two input fuzzy P and fuzzy PD controller with a differentiator added at the fuzzy controller input to generate the derivative of error term.

The development of a real-time fuzzy PD controller for dc motor position was developed in (Delibasi A., et al). The crisp controller inputs were the position error and the error change. The input variables both have seven membership functions and a 7 by 7 (49 rules) rules table was developed. When the fuzzy logic controller (FLC) was compared with a conventional PID controller it showed a better performance by meeting the set objective of 0.5 or less peak overshoot. In this paper the designed controller has only 25 rules (each of the two input variables has five membership functions) and was able to obtain better result by proper low-level parameters tuning.

Other works related to the fuzzy control of electric motors are (Sheeba C. J., et al), (Raghuwanshi K.., et al.).

In this paper section one is an introduction to fuzzy control, while section two details the development of the DC motor model. In section three a Simulink model of the DC motor is developed. Also the fuzzy control system design is presented. The simulation and tuning of the fuzzy controllers is presented in section four. Section five is conclusion.

2.0 MODEL DEVELOPMENT

In this section the dynamic model of a separately excited dc motor is derived. This model is used to assemble a SIMULINK model and MATLAB commands are used to derive the transfer function and state-space representations of the model.

Certain assumptions were made to simplify the development of the model. The motor inductances and resistances were assumed to be constant, and frictional losses zero. Other nonlinearities such as backlash were also ignored.

2.1 DC motor model

A separately excited armature controlled dc motor is usually represented as shown in Figure 1,

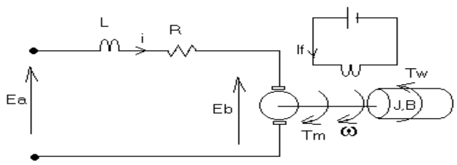

Figure 1 Schematic of a Separately Excited dc Motor

Where the variables and parameters associated with the motor are summarized below

R = armature winding resistance (ohms);

L = armature winding inductance (henrys);

i = armature current (amps);

i_f = field current (amps);

E_a = applied armature voltage (volts);

E_b = back emf (volts);

ω = angular velocity of the motor rotor (rad/sec);

θ = angular displacement of the motor rotor (rad);

T_m = torque developed by the motor (Newton-meter);

J = moment of inertia of the motor rotor with attached mechanical load (kg-m^2);

B = viscous-friction coefficient of the motor rotor with attached mechanical load ((Nm-m)/(rad/sec)); and

T_w = disturbance load torque (Newton-meter).

For the armature circuit the KVL equation can be written in differential form as

$$L\frac{di}{dt} + Ri + E_b = E_a \qquad (1)$$

Using Newton's law of motion the torque equation is written as

$$J\frac{d\omega}{dt} + B\omega + T_W = T_M \qquad (2)$$

For an armature controlled dc motor the developed motor torque is directly proportional to the armature current ***i*** (Chen Z., et al).

$$T_M = K_t i \qquad (3)$$

Where, K_t is the motor torque constant.

Also the back emf induced in the armature circuit E_b (volts) is directly proportional to the rotor velocity ω (rad/sec)

$$E_b = K_b \omega \qquad (4)$$

Where, K_b is the back-emf constant. The torque constant K_t is equal to the back-emf constant, therefore,

$$K_t = K_b = K \qquad (5)$$

Taking the Laplace transform of equations (1, 2, 3, 4) and assuming zero initial conditions, the speed can be expressed as:

$$\omega(s) = \frac{K_t E_a(s)}{[sL+R][Js+B]+K_t K_b} - \frac{[sL+R]T_W(s)}{[sL+R][Js+B]+K_t K_b} \qquad (6)$$

The model represented by equation (6) is presented in block diagram form in Figure 2. To get the transfer function between the motor speed and the applied voltage, the disturbance torque T_w is made equal to zero.

$$\frac{\omega(s)}{E_a(s)} = \frac{K_t}{[sL+R][Js+B]+K_t K_b} \qquad (7)$$

And since in the S.I. measurement system $K_t = K_b = K$, the transfer function between the motor speed ω and the applied armature voltage E_a is given as

$$\frac{\omega(s)}{E_a(s)} = \frac{K}{[sL+R][Js+B]+K^2} \qquad (8)$$

It is thus clear that the model represents a second order system.

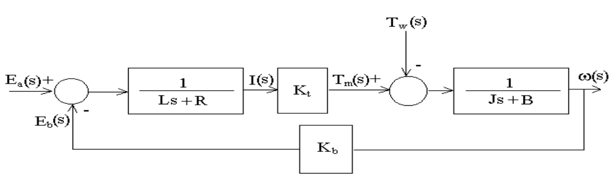

Figure .2 Block diagram of an armature controlled dc motor

2.2 Fuzzy PID controllers

The equation of a conventional P (in which only pure gain is used for compensation) controller is given by:

$$u(t) = K_p * e(t) \quad (9)$$

Where, *u(t)* is the controller output and K_p is the proportional gain factor. The controller is shown in Figure 3.

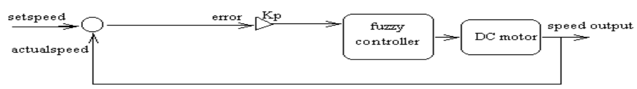

Figure 3 A fuzzy P controller block diagram

The equation for a conventional PD controller is given by

$$u(t) = K_p * e(t) + K_d * er(t) \quad (10)$$

Where, *u(t)* is the controller output, K_p is the proportional gain factor and K_d is the differential gain factor. This controller is shown in Figure 4.

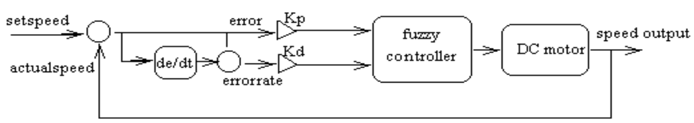

Figure 4 A fuzzy PD controller

Also the fuzzy PI controller is modeled by the equation:

$$u(t) = K_p * e(t) + K_i * es(t) \quad (11)$$

Where K_p and K_i are the proportional and integral gain terms.

The PI controller is shown in Figure 5.

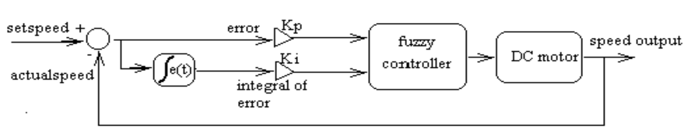

Figure 5 A fuzzy PI controller

The fuzzy PID controller can be constructed as a parallel combination of the PD and PI controllers. The equation of the PID controller is

$$u(t) = K_p * e(t) + K_i * es(t) + K_d * er(t) \qquad (12)$$

And the PID controller can be represented as shown if Figure 6.

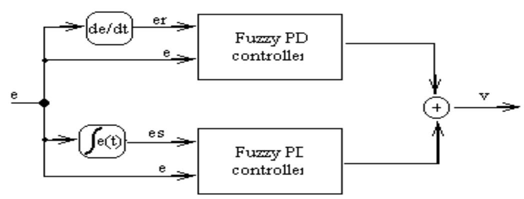

Figure 6 A fuzzy PID controller

3.0 SIMULINK MODELS

Figure 7 shows an analogue computer model of the motor in simulink. A dc motor with the following parameters is used for the control system design (Fitzgerald A.E., et al, 1988):

Rated Power = 0.75 kW

Rated Voltage = 240V

Rated Speed = 500 r/min (52.3 rad/s)

K_t= 4.23 N-m/amp

K_b= 4.23 V/(rad/sec)

L=0.055 H

B=0.273 N-m/(rad/sec)

J=0.068 kg-m^2

R=7.56 Ω.

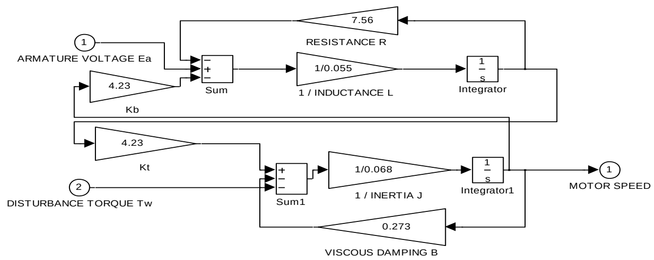

Figure 7 The Simulink motor model with motor parameters

The model was saved as a simulink model file.

The matlab function 'linmod', produces the linear state space model,

$$\dot{x} = \begin{bmatrix} -4.0147 & 62.205900 \\ -76.9091 & -137.4545 \end{bmatrix} x + \begin{bmatrix} 0 & -14.7059 \\ 18.1818 & 0 \end{bmatrix} u \tag{13}$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} x + \begin{bmatrix} 0 & 0 \end{bmatrix} u \tag{14}$$

Where,

$$\dot{x} = \begin{bmatrix} \ddot{\omega} \\ \dot{i} \end{bmatrix} \qquad x = \begin{bmatrix} \dot{\omega} \\ i \end{bmatrix} \qquad u = \begin{bmatrix} E_a \\ T_w \end{bmatrix} \tag{15}$$

The transfer function using the 'ss2tf' functions is: $\frac{\omega(s)}{E_a} = \frac{1131}{s^2 + 141.5s + 5336}$ (16)

And the closed-loop transfer function is given by:

$$\frac{\omega(s)}{E_a} = \frac{1131}{s^2 + 141.5s + 6467} \tag{17}$$

When the reference voltage is set at rated voltage 240 V and the model simulated, the motor speed response is given in Figure 8.

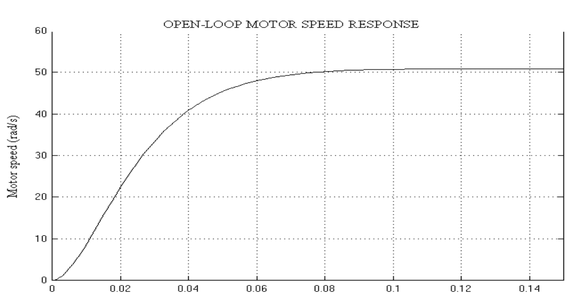

Figure 8 The open-loop speed response to 240 V input.

From the above graph the steady-state speed is approximately 51 rad/s, which is less than the rated speed of 52.3 rad/s. The steady-state is reached after approximately 1.1 seconds.

The transfer function obtained is

$$\frac{\omega(s)}{T_W} = \frac{-14.71s - 2021}{s^2 + 141.5s + 5336} \qquad (18)$$

From the motor parameters, the rated torque for the motor is given by:

$$T_{M\,(rated)} = \frac{0.75kW}{52.3rad} = 14.3Nm \qquad (19)$$

From the simulink model**,** the response of the motor to a step disturbance torque is shown in Figure 9.

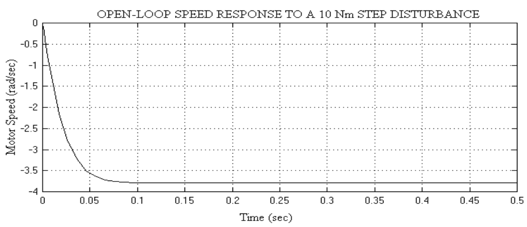

Figure 9 The Open-loop speed response to a 10Nm step disturbance

Clearly the motor speed response is short of adequate. The response should ideally track the set speed and the response to a disturbance should be zero.

3.3 Performance specifications

In this work, performance specifications in (Delibasi, A., et al.) are taken as reference. The performance requirements are:

1. Zero steady-state error.
2. Settling time (2 % steady-state value) < 0.1 sec
3. Overshoot < 2 %
4. And rise-time (0 to 100% steady state value) < 0.1 seconds.

The roots of the open-loop characteristic equation are given by: roots (DENE)

s = -70.7346 +18.2387i, -70.7346 -18.2387i

It is thus clear that the system is stable.

The open-loop response of the motor to a 240 (rated motor-voltage) step-voltage input is shown in Figure 8. The response indicates zero overshoot, a rise time of 0.08 seconds, a settling time of 1.1 seconds and a steady-state error of 1 rad/sec. This is clearly a poor response in view of the set requirements.

3.8 Fuzzy controller design

The fuzzy PID controller is designed using the MATLAB's **fuzzy** and **simulink** toolboxes.The matlab fuzzy toolbox is used to design the fuzzy inference system (FIS). The motor speed error and error-rate (derivative) are taken as the controller inputs. Speed error is given by:

Speed error(e)=setspeed(ss)-actualspeed(as)

Where setspeed (ss) is the reference speed or the command speed i.e. the speed, which the motor is commanded to attain. The actual-speed (as) is the actual motor speed. Thus speed-error is the first variable for the fuzzy controller and is thus the first linguistic variable as in the Figure 10 and they are used to implement the first stage of fuzzy control, that is, the fuzzification for the speed-error linguistic variable. Figure 10 shows the actual membership functions for speed-error as set in the fuzzy inference system (FIS) **PD.** The details for designing the FIS are available in the matlab documentation for the **fuzzy** control toolbox (Mathworks 1987).

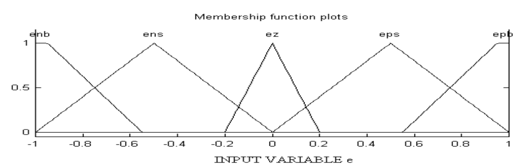

Figure 10 The speed-error e membership functions

The next linguistic variable chosen to improve the precision of the control actions is the rate of change of error or error-rate, which is practically implemented as the derivative of the error. The error-rate variable was also given five membership functions for the fuzzification process. They are,emb, ems, erz, erps and erpb. There is only one output linguistic variable, the control voltage v, with seven membership functions so that a greater degree of control over the output variable may be obtained. The output variable v membership function as used in the fuzzy inference system P and PD is shown in Figure 11.

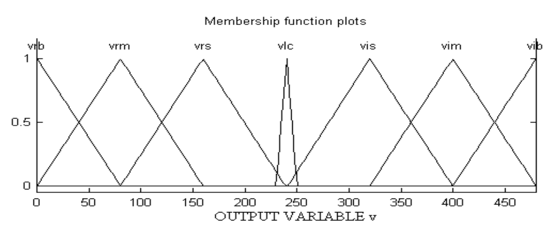

Figure 11 The output variable v membership function

After a number of trials and subsequent simulations, the appropriate rules table (or rules matrix) for the error **e** and error-rate **er** is obtained and these rules are entered in the rules editor of the fuzzy toolbox for the FIS **PD.** The same was done for for P.

The DC motor model developed in section 3.2 is used to build another Simulink model that incorporates the fuzzy controller as shown in Figure 12.

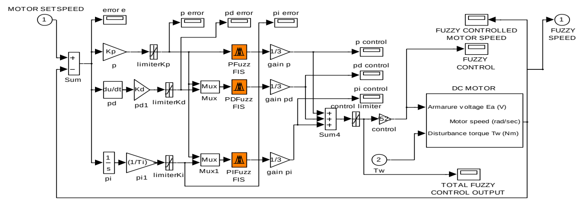

Figure 12 The fuzzy PID control system model

To facilitate a user-friendly interface and protect the model from inadvertent changes the model is masked and input and output facilities provided. The masked model is shown in Figure 13.

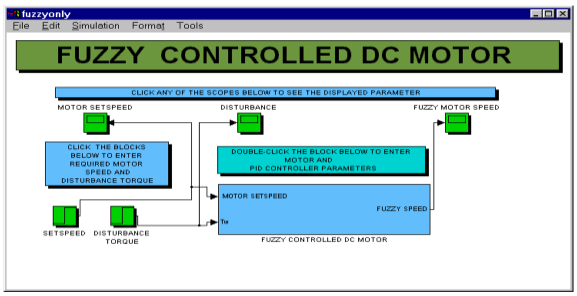

Figure 13 The masked fuzzy PID control system model fuzzonly.

4.0 FUZZY CONTROLLER PARAMETERS TUNING AND PERFORMANCE EVALUATION

In this section, the performance of the developed fuzzy PID controller is evaluated and compared with the classical PID controller. The investigation covers the fuzzy P and PD controllers.

4.1 The fuzzy P controller performance

The Fuzzy PID controller in **fuzzyonly** can be set to perform as a Fuzzy P controller by setting the gains When the proportional controller gain is set to 1 the motor speed response is shown in figure 16.

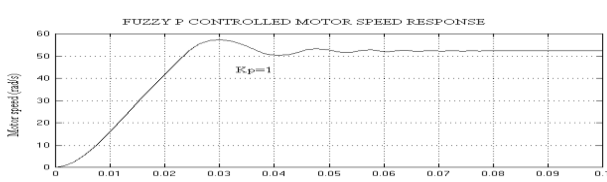

Figure 16 Fuzzy P controlled motor response (K_p=1)

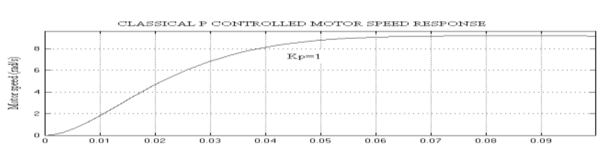

Figure 17 Classical P controlled motor response (K_p=1)

The response rise-time (0-100%) = 0.0244seconds, overshoot = 9.69 %, settling time (2% set-value) ≅ 0.05 and steady-state error = 0. The response of the classical P controller with the same gain setting is shown in Figure 17 its rise-time (0-100%) = ∝ seconds, overshoot = -, settling time (2% set-value) ≅ ∝ and steady-state error = 83%.

From Figure 16 and Figure 17 the fuzzy P controller has almost zero steady-state error, while the classical P controller has an error of 43%. Therefore it is clear that with the fuzzy PID controller the system can be reasonably controlled with only the K_p gain, but for the classical controller the I term must be introduced to eliminate the error. After a number of trials in which K_p is progressively reduced it was found that reducing the gain has little effect on the response until the around the value 0.00000001; the classical controller response for this gain setting is effectively zero. For the fuzzy controller the response is shown in Figure 18.

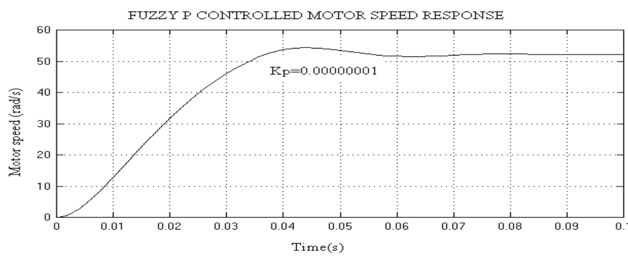

Figure 18 Fuzzy P controlled motor response (K_p=0.00000001)

Rise-time (0-100%) = 0.0371seconds, overshoot = 1.98 %, settling time (2% set-value) ≅ 0.05 and steady-state error = 0.21 (0.4 %). For a gain of 100, the fuzzy P controller response is shown in Figure 19.

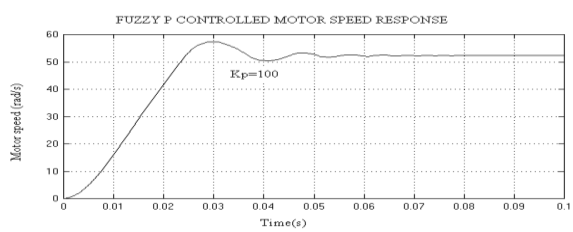

Figure 19 Fuzzy P controlled motor response (K_p=100)

Rise-time (0-100%) = 0.0244 seconds, overshoot = 9.56 %, settling time (2% set-value) ≅ 0.05 and steady-state error = 0.

For the same gain setting the classical controller has the response in Figure 20.

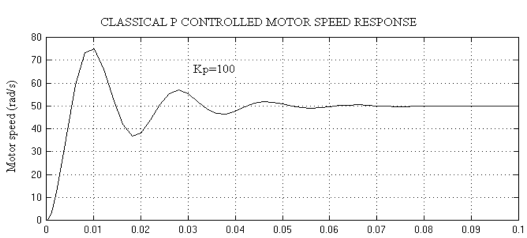

Figure 20 Classical P controlled motor response (K_p=100)

With rise-time (0-100%): 0.006 seconds, overshoot: 43 %, settling time (2% set-value) ≅ 0.03 and steady-state error: 2.4 rad/s (4.6 % of set speed). Although the classical controller shows fast response, the overshoot is clearly too high and the steady-state error is unacceptable. From the simulations above it is clear that the classical P controller on its own can never give the required performance no matter how much the gain parameter is adjusted even though it shows a marked difference in performance for relatively small changes in the gain parameter value. The fuzzy P controller on the other hand, shows a rugged capability to attain the set point, although adjusting the gain has little effect on the performance. Therefore, for a fuzzy controller to achieve optimum performance the most important aspect of the controller design is the proper choice of membership functions, universes of discourse and rules base (high-level tuning (Jantzen, J.)). Therefore, once a fuzzy controller is well designed the tuning of the gain parameters is not as crucial as in the case of the classical controllers.

4.3 PD fuzzy based controllers

The responses of the PD based fuzzy and classical PD controllers are shown in Figures 21 and 22.

I The fuzzy PD controller performance

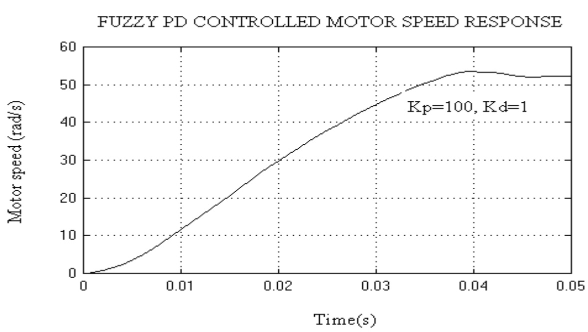

Figure 21 Fuzzy PD controlled motor response (K_p=100, K_d=1)

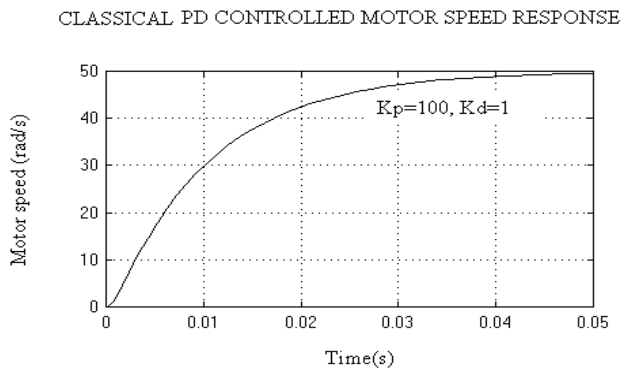

Figure 22 Classical PD controlled motor response (K_p=100, K_d=1)

5.0 CONCLUSIONS

In this paper the design and performance evaluation of a direct fuzzy P and PD controller for dc motor speed control and a critical comparison with a classical PID controller has been performed. The fuzzy controllers of P and PD type are shown to be capable of giving zero steady-state error, in contrast to the classical controller for which pure P control could not achieve steady-state error elimination. Also the fuzzy controller performance has been shown to be less stringent in terms of controller parameter settings. An inherent lapse in the performance of fuzzy controllers is the presence of some ringing in the response (Pivonka, P.). The fuzzy controller developed in this project has manifested very little of this phenomenon

6.0 REFERENCES

Altrock, C.V. (1995). Fuzzy Logic and Neurofuzzy Applications Explained, Prentice Hall, New Jersey.

Butkiewitcz, B. (2000). About Robustness of Fuzzy Logic PD and PID Controller under Changes of Reasoning Methods, Institute of Electronic Systems,.

Chen, Z., Hsu, E. and Sobrado, J., The Fuzzy Shower Challenge. http://ai.iit.nrc.ca/fuzzy/shower/title.html.

Delibasi, A., Turker, T., Cansever, G. " Real-Time DC Motor Position Control by Fuzzy Logic and PID Control

Fitzgerald, A.E., Kingsley, C. and Umans, S.D. (1988). Electric Machinery, McGraw-Hill, Singapore, 1988.

Gopal,, M. (2002). Control Systems, Tata McGraw-Hall, New Delhi.

trollers Using Labview," www.yildiz.edu.tr.

Jantzen, J., "Tuning Of Fuzzy PID Controllers," jj@iau.dtu.dk.

Jantzen, J. (1998) Tutorial on Fuzzy Logic, Department of Automation, Technical University of Denmark, Denmark.

Mann, G.K.I., Hu, B.G. and Gosine, R.G. (1999). "Analysis of Direct Action Fuzzy PID Controller Structures," IEEE Transactions on Systems, Man and Cybernetics-Part B: Cybernetics, Vol.29, No.3.

http://www.engin.umich.edu/group/ctm/PID/PIDhtml
Mathworks (1987). SIMULINK Dynamic System Simulation for MATLAB: The MathWorks Inc., Natick MA.
Mathworks (1987). Fuzzy Logic Toolbox For Use with MATLAB: The MathWorks Inc., Natick MA, 1999.
Olsen, D.," Fuzzy Logic Control in Autonomous Robotics: Investigating the Motorola MC68HC12 on a Line Following Robot," University of Minnesota, Duluth 1023 University Drive, Duluth, MN 55812. USA.
Pivonka, P., Comparative Analysis of Fuzzy PI/PD/PID Controller Based on Classical Controller Approach, Faculty of Electrical Engineering and Communication, Brno University of Technology, Czech Republic.

Raghuwanshi K.., Saxena S. (2014), "Adaptive Controller used for the Speed Control of DC Motor" International Journal of Advanced Technology & Engineering Research (IJATER) www.ijater.com Volume 4, Issue 3, May.
Reznik, L. (1997). .Fuzzy Controllers, Newnes, Oxford.
Sen, P.C. (1997). Principles of Electric Machines and Power Electronics, John Wiley & Sons, New York.
Thompson (1987). Control Systems Engineering and Design, Longman, Hong Kong.
Sheeba C. J., Nivedhith P., (2014), International Journal of Electrical, Electronics and Data Communication, ISSN: 2320-2084 Volume-2, Issue-4, April.
Yurkovich, S., Passino, K.M. (1999). "A Laboratory Course on Fuzzy Control," IEEE Transactions on Education, Vol. 42, No. 1, February.

PERFORMANCE COMPARISON OF NEURAL NETWORK AND DIFFERENTIAL EVOLUTION IN DETERMINATION OF AIR QUALITY

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ABSTRACT

This paper applies neural networks and differential evolution to the estimation of air quality and compares the accuracy of their results using the mean square error (MSE) method. Air pollution is an ever increasing menace in major cities around the world. The MSE approach has been adopted because it is the basis of the Widrow-Hoff or least mean square (LMS) learning algorithm for neural networks and also the gradient-descent optimization technique for differential evolution. Therefore, it provides a common platform for comparing the performance of both algorithms. The air component markers being analysed include oxides of carbon, nitrogen, sulphur and also ammonia. The simulation results show that differential evolution demonstrates fast convergence time and lower MSE values compared to the neural model.

Keywords: feedforward neural network, air pollutants, differential evolution, MSE, metal oxide semiconductor

INTRODUCTION

The problem of air pollution has been a major concern particularly in highly industrialized cities of the world. Common examples are the carbon-based fog clouds seen frequently over the cities of Hong Kong and Tokyo. It has been observed that frequent exposure to air pollutants is likely to result in heart disease, respiratory illness and other health risks, which eventually leads to high mortality rates (Bassel, 1981, Odigure, 2008 and Ediagbonya, 2013). Major sources of air pollution in major cities include carbon monoxide (CO) fumes from vehicle exhausts, refinery and industrial emissions, waste incineration and occassional bush and forest burning. In Kano metropolis, Nigeria, Nabegu (2010) established that improper management of municipal solid waste is another contributing factor to environmental air pollution. It was established in the study that 80% of the population in Kano metropolis do not have access to waste collection services. Also, of the 20% that is collected, 92% of the population considered the service to be extremely poor (Nabegu, 2010). With rising population figures and these poor statistics, there is little wonder why air pollution is increasingly becoming a menace. In addition to comparing the data mining capabilities of neural networks and differential evolution, this work aims to implement softcomputing algorithms which can determine the concentration of the specified pollutants in realtime.

Differential evolution (DE) is a metaheuristic softcomputing technique which is particularly suited to multi-modal or multi-objective function problems (popularly termed non-deterministic polynomial-time or NP-hard problems). It was first proposed by Kenneth Price and Rainer Storn in 1995 when they used it to successfully solve a 33-dimensional Chebyshev polynomial (Price, Storn and Lampinen, 2006). Since then, it has found widespread application in various fields such as in economics, engineering and science to mention a few (Ardia, Boudt et al, 2011). DE is especially suitable for numerical optimization which have no particular defining derivative function. It is for this reason that the algorithm is termed multi-modal and derivative-free. The algorithm is said to have been successfully implemented when desired objectives have been maximised while simultaneously minimising constraints.

Artificial neural networks (ANNs) are an extremely powerful and reliable tool for implementing artificial intelligence. They have been used extensively for many years for data classification and pattern recognition. The key difference between ANNs and conventional computers with regard to data processing is that while computers require a specific set of instructions to successfully solve a problem, neurals networks self-organise their internal components (neurons, axons and dendrites) to obtain the most suitable solution. This approach is based on the human brain's method of data processing which gives an appropriate response based on its ability to either excite or inhibit neural pathways based on a set of firing rules. ANNs have the ability to make sense of extremely complicated or imprecise data by detecting trends and patterns that are too complex to be seen by humans and available computer techniques (Buhari, 2011). The first artificial neuron was applied by neurophysiologist Warren McCulloch and logician Walter Pitts in 1943. Related work using both techniques is found in (Holland, 1975, Lipmann, 1987, and Ardia et al, 2011).

Both neural networks and differential evolution can perform data mining using the MSE approach. This provides a means of comparing the performance of both algorithms by applying them to the classification of similar data sets.

Theoretical Background

The mean square error (MSE) method of data estimation is used to obtain the estimate of an unknown quantity U in terms of certain predetermined or observed data (Guo, Shamai and Verdu, 2005 and Shannon, 1948). Assume $A_1, A_2, \ldots\ldots\ldots\ldots A_n$ represent a sequence of random variables about which a set of observations are available, and U represents the unknown random variable. The task is to obtain the best possible estimate for U in terms of the known observations $A_1, A_2, \ldots\ldots\ldots\ldots A_n$ (MSE). Assume,

$$\hat{U} = \Gamma(A_1, A_2, \ldots\ldots\ldots A_n) = \Gamma(\hat{A}) \qquad (1)$$

Equation (1) represents an estimate for U in terms of the known observations. $\Gamma(\cdot)$ can be either a linear or non-linear function of $\hat{A}$. The error of the above estimate is given by:

$$\varepsilon(\hat{A}) = U - \hat{U} = U = \Gamma(\hat{A}) \qquad (2)$$

$|\varepsilon|^2$ is the square of the above error. Since ε is also a random variable, $M\{|\varepsilon|^2\}$ is the mean square error (MSE). MSE minimization (MMSE) criterion for estimation involves minimizing the MSE by variation over all possible forms of $\Gamma(\cdot)$. With this criterion, the function estimator is chosen such that the MSE is at a minimum (Bhattad and Narayanan, 2004). Under the MMSE, the best estimator for the unknown U in terms of $A_1, A_2, \ldots\ldots\ldots A_n$ is given by the conditional mean of U given $\hat{A}$ such that:

$$\hat{U} = \Gamma(\hat{A}) = \mathrm{E}\{U \mid \hat{A}\} \qquad (3)$$

The MSE is given by:

$$\delta_{\varepsilon}^2 = \mathrm{E}\{|\varepsilon|^2\} = \mathrm{E}\{\left|U - \hat{U}\right|^2\} = \mathrm{E}\{\left|U - \Gamma(\hat{A})\right|^2\} \, (4)$$

The minimum value of the MSE is given by:

$$\delta_{\min}^2 = \mathrm{E}\{\left|U - \mathrm{E}(U \mid \hat{A})\right|^2\} \qquad (5)$$

The measured air sample points from the observed data from which the MSE can then be estimated for both good and poor air quality given the desired values for both observation sets.

DE as an optimization algorithm is best suited to non-continuous, noisy and random-type problems (Zhang and Sanderson, 2009). Examples of such problems include parallel computing, multi-objective and constrained optimization, and filter design. DE as an optimizer performs the following in order to obtain the best possible solution to a problem:

- Initialization: This is the first step in the DE optimization process and includes *boundary specification* and *index generation*. Boundary specification entails setting upper and lower limits for parameters. This is done using upper and lower initialization vectors v_u and v_l. Index generation involves using vector parameters with values ranging from 0 – g. The d-th parameter of the m-th vector has an initial value:

  $$x_{d,m,0} = rand_d(0,1) \cdot (v_{d,u} - v_{d,l}) + v_{d,l} \, (6)$$

  The random number generator $rand_d(0,1)$ returns a uniformly distributed random number within the range $[0,1)$. The subscript 0 is added to indicate that the value being obtained is an *initial value*. DE treats all variables internally as floating-point values irrespective of their type.
- Mutation: This involves obtaining a trial vector population (child vector) from the existing or parent population. This vector is called the *mutant vector*, M and its purpose is to control the rate at which the vector population evolves. It is obtained according to the following relation:

  $$M_{i,g} = x_{r0,g} + F \cdot (x_{r1,g} - x_{r2,g}) \, (7)$$

  Where F is the scaling factor (with an upper limit of 1.0), r0=base vector index, i=vector index, r_1, r_2=difference vectors

Equation (7) represents a form of mutation called differential mutation

- Crossover: This stage distinguishes DE from other evolutionary algorithms. While most EAs have the entire population moving together, DE allows only the best fitting candidates to move on to the next stage. This stage involves crossing each vector with a mutant vector $N_{i,g}$ such that:

$$N_{i,g} = N_{j,i.,g} = \begin{cases} M_{j,i,g} & if \quad (rand_j(0,1) \le C_r \, or \, j = j_{rand} \\ x_{j,i,g} & otherwise \end{cases} \tag{8}$$

Where C_r=crossover probability (0,1)

If the random number is less than or equal to C_r, the trial parameter is inherited from $M_{i,g}$. Otherwise it is copied from $x_{i,g}$.

- Selection: DE compares the trial vector to the target vector from which it inherits its parameters. If the trial vector has an objective function value equal to or less than that of the target vector, it replaces the target vector in the next generation. Otherwise, the target vector retains its position in the population for at least one more generation. The trial vector $t_{i,g}$ is compared to the target vector $x_{i,g}$ according to the relation:

$$x_{i,g+1} = \begin{cases} t_{i,g} & if \; f(t_{i,g}) \le f(x_{i,g}) \\ x_{i,g} & otherwise \end{cases} \tag{9}$$

Once a new population has been selected, the steps described above are repeated until an optimum is located or the specified maximum number of generations is reached.

The DE strategy employed in this work is the DE/rand/1/bin where *rand* denotes that a candidate for mutation is randomly chosen , *1* denotes that a single difference vector is used, and *bin* shows that crossover is according to independent binomial experiments.

Artificial neural networks (ANNs) function based on biological neurons. It is a known fact that humans have the ability to deduce or learn from past experiences. This ability is adopted by ANNs to draw conclusions based on patterns they recognise from data that is presented to them. They have been used extensively in time-series prediction in finance, medical diagnosis, and fraud detection (Papert and Minsky , 1969). It should be noted that neural networks are only as good as the training set used to generate them. As a result, the training stage of neural network development is vital. Training data also has to be updated regularly if the neural network results are to remain accurate (Alkon, 1989). Neural networks are suitable for prediction and estimation especially when input and output data patterns are well understood. Supervised and unsupervised learning are the two most common methods of training neural networks. The former involves adjusting network weights in order to minimize the error between desired and actual outputs. The latter involves training the neural network in such a way that similar input data would yield the same results. In other words, the neural network is allowed to organise itself since no dependent variable(s) is/are specified in the training data. Another effective technique of training neural networks is back-propagation (developed in the 1980s). It minimizes the error by taking the difference between actual and desired results and feeding this error back through the network while adjusting network weights (Lipmann, 1987). Figure 1 shows the structure of an artificial neuron.

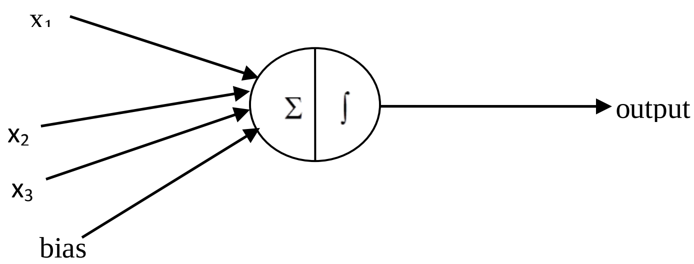

Figure 1. Artificial Neuron (Perceptron)

The neural network structure being used in this work is a feed forward neural network with learning by back-propagation. Feed forward neural networks allow data flow in only one direction(from input to output). A hidden layer makes the network more powerful by allowing it to recognize more patterns (Aleksander and Morton, 1990).

Neural Network Simulation and DE Algorithm

The structure of the feedforward neural network to be used in the simulation of air samples consists of two process layers of five neurons to minimize the tendency of premature convergence. This network structure was selected because it outperformed other structures tested using available training data. 50% of the data samples were used for training while 50% were used for testing. This ensured that the 'peaking effect' associated with test error was avoided. The transfer function used in the training process is the sigmoid or squashing function defined by the relation:

$$f(x) = \frac{1}{1+e^{-\sum_i w_i x_i}} \qquad (10)$$

Error back-propagation learning is enforced using the steep descent minimization method (Widrow and Lehr, 1995). Weight and threshold coefficients between any two nodes *a* and *b* are adjusted according to the following expressions:

$$w_{ab}^{k+1} = w_{ab}^{k} - \eta\left(\frac{\partial E}{\partial w_{ab}}\right)^{k} \qquad (11)$$

$$v_{a}^{k+1} = v_{a}^{k} - \eta\left(\frac{\partial E}{\partial v_{a}}\right)^{k} \qquad (12)$$

Where η is the learning rate and E is the back-propagation error, w_{ab}, v_a are the weight between node a and b, and the threshold associated with a particular node a repectively.
The structure of the neural network model used in this work is shown in figure 1.
Neural simulation is carried out using Neurosolutions version 5 training software. The structure of the neural network is shown in figure 2.

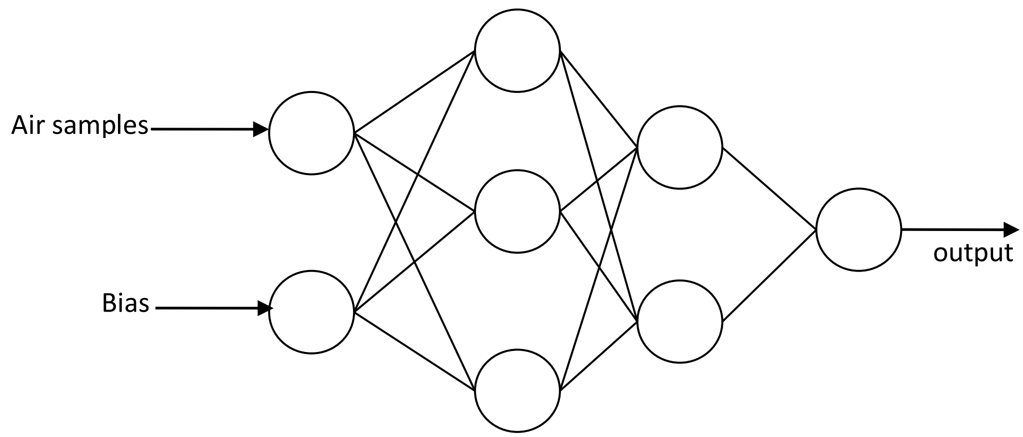

Figure 2. Structure of Artificial Neural Network

In theory, the classification should be linear, since air samples are categorised as either good or bad. In practice, however, it has been observed that the interaction among sample points is somewhat semi-linear (Essiet and Dan-Isa, 2013). This is the reason why the sigmoid function is selected as the biasing function. The neural network's learning algorithm is based on the principle of adaptation by gradient descent. Adaptation involves adjusting the network's synaptic weights in such a way that the output response to associated inputs matches the desired response as closely as possible. In other words, it minimizes the MSE as much as possible.

The method of gradient descent is described according to:

$$G_{j+1} = G_j + \eta(-\nabla_j) \qquad (13)$$

From (13), η is the learning rate while ∇_j is the value of the gradient at a certain point on the MSE surface corresponding to $G = G_j$. An instantaneous gradient based on the square of the instantaneous error is:

$$\hat{\nabla}_j = \frac{\partial E_j^2}{\partial W_j} = \begin{Bmatrix} \dfrac{\partial E_j^2}{\partial w_{0j}} \\ \vdots \\ \dfrac{\partial E_j^2}{\partial W_{nj}} \end{Bmatrix} \qquad (14)$$

The LMS algorithm uses (14) in instead of ∇_j. Substituting into (13) yields:

$$G_{j+1} = G_j = \eta(-\hat{\nabla}_j) = G_j - \eta \frac{\partial E_j^2}{\partial W_j} \qquad (15)$$

The back-propagation algorithm applied to hidden layer learning and adaptation is based on the principle of minimal disturbance (Widrow and Lehr, 1995). This principle allows the network to adapt in such a way as to reduce the output error for the current training pattern with minimal disturbance to the responses already learned. This learning approach makes the idea of generalization realisable.

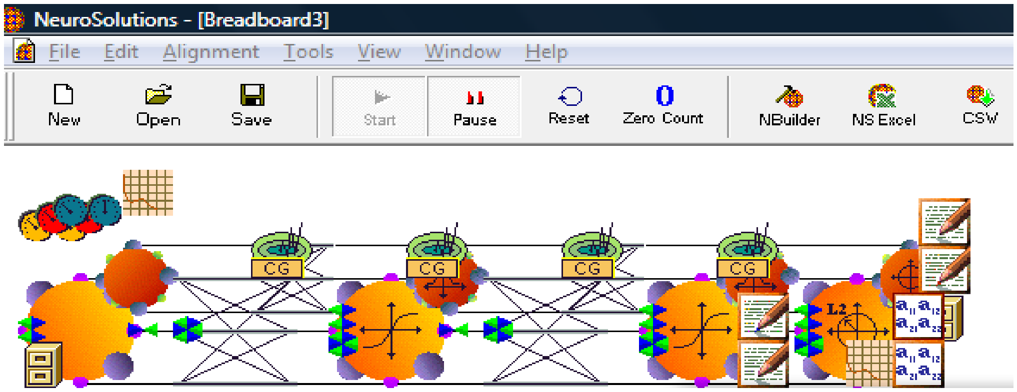

Figure 3. NeuroSolutions Breadboard Simulation of feedforward Neural Network

Air data samples were obtained using a Figaro TGS 2602 air quality monitor in three (3) separate locations around Kano metropolis namely Sabon Gari market, Kano City centre and Nassarawa GRA.

The TGS 2602 has high sensitivity to air contaminants (such as cigarette smoke) as well as hydrogen sulphide from waste materials. The sensor measurements are taken according to atmospheric temperature (ºC)/% of relative humidity(RH). Measurements were generally taken at 30ºC/60%RH to ensure uniformity of results.

The flowchart summarising the DE algorithm used is shown in figure 3.

DISCUSSION OF RESULTS

The neural network and DE algorithm were both used to analyse air sample points obtained using the TGS 2602. The samples obtained at Sabon Gari market and Kano City centre were analysed as having poor quality while those obtained at Nassarawa GRA were good quality samples. 150 sample points were obtained for the poor quality class while 120 sample points were obtained for the good quality class. Data points were obtained in terms of the sensor resistance ratio at 30ºC/60%RH. The sensor resistance is obtained according the following relation:

$$R_{sensor} = \frac{V_{supply} - V_{output}}{V_{output}} \times R_{load} \qquad (13)$$

Sensor resistance ratio values of between 0.80 and 0.95 were generally observed for good air quality while 1.20 - 1.65 was recorded for poor air quality. The confusion matrix results for neural network and DE respectively are shown in tables 1 and 2.

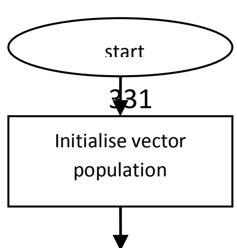

Figure 4. DE Algorithm for Air Quality Data Analysis

Table 1. Confusion matrix showing accuracy of data mining results using neural network

	Good air quality (predicted)	Poor air quality (predicted)	Accuracy %
Good air quality (actual)	109	11	90.8%
Poor air quality (actual)	8	112	93.3%
Overall Accuracy			92.05%

Table 2. Confusion matrix showing accuracy of data mining results using differential evolution

	Good air quality	Poor air quality	Accuracy %

	(predicted)	(predicted)	
Good air quality (actual)	111	9	92.5%
Poor air quality (actual)	6	114	95.0%
Overall Accuracy			93.75%

Table 3. Comparison of DE and Neural Network Using MSE (results obtained using MATLAB)

Session	Neural Network		Differential Evolution	
	Convergence rate (epochs)	MSE	Convergence Rate (epochs)	MSE
1	220	1.778×10^{-15}	117	1.888×10^{-24}
5	345	1.896×10^{-9}	168	1.954×10^{-21}
10	163	3.616×10^{-17}	202	1.432×10^{-19}
13	456	2.688×10^{-15}	196	2.623×10^{-22}
16	203	1.962×10^{-12}	216	2.851×10^{-26}
19	144	2.122×10^{-20}	200	1.081×10^{-25}
21	298	`1.863×10^{-23}	114	2.869×10^{-15}
24	317	1.118×10^{-21}	109	2.452×10^{-12}
27	206	1.264×10^{-21}	120	1.814×10^{-23}

30	172	1.786×10^{-22}	153	1.659×10^{-22}

The results obtained in table 2 show that DE was found to be slightly more accurate at predicting correct results for both sets of data compared to the neural network. Tabulated results comparing both algorithms using the proposed mean square error (MSE) method (crossection of 30 trials) are shown in table 3.

From table 3, it can be seen that the convergence rate for DE is comparatively lower than that of the neural network. DE converged in as low as 109 epochs compared to the neural network which had the lowest convergence rate of 144 epochs (session 19). The MSE results also show that DE converged with less error between actual and processed output data values. MSE recorded as low as 1.081E-25 during session 19 while the lowest for neural network was 1.863E-23 during session 21. These results demonstrate that DE has proved to be faster and more accurate in this work in the determination of air quality compared to the feedforward neural network. Both algorithms developed in this work could be embedded in appropriate hardware for the realtime estimation of air quality.

CONCLUSION

The aim of this work, which is to compare the performance of DE and neural network in the estimation of air quality using MSE, has been achieved.

The results obtained clearly show that in this work, DE outperformed the neural network in terms of mining speed and accuracy of results obtained. Both algorithms have proved to be both easy to use and accurate in terms of data mining and are therefore highly recommended for applications involving noisy and random-type data points. They can therefore be used to implement realtime air quality estimation systems which can be installed at strategic places to provide data for use by environmental monitoring agencies. This would help to combat the risks associated with air pollution especially in major cities around the world.

REFERENCES

Aleksander, I. and Morton, H. (1990). *An Introduction to Neural Computing.*

Alkon, D. (1989). *Memory Storage and Neural Networks.* Scientific American.

Ardia, D., Boudt, K. et al. (2011). Differential Evolution with DEoptim: An Application to Non-Convex Portfolio Optimization. *R Journal* , 27-34.

Ayodele, J. A. (2007). Carbon Monoxide as Indoor Pollutant in Kano Metropolis. *Journal of Applied Science and Environmental Management* , 27-30.

Bassel, F. (1981). *Air Pollution Control.* New York: John Wiley.

Bhattad, K. and Narayanan. (2004). An MSE Based Transformation Chart to Analyze Iterative Decoding Schemes. *42nd Allerton Conference on Communication, Control and Computing.* Monticello, Illinois.

Buhari, M. (2011). Neural Networks. In A. Dan-Isa, *Soft Computing and Metaheuristics* (pp. 10-33). Zaria: ABU Press.

Dekoing, H. S. (1985). *Biomass Fuel Combustion and Health.* World Health Organization.

Ediagbonya, T. (2013). Air Pollution and Respiratory Morbidity in an Urban Area of Nigeria . *Greener Journal of Environmental Management and Public Safety* , 10-15.

Essiet, I. (2014). Neural Network for the Estimation of Ammonia Concentration in Breath of Kidney Dialysis Patients. *IOSR Journal of Computer Engineering* , 61-65.

Essiet, I. O. and Dan-Isa, A. (2013). Practical Discrimination of Good and Bad Food using Metal Oxide Semiconductor Odour Sensor. *Acta Periodica Technologica* , 39-47.

Guo, D., Shamai, S. and Verdu, S. (2005). Mutual Information and Minimum Mean Square Error in Gaussian Channels. *IEEE Transactions on Information Theory* , 1261-1282.

Holland, J. (1975). *Adaptation in Natural Artificial Systems.* Michigan: University of Michigan Press.

Lipmann, R. (1987, April). An Introduction to Computing with Neural Networks. *IEEE ASSP Magazine* .

Nabegu, A. (2010). An Analysis of Municipal Solid Waste in Kano Metropolis, Nigeria. *Journalof Human Ecology* , 111-119.

Odigure, J. (2008). *Safety, Loss and Pollution Prevention in Chemical Process Industries.* Minna: Jodigs & Associate.

Papert and Minsky . (1969). *Perceptrons: An Introduction to Computational Geometry.* Massachusetts: MIT Press.

Price, K.V., Storn, R.M. and Lampinen, J.A. (2006). *Differential Evolution: A Practical Approach to Global Optimization.* Berlin: Springer-Verlag.

Shannon, C. (1948). A Mathematical Theory of Communication. *Bell System Technologies Journal* , 379-423.

Widrow, B., and Lehr, M. (1995). *Perceptrons, Adalines and Backpropagation.* Cambridge: MIT Press.

Zhang, J. and Sanderson, A.C. (2009). JADE: Adaptive Differential Evolution with Optional External Archive. *IEEE Transactions on Evolutionary Computation* , 945-958.

3D-BASED FACE REGISTRATION USING INTRINSIC PROPERTIES

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ABSTRACT

Face segmentation and registration are crucial preprocessing steps for many face related processes such as face recognition, face authentication and facial expression recognition. Although, the task of face and expression recognition are fairly simple to human, but automatic recognition of these tasks by machine remains a difficult task due to variations in face orientation, pose variations and occlusion changes. In this work, we propose a robust and fast face alignment method that aligns the face intrinsic coordinates to the world coordinate system. The UPM-3DFE face database is used in evaluating the proposed method. The face shape residue is used to compute the difference between the depth images of neutral and expressive face belonging to the same individual. Results indicated that after applying the new alignment method, the differences between the two face images have reduced to a mean value of ± 10.

KEYWORDS: 3D face depth image, face residual image, 3D face rotation, facial expression recognition, face registration

1. INTRODUCTION

The recent technological development which makes 3D acquisition fast and efficient had made 3D face related processes one of the most active research topics among image processing community. The 2D image based face modalities is greatly affected by the changes in illumination and pose variation (Rabiu et al, 2012; Rabiu et al, 2013a). These issues are greatly reduced where 3D based images are used. In general, a good face recognition or expression recognition system requires that, all faces under consideration should be in a canonical shape; that is appear to be oriented in the same direction. Thus, face registration is an important preprocessing step for face related processes. The purpose of face registration is to bring two or more face images into correspondence with each other, such that objective comparison between them can be made possible.

In past three decade, researchers have proposed various algorithms for face alignment. For example, iterative closest point (ICP) based method and its variant (Salah et al.,2008; Alyuz et al., 2009; Haar and Veltkamp, 2009; Yunqi et al., 2009; Huang et al., 2011), and face symmetry plane analysis method (Tang et al. 2008; Spreeuwers, 2011). These methods have recorded impressive results. Perhaps the most serious shortfall of ICP base approach is its heavy computational cost, since distance of individual point pair needs to be minimized iteratively by rotating and translating one face image in relation to the other. In the case of face symmetry analysis approach, registration is achieved, using four step procedures;

(i) computing the principal component analysis to roughly determine the face symmetry (ii) this plane is used in constructing the mirror version of the original image (iii) ICP is then used to register the mirror image to the original image. (iv) a fixed nasal bridge angle is assumed for all images to correct imperfection in the x-axis. Conversely, studies in human face anthropometrics (Milgrim et al., 1996; Porter and Olson, 2001; Heidari et al., 2009; Dong et al., 2010) have suggested that, the human nose and indeed its nasal bridge angle varies among different racial and ethnic groups. Therefore, the assumption that nasal bridge inclination is constant can only be applicable to an isolated human race which is not realistic in typical human societies. For instance Figure 1 depicts profile images of two persons from different ethnic groups. It is very clear from these images that, the nasal bridge angles θ_1 and θ_2 formed in the two images differs significantly.

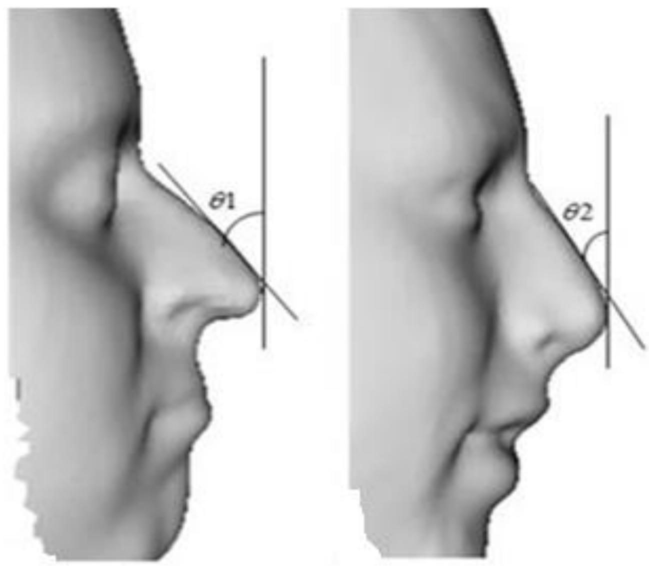
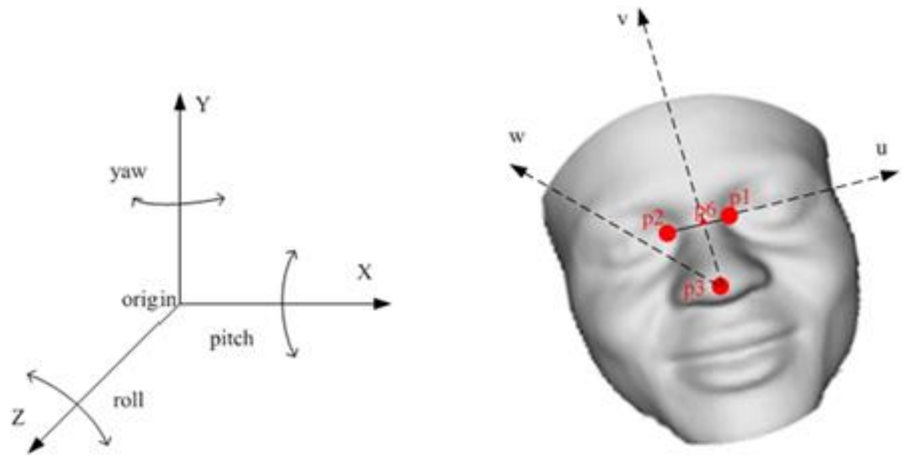


Figure 1: Nose bridge angles from two subjects of different ethnic background (images from UPM-3DFE)

In this work, we proposed a fast and robust method to solve the problem of face alignment which simply transforms the intrinsic coordinate of the given point cloud data into the standard world coordinate system. The intrinsic coordinate system of the face is uniquely defined by the following. (1) The distance between the two inner eyes corners, (2) the nose bridge line (3) the normal vector at the nose tip. The paper is organized as follows: Section 2 briefly described rotation in 3D space. The proposed face alignment method is presented in section3. Results and discussion are reported in section 4. Finally, conclusions are drawn in section 5.

2. THREE DIMENSIONAL ROTATIONS IN EUCLIDEAN SPACE

In this work, we attempt to solve the problem of face mismatch by aligning the three intrinsic coordinates system of the face model (u, v, w) to the three world coordinate system (X, Y, Z) as shown in Figure 2. In the field of computer graphics, the nomenclature world coordinate frame refers to the scene frame, which represents the geometric changes of the scene. Figure 2 (left) depicts a typical world coordinate system. Generally, the X-axis expresses the horizontal changes in the scene and points to the right from the origin. The Y-axis represents the vertical changes in the scene and point up from the origin. The Z-axis represents the depth changes and points outwards toward the viewer. All the three coordinate axes are orthogonal to each other and the point where they all cross is known as origin.



(a) (b)

Figure 2: world coordinate system (a), intrinsic coordinate of the face (b)

Two main issues of great concern in 3D rotations are: (i) the shape related issue and (ii) the pose related. The first one is concern with the shape of the object after the transformation. Rotation in Euclidean space preserves the entire object's geometric information such as distances and angles. In other words it is independent of the camera-object relationship. However, such transformation causes the coordinate values of all points to assume new values. Conversely, the pose related issue has a strong camera-object relationship; as a result the rotational transformation causes a change in object's pose. For example, the point P_{xy} in the X-Y plane when rotated to a new position P' by an angle $\emptyset$ preserves same distance to the origin but assumes new vales of X' and Y' as illustrated by Figure 3.

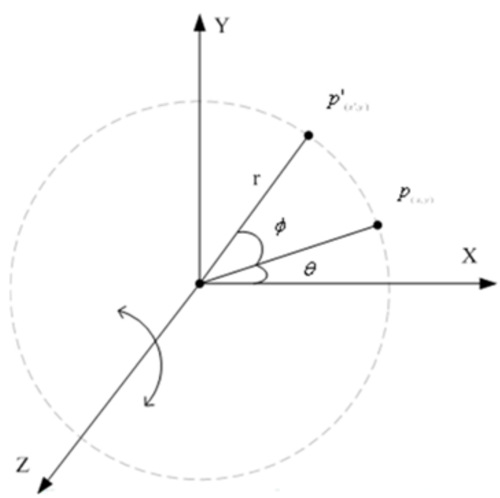


Figure 3: Rotation in 3D space

From Figure 3 it is noted that, after the rotation the coordinates of P and P' are different, but their respective distances r from the origin is preserved. Let the transformation operator be denoted by T, thus it can be deduce from Figure 3 that the new position of P is given as:

$$P'_{(x\,y)} = (rcos\theta + \emptyset, rsin(\theta + \emptyset))$$

$$= (rcos\theta cos\emptyset - rsin\theta sin\emptyset, rcos\theta sin\emptyset + rsin\theta cos\emptyset)$$

$$= (xcos\theta - ysin\theta, xsin\theta + ycos\theta) \quad (1)$$

In the case of 2D images, the axis of rotation is always perpendicular to X-Y plane, which corresponds to the Z-axis rotation in 3D. Thus, the transformation operator T can be derived from equation (1) as reported by Davis (2001).

$$T_{(Z)} = (xcos\theta - ysin\theta, xsin\theta + ycos\theta, Z) \quad (2)$$

where subscript z denotes the axis of the rotation, and x, y correspond to u, v axes respectively. Equation (2) can be written in a matrix form as:

$$T_{(Z)} = \begin{pmatrix} cos\theta & -sin\theta & 0 \\ sin\theta & cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad (2b)$$

Similarly, equations of rotation about the other two principal axes can be obtained using the same procedure discussed above. Equations (3) and (4) give the transformation operator T for rotations about X −axis and Y −axis respectively.

$$T_{(X)} = (x,\ ycos\theta - zsin\theta,\ ysin\theta + zcos\theta) \quad (3)$$

$$T_{(y)} = (xcos\theta + zsin\theta,\ y, -xsin\theta + zcos\theta) \quad (4)$$

3. METHODOLOGY

Face pose correction is a crucial preprocessing step for face analysis, it basically refers to techniques aim at bringing two or more 3D faces into alignment so that the transformed faces appear to be staring directly at the imaging sensor. This problem requires the correction of six degree of freedom (6DoF) corresponding to three angles rotation; the rotation around X-axis (pitch), the rotation around Y-axis (yaw) and the rotation around Z-axis (roll).

Our proposed algorithm for aligning the point cloud data to the world coordinate system is outline in Fig

Face alignment algorithm

Input image = cropped 3D face with the 3 detected vertices p_1, p_2 and p_3.

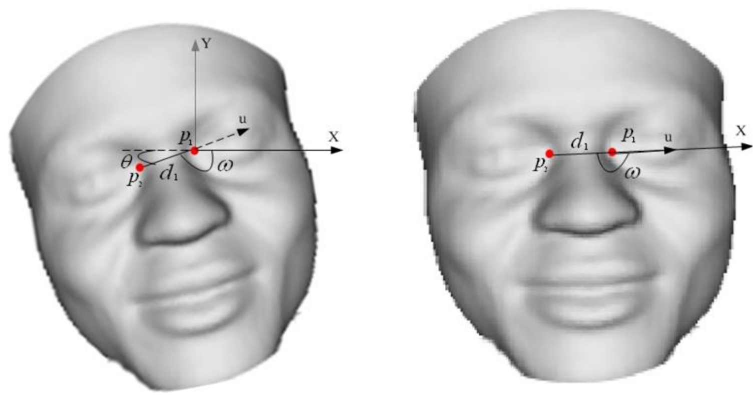
- ***Step 1:*** *Shift the origin of the word coordinate to point p_1.*
- ***Step 2:*** *Keeping v and w constant extend the X-axis to the right.*
- ***Step 3:*** *Determine the angle θ formed between X, p_1 and p_2 with angle at p_1.*
- ***Step 4:*** *Rotate the face data about Z-axis using θ.*
- ***Step 5:*** *Search for two nearest points to the point p_3 call these points p_4 and p_5.*
- ***Step 6:*** *Form a triangle between p_3, p_4 and p_5.*
- ***Step 7:*** *Compute the normal vector $\bar{n}$ to the triangle surface.*
- ***Step 8:*** *Move the origin of the word coordinate to the nose tip point p_3.*
- ***Step 9:*** *Determine the angle $\emptyset$ formed between the $\bar{n}$ and Z-axis*
- ***Step 10:*** *Rotate the face data about X-axis using angle $\emptyset$.*
- ***Step 11:*** *Form a horizontal cutting plane passing through the nose K_1 using the following points $X - axis_{min}$, $X - axis_{max}$ and $Z - axis_{min}$.*
- ***Step 12****: Center the plane K_1 on the nose tip point p_3.*
- ***Step 13:*** *Extend a line from nose tip point p_3 to bisect line d_1, call this point p_6.*
- ***Step 14:*** *Form a vertical cutting plane K_2 using the following points, p_3, p_6, $Z - axis_{min}$.*
- ***Step 15:*** *Center the plane K_2 on the nose tip point p_3.*
- ***Step 16:*** *Determine the angle $\emptyset$ formed between planes K_1 and K_2.*
- ***Step 17:*** *Rotate the face data around Y-axis to make angle $\emptyset = 90^o$\$.*

Output = correctly posed face.

The points p_1, p_2 and p_3 were robustly detected using the technique introduced by Rabiu et al (2013).

3.1 Roll Pose Correction

For a face to be in a correct or standard roll position, our methods assumes that the intrinsic u-axis of the image must be in parallel with X-axis of the world coordinate as shown in Figure 5, steps 1 to 4 of the proposed algorithm.

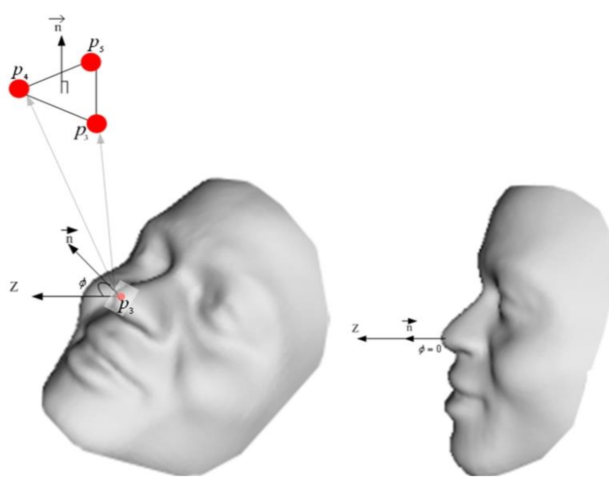


(a) (b)

Figure 5. Roll Pose Correction

3.2 Pitch Pose Correction

To correct a possible in-perfection in the face's pitch pose position, the proposed algorithm attempts to align the intrinsic attribute of the face to the world coordinate system, steps 5 to 10 of the algorithm. The attribute of interest here is the normal vector to the area around the nose tip. Aligning the normal vector to the nose surface with the Z-axis of the world coordinate brings any possible ill-pitch pose of the face, as illustrated in Figure 6.



(a) (b)

Figure 6: Pitch Pose Correction

3.3 Yaw pose correction

In the last stage of the new face pose correction algorithm, the novel method attempts to correct the sideways pose imperfection by fitting two cutting planes to the face data as demonstrated in Figure 7 steps 11 to 17 of the proposed algorithm.

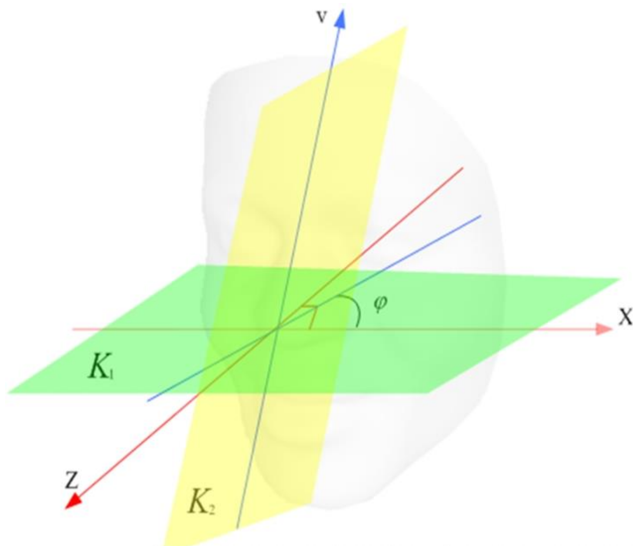


Figure 7: Yaw Pose Correction

4. RESULTS AND DISCUSSION

To test the novel algorithm of 3D face registration presented in section 3, the 350 face images from UPM-3DFE database were used (Rabiu et al 2012b). The database was developed at Universiti Putra Malaysia; the images correspond to faces of 50 subjects drawn from different ancestral background whose ages vary from 10 to 60 years. Each subject presents six basic expressions (happy, sad, angry, fear, disgust and surprise) plus the neutral face image, totaling seven images per participant.

The shape residues were used to measure the disparity between neutral face and expressive one. This was achieved by computing the difference between the depth images of neutral and expressive face belonging to the same individual. Since the images are from the same person, the shape residue is expected to be low for images that are properly aligned. Figure 8 shows the color map of shape residues before and after the alignment, the color map scale represents the disparities in depth at each location between the neutral face and the expressive ones. Locations with higher positive disparity are shown as dark-red, those with higher negative disparity as dark-blue and those with slight positive and negative differences are shown as yellowish and greenish respectively.

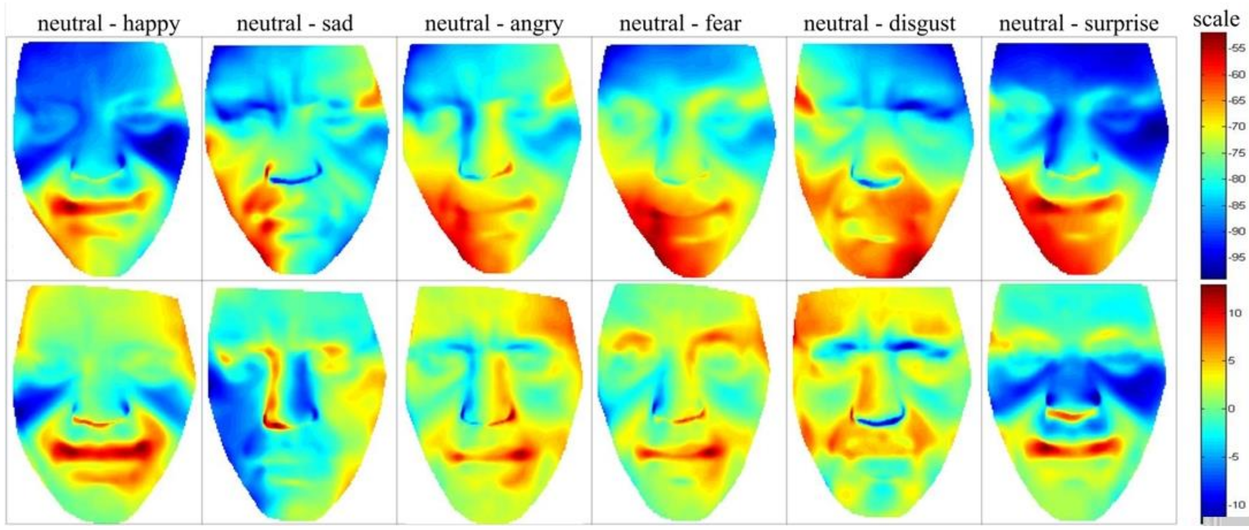


Figure 8- Illustration of Face Alignment: Upper row, image Residues before alignment (large differences). Lower row, image residues after alignment (smaller differences)

It can be observed from the Figure 8 top row (image residues before the alignment) that, majority parts of these images are covered with dark-blue and dark-red, indicating higher disparity between the two images with a mean differences of -55 to 95, especially around expressive sensitive regions (mouth and eye regions), even though the images belong to the same subject. However, after a applying the proposed face alignment technique Figure 8 bottom row, the images now appear to have more yellowish and greenish look, indicating much lower disparities with mean differences of ±10.

5. CONCLUSION

In this work we presented a new 3D face registration method that aligns the face intrinsic coordinates to the world coordinate system. Using two inner eye corners the possible ill- roll pose of the face mesh is corrected. The pitch pose is corrected using the normal vector detected at the nose tip surface. Finally, the yaw pose is corrected using two orthogonal planes, one inserted vertically, while the other horizontally into the face meshes. The new method was tested on 350 face images corresponding to 50 persons from different ethnic groups. The proposed method successfully reduced the image residue between the neutral and expressive faces from mean value of -55to95 before the alignment to a mean difference of ±10 after the alignment.

REFERENCES

Davis, T. (2001), *Homogeneous coordinates and computer graphics*, http://www.geometer.org/mathcircles, (accessed 22 July, 2011).

Dong, Y., Zhao, Y., Bai, S., Wu, G. and Wang, B. (2010). *Three-dimensional anthropometric analysis of the Chinese nose.* Journal of Plastic, Reconstructive & Aesthetic Surgery 63 (11): 1832–1839.

Haar, T. and Veltkamp, R. (2009). *A 3D face matching framework for facial curves.* Graphical Models 71 (2): 77–91.

Heidari, Z., Mahmoudzadeh-Sagheb, H., Khammar, T. and Khammar, M. (2009). *Anthropometric measurements of the external nose in 18–25-year-old Sistani and Baluch aborigine women in the southeast of Iran.* Folia Morphologica 68 (2): 88–87.

Huang, D., Ouji, K., Ardabilian, M., Wang, Y. and Chen, L. (2011). *3D face recognition based on local shape patterns and sparse representation classifier.* Advances in Multimedia Modeling 6523 (2011): 206–216.

Milgrim, L., Lawson, W. and Cohen, A. (1996). *Anthropometric analysis of the female Latino nose: revised aesthetic concepts and their surgical implications*. Archives of Otolaryngology- Head and Neck Surgery 122 (10): 1079–1086.

Porter, J. and Olson, K. (2001). *Anthropometric facial analysis of the African American woman.* Archives of Facial Plastic Surgery 3 (3): 191–197.

R. Habibu, M. Syamsiah, M. M. Hamiruce, and S. M. Iqbal, (2012). *UPM-3D facial expression recognition Database (UPM-3DFE)*, in *PRICAI 2012: Trends in Artificial Intelligence*, Springer, 2012, pp. 470–479.

Rabiu, H., Saripan, M. I., Mashohor, S., & Marhaban, M. H. (2012)b. *3D facial expression recognition using maximum relevance minimum redundancy geometrical features*. *EURASIP Journal on Advances in Signal Processing*,*2012*(1), 1-8.

H. Rabiu, M. Ajiya and D.S Shuaibu (2013a). *An Investigative Study on the Influence of 3D Geometrical Face Features and their Significance on Facial Expression Recognition*. Zaria Journal of Electrical Engineering Technology.

Rabiu, H., Saripan, M. I., Marhaban, M. H., & Mashohor, S. (2013b, October). *3d-based face segmentation using adaptive radius.* In *Signal and Image Processing Applications (ICSIPA), 2013 IEEE International Conference on* (pp. 237-240).

Salah, A., Alyüz, N. and Akarun, L. (2008). *Registration of three-dimensional face scans with average face models.* Journal of Electronic Imaging 17 (1): doi:10.1117/1.2896291.

Spreeuwers, L. (2011). *Fast and accurate 3d face recognition.* International Journal of Computer Vision 93 (3): 389–414.

Tang, X., Chen, J. and Moon, Y. (2008). *Accurate 3D face registration based on the symmetry plane analysis on nose regions.* In Proceedings of the 16th European signal processing conference Lausanne, Switzerland, August 25-29.

Yunqi, L., Dongjie, C., Meiling, Y., Qingmin, L. and Zhenxiang, S. (2009). *3D face recognition by surface classification image and pca.* In Proceedings of the Second International Conference on Machine Vision, Dubai, United Arab Emirates, 28-30 Dec. 2009, 145–149.

EFFECT OF CASE-HARDENING ON MECHANICAL PROPERTIES OF MEDIUM CARBON STEEL (AISI C-1036) USING NATURAL CARBONACEOUS MATERIALS

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ABSTRACT

This paper examined the effect of case-hardening on mechanical properties of medium carbon steel grade using natural carbonaceous materials. The three carbonaceous materials used in this work were Palm Kernel Charcoal (PKC), Wood Charcoal (WOC), and Bone Charcoal (BOC), each of which contains a certain amount of carbon required to effect case hardening. Microstructural and chemical analyses of the samples were carried out.The samples were subjected tohardness and tensile tests. The results revealed that a tensile strength of 1684.17 N/mm^{2}for PKC an increase of 376N/mm^{2}compared to WOC, and BOC which imparted maximum tensile strength of1507.35 and 1500.35 N/mm^{2}respectively.Casehardening of AISI C-1036 steel using WOC and BOC increases the tensile strength of the steel by 689 and 703 N/mm^2 respectively within the range of 800 to 950^o C compared with PKC which resulted in an increase of 376N/mm^2. Case-hardening treatment offers a means of enhancing the strength and wear resistanceof parts madefrom relatively-inexpensive easilyworked materials. Case hardening treatment using PKC enhances mean hardness from 48.5 HRB to 64.4HRB (32.8%) compared with 20.6% and 11.8% for WOC and BOC respectively.This technique can be used to boost the service-life for most of our steel components.

SIGNIFICANCE: Low carbon content in medium carbon steel hinders its usefulness when subjected to dynamic and thermal stresses. The use of these natural carbonaceous materials will improve both the wear résistance and the fatigue strengthof medium carbon steel components under dynamic and thermal stresses. The results will also be useful to the manufacturing industries in order to impart different properties to medium carbon steel.

KEYWORDS: Carburizing, Depth case, Hardness, Tensile strength, Carbonaceous materials, Austenizing temperatures, Metallography.

1.0 INTRODUCTION

Case hardening produces a hard, wear-resistant surfaceor case over a strong, tough core. The principalforms of casehardening are carburizing, cyaniding, and nitriding. Only ferrous metals are case hardened.Case hardening is ideal for parts that require a wear-resistant surface and must be tough enough internally to withstand heavy loading. The steels best suited for case hardenings are the medium-carbon and medium carbon-alloy steels. When high-carbon steels are case-hardened, the hardness penetrates the core and causes brittleness. In case hardening, the surface of the metal is chemically changed by introducing a high carbide or nitride content but the core remains chemically unaffected. When heat-treated, the high-carbon surface responds to hardening and the core toughens.

The advent of different heat treatment methods such as carburizing and furnace expedite the production of good carburized steel which provided relief to early metallurgists. The application of modern and innovative heat treatment methods (such as liquid carburizing) and furnace assist the metallurgist to evaluate the effect of any heat treatment methods on the mechanical properties of steel and providing precision in heat treatment process. During carburization in salt bath, the surface of medium carbon steels becomes enriched with carbon and a little nitrogen, usually at temperatures between 850 and 950^oC. It is the task of the molten salts to heat upon the parts to the reaction temperature and to release carbon by decomposing the cyanide. Decomposition of the carbon can be accelerated by the addition of earth alkaline compounds, such as salt–baths, designated“activated carburizing baths”.

Having carburized the work pieces, a wear resistant surface with a hardness of more than 50HRC and a tough core with strength of up to about 13000N/mm^2 are possible, depending on the material from which the component is manufactured. Meanwhile, great demands are made of mechanical properties of case hardened components. At this level, the composition of the carburized marginal zone is important. Properties, such as surface hardness and wear resistance, fatigue strength and impact values are greatly influenced by the structure and composition of the marginal zone (Adegbola, 2005).

2.0 MATERIALS AND METHODS

2.1 Materials

The medium carbon steel (AISI – C1036) was obtained from Dana Steels Rolling Mill Ltd, Katsina, Nigeria. The specimen was pickled and cleaned before burying into carbon –rich mixture (Palm Kernel charcoal, Bone charcoal, and Wood charcoal).These sources of Carbon were packed with molasses which act as a binder that enables the specimen to be thoroughly heat treated without any loss of carbon atom at different austenizing temperatures and carburizing times. The bottom of the carburizing container was covered with the carburizing materials to about 20-30mm deep before burying the specimens.The carburized containers were placed in an electric furnace and heated to temperature range of 800^oC - 950^oC and the temperature was maintained for duration of 2 hours. The specimens were subsequently allowed to cool in still air. For tempered specimens, the steel will then be heated to 200^oC for 2 hours and Palm Kernel as a Carburizer will enable the Carburized parts to be tough, that is, hard case and soft core.

The carburized component was later prepared for micro structural examination by grinding and polishing the surface using 240 and 320 grades of emery paper before finally carrying out the etching. Etching is performed by using 5% Nital.

2.2 Experimentation

i. Hardness test

A carburized steel specimen with palm kernel charcoal was subjected to hardness test in accordance with ASTME18 specification for metals on a Welltest Rockwellhardness tester. The test was conducted with a $^{1}/_{16}$*-inch-diameter (1.588 mm)* steel ball with a minor load 10N and major loadof 100N on a HRB scale. An image was selected toenlarge the indenter by allowing it to move down into position on the part surface of the test metal. The minor load was applied to establish the zero reference position. The major load was subsequently applied to exceed the zero reference position for aspecific dwell time, and gradually released leaving the applied minor load. The Rockwell hardness number representing the difference in depth from the zero reference position as a result of the application of the major load was read off. Similar test procedure was also adopted for specimens carburized with wood charcoal and bone charcoal respectively.

ii. Tensile test

A standard test specimen of circular cross sectional carburized steel with palm kernel charcoal was axially loaded in TQSM 100 Universal Material Testing Machinein accordance with ASTM E8 standard for tensile testing of metals. During testing, the sample was gripped at each end and in order to ensure simple uniaxial loading and to avoid fracture occurring in the region being gripped. The load was increased at a constant rate by a hydraulic action causing the elongation, reduction of cross sectional area and eventual fracture of specimens. Furthermore, maximum tensile strength of the specimens was calculated. Similar test procedure was also adopted for specimens carburized with wood charcoal and bone charcoal respectively.

2.3 Metallographic Examination

A sample from each group was prepared for micro-structural examination following the five steps below:

(1)Mounting of specimens: The specimens were mounted on the table vice of the grinding machine.

(2) Grinding of the mounted specimens: The mounted specimens were ground on the machine

(3) Polishing of the ground specimens to mirror finishing: 240 and 320 grades of emery paper were used to polish the specimens to mirror finishing manually.

(4)Etching of the polished surface: Etching was performed by using 5% Nital.

(5)Micrographic Examination: The micro-structural examinations of the prepared samples were viewed under Scanning Electron Microscopic equipment (SEM) Model No. JEDL-120AUS with a powerful microscope set @ 100 magnification in accordance with ASTM E1077 (See appendix for photograph).

3.0 RESULTS AND DISCUSSION

3.1 Results

The experimental results are as follows:

i) Hardness Testing

ii) Tensile Testing

1. **Hardness Testing Results**

Table 3.1: Hardness of the medium carbon steel (AISI C1036) specimen case hardened with natural carbonaceous materials

Types of Carbonaceous Material	Mean Hardness No. (HRB)	Increase in hardness %

Palm kernel charcoal	64.4	32.8
Wood charcoal	58.5	20.6
Bone charcoal	54.2	11.8
Control Specimen (as received)	48.5	___

2. **Tensile Strength Test Results**

Table 3.2: Tensile strength of sample AISI C-1036 steel

Temperature (^oC)	**Tensile strength of medium carbon steel (N/mm^2)**		
	Palm Kernel	**Wood Charcoal**	**Bone Charcoal**
800^oC	1308.1	817.77	797.00
850^oC	1507.35	1220.02	1170.05
900^oC	1584.02	1487.35	1439.48
950^oC	1684.17	1507.35	1500.35

4.0 DISCUSSION OF RESULTS

From plates 1- 4, the microstructures revealed that, hardness reduces progressively until it reaches the core hardness. This necessitated the caution for not grinding the parts excessively, otherwise the resulting surface hardness and strength will be significantly diminished. The microstructures also revealed that martensite partly transformed into ferrite (white) and cementite. The case of the steel became hardened with soft core, which resulted in toughness of the entire component, thereby making the steel component to be tough and becomes wear resistant against the surface of any other mating component.

The effect of the thermo chemical heat treatment on tensile strength (Fig.4.1 and Fig. 4.2) showed a maximum tensile strength of 1684.17 N/mm^2forPKC compared to WOC and BOC which impart 1507.35 and 1500.35 N/mm^2 respectively. In other words PKC as a carburizer will enable the carburized parts to be tough, that is, hard case and soft core having been tempered to 200^oC for 2 hours. However, carbonaceous heat treatment using WOC and BOC resulted in increase of 689 and 703N/mm^2 respectively within the range of 800^oC to 950^oC compared with PKC which increases the tensile strength by only 376N/mm^2.

The summary of the performance is depicted in *column bar chart* (Figs 4.1 & 4.2), where PKC records the highest increase in hardness of 32.8% compared with 20.6% and 11.8% in carburizing with WOC and BOC respectively. This comparatively shows the relative ease with which carbon diffuses into the part surface in carburizing with PKC.

Results obtained with the carburizing materials that were investigated compare favourably with those quoted by Neely (1979); Repp*et al.* (1982); and Oberg *et al.* (1984) for the same class of medium carbon steel. Neely reported values of 60HRC to 62HRC for mild steel carburized and quenched from 925^{o}C. Repp*et al.* (1982) reported surface hardness of between 60HRC to 66HRC for case hardened mild steel. Oberg *et al.* (1984) reporting in Brinell Hardness Number quoted a range of 400BHN to 700BHN. It is to be noted that values quoted by these authors were obtained with industrial carburizing materials. These materials contain energizers that hasten carburization process. With the addition of energizers to the local carbonaceous materials used in this study, better results may be obtained in shorter times.

5.0 CONCLUSIONS

From the experimental results and analysis in this work, the following conclusions can bedrawn:

1. The microstructures revealed that hardness reduces progressively until it reached the core hardness.
2. Case hardening of AISI C-1036 steel using WOC and BOC increases the tensile strength of the steel by 689 and 703 N/mm^2 respectively within the range of 800 to 950^o C compared with PKC which resulted in an increase of only 376N/mm^2.
3. Case-hardening treatment offers a means of enhancing the strength and wear resistance of parts made from relatively-inexpensive easily worked materials.
4. Case hardening treatment using PKC enhances mean hardness from 48.5 HRB to 64.4HRB (32.8%) compared with 20.6% and 11.8% for WOC and BOC respectively.
5. The case of the steel became hardened with soft core, which resulted in toughness of the entire component, thereby making the steel to be tough and wear resistant.

5.1 Recommendations

1. That palm kernel charcoal, wood charcoal and bone charcoal should be processed into standard carburizing materials.
2 That the workshops on process of pack carburizing with palm kernel charcoal, wood charcoal and bone charcoal should be organized for machinists, fabricators, blacksmiths and manufacturers engaged in the production and re-conditioning of steel parts like shafts, cams, gears, pinions, sprockets, hand tools and agricultural implements**.**

6.0 REFERENCES

Adegbola, A.A (2005) *''Basic Materials, Properties and Applications''* Debo print (Ibadan): Primer Edition; PP58-88

Adegbola,A.A (2004) *"Performance and Evaluation of Different carburizing Media-Arrhenius Approach*"(A case study of carburizing steel)The Engineer Vol. 3,No 1

Agraval.B.K (1989)*"Introduction to Engineering Materials"* Tata McGraw Hill Publishing Coy. Limited, New Delhi: First Edition pp 158- 331

Arzamasov, B (1989) "Materials Science" Mir Publishers, Moscow. Pp 96-133,

ASTM B 934-04a (Oct 2004): Standard Test Method for Metallographically Estimating the observed Case-Depth of Ferrous Powder Metallurgy (P/M) Parts Using Micro indentation Hardness Measurements.

Chaves, J.C., (2001)*The Effect of Surface Condition and High Temperature Oxidationon Quenching Performance of 4140 Steel in Mineral Oil*, in *ManufacturingEngineering*., Worcester Polytechnic Institute: Worcester. p. 8, 9.29.

Dempsey, J. (2002)"*Glossary of blacksmithing and metalworking terms*" Available: http://www.anvilfire.com/FAQs/gloss_content.htm

Ede, A.J (1967) *"An Introduction to heat Transfer, Principle and Calculations"* Pergraman Press Limited first Edition PP 210

Geoffrey, P (1999)"Carburizing: Microstructures and Properties". ASM International.pg 11

Higgins, R.A (1993) "Engineering Metallurgy" ELBS, England.Pp34-46;Pp251-279,

Jain, R.K (2003): Production Technology, 16th Edition, Published by Romesh Chander Khanna, India.

Kai Y,Tsuchida Y and Enokizono M (2005)"Non-destructive evaluation of Case hardening by measuring magnetic properties Electromagnetic Non-destructive Evaluation(IX) ed L Udpa and N Bowler(Amsterdam:IOS Press)

Love, G.H. (1979)"*The theory and practice of metalwork*" Longman, London, England, UK.

Neely, J. (1979)*"Practical metallurgy and materials of industry*" John Wiley and Sons, New York, NY, USA.

Oberg, E.; Jones, F.D.; and Horton, H.L. (1984)*"Machinery's handbook"* 22nd ed., Industrial Press, New York, NY, USA.

Oberg, E., Jones, F., and Ryffel, H. (1989) "*Machinery's Handbook" 23rd Edition.* New York: Industrial Press Inc. Retrieved from www.goggles.com on 10th April, 2012.

Panagiotidis, P.P, Antonatos, A.S, Tsananas, G.M (2007) Case Depth determination by using Vickers Micro –Hardness Test Method www.hsnt.gr, E-mail: hsnt@hsnt.gr

Rajan, T.V, Sharma, C.B, and Sharma, A (1998) *"Heat Treatment Principle and Techniques"* Easter Economy Edition Prentice Hall of Ludia Private Limited.

Repp, V.E., and McCarthy, W.J. 1992.Machine tool technology.McKnight Publ., Bloomington, IL, USA.

Robert H.T, Dell K.A and Leo, A (1994) "*Manufacturing Processes*" Reference Guide. Industrial Press Inc., Pg.421-426 Retrieved from www.goggles.com on 10th April, 2012

Shrager, A.M. (1961)"*Elementary metallurgy and Metallography*".Dover Publ., New York, NY, USA.

SkewmamP.G(1989) *"Diffusion in Solid"*McGrawHill Book Company; New York. Reprinted by the Mineral Metal and Materials Society WarrendaleP.A Datasheet for Non Heat Treaters; the Contact Heat Treatment Association Samora-Polytechnics Inc

www.sciencedirect.com

www.steeltalk.com

APPENDIX

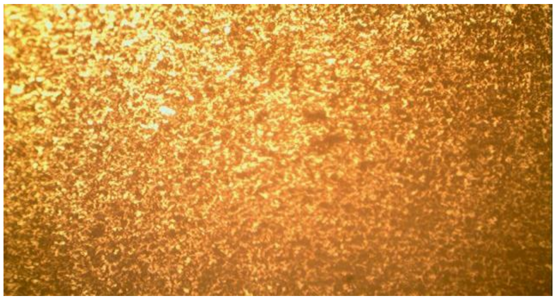

Plate 1: AISI C-1036 steel control (as –received) microstructure. X 100mag

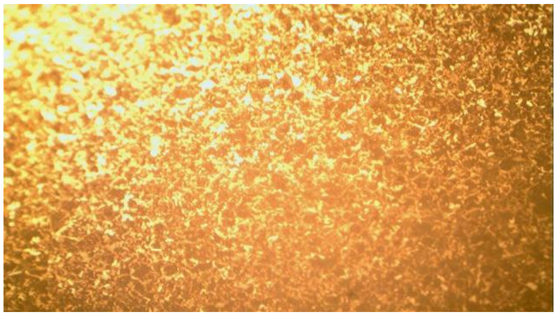

Plate 2:AISI C-1036 steel carburized using PKC x 100mag

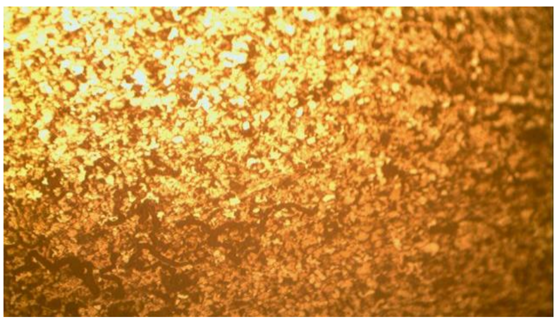

Plate 3: AISI C-1036 Steel carburized using BOC x 100mag

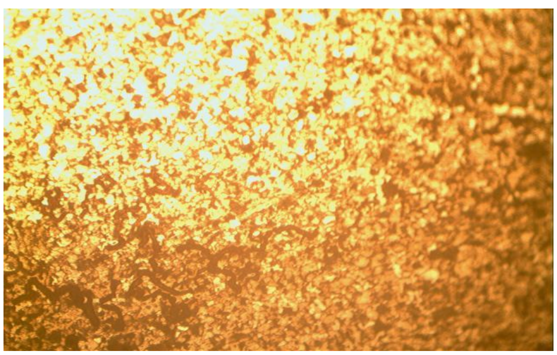

Plate 4:**AISI C-1036** ***Steel carburized using WOC x100mag***

APPENDIX II

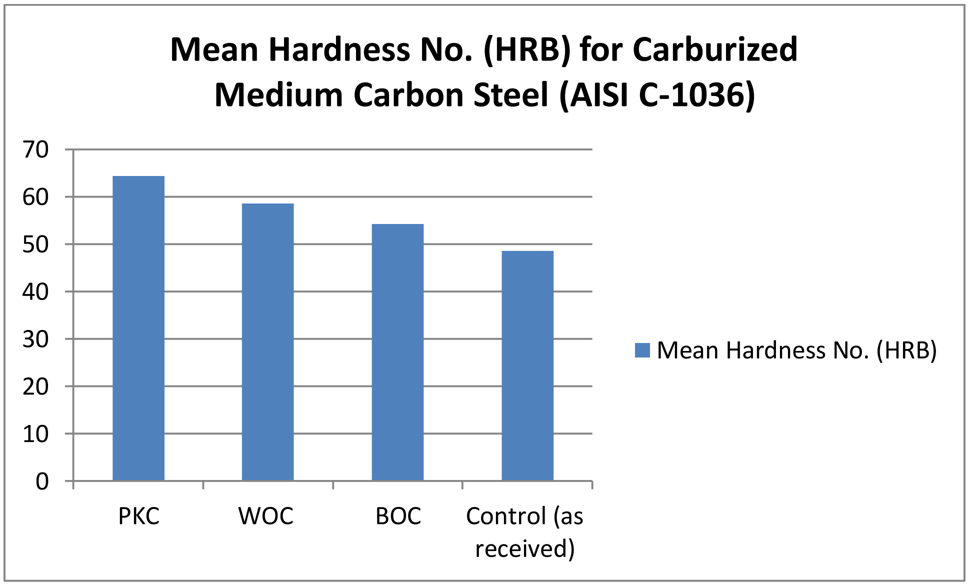

Fig 4.1: Mean Hardness Numbers for Carburized Medium Carbon Steel (AISI C-1036)using Natural Carbonaceous Materials

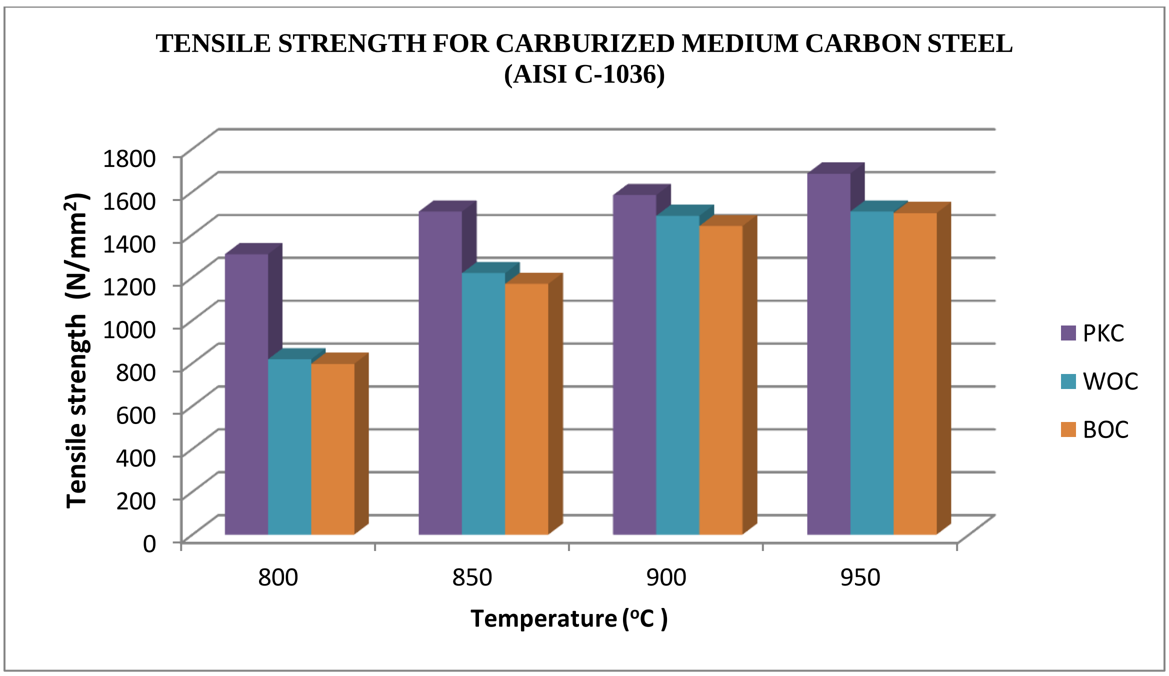

Fig 4.2: Tensile Strength of Carburized Medium Carbon Steel using Natural Carbonaceous Materials at different temperatures.

APPENDIX III

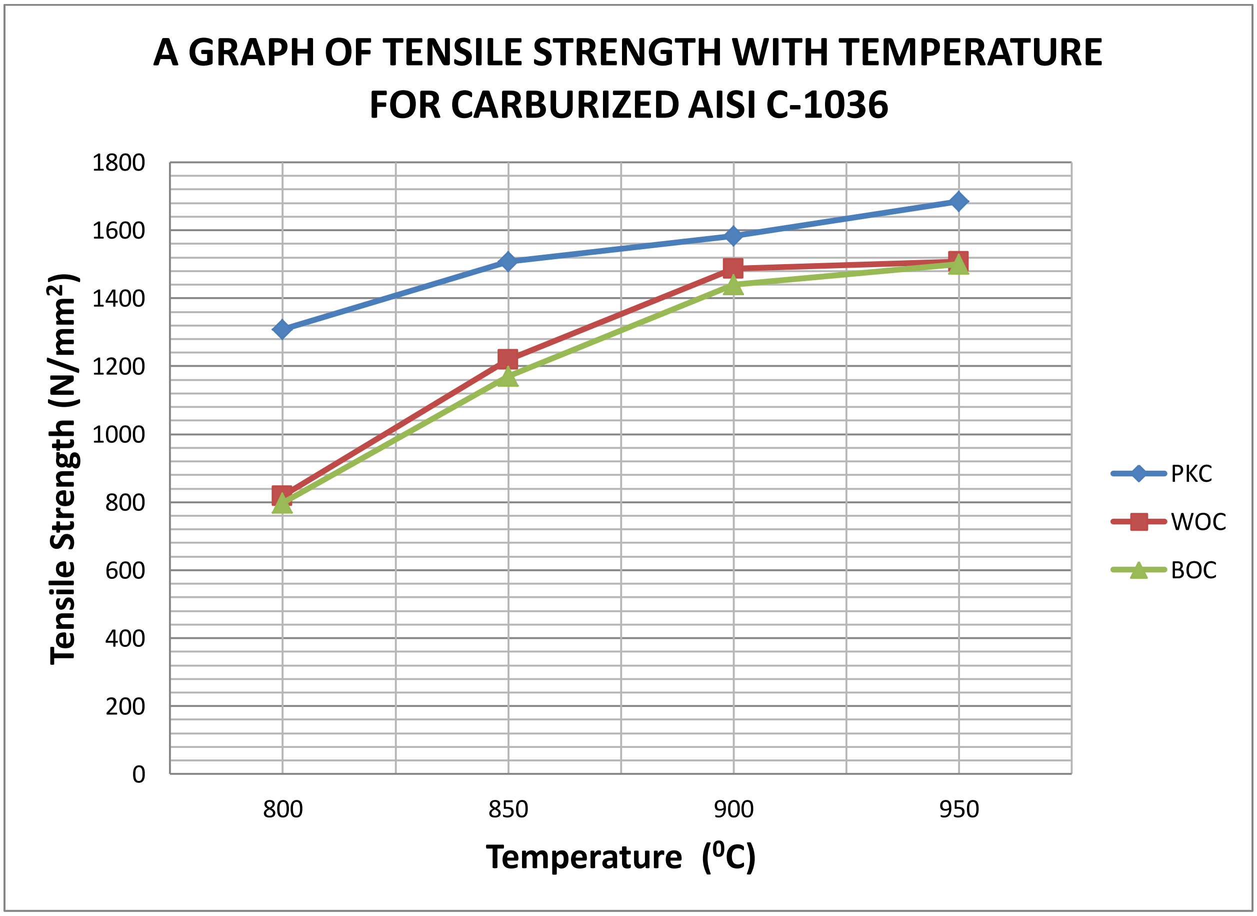

Fig 4.3: A graph of Tensile Strength of Carburized Medium Carbon Steel using Natural Carbonaceous Materials at different temperatures.

APPENDIX IV

Table 4.1: Composition of AISI C-1036

SAE Number	AISI Number	Carbon C	Manganese Mn	Phosphorus P(Max.)	Sulphur S (Max.)
1036	C1036	0.32 – 0.38	0.60 – 0.90	0.040	0.050

INVESTIGATING THE EFFECTS OF THE USE OF DETERGENT AS ALTERNATIVE BRAKE FLUID IN AUTOMOBILES

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ABSTRACT

The study reveals that 91.9% of respondents agree that detergent is used as brake fluid by commercial vehicle drivers in Kano and that half of the users had experienced brake failure at certain times. Some relevant tests as specified for brake fluids by the US Department of Transport (DOT), FMVSS 116 document, were carried out on a solution of OMO detergent, which failed four out of seven tests. The Equilibrium Reflux Boiling Point (ERBP) of the detergent fluid was found to be 96°C which falls far short of the minimum requirement of 205°C. The detergent has a viscosity of 1.18 at 27°C and 1.14 at 96°C which has fallen short of the minimum viscosity of 1.5 for both DOT 3 and DOT 4 brake fluids. The corrosion test showed that the master cylinder cast iron body has corroded almost three times the recommended standard, the steel piston corrosion was more than four times the minimum value and the steel piston corrosion was more than twice. However, the aluminium master cylinder showed minimum corrosion rate of 0.12 mg/cm^2, which is slightly above the standard value of 0.1 mg/cm^2. However, the pH value, effect on elastomer (rubber) and its pressure at room temperature were at acceptable levels. Since it failed four out of the seven tests it was found unsafe for use as brake fluid. The Authorities in-charge of vehicle inspection and safety should sensitize the public particularly commercial drivers on the danger of using detergent as brake fluid and they should also carry out routine checks on vehicle brake fluids and penalise offenders who use fluids other than those recommended by the regulatory bodies. Government should establish specific fine for drivers who use detergent as brake fluid, including it as an act of dangerous driving.

SIGNIFICANCE: This research provides technical information on whether or not detergent is suitable for use as brake fluid in automobile, educate the public on the choice and proper use of brake fluids which will help in saving of lives and preventing property loss due to use of wrong fluids for the brake system in Automobiles.

KEY WORDS: Brake Fluid, Detergent, Automobile, Kinematic Viscosity, Corrosion, Equilibrium Reflux Boiling Point .

1.0 INTRODUCTION

1.1 Background

Brake fluid is a type of hydraulic fluid used in brake application in automobiles and light trucks. It is used to transmit force under pressure through the hydraulic lines to the braking mechanism. Brake application produces a lot of heat so brake fluid must have a high boiling point to remain effective and must also not freeze during winter. Overheated brake fluid will produce gas bubbles which will lower the pressure in the system which necessitates "pumping the brake pedal" to make it effective.

Some of the more important characteristics of a good quality brake fluid include maintenance of even viscosity throughout a wide temperature variation (including freezing temperatures), its boiling point should be above the highest operating temperature and it must not corrode the components of the brake system.

The practice of using fluids in the brake system other than those recommended by automobile manufacturers and regulatory bodies has been observed among some drivers, especially those of commercial vehicles (taxis and mini buses). Detergents and other fluids are being used as brake fluids. These cannot be ascertained suitable for brake and the braking system component materials. The concern of this research work is focused on the detergent, popularly used by taxis and commercial buses drivers, which is dissolved in water to form a solution and wrongly used as brake fluid.

2.0 LITERATURE REVIEW

2.1 Braking in Automobile

Overheating of the wheels due to excessive use of brakes often results in decreased efficiency and even brake failure (brake fade). (Mudd, 1969).In April 2007, BMW recalled over 160,000 SUVs because of a problem that could cause a potential loss of brake fluid or even the -brake circuit to fail completely. In addition, in May of the same year, Chrysler recalled 60,000 vehicles due to an issue with potential brake failure (Johnson, 2009). Toyota & Honda also recalled thousands of vehicles within the last few years. All standard/good brake fluids are virtually incompressible and the system works properly as its mechanical and hydraulic design allows (Smith, 2004). DOT 3, DOT 4 and DOT 5 brake fluids are compatible with most brake system materials, except in the case of some silicone rubber external components such as caliper piston boots, which are attacked by silicon fluids and greases (Wall, 1999). The technical data for DOT 3 and DOT 4 brake fluids as specified by FMVSS 116 are shown in Appendix 1.The brake fluid industry has, by consensus, decreed that glycol ether fluids are the most economical way to meet the standard requirements (Walker, 2004).

Thirteen tests are specified for brake fluids, according to FMVSS 116. If a fluid fails any of the tests it is considered not safe for use. They are Equilibrium Reflux Boiling Point (ERBP), Wet ERBP, Kinematic viscosity, pH value, Fluid stability, Corrosion, Fluidity and Appearance at low temperature, Water tolerance, Compatibility, Resistance to oxidation, Effects on Elastomers, Stroking properties and Container information.

Brake fluid should have a boiling point significantly above the operating temperature. As its temperature rises above the boiling point the fluid vaporizes making it compressible. The result will be loss of brake power and the consequences are grievous if the vehicle is on high speed or on a busy traffic. During the first two years of service the brake fluid will pick up about 3.5 % of water which will cause the boiling point to fall. This is simulated in the wet boiling point test to ensure no loss of brake performance (Miswa, 2000)

The pH test provides a measure of the balance of the inhibitors added to protect against corrosion of the metal components of the braking system. It also ensures that the brake fluid is correctly formulated to neutralise the harmful effects of acidic degradation products formed during service. If not correctly formulated with anti oxidants severe degradation can occur in brake fluid leading to reduction of boiling point and the formation of corrosive by-product. Fluid stability test measures the resistance of the brake fluid to high temperature degradation. Brake fluids must show high resistance to oxidation during their service life as the by-products of this process are corrosive and may lead to solid build up in the brake pipes. (Miswa, 2000)

According to Talbot, (1998) almost all the environments in which metal is used are potentially hostile and their successful use in engineering and commercial applications depends on protective mechanism. In the formulation of brake fluids, inhibitors are added to protect the materials of the braking system from corrosion. Samples of seals and hoses (elastomers) are placed in the fluid at elevated temperature for a long period of time. Any change in the dimensions must fall within the defined limits

3.0 MATERIALS AND METHODS

3.1 Data collection

Collection of data on the use of detergent as brake fluid was conducted by using two sets of questionnaires one for drivers/users of vehicles (Appendix I) and the other for mechanics (Appendix II).

A total of thirty eight (38) questionnaires were completed. Four categories of drivers/users were contacted; they are;

i. Pickup and light truck drivers
ii. Town service bus and taxi cab drivers
iii. Long distance bus and car drivers
iv. Private car drivers

3.2 Practical Work

3.2.1 Preparation of Detergent

Bearing this in mind, 2 packs of 30g powdered OMO detergent were dissolved in one litre of water. The concentration is therefore 60g/l. This is the bench mark upon which subsequent preparations for further tests were based. In doing this, proper stirring was made to achieve maximum dissolution of the powder in water.

3.2.2 Equilibrium Reflux Boiling Points

To measure the boiling point of the detergent, 200ml of the fluid was poured into a beaker and placed on an electric heater. A thermometer was used to measure the temperature.

3.2.3 Measurement of Kinematic Viscosity

Kinematic viscosity is generally expressed in seconds (s) flow time after which it is converted to centi-Stokes (cSt). The flow cup viscometer used is type VHA 580-070, BS 3900 for which the cup constant, *k* is 0.1017.

The flow cup viscometer was held in retort stand with a beaker placed under it as receiving container. It was then filled up with the detergent fluid at room temperature of 27°C. The fluid was allowed to over flow the brim. In the process the orifice was held closed by a rubber cork. The cork was then released while the stop watch was switched on. The watch was stopped at the end of the out flow of the fluid and the time was recorded. This was repeated twice and the average time taken. The average time was used in the calculation of the viscosity as recorded below in Table 1.

The same procedure was followed in determining the viscosity of the fluid at 96°C.

3.2.4 pH Test

A digital pH meter model Hanna PH209 was used to determine the pH value of the detergent. The measurement was carried out at a temperature of 27°C.

Tap water was used as a standard buffer solution which is expected to be neutral, having a pH value of 7. The water was poured into a beaker to level of 150ml and the electrode of the meter dipped into it while it was adjusted to a pH reading of 7. The electrode was then removed and cleaned and dipped into another beaker containing 150ml of detergent solution under the same temperature condition. The meter was allowed to settle after fluctuating a little. The meter then settled at a reading of pH value of 7.96.

The pH specification for DOT 3 and DOT 4 brake fluids according to FMVSS 116 standard is 7.0-11.5.

3.2.5 Corrosion Test

According to FMVSS 116 procedure for corrosion test, evaluating the corrosiveness of a brake fluid involve the use of the components that are commonly used as brake system materials. Before the heating process was commenced, the weights of the components were measured using an electronic weighing balance capable of weighing to the nearest 0.1mg. The surface areas of the pieces of metals were measured and recorded using a digital calliper. Cast iron – brake cylinder, Aluminium – brake cylinder, Steel – brake piston, Aluminium – brake piston and Steel – fluid pipe were used for the tests. The specimens were placed in a beaker containing the detergent fluid. They were kept in the oven at 100°C for an average of 6 hours daily. The specimen remained in the fluid for seven days. At the end of the period, the metal specimens were removed, rinsed, examined and weighted. The results are given in Table 2.

3.2.6 Effect on rubber (Elastomer)

Specimens of hose and two seals were placed in the detergent and heated at regulated temperature of 70°C for three hours. The specimens were removed and the internal and external diameters were measured. They were further heated to 96°C following the same procedures and the dimensions recorded. (See Table 3)

3.2.7 Specific gravity

In measuring the specific gravity of the fluid, an empty beaker was first weighed. 200ml of the fluid was then poured into the beaker and weighed. An equal volume of water was also weighed. To determine the mass of the fluids, the mass of the empty beaker was subtracted from the mass of fluid and water. The measurements were taken at 27^{o}C

3.2.8 Pressure test

Pressure test is not one of the recommended tests by DOT. It was carried out to determine if the detergent will maintain a normal pressure that a brake fluid will provide at room temperature. A brake pressure testing machine was used in the test. DOT 3 brake fluid was poured into the machine`s master cylinder reservoir. It was bled to remove air from the system. The brake pedal was pressed down and the pressure read from the gauge attached to it. The brake fluid was then removed and replaced by the detergent, following the same procedures.

4.0 RESULTS AND DISCUSSION

4.1 Results

(1) Questionnaires

Questionnaire I which was designed for users/drivers of various vehicles had twenty eight (28) respondents in all. Ten (10) respondents were from the Questionnaire II', which is meant for mechanics.

The following results were established from questionnaires I & II

i. 91.9% of the respondents agree that detergents are used as alternative to brake fluids.
ii. 10.5% agreed to have used the detergent as brake fluid
iii. 2.6% see nothing wrong in using detergent as brake fluid
iv. There is 100% agreement that detergent cannot function as effectively as the normal brake fluid
v. 50% of the detergent users have experienced brake failure at certain times.
vi. 30% will agree to use detergent if brake fluid is not readily available; 13.2% from pickup/light truck drivers, 13.2% from bus drivers, 2.6% from long distance car drivers and 0% from private car drivers.

(2) Equilibrium Reflux Boiling Point

The boiling point of the detergent is 96^{o}C. This is far lower than the standard ERBP which is a minimum of 205^{o}C for DOT 3 and 230^{o}C for DOT 4. The detergent can easily vaporize and consequently cause brake failure.

(3) Kinematic Viscosity

The viscosity was measured using a flow cup viscometer. The detergent was found to have a viscosity of 1.18 at 27^{o}C and 1.14 at 96^{o}C. (See details in Table 1 below).

Table 1: Detergent fluid viscosities

S/N	Temp ^{o}C	Flow Time(s)			Average Time(s)	$v=kt$ (mm^2/s) [cSt]
		1st reading	2nd reading	3rd reading		
1	27	11.69	11.61	11.65	11.65	1.18

2	96	11.20	11.15	11.24	11.97	1.14

(4) pH TEST

The pH value of the detergent was 7.96 which is slightly basic.

(5) Corrosion Test

Table 2: Results of Corrosion Test

S/N	**MATERIAL**	**PART**	**INITIAL WEIGHT, W_1 (mg)**	**FINAL WEIGHT W_2(mg)**	**SURFACE AREA, A (cm^2)**	**MATERIAL LOSS (mg/cm^2)**	**FMVSS 116 (mg/cm2)**
1	Cast iron	Master cylinder	24505.8	24493.2	22.0073	0.58	0.2
2	Aluminium	Master cylinder	10315.3	1031.25	24.0218	0.12	0.1
3	Steel	Piston	14725.7	14720.2	12.4116	0.44	0.2
4	Aluminium	Piston	8682.5	8682.3	6.7830	0.29	0.1
5	Steel	Pipe	4810.7	4797.7	15.6456	0.83	0.2

(6) Effect on elastomer

Table 4: Effect of detergent on sizes of elastomers at high temperature

MATERIAL		**At room temp(27^{o}C)**	**At 70^{o}C**	**Size change (mm)**	**size change (%)**	**At 96^{o}C**	**Size change (mm)**	**size change (%)**
Brake hose	**Internal Diamerer**	8.24	8.25	0.01	0.12	8.26	0.02	0.24
	External Diamerter	19.26	19.27	0.01	0.05	19.29	0.03	0.16
Rubber seal 1	**Internal Diamerer**	11.96	11.98	0.02	0.17	12.09	0.13	1.10
	External Diamerter	22.08	22.11	0.03	0.14	22.13	0,05	0.23
Rubber seal 2	**Internal Diamerer**	10.30	10.31	0.01	0.10	10.40	0.10	0.97
	External Diamerter	21.94	21.96	0.02	0.10	22.00	0.06	0.27

(7) Pressure test

The pressure test carried out on the detergent indicates that there is no deference in pressure between the DOT 3 fluid and the detergent fluid. Both have pressures of 3.5 bars (350 kN/m^2). Hence at low temperature the detergent can deliver the needed pressure to efficiently actuate the brakes.

(8) Specific gravity

The specific gravity measurement results are given in Table 4.

Table 4: Measurement of fluids densities

	MATERIAL	WEIGHT OF BEAKER (kg)	WEIGHT OF BEAKER + MATERIAL (kg)	WEIGHT OF MATERIAL (kg)	VOLUME OF METERIAL (m^3)	DENSITY OF MATERIAL (kg/m^3)
1	Detergent	0.1721	0.3803	0.2082	0.0002	1041
2	Water	0.1721	0.3718	0.1997	0.0002	998.5

$$\text{Specific gravity of detergent} = \frac{1041\text{kg/m}^3}{998.5\text{kg/m}^3} = 1.043$$

4.2 DISCUSSION OF RESULTS

Since 91.9% of the respondents agree that detergents are used as alternative brake fluid and that half of the users experienced brake failure at certain times, this is bound to cause road accidents, particularly involving commercial vehicles.

Boiling point of detergent of 96^{o}C is far below the ERBP standard of 205^{o}C for DOT 3 and 230^{o}C for DOT 4 brake fluids. The detergent can easily vaporise and consequently cause brake failure.

The kinematic viscosities of the detergent of 1.18 at 27^{o}C and 1.14 at 96^{o}C are far below FMVSS 116 standard value of 1.5 for both DOT 3 and DOT 4. The pH Test shows that the detergent has a pH of 7.96 and is therefore slightly basic. This is within the standard pH range of 7-11.5 for DOT 3 and DOT 4.

The corrosion level of the master cylinder cast iron body of 0.58mg/cm^2 is almost three times the recommended standard of 0.2mg/cm^2, while the steel pipe corrosion, 0.83mg/cm^2 was more than four times the minimum allowed in the standard. The steel piston corrosion, 0.44mg/cm^2 was more than twice the minimum value. However, the aluminium master cylinder showed minimum corrosion rate of 0.12mg/cm^2, which is slightly above the standard value of 0.1mg/cm^2 but the aluminium piston corrosion was almost three times the minimum allowed in the standard.

Effect of elastomer, the rubber seals used have slightly hardened but the dimensional changes at high temperatures were within the limit in the standard. Specific gravity of 1.043 is below the standard range of 1.055-1.065

The pressure test conducted on the detergent, however, showed that there is no difference at room temperature.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

(1) From the Questionnaires it can be concluded that 91.9% of the respondents agreed that some drivers use detergent as brake fluid in their vehicles. This was verified by 9.2% of the respondents who agreed to have used the detergent as brake fluid and that 57% of the users experienced brake failure while driving.

(2) Of the seven tests carried out, the detergent fluid failed four. Its boiling point of 96^{o}C is too low compared to 205^{o}C which is the minimum required.. This definitely will cause failure of the brake at high temperatures.

(3) Another important property of the brake fluid – viscosity, is too low for the detergent.

(4) The detergent shows high level of corrosiveness. This portends high danger to the braking system. Wear in the braking system due to corrosion will lower the hydraulic pressure making the brakes ineffective.
(5) The detergents specific gravity of 1.043 is low compared with the standard range of 1.055 to 1.065.
(6) The other three tests: pH value, effect on rubber, and pressure at room temperature were passed by the detergent but they are not enough to make it suitable for use as brake fluid because if a fluid fails any of the tests it is considered not safe for use.

5.2 RECOMMENDATIONS

(1) The Authorities in-charge of vehicle inspection and safety should sensitize the public particularly commercial drivers on the danger of using detergent as brake fluid.
(2)The Authorities should also carry out routine checks on vehicle brake fluids and penalise offenders who use fluids other than those recommended by the regulatory bodies.
(3)Government should establish specific fine for drivers who use detergent as brake fluid, including it as an act of dangerous driving.

REFERENCES

Bates, R. G. (1973). Determination of pH, Theory and Practice, 2nd edition, John Wiley and Son. 28-29

FMVSS 116 (April 22, 2005) *National Highway Traffic Safety Administration, TP-116-04* Available from http://www.nhtsa.dot.gov

Haycock R. F, Caines A.J and Hillier J. E. (2005) *Automotive Lubricants Reference Book 2nd edition*, John Wiley and sons.

Hunter J. E., Cartier S., Temple D., and Mason R. L.(Feb, 1998), *Brake fluid Vapourization as a contributing factor in motor vehicle collisions*, International Congress and exposition, Accident Reconstruction, Detroit. Available from http://www.sae.org/technical/papers/980371 (Accessed 7 April 2009)

Johnson, N. (2009). *Prevention is better than cure in case of Brake Failure.* Available from: http://toplawyersinsanantonio.com/auto_accident_lawyer. (Accessed 1 May 2009)

Miswa Chemicals Ltd (2000), *Brake Fluid Testing Requirements.* Available from: http://www.miswa.co.uk.html.

Mudd, S. C., (1969) *Technology for Motor Mechanics: 3,* Edward Arnold (publisher) ltd, London. 41

"pH". *IUPAC Goldbook*. Available from: http://goldbook.iupac.org/P04524.html. Smith C. (2004) *Carroll Smith's Notes on Brake Fluid*, Stoptech LLC

Swiderek K.M.,Alpert A.J, Heckendorf A. Nugent K. And Patterson S D (1997), *Structural Analysis of Proteins and Peptides in the presence Detergents: Tricks of the trade;* Journal of biomolecular Techniques. Available from: www.abrf.org/ABRFNews/1997/December1997/dec97detergent.html

Talbot, D and Talbot, J. (1998). *Corrosion Science and Technology (Electronic version).* CRC press: Boca Raton. 16-19

The Engineering Toolbox, *Dynamic, Absolute and Kinematic Viscosity.* Available from http://www.engineeringtoolbox.com/dynamic-absolute-kinematic-viscosity-d_412.html.

Viswanath D.S, Ghosh T. K, Prasad D.H.L., Dutt N. V. K, Rani K. Y.(2007) *Viscosity of Liquids, Theory, Estimation, Experiment and Data,* Spinger, Dordrecht .1-9, 54-58

Walker J. Jr. (2004) *James Walker's Notes on Brake Fluid*, Stoptech LLC available from: http://www.stoptech.com/tech_info/wp_brakefluid_1a.shtml.

APPENDIX I: DOT 3 and DOT 4 specifications (Miswa, 2000)

S/N	TEST REQUIREMENTS	DOT 3 SPECIFICATION	DOT 4 SPECIFICATION
1	Equilibrium Reflux Boiling Point ^{o}C	205 min	230 min
2	Viscocity@100^{o} C	1.5 min	1.5 min
3	pH Value	7-11.5	7-11.5
4	Corrosion loss in mg/cm^2 Steel and cast iron Aluminum	 0.2 0.1	 0.2 0.1
5	Effect on Rubber (SBR Rubber) 70^{o} C Swell (mm) 120^{o}C	 0.15-1.4 0.15-1.4	 0.15-1.4 0.15-1.4
6	Specific gravity	1.055	1.065
7	Pressure test	-	-

DEVELOPMENT AND EVALUATION OF THE PHYSICAL AND MECHANICAL PROPERTIES OF CATTLE HORN – PLASTIC COMPOSITE FOR PARTICLE BOARD MANUFACTURING

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ABSTRACT

This research work studied the feasibility of developing a composite using Ankole Watusi cattle horn as the reinforcement and polyester resin as the matrix. To achieve this, the matrix and reinforcement were mixed in various compositions and samples produced from them. The physical and mechanical properties of the developed samples were determined in order to evaluate the composite's performance, which include compression strength, flexural strength, tensile strength, moisture content, water absorption and the dry densities. Based on the flexural strength and the water absorption of the various composite compositions developed a composite with 27% mass of cattle horn as reinforcement (sample E) was selected. Compression strength, flexural strength, tensile modulus, percentage moisture content, percentage water absorption, dry densities of the sample E were obtained as: 34.25Mpa, 65.89Mpa, 22.69Mpa, 1.248%, 0.44%, 1184kg/m^3 respectively. Based on the properties of the developed composite, the composite is very suitable for used in industrial particle board applications.

Key Words: Composite, Mechanical properties, Physical Properties.

1.0 INTRODUCTION

In Africa, cattle have been one of the major providers of meat for consumptions along-side other small animals such as rams, sheep, goats etc. However these cattle can serve other vital uses from some of their parts which are normally disposed, where some of these uses have been utilized to some extent while others have been greatly discarded. The hides and skin of these cattle have being harnessed to some extent, especially by production companies, where they use the hide for the production of leather associated materials, which include (bags, shoes, belts etc). Other parts such as horns and hooves have commonly been regarded as by-products and have been disposed in large amount including burning them. However some very vital researches have been made generally on horns, with some specific researches on the wild boar horn and other peculiar types of horns. In this research work, the cattle horn is of much interest due to its abundance in the northern part of Nigeria especially in Kano State, where it is yet disposed in tones daily. The research will open a room for more researches on the cattle horn, giving a guide in the direction of the potentiality lying in the wasted cattle horn.

Horns are the pointed projections, from the forehead of animals such as bison, sheep, goats and cattle; they start to grow soon after birth and continue to grow throughout the life of the animal.

The main aim of this work is to develop a composite for industrial particle board production - Industrial particle board is mainly of three types ceramic, metallic and polymeric, commonly used in the fabrication of components such as chopping disks, table tops and ornaments among others - using cattle horn as reinforcement and unsaturated polyester as matrix. Also to evaluate the mechanical and physical properties of various compositions of the developed composite in order to explore information about the composite that could be used to harness those hidden potentialities.

The research is motivated by the need to harness the potentials of the cattle horn as well as eliminate the waste generated by its disposal.

1.1 Composites

A composite material is a mixture of two or more materials that differ in form and chemical composition and are essentially insoluble in each other. Composites are mostly produced synthetically by combining various types of particles, fibres or combinations of both particles and fibres with different matrices to increase strength, toughness, and other properties. There are three important types of composite materials, these are polymeric, metallic, or ceramic matrices (Stuart, and Palo, 1989). Essentially, a composite has two constituents: matrix (continuous phase) and reinforcement (fibres or/and particles), other additions such as surfacants are commonly used to improve on the matrix-particle interactions for better performance. In recent years, tremendous progress has been achieved in the development of biodegradable composites from renewable agricultural based materials (Bakare et al., 2010).

Agricultural based materials such as natural oils and animal by-products were used in production of these composites. Guner et al., (2006), and Bakare et al., (2008) have shown that polyurethane as composites matrix can be prepared from non-edible vegetable oils as against the popular petroleum based oil. The Rubber Seed Oil is non-edible oil from Rubber Tree. Similarly some of the Animal by-Products, Chicken Feather, Cow Bone and Cow Horn have been suggested as viable reinforcement material to replace the conventional matrix and fiber such as glass and kellar. Recent studies on the Animal by-Products demonstrated that they are potential composites reinforcement materials and some of the advantages of the Animal by-Products are inexpensive, renewable, and abundantly available. Their composites reinforcement has certain desirable properties that include lightweight, high thermal insulation, excellent acoustic properties, nonabrasive behaviour and excellent hydrophobic properties (Uzun et al., 2011).

1.2 Materials

This section presents the various materials and equipments used for the development of the composite.

1.2.1 <u>Crushing of the Ankole Watusi cattle horn</u>

The machines and equipment used include: cutting disk, brush, standing vice, angle crusher, Bauchi state waste recycling machine, Henderson Technologies hammer mill, mini plastic recycling crusher, standard sieves (ASTM), weighing machine, mettler balance, eye googles, safety gloves and boots, sack and plastic bags.

1.2.2 <u>Development of the mould:</u>

The equipment and materials used to develop the moulds include: fibre glass mat, polyester resin, polyvinyl alcohol, methylethylketoneperoxide, naphthalene, ruler, masking tape, carton, scissors, bowl, brush, wax, working table and a nose mask.

1.2.3 Development of the composite:

The equipment and materials used to develop the composite include: 1mm Ankole Watusi cattle horn particles, polyester resin, mould, naphthalene, methylethylketoneperoxide, polyvinyl alcohol, wax, brush, mixing bowl, working table and a nose mask.

1.2.4 Development of test specimens/samples:

These materials and instruments used include: cutting disk, cutting machine, standing vice, grinder, hack saw, vernier calliper, hand file, ruler and a marker.

1.2.5 Development of flexural test special attachment/head:

The equipment and materials needed are: standing vice, welding machine, hack saw, 6.4mm diameter rod, grinding machine.

1.2.6 Flexural strength of the polyester-Ankole Watusi cattle horn composite of various compositions and samples:

The machine and materials used include: Testometric universal materials testing machine, special flexural test attachment/head and the developed samples.

1.2.7 Compression strength of the polyester-Ankole Watusi cattle horn composite of various compositions and samples:

The machine and materials used for this test are: Testometric universal materials testing machine, compression test accessories, support plates and the developed samples

1.2.8 Tensile strength of the polyester-Ankole Watusi cattle horn composite of various compositions and samples:

The machine used is the Testometric universal materials testing machine, tensile test accessories and the developed samples.

1.2.9 Water absorption of the polyester-Ankole Watusi cattle horn composite of various compositions and samples:

The machine and materials used include mettler weighing balance, water bath, distilled water and the developed samples.

1.2.10 Moisture content of the polyester-Ankole Watusi cattle horn composite of various compositions and samples:

The machine and materials used are: oven, mettler weighing balance and the developed samples.

1.2.11 Density evaluation of the polyester-Ankole Watusi cattle horn composite of various compositions and samples

Materials and instruments required are: mettle balance, vernier calliper, and the developed samples.

1.3 Experimental Methods

This section presents the various methods used to develop the composite.

1.3.1 Production of the Ankole Watusi cattle horn particles (reinforcement):

The cattle horns were cleaned and then crushed in stages and the particles were then sieved to 1mm particle size.

1.3.2 Design and development of the mould:

Sample moulds were developed based on the various sample sizes needed for the various physical and mechanical tests. The sample mould was produced using polyester and fibre glass.

1.3.3 Development of the composite

The composite mixture was finally developed by combining a mixture of the reinforcement (Ankole Watusi cattle horn) and the matrix (polyester resin) while varying their percentage by mass yet maintaining a fixed total mass of the mixture at 300grms as shown in table 1. The samples for the various tests were produced using hand lay-up method.

Table 1: Various compositions of the composite

PERCENTAGE BY MASS (gram)				
SN	CAST SAMPLE	MASS OF HORN PARTICLE	MASS OF MATRIX MIXTURE	TOTAL MASS
1	A	0grms	300grms	300grms
2	B	20grms	280grms	300grms
3	C	40grms	260grms	300grms
4	D	60grms	240grms	300grms
5	E	80grms	220grms	300grms
6	F	100grms	200grms	300grms

The samples were developed by incremental addition of the cattle horn from 0grams until saturation of the resin was attained at 100grms as shown above.

1.3.4 Compression strength test of the polyester-Ankole Watusi cattle horn composite of various compositions

Compressive properties describe the behaviour of a material when it is subjected to a compressive load. Loading is at a relatively low and uniform rate. The compression test was conducted based on ASTM D695. The standard requires that the specimen is compressively loaded at a rate of 1.3 mm/min until fracture ASTM D695, ISO 604.

The maximum load at which the material fails is recorded and used to evaluate the compression strength using the equation given below:

$$compressive\ strenght = \frac{maximum\ load\ (N)}{original\ area\ (mm^2)}$$

1.3.5 Tensile strenght of polyester-Ankole Watusi cattle horn composite of various compositions

The tensile test was conducted based on the ASTM D638. Material was cut into one of the five ASTM D638 Specimen “dumbbell” shapes, which was then loaded into the tensile grips of the Testometric universal materials testing machine. The test was run at a constant rate of speed of 10mm/min until the sample breaks, hence the maximum load applied and the elongation at breaking point were recorded and the tensile strength is computed using the following equations.

$$Tensile\ strength\ \left(\frac{N}{mm^2}\right) = \frac{Force\ (N)}{area\ (mm^2)}$$

1.3.6 Flexural strenght of polyester-Ankole Watusi cattle horn composite of various composition

The Flexural strength is the maximum outer fibre stress sustained by a material during flexural testing, it measures the force required to bend a beam under three or four point loading conditions. The data is often used to select materials for parts that will support loads without flexing. The test was conducted based on ISO 178. The specimen was placed on a simple supporting beam at its ends, and the load (continuous loading) is applied to the center by the flexural test special attachment/head producing three points bending at a rate of 1.2mm/min. maximum stress and strain occur at the underside of the specimen.

$$Z = \frac{bh^2}{6}, \quad M = \frac{PL}{4}, \quad bending\ stress\ (N/mm^2) = \frac{M}{Z}$$

Where:

a. Z= section modulus,
b. M= maximum bending moment for a simply supported beam,
c. P= break load (N),
d. L= distance between the supports of the beam (mm),
e. b= width of the beam (mm),
f. h= thickness of the beam (mm).

1.3.7 Water absorption test of polyester-Ankole Watusi cattle horn composite of various compositions

Water absorption is the percentage increase in weight of a material after exposure to water under specified conditions; it is used to determine the amount of water absorbed under the conditions. This may cause dimensional instability with property degradation and ultimately lead to failure. The water absorption test was conducted according to ISO 62. The mass of the dry samples were measured using a mettler balance and the masses were recorded, after which they were immersed in distilled water at room temperature for 24hours. The samples were then removed sequentially and partly dried with a clean cloth and reweighed using the same mettler balance, hence the masses were also recorded accordingly. Water absorption is expressed as increase in weight percent as given by the equation below.

$$\%\ water\ absorption = \frac{wet\ weignt - dry\ weight}{dry\ weight}\ x\ 100$$

1.3.8 Moisture content of dry Ankole Watusi cattle horn

Fresh samples of the material were heated in an oven to remove its water content until it is perfectly dry. The initial mass of the sample was measured using a mettler balance before heating, subsequently mass readings were taken after every two hours until a constant mass is achieved in accordance to ASTM D2654.

$$\%\ moisture\ content = \frac{Wet weight - Dry weight}{Dry weight}\ x\ 100$$

1.3.9 Density evaluation of the polyester-Ankole Watusi cattle horn

Density of a material is defined as the ratio of the volume and mass of the material, this is determined mathematically for both the dry and wet masses. Dry masses of all the samples are measured as well as their corresponding wet masses, which are then evaluated along with their respective measured volumes. These were evaluated following the relations given below.

$$V = L \times W \times T, \qquad \rho = \frac{M\ (kg)}{V\ (m^3)}$$

Where:

a. L= length of the sample,
b. W= width of the sample,
c. T= thickness of the sample,
d. V= volume
e. ρ= density of the composite sample.

2 RESULTS AND DISCUSSION

2.1 Experimentation and Presentation of Results.

The results obtained from the various experiments carried out are presented below.

2.1.1 Determination of the compression strength of the polyester – Ankole watusi cattle horn composite.

The result of the experiment conducted to determine the compression strength of the polyester-Ankole Watusi cattle horn composite is shown in table 1.

Table 2: Compression strength of the composites of various compositions.

S/N	Sample	Average Area (mm^2)	Compression strength (MPa)
1	A	100	37.32
2	B	100	39.86
3	C	100	36.37
4	D	100	37.22
5	E	100	34.25
6	F	100	27.98

Various compression strengths computed from the experimental results of the loads obtained.

2.1.2 Determinetion of the flexural strength of the Polyester – Ankole watusi cattle horn composite.

The result of the experiment conducted to determine the flexural strength of the polyester-*Ankole Watusi* cattle horn composite is shown in table 2.

Table 3: Flexural strength of the composites of various compositions.

S/N	SAMPLE	% Mass of Reinforcement	FLEXURAL STRENGTH (MPa)
1	A	0	160.13
2	B	7	58.67
3	C	13	55.91
4	D	20	54.47
5	E	27	65.89
6	F	33	45.28

Values of flexural strengths were computed from the experimental results obtained using the loads, and determined parameters Z and M.

2.1.3 Determination of the tensile strength of the polyester – Ankole watusi cattle horn composite.

The result of the experiment conducted to determine the tensile strength of the polyester-Ankole Watusi cattle horn composite is shown in table 3.

Table 4: Tensile strength of the composites of various compositions.

S/N	SAMPLE	% Mass of Reinforcement	ULTIMATE TENSILE STRESS (MPa)	STRAIN	TENSILE MODULUS (MPa)
2	B	7	0.93	0.04	24.56
3	C	13	0.96	0.03	33.39
4	D	20	1.35	0.02	57.25
5	E	27	0.98	0.04	22.69
6	F	33	0.98	0.02	42.30

Values of tensile strength obtained computationally from the relevant experimental data.

2.1.4 Determination of the moisture content of the polyester – Ankole watusi cattle horn composite.

The result of the experiment conducted to determine the moisture content of the polyester-Ankole Watusi cattle horn composite is shown in table 4 and 5.

Table 5: Moisture contents of the composites of various compositions.

S/N	SAMPLE	% Mass of Reinforcement	% MOISTURE CONTENT
1	A	0	0.356
2	B	7	0.847
3	C	13	0.812
4	D	20	1.114
5	E	27	1.248
6	F	33	2.463

Percentage moisture contents were determined experimentally by comparing the initial and dried weights of the various samples.

2.1.5 Determination of the water absorption of the polyester – Ankole watusi cattle horn composite. The result of the experiment conducted to determine the water absorption of the polyester-Ankole Watusi cattle horn composite is shown in table 6.

Table 6: Water absorption of the composites of various compositions.

S/N	SAMPLE	% Mass of Reinforcement	AVERAGE WATER ABSORPTION (%)
1	A	0	0.05
2	B	7	0.64
3	C	13	0.44
4	D	20	0.53
5	E	27	0.44
6	F	33	2.86

Percentage water absorption values were obtained experimentally by comparing the dry and wet masses of the samples.

2.1.6 Determination of the dry densities of the polyester –Ankole watusi cattle horn composite.

The result of the experiment conducted to determine the wet and dry densities of the polyester-Ankole Watusi cattle horn composite is shown in table 6.

Table 7 Dry densities of the composites of various compositions.

S/N	SAMPLE	% Mass of Reinforcement	AVERAGE DRY MASS (Kg)	AVERAGE VOLUME (m^3)	DRY DENSITY (Kg/m^3)
1	A	0	0.00613	0.00000427	1436
2	B	7	0.00520	0.00000368	1413
3	C	13	0.00531	0.00000420	1264
4	D	20	0.00501	0.00000377	1329
5	E	27	0.00533	0.00000450	1184
6	F	33	0.00524	0.00000456	1149

Values of both dry densities were determined computationally from the experimental data.

3.0 DISCUSSION OF RESULTS

3.1 Experimentation

3.1.1 Compression test

The compression strength of the developed composite generally decreases with the increase in the mass of the cattle horn particulate in the composite (table2 and fig1). The variation of the compression strength with the content of the cattle horn particulate could be mathematically represented by $Y = -0.2673x + 39.956$.

The highest compression strength achieved was 39.86MPa for a composite with 7% mass of cattle horn particulate and the least compression strength was 27.98MPa for a composite with 33% mass of cattle horn particulate.

3.1.2 Flexural strength

The flexural strength of the developed composite generally decrease with the increase in the mass of the cattle horn particulate in the composite (table3 and fig2). The variation of the flexural strength with the content of the cattle horn particulate could be mathematically represented by -0.2390x + 113.23. The highest flexural strength achieved was 65.89MPa for a composite with 27% mass of cattle horn particulate.

3.1.3 Tensile strength

The tensile modulus of the developed composite generally slightly increase with the increase in the mass of the cattle horn particulate in the composite (table4 and fig3). The variation of the tensile modulus with the content of the cattle horn particulate could be mathematically represented by$Y 0.3572x + 28.895$.

The highest tensile modulus achieved was 57.25MPa for a composite with 20% mass of cattle horn particulate.

3.1.4 Moisture content

The moisture content of the developed composite generally increase with the increase in the mass of the cattle horn particulate in the composite (table5 and fig4). The variation of the moisture content with the content of the cattle horn particulate could be mathematically represented by $Y = 0.0517x + 0.2791$.The highest moisture content observed was 2.463% for a composite with 33% mass of cattle horn particulate and the least moisture content was 0.812% for a composite with 13% mass of cattle horn particulate.

3.1.5 Water absorption

The water absorption of the developed composite generally increase with the increase in the mass of the cattle horn particulate in the composite (table6 and fig5). The variation of the water absorption with the content of the cattle horn particulate could be mathematically represented by $Y = 0.0577x - 0.1351$.

The highest water absorption observed was 2.86% for a composite with 33% mass of cattle horn particulate and the least water absorption was 0.44% for a composite with 13% mass of cattle horn particulate.

3.1.6 Density

The dry density of the developed composite generally decreases with the increase in the mass of the cattle horn particulate in the composite (table7 and fig6). The variation of the dry density with the content of the cattle horn particulate could be mathematically represented by $Y = -8.8177x + 1442.9$.

The highest dry density observed was 1413kg/m^3 for a composite with 7% mass of cattle horn particulate and the least dry density was 1149kg/m^3 for a composite with 33% mass of cattle horn particulate.

4.0 CONCLUSION AND RECOMMENDATION

CONCLUSION

Composite of various compositions was developed from unsaturated polyester resin as matrix and cattle horn particulate as reinforcement. The mechanical and physical properties of the various compositions of the composite developed were determined through experimental procedures. Based on the results of tests conducted, the composite is very suitable for used in industrial particle board applications.

It would be recommended that casting should be done under high pressure to check casting defects, finishing operations should be implored on the particle board and weathering tests should be conducted to determine its weathering properties. Materials such as shoe-hills, shoehorn, chopping disk, table-tops and ornaments among other applications seem suitable for fabrication.

REFERENCES

1. Abbey K. M. (2007). Uses and prizes of worked cattle horns for sale. Abbeyhorn online advertisement.
2. Bakare, I. O., Okieimen, F. E., Pavithran, C., Abdul-Khallil, H. P. S., Brahamkumar, M., (2010). Mechanical and thermal properties of sisal fiber-reinforced rubber seed oil-based polyurethane composite. Journal of Material and Design. Elsevier Ltd. Vol.10. 1 – 5.
3. Baja S. J. (2003). Thermoplastic Coatings and Division Jiantian Institute for research and development.
4. Ben K. (2012). Electrical and Optics Engineering course guide.
5. Comyn J. (2007). Breeds of Livestock Project research. Educational and trade centre Benue State Nigeria.
6. Garcia M.R. (2010). Breeds of Cattle. Oklahoma State University.
7. Hull, D. Clyne, T.W. (1996). An introduction to composite materials. Cambridge University Press, Cambridge.
8. Hong, C.K., Wool, R.P. (2005). Development of Bio-Based Composite Materials from Soybean Oil and Keratin Fibers. Journal of Applied Polymer Science, 95: 1524-1538.
9. Karmakar A. C. (2013). Cow genome 'to transform farming'. Wikipedia the free Encyclopaedia.
10. Kelly, A. (1967). Development of Composite material. Journal of Science American, B:217: 161.
11. Professor Morgan j. (2003). Department of Mechanical Engineering, Center for Advanced Vehicular Systems (CAVS), Mississippi State University.

12. MChei P. (2006). Department of Engineering Mechanics, Tsinghua University, Beijing 100084, China.
13. McNatt, J. C. (1973). Basic Engineering Properties of Particle Board. USDA Forest Service Res. Pap. FPL206.
14. Nohakal H.N (2006). Effect of Water Absorption on the Mechanical properties of hemp fibre reinforced unsaturated polyester composites.
15. Omorogbe Osaze, (2002). Development and characterization of some animal by-products reinforced rubber seed oil based polyurethane composite for the production of automobile dashboards, Ahmadu Bello University Zaria.
16. Cooper D.B. (2009) Fundamentals of Semi-Conductors OPI, Online Courses Online University.
17. Kennedy M. C. (2012). Electricity. IB Physics note. Matter and Physics.
18. Jian Qiao Li (2008). Three Dimensional Geometric Modelling of Wild Boar Head by Reverse Engineering. Journal of Bionic engineering Technology by.
19. Justin, R. and Walter, F. S., (2005) Polyethylene reinforced with keratin fibres obtained from chicken feathers. Journal of Composites Science and Technology. Elsevier Ltd. Vol. 65, Issue 2, 173 – 181.
20. Lucas Tom. (2004). Acta Biomaterialia journal Vol 6 2010 319–330.
21. Umma A. (2007). Characterization and Potential application of Kano Cattle Horn. Bayero University Kano, published by Journal of Engineering Technology.
22. Usman, H., Nasiru, M., 2005. Commodity Chain Analysis of Cattle Marketing in Nigeria; a Case Study of K.R.I.P Rea Kano State. A Report Submitted To Adeni Project/Naerls Zaria.

    Yawas, D. S. and Jimoh, G. A. (2011) Development of polyester composite reinforced with cow bone for automotive applications. Book of Abstracts, the 27th annual conference/AGM, Nigerian metallurgical society.

APPENDIX

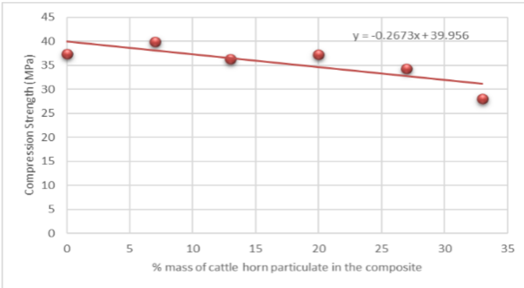

Fig1: Compression strength versus % mass of cattle horn particulate in the composite

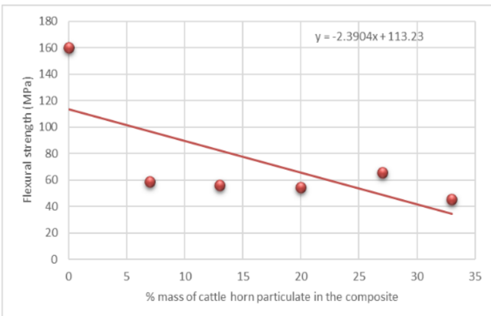

Fig2: Flexural strength versus % mass of cattle horn particulate in the composite

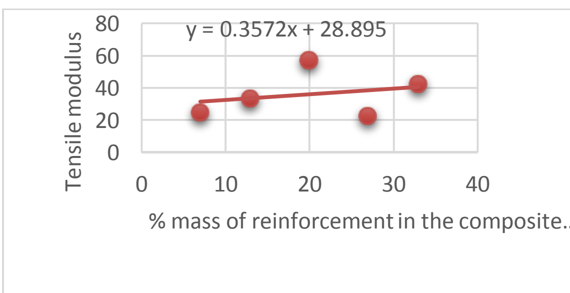

Fig3: Tensile modulus versus % mass of cattle horn particulate in the composite

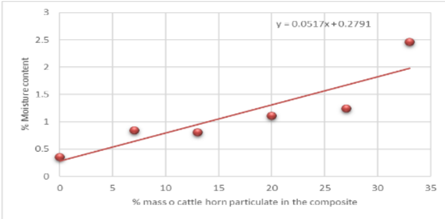

Fig 4: Moisture content (%) versus % mass of cattle horn particulate in the composite

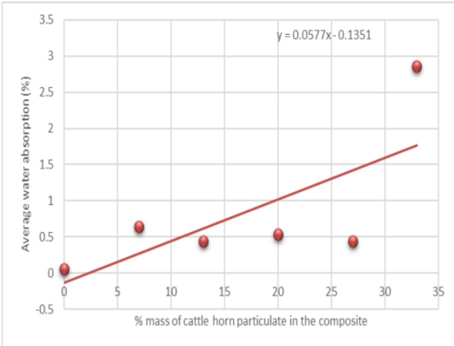

Fig5: Water absorption versus % mass of cattle horn particulate in the composite

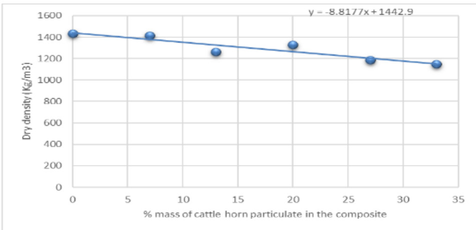

Fig6: Dry Densities versus % mass of cattle horn particulate in the composite

Plate 1: Developed composite particle board.

DOUBLE FREQUENCY SPACED MULTIPLE WAVELENGTH BRILLOUIN/ERBIUM FIBER LASER

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ABSTRACT

Multiple wavelength fiber lasers offers numerous advantages in the support of dense wavelength division multiplexing systems that evolved in order to harness the massive bandwidth provided by optical fiber in optical communication systems. An experimental structure that produced 9 optical channels, with 20 GHz (double frequency spaced) separation between channels is presented. The structure utilizes Brillouin gain generated in a single mode optical fiber to initiate lasing. The Brillouin gain is assisted by erbium gain, obtained from erbium doped fiber amplifier. The demonstrated laser mitigates the problem associated with modulation of single spaced fiber lasers. The laser produced 9 channels at BP signal power of - 30 dBm at BP wavelength of 1550 nm which is centered within the C – band optical communication window

Keywords: Brillouin, Erbium, Fiber, Laser, Wavelength, Channels

1. INTRODUCTION

Dense wavelength division multiplexing (DWDM) was introduced in optical communication in order to utilize the massive bandwidth offered by optical fibers (Kim, Chun et al. 2010). Lasers provide coherent source of light that act as carrier wave in this type of communication systems. A good candidate that supports the DWDM technique is laser with multiple output wavelengths (Harun, Cheng et al. 2007). Among the different types of laser technology, fiber based lasers offers numerous advantages that include compatibility with other optical devices and the ease of generation of multiple wavelengths from a single wavelength coherent light source. Fiber lasers also offer high stability, narrow linewidth and low threshold value (Smith, Zarinetchi et al. 1991; Fan, Lu et al. 2003; Lu and Grover 2005; Al-Mansoori, Iqbal et al. 2006; Nasir, Yusoff et al. 2009). Fiber lasers are normally generated from stimulated Brillouin scattering (SBS) effect in a suitable resonator (Stepanov and Cowle 1997). SBS occurs in optical fibers through the generation of a backward propagating signal, termed Brillouin Stokes (BS), which appears when the power of the injected input signal reaches SBS threshold value. The frequency of the BS signal is normally downshifted from the frequency of input incident light by a value determined by the material that is used in the fabrication of the fiber. For a silica-based fiber, the value is intrinsically 0.08 nm (10 GHz) (Jackson, Sabella et al. 2007). Fiber lasers generated from SBS effects are generally termed Brillouin Fiber lasers (BFL). BFLs are however highly inefficient due to the low Brillouin gain generated from the SBS effect (Ippen and Stolen 1972).

To make such lasers efficient, researchers reported integration of some form of fiber based amplification to the Brillouin gain. The amplification schemes employed are mainly erbium doped fiber amplifier (EDFA) and Raman fiber amplifier (RFA) (Cowle and Stepanov 1996; Shirazi, Harun et al. 2014). Amplification bandwidth of EDFA however coincided with the bandwidth of the low loss optical transmission window centered at 1550 nm In this way, EDFA are massively deployed in long – haul optical transmission systems (Desurvire, Bayart et al. 2002). Also, hybrid integration of Brillouin and Erbium gains offers better optical signal – to – noise ratio than the integration of Brillouin and Raman gains in optical fibers (Ajiya, Mahdi et al. 2009). It has been reported that it is very difficult to modulate channels at the dense 10 GHz separation intrinsically offered by the Brillouin gain in Silica based fibers (Shee, Al-Mansoori et al. 2010).

In this paper, multiple wavelength fiber laser structure that utilizes optical integration of Brillouin and Erbium gains is reported. Furthermore, the laser's output channels are designed to be rigidly separated by 20 GHz (0.16 nm) so as to mitigate the problem of modulation intrinsically offered by 10 GHz channels' separation.

2. EXPERIMENTAL SET UP

The proposed fiber laser structure as depicted in Fig. 1 consist of 25 km spool of single mode fiber (SMF), 3 dB coupler, an isolator, a circulator, Cir, erbium doped fiber amplifier (EDFA), and a Brillouin pump (BP) provided by a tunable laser source (TLS).

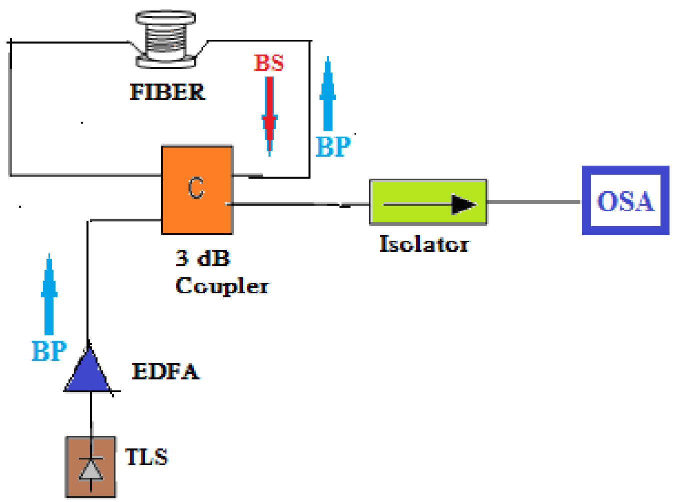

Fig. 1 Structural Set Up of the 20 GHZ spaced Fiber Laser

Furthermore, the structure consists of optical spectrum analyzer (OSA), through which measurements are taken. The 3 dB (50/50) optical coupler provides a mechanism for coupling the Brillouin pump signal into the optical fiber, the SMF. It also provides a means for connecting the laser's output to the OSA through the optical isolator that prevent unnecessary back reflection of light into the resonator. The EDFA was employed to provide optical amplification of the Brillouin pump signal before being injected into the laser's cavity. This arrangement is referred to as BP pre-amplification technique (Al-Mansoori and Mahdi 2008). To generate the lasing output, the pre-amplified BP signal is first injected into the resonator. At the coupler, 50% of the BP will be directed into the SMF. When the power of the injected BP signal is sufficient enough to overcome the Brillouin threshold of the SMF, first order Brillouin Stoke (BS) signal will be created that will propagate in the opposite direction to the flow direction of the BP signal. The BS signal is frequency downshifted by 10 GHz from the wavelength of the BP signal. This phenomenon is intrinsically generated in the fiber, being silica based. Also, at the coupler, 50% of the BS signal will be guided into the SMF through its other end. This signal will now act as a BP signal in the fiber. When its power supersede the Brillouin threshold in the SMF, another BS signal will be generated that will also propagate in the opposite flow direction of the first BS signal. The process will be continued until the power of the BS signal, acting as subsequent BP signals diminishes thereby not becoming unable to overcome the Brillouin threshold of the SMF. The generation of the multiple output will now ceased. The coupler however isolates the odd-order Brillouin Stokes from circulating in the cavity and allowed the even-order Brillouin Stokes to be directed to the output and be monitored through the OSA. In this way, double spaced (20 GHz) separation between channels is achieved.

3. RESULTS AND DISCUSSION

The amplification profile of the EDFA was first investigated. A BP signal with a power of -49 dBm was passed through the EDFA. At the output of the amplifier, a signal with a power of 2.34 dBm was recorded as shown in Fig. 2

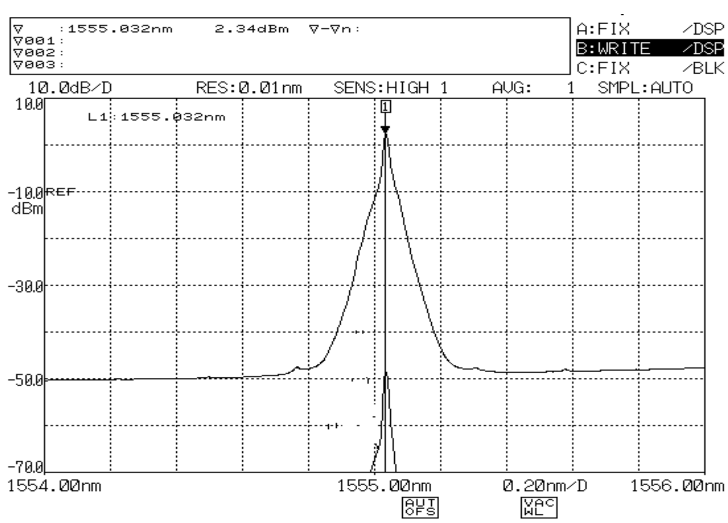

Fig. 2 Amplification profile of the EDFA

It can therefore be seen clearly that the EDFA was able to amplify the input BP signal. Thereafter, the amplified BP was injected into the resonator. At BP signal power of -30 dBm, 9 output channels are produce by the structure as depicted in Fig. 3

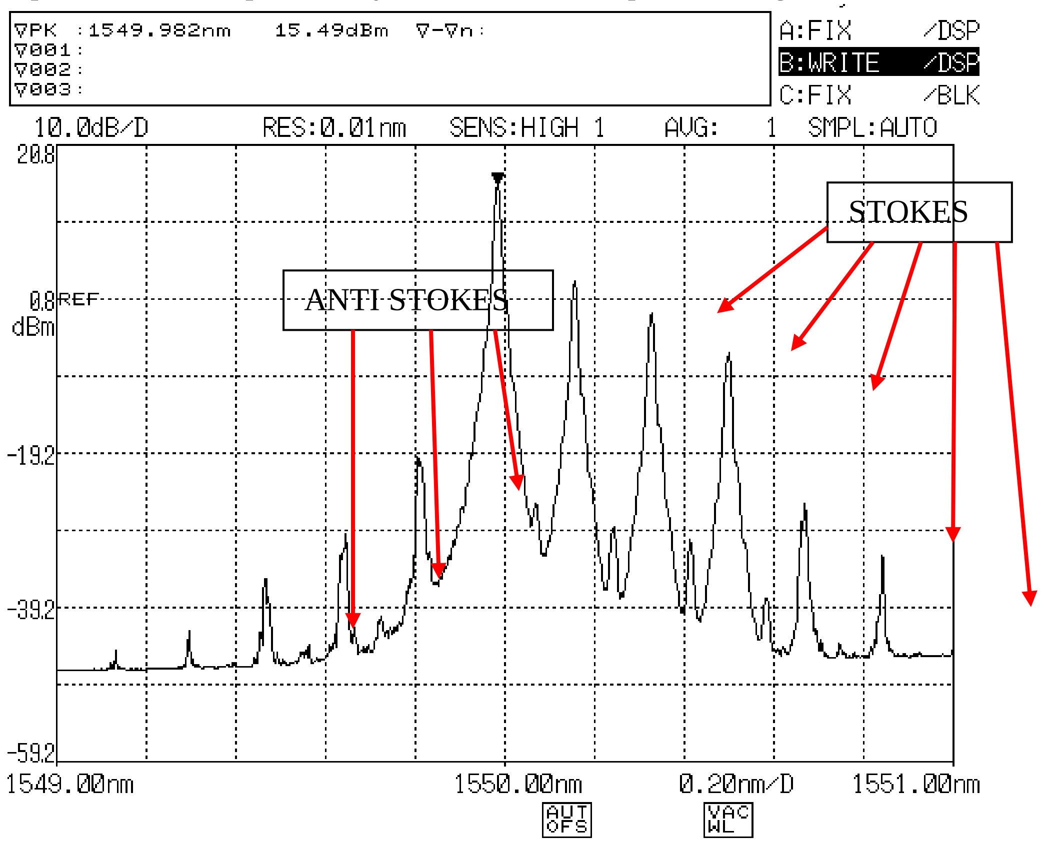

Fig.3 Spectrum of the maximum lasing channels generated

The nine channels generated are made up of the BP, five Stokes and three anti-Stokes that can be seen from Fig.3. The BP has a power of 15.5 dBm while the Stokes has maximum powers of 1.2 dBm, - 0.2 dBm, - 6.2 dBm, - 25.2 dBm and – 31.2 dBm respectively. On the other hand, the anti-Stokes has powers of -20 dBm, -29 dBm and -35 dBm respectively. The Stokes and the anti Stokes power diminish with subsequent channel generation due to the fact that subsequent BP signals are themselves BS signals. This trend is shown in Fig. 4

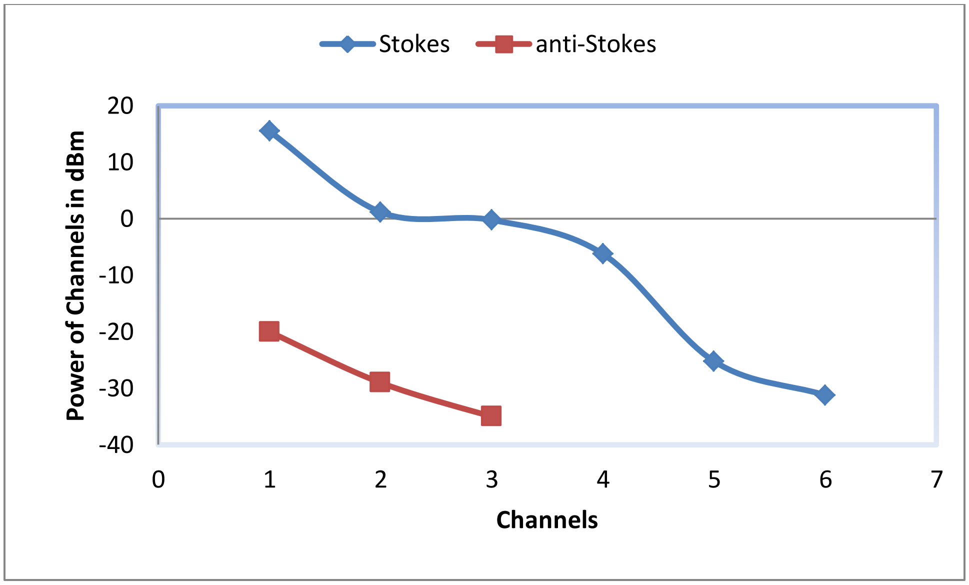

Fig. 4 Diminishing of BS power with channel generation

4. CONCLUSION

Multiple channels Brillouin fiber with the assistance of Erbium doped fiber amplifier is successfully demonstrated. The laser's channels are separated by double Brillouin frequency (20 GHz) spacing. The double Brillouin frequency separations between channels were obtained by utilizing a 3 dB optical coupler that was able to discriminate between odd- ordered and even-ordered Stokes. The odd ordered Brillouin Stokes signals are effectively suppressed in the lasing cavity. The double spaced channels could ease modulations problems associated with the intrinsically 10 GHz spacing between channels. The demonstrated laser produced 9 channels at BP signal power of - 30 dBm at BP wavelength of 1550 nm which is centered within the C – band optical communication window

ACKNOWLEDGEMENT

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REFERENCES

Ajiya, M., M. A. Mahdi, et al. (2009). "*Seamless Tuning Range based-on Available Gain Bandwidth in Multiwavelength Brillouin Fiber Laser* " Optics Express **17**(8): 5944 - 5952.

Al-Mansoori, M. H., S. J. Iqbal, et al. (2006). "*Low threshold characteristics of an L-band Brillouin-erbium comb fiber laser in a linear cavity*." Journal of the Optical Society of America B **23**(11): 2281-2284.

Al-Mansoori, M. H. and M. A. Mahdi (2008). "*Tunable range enhancement of Brillouin-erbium fiber laser utilizing Brillouin pump preamplification technique*." Optics Express **16**(11): 7649-7654.

Cowle, G. J. and D. Y. Stepanov (1996). "*Hybrid Brillouin/erbium fiber laser*." Optics Letters **21**(16): 1250-1252.

Desurvire, E., D. Bayart, et al. (2002). *Erbium-Doped Fiber Amplifiers: Device and System Developments*. New York, John Wiley and sons, Inc.

Fan, Y. X., F. Y. Lu, et al. (2003). "*Narrow-linewidth widely tunable hybrid Q-switched double-clad fiber laser*." Optics letters **28**(7): 537-539.

Harun, S. W., X. S. Cheng, et al. (2007). "*Self-excited brillouin–erbium fiber laser for DWDM applications."* Optics and Laser Technology **39**(1): 94-97.

Ippen, E. P. and R. H. Stolen (1972). "*Stimulated Brillouin scattering in optical fibers*." Applied Physics Letters **21**(11): 539-541.

Jackson, S. D., A. Sabella, et al. (2007). *"Application and development of high-power and highly efficient silica-based fiber lasers operating at 2 µm.*" IEEE Journal of Selected Topics in Quantum Electronics **13**(3): 567-572.

Kim, Y.-J., B. J. Chun, et al. (2010). "*Generation of optical frequencies out of the frequency comb of a femtosecond laser for DWDM telecommunication.*" Laser Physics Letters **7**(7): 522 - 527.

Lu, Z. G. and C. P. Grover (2005). "*A widely tunable narrow-linewidth triple-wavelength erbium-doped fiber ring laser.*" IEEE Photonics Technology Letters **17**(1): 22-24.

Nasir, M. N. M., Z. Yusoff, et al. (2009). "*Low threshold and efficient multi-wavelength Brillouin/erbium fiber laser incorporating a fiber Bragg grating filter with intra-cavity pre-amplified Brillouin pump.*" Laser Physics Letters **6**(1): 54 - 58.

Shee, Y., M. Al-Mansoori, et al. (2010). "*Multiwavelength Brillouin-erbium fiber laser with double-Brillouin-frequency spacing.*" Optics Express **19**(3): 1699-1706.

Shirazi, M., S. Harun, et al. (2014). "*Multi-wavelength Brillouin Raman erbium-doped fiber laser generation in a linear cavity.*" Journal of Optics **16**(3): 035203.

Smith, S. P., F. Zarinetchi, et al. (1991). "*Narrow-linewidth stimulated Brillouin fiber laser and applications*." Optics Letters **16**(6): 393-395.

Stepanov, D. Y. and G. J. Cowle (1997). "*Properties of Brillouin/erbium fiber lasers.*" IEEE Journal of Selected Topics in Quantum Electronics **3**(4): 1049-1057.

ASSESSMENT OF THE RELIABILITY INDICES OF 11KV DISTRIBUTION FEEDERS - CASE STUDY OF ILORIN, NIGERIA

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ABSTRACT

This paper presents the reliability evaluation of 11KV distribution feeder network based on the interruptions caused by distribution feeders and computes the reliability indices associated with feeders Ll, L2, L3 and L4 using SCILAB. The objectives of this study are to increase the lifetime of the feeders and reduce sudden failures. The study data was collected from Ilorin Electricity Distribution Company. These indices will assist distribution system engineers in system design, planning and operation. An overall picture of results obtained was graphically depicted. The reliability indices of these feeders were also compared to what is obtainable in other developing countries and the wide gap observed in the results obtained show the unreliable nature of these distribution feeders. Also, the contribution of other distribution system component such as transformers, circuit breakers and overhead lines to the overall reliability of the distribution system was also highlighted. The paper is concluded with suggestions on how to improve both the quality and reliability of electricity supply in the country.

KEYWORDS: Reliability, distribution system, feeders, SCILAB

1. INTRODUCTION

The term reliability has a very wide range of definitions and cannot be associated with a single definition. However, from engineering point of view, reliability can be defined as the probability that a system will perform required function under a given condition for a stated period, usually a thousand hours or million hours (Abdullahi et al.2007). The reliability of a system or equipment as defined by Iresome and Coombs (1998) is the conditional probability at any given confidence level that the system or equipment will perform its intended function at a given age, for a specific length of time when used in the manner and purpose intended while operating under specific environment. The reliability of an electric power system is, therefore, defined as the probability that the power system will perform the function of delivering electric energy to customers on a continuous basis and with acceptable service quality (Bhavaraju et al. 2005). Reliability can be discussed under two major categories; system adequacy and system security.

System adequacy relates to the existence of sufficient generation, transmission and distribution facilities within the system to satisfy the customer load demand. System security, on the other hand, relates to the ability of the system to respond to disturbances arising within the system. The distribution system acts as the vital link between the bulk system (generation and transmission combined) and the consumers. They are useful for planning; design; operation and maintenance Distribution systems also contribute as much as 90% towards customer outages and supply unavailability. The reliability of the distribution system is thus of great importance to the overall system reliability. No matter how reliable the generation and transmission systems may be, their reliability will not manifest if the distribution system is unreliable. The degree of reliability is measured by the frequency, duration and magnitude of adverse effects on the electric power supply. Clearly, it is not possible to plan to prevent all interruptions, yet planning can decrease the rate of occurrence of service interruptions. There are many causes for equipment outages and service interruptions. Outages can be caused by equipment failure due to weather conditions or other causes, and by equipment being switched off deliberately, by mistake, or by failure of control equipment. Service interruptions can be caused by a downed line, failed cables, a damaged transformer (e.g., by overloading), or failures in customers' equipment (e.g., open wiring, corroded switchgear). Momentary interruptions can be caused by natural events such as trees brushing conductors, thus causing a high-impedance fault; small animals contacting conductors and being vaporized; or lightning. Because reliability is a probability, even highly reliable systems have some chance of failure. However, testing reliability requirements is problematic for several reasons. A single test is insufficient to generate enough statistical data. Multiple tests or long-duration tests are required but usually expensive. Some tests are simply impractical. It is therefore important to design a realistic and affordable test program that provides enough evidence that the system meets its requirement. The failure of components, structures, and systems occur as a result of fatigue or faults in the system. That a system must one day fail has become a reality no matter how perfect the design may be. The failure frequency and consequent losses can however be minimized. The need to minimize failure frequency and cost has been the impetus towards the study of failures in systems and thus device means of improving the reliability of such system. The de-regulation of any electric utility company will result in a major cost cutting at many utilities. These cost cuts in equipment, crew size, maintenance, etc., could mean major reductions in reliability. It is therefore important to have a standard reporting of reliability indices to enable monitoring of distribution components. The question to the utility is how will reliability be increased at the lowest possible cost?

A lack of extensive and dependable equipment failure data has been a hindrance to quantitative distribution system reliability assessment in the past. Twenty years ago, few utilities recorded equipment failure data. A survey found that less than ten percent of responding utilities maintained component population records sufficient to provide failure rate data necessary for predictive reliability assessment (EPRI White Paper, 2000)

The Nigerian electric power system has attracted increasing attention within the last decade essentially because of the glaring unreliability of the system. In spite of reported huge investments and policy innovations, the performance of the system is far below expectation, being characterized by frequent failures and long outage durations. Reportedly, billions of Naira has been pumped into the system within the last few years, for generation system reactivation, for transmission and distribution system reinforcement and expansion (Momoh A. 2004). Independent Power Producers (IPPs) have been encouraged to invest in power generation to boost output. An amount of unbundling has been introduced to decentralize the management of the system. There has been little or nothing to show for all these. Incessant and high frequency failures, under voltage supplies, system collapse, regular load shedding and protracted outages are still the order of the day (Megobowon et al 2009).
Various studies have shown that about 75-80% of electric power interruptions are due to distribution system problems. The power industry is gradually moving towards a deregulated, competitive environment where accurate information about system performance is required to ensure that maintenance money is spent wisely and that consumer expectations are met.

2. METHODOLOGY AND DATA PRESENTATION

The data collated from three 11KV distribution feeders from the Ilorin Electricity Distribution Company is summarized in (H. Ismail et al 2013). SCILAB was used to evaluate the reliability indices and the result presented in tables 5.1-5.4. SCILAB is an open source programming language associated with a rich collection of numerical algorithms provided under the Cecill language (available online at www.cecill.info). Graphical representation of the reliability indices for the year under consideration are as presented in Figures 1.1-1.9. Total number of distribution component failures are also presented in Figure 2.1. The reliability indices of these feeders were compared with those obtainable in other countries. Feeders under consideration and their load capacities are as in Table 1.1.

3. RELIABILITY INDICES

(i) System Average Interruption Frequency Index (SAIFI)

This index is the average number of interruptions per customer served per year. It is determined by dividing the accumulated number of customer interruptions in a year by the number of customers served. A customer interruption is considered to be one interruption to one customer.

(ii) Customer Average Interruption Frequency Index (CAIFI)

This index is the average number of interruptions per customer interrupted per year. It is determined by dividing the number of customer interruptions observed in a year by the number of customer affected. The customers affected should be counted only once regardless of the number of interruptions that they may have experienced during the year.

(iii) System Average Interruption Duration Index (SAIDI)

This index is the average interruption duration for customers served during a year. It is determined by dividing the sum of all customer interruption duration during a year by the number of customers served during the year.

(iv) Customer Average Interruption Duration Index (CAIDI)

This index is the average interruption duration for customers interrupted during year. It is determined by dividing the sum of all customer sustained interruption duration by the number of sustained customer interruptions over a one year period.

(v) Average Service Availability Index (ASAI)

This is the ratio of the total number of customer hours that service was available during a year to the total customer hours demanded. Customer hours demanded are determined as the twelve-month average number of customers served timed 8760 hours. This is sometimes known as the "Service Reliability Index".

Examples of reliability standards used by some utilities are ASAI□0.9998, SAIFI<1, CAIDI<2 hours; ASAI□0.99975 for urban, □0.99935 for low-density rural, CAIDI□270 min, SAIDI□187 min; SAIFI 0.75 for residential, 0.6 for commercial; SAIDI 65 min for residential, 45 min for commercial, at most one outage/year and 80 min for very large commercial (EPRI White Paper, 2000).

Table 1: Feeders under consideration and Load Capacity

Feeder Designation	Load Capacity (MW)	Number of Transformer
11KV Feeder L1	5.7	48
11KV Feeder L2	6.5	55
11KV Feeder L3	6.9	62
11KV Feeder L4	7.8	54

4. RELIABILITY MODEL

For the purposes of data analysis, the following reliability indices were used as inputs to the SCILAB program whose results are presented in tables 5.1- 5.6 below

$$\mathrm{SAIDI} = \sum \left(r_i \times N_i\right) / N_T = \frac{\text{Customer Interuption Duration}}{\text{Total Number of Customers Served}} \qquad (1)$$

$$\text{CAIDI} = \sum {}^{(r_{i \times N_i})}\Big/_{\sum(N_i)} = \frac{\text{Customer Interruption Duration}}{\text{Total Number of Customer Interruption}} \ldots (2)$$

$$\text{SAIFI} = \sum {}^{(N_i)}\Big/_{N_T} = \frac{\text{Total Number of Customer Interruption}}{\text{Total Number of Customer Served}} \ldots (3)$$

$$\text{ASAI} = \left\{1 - \left(\sum\left({}^{(r_{i \times N_i})}\Big/_{N_T * T}\right)\right)\right\} * 100 \qquad (4)$$

5. DATA PRESENTATION

Tables below show data obtained from SCILAB program for the reliability of system distribution on feeders L1, L2, L3 and L4

Table 2: Reliability Indices on feeder L1

YEAR	CAIDI (Hrs)	SAIFI (Hrs)	SAIDI (Hrs)	ASAI (per unit)	ASUI (per unit)
2000	6.2554	0.2354	4.2113	0.6254	0.3746
2001	5.2344	0.2145	4.1255	0.4566	0.5434
2002	5.1088	0.1003	4.8477	0.6233	0.3767
2003	4.2441	1.2331	5.2344	0.5519	0.4881
2004	6.1145	1.0025	6.2441	0.7321	0.2679
2005	4.2145	0.5648	3.5221	0.5033	0.4967
2006	5.1123	1.2479	4.2553	0.6023	0.3977

Table 3: Reliability Indices on feeder L2

YEAR	CAIDI (Hrs)	SAIFI (Hrs)	SAIDI (Hrs)	ASAI (per unit)	ASUI (per unit)
2000	5.2114	1.5789	5.2345	0.9987	0.0013
2001	4.1132	1.0032	2.1134	0.1245	0.8754
2002	5.1145	1.2479	4.1255	0.8711	0.1289

2003	4.1478	0.6541	4.2566	0.4799	0.5201
2004	3.1277	0.5490	4.1223	0.1233	0.8767
2005	4.2578	1.5479	5.1447	0.2253	0.7747
2006	4.6987	1.5541	4.1658	0.4588	0.5412

Table 4: Reliability Indices on feeder L3

YEAR	CAIDI (Hrs)	SAIFI (Hrs)	SAIDI (Hrs)	ASAI (per unit)	ASUI (per unit)
2000	5.2415	1.4798	5.2336	0.7887	0.2113
2001	5.1447	1.4287	5.4112	0.6235	0.3765
2002	5.2143	1.5547	4.5264	0.9512	0.0488
2003	5.1447	0.6258	4.1147	0.5079	0.4921
2004	5.2336	1.5647	4.1998	0.8223	0.1777
2005	6.1245	2.5411	5.6234	0.7457	0.2543
2006	6.2355	2.3362	4.2398	0.6546	0.3454

Table 5: Reliability Indices of Feeder L4

YEAR	CAIDI (Hrs)	SAIFI (Hrs)	SAIDI (Hrs)	ASAI (per unit)	ASUI (per unit)
2000	4.3565	1.2544	4.2556	0.7301	0.2699
2001	3.4596	1.3998	5.2635	0.2541	0.7459
2002	3.5712	1.5708	4.9987	0.7998	0.2002
2003	2.4756	1.0069	4.2223	0.5236	0.4764
2004	2.5596	0.7082	3.2369	0.4879	0.5121
2005	4.5142	1.6544	4.2315	0.5698	0.4302
2006	2.1442	0.5813	5.4112	0.8974	0.1026

Table 6: Total Component Failures

Component	2000	2001	2002	2003	2004	2005	2006
Transformers	12	5	19	10	25	14	12
Surge Arrestors	28	36	18	39	25	19	32
Overhead Lines	58	44	36	55	61	41	68
Circuit Breakers	14	11	18	21	16	29	41

6. RESULTS

Figures 1-5 depicts the variation of feeders L1-L4 for the period under consideration and their various reliability indices.

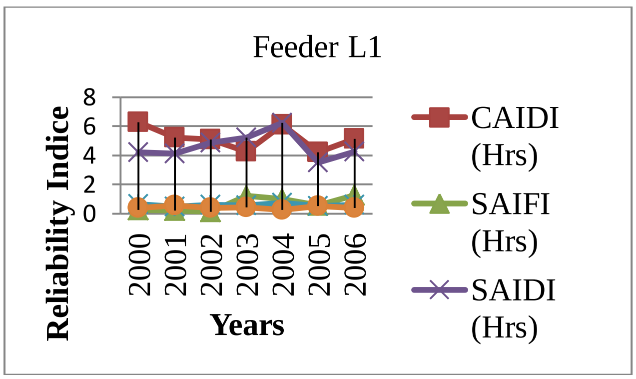

Figure 1: Variation of Reliability Indices for Feeder L1

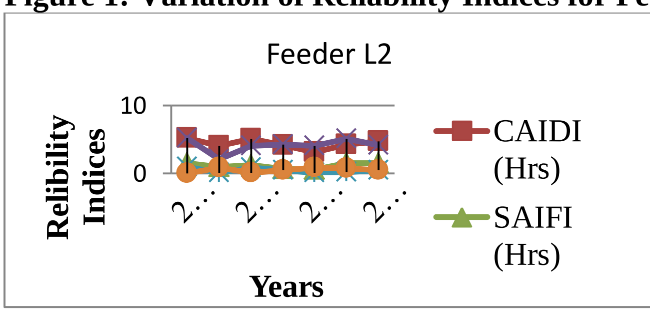

Figure 2: Variation of Reliability Indices for Feeder L2

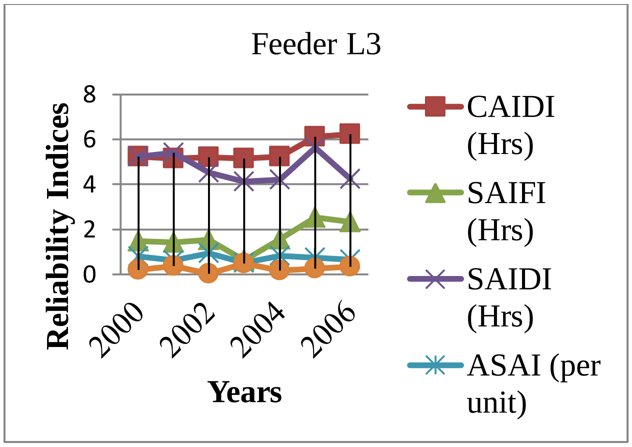

Figure 3: Variation of Reliability Indices for Feeder L3

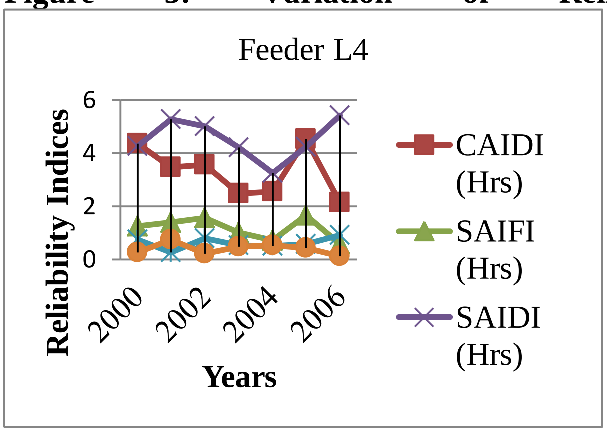

Figure 4: Variation of Reliability Indices for Feeder L4

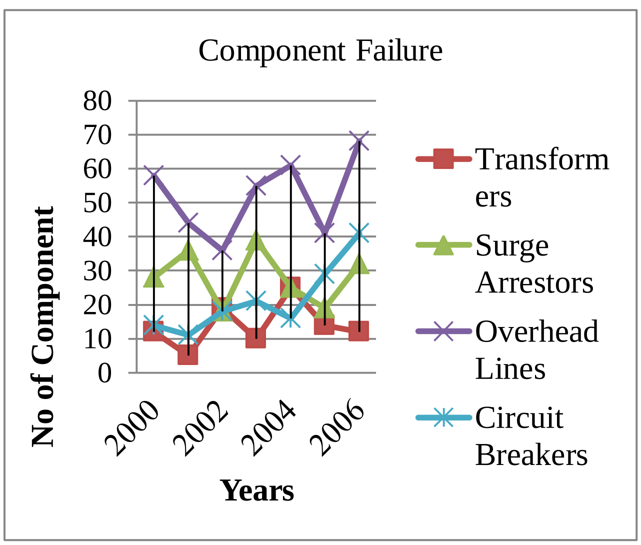

Figure 5: Rate of Distribution Component Failures

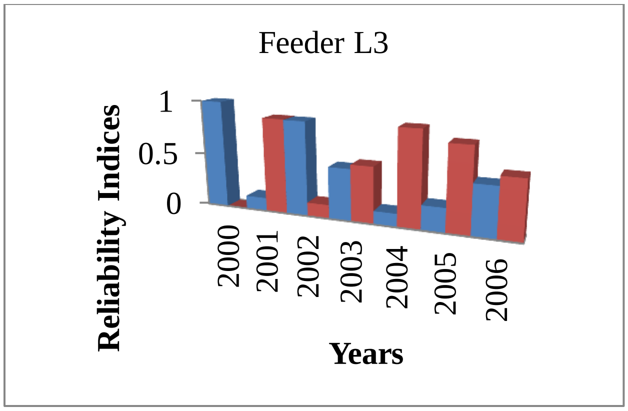

Figure 6: Feeder L2 with low unavailability

5. DISCUSSION OF RESULTS
6.

From Fig. 1, average system CAIDI on feeders L1 due to failures of system components is obtained as 6.2554(2000), 5.2344 (2001), 5.1088 (2002), 4.2441 (2003), 6.1145 (2004), 4.2145 (2005), and 5.1123(2006). These CAIDI values are extremely high compared to (IEEE Std 1366-2000) which means more time was spent carrying out unscheduled repairs.

SAIFI measures the average number of interruptions per customer served per year, it can be seen that the average system SAIFI for years 2000-2006 is 1.1586 which is the time over which the average customer was without power for a period of one year. This is high when compared to what is obtainable in other high density urban areas as discussed in (Inusa, 2010) and (Adamu et al. 2011). Baltimore utility company reports an average SAIDI value of 0.03 hours per customer interruption. The average SAIDI value obtained from this study for the period under review is 4.5203 per customer. This is exceedingly high and means that the customer experience more interruptions per year due to low generation of the feeders. Average ASAI and ASUI figures are as depicted below. This means that the feeders under review were available for 72.86% though such availability is determined by other factors such as scheduled and unscheduled maintenance, system collapse and load shedding on the distribution network. It is also observed that both the number of customer interruptions and customer interruption duration increases with increasing unavailability of the distribution system for the years 2001-2006.

Also, it can be observed that feeder L2 has the highest unavailability of all the feeders studied as the average unavailability of this feeder for the five years under consideration was found to be 0.2723.

7. CONCLUSION

This work has assessed the reliability of four Ilorin feeders L1, L2, L3 and L4 using the SCILAB program to evaluate the indices. It has evaluated the interruptions caused by distribution system components and the reliability indices associated with the feeders.

From all indications, the very poor reliability state of the feeder lines has been observed. The failure rate of the feeder is too high to be acceptable. There is a wide gap between the performances of power systems in the developed world and the performance observed in this study. In Japan for instance, there has been a steady decline in customer supply outages since 1975. By 1994, customer outages figures had declined to an average of two per ten years (Hesham et al. 1994). The figures for other developed nations at that time were estimated to be two per year (Hayakashi et al.1998).
This study could be used to examine preventive maintenance modelling in order to evaluate its effects on the components of the station. This could help in increasing the electricity supply and decreasing the operating cost of the power station.

REFERENCES

Abdullahi, M.I.; Akinsanmi, O.; Muazu, M.B. and Jubril, Y. 2007. Reliability assessment of an electronic system: A case study of a British siren in Nigeria. J. Appl. Sci. Res.3: 1,671-5.

Ireson, W.G.; and Coombs, C.F;. 1988. A Handbook of Reliability Engineering and Management, 2nd ed. McGraw-Hill, New York, NY, USA.

Bhavaraju, M.P.; Billinton, R.; Brown, R.E.; Endrenyi, J.; Li, W.; Meliopoulos, A.P.; and Singh, C. 2005. IEEE Tutorial on Electric Delivery System Reliability Evaluation. IEEE Power Engineering Society (PES), Publication 05TP175: 39-51.

Reliability of Electric Utility Distribution Systems: EPRI White Paper, EPRI, Palo Alto, CA: 2000. 1000424

Momoh A. 2002. Privatization is replacing state monopoly with private monopoly. NEPA Review. October -December. pp. 24-34.

Megbowon I.O. and Popoola J.J, 2009. An Investigation into the Distribution of Time between Failures on Distribution Feeder lines in South Western Nigeria, ARPN Journal of Engineering and Applied Sciences, Vol. 4 No 6, August 2009 pp 44-45.

Inusa Danliti, 2010. Master's Degree Thesis (Un-published), Department of Electrical Engineering, Bayero University, Nigeria.

S.S Adamu and K.A Popoola; (2012) "Reliability Assessment of Electric Power Distribution System: A Case Study of Lokoja 11 KV Distribution Feeders, University of Ibadan, ETM Conference pp37 -43.

Robert P. Broadwater, Hesham E. Shaalan, (1994), Distribution System Reliability and restoration analysis, Electric Power System Research, pp. 203-211.

E. E Ilochi, O. Akamnonu and AU Esenabhaiu, " Experience with frequency and duration method in reliability assessment of distribution feeders – A Study of Power Holding Company of Nigeria (PHCN), Plc. Enugu Distribution Company, Enugu, Nigeria.

Jimoh, A. A. and Adegboye, B. A, April 1995 "A study of the reliability performance of Kanji hydroelectric power station using the frequency and duration method", African Journal of Science and Technology, Series A, Vol. 11.

APPLICATION OF ISO-SAFETY DESIGN CHARTS FOR REINFORCED CONCRETE COLUMNS TO EUROCODE 2

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ABSTRACT

Engineering design is usually a trade-off between maximizing safety levels and minimizing cost. However deterministic safety factors do not provide adequate information to achieve optimal use of the available resources to maximize safety, while the probabilistic analysis does. This paper applies the concept of reliability for the design of reinforced concrete columns to Eurocode 2. Individual parameters were considered random with practical probability distributions. Interaction curves were plotted for varying safety indices. The choice of target reliability index was made to correspond to values recommended for the ultimate limit state by Joint Committee on Structural Safety. It was shown for short column that for the same bending and geometrical conditions of the column, the design results for target safety indices of 2.5 and 3.0 are the same. However, at target safety levels of 4.0 and 5.0, there is an increment of 825mm^2 and 1237mm^2 respectively, in the area of steel provided as compared to target safety of 3.0. It was observed that the safety index along the entire interaction curves of any selected Iso-safety design charts (reliability-based design chart) is the same, therefore any column designed using the charts would have a specific level of safety.

***Keywords**:* Structural design, Reliability, Reinforced concrete column, Interaction curves.

1. INTRODUCTION

Columns are compression members which transmit compressive forces from one part of a structure to another. The most well known form of a column is a straight strut with axial compressive forces on opposite ends. Columns were at first made of wood and stone as found in many ancient Greek and Roman buildings. Columns were first used as roof supports for these old buildings and had very large cross sections. The design of column was mainly on artistic considerations with little engineering considerations as is understood today. The load carrying capacity of these columns was by far under-utilized (Wellmanns, 2007).

. Design is a decision making process. Consequently, design problems, in contrast to analytical problems rarely have unique solutions. Hence, designers endeavour to optimize design to achieve important objectives that would satisfy operational and economic requirements within acceptable safety margins. Structural concrete members often show great deviation in structural performance from that predicted by the current methods of analysis and design. In certain cases, predictions considerably underestimate their capabilities while in others the predictions are clearly unsafe as they overestimate the ability of the structural member to perform its prescribed objective.

It was also observed by Afolayan (2005) that the traditional way of dealing with uncertainties in design process is by the use of conservative values of the uncertain quantities and/or safety factors in a deterministic framework. The short-comings of this approach may become more obvious when designing for loads with very high variability.

Wright (2003) pointed out those deterministic characteristics as "exact" models that will produce the same outcome each time they are run, therefore, ignores the uncertainties of the input. Yang and De Wolf (2002) added that such uncertainties must be taken into account to assess the safety and performance of the structure and in view of these uncertainties.

Ocholi (2000) stated that the probability of structural failure from all possible causes, both from violation of predefined limit state and from other causes is unavoidable.However, since no structure may be free from the possibility of failure, loads must be designed to fit the risk.

A deterministic design approach does not have an explicit consideration for this. Ocholi (2000) noted that uncertainties and their significance on structural safety and performance can be analyzed systematically only through methods of probability. A more meaningful treatment of uncertainties can be through a probability-based design philosophy, which has received considerable attention.

2. METHODOLOGY

Probabilistic design is concerned with the probability that a structure will realize the functions assigned to it during its design life. In this paper, the reliability method employed is briefly reviewed. If R is the strength capacity and S the loading effect(s) of a structural system which are random variables, the main objective of reliability analysis of any system or component is to ensure that R is never exceeded by S. In practice, R and S are usually functions of different basic variables (Gollwitzer et al., 1988).

In order to investigate the effect of the variables on the performance of a structural system, a limit state equation in terms of the basic design variable is required. This limit state equation is referred to as the performance or state function and expressed as:

$g(\mathbf{X}) = g(X_1, X_2, \ldots, X_n) = R - S$ (1)

Where X_1 for $I = 1, 2, \ldots$ n represent the basic design variables.

The limit state of the system can then be expressed as

$$g(\boldsymbol{X}) = 0 \qquad (2)$$

Graphically, the line $g(\boldsymbol{X}) = 0$ represents the failure surface, while $g(\boldsymbol{X}) > 0$ represents the safe region, and $g(\boldsymbol{X}) < 0$ corresponds to the failure region as shown in figure 1.

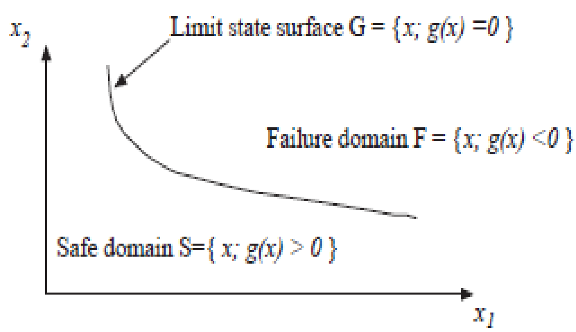

Figure 1: Failure domain, Limit state surface and safe domain ((Thoft-Christensen and Baker, 1982).

The calculation of the limit state function is performed for discrete combination of basic variables (Mosley et at., 2007).

In terms of variables therefore;

$G(X) = (A + B + C) - D$ In which;

$A = (\frac{N}{(bhf_{ck})}\{0.5 - 0.4 (\frac{x}{d})(\frac{d}{h})\}$,

$B = (0.5P \frac{f_{sc}}{f_{ck}} \{0.4(\frac{x}{d})(\frac{d}{h}) - 1 + (\frac{d}{h})\});$

$C = (0.5P \frac{f_{st}}{f_{ck}} \{\frac{d}{h} - 0.4(\frac{x}{d})(\frac{d}{h})\})$ and

$D = (\frac{M}{(bh^2 f_{ck})})$

$G(X) = (\frac{N}{(bh f_{ck})} \{0.5 - 0.4 (\frac{x}{d})(\frac{d}{h})\} + (0.5P \frac{f_{sc}}{f_{ck}} \{0.4(\frac{x}{d})(\frac{d}{h}) - 1 + (\frac{d}{h})\}) + (0.5P \frac{f_{st}}{f_{ck}} \{\frac{d}{h} - 0.4(\frac{x}{d})(\frac{d}{h})\}) - (\frac{M}{(bh^2 f_{ck})})$

Where;

N is the Axial load, M is the design Moment, f_{sc} is the compressive stress in reinforcement, f_{st} is the tensile stress in reinforcement, b is the breadth of the section, h is the overall depth of the section, ρ is the percentage of reinforcement, $\frac{d}{h}$ - is the reinforcement position and $\frac{x}{d}$ is the position of neutral axis.

When constructing a load-moment diagram, five points at a minimum should be considered; (1) the pure axial load-carrying capacity (no eccentricity), *Po*; (2) the pure moment capacity (no axial load), *Mo*; (3) the point of maximum moment, (*Mmm*, *Pmm)*; (4) the balanced point (*Mb*, *Pb*); and (5) the point defining the boundary for tension-controlled limit state, (*Mt*, *Pt*). With these five points, a conservative interaction space can be defined. However, providing intermediate points above and below the balanced point provides a more accurate accounting of the interaction space, and always increases the interaction area.

The proposed charts are shown in the figures 2, 3, 4 and 5.

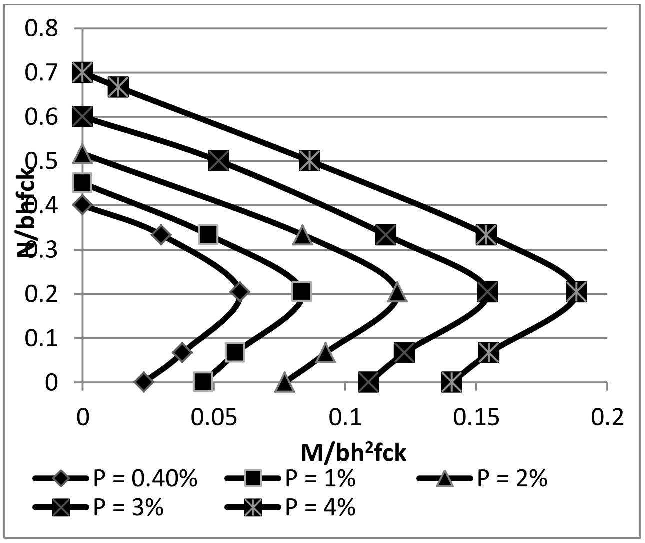

Figure 2: Reliability Based column design chart for β_t = 2.5, d/h = 0.8

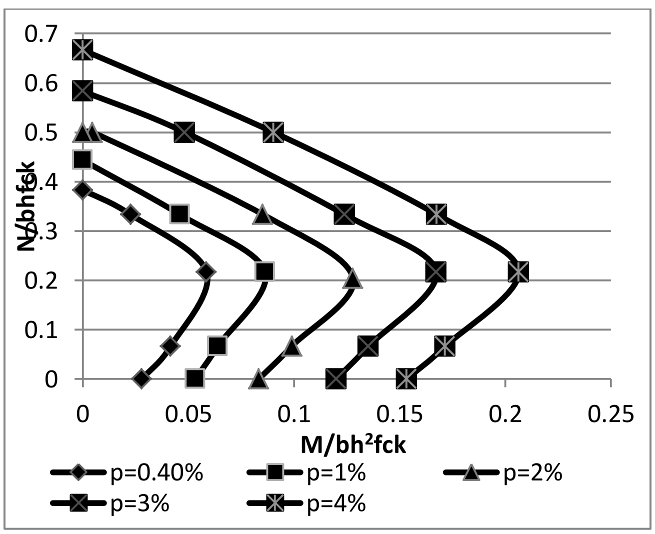

Figure 3: Reliability Based column design chart for β_t = 3.0, d/h = 0.85

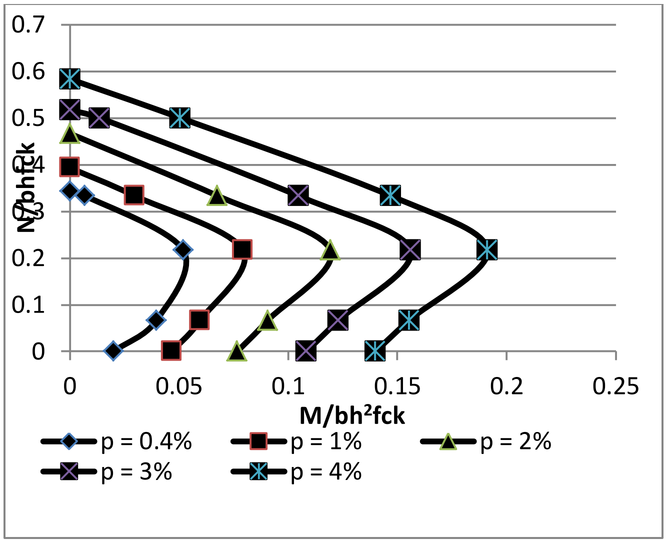

Figure 4: Reliability Based column design chart for β_t = 4.0, d/h = 0.85

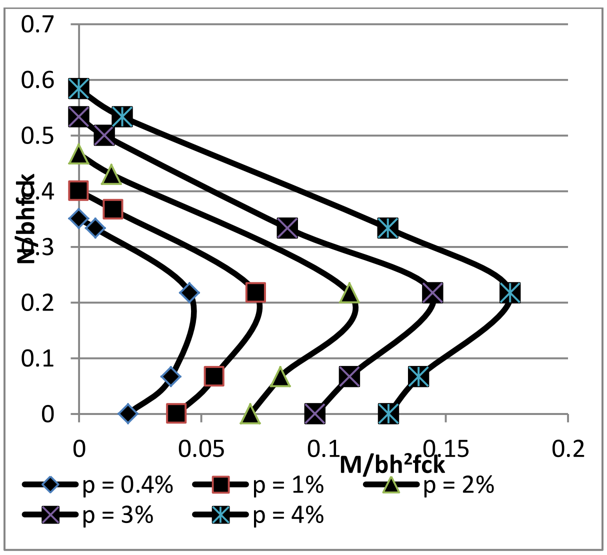

Figure 5: Reliability Based column design chart for β_t = 5.0, d/h = 0.85

3. DISCUSSSION

Design Examples Using Proposed Charts

An internal column of an 8-storey building with dimension 275 x 300 x 3500 mm was subjected to an ultimate axial load (N_{Ed}) of 1600 kN and bending moment (M) of 60 kNm including effect of imperfections. The column was designed assuming that the characteristic strengths of concrete (f_{ck}) and steel (f_{yk}) are 25N/mm^{2}and 500 N/mm^2 and deviation allowance, Δc_{dev} is 5 mm (Chanakya 2009).

It was required to calculate the area of steel required from:

i. The EC 2 (2004) design charts
ii. The proposed Iso-safety design chart at a target safety index of 2.5
iii. The proposed Iso-safety design chart at a target safety index of 3.0.
iv. The proposed Iso-safety design chart at a target safety index of 4.0 and
v. The proposed Iso-safety design chart at a target safety index of 5.0.

i) Using the EC 2 (2004) design charts

Design moment, M_{Ed}

Minimum eccentricity, e_0 = h/30 = 300/30

= 10mm ≥ 20mm (EC 2)

Minimum design moment = $e_0 N_{Ed}$

$= 20 \times 10^{-3} \times 1.6 \times 10^3 = 32$ kNm < M

Hence M_{Ed} = M = 60 kNm assuming $\lambda < \lambda_{lim}$.

Minimum cover to links for exposure class XC1, $c_{min,dur}$ = 15 mm (EC 2,2004).

Assuming diameter of longitudinal bars

(Φ) = 25 mm, minimum cover to main steel for bond, $c_{min,b}$ = 25 mm and the nominal cover, c_{nom} = $c_{min,b} + \Delta c_{dev}$ = 25 + 5 = 30 mm

Assuming diameter of links, (Φ') = 8 mm,

⇒ Minimum cover to links = $c_{nom} - \Phi' - \Delta c_{dev} = 30 - 8 - 5 = 17$ mm > $c$min,dur

= 15 mm OK.

Therefore, d_2 = 30 + 25/2 = 42.5 mm

d_2/h = 42.5/300 = 0.141;   d/h = 257.5/300

= 0.85.

Round up to 0.15 and use EC 2 (2004) column chart with $d_2/h = 0.15$.

Longitudinal steel area:

$\frac{N_{Ed}}{bhf_{ck}}$= 1.6 x 10^6/275 x 300 x 25 = 0.78

$\frac{M_{Ed}}{bh^2 f_{ck}}$= 60 x 10^6/275 x 300^2 x 25 = 0.097

From EC 2 (2004) design chart, $\frac{A_S F_{YK}}{bhf_{ck}}$ = 0.25

Area of steel required is A_s = 0.25 x bhf_{ck}/f_{yk} = 0.25 x 275 x 300 x 25/500 = 1031.25mm^2.

Minimum longitudinal steel Area (EC 2) is $A_{smim} = 0.10N_{Ed}/0.87f_{yk} \geq 0.002A_c$;

367.8mm^2 ≥ 165mm^2. Therefore it is O.K..

ii) Using proposed iso-safety design chart at a target safety index of 2.5

Area of steel required A_s was calculated as equivalent to 1650mm^2.

iii) Using the proposed iso-safety design chart at a target safety index of 3.0

Area of steel A_s required was equivalent to 1650mm^2.

iv) Using the proposed iso-safety design chart at a target safety index of 4.0

Area of steel A_s was calculated as equivalent to 2475mm^2

v) Using the proposed iso-safety design chart at a target safety index of 5.0

Area of steel A_s required was equivalent to 2887mm^2.

Table 1: Summary of Design Examples Using Proposed Charts

S/No.	Chart type	$\frac{A_S F_{YK}}{bhf_{ck}}$	Area of steel A_s (mm^2)
1	EC 2 (2004) design charts	0.25	1031.25mm^2.

2	Iso-safety design chart at a target safety index of 2.5	0.4	1650mm^2
3	Iso-safety design chart at a target safety index of 3.0	0.4	1650mm^2.
4	Iso-safety design chart at a target safety index of 4.0	0.6	2475mm^2
5	Iso-safety design chart at a target safety index of 5.0	0.7	2887mm^2

4. CONCLUSION

The Iso-safety charts have a major advantage over deterministic charts by the systematic adjustment of design criteria which reflect on the consequences of ailure because of the explicit probabilistic treatment given to uncertain variables in the design equations

It was shown for short column that for the same bending and geometrical conditions of the column, the design results for target safety indices of 2.5 and 3.0 are the same. However, at target safety levels of 4.0 and 5.0, there is an increment of 825mm^2 and 1237mm^2 respectively, in the area of steel provided as compared to target safety of 3.0.

5. RECOMMENDATION

It is recommended that Reliability based design curves, should be used by designers for the design of Reinforced Concrete Columns to achieve a probability-based design.

6. REFERENCES

Afolayan, J. O., (2005), Probability Based
Design of Glued Thin-Webbed Timber
Beams, *Asian Journal of Civil Engineering*

(Building and Housing) vol. 6, 75-84

Chanakya Arya (2009) *Design of Structural Elements*.3rd Edition, published by Taylor & Francis,2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN.

Eurocode 2:((2004) *Design of Concrete Structures - Part 1-1: General Rules and Rules for Buildings,* Approved by CEN on 16 April 2004, Brussels

Gollwitzer, S., Addo, T. and Rackwitz, R., (1988), FORM *Manual,* RCP GmbH, Munich, Germany.

JCSS-, (2001). *Bases of Design*, Joint Committee on Structural Safety. JCSS OSTL/DIA/VROU.12th Draft.

Mosley W.H., Bungey J.H. and Hulse R. (2007), *Reinforced Concrete Design,* MacMillan, Hampshire, 6th edition.

Ocholi, A., (2000), Reliability-Based Design of a Steel Roof Truss System, Unpublished M.Sc.Thesis, Department of Civil Engineering, Ahmadu Bello University Zaria, Nigeria.

Thoft-Christensen, P. and Baker M.J. (1982), Structural Reliability Theory and Its Applications, Springer-Verlag, Germany, pp: 82.

Wellmanns R. G. (2007), An investigation into the structural behavior of 350W structural steel axial members, A Dissertation Presented to the University of Johannesburg.

Wright, J. F., (2003), Monte Carlo Risk Analysis, A Solution for Technical Risk Analysis, James F. Wright, PhD Ltd. Co, Pp 1-6.

Yang J. and De Wolf J. (2002), Reliability Assessment of Highway Truss Sign Supports. *Journal of Structural Engineering*, ASCE Vol 128, No. 11, 1429-1438.

ASSESSMENT OF SOUND LEVEL IN SIZE REDUCTION MACHINES USED IN SOME SELECTED LOCAL GOVERNMENT AREAS OF KANO STATE NIGERIA

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ABSTRACT

This study assessed the sound levels of size reduction machines (specifically the burr and hammer mills) used for dry and wet milling in Kano State.T-tests showed significant differences in the mean values of sound levels between hammer and burr mills for both dry and wet milling. Mean sound level at operator's ear for dry milling with burr mill was 93.43 dBA.The higher mean sound level value of 99.43dBAwas that recorded at the operators' ear during dry milling using hammer mill.All sounds measured at the operator's ear were found to exceed the safe level (75dBA). Basedon the OSHA standards, the allowable (safe) daily hours of continuous sound exposure in dry milling should not exceed 5 and 3 hours for hammer and burr mill operators, respectively. Otherwise, the use of ear muffs becomes necessary to safeguard permanent hearing impairment.

KEYWORDS Size reduction, noise, burr mill, hammer mill, hearing impairment.

1.0 INTRODUCTION

In Nigeria size reduction process in most cases is done at the small-scale (sometimes at family) mills using hammer or burr mills. The capacity of such mills can be as low as 20kg/h and as high as 100kg/h. These mills are of different makes and designs. They are equally housed in structures made of different materials and with different sizes and designs. Casual observation of the mills shows that they are noisy and may be hazardous to the operators and client (Yisa, 2005).

As a result of growth in food demand, size reduction of Agricultural materials becomes more demanding (Kaul and Egbo 1985). They are used to reduce the size of grains, vegetables and fruits that constitutes the eating culture of the people. Eighty percent (80%) of grains produced in Nigerian villages are processed by size reduction usually by use of grinding mills (Kaul and Egbo 1985).Frequent size reduced agricultural products in Kano state includes: maize, groundnut, beans, millet and tomatoes.

The reduction in size of agricultural products is brought about by mechanical means without change in chemical properties of the materials (Enrique, 2012). This improves the eating quality or suitability of foods for further processing and to increase the range of available products. Development of varieties of size reduction machines has resulted in the reduction or total removal of drudgery from processes which hitherto, were tedious to accomplish. The size of agricultural products may be reduced in several ways. The main methods used are crushing, impact, shearing and cutting (Fellows, 2003).

The common types of mills employed are hammer, roller and burr types. In a hammer mill, swinging hammer heads are attached to a rotor that rotates at high speed inside a hardened casing. The material is crushed and pulverized between the hammers and the casing and remains in the mill until it is fine enough to pass through a screen which forms the bottom of the casing. Roller mills are similar to roller crushers, but they are smooth or finely fluted rolls and rotate at differential speeds. They are used very widely to grind flow flour. They are used alone or combined with hammer mills (Fellows, 2003).

According to Perry and Green (1997), burr mill, plate mill or disc mill have two roughened chilled cast iron plates of 4’’- 60’’ (i.e. 102mm- 1524mm) in diameter which rub together, one plate is stationary and the other one rotates on a shaft with operation speed usually less than 1200 rpm. Grain fed between the plates are crushed and sheared, the fineness of grinding is controlled by the size and quantity of burrs on the plate and the clearance between the two plates (Kaul and Egbo, 1985). The burr mill can also be referred to as attrition mill and could be powered manually, mechanically or electrically. Burrmills are used for wet and dry milling of crops.

The total impact or friction energy is not used in the size reduction; rather some are converted into sound energy. Thoughmany benefits have been derived from size reduction machines, but great nuisance is also associated with its use due to the characteristic sounds they produce loud enough to cause human hearing difficulty to its operators and clients (mostly women and children). In mills powered by petrol and diesel engines, loud noise is produced from the combustion of fuel which add to the attrition noise from the plates. Mills powered by electric motors offer less noise (Kaul and Egbo, 1985). The former case, however, is common in the study area due to inadequate and erratic electric power supply.

Sound is defined as the sensation of hearing perceived by the ear. It is originated by vibrations from some sources and such vibrations can be transmitted through various media. Two primary attributes of sound are frequency and intensity (McCormick and Sanders, 1982). Sound above 75 dBA pose a serious health hazard to humans if the person is exposed to the sound for a prolonged period of time. According to Occupational Safety and Health Standards (USA), there are permissible noise exposure durations based on the sound intensity levels measured in dB.

2.0 MATERIALS AND METHODS

Size reduction machines used in this study were the burr mill and the hammer mill. Although burr mills pre-dominate, the two mills are the machines commonly available in the communities under study. Random samples of these machines were taken forten (10) local governments of Kano state (Municipal, Dala, Fagge, Tarauni, Gwale, Kumbotso, Ungogo, Rimingado, Bichi and Nassarawa). The crop used during size reduction operations was Maize, of QPM variety.

The instruments used for measurements were: Sound level meter, (model RS232C, Resolution,0.1dB, range 30-130 dBA sound intensity levels); Temperature/humidity meter (for the temperature and humidity (ambient) at the time during which the sound level was measured). Measuring tape was used to measure all relevant distances and the workplace geometry (length, breadth, and height).

Sound intensity levels were recorded at the operator's ear. By-stander readings were those recorded at a distance of 4m away from the sound source (mill). In each reading, three replications were taken and a mean value computed. Based on preliminary rapid appraisal studies, the mills considered for the study were of similar age, makes and models. T test tool pack of Microsoft Excell 2007was usedfor comparison of the mean values between and within the two different machines for each of the milling operation (wet and dry) at both operator and client/bystander positions.

3.0 RESULTS AND DISCUSSIONS

Table 1 shows result of the summary of sound levels measured for burr and hammer mills (dry and wet milling) in different local governments at both the operator and client/bystander positions. Mean values for hammer and burr mills in dry milling at operator's ear are 99.43dBA and 93.42dBA respectively. Differences between these values are highly significant (t stat=3.74, t critical =1.75, p = 0.000976). Mean values for hammer and burr mills in wet milling at operator's ear are 80.06dBA and 77.78dBA respectively. Differences between these values are significant (t stat=2.02, t critical =1.75, p = 0.0304). Hence there exist significant differences between the machines for both types of operations on operator's ears, with hammer mills having the higher sound level. These findings agree with the study by Shiru (2001) in Gbako Local Government Area of Niger State which revealed that the maximum sound level recorded for the noise level in the selected mills was 119.3 dB during maize grinding.
From preliminary field appraisal study, 4 m was established as the mean distance from power source where by-standers stay and wait before their work is finished. In the case of sound levels measured 4m away, mean values for hammer and burr mills in dry milling are 82.06dBA and 77.38dBA respectively. For wet milling, the mean values are 81.28dBA and 77.72dBA respectively. Differences were significant. The differences between sound level values of dry and wet milling for a particular machine were not significant. This applies to measurements conducted at operator's ear and at 4m away.

4.0 CONCLUSIONS

The mean values for sound intensity levels were determined for both hammer and burr mills for dry and wet milling at operator's ear and bystander/client positions. It was found out that the values exceed the safe level for continuous daily exposure. Appropriate number of daily exposure hours and the use of ear protection devices were suggested to curb cases of permanent hearing impairment.

5.0 RECOMMENDATIONS

Based on findings in this study, the following recommendations are made:

Operators, who work with burr or hammer mills for more than three (3) continuous hours daily, need to wear ear protection devices. Users may prefer the use of burr mills to hammer mills because of lower sound levels. As a matter of policy, Kano State government needs to make it mandatory for manufacturers or their dealers to provide ear muffs at purchase of size reduction machines. Researchers should intensify efforts into ways of noise reduction or dampening for these milling machines. NESREA or any relevant agency should endeavour to update and enforce occupational noise exposure standards suited to our situation.TABLE 1: THE MEAN VALUES OF SOUND LEVELS FOR BURR AND HAMMER MILLS (DRY AND WET MILLING) IN THE SELECTED LOCAL GOVERNMENT AREAS OF KANO STATE

Local Gov't Area	Machine type	Milling type	OperatorsEar, dBA	4m Away dBA
MUNICIPAL	Hammer mill	Dry	107.25	78.20
		Wet	91.6	76.40
	Burr mill	Dry	92.30	70.15
		Wet	95.62	77.74
FAGGE	Hammer mill	Dry	99.56	80.70
		Wet	99.70	79.60
	Burr mill	Dry	93.77	81.00
		Wet	92.33	77.97
DALA	Hammer mill	Dry	98.80	82.35
		Wet	98.50	75.65
	Burr mill	Dry	91.62	80.05
		Wet	97.33	83.80
NASSARAWA	Hammer mill	Dry	97.3	84.30
		Wet	96.65	78.40
	Burr mill	Dry	95.65	77.35
		Wet	99.00	80.60
TARAUNI	Hammer mill	Dry	98.20	82.93
		Wet	100.05	86.20
	Burr mill	Dry	92.97	81.90
		Wet	96.10	77.98
GWALE	Hammer mill	Dry	106.4	86.30
		Wet	97.55	85.95
	Burr mill	Dry	89.90	79.30
		Wet	90.20	80.00
KUMBOTSO	Hammer mill	Dry	99.70	75.50
		Wet	97.40	83.50
	Burr mill	Dry	97.20	80.70
		Wet	95.10	84.50
UNGOGO	Hammer mill	Dry	93.45	85.30
		Wet	95.10	84.50
	Burr mill	Dry	89.6	77.15
		Wet	97.50	72.23
RIMINGADO	Hammer mill	Dry	95.65	85.57
		Wet	94.35	82.30
	Burr mill	Dry	96.70	70.70

		Wet	88.40	75.90
BICHI	Hammer mill	Dry	98.00	79.45
		Wet	96.25	80.30
	Burr mill	Dry	94.55	75.46
		Wet	89.48	76.18

REFERENCES

Enrique, O.R. (2012). Food Engineering Series; Non-Thermal Food Engineering Operation; Size Reduction .Springer Science & Business Media LLC, pp 71-87.

Fellows, P.J (2003). Food Processing Technology: Principles and Practice 2nd Edition 2000, WoodheadPublishing Ltd and CRC Press LLC. Pp 98-117

Kaul, R.N and Egbo, C.O. (1985). Introduction to Agricultural Mechanization. Macmillan, London, England, UK.pp. 128-41.

Mc Cormick, E.J. & Sanders, M. S. (1982). *Human factors in engineering design.* Published by MC Graw HILL Book Company New York Fifth Edition. pp109

OSHA Standards (2002). Occupational Noise Exposure. Occupational Health and Environmental Control. Occupational Safety and Health Standards 1910.95. USA.

Perry, R.H and Green, D.W (1997). Principles of Size Reduction and Size Enlargement, Chemical EngineeringHandbook 7th Edition McGraw-Hill, New-York pp 120

Shiru, J.J. (2001). *Assessment of ergonomic factors in selected small scale millsin Minna, Niger State*. Unpublished M. Eng Thesis. Department of Agricultural Engineering Federal University of Technology Minna, Niger state.

Yisa M.G. (2005).Ergonomics in small-scale grain mills in Nigeria. ***A****frican Newsletter on Occupational Health and Safety*; 15:7-10

Optimizing Energy Consumption in Wireless Sensor Networks using an Energy-Aware Transmission Scheme

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ABSTRACT

In this paper, we proposed a scheme to extend the network lifetime of a wireless sensor network, whereby each sensor node decides whether to transmit a packet or not and with what range to transmit the packet. A sensor node makes this decisions based on its energy resource and the information contained in each packet. The information content in each packet is gathered through a system of rules that decide if an event worth reporting has occurred, and how important such an event is. While the most important packets are propagated by all sensor nodes, and with different transmission ranges depending on their battery life, low importance packets are propagated by only sensor nodes that have high energy reserves and with greater transmission ranges due to high reserves. The result obtained from simulations shows that by adjusting the transmission ranges based on energy reserves, a considerable increase of lifetime is achieved.

Keywords: Energy-aware; Wireless sensor networks; Transmission range adjustment; Priority balancing

INTRODUCTION

A wireless sensor network (WSN) is a sensor network composed of large number of sensor nodes (small, low-cost, low-power devices with sensing, data processing, and communicating components) that are densely deployed either inside the phenomenon or very close to it [1]. Typically, a sensor node is a tiny device that includes three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for local data processing and storage, and a wireless communication subsystem for data transmission. In addition, a power source supplies the energy needed by the device to perform the programmed task.

This power source often consists of a battery with a limited energy budget. In addition, it could be impossible or inconvenient to recharge the battery, because nodes may be deployed in a hostile or unpractical environment [2]. WSNs are being used in a wide variety of critical applications such as military, health-care applications [3], health care [4], environmental monitoring [5], and defense [6]. A key research area is concerned with overcoming the limited network lifetime inherent in the small, locally powered sensor nodes [1]. To improve this limited network life time, new and modified routing algorithms were proposed.

The main objective of a wireless sensor network is to transmit data by increasing the network lifetime and by employing energy efficient routing protocols [7].

In this paper, we proposed an energy efficient technique to extend the network lifetime of a wireless sensor network referred to as IRT or **I**DEALS|**R**MR|**T**RA (Information manageD Energy aware Algorithm for sensor networks with Rule Managed Reporting and Transmission Range Adjustments). The extension in the network lifetime is achieved at the possible sacrifice of low importance packets and adjustment of transmission ranges based on nodes energy resource. One big advantage of this technique is that, nodes do not have to transmit packets with their maximum transmission ranges all the time. They take into consideration their energy resource and adjust their transmission range accordingly. Nodes also maintain full connectivity by making their minimum transmission range cover at least one sensor node.

The rest of this paper is organized as follows: Section 2 presents related work. Section 3 presents our proposed research. Section 4 gives the performance analysis (simulation results and discussions). Section 5 provides conclusion and future work.

2 RELATED WORK

The energy management technique IDEALS|RMR [8] extends the lifetime of a wireless sensor network, whereby a node with high energy reserve act for the good of the network by forwarding all packets that come to it and by generating its own packets. However, a node with low energy reserve acts selfishly by only generating or forwarding packets with high information content. In addition, IDEALS|RMR uses a single-fixed transmission range for each sensor node regardless of whether its energy resource is high or low and this causes redundancy in energy consumption as lots of areas are covered by several sensors.

Authors in [9] developed a power saving technique by combining two methods: scheduling sensors to alternate between active and sleep mode method, and adjusting sensors sensing range method. They combined both methods by dynamic management of node duty cycles in a high target density environment. In their approach, any sensor schedules its sensing ranges from 0 to its maximum range, where 0 corresponds to sleep mode. Adding the system of information control proposed in this paper could significantly save energy.

Authors in [11] try to deal with the problem of energy holes (unbalance distribution of communication loads) in a wireless sensor network. This means that, energy of nodes in a hole will be exhausted sooner than nodes in other region. As, energy holes are the key factors that affects the life time of wireless sensor network, they proposed an improved corona model with levels for analyzing sensors with adjustable transmission ranges in a WSN with circular multi-hop deployment. Additionally, the authors proposed two algorithms for assigning the transmission ranges of sensors in each corona for different node distributions. These two algorithms reduce the searching complexity as well as provide results approximated as optimal solution.

M. Busse et al. [12] maximize the energy efficiency by proposing two forwarding techniques termed single-link and multi-link energy efficient forwarding. Single-link forwarding sends a packet to only one forwarding node; multi-link forwarding exploits the broadcast characteristics of the wireless medium. This leads to efficiency because if one node doesn’t receive a packet, another node will receive the packet and performs the forwarding process. There is however a tradeoff of delivery ratios against energy costs.

Based on extensive survey on Wireless sensor networks so far, we believe that energy management information control of [8] coupled with transmission range adjustment in [11] was never considered, hence in this paper, we find it worth considering. Our proposed IRT system extends the network lifetime for packets with high information content by losing packets of less important just as IDEALS|RMR does. However, transmission range of a sensor is adjustable in IRT, thus allows the sensor more choice to reduce its energy consumption, hence prolong the lifetime of WSN.

3 THE PROPOSED IRT SCHEME

Researchers are continuously developing new and modifying existing energy management techniques in order to improve the network life time of WSNs. This is because radio communication is often the most power-intensive operation in a WSN device [8]. For that reason, we modified the IDEALS|RMR energy management scheme to improve the network life time. The main contributions of this study are:

- Coupling IDEALS|RMR with transmission range adjustment (TRA).
- Performing a detailed analysis by simulating IRT, IDEALS|RMR and tradition simulation to prove that IRT is the most energy efficient technique.

Figure 1 shows the operation of IRT. When a sensor senses the data, it passes it to the controller, which sends a value (e.g. temperature) to RMR (Rule Management Reporting) unit. RMR is a technique which determines if an event worth reporting has occurred, and how important such an event is. The value is received by the *Rule Compliance Testing.* This rule compliant testing's responsibility is to determine if an event worth reporting has occurred. It does that by checking the sensed value against the rules in the *Rule Database (*getting *history* information about the previously sensed values*)*, at the same time, updates the history with the current information of packets and sensed value. Rules may be fulfilled or not, any rules which are fulfilled are passed to the *Message Priority Allocation* to determine how important the content of the packet is. It does that by assigning message priorities (MP) to each fulfilled rule. In this work, five different MPs are used (MP1-MP5). MP1 related to most important packet. (For example, temperature is higher than normal and requires urgent attention). In the contrary, MP5 relates to the least important packet (for example, a normal temperature packet, to indicate everything is fine).

Any number of predefined rules can be entered by the designer, and describing different events that can be detected in the sensed environment, examples of possible rules are

1. Threshold rules (report when the sensed value crosses a preset value).
2. Differential rules (report when the change in the sensed value is larger or smaller than a preset value).
3. Routine rules (report when a packet of that importance or higher has not been sent for a preset period) [8].

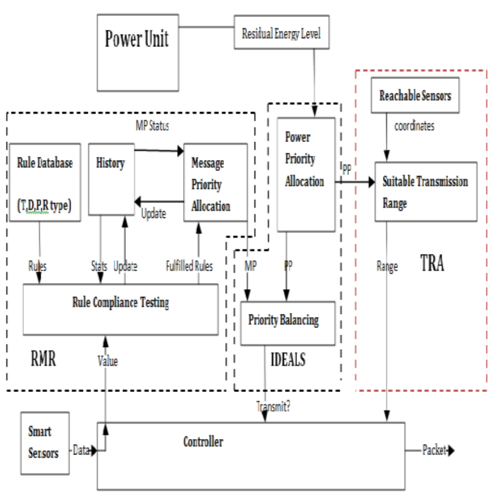

Fig.1. The proposed IRT system diagram.

Afterwards, the MP obtained from message priority allocation is passed to the IDEALS unit. Its responsibility is to decide if the node should transmit a packet or not, and it's done by *Priority Balancing*. The node's energy resource is characterized by *power priority allocation,* which assigns a power priority (PP) based on the state of the battery. The highest power priority is PP5, and it's allocated to a node with the highest energy reserve, while the lowest power priority is PP1 and it's allocated to the node with the lowest energy reserve. When priority balancing receives MP and PP, it compares them and if PP ≥ MP, then a packet will be transmitted.

Finally, when a node decides to transmit a packet, PP is passed to *transmission range adjustment* (TRA) unit. Its purpose is to decide with what range a sensor node will transmit a packet, which is done by *Suitable Transmission Range.* Suitable transmission range gets power priority (PP) from power priority allocation and coordinates from *reachable sensors.* These reachable sensors are the entire sensors in the maximum transmission range of a sending sensor node. Now, based on the value of the power priority and the coordinates of the sensors in the maximum transmission range of the sending sensor node, a suitable transmission range is determined and passed to the controller to successfully transmit the packet with the new range. In this work, five different TRs are used (TR1-TR5), where TR1 is the minimum transmission range and TR5 is the maximum transmission range.

There is a one-to-one mapping of the power priority to the transmission ranges. When a packet is ready to be transmitted, meaning that PP≥MP, the transmission range will be mapped to the value of PP. The priority allocation, balancing process and transmission range adjustment can be seen in Figure 2. For example, when we have a full battery PP5, we will transmit all packets regardless of their message priority MP1 to MP5 with the maximum transmission range TR5. However, if our battery decreases to the minimum PP1, we will have the chance to transmit only packets with the highest message priority MP1 and with the lowest transmission range TR1.

Priority balancing and transmission ranges can also affect routing process-if a node's residual energy level does not warrant sending a packet of a certain priority, it will not participate in routing. Data deemed not to be significant enough (considering the state of the network) can be dropped at a number of stages: event generation (if a change in the data does not trigger a rule, an event will not be generated), local priority balancing (if the PP<MP, the packet will not be created from the generated event), and routing (if no route exists across the network where PP≥MP due to loops, the packet will not reach its destination).

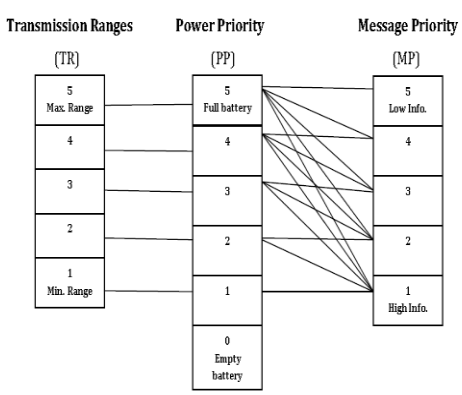

Fig. 2. Priority Balancing with Transmission Range.

4 PERFORMANCE ANALYSIS

We performed our simulation using C programming, where we compared the data sets of tradition simulation, IDEALS|RMR, and IRT. Repetitive simulations were perfumed for IDEALS|RMR, and IRT to verify our simulation results provided in Figure 5. IRT system is not suited for applications where all data are equally important.

4.1 Simulation setup

Initially, all sensor nodes have the same initial energy of 100 Joules [8], the equation (1) shows the energy required to transmit a packet, where E_{elec}[J] is the energy required for the circuitry to transmit or receive a single bit, E_{amp}[J] is the energy required for the transmit amplifier to transmit a single bit a distance of one meter, d is the separation distance in meters and l is the length of the packet 1000bits. As it can be seen in Figure 4, 20 sensors nodes were used, distributed them randomly in a 70×70 meters area and each node has the same maximum transmission range of 20 meters. The coordinate of the sensors is saved in a file and given as input to the program. Therefore, the distance to each of the sensors in the maximum transmission range of a sending sensor is determined using the distance formula of equation (2). Other simulation parameters are listed in table 1 as shown below.

TABLE 1. Simulation parameters

Simulation area	70×70 meters dimension
Number of nodes	20 nodes
Packet length	1000 bits
Initial node energy	100 Joules
Simulated Node Id	node-08
Minimum transmission range	13.038405 meters
Maximum transmission range	20 meters
Simulated node Coordinate	(x = 38 , y = 37)

$$E_{tx}(l,d) = E_{elec}l + E_{amp}ld^2 \quad [10] \qquad (1)$$

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$ [10]

(2)

First, the user has to create a file, and provide the coordinates of sensors in it; the program then outputs (sending node id, its coordinates, the node id's in its maximum transmission range and their distance to the sending node), for all sensor coordinates provided. One sensor is now chosen for the simulation as the remaining sensors are assumed to be identical. The chosen sensors id and the distance to its closest sensor are given as inputs, the sensor senses data and our IRT algorithm is perfumed as illustrated in Figure 3. Since the maximum transmission range (TR5) is fixed for every sensor, five different transmission ranges can be calculated by considering the minimum transmission range (TR1) as the distance to the closest sensor in the sending sensor's maximum transmission range. So the ranges between TR1 to TR5 are calculated by successively adding the ΔTR = (TR5-TR1)/4. That is, TR(i) = TR(i-1) + ΔTR, for i=2,3,4. For example, adding ΔTR to TR1 gives TR2, and so on. The reason we took TR1 as the distance to the closest sensor in the sending sensor's maximum transmission range is because it covers at least one sensor so that in the worst case (PP1), we have full connectivity (packets can be delivered to the sink node).

All nodes except the sink node (final destination of packets), performs multi-hop routing of packets by using flooding algorithm. Our program is so dynamic that different coordinates from the ones used in our simulation can be entered and any node can be chosen for the simulation. Figure 4 shows a snap shot of randomly distributed nodes used in the simulation. Circles represent the maximum transmission range of sensors and lines represent possible communication link [8]. We chose node-8 as it's located in the middle. We assumed packets are transmitted every 5 minutes.

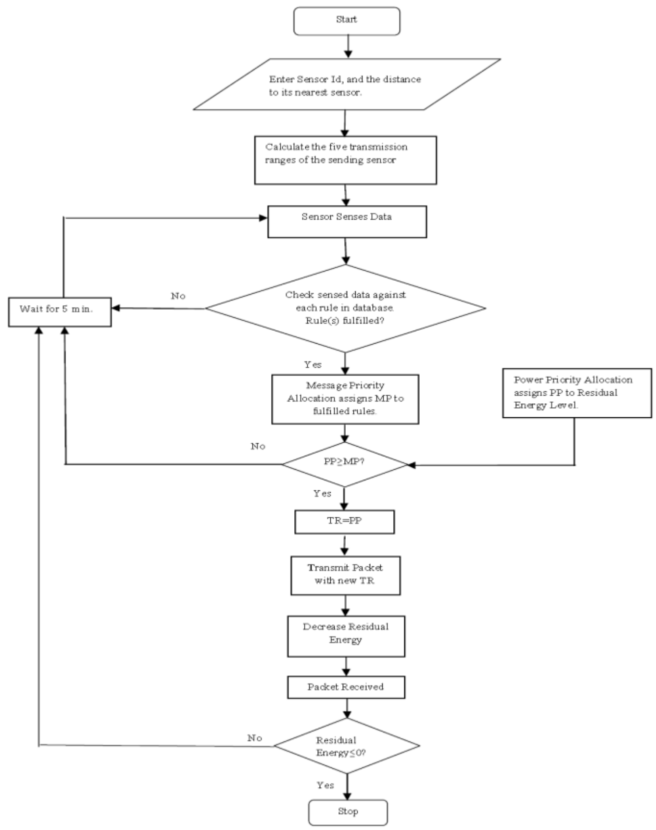

Fig. 3. Flowchart of IRT

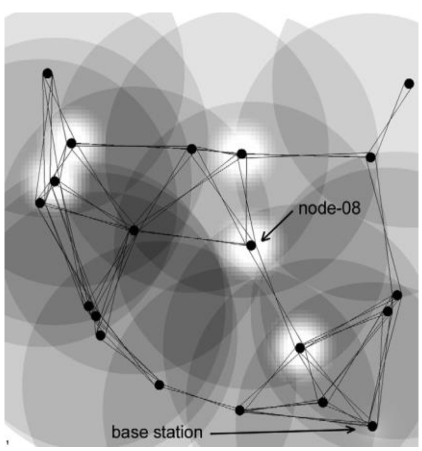

Fig. 4. A snap shot of randomly distributed nodes used in the simulation.

4.2 Simulation Results

The simulation was conducted to show how the network life time can be improved by using IRT technique proposed in this paper. The data generation in our simulation is not so important, what is important is whether rules are fulfilled or not, and the power priority of the residual energy. Node-08 was use in this simulation due to its location; any node could be taken as well.

(1) Node energy Depletion Times: Figure 5 shows the time it takes for a technique (traditional, IDEALS|RMR, IRT) to deplete its energy reserve. ‘100’ means nodes energy is full, ‘0’ means nodes energy is depleted. It can be seen that in the tradition simulation that node-8 depletes its energy reserve at around 10 hours, as it is sending packets every 5min. without taking into account the information contents, and energy levels. In the simulation of IDEALS|RMR, packets are not transmitted every 5min., as the packet importance are considered before transmission. Hence, the node lifetime significantly increases for an additional 27hrs. Finally, in the IRT simulation, packets are also not transmitted every 5min., as the importance of packets are considered before transmission. Unlike IDEALS|RMR which uses one fixed transmission range, IRT can adjust its transmission range based on nodes energy level, thus allows the node more choice to reduce its energy consumption. As a result, our proposed IRT scheme shows a significantly high increase in node life time compared to the other two simulations. As shown in Figure 5, the attained improvement of IRT over IDEALS|RMR and traditional schemes reaches 80% and 530% respectively.

As illustrated in Figure 5, the energy level of the IDEALS/RMR and IRT schemes drops suddenly and then becomes constant, this process continues until the battery is completely depleted. The sudden dropping of energy level represents continues packet transmission because PP≥MP (battery level is high enough to allow a node to transmit a packet of that importance) while the constant energy level represents PP<MP (battery level is not high enough to allow a node to transmit a packet of that importance, therefore no transmission occurs).In a nutshell, if a packet is not transmitted due to PP<MP, the same battery level will be maintained until a packet arrives in which PP≥MP, as can be seen in Figure 2.

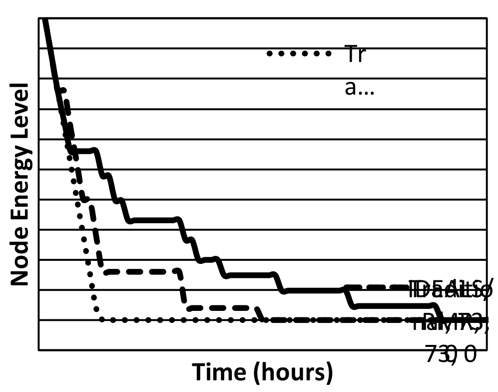

Fig. 5. Node energy depletion times.

(2) Network Connectivity (NC): The network connectivity is the measure of the ability of any node in the network to successfully transmit a message to the sink node. If the network is 100% connected, then any node in the network can successfully transmit a message to the sink node. However if the network is 50% connected, then only half of the nodes can successfully transmit a message to the sink node. Figure 6 shows that the connectivity of the Traditional simulation is completely lost after around 9 hrs. Figure 7 shows the connectivity of the IDEALS|RMR simulation. It is clear from the figure that the simulation extends the network lifetime and hence improves the network connectivity. The network lifetime for the most trivial message (MP5) is lost after around 4hrs (therefore no message of MP5 importance can reach the sink node after 4hrs) while it is connected for about 76%. However the network is still around 80% connected for the most important message (MP1) for 34 hrs. This is because the messages are not transmitted every 5 minutes as in the traditional scheme simulation. Figure 8 shows the performance of the IRT scheme simulation. As it can be seen from the figure, the simulation manages to extend the network lifetime almost twice that of the IDEALS/RMR scheme. This is because of the adjustment of transmission range based on nodes energy level. Additionally, network lifetime for the most trivial message is lost after around 13hrs while it is connected for about 76%. However the network is 79.6% connected for the most important message for 63hrs.

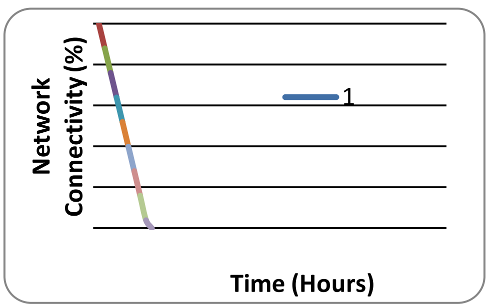

Fig. 6.Network Connectivity of the Traditional Simulation

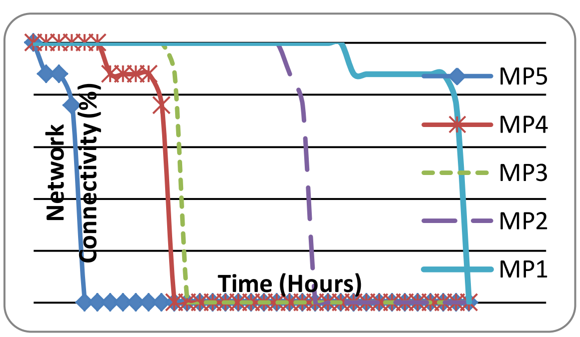

Fig. 7. Connectivity of the IDEALS|RMR Simulation

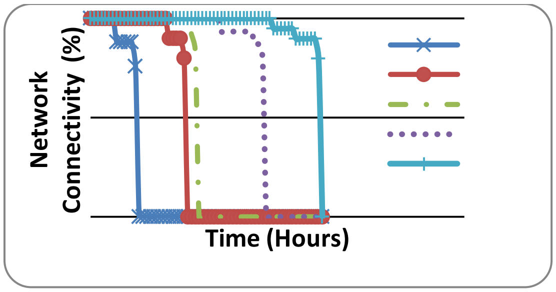

Fig.8. Connectivity of the IRT Simulation

5 CONCLUSIONS

In this paper, we proposed an IRT scheme, which operates upon a combination of information management reporting (determining the information contents of a packet and how important such an information is, through a system of rules), energy management (balancing the residual energy level with the packet importance) and transmission range adjustment (determining a suitable transmission range for a node based on its residual energy level) which has never be considered before. Simulation was done using c programming where a single node was simulated to show the operation of our algorithm and display the results. The result shows that by adjusting the transmission range of a sensor node based on its battery life, the nodes battery life is extended significantly compared with the other two methods (Traditional and IDEALS|RMR).

REFERENCES

1. Akyildiz, I.F., Su, W., Sankarasubramaniam, Y., Cayirci, E.: Wireless sensor networks: a survey, Comp. Netw. 38, 393-422 (2002).

2. Anastasi, G., Conti, M., Francesco, M.D., Passarella, A.: Energy conservation in wireless sensor networks: A survey, Ad Hoc Networks 7, 537–568 (2009).

3. Elrahim A.G.A., Elsayed, H.A., Ramly, S.E.L., Ibrahim, M.M.: An Energy Aware WSN Geographic Routing Protocol, Universal Journal of Computer Science and Engineering Technology 1 (2), 105-111 (2010).

4. Lo, B.P.L., Yang G-Z., Key technical challenges and current implementations of body sensor networks, in: Proceedings of the Second International Workshop Wearable and implantable Body Sensor Networks (BSN’2005), London, UK, April 2005.

5. Werner-Allen, G., Lorincz, K., Ruiz, M. et al.: Deploying a wireless sensor network on an active volcano, Internet Computing, IEEE 10 18-25 (2006).

6. Simon, G., Maroti, A. Ledeczi, et al.: Sensor network-based countersniper system, in: Proc. Conf. Embedded Networked Sensor Systems, Baltimore, MD, 1-12 (2004).

7. Bhattacharyya, D., Kim, T., Pal, S.: A Comparative Study of Wireless Sensor Networks and Their Routing Protocols, in Sensors 2010.

8. Merrett, G.V., A`l-Hashimi, N.M., White, N.R.: Energy managed reporting for wireless sensor networks, Sensors and Actuators A 142, 379-389 (2008).

9. Mingming, L., Jie, W., Mihaela, C., Minglu, L., Energy-Efficient Connected Coverage of Discrete Targets in Wireless Sensor Networks, International Journal of Ad Hoc and Ubiquitous Computing 4, 137 - 147 (2009).

10. The Distance Formula, accessed March 2011.

11. Song, C., Liu, M., Cao, J., Zheng, Y., Gong, H., Chen, G.: Maximizing network lifetime based on transmission range adjustment in wireless sensor networks, Computer Communications 32, 1316–1325 (2009).

12. Busse, M., Haenselmann, T., Effelsberg, W.: Energy-efficient forwarding in wireless sensor Networks, Pervasive and Mobile Computing 4, 3–32 (2008).

DIRECT DIGITAL SYNTHESIS OF A FREQUENCY MODULATION SYSTEM

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ABSTRACT

Frequency modulation (FM) presents a versatile technique of transforming a baseband signal for the purpose of transmission either in commercial FM radio, cellular radios and other forms of signal transmission. The digital FM approach, however, offers some advantages over the analog form; it provides more information capacity, compatibility with digital data services, higher data security, better quality communications, and quicker system availability. One type of digital FM approach is the direct digital (frequency) synthesis technique (DDS). The DDS utilizes a numerically controlled oscillator and a digital to analog converter. A high-quality, full digitally processed frequency Modulation (FM) system based on DDS techniques is modeled and simulated using MATLAB/SIMULINK®. The approach here is to generate a center frequency digital word for the DDS which is then added to the baseband signal's amplitude converted to frequency word to generate the frequency modulated signal. Simulation studies on the developed model indicate that, for any modulating signal, the output signal's frequency deviates from the center frequency in proportion to the strength of the modulating signal. More simulation results proved that the direct digital synthesis based frequency modulation system; with a programmed center frequency produces a low noise system, and also requires fewer components. Also the result shows that when there is no input signal the system behaves like an oscillator with the center frequency value.

KEYWORDS: Direct digital synthesis, Frequency modulation, sigma-delta ADCs

1 INTRODUCTION

Nowadays there is a great effort to replace all (or nearly all) the analog components of a communication system by architectures using digital hardware, whose functionality can be software configurable using FPGAs and/or DSPs. Radio communication systems based on these new architectures are generally termed software radios. With the development of VLSI technology and the requirement of modern communication systems, direct digital synthesizers have been widely used in software defined radios and wireless transceivers (Menakadevi et'al 2012). Software Defined Radio was defined in (Markus et'al 2003) and were implemented in (Becker 1999, Miranda et'al 2000, 2001) using various synthesizer chips. This kind of radio architecture possesses important advantages when compared to its analog counterparts. The most relevant are: Substantially better repeatability and stability, Implementation of signal processing functions that are unrealizable with analog hardware, Hardware "tweaking" replaced by software tuning, Design of cost-effective multifunction radios, cost and development time reduction.

This paper is arranged in such a way that it gives an overview of direct digital synthesis techniques, and develops a frequency modulation system model based on DDS technique which is then simulated.

2 DIRECT DIGITAL SYNTHESIS TECHNIQUE

Direct Digital Synthesis (DDS) is an electronic method for digitally creating arbitrary waveforms and frequencies from a single, fixed source frequency.
To generate a fixed-frequency sine wave, a constant value; the phase increment that is determined by the binary number is added to the content of phase accumulator for each clock cycle. If the phase increment is large, the phase accumulator will step quickly and thus generate a high frequency sine wave. If the phase increment is small, the phase accumulator will take many more steps, accordingly generating a slower waveform (vanka 2001, AnalogDevice 1999)

The basic block diagram of a direct digital frequency synthesizer is shown in Figure-1 (Yamagishi et'al 1998). As shown in Fig. 1, the main components of a DDS are a phase accumulator, phase-to-amplitude converter (a sine look-up table), a Digital-to-Analog Converter and filter. A DDS produces a sine wave at a given frequency. The frequency depends on three variables; the reference-clock frequency f_{clk}, the binary number programmed into the phase register (frequency control word) and length of n-bit accumulator. The binary number in the phase register is the main input to the phase accumulator (Menakadevi et'al 2012).

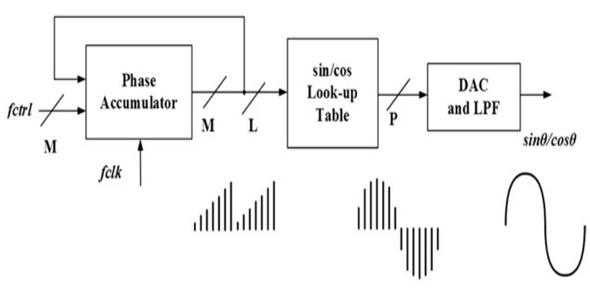

Figure 1 DDS function blocks and signal flow diagrams

The phase accumulator consists of an n-bit frequency register which stores a digital phase increment word followed by an n-bit full adder and a phase register. The digital input phase increment word is entered in the frequency register. At each clock pulse this data is added to the data previously held in the phase register. The phase increment word represents a phase angle step that is added to the previous value at each $1/f_{clk}$ seconds to produce a linearly increasing digital value. The phase value is generated using the modulo, 2^n over flowing property of an n-bit phase accumulator. The rate of the over flows is the output frequency f_{out} (chau et'al 1998), given by

$$f_{out} = \frac{f_{clk} \times f_{ctrl}}{2^M} \qquad (1)$$

The phase argument to the sine computation block is generated by exploiting modulo 2^n over flow of an n-bit accumulator, which can be adjusted by a frequency control word f_{ctrl} (Shu-Chung 2010). And its output spectrum contains the fundamental plus aliased signals (images) that occur at integer multiples of the system clock frequency ± the selected output frequency. A graphical representation of the sampled spectrum, with aliased images, is shown in Fig. 2 (analog.com).

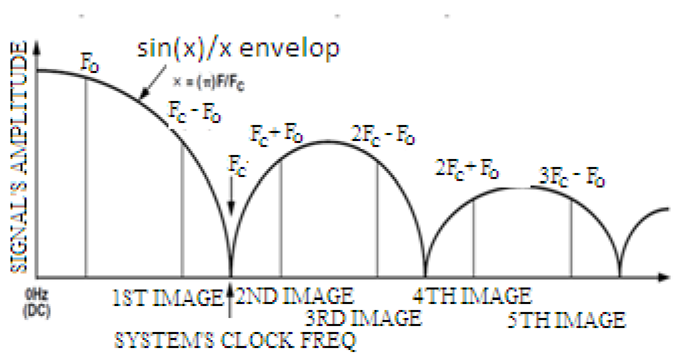

Figure 2 Output spectrums of sampled SIN(X)/X

A. DDS FM MODEL

The model of the direct digital synthesis frequency modulated transmitter is developed using MATLAB SIMULINK and each block were developed separately and finally connected appropriately. The MATLAB SIMULINK model blocks were divided into Analog to Digital Conversion unit, Numerical control oscillator unit and Digital to Analog Conversion Unit.

1 Analog to digital conversion unit

A first order Sigma-Delta based analog to digital converter is developed in the MATLAB SIMULINK environment as shown in figure 3 which is adopted from (Jarman 1995).

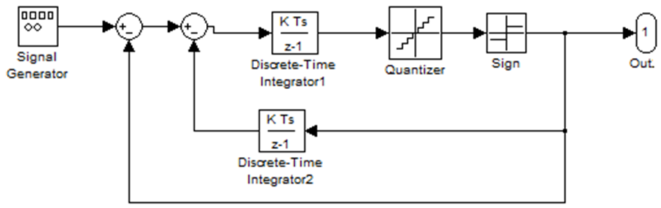

Figure 3 First-order sigma-delta ADC

The input signal of the system is the analog signal from the sine wave block which is in time based mode. The Sum block performs subtraction on its inputs. The Discrete-Time Integrator block allows to define initial conditions on the block dialog box or as input to the block, define an input gain (K) value, Output the block state, define upper and lower limits on the integral and reset the state depending on an additional reset input. A brief introduction of how the integrator works follows. For this method, 1/s which is an integration in time domain is approximated by T/(z-1) in digital form. The resulting expression for the output of the block at step n is

$$y(n) = y(n-1) + KTu(n-1) \qquad (2)$$

The block uses the following steps to compute its output (MATLAB V2008B):

Step 0: $y(0) = IC$ (clip if necessary)
$y(1) = y(0) + KTu(0)$
Step 1: $y(2) = y(1) + KTu(1)$
. . .
. . .
Step n: $y(n+1) = y(n) + KTu(n)$ (clip if necessary)

With this method, input port 1 does not have direct feed through.

The quantizer block passes its input signal through a stair-step function so that many neighboring points on the input axis are mapped to one point on the output axis. The effect is to quantize a smooth signal into a stair-step output. The output is computed using the round-to-nearest method, which produces an output that is symmetric about zero.

$$y = q \times round\left(\frac{u}{q}\right) \qquad (3)$$

Where y is the output, u is the input, and q the Quantization interval parameter.

The sign block indicates the sign of the input signal using the following expression:

$$out1 = \begin{cases} 1\,; & u > 0 \\ 0\,; & u = 0 \\ -1\,; & u < 0 \end{cases} \qquad (4)$$

2 Numerical control oscillator

The phase accumulator and phase to angle converter are configured in MATLAB/SIMULINK® environment as shown in figure 4 which is adopted from (analog.com). The additional block labeled "Convert 2-D to 1-D" in figure.4, reshapes an M-by-N matrix input to a one dimensional vector with length M*N.

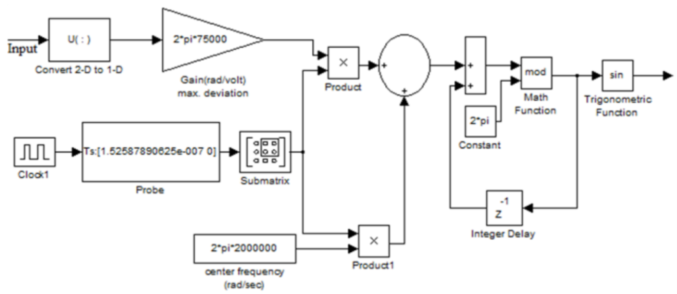

Figure 4 NCO model adopted from (analog.com)

The digital word, $\overline{U}$, which is a vector of y, from ADC blocks is the input to the NCO model as shown in figure 4. The digital word is then multiplied in the gain block by a constant value, ω_{MD} (gain) which is in radians per volt per sec. The output of the gain block $\overline{Y_1}$ is then multiplied by sampled time, T_s from the clock signal labeled 'Clock1' to give the discrete phase data, $\emptyset_1$ as given in equation 5.

$$\emptyset_1 = \overline{Y_1} \times T_S \qquad (5)$$

Where

$$\overline{Y_1} = \omega_{MD} \times \vec{U} \qquad (6)$$

$$T_S = \frac{1}{F_{MCLK}} \qquad (7)$$

and

$$\omega_{MD} = 2\pi F_{MD} \qquad (8)$$

The clock block generates a clock signal, F_{MCLK} for the logic systems to control the execution, enable and trigger subsystems.

The probe block outputs selected information about the signal on its input. The sample time is selected for the output of the probe. The sampled time is multiplied by the gain block to give the phase angle of the center frequency as given in equation 9.

$$\emptyset_2 = \omega_c T_S \qquad (9)$$

where

$$\omega_c = 2\pi f_c \qquad (10)$$

The phase value of the center frequency and digital word are then added to give the phase modulation. From equation 5 and 9, the modulated angle $\emptyset^n$ is given by equation 11.

$$\emptyset^n = \emptyset_1 + \emptyset_2 \qquad (11)$$

The math function (MOD) outputs the sequence of phase data repeatedly from zero to 2π as shown and given in equation 12.

$$\begin{aligned} \emptyset &= mod(\emptyset^n, 2\pi) \\ &= 2\pi - \emptyset^n \times floor\left(\frac{2\pi}{\emptyset^n}\right) \end{aligned} \qquad (12)$$

The Integer Delay block delays the phase data by one sample periods with zero initial condition. The Trigonometric function block works as a lookup table for generating sinusoidal function based on the discrete phase data as given in equation 13.

$$Y = \sin\emptyset \qquad (13)$$

The output of the numerical control oscillator, Y is the discrete amplitude of the sinusoidal signal. Therefore, the signal needs to be reconstructed back to continuous analog signal. The sampled digital signal is then converted from digital to analog and filtered with a reconstruction filter to produce an analog output signal.

III. SIMULATION RESULTS

There are two different output signals in the NCO signal flow paths. The first one is the output of the phase accumulator, PA which is the phase that repeatedly flows from 0 to 2π, and the second signal is the output of the phase to amplitude converter, PAC. For the PA the output signal is the discrete value of the phase data that are converted to sinusoidal discrete amplitude values. For every 0 to 2π phase there is corresponding discrete values in the PAC output that are serially in sinusoidal nature. The model is simulated using zero, constant dc, sawtooth, and sinusoidal input signal with figures 5, 6, 7 & 8 showing the time domain of input and output signal relationship for 5KHZ center frequency and 2KHZ maximum deviation.

When the input signal is zero the model behaves as an oscillator with the output frequency the same as the center frequency value and with no frequency deviation. The captured signal from the SIMULINK® environment is shown in figure 5.

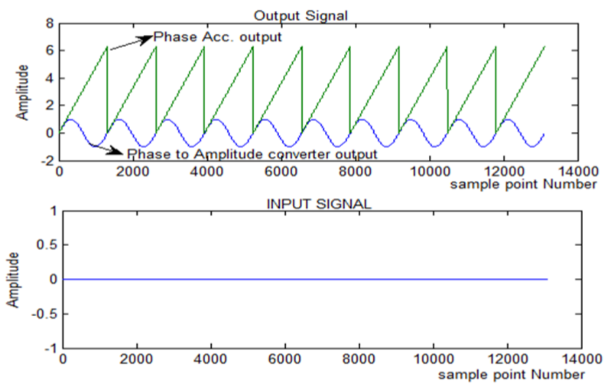

Fig. 5 Output signals of PA and PAC for zero input signal

When the input signal is constant with the magnitude value of 0.5, then the output signal is the sum of the center frequency and half of the maximum deviation, which is 6kHZ. The output signal for constant input signal is shown in figure 6.

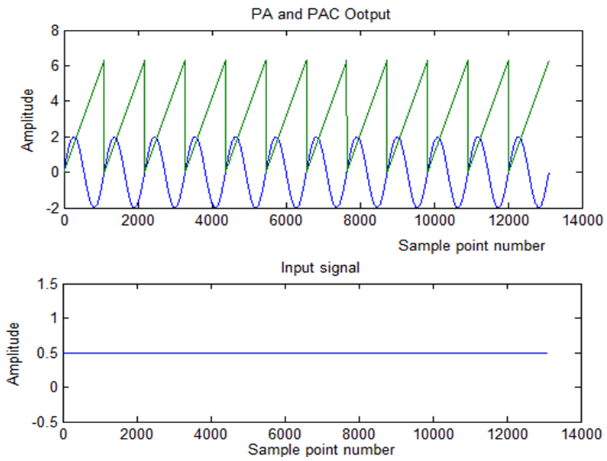

Figure 6 output signals of PA and PAC for constant input signal

When the input signal is sinusoidal in nature, the frequency of the output signal is proportional to the strength of the input signal as shown in figure 7. This plot shows that output of NCO is frequency modulated signal.

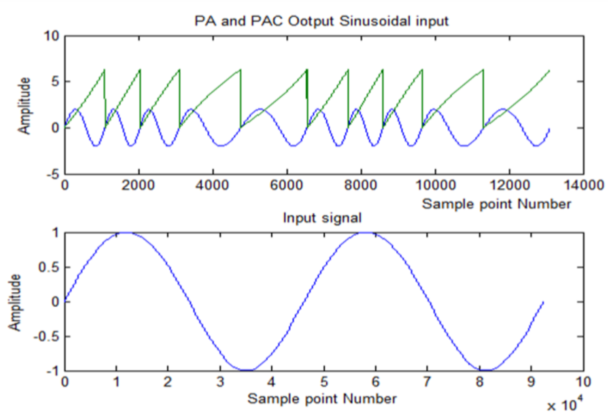

Figure 7 output signal of PA and PAC for sinusoidal input

The signal source block in the SIMULINK library is used to generate a sawtooth signal and fed to the model. The corresponding output signal is also shown in figure 8 which also indicated that the frequency of the output signal is proportional to the strength of the input signal.

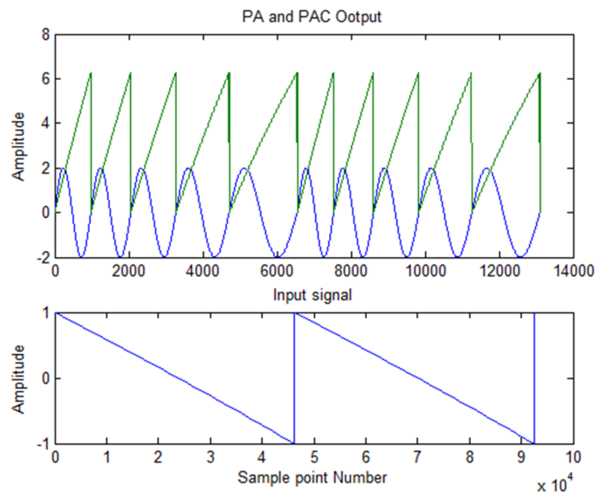

Figure 8 output signal of PA and PAC for sawtooth input signal

The frequency spectrum scope in the SIMULINK displays only frequency values from zero to sampling frequency. The sampling frequency in the model is specified to be 6553600Hz. For the case when the center frequency is changed to 2MHz and the peak deviation is set at 75 kHZ, then there are two frequencies within the display limit of the spectrum. The first frequency is the fundamental frequency which is 2MHz with the peak deviation of 75 kHZ, whereas the second frequency is the first harmonic (image) of the fundamental frequency with the value 6553600-2000000=4.5536MHz and the peak deviation of 75kHZ. The frequency spectrum plot from the SIMULINK environment is shown in figure 9.

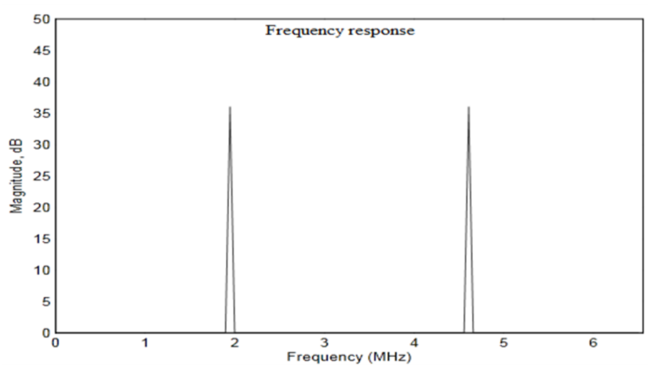

Figure 9 Frequency spectrum of 2 MHz center frequency with frequency 75 kHZ deviation

The results from the model simulation as shown from figures 5 to 9 proved that the generated signal is frequency modulated, and is made up from its sampled discrete definition. Also of all the classic signal generation techniques, it is clear that DDS truly constructs the output signal from the Read Only Memory look-up table as implemented by Trigonometric function block in figure 4.

IV. CONCLUSIONS

This work develops a model of a low-cost, fully-digitally processed, and high-quality programmable monaural FM system with reduced complexity. These attributes coexist due to the frequency synthesis technique employed: the direct digital synthesis, DDS which allows easy programming of the center frequency and fine tuning resolution unlike the direct analog synthesis techniques which uses complex circuit, consumes relatively high power, and also suffer from oscillator frequency variations. The simulation results obtained from the models offered good perspectives regarding the DDS frequency modulated system evolution.

REFERENCES

1. A Technical Tutorial on Digital Signal Synthesis, Online Available at http://www.analog.com/UploadedFiles/Tutorials/450968421DDS_Tutorial_rev12-2-99
2. AnalogDevice 1999 "AD9851, CMOS 180 MHz DDS/DAC Synthesizer, Data sheet" Analog Devices, Inc. Available at http://www.analog.com
3. Becker D. R. "High Quality, All-Digital RF Frequency Modulation Generation with the ADSP-2181DSP and the AD9850 Direct Digital Synthesizer" AN-543 APPLICATION NOTE: Analog Devices, Inc., 1999. Available at http://www.analog.com
4. Chau Y. A., Yao-Hua C., March 2011, "A high-performance ROM-less direct digital frequency synthesiser" AEU - International Journal of Electronics and Communications, Volume 65, Issue 3, Pages 272-274
5. Jarman D. may 1995, "A Brief Introduction to Sigma Delta Conversion", Intersil Corporation, Application Note, AN9504
6. Markus D. M. Kambiz and A. Nancy, 2003 "Software Defined Radio: Architectures, Systems and Functions" Wiley & Sons, ISBN 0-470-85164-3, Page xxxiii
7. MATLAB/Simulink, V2008B "Student Edition of MATLAB/Simulink, V2008B" Mathworks, Natick, MA
8. Menakadevi T. *et'al*, June 2012 "Direct Digital Synthesizer using Pipelined CORDIC Algorithm for Software Defined Radio" International Journal of Science and Technology, Volume 2 No.6.
9. Miranda† H. C. *et'al* 2000 "An all-Digital Stereo FM Transmitter" INESC - Instituto de Engenharia de Sistemas e Computadores and FEUP - Faculdade de Engenharia da Universidade do Porto,
10. Miranda† H. C. *et'al* April 23-24, 2001 "soft FM: An all-Digital Stereo FM Transmitter with RDS based on software Radio Architectures" ConFTele-National Telecommunications Conference, Figeira da Foz, Portugal.
11. Shu-Chung Yi , "A direct digital frequency synthesizer based on ROM free algorithm" AEU - International Journal of Electronics and Communications, Volume 64, Issue 11, November 2010, Pages 1068-1072.
12. Vankka J., 2001"1. Direct Digital Synthesizers: Theory, Design and Applications", London, Kluwer Academic Publishers..
13. Yamagishi A., et al. 1998 "A 2-V, 2-GHz low-power direct digital frequency synthesizer chip-set for wireless communication" IEEE Journal of Solid-State Circuits, 33(2):210–7

DEVELOPMENT OF WEB GEOSPATIAL DECISION SUPPORT SYSTEM (DSS) FOR IRRIGATION WATER MANAGEMENT

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ABSTRACT

A web base geospatial Decision Support System (DSS) was developed for easy access to farm information, because data on water is crucial for efficient irrigation water management. Huge amount of water is lost especially at farm level due to lack of update information on water demands of the field as well as equity distribution. The system was built based on the field water balance model, taking into considerations both losses from the field and contribution from underground water to the field. This system was built using ESRI products; ArcGIS viewer for flex, Microsoft SQL database enterprise 2012 and ArcGIS Server10.1 advance. The system is web based, interactive with user friendly GUI by widgets technology and provide information concerning irrigation water demand and supply, yield and performance indicators such as irrigation efficiency, relative water supply, water productivity index which are vital information for farmers and irrigation water managers, to some extent even the policy makers. The results could be viewed in the form of thematic maps, tables, and charts; also for modelling, conducting spatial analysis and visualizing the system output which makes it easy to be interpreted. The developed system was very interactive and the interface simplified such that the user need not be a GIS expert before explore and retrieve information in order to make decision for best practices on rice irrigation water management.

Keywords: ArcGIS for Server, ArcGIS Viewer for flex, DSS, Irrigation, and Web.

Significance:
The importance of managing irrigation water management cannot be overemphasized, nowadays the role of information and communication technology in developing a system for efficient management of irrigation water is beneficial especially in water scarce areas. Using this technology Irrigation facilities can be operated away from farm and real-time information especially now that satellite data are becoming available with short temporal resolution.

1.0 INTRODUCTION

Web GIS, a new generation of Internet services and technology which supports user interaction significantly (Zhang et al., 2012; Jia et al., 2009; Zhao et al., 2001). The evolution prescribe GIS further away from only data browsing and managing for individual decisions, and more towards group participating and communicating on both scientific and social decision issues (Craig et al., 1999; Carver, 1999).
The web development is growing faster than ever before and this is an evolutionary transformation of usual individual activities on desktop to a multi interactive manipulation of data and information worldwide.

As Craig et al., (1999) described the Public Participation GIS principles as accessibility, understand-ability, and accountability, hence Web GIS continues to draw attention as a public participation tool (Sakamoto & Fukui, 2004). There are many tools both open source and commercial that offers software for developing web GIS, many of which are open source. Despite numerous open source yet in this work a commercial one was chose, this is for the fact that commercial software offers advance functions in GIS and free support online which makes work easy.

GIS now has become a public interaction tool, this can be clearly seen as nowadays ESRI base maps, Bing maps, Google Maps, Google explorer, Google Earth, Yahoo Maps, and many other open source and commercial applications provide different kinds of GIS information such as maps, satellite images and terrain maps covering substantial areas around the globe (Zhelu 2009).

Internet is the easiest way of information sharing, irrigation management system can also benefit from it. Integrating GIS functionality with internet capacity will redefine the way of decision-making, sharing and processing of information. In irrigation systems weather plays crucial role in decision making, implementing and forecasting. Temperature, humidity, precipitation, and solar radiation are the most important parameters to calculate evapotranspiration by which crop water requirement can be determined.

Water management of irrigated lands are becoming crucial in global water resource management. Many irrigation schemes are exploring different, cheaper and more efficient ways of curbing huge water losses from flood irrigation system. The application of modern technology such as GIS, GNSS, and Remote Sensing to agriculture has brought unprecedented revolution in agricultural water management. Good water management means applying the precise amount of water at the right time in the right place and as at when needed. Many computer aided tools have already been developed with the aim to improve water management of irrigation schemes (Rowshon & Amin, 2010).

Information system played important role in supporting managers in their unstructured decision making activities. As decisions are irreversible and have far-reaching consequences, effective decision making can never be overemphasized especially in high capital investments like irrigation schemes. A Decision Support System (DSS) is a set of tools and procedures that work interactively to manage a particular system; it is capable of enhancing the quality of the decision-making processes in the system.

Decision support systems are sub-set of computer-based information systems. The concepts of computerized (DSS) that assist users in complex decision making processes have been in use since past three decades. However, decision support systems that model soil, plant and weather conditions have been used to calculate when an irrigator should irrigate, based on crop water requirements (Rahman & Khan 2009). It is known that if DSS-derived irrigation schedules were followed, water savings can be achieved through efficiency and yield gains. (Greenwood 2002) stated that some the advantages of the web-based GIS are that it reduces the software cost and the load on computer system as a result of software installation, easy to support and carryout maintenance, shortens the users learning curve and provides a superior environment for DBMS integration and presentation. Much more literatures were unfolding on Decision Support System. Many of the early researches were on automated report generation using main frame computers (Power 2003). Some were on business problem and water quality issues (Bonczek et al., 1984). It is worth reiterates that DSS is decision support and not making decision, this was due to the fact that it addresses the advantage of computer to manipulate large amount of data but yet rely on decision maker's judgment. Heilman et al. (2005) present several arguments concerning the early application and development of DSS including the most recent ones which were often design based on spatial database in Geographic Information System (GIS) format. Multi-objectives decision making tool can also be incorporated in GIS application (Malczewski 1999), which opens a new window for transforming decision approach in agriculture.

Due to the emergent of new communication hand held devices, it become necessary to develop an integrated system for easy monitoring and accessing remote information for the farmers, water managers and policy makers alike. It is necessary to develop a quick-response software system for daily crop water needs; real-time water resources assessment especially the field water depth. Such a prediction and assessment system can provide scientific decision support for water resources regulation. The development of distributed hydrologic models and Web GIS provides good conditions for establishing these types of systems. To practice smart farming effectively is to be able to keep close monitoring of the farm without necessarily travel to the farm. Thus, Computers, Smart phones are now available and affordable within the reach of farmers.

The focus of this study is to develop Web GIS DSS application tool that is user friendly interface for quick access and generating various reports and graphs essential for planning of activities and monitoring of Irrigation Water Management.

2.0 METHODOLOGY

2.1 Data Acquisition

Data for the model will be obtained from field experimental data, weather data, satellite data and archives data from the Institutions, Ministries, Government and non-Governmental agencies

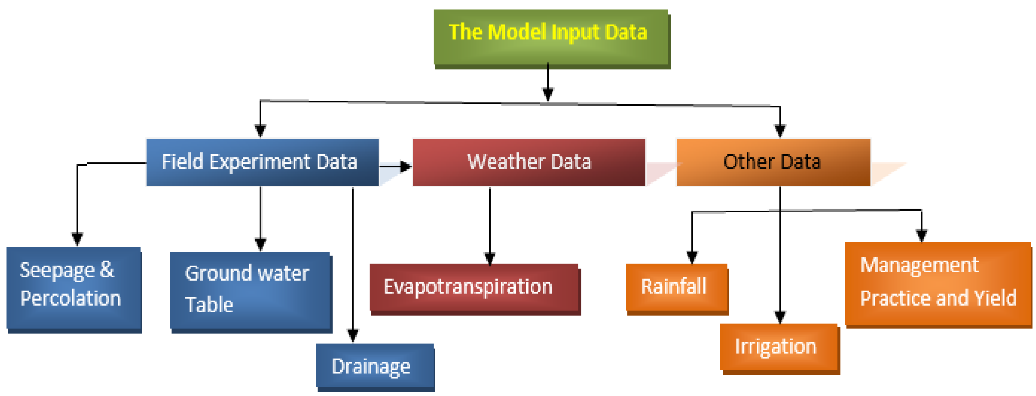


Fig. 2.1 Data components of the model

2.2 Models and Model Development

The irrigation water balance models and other key performance indicators that were useful in the irrigation operations and will be used in the development of the system for efficient and equity water distribution as presented in the following equations.

$$SWD = IRR + ER\,S - SM - ET - SP - DR + GW \qquad (1)$$

Where;

	SWD	=	field Standing water depth (mm)
	IRR	=	Irrigation (mm)
	ER	=	Effective rainfall (mm)
	SM	=	Soil Moisture (mm/m)
	SP	=	Seepage percolation (mm)
	DR	=	Drainage and Runoff (mm)
	GW	=	Ground water influence (mm)

2.3 Water Productivity Index (WPI)

$$\text{Water Productivity Index} = \frac{\text{Yield (kg)}}{\text{Total water consume (m}^3\text{)}} \quad \text{(Tuong 2003)} \qquad (4)$$

2.4 Irrigation System Efficiency (eS)

The irrigation system efficiency is the combination of system water conveyance and distribution and can be written as;

$$eS = \frac{V_f + V_{nc} + V_{nd}}{V_r + V_i} \quad \text{(Lenton, 1984)} \qquad (5)$$

2.5 Overall project Efficiency (ep)

Separate assessment of the conveyance, distribution, and field application efficiencies and therefore can be written as;

$$eP = \frac{V_m + V_{nc} + V_{nd}}{V_r + V_i} \quad \text{(Lenton, 1984)} \qquad (6)$$

Where;

V_r = volume of water diverted from the river

V_d= Volume diverted to the distribution system
V_i = Inflow from other source (if there is any)
V_{nc} = Non irrigation deliveries from conveyance system
V_{nd} = Non irrigation deliveries from distribution
V_f= volume of water delivered to the field
V_m = Volume of water needed for crop growth for the growing season.

2.6 Water Delivery Performance (WDP)

(Lenton 1984) has put the approaches to the performance indicator of irrigation system by water delivery and therefore defines water Delivery Performance (WDP) as an indicator of performance of an irrigation system to monitor productivity and equity. WDP can be defined as follows;

$$\mathrm{WDPi} = \sum_{i=1}^{n} \frac{K(t)V_i(t)}{V_i^*(t)} \tag{7}$$
$$V_i(t) \le V_i^*(t) \tag{8}$$
$$\sum_{i}^{n} K(t) = 1 \tag{9}$$
Where,

Vi(t) = Volume of water delivered to farm i during the week (t) or other time period of the cropping season.
$V^*_i(t)$ = target volume of water to be delivered to farm i during the week t of cropping season, calculated for actual crops grown and existing condition of soil, rainfall and other sources of water.
K(t) = Weighting factor indicating the relative importance of water at different stages of crop growth.
WDPi would equal to unity if the water delivered to the farm during each week of the cropping season is equal to the target water delivery and zero if water is never delivered during any of the weeks of the cropping season. If water is delivered at the wrong time and/or in the amounts, WDP will vary between zero and one. WDPi as defined here assumes that if water delivered is greater than target water delivery, water delivery performance is not affected. Lenton (1984) also suggested a modification to the definition of WDPi which explicitly accounts for the harmful effect of over irrigation. It is expressed as follows;

$$WDPi = \sum_{1}^{n} \epsilon_i(t) \tag{10}$$
Where;
$$\epsilon_i(t) = \frac{K(t)V_i(t)}{V_i^*(t)} \tag{11}$$
If, $V_i(t) \le V_i^*(t)$
$$\epsilon_i(t) = \frac{K(t)V_i^*(t)}{V_i(t)} \tag{12}$$
If, $V_i(t) > V_i^*(t)$

The concept and definitions of water delivery performance are a major contribution to the thinking on performance indicators which combine the effects of adequacy and timeliness with appropriate weights attached to critical periods of crop growth. It is easy to communicate to the managers of the system and it is easy to compute.

2.7 Water Use Efficiency (WUE)

$$WUE = \frac{ET - SP - SM}{IR + ER + GW} \times 100\% \qquad (13)$$

2.8 Web GIS Development

ArcGIS for Server is software that makes geographic information available to organizations and optionally anyone with an Internet connection. These were accomplished through web services, which allow a powerful server computer to receive and process requests for information sent by other devices. There are many ways to create web application, one of which was adopted here is ArcGIS viewer for flex, which is a configurable web application built on the ArcGIS API for Flex. It allows creating customized GIS web map applications with little or no programming. The ArcGIS Viewer for Flex was designed to work with services from GIS server. It also referenced an intelligent web maps that were authored using ArcGIS.com or Portal for ArcGIS. The ArcGIS Viewer for Flex supports data display, interactive querying, web editing, data extraction, geocoding, and printing.

ArcGIS Server allows developing web application to share GIS resources across an enterprise and across the web. GIS resources are the maps, address locators, geodatabases, charts tools etc. These resources were shared by first hosting them on ArcGIS Server system, or GIS server, and then allowing client applications to use and interact with the resources.

ArcGIS Server also consists of services, applications, and KML network links that have been published to the server. In addition, a Manager application was responsible for creating and organizing services and basic applications. ArcGIS Server is used to introduce advanced GIS function to the internet environment and to publish information based on GIS platform.

2.9 Web GIS System Development

As Craig et al.(1999) described the Public Participation GIS principles as accessibility, understand ability, and accountability, Web GIS continues to draw attention as a public participation tool (Sakamoto et al., 2004).

The life cycle of the system depends on a series of system steps that are sequentially organized in order to achieve the needed result; however, the development of a system undergoes the following order (Fig. 2.2). Like in any software development the same pattern of system life cycle is adopted.

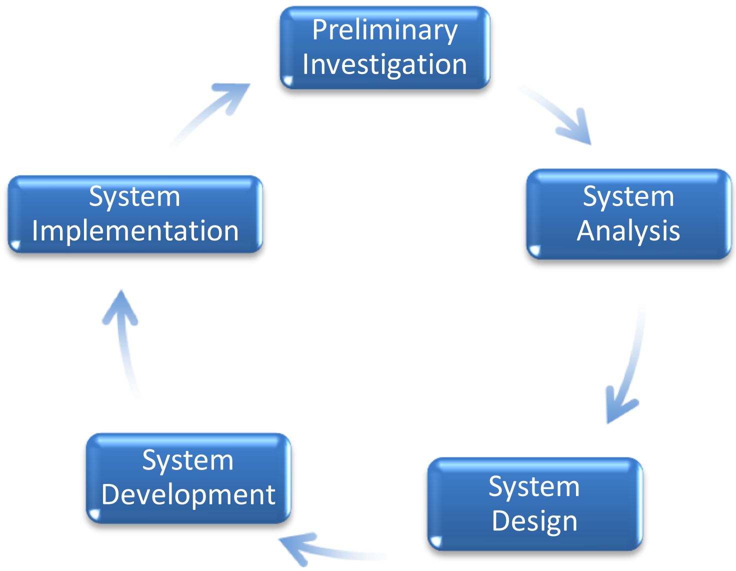


Fig. 2.2 Life cycle of the system development

2.10 Data Preparations and Publishing to Server

All information used to be prepared in the GIS platform arranged as layers and stored in a registered database, these layer information were then configured and published as services. These services were analysed by service editor to ensure error free before published to the server as map services and feature services depending on the chosen choice.

2.11 System Design

This system used Microsoft SQL database 2012 enterprise in conjunction with ArcSDE to manage the way spatial and attribute data were stored in a relational table. This maximizes data space to ensure the integrity of the entity. The database was registered with the ArcGIS Server in order for the Server to read data from the database, this is to ensure that information is secured.

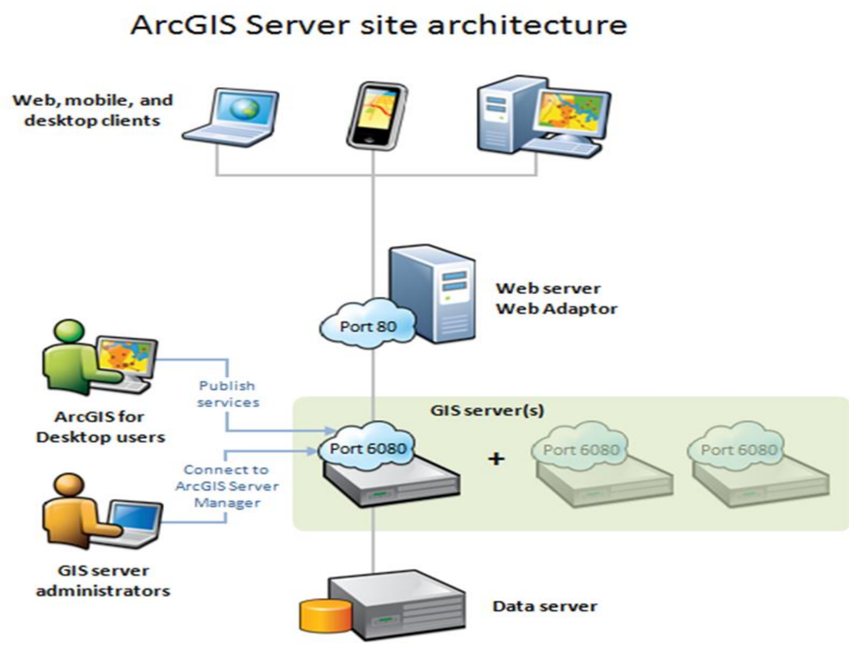


Fig. 2.3 ArcGIS server Architecture and database

2.12 Architecture of Flex Viewer

Flex Viewer is a plug-in based on Adobe air, an application builder framework developed by ESRI's company based on the technology of ArcGIS Server REST services. This framework offered the basic modules for designers. Designers only need to add the configuration code into the xml file to deploy a new module to the existing Flex Viewer rapidly in the form of widgets. The flex Viewer allows building a highly powerful system that displays the information published in the ArcGIS Server for visualising, querying and conducting some geoprocessing services. The widgets was customized to suit our choice, the final output depends on individual skills. Real time information could be assessed when incorporated with the right instrument in place or when satellite is readily available.

3.0 RESULTS

A number of geographical features, models and real-time information were used in the procedure of management, and it is difficult to analyse and display with the traditional management information system. GIS technology makes the system easily and quickly for decision-makers to access and analysed information. GIS is more expressly and effectively to describe the information in terms of visual image, charts and tables and quickly draw conclusion.

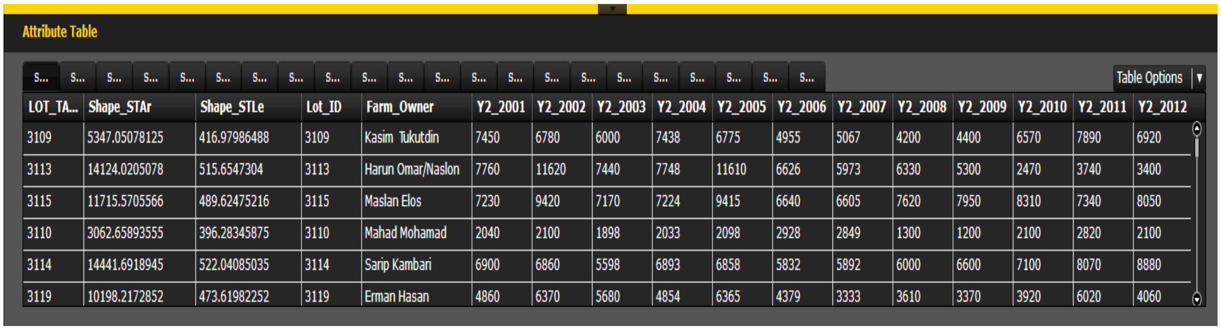
3.1 System functions

The end users could be connected to the central server using a Web browser by signing in using their respective login details. The users were divided into three categories, common users, farmers and professional users, each of which have different rights. Common users can only check for information like present status of the water level at fields while farmers can in addition query the existing computation results, while professional users can do their own computations and analysis in addition to querying the system and add the result as a layer to be approved for publishing by the publisher or admin.

The system is equipped with widgets which execute different functions, in this case the geoprocessing widget process the layer task and add to the service for web viewing. The attribute table was displayed to enable select a layer from attribute table and execute query. Real time information was made possible as the displayed result can be view instantaneously. The search widget enable easy and quick search of the system and zoom to the area searched and selected. The developed GIS application is user friendly in the sense that the widget system made it easy to understand the results of the displayed information. The layers have legends to help interpret which layer represents what activity or aspect of the farm services.

3.2 Attribute Table widget tool

The Attribute Table widget displays a tabular view of a feature layer's attributes. If the feature layer is editable, you can edit the records within the table widget as well. If working with more than one feature layer in the map, multiple tabs display allowing you to toggle between the layers' attribute tables.



LOT_TA...	Shape_STAr	Shape_STLe	Lot_ID	Farm_Owner	Y2_2001	Y2_2002	Y2_2003	Y2_2004	Y2_2005	Y2_2006	Y2_2007	Y2_2008	Y2_2009	Y2_2010	Y2_2011	Y2_2012
3109	5347.05078125	416.97986488	3109	Kasim Tukutdin	7450	6780	6000	7438	6775	4955	5067	4200	4400	6570	7890	6920
3113	14124.0205078	515.6547304	3113	Harun Omar/Naslon	7760	11620	7440	7748	11610	6626	5973	6330	5300	2470	3740	3400
3115	11715.5705566	489.62475216	3115	Maslan Elos	7230	9420	7170	7224	9415	6640	6605	7620	7950	8310	7340	8050
3110	3062.65893555	396.28345875	3110	Mahad Mohamad	2040	2100	1898	2033	2098	2928	2849	1300	1200	2100	2820	2100
3114	14441.6918945	522.04085035	3114	Sarip Kambari	6900	6860	5598	6893	6858	5832	5892	6000	6600	7100	8070	8880
3119	10198.2172852	473.61982252	3119	Erman Hasan	4860	6370	5680	4854	6365	4379	3333	3610	3370	3920	6020	4060

Fig. 3.1 Attribute Table

Once the web application loads, the Attribute Table widget checks for any feature layer feature(s) in the current extent and populates the attribute table with its feature(s). Aside from providing a tabular display of the layer's data, the features can be selected, deselected, and zoomed-to by interacting with the attribute table. If these feature layers are editable, the corresponding feature attributes will also be editable. In addition, the fields can be sorted by clicking on its heading.

3.3 Customizing the Pop-ups Widgets

The ArcGIS Viewer for Flex Application Builder supports pop-ups created either on ArcGIS.com or configured using a configuration dialog box. Pop-ups can be used for different types of layers. Starting with version 2.3, ArcGIS Viewer for Flex supports pop-up windows for tiled and dynamic map services, as well as feature layers. This pop-up functionality is built in to the API and is not a separate widget. The pop-ups were configured in the application builder based on the content and/or formatting desired. The pop-ups displayed instantly the content of the map as configured to show. Below were some pop-ups displayed on web application of some charts, model outputs and layers.

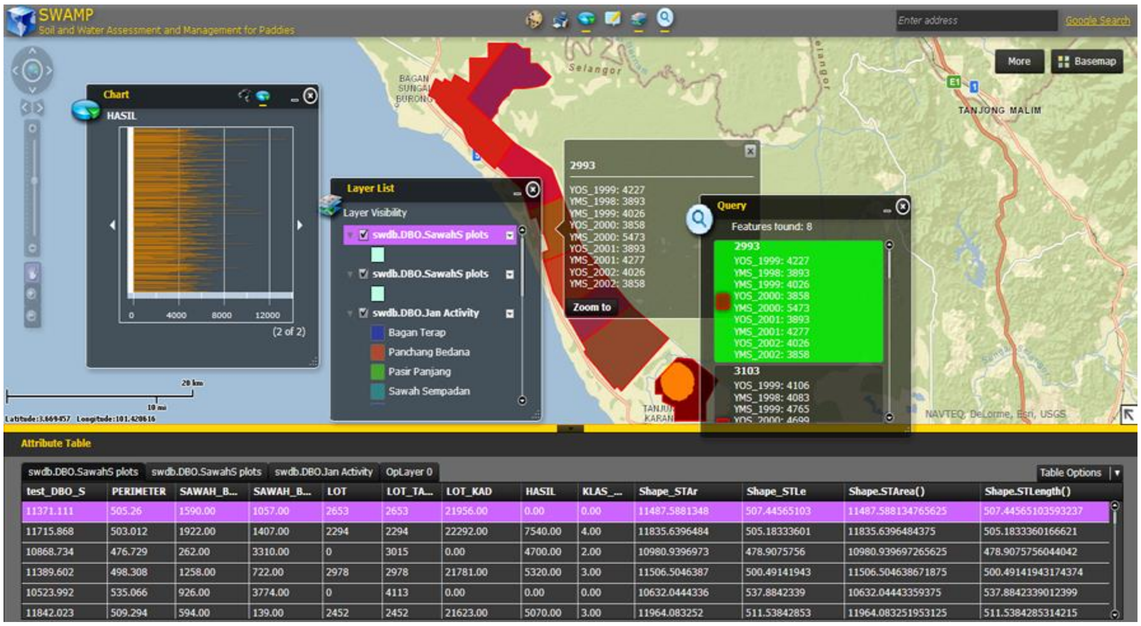


Fig. 3.2 Farm activity interface showing pop-up of different information online

4.0 DISCUSSIONS

This web GIS DSS is not new rather what is new is the specific models built for the research area. And the customization of the widgets system to address peculiar on-farm water balance model on the farm. This system saves time and resources and is flexible to handle with little practice and it's anticipated to gives high accuracies in the overall output. The user will select appropriate combination of a required item that is needed to view its output. The particular information for the event was imported from the attributes table by structured query language. The systems also function as tool to know at any instance what activity is taking place at any point in time.

For fertilizer application it will enable farmers to know exactly the application rate of fertilizer base on the soil fertility map of the area. The geoprocessing functions was so powerful for conducting spatial analyst built using the ModelBuilder to process and output as a layer added to the map. The system also displays the attribute table which can be used to visualize and select. This system is user friendly irrigation water management tool for viewing, modelling; conduct some spatial analysis and visualizing the system output. The developed system is very interactive and the interface was simplified such that the user need not be a GIS expert to explore and retrieve information and make decision for best practices on irrigation water management.

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REFERENCES

Bonczek, R.H., C.W.H.. and A.B.W., 1984. Developments in Decision Support Systems. *Advances in Computers*, 23, pp.141–175.

Carver, S.J., 1999. Developing Web-based GIS/MCE: Improving access to data and spatial decision support tools. In *A geographic information sciences approach Ashgate, New York, pp. 49–76.* pp. 49–76.

Craig W., Harris. T., Weiner, D., 1999. Empowerment, marginalization and public participation GIS. In *Report of Varenius Workshop,*. Santa Barbara, NCGIA, pp. 22–24.

Greenwood, R.W., 2002. Using MapServer to Integrate Local Government Spatial Data. , (September), pp.11–13.

Heilman P., I. S. Cohen, H. M. Rodriguez, R.S.M., 2005. Working Smarter: Research and decision support system in Mexican Agriculture. In *Texas A&M press. www.tucson.ars.ag.gov*.

Lenton, R., 1984. A note on Monitoring productivity and Equity in Irrigation System. *Int. J. Water Resources Development*, pp.51–65.

Malczewski, J., 1999. *GIS and Multicriteria Decision Analysis*, New York: John Wiley and Sons).

Power, D.J., 2003. “Defining Decision Support Constructs,.” In *Seventh International Conference on Decision Support Systems (ISDSS’03)*. Ustron, Poland, pp. 13–16.

Rahman, S.M.M. & Khan, M.R., 2009. Development of a DSS for Integrated Water Resources Management in Bangladesh. , (July), pp.2756–2762.

Rowshon M K and Amin M S M, 2010. GIS-based irrigation water management for precision farming of rice. *Int J Agric & Biol Eng*, 3(3), pp.27–35.

Sakamoto A. & Fukui, H., 2004. Development and application of a livable environment evaluation support system using Web Gis. *Journal of Geographical Systems, Springer (Berlin / Heidelberg)*, 6(2), pp.175–195.

Tuong, T.P., 2003. Rice Production in Water-scarce Environments. *Water*, pp.53–67.

Yangwen, J. et al., 2009. A WebGIS-based system for rainfall-runoff prediction and real-time water resources assessment for Beijing. *Computers & Geosciences*, 35(7), pp.1517–1528. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0098300409000302 [Accessed March 13, 2012].

Zhang, H., Yi, S. & Wu, Y., 2012. Decision Support System and Monitoring of Eco-Agriculture Based on WebGIS in Shule Basin. *Energy Procedia*, 14, pp.382–386. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1876610211043621 [Accessed May 30, 2013].

Zhao, L., Lu, H. & Yu, Y., 2001. Designing And Implementing An Online WebGIS-Based Decision Support System I . Background and Current Development of II . The Architecture and Structure of.

Zhelu, Y., 2009. *A web-based Geographical Information System prototype on Portuguese traditional food products*, *Msc Thesis ISEGI-UNL Portugal. 55*. ISEGI-UNL Potugal.

MEDIUM-TERM LOAD FORECASTING FOR KUMBOTSO DISTRICT, KANO STATE

USING ARTIFICIAL NEURAL NETWORKS (ANN)

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ABSTRACT

Load forecasting is the technique for prediction of electrical load. In a deregulated market there is need for a generating company to know about the approximate load demand by the consumers. If the generation is not sufficient to fulfil the demand, there would be problem of irregular supply. The learning property of artificial neural network (ANN) in solving nonlinear and complex problems makes it suitable for the application of forecasting problems. This report presents the development of an ANN based medium-term load forecasting model for the Power Holding company of Nigeria-Kano to predict the load demand of Kumbotso District in Kumbotso Local Government Area Kano. The daily load profile with a lead time of 1-24 hours for the year 2012 was obtained from the utility company, and the demographic information of the area for the corresponding year was also obtained from the National Population Commission Kano. The Levenberg-Marquardt optimization technique was used as a back propagation algorithm for the Multilayer Feed forward ANN model using MATLAB-R2011a ANN Tool box. The forecasted next month and daily loads are obtained based on the stationary output of the ANN with performance Mean Squared Error (MSE) of $1.05e^{-5}$. *The model will be found to be useful for the weekly and monthly operational planning for the utility company.*

Key Words: Artificial Neural Network, Back propagation algorithm, Medium-term load forecasting.

1.0 INTRODUCTION

The importance of electrical energy in modern world cannot be overemphasized. We use energy in various forms in our day to day life, electricity, solar energy, wind energy, and many other forms. A reliable and continuous supply of electrical energy is necessary for the functioning of today's complex societies.

In order to meet up with customer expectations of high quality electrical energy at required periods and in the most economically possible manner, electrical utility companies face many operational and technical difficulties. For the purpose of optimal planning and operation, modern control theory and optimization techniques are being applied with the expectation of considerable cost savings. This goal can be achieved with the knowledge of future power system load at hand. Thus a great saving potential exist for the electric utilities. The importance of accurate load forecast is therefore vital and will increase in the future because of the dramatic changes occurring in the structure of the utility industry due to deregulation and competition.

From the beginning of 1990s, load forecasting with Artificial Neural Network (ANN) have become the commonly used method. ANNs are capable of identifying the complex interactions between independent variables since it has non-linear architectural structure. Utility providers have to deal with complex load series when performing load forecasts. Complex in the sense that the load at a given hour is dependant not only on the load at the previous hour, but also on the load at the same hour on the previous day, and on the load at the same hour on the day with the same denomination in the previous week. In a medium term load forecasting, in addition to load data, weather related data and the population size of customers is also used. .

Load forecast can be divided into three categories, short term load forecast which are usually from one hour to one week, medium-term load forecast which are usually from one week to one year and long term load forecast which are longer than a year [1].

For a medium term load forecasting, several factors should be considered, such as the historical load, weather data, the number of customers in different categories, the economic and demographic data and their forecast [2].

Load forecast, Short Term Load Forecast (STLF) studies began in early 1960s; one of the first studies was done by Heinemann et al. in 1966 which dealt with the relationship between temperature and load [3]. In 1971, a load forecasting system was developed by Lijesen and Rosing which used statistical approach [4]. In 1987, Hegan and Bahr forecasted load using a time series model [5]. From 1990, researchers began to implement different approach electricity load forecasting other than statistical approach mainly due to the requirement for huge data sets to implement the STLF system. In 1991 park et al. were among the first group of researchers who chose to use the ANN approach for STLF [6]. Some group of researchers implemented Medium Term Load Forecast (MTLF) system using hybrid methods.

In this paper, Artificial Neural Network (ANN) is used to obtain the medium term load forecast model with the historical load demand data, demographic data of the area and temperature as the input parameters collected for a period of one year

2.0 METHODOLOGY.

A simple data collection method (walk through) was employed to ensure adequate historical samples of the load. Data scaling is also carried out in order to improve interpretability of network weights. The data was normalized between the value of 0 and 1.

The Artificial Neural Networks multilayer feed forward (MLP) network architecture is proposed for this study. This is because of its ability to learn complex relationships between input and output patterns that will be difficult to model with conventional techniques such as time series and regression analysis.[1]

In order to determine the connection weights between the neurons, the conventional back-propagation algorithm is proposed by using available algorithms from Matlab-R2011a ANN toolbox. The network will be trained with load data of previous years which was obtained from PHCN and National Population Commission Kano. In this forecasting application, the number of input and output nodes will be equal to the number of utilized forecast indicators which are previous loads, day temperatures and population size, and the number of desired output(day hourly loads) respectively. However, there is no theoretical approach to calculate the appropriate number of hidden layer nodes. This number will be determined using a similar approach for training epochs i.e by examining the error (MSE) over a validation set for a varying number of hidden layer nodes, a number yielding a smaller error will be selected.

The output of the trained network will be compared with the actual load data obtained from PHCN to check the accuracy of the trained network.

The MATLAB/SIMULINK software will be used in simulating the load data.

2.1 Artificial neural networks

A neural network is a machine that is designed to model the way in which the brain performs a particular task. The network is implemented by using electronic components or is simulated in software on a digital computer. A neural network is a massively parallel distributed processor made up of simple processing units, which has a natural propensity for storing experimental knowledge and making it available for use. It resembles the brain in two respects:

(i) Knowledge is acquired by the network from its environment through a learning process.

(ii) Interneuron connection strengths, known as synaptic weights, are used to store the acquired knowledge.[4]

An ANN mostly is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase.

2.2 Artificial neural network model

An artificial Neural network (ANN) is a data processing system, consisting large number of simple highly interconnected processing elements as artificial neuron in a network structure. A neuron is an information processing unit that is fundamental to the operation of a neural network [7].

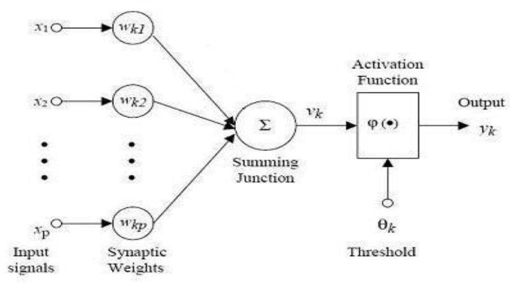

Fig. 1 Model of Artificial Neural Network [4]

The three basic elements of the neuron model are:

(1) A set of weights, each of which is characterized by a strength of its own. A signal "xj" Connected to neuron "k" is multiplied by the weight "wkj". The weight of an artificial neuron may lie in a range that includes negative as well as positive values.

(2) An adder for summing the input signals, weighted by the respective weights of the neuron.

(3) An activation function for limiting the amplitude of the output of a neuron. It is also referred to as squashing function which squashes the amplitude range of the output signal to some finite value.

$$V_k = \sum_{j=1}^{p} W_{kj} * X_j \quad (2.1)$$

$$and\ Y_k = \varphi(V_k + \theta_k) \quad (2.2)$$

Where V_k is the output of the sigmoidal activation function and Y_k is the output of the overall network.

2.3 Recurrent neural network (RNN)

A Recurrent Neural Network is a class of neural network where connections between units form a directed cycle. Unlike feed-forward neural networks, RNNs can use their internal memory to process arbitrary sequences of inputs. A recurrent neural network consists of at least one feedback loop. It may consist of a single layer of neurons with each neuron feeding its output signal back to the inputs of all the other neurons.

2.4 Back propagation algorithm

The error back-propagation algorithm is an algorithm that relies on the error correction learning rule to train neural networks. It is considered a generalization of the commonly used adaptive filtering algorithm or least mean square (LMS) algorithm. Error back-propagation learning involves a forward pass and backward pass through the different layers of the network [9]. An input vector is applied to the nodes of the network in a forward pass which then propagates through the network layer by layer. The response of the network is to create a set of outputs. While the network weights are fixed during the forward pass, during the backward pass they are adjusted in tandem with the error correction rule. An error signal is produced when the actual response of the network is subtracted from a desired response. It is then propagated backward through the network in the opposite direction of the synaptic connections. By adjusting the weights, the actual network response will approach the desired response. It should be noted that a multilayer perceptron has three distinctive characteristics: A nonlinear activation function is necessary for each neuron in the network. Generally this means using a sigmoid function commonly defined by the logistic function:

$$y = \frac{1}{1+e^{-x}} \quad (2.3)$$

3.0 Data collection and pre-processing

A simple data collection method was employed to ensure adequate historical samples of the load. Load Data used in this work were collected from the Power Holding Company of Nigeria (PHCN) kumbotso unit and that of the population was collected from National Population Commission Kano.

3.1 Data scaling method

Data scaling is carried out in order to improve interpretability of network weights. The equation below has been adopted and implemented to normalize the historical load data.

$$Normalized\ output = \frac{Actual\ value}{maximum\ value}$$

The load value is normalized into the range between 0 and 1 and then the neural networks are trained using the suitable algorithm. Neural networks provide improved performance with the normalized data. The use of original data as input to the neural network may increase the possibility of a convergence problem.

4.0 MATLAB implementation of ANN.

The Fig. bellow shows an open ntstool in Matlab R2011a

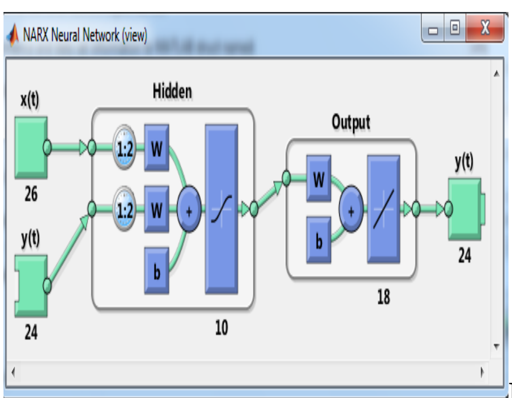

Fig. 2 Network Architecture [10]

This fig. shows the preparation of input and target data in work space. The importation of the prepared data to the Matlab environment is also done here.

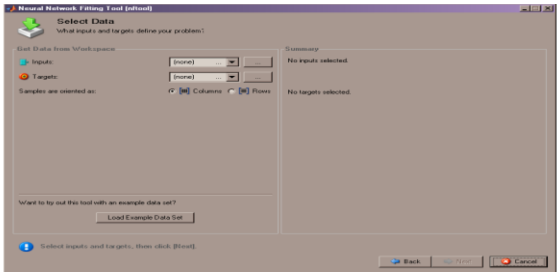

Fig. 3 Data select environment.[10]

The Fig. 4 bellow shows the Matlab dialogue box where the training, validation and Testing parcentage of the data can be set as desired. In this paper, training, validation and testing are set to 60%, 20% and 20% respectively.

Fig. 4 Partitioning Dialogue box[10]

5.0 Simulation and Result.

For evaluating the proposed load forecast model, several neural network architectures were implemented in MATLAB R2011a (results not shown). Feed Forward Network and Recurrent Network – these two networks were implanted according to their default architectures as provided in MATLAB.

The network model was trained using Levenberg-Marquardt Backpropagation Algorithm with the help of Neural Network Time Series Training tool. After that the network was simulated and its performance was observed.

The results obtained after several training of the ANN model were the regression analysis plots between the output and target vectors, the general network error performance and the training state.

(1)The regression plot consists of four regression analysis plots; the first is a plot of the computed network output of the training data set versus target output, the second one is that of the validation data output versus target output. The third one is the plot of Test data output set against the target output. The final plot is that of the overall network output data set versus the target data set.

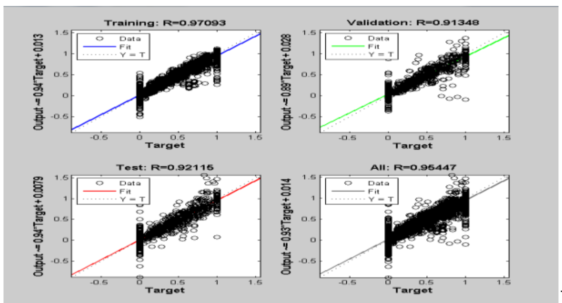

Fig. 5 Regression Plot

(2) The performance function versus number of epochs plot describes the plot of the mean squared error against the number of training epochs. It also shows the learning trend and computational error improvement as the number of iterations increases.

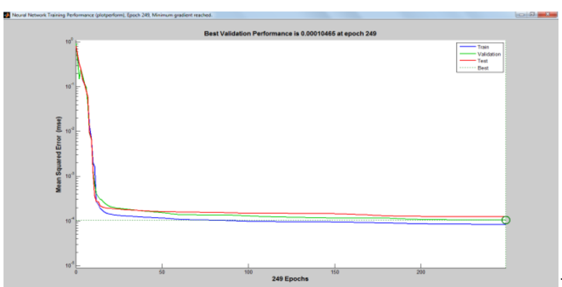

Fig. 6 Performance Plot

(3) The training state plot consists of three different plots. The first plot is that of learning function versus number of epochs. The second plot is that of the learning rate (mu) versus increasing number of epochs. The final plot is that of the validation checks carried out automatically any time a sudden change is observed in the network gradient computation is carried out.

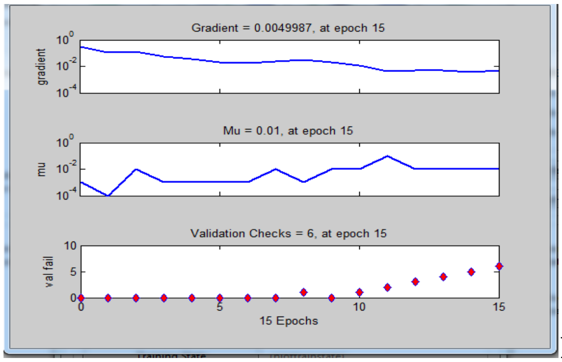

Fig. 7 Training State Plot

5.1 Comparison of Actual and forecasted Loads

This plot shows the correlation between the actual load and the forecasted loads in graphical form.

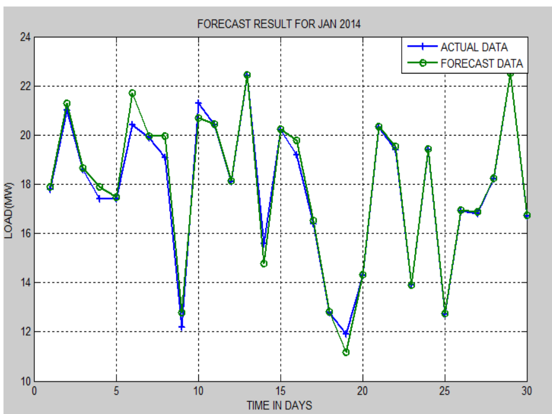

Fig 4.3 (a) Comparison Plot Between Actual and Forecast Loads for the Month of Jan 2012

5.2 Prediction

The graph shown in Fig.8 below shows a prediction of the load demand for the first week of January 2014.

However, this would not necessarily be the exact expected load because of the fact that the data set used in training the ANN network was not sufficient enough and also does not include seasonality factors to give strong prediction ability of the model.

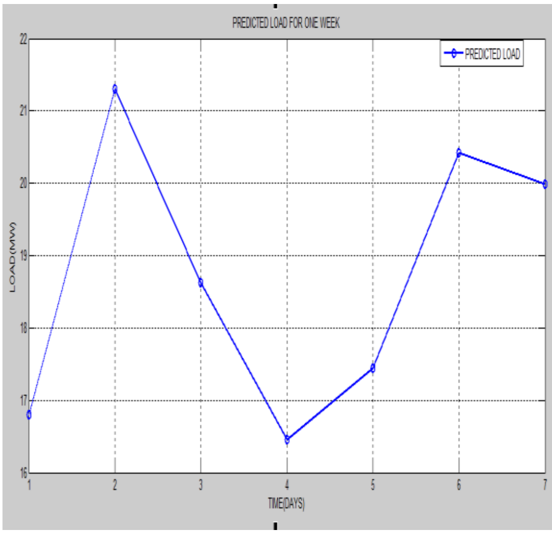

Fig. 8 Predicted load from 1st-7th January, 2014

5.3 REMARKS The results presented in this chapter are based on the 2012 previous load demand of Kumbotso town data set. The results have shown that the forecast performance of future load by the neural network model seems satisfactory.

Thus, further evaluation of this model through comparison with other state of the art load demand prediction approaches will form the key part of the future research/investigation.

6.0 CONCLUSION

A load forecasting model using Matlab-R2011a ANN Tool box was designed, the implementation of the network architecture, training of the Neural Network and simulation of test results were carried out successfully with a good degree of accuracy resulting into one month output load output set with $1.05e^{-5}$ forecast error.

PHCN-Kano can use this study to determine the amount of energy required in the affected area considering the rapid growth of Small and medium scale enterprises in the area.

REFFERNCES

[1] Salman Quayum, yousof Ibrahim khan, saidur Rahman, parijat barman(2011) "*Artificial Neural Network based short term load forecasting of power system*" International Journal of computer sciences and engineering, (0975-8887), volume 30-No.4

[2] Shamsher Kadir Sheikh and M.G. Unde, (2012) "*Short term load forecast using Artificial Neural Network Technique*" International Journal of Engineering Sciences and Emerging Technologies.

[3] Tai Hein Fong (2009) "*Case study of short-term Electricity load forecasting with temperature dependency"*.

[4] G.T. Heinemann, D. A. Nordmian, E. C. Plant.(1966) "*The relationship between summer weather and summer loads – a regression analysis*", IEEE Transactions on Power Apparatus and Systems, Vol. PAS – 85, no. 11, pp 1144 – 1154,

[5] D .P. Lijeseng, J. Rosing (1971) " *Adaptive forecasting of hourly loads based on load measurement and weather information*", IEEE Transactions on Power Apparatus and Systems, Vol PAS – 90, no. 4, pp. 1757 – 1767,

[6] M.T. Hagan, S. M. Behr.(1987) "*The time series approach to short term load forecasting*", IEEE Transactions on Power Apparatus and Systems, Vol. 20, no. 3, pp. 785 – 791,

[7] D. C Park, M. A. Elsharkawi, R. J. Marks II, L.E. Atlas, M. J. Damborg (1991) "*Electrical Load Forecasting using artificial neural network*", IEEE Transactions on Power Systems, Vol 6, no. 2, pp 442 – 449.

[8] D. Srinivasan, S .S Tan, C. S Cheng, Eng Kiat Chan (1999) "*Parallel neural network-fuzzy expert system strategy for short-term load forecasting: system implementation and performance evaluation*", IEEE Transaction on Power Systems, Vol. 14, no. 3, pp 1100 – 1106.

[9] Haykin S (1999) "*Neural networks – A comprehensive Foundation, 2nd edt"*., Prentice Hall, upper saddler River,

[10] MATLAB(R2011a)

PERFORMANCE COMPARISON OF GA-PID WITH FUZZY LOGIC CONTROLLER FOR POSITION TRACKING OF BRUSHLESS DC MOTOR

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ABSTRACT

The brushless DC (BLDC) motor has been found to offer many advantages that includes simple to construct, high torque capability, small inertia, low noise etc. BLDC is an unstable and non-linear system which implies that its internal parameter will change for different input conditions. Therefore, there is need for an excellent controller that will stabilize the position of BLDC motor, as most of conventional controller available lack accuracy, robustness and sharpness required. This paper considered two control schemes: Fuzzy logic controller (FLC) and PID optimized with Genetic Algorithm (GA-PID) controller, for position tracking of BLDC motor. The FLC scheme was designed with the joint angle error and its derivative as the input of the controller using Fuzzy logic toolbox in MATLAB Simulink environment. Meanwhile, a Matlab script for genetic algorithm was written with the aim of obtaining the optimum PID parameters that accurately track the position of BLDC by minimizing an objective function (Integral time average error ITAE). For the purpose of comparison between the two proposed schemes various position tracking reference are tested. The results show that GA-PID control schemes proved superiority when considering settling time and rise time under zero disturbance with values 0.08 seconds and 0.00 seconds respectively as compared with settling time of 0.42 seconds and rise time of 0.02 seconds for FLC. However, FLC proved better when a disturbance was introduced with settling time of 0.10 seconds and percentage overshoot of 0.00 as compared with settling time of 19.80 seconds and percentage overshoot of 48% for GA-PID. Therefore, both controllers can serve as valuable and effective controllers for the system.

Keywords: Objective function, Fuzzy logic, brushless motor, Genetic Algorithm, Stability.

1.0 INTRODUCTION

The industrial world of today is fast growing and so is the demand for precision and robustness. There are several applications today that demand high performance BLDC motor drives. Among the various motors, brushless dc motors are gaining widespread popularity in electric vehicles, aerospace, military equipments, hard disk drives, HVAC industry, medical equipments etc., due to their well-known advantages like high efficiency, low maintenance and excellent speed-torque characteristics. The conventional controllers used in high performance drives are proportional integral (PI) or proportional integral derivative (PID) controllers. These are constant gain controllers and require accurate mathematical models or system response for their design. The BLDC motor drive system is highly non-linear. It is often very difficult to obtain an accurate mathematical model for BLDC motor drive systems when the motor and load parameters are unknown and time-varying. The conventional controllers fail to give optimal performance during change in operating conditions like variations in parameters, saturation and noise propagations. This has resulted in an increased interest in intelligent and adaptive controllers. Fuzzy logic and GA-PID are some of the popular strategies to deal with uncertain control systems. These controllers can offer a number of attractive properties for industrial applications such as insensitivity to the parameter variations and external disturbances, in addition to quick in response and very high precision. There has been a significant and growing interest in the application of fuzzy logic and optimized PID (GA-PID) controllers to control complex, nonlinear systems. The design of fuzzy logic controller doesn't require mathematical model of the system, but rules describing the behavior of the system have to be framed based on the knowledge of the system. It is possible to quickly develop and implement a fuzzy controller for nonlinear systems such as BLDC motor drives. GA is stochastic global search methods based on the mechanics of natural selection and natural genetic. They are iterative method widely used in optimization problems in general branches of science and technology. It was first proposed by Holland in 1976. GA offer some advantages over other search tools in the following ways [1]:

- GAs search from a population of points not a single point
- GAs use probabilistic transition rules not deterministic ones
- GAs work on encoding parameters set rather than the parameter set itself (except where real-valued individuals are used)
- GAs do not require derivative information or other auxiliary knowledge; only the objective function and the corresponding fitness levels influence the directions of the research.

To obtain a solution to a problem through genetic algorithms, the algorithm is started with a set of solutions (represented by chromosomes) termed as the population. This is Initialization. This is followed by selection, which means choosing random solutions of one population to forms a new population base on their evaluation on the objective function. This can be done either by Roulette wheel or Stochastic universal sampling. The former was used because it ensures that each parent chance of being selected is proportional to its fitness value but possibility also exists to choose the worst population member. The new population is formed assuming that the new one will be better than the old one. Parent solutions are selected from the population to form new solutions (offspring) based on their fitness measure through the application of genetic operators such as crossover (exchange of genes from parents), mutation (sudden change in genes, this should however be introduce on a minimum probability) etc. These processes are repeated over several iterations until a stopping criterion is reached [2].

Although both optimized PID (GA-PID) and FLC have been applied successfully in many applications, they also have some limitations such as non deterministic nature of GA and tax in tuning FL. This paper considered performance comparison of Fuzzy logic and GA-PID for position tracking of brushless dc motor. The information referred from various literatures for carrying out this work is as follows. The modeling of brushless dc motor, estimation of parameters and control schemes are discussed in [3,4,5]. The effect of change in motor parameters, load disturbances on the performance of the brushless dc drive system is discussed in [6,7,8]. Several tuning methods for the PI and PID controllers are described in [9,10,11]. Design, implementation and performance analysis of sliding mode controllers for various applications such as AC motors, BLDC motor, etc., are presented in [12,13,14,15,16]. Design and implementation of fuzzy based controllers for improving the performance of dc motors and brushless dc drives under different operating conditions are discussed in [17,18,19,20,21]. Controllers design with artificial tunable gain is explained in [21,22,23]. The simulation software MATLAB/Simulink is explained in [24].

The rest of the paper is organized as follows. Section Two deals with modelling of BLDC motor drive, section three, dwells on the controllers design for the BLDC motor drives, Section four presents the comparison between the results obtained from simulation and the its discussion, and finally, Section five concludes the paper.

2.0 MODEL DESCRIPTION

Consider the block diagram of a brushless dc motor in Figure 1. The simplified mathematical dynamic equation is obtained from the figure using Newton's laws of motion as follows.

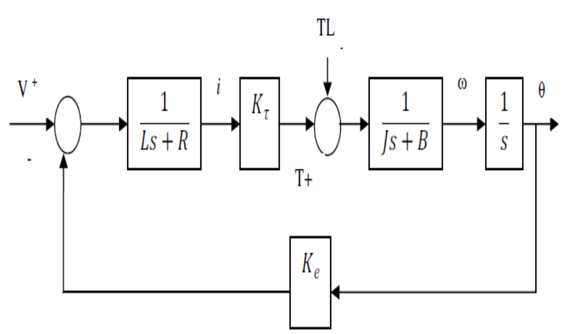

Figure 1 Block diagram of brushless dc motor

The analysis of BLDC motor is based on the assumption that there is no loss in the torque for simplification and accuracy. The BLDC motor is type of unsaturated. To perform the simulation of the position control, an appropriate model needs to be established. Based on the equivalent circuit of BLDC motor shown in Figure 1, the dynamic equations of BLDC motor using the assumption can be derived as: The motor torque, T_m is related to the armature current I_a by a constant factor of K

$$T_m = KI_a \qquad (1)$$

The back emf, e_b is related to angular velocity, w_m by;

$$e_b = Kw_m = K\frac{\partial \theta_m}{\partial t} \qquad (2)$$

From Figure 1, the following equations can be written based on Newton's Second Law combined with Kirchhoff's law;

Newton's Second Law,

$$T_m = J_m \frac{\partial^2 \theta_m}{\partial^2 t} + B_m \frac{\partial \theta_m}{\partial t} \qquad (3)$$

Substituting equation (1) into equation (3) to obtain;

$$J_m \frac{\partial^2 \theta_m}{\partial^2 t} + B_m \frac{\partial \theta_m}{\partial t} = KI_a \qquad (4)$$

Applying Khirchhoff'sLaw,

$$L\frac{\partial I_a}{\partial t} + I_a R = V_a - e_b \qquad (5)$$

Substitute equation (2) into equation (5) to obtain;

$$L\frac{\partial I_a}{\partial t} + I_a R = V_a - K\frac{\partial \theta_m}{\partial t} \qquad (6)$$

By taking Laplace Transform, equation (5) and (6) can be expressed in term of **s** as;

$$J_m s^2 \theta_m(s) + B_m s\theta_m(s) = KI_a(s) \qquad (7)$$

$$LsI_a(s) + RI_a(s) = V_a(s) - Ks\theta_m(s) \qquad (8)$$

From equation (7), *Ia(s)* can be expressed as;

$$I_a(s) = \frac{s\theta_m(s)[J_m s + B_m]}{K} \qquad (9)$$

Substitute equation (9) into equation (8) to obtain;

$$V_a(s) = \frac{s\theta_m[J_m s + B_m][Ls + R] + K^2}{K} \quad (10)$$

Therefore, from the equation (10), he transfer function in term of position, θ_m as an output and the voltage, Va (s) as an input can be obtained;

$$\frac{\theta_m(s)}{V_a} = \frac{K}{\mathrm{s}[J_m s + B_m][Ls + R] + K^2} \qquad (11)$$

The constants value of voltage, Va, torque constant factor, K, rotor inertia, Jm, damping ratio, Bm, resistance R and inductance, L for BLDC motor must be known. The specifications of BLDC motor which will be used are described in the Table 1 [21]:

Table 1 Parameters of BLDC motor

Symbol	Description	Value	Unit
Rs	Phase resistance	4.31	Ohm(Ω)
Ls	Phase resistance	2.758×10^{-6}	H
$K_T = K_e = K$	Torque constant	36.8	mNm/A
J_m	Rotor inertia	11×10^{-6}	Kgm^2
Vdc	Rated voltage	36	V
P	Pole pairs	1	
T	Peak torque	154	mNm
B_m	Damping ratio	0.708×10^{-4}	Nms

Thus, substituting these parameter values into equation (11), the transfer function of BLDC is as shown in equation (12)

$$\frac{\theta_m(s)}{V_a} = \frac{776.2076}{s^2 + 6.4364s} \qquad (12)$$

3.0 CONTROLLER DESIGN

In this section, the two proposed controllers designs are carried out which are FLC and GA-PID based controllers.

3.1 FLC DESIGN

Fuzzy logic design is presented as described in [25]. The two inputs of fuzzy logic are position angle error (e) and its derivative ($\dot{e}$) as shown in Figure 2. The control output signal is generated based on the magnitude of the input signals. A total of 25 possible control signals are sent to the system depending on the degree of variation of error angle and its derivative as shown in Table1. The membership function of the inputs are chosen to be five and that of output membership function was chosen to be seven for a better result, since accuracy depends greatly on the number of membership function, that is to have a tighter control [26,27]. The membership functions for each input are *nb, ns, z, ps, pb,* which represent Negative big, Negative small, Zero, Positive small, and Positive big respectively. The output membership functions are *rb, rm, rs, lc, is, im, ib* which correspond to Reduced big, Reduce medium, Reduce small, leave constant, increase small, Increase medium, Increase big respectively. Note that the output from the fuzzy controller is the voltage as shown in Figure 2.

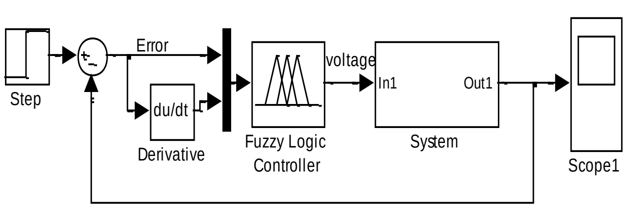

Figure 2 Fuzzy Controller

In order to achieve fuzzy control, the following steps are followed:

Fuzzification Stage: In this stage, input values are mapped to domain of fuzzy variable (i.e the crisp inputs variable are assigned linguistic label). In this work, Symmetrical Triangular membership functions are used. Then the fuzzy rule base must be formed based on the expert knowledge of the system. For example, if ***angle error(e) is negative big(nb) and the derivative angle error(ė) is negative big(nb) then reduce the voltage big (vrb)***. This is one of many possible fuzzy rules used in this work. Table 1 shows the rest of fuzzy base rules used. These fuzzy rules are then applied on fuzzy input variables to give fuzzy output variables. This process is called fuzzy inference stage.

Fuzzy inference engine: They are two types of approach in designing of inference engine viz: Composition based inference and Individual rule-based inference. The former which make use MAX-MIN was used in this work as an inference engine to determine the degree of membership function of the output variables.

Defuzzification Stage: In this stage all the consequent were aggregated to obtained a crisp output. In fact, it is aimed at producing a non-fuzzy control that best represent the degree of certainty of an inferred fuzzy control action. They are several numbers of procedures of defuzzifying the rules aggregate for the Mamdani, methods such as Center of gravity, First of maxima, Middle of maxima, Center of sum etc. In this work Center of gravity was used because its considered as the most efficient in that it gives a defuzzification output which conveys the real meaning of the action that had to be taking at that instance [27].

TABLE I Fuzzy Base rules

$e \backslash \dot{e}$	**nb**	**ns**	**z**	**ps**	**pb**
nb	vrb	vrb	vrm	vrs	vlc
ns	vrb	vrm	vrs	vlc	vis
z	vrm	vrs	vlc	vis	vim
ps	vrs	vlc	vis	vim	vib
pb	vlc	vis	vim	vib	vib

3.2 GA-PID CONTROLLER DESIGN

In this section the design of model base GA-PID is presented. The GA-PID Controller is incorporated in the system as shown in Figure 4. The general transfer function of the controller is given as:

$$C = K_p\left(1 + \frac{1}{sT_i} + sT_d\right) \qquad (14)$$

$$C = K_p + \frac{K_i}{s} + K_d s \qquad (15)$$

Where: K_p, K_d , and K_i are the controller gains.

The objective function to be minimize is

$$\text{ITAE}=\int_0^\infty t\left|e\right|dt \qquad (16)$$

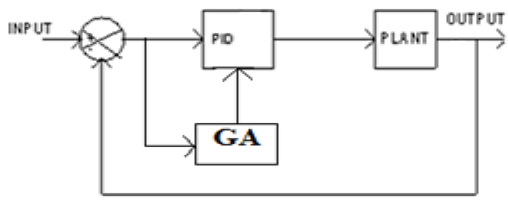

Figure 3 Block diagram of System with GA-PID controller

Figure 3 shows the block diagram of GA-PID. The error from the system is fed to GA for minimization. The flow chat for the GA process is shown in Figure 4.

Figure 4. Flow Process in Application of GA

4.0 RESULTS AND DISCUSSION

After the design and simulation of the controllers using Matlab, each of the controller were run under various input conditions and the results are plotted. The performance of each controller were evaluated using standard performance indices like (settling time, Overshoot, rise time and steady state error)

The results from the two controller schemes are compared in this section. The responses of Fuzzy logic and GA-PID controller for position of brushless dc motor are shown in Figs (5, 6, 7 & 8) under various input steps value. TABLE (III, IV, V and VI) summarizes performance index used for the two controller schemes in two decimal places.

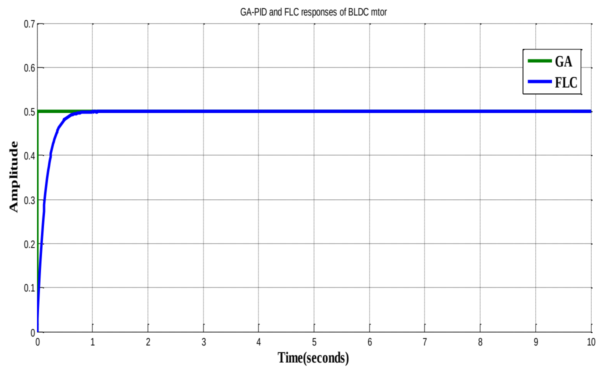

Figure 5. Response of the controllers under step level of 0.5

From the Figure 5, it can be seen that the GA-PID settled much faster than the FLC as shown in Table II. Note that the following values are in two decimal places

Table II Response under step level of 0.5 input

Performance index	***GA-PID***	***FLC***
Settling Time (sec)	0.08	0.42
Overshoot	0.00	0.00
Rise time (sec)	0.00	0.02
Steady state error	0.00	0.00

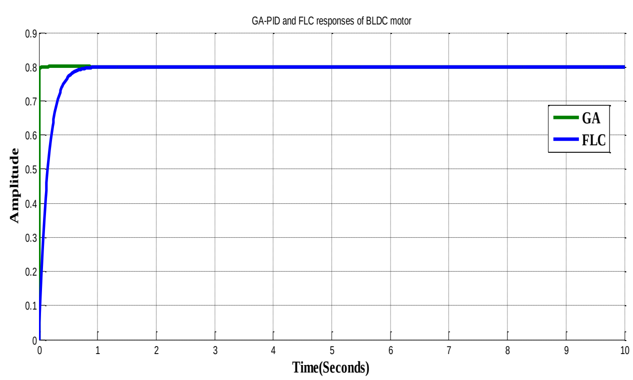

Figure 6. Response of the controllers under step level of 0.8

The response of the controller under step level of 0.8 is shown in Figure 6. The results shows that GA-PID still settled quickly. The summary of the result is shown in Table III.

Table III Response under step level of 0.8 input

Performance index	***GA-PID***	***FLC***
Settling Time (sec)	0.05	0.64

Overshoot	0.00	0.00
Rise time (sec)	0.00	0.08
Steady state error	0.00	0.00

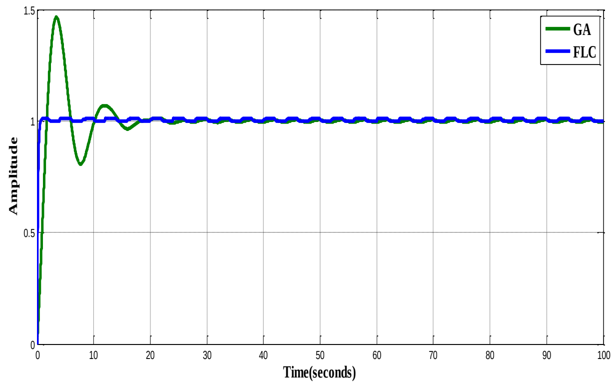

Figure 7. Response of the controllers under step level of unity with disturbance

The response of the two controllers under step input with input disturbance is shown in Figure 7. FLC shows robustness as it rejects disturbance. This shows that FLC has proven to be better of the two controllers when a sinusoidal signal of 0.2 amplitude is used as the disturbance. The summary of the response is shown in Table IV.

Table IV Response under step input with disturbance

Performance index	***GA-PID***	***FLC***
Settling Time (sec)	19.80	0.10
Overshoot	48%	0.00
Rise time (sec)	0.00	0.20
Steady state error	0.00	0.00

5.0 CONCLUSION

It was observed that the two proposed control schemes performed well in the tracking of position of brushless motor, the GA-PID controller performs much better than the FLC controller when considering settling time and rise time with values 0.08 seconds and 0.00 seconds respectively as compare with settling time of 0.42 seconds and rise time of 0.02 seconds for FLC under various step input levels considered with no disturbance. However FLC proved better when a disturbance was introduced with settling time of 0.10 seconds and percentage overshoot of 0.00 as compared with settling time of 19.80 seconds and percentage overshoot of 48% for GA-PID. Therefore, GA-PID and FLC controllers can serve as valuable and effective controllers for the system.

REFRENCES

[1] N. Magaji and M. W. Mustafa "Optimal location and signal selection of SVC device for damping oscillation" Int. Rev. on Modeling and Simulations Vol.3, pp.56-59, 2010.

[2] S. Sumathi and S. Paneerselian, Computational Intelligence Paradigms, Taylor and Francis Group, LLC, 2010, p.692.

[3] Pillay, P., and Krishnan, R. "Modeling, Simulation, and Analysis of Permanent-Magnet Motor Drives, PartII:The Brushless DC Motor Drive," *IEEE Transactions of Industry Applications,* vol. 25, no. 2, pp. 274 –279,March/April 1989.

[4] E. Cerruto, A. Consoli , A. Raciti, and A. Testa, " A robust adaptive controller for PM motor drives in robotic application", *IEEE Transactions on Industrial Applications*., vol. 28, pp. 448 454, Mar-April 1992.

[5] Hendershot, J.R., and Miller, T.J.E. Design of brushless Permanent magnet Motors, Oxford, U.K.: Oxford Science, 1994.

[6] Shanmugasundram, R., Zakariah, K.M., and Yadaiah, N. "Modelling, simulation and analysis of controllers for brushless direct current motor drives*," Journal of Vibration and Control [online],* vol. 0, no. 0, pp. 1-15, May2012.

[7] Wallace, A.K., and Spee, R. "The effects of motor parameters on the performance of brushless DC drives," *IEEE Transactions on Power Electronics,* vol. 5, no. 1, pp.2-8, Jan.1990.

[8] Varatharaju, V.M., Mathur, B.L., and MATLAB/Simulink and effects of load and inertia changes," *Mechanical and Electrical Technology (ICMET)*

[9] Basilio, J.C., and Matos, S.R. "Design of PI and PID Controllers with Transient Performance Specification," *IEEE Transactions*

[10] Krohling, R. A., Jaschek, H., and Rey, J. P. "Designing PI/PID controller on genetic algorithm," *Proc. 12th IEEE Int* pp. 125–130, July 1997.

[11] AtefSaleh Othman Al-Mashakbeh," Proportional Integral and Derivative Control of Brushless D Motor,"*European Journal of Scientific Research*

[12] K. D. Young, V. I. Utkin, and Ü. Özgüner, "A control engineer's guide to sliding mode control," *Transactions on Control Systems*

[13] A. Sabanovic and F. Bilalovic, "Sliding mode control of AC drives," *Applications,*vol. 25, no. 1, pp. 70

[14] Y. J. Huang and H. K. Wei, "Sliding mode control design for discrete multivariable systems with time delayed input signals," *International*

[15] Yan Xiaojuan, Liu Jinglin, ”A *3rd International Conference on Advanced Computer Theory and Eng*
[16] T. C. Kuo,Y. J. Huang,C. Y. Chen, and C. H. Chang,”Adaptive Sliding Mode Control with PID Tuning for Uncertain Systems, *”Engineering*
[17] Pierre Guillemin “Fuzzy Logic Applied to Motor Control,” vol. 32, no. 1, pp. 51-56, Jan./Feb. 1996.
[18] Rubaai, A., Ricketts, D., and Kankam, M. D. “Laboratory implementation of a microprocessor logic tracking controller for motion controls and drives,” vol. 38, no. 2, pp. 448–456, Mar./Apr. 2002.
[19] Fernando Rodriguez, and Ali Emadi “A Novel Digital Control Technique for Brushless DC *IEEE Transactions on Industrial Electronics*
[20] Yen-Shin Lai, Fu-san Shyu, Yung for Brushless DC Motor Drives fed by MOSFET Inverter 19, no. 6, pp. 1646-1652, Nov. 2004.
[21] AnandSathyan, Nikola Milivojevic, Young Based Novel Digital PWM Control Scheme for BLDC Motor Drives,” *Applications*, vol. 56, no. 8, pp. 3040
[22] Piltan, F., et al. "Design slidin gain".*Canaidian Journal of pure and applied science*
[23] Y. Li and Q. Xu, "Adaptive Sliding Mode Control With Perturbation Estimation and PID for Motion Tracking of a Piezo *Transactions on*, vol. 18, pp. 798
[24] www.mathworks.in
[25] L. A. Yusuf, N. Magaji “ Comparison of fuzzy logic and GA-PID controller for position control of inverted pendulum” International review of automatic control (IREACO) vol. 7, issue 4 pp. 380-385. July 2014.
[26].J. Ciganek, F. Noge, S. Kozak” Modelling and control of mechatronic systems using fuzzy logic” International review of automatic control(IREACO) (theory and application) Vol.7 No1, pp 45-51. (2014)
[27]I.J.Nagrath, M. Gopal. “Control Systems Engineering” Published by New Age International (P) Ltd, Fifth Edition. 2007 pp783-800.

Comparison of Wavelet and Filtering Techniques for Denoising ECG Signal

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ABSTRACT

A proper processing of biomedical signals enhances their physiological and clinical information because they carry vital information about the behaviour of the living systems under study. With the analysis of the Electrocardiogram (ECG) signal it may be possible to predict heart problems and play an important role in diagnosis process or monitor patient recovery after a heart intervention. The quality of this signal is degraded mainly by many sources of noise such as power line interference (PLI), baseline drift, muscle contraction noise etc. Present work deals with the design of filter banks based on the discrete wavelet transform (DWT) as well as design of low pass Chebyshev Type I and Butterworth filters using FDA tool in MATLAB environment. De-noised ECG signal is compared with original signal using Mean Square Error (MSE). Results show that denoising schemes involving wavelet domains are able to reduce noise from ECG signals more accurately and consistently with mse of 0.0012 in comparison to noise reduction algorithms in filtering technique which has mse of 0.0799 and 0.1814 for Chebyshev and Butterworth filters respectively.

***Keywords*— ECG, DWT, Butterworth, Chebyshev, MSE**

I. INTRODUCTION

Among the main causes of death in the world nowadays are cardiac diseases and cardiac failure. Therefore a need in the development of methods and systems for monitoring its functionality is very high. One of the most powerful diagnostic tools in medical application that is commonly used for the assessment of the functionality of the heart is Electrocardiography (ECG). The ECG is nothing but the recording of the heart's electrical activity. The deviations in the normal electrical patterns indicate various cardiac disorders (Guyton and Hall, 2006).

It is very important to detect and diagnose as early as possible and accurately these cardiac arrhythmias since they usually cause sudden cardiac death. Therefore, the usage of computer software to automatically detect the ECG beats and diagnose the ECG classes is widely used as a reliable technique for the diagnosis of those diseases. However, recording of ECG signal in a clinical environment is normally corrupted with two major noises generated by biological and environmental resources. (Rangaraj, 2002) The first group includes muscle contraction or electromyographic (EMG) interface, baseline drift, ECG amplitude modulation due to respiration and motion artifacts caused by changes in electrode skin impedance with electrode motion. The second group includes power line interference, electrode contact noise, instrumentation noise generated by electronic devices used in signal processing, electrosurgical noise and radio frequency. Different types of interferences are listed in figure 1.

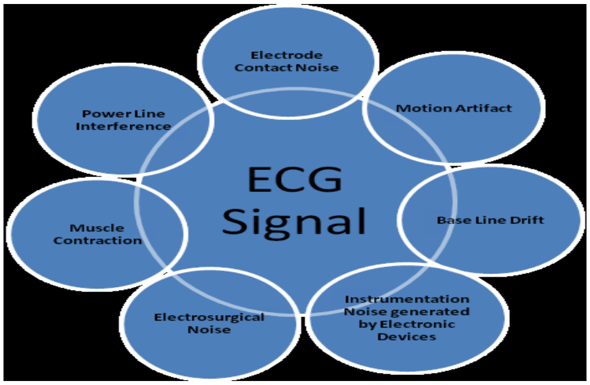

Fig. 1. Interferences in the ECG signal

For the correct evaluation and interpretation of ECG signal it is necessary to suppress these artifacts from the original signal. Therefore, there are several studies proposed in the literature on the development of methods for noise reduction and enhancement. One of the most widely used methods is the least mean square adaptive algorithm (LMS). But this algorithm is not able to track the rapidly varying nonstationary signal such as ECG signal within each heart beat. (Almenar and Albiol, 2005) Presented some of these algorithms which use LMS such as the time- sequence adaptive filter (TSAF), adaptive impulse correlated filter (AICF), and the signal-input adaptive filter (SIF). The TSAF is not robust to noise, and has null output if the beat period increases (makes it have no effect). The disadvantages of AICF are being not very robust to noise, and it's repetitive, it means that for example amplitude R or P is the same in each beat. The SIF is the best, it's not repetitive and it's robust to noise, but it slightly smoothes the mean parameters like R or P amplitudes. Many researchers work on signal noise removing by different filtering method and algorithms which include a method using high pass filter to removes very low frequency component from ECG recording as presented in (Jacek et al., 1999). Linear filtering is also performed for removing baseline wander from ECG signals in the frequency range of 0.5Hz (Van Alste and Schilder, 1985). Adaptive filtering proposed by Windrow can also be used to remove baseline wander. Reference signal is needed in this method, which adds to complexity of hardware and software adaptive filter etc (Jane et al., 1992; Laguna et al.,1992; Meyer and Keiser 1977). Removal of baseline wander and PLI by digital IIR filter (Meyer and Keiser 1977). Santpal Singh Dhillon and Saswat Chakrabarti have used a simplified lattice based adaptive IIR Notch filter to remove power line interference (Singh and Chakrabarti, 2001). Also, comparison of different of different ECG Denoising Techniques Based on PRD & Mean Parameters was presented in (Parsad et al., 2014).

The earlier method of ECG signal analysis was based on time domain method. But this is not always sufficient to study all the features of ECG signals. So, the frequency representation of a signal is required. Among the various time frequency transformations the wavelet transformation is found to be simple and more valuable. Some of the works presented in literature using wavelet includes work by Donoho and Johnstone who proposed several wavelet shrinkage approaches [Donoho and Johnstone, 1994; Beheshti et al., 2008). (Ustündağ et al., 2013) Presents Performance comparison of wavelet thresholding techniques on weak ECG signal denoising, Denoising ECG signal using Undecimated wavelet transform was carried out in (Gayal and Shaikh, 2014). Therefore, this paper presents a comparison analysis of classical filtering techniques using Butterworth and Chebyshev filters with discrete wavelet transform method. After a brief introduction of electrocardiography in section 2, ECG filtering was presented in section 3; the wavelets will be summarized at Section 4. Work methodology and results and discussion were presented in section 5 and 6 respectively. Finally, conclusion of the work will be given.

II. ELECTROCARDIOGRAPHY

ECG signal is a bioelectrical signal which depicts the cardiac activity of the heart and it is a technique used primarily as a diagnostic tool for various cardiac diseases because of its simplicity. By attaching electrodes at different outer surface of the human skin, electrical cardiac signals can be recorded by an external device. These currents cause the contractions and relaxations of heart by stimulating cardiac muscle (Guyton and Hall, 2006; Acharya, 2012) and travel as electrical signals through the electrodes to the ECG device, which records them as characteristic waves. Different waves and fiducial points of ECG reflect the activity of different parts of the heart which generate the respective flow of electrical currents (Texas, 2012). Figure 2 below shows a schematic representation of a normal ECG and its various waves.

The most important features include the information lying in the P, Q, R, S, and T waves of the ECG signal, ECG beats should be classified based on these features in order to detect different types of cardiovascular diseases. The length of a normal QRS wave is between 80 to 120ms (Martis et al., 2012).

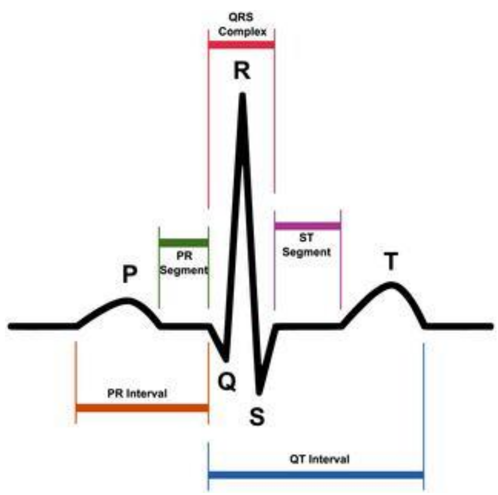

Fig. 2. Normal ECG wave (Murugavel, 2005)

III. ECG FILTERING

A. Butterworth Filter

Butterworth filters are having a property of maximally flat frequency response and no ripples in the pass band. It rolls of towards zero in the stop band. Its response slopes off linearly towards negative infinity on logarithmic Bode plot. Like other filter types which have non-monotonic ripple in the passband or stopband, these filters are having a monotonically changing magnitude function with ω. Butterworth filter has a slower roll off when compared with chebyshev type I/type II filter or an elliptic filter. Hence for implementing a particular stopband specification it will require a higher order. We notice that its pass band is accompanied with a more linear phase response in comparison to chebyshev type I/type II and elliptic filter.

B. Chebyshev filters

Chebyshev type I filters are analog or digital filters having the property of more pass band ripple and type II filters are having more stopband ripple. These filters have a steeper roll off than Butterworth filters. Chebyshev filters reduce the error between idealized and actual filter characteristics over the range of filter but drawback they face is the ripples in the passband (Sonal et al., 2012).

IV. WAVELET ANALYSIS

The wavelet transformation is based on a set of analyzing wavelets allowing the decomposition of ECG signal in a set of coefficients. Each analyzing wavelet has its own time duration, time location and frequency band. The wavelet coefficient resulting from the wavelet transformation corresponds to a measurement of the ECG components in this time segment and frequency band.

The continuous wavelet transform (CWT) has been developed as a method to obtain simultaneous, high resolution time and frequency information about a signal. The CWT unlike Short Time Fourier Transform (STFT) uses a variable sized window region. Since the wavelet may be dilated or compressed; different features of the signal are extracted. While a narrow wavelet extracts high frequency components, a stretched wavelet picks up the lower frequency components of the signal (Addison, 2002).

The CWT is computed by correlating the signal s (t) with families of time-frequency atoms Ψ (t), it produce a set of coefficients C (a,b) given by :

$$C(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{+\infty} s(t)\Psi^{*}\left(\frac{t-b}{a}\right) dt \qquad (1)$$

where b is the time location(translation parameter), a is called scale factor and it is inversely proportional to the frequency (a>0), *denotes a complex conjugate and $\Psi(t)$ is the analysing wavelet (mother wavelet).

The Discrete Wavelet Transform (DWT) is a time-scale representation of the digital signal and is obtained using digital filtering techniques. It is found to yield a fast computation of wavelet transform, easy to implement and adopts dyadic scales and translations in order to reduce the amount of computation time, which results in better efficiency of calculation. DWT can be obtained by

$$C_{mn} = \frac{1}{\sqrt{a}} \int_{-\infty}^{+\infty} s(t)\Psi_{mn}(t)\, dt \qquad (2)$$

where the dyadic scaled and translated wavelet is defined as

$$\Psi_{mn}(t) = 2^{-m/2}\Psi(2^{-m}t - n) \qquad (3)$$

The most common wavelets providing the orthogonality properties are Daubechies, Symlets, Coiflets and Discrete Meyer in order to provide reconstruction using the fast algorithms (Addison, 2002).

The successive low-pass and high-pass filters calculating three levels of DWT is shown in Figure 3.

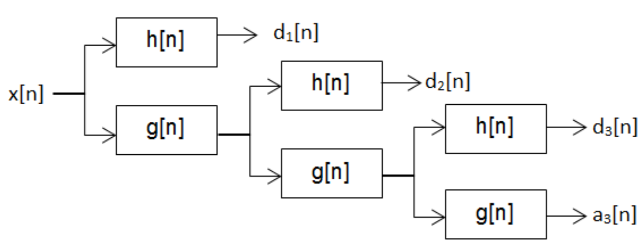

Fig. 3. Three level Wavelet decomposition tree

Each stage consists of two digital filters and two downsamplers by 2 to produce the digitized signal. The low pass filter is denoted by g[n] while the high pass filter is denoted by h[n]. At each level, the high pass filter produces detail information; d[n], while the low pass filter associated with scaling function produces coarse approximations, a[n]. The filtering and decimation process is continued until the desired level is reached. The maximum number of levels depends on the length of the signal. Only the last level of approximation is save among all levels of details, which provides sufficient data. The filter coefficients can be obtained from mother wavelet and scaling functions (Addison, 2002).

V. METHODOLOGY

A. In the first step different filters were designed with the help of FDA tool in Matlab software. FDA tool parameters were chosen with sampling frequency of 1000Hz, cut off frequency of 10Hz and different filter order were tested. Figure 4 shows the general block diagram of filtering method.

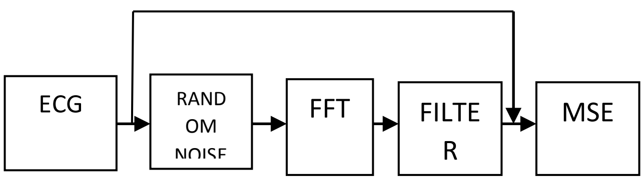

Fig. 4. Filtering Technique

B. The proposed method is based on decomposing the signal into three levels of wavelet transform by using different wavelet families and determining a threshold through a loop to find the value where minimum error is achieved between the detailed coefficients of thresholded noisy signal and the original.

The method can be divided into the following steps:

1- Noise Generation and addition: A random noise is generated and added to the original signal. Mathematically defined:

$$S(n) + X(n) = Xs(n)$$

where S(n) is the random high pass noise, X(n) is free of noise ECG and Xs(n) is the noisy ECG signal.

2. Decomposing of the noisy and original signals using wavelet transform:

The noisy and original signals are decomposed into three levels by discrete wavelet transform using the different wavelet family.

3. Choosing and applying threshold value: For each level a threshold value is found through a loop, and it is applied for the detailed coefficients of the noisy and original signals. The optimum threshold is chosen by taking the minimum error between the detailed coefficients of noisy signal and those for original signal.

4. Reconstruction:

The original signal is reconstructed using Inverse Discrete Wavelet Transform IDWR (Figure 5).

Thresholding of wavelet coefficients affects greatly the quality of ECG morphology, thus, threshold determination is very essential issue in this case. Two concepts are presented in study to accomplish high quality ECG signal reconstruction; threshold determination using above method and the idea of not to threshold the approximation coefficients of ECG signal. The approximation coefficients contain the low frequency of the original signal where most energy exists. Finally, the root mean square error (MSE) is calculated to verify the improvement in the reconstructed signal.

Figure 5 below is the scheme for wavelet signal denoising:

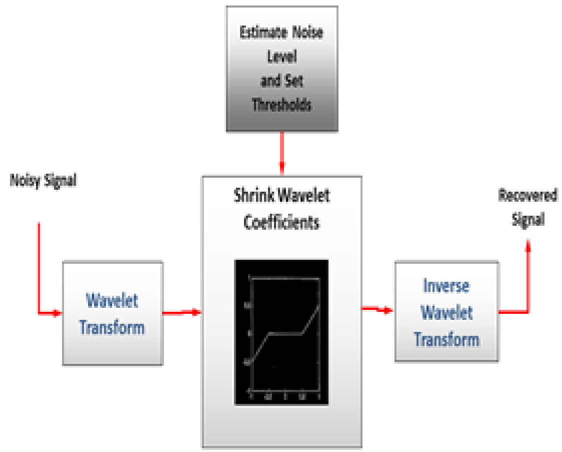

Fig. 5. Wavelet denoising scheme

VI. **RESULTS AND DISCUSSION**

In the proposed de-noising scheme, the ECG signal was created using a matlab function ecg(512), after replicating the signal to obtain more data, noise was added to the clean signal. Filtering technique using butterworth and chebyshev type I was carried out. Thereafter, the decomposition of ECG signal was carried out using different wavelet families in order to find the effective and robust ECG denoising scheme, also reconstruction of the original signal was carried out. The effectiveness of proposed scheme was determined by the MSE. The result of each method was presented as shown in A to C.

A. *Performance Analysis of Filtering Technique*

Several numbers of filter orders were experimented with cut off frequency of 10Hz and sampling frequency of 1000Hz. The experiment was carried out using FDA tool in Matlab 2013 environment. Table 1 and 2 below gives the performance measure for Butterworth and Chebyshev filter type I with MSE as an estimation parameter.

Table I

Performance measure for Butterworth filter

S/N	ORDER(N)	MSE
1	2	0.0799
2	4	0.3214
3	6	0.4031
4	8	0.3359
5	10	0.2971
6	12	0.3029

Table II

Performance measure for Chebyshev filter

S/N	ORDER(N)	MSE
1	2	0.2077
2	4	0.2401
3	6	0.2012
4	8	0.1814
5	10	0.1968
6	12	0.2117

From the result above, Chebyshev type I filter performs better than Butterwoorth filter with MSE of 0.0799 against 0.1814 respectively.

B. *Comparison on Wavelet Families for DWT Technique*

As another experiment, different wavelet families are compared in terms of MSE. Table 3 gives the results of this comparison. According to the table, Bior2.6 and db10 outperforms other wavelets.

Table III

The performance comparison of wavelet families

Wavelet Name	MSE
Db2	0.0020
Db4	0.0014
Db7	0.0016
Db10	0.0013
Bior1.5	0.0037
Bior2.6	0.0012
Bior3.7	0.0016
Bior6.8	0.0014
Coif2	0.0014
Coif5	0.0015
Sym5	0.0015
Sym8	0.0014

C. *Comparison of Filtering and DWT Techniques*

Table 4 below shows the performance of ECG denoising using filtering technique and DWT technique. From the result, it was clearly seen that DWT denoised ECG signal better and clear and shows good performance compared to digital filters.

Table IV

Performance measure for Filtering and DWT technique

S/N¤	METHOD¤	MSE¤
1¤	Butterworth¤	0.1814¤
2¤	Chebyshev¤	0.0799¤
3¤	DWT¤	0.0012¤

Figure 6 below shows the ECG signal before and after applying wavelet ECG denoising scheme.

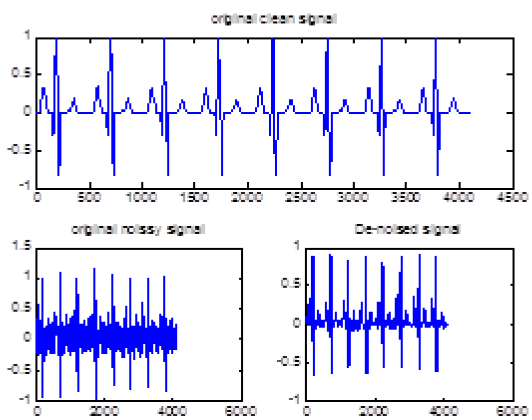

Fig. 6. ECG signal before and after denoising using DWT

VII. CONCLUSION

In this work the design and performance analysis of denoising ECG signal techniques was carried out for the reduction of noise in order to make the ECG signal cleaner and better interpretable by human or machine observer using digital filters and DWT technique. From the results presented wavelet prove itself as a powerful transform for denoising signals in which the mean square error of 0.0012 was found as compared to 0.0799 and 0.1814 for Chebyshev and Butterworth filters respectively. Therefore, Wavelet transform is more suitable for analyzing the pseudo periodic, non stationary ECG signal. Still there is lot of scope of Wavelet transform to be used for analyzing ECG signal. The suitability of Wavelet transform in denoising ECG signal depends upon the proper selection of mother wavelet. It is my hope that this work will be helpful especially for beginners who are interested to work in biomedical signal analysis.

REFERENCS

Almenar V, and Albiol A, (2005), A new adaptive scheme for ECG enhancement, Signal Processing 75, pp: 253-265.

Acharya R, Suri T.S, Span A.E., Krishnan S.M, (2012), Advances in cardiac signal processing, Springer. 2012.

Addison P.S, (2002), The Illustrated Wavelet Transform Handbook Introductory Theory and Applications in Science, Engineering, Medicine and Finance, CRC Press, 2002.

Beheshti S., Nikvand N., Fernando X.N, (2008), Soft thresholding by noise invalidation, in Communications 24th Biennial Symposium

on, pp.235-238.

Donoho D, Johnstone I, (1994), Ideal spatial adaptation by wavelet shrinkage, *Biometrika*, vol.81, pp.425-455.

Gayal S. B, and Shaikh F.I, (2014), Denoising of ECG signal using Undecimated Wavelet Transform, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, ISSN (Online): 2278 – 8875, Vol. 3, Issue 1, January 2014.

Guyton A. C, Hall J. E, (2006), Textbook of Medical Physiology (11th ed.). Philadelphia: Elsevier Saunder.

Jacek M, Leski and Henzel N, (1999), ECG baseline wander and powerline interference reduction using nonlinear filter bank, signal processing, Vol. 85, No. 4, pp. 781-793.

Jane R., Laguna P, et al, (1992), Adaptive baseline wander removal in the ECG: Comparative analysis with cubic pline technique, Computers in Cardiology, pp. 143-146.

Laguna P, Jane R, Caminal P, (1992), Adaptive Filtering Of ECG Baseline Wander, Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, pp. 508-509.

Martis R.J, Acharya U.R.K, Mandana M, Ray A.K, Chakraborty C, (2012), Application of principal component analysis to ECG signals for automated diagnosis of cardiac health, Expert Syst. Appl.39, pp11792–11800.

Meyer C. R. and Keiser H. N,(1977), “Electrocardiogram baseline noise estimation and removal using cubic splines and statespace computation techniques,” Computers and Biomedical Research, Vol. 10, no. 5, pp. 459–470.

Murugavel R, (2005), Heart-Rate and EKG Monitor Using the MSP430FG439, Application Report SLAA280A, pp.1-12.

Parsad K, Sharma and Kaur M, (2014), Comparison of Different ECG Denoising Techniques Based on PRD & Mean Parameters,International Journal of Multidisciplinary and Current Research, ISSN: 2321-3124.

Rangaraj M.R, (2002), Biomedical signal analysis, a case study approach”, John wiley and sons,inc. 2002.

Singh Dhillon S., Chakrabarti S, (2001), Power Line Interference removal From Electrocardiogram Using A Simplified Lattice Based Adaptive IIR Notch Filter, Proceedings of the 23rd Annual EMBS International conference, October 25- 28, Istanbul, Turkey, 2001.

Sonal K., Jagtap, Uplane M. D, (2012), A real time Approach: ECG Noise Reduction in Chebyshev Type II Digital Filter, International Journal of Computer applications, Vol. 49, no. 9, July 2012.

Texas H.I, (2012), “Heart Anatomy” in health information centre, http://www.texasheartinstitute.org/HIC/Anatomy/ 2012.

Ustündağ M, Sengür A, Gökbulut M., Ata F, (2013), Performance comparison of wavelet thresholding techniques on weak ECG signal denoising, PRZEGLĄD ELEKTROTECHNICZNY, ISSN 0033-2097, R. 89 NR 5/2013.

Van Alste J. A. and Schilder T. S, (1985), Removal of base-line wander and power-line interference from the ECG by an efficient FIR filter with a reduced number of taps, IEEE Transactions on Biomedical Engineering, Vol. 32, no. 12, pp. 1052–1060.

THE ESSENCE OF INNOVATION IN ENGINEERING AND TECHNOLOGY

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ABSTRACT

This paper presents the essence of innovations in engineering and technology. It indicated that Innovation can drive productivity improvement across all industrial sectors. Many industries essential to the economic growth of the country such as construction, mining, telecommunications and manufacturing require significant innovations in engineering. Nigeria ranked 120 out of 142 countries on the 2013 Global Innovation Index, and Out of 143 countries listed in the ***Global Innovation Index*** *report released in Sydney, Australia, in 18th July 2014, Nigeria is in the 110th position. With the score is 27.8, with a 0.23%. By focusing on innovation in industries relevant to engineering, it is possible to increase productivity and contribute to the economic prosperity of the nation. while the world has changed drastically and organisations pride themselves for having a process for everything, the process of innovation remains ad hoc, unsystematic, piecemeal, seat of the pants, and, heavily dependent. It was understood that Innovation in engineering encompasses an end-to-end process.*

KEYWORDS: Innovation, Construction, ing, Telecommunications, Manufacturing,

Mining

1.0 INTRODUCTION

Innovation in engineering and technology is much more than research and development. It encompasses an end-to-end process, such that it extracts value through implementation. Innovation involves; creating or generating new activities, products, processes and services, seeing things from a different perspective, moving outside the existing paradigms, improving existing processes and functions, disseminating new activities or ideas, adopting things that have been successfully tried elsewhere. Indeed, innovation covers the area from minor quality improvements to 'cutting edge' products and services.

1.1 Technological Innovation

Ttechnological innovation is a part of the total innovation discipline. It focuses specifically on technology and how to embody it successfully in products, service sand processes. Technology as a body of knowledge might thus be seen as a building block for technological innovation, serving as conerstone to research, design, development, manufacturing and marketing.

1.2 Why concerned with innovation ?

Innovation is extremely important to a country as it is closely related to productivity. Although there are a number of avenues to increase productivity, innovation is the most significant factor (DIISR, 2011). In the absence of sustained innovation, the rate of growth in labour-constrained economy will ultimately fall to zero. Innovation can drive productivity improvement across all industrial sectors (Gans and Stern, 2003). Many industries essential to the economic growth of the country such as construction, mining, telecommunications and manufacturing require significant engineering techniques. By focusing on innovation in industries relevant to engineering, it is possible to increase productivity and contribute to the economic prosperity of the nation.

Creativity is seeing what everyone sees and think what no one else has thought before. Invention is transforming those new thoughts into tangible ideas. Innovation goes even further, involving preparedness to mix with the commercial world to turn novel ideas into products (Engineers 2011).

The expertise of the engineering profession is vital to convert innovative ideas into reality for common use. Many of the comforts enjoys today have been the result of innovative engineers. Examples include electrical appliances, transportation, buildings, telecommunications and urban infrastructure. Innovation and technology have become two inseparable words in the annals of human history. The technology driven by Engineers are therefore the forefront of innovation.

Engineers in Nigeria considers it essential that all engineers must have highly developed innovative skills, so that they can make a better contribution to the society. One of our guiding principles is to stimulate and learn from the creativity and innovation of our members. In addition, skills relating to innovation are embedded in competency and standards of the engineering team. Engineering innovation has also been identified as one of the performance of professional engineers which was included in the protocol developed by the Warren Centre for Advanced Engineering and industry and professional engineering organisations (Warren , 2009).

2.0 NIGERIA'S PERFORMANCE

Nigeria ranked 120 out of 142 countries on the 2013 Global Innovation Index, and Out of 143 countries listed in the **Global Innovation Index** report released in Sydney, Australia, in 18th July 2014, Nigeria is in the 110th position. With the score of 27.8, and at 0.23% rate, which measures countries' innovation capabilities and how they drive economic growth and prosperity. A decade of policy neglect has hurt Nigeria's innovation performance, making it less productive and competitive, and reducing its' ability to meet up the needs and aspirations of Nigeria families and communities (DIISR, 2009).

The mediocre performance relating to innovation in Nigeria is often attributed to our relative wealth arising from the resources boom. However, we cannot assume that this will continue forever. In order to be prosperous in the long term, we need to be become a knowledge-based innovative economy where we can compete with other countries. However, this takes time. For example, Singapore began focusing on becoming an innovative country in the 1980s

and 1990s by starting programs such as PS21 (Public Service for the 21st century) (Fernando, 2004). It is feared that Nigeria has already delayed too long and that there is an urgent need to concentrate on our efforts to be more innovative.:

Nigeria is relatively weak with regard to business R&D directly funded by government with the proportion of firms that develop product innovations which are new to the market, being ranked towards the bottom of the group of OECD countries. (DIISR, 2010)

TABLE 1: The Global Innovation Index surveys 143 economies around the world, using 81 indicators – to gauge both their innovation capabilities and measurable results.

Global Innovation Index Export

Rank	Country	Score	Value	Percentage Rank	Score View
40	Mauritius	40.9	-	0.73	
51	Seychelles	38.6	-	0.65	
53	South Africa	38.2	-	0.63	
85	Kenya	31.9	-	0.41	
91	Uganda	31.1	-	0.37	
92	Botswana	30.9	-	0.36	
96	Ghana	30.3	-	0.33	
97	Cabo Verde	30.1	-	0.32	
98	Senegal	30.1	-	0.32	
102	Rwanda	29.3	-	0.29	
104	Gambia	29.0	-	0.27	
107	Mozambique	28.5	-	0.25	
108	Namibia	28.5	-	0.25	
109	Burkina Faso	28.2	-	0.24	
110	Nigeria	27.8	-	0.23	
113	Malawi	27.6	-	0.21	
114	Cameroon	27.5	-	0.20	
116	Côte d'Ivoire	27.0	-	0.19	
117	Lesotho	27.0	-	0.18	

Source : (Paruolo, et al 2013).

2.1 Barriers to innovation

Technological innovation arises from unexpected breakthroughs in technological R&D and from deliberate refinement of materials and processes. All of these give rise to opportunities. Once again the challenge is to assess the potential reward against the assessed risk. More R&D funding is by no means the most important factor; much more important is the climate and culture in which the R&D is performed and calibre of the people who lead and foster the environment for innovation.

Engineers Nigeria members have identified the following barriers to innovation:

• Lack of leadership and commitment from management to innovate

• Lack of resources – both time and financial

• Lack of clearly articulated market needs or challenges (to be overcome by innovative technologies)

• Intellectual property (IP) held by an organisation unable to deliver on the innovation (e.g. research institutions in government procurement of infrastructure, the IP may be retained by the relevant government, rather than the service providers who may be better placed to commercialise innovations)

• Lack of innovative culture in organisations

• Unavailability of technology resources and inadequate strategic alliances, including industry/university collaborations

• Uninformed clients and customers

• Emphasis on lowest cost rather than value and outcomes

• Extreme risk averseness, especially in procurement

• Need to comply with current standards

• Complicated government policy and programs to support innovation

• Inadequate levels of skilled staff

• Lack of financial support and venture capital with financial institutions lending mainly against 'bricks and mortar' (Engineers , 2011, DIISR, 2009: & 2008)

2.2 Skills and education

A quality education in science, maths and technology is needed to produce the new generation of innovators and technology-literate citizenry to find solutions to the societal and global issues that we face. (Cutler, 2008)

If Nigeria wants to be a highly innovative knowledge-based economy we need to ensure that future generations will be more innovative.

Conventional education systems do not provide adequate incentives and encouragement for students to develop their creative skills. Some attributes of creative children often frustrate those teachers who do not know how to recognise them. Deliberate programmes need to be introduced for students to develop their creative skills. Creative young talent should be identified and developed. This submission recognised that it is important for teachers to be trained in developing creative skills in children and for all educational institutions, from primary schools to universities, to promote, encourage and foster a culture of innovation.

The Nigerian Society of Engineers should be supportive of government incentives being used to develop programs to educate students on how to recognise and develop innovative ideas.

3.0 LEGAL AND REGULATORY FRAMEWORKS

Innovation regulation "can be either a useful support, facilitating the invention and diffusion of standards; or it can be an impediment, blocking the creation and spread of new products and services." (NESTA, 2011)

A significant responsibility of the Nigerian Government with regard to the national innovation system is to establish the legal and regulatory framework to govern and protect innovation activities. Regulation can be seen as an incentive for businesses to invest in innovation and a means for protecting rights resulting from innovation activities. This includes the protection of intellectual property through laws relating to patents, trademarks, designs and copyright.

Nigeria has obligations to comply with agreed international standards on the protection and exploitation of intellectual property rights, particularly through the World Trade Organization's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). However, while in some ways intellectual property can protect innovation, it can also have an inhibiting effect. The Cutler Review stated that: Because new knowledge always builds on old knowledge, the property rights we have erected to encourage innovation can actually obstruct it. This is particularly so where intellectual property rights are too easily granted, and where they are ambiguously defined, so that innovators are uncertain as to what innovations might be subject to the prior claims of patent holders. (Cutler, 2008)

The Government of Nigeria should introduce the Intellectual Property Laws Amendment (Raising the Bar) Bill into Parliament in recognition of this. The Explanatory Memorandum to the Bill should state that "particular concerns have been raised that patents are granted for inventions that are not sufficiently inventive, and that the details of inventions are not sufficiently disclosed to the public". Accordingly, the Bill should amends the Patens Act 1990, the Trade Marks Act 1995, the Copyright Act 1968, the Designs Act 2003 and the Plant Breeder's Rights Act 1994. In addition to these legislative changes, the Advisory Council on Intellectual Property has should release paper on the Review of the Innovation Patent System. The purpose of the review is to "investigate the effectiveness of the innovation patent system in stimulating innovation by Nigerian small to medium business enterprises.

In an increasingly globalised world, the products of innovations of Nigeria companies should be sold worldwide. Government could give consideration to reviewing the patent application process to assist organisations to achieve worldwide protection if they are successful with obtaining a Nigeria patent. For example, technical and funding support for selected patent applications for worldwide protection would assist in providing valuable protection for companies as they build their markets.

The protection of new technology and research is essential in order to maximise innovation outcomes in Nigeria. Engineers are in an ideal position to assist governments to improve the legal and regulatory environment by relating their experiences as innovators.

3.1 Collaboration for innovation

Nigerian's innovation system is handicapped by fragmentation, duplication and a lack of coordination. Business-to-business and research-to-business links are poor.

An increased focus on encouraging collaboration between businesses and universities, TAFEs and other publicly funded organisations is highly desirable. SMEs, in particular, are often unaware of the benefits that can be gained from collaboration, let alone the assistance and facilities available through research organisations.

Consumers today have increasing opportunities to influence the design, introduction and trajectory of new products and services in both the private and the public sector. They also have the ability to directly influence innovation and encourage the development of new technologies. (OECD, 2010) It is said that innovation is not an event, but a campaign. A potential untapped source of consistent innovation opportunity is in the planning, design and delivery of our infrastructure. Greater collaboration between customers and suppliers and a move to functional specifications for engineering projects will foster innovative solutions.

3.3 Promoting innovation

while the world has changed drastically and organisations pride themselves for having a process for everything, the process of innovation remains ad hoc, unsystematic, piecemeal, seat of the pants, and, heavily dependent onluck" (Tucker, 2003).

If a country wants to be highly innovative, innovation should come from all sections of society: children, teachers, employees, employers and research organisations. Innovations should not be restricted to high-level cutting-edge technology, but should include all products, services and systems from minor improvements to major breakthroughs. Governments must take this message to all sections of society. Innovation can be characterised in a number of ways. In broad terms, it can be divided into the type of innovation that is technological (product and process) or non-technological (corporate and marketing) (OECD, 2010). Technological innovation involves the development of new technology, whereas corporate innovation encompasses innovation as a

culture that permeates organisations.

Government could give consideration to updating Nigeria's intellectual property laws to provide support for new and emerging technologies and to implement measures to assist organisations to achieve worldwide protection if they are successful in obtaining a Nigerian patent. This would provide valuable protection for companies as they build their worldwide markets.

3.4 Government incentives

Long-term stability in tax incentives is highly desirable due to the long period between concept and commercialisation. The current system of frequent changes in policy and incentives results in confusion and higher costs for all organisations.

There needs to be a reduction in the number of organisations providing grants and financial support for innovation without reducing services provided to industry. Emerging companies require a single point of contact (for state and federal programmes) and simplified access to support available for innovation.

Consideration should be given to expanding the level of financial support available to Nigerian's innovations. These could include, for example:

a. Additional taxation and other incentives to organisations that are commercialising innovations,

b. Using Nigerian's Future Fund to finance commercialisation of projects that are likely to generate high returns for Nigeria,

c. Additional tax incentives for financial institutions to finance innovative ventures at reasonable rates without reliance on 'bricks and mortar' as collateral,

d. Expanding the limited pool of domestic venture capital by making investments in Nigerian ventures more attractive to overseas investors.

4.0 COLLABORATION FOR INNOVATION

In allocating funding for co-operative ventures, priority industries should be identified so that the limited investment in innovation is more effective in developing niche industries in areas where Nigeria already has a significant knowledge base. Cooperative Research Centres (CRCs) are supported, however the manner in which the value of Intellectual Property (IP) is captured needs to be reviewed, especially where innovations are commercialised. The current system is legally complex, and alternative models, including those from the USA, should beconsidered.

Support mechanisms from other countries including the USA and UK should be adapted for Nigeria. A voucher system to access financial support as advocated in the Cutler Review, similar to the Dutch model,is supported.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

It was understood that Innovation in engineering encompasses an end-to-end process, such that it extracts value through implementation and it covers the area from minor quality improvements to 'cutting edge' products and services.

5.2 Recommendations

Nigerian innovations in engineering should be promoted and celebrated by:

a. Developing and promoting a national award for innovation in engineering which could be awarded, for example, by the Minister's of Science, and Engineering Innovation Council during Engineering Week (similar to the Prime Minister's award for Science during Science Week).

b. Promoting innovations in engineering via social media and the internet, for example, with a suitable web space

c. Establishing a trade show, to showcase Nigerian engineering innovations with invitations to overseas venture capitalists to invest in Nigeria

d. Drawing on the expertise of engineers in innovation with a formal nomination process via Engineers Nigeria to the various government committees and councils involved in innovation including the Innovation Councils established by Nigeria Industry, Commercialisation Nigeria, the boards of organisations running the COMET program and similar.

REFERENCES

Cutler T (2008) Venturous Australia: Building strength in innovation. Cutler and Company, North Melbourne, of the National Innovation System.aspx Availabe at: http://www.innovation.gov.au/Innovation/Policy/Pages/Review

Department of Innovation, Industry,Science and Research [DIISR](2011), Australian Innovation System Report,

Department of Innovation, Industry, Science and research (2008),Canberra, Engineering Practice,The Warren Centre for Advanced Engineering Ltd, Sydney. Availabe at: http://www.innovation.gov.au/Innovation/Policy/Aust

Department of Innovation, Industry, Science and Research [DIISR] (2009) Powering Ideas: An Innovation Agenda for the 21st Century. Common wealth of Australia, Canberra. Availabe at: http://www.innovation.gov.au/Innovation/Policy/Pages/ powerindideas:aspx.

Department of Innovation, Industry, Science and Research [DIISR] (2010) Australian Innovation System Report Commonwealth of Australia, Canberra: Availabe at: http://www.innovation.gov.au/Innovation/Policy/Pages/

Australian Innovation System Report aspx

Engineers Australia (2008), Submission to the Review of the National Innovation System, April 2008, Engineers Australia, Barton. [A Book, Journal Preceedings or obtained from web]

Engineers Australia (2009). Engineering the Future of Australian Manufacturing, Institution of Engineers Australia, Barton, Availabe at http://www.engineersaustralia.org.au/da/index/getfile/id/8706

Engineers Australia (2010). Engineers Australia Strategic Plan 2010-2015, Availabe at

www.engineersaustralia.org.au/strategicplan.

Engineers Australia (2011b). Feedback from Engineers Australia Members, September ,unpublished.

Fernando, MS (2004). Be Innovative: It is the way forward for Engineers. Engineering Leadership Conference, Institution of Engineer Australia, Sydney. [A Book, Journal Preceedings or obtained from web]

Gans J, Stern, S. (2003) Assessing Australia's Innovative Capacity in the 21st Century: Intellectual Property Research Institute of Australia. The University of Melbourne, Victoria. pp.3,8,52, Availabe at: http://www.mbs.edu/home/jgans/papers/Innovation%20Index%20Australia.pdf

NESTA (2011). Creating Innovation in Small and Medium-sized Enterprises: Evaluating the short-term effects of the Creative Credits pilot, Working Paper:

National Endowment For Science,Technology and the Arts, Availabe at

http://zwww.nesta.org.uk/publications/assets/features/creating_innovation_in_smes

OECD (2010a). Measuring Innovation: A new perspective, OECD Publishing, Availabe at www.oecd.org/innovation/strategy/ measuring.

Paruolo, P., M. Saisana, and A. Saltelli. (2013) 'Ratings and Rankings: Science?' Journal of the Royal Statistical Society 176 (3): 609–34. doi: 0964–1998/13/176000

Tucker, R. B (2003) '7 Strategies for Generating Ideas', The Futurist, March-April 2003, Availabe at http://www.innovationresource.com/articles/article_files/seven_strategies.htm.

Warren Centre (2009). Professional Performance, Innovation and Risk in Australian Engineering Practice,The Warren Centre for Advanced Engineering Ltd,Sydney University,http://sydney.edu.au/warrencentre/PPIR/report/full_report. Pdf.

A STUDY OF THE EFFECT OF TEMPERING ON THE MECHANICAL PROPERTIES OF 12mm REINFORCEMENT STEEL RODS PRODUCED BY KATSINA STEEL ROLLING MILL

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ABSTRACT

This paper presents an investigation into the effects of tempering on the mechanical properties of reinforcement steel bars. The steel bars were cut into chemical, tensile and hardness test samples. The tensile strength and hardness values of both the heat-treated (tempering) and as-received samples were determined. From the results obtained compared with standard values set by the standard organization of Nigeria (SON), samples from the manufacturer satisfy the standard of 420N/mm^2 yield strength. Hardness value of 5HRC was obtained for as a received while 6.75HRC was obtained for the tempered samples. It was observed that after tempering there was appreciable increase in hardness value.

SIGNIFICANCE: Material testing is widely used during research and development programmes and also for the compilation of general design data files. Materials specifications are given to uniquely define the qualities of a material necessary to serve, most efficiently, a given need. The specifications generally indicate the material composition as well as relevant properties such as mechanical properties as well as heat treatment given the material upon which the engineer can base his design.

This work has shown that some mechanical properties of reinforcement steel rods can be improved by heat treatment. It is of great benefit especially to those into construction. It is of extreme importance that the user of materials be able to obtain reliable information on the properties of those materials (Vernon, 1992).

KEYWORDS: Reinforced steel rod, chemical composition, tempering, yield load, maximum load, yield strength, ultimate tensile strength and percentage elongation.

1.0 INTRODUCTION

The word reinforced simply means to strengthen something, to make something stronger by providing additional external stiffening for it.

Therefore, reinforced steel rod is an intermitted arrangement of a steel ribs bounded round or side by side on a steel rod consistently throughout its length for maximum rigidity and durability when it is been used.

Reinforced steel rod is commonly used in reinforced concrete and reinforced structures; it is usually formed from carbon steel and is given ridges for better mechanical anchoring into the concrete.

Reinforced Steel Rods play a vital role in concrete project such as building, bridges, dam construction, suck away slabs and columns. It helps the column and beam to withstand tensile and axial load, it prevent cracking, collapsing, deflection and it holds the building firmly.

It gives an extra strength to a project which makes it to last long. For example in bridge construction where it is designed to carry high load and strength and where the rate of load that it will accommodate depend on the number of vehicles, people, animal and heavy trucks that pass or cross over it everyday and night. It is very important to consider this load and the tensile strength of the column and beams of the bridge which make up the whole structure, that is why when constructing a bridge adequate reinforced steel rod, cement and sand are casted together in order to give extra strength to the casting, the reinforced steel rod in order to hold the mixture together.

A look at reinforcement steel bars available in the market, shows that most if not all do not carry any specification. Visit to local manufacturers revealed that many of them do not undertake any serious measure of quality control testing. Material testing has not been accorded its importance in Nigeria, which has lead to problems of over loading resulting in failure and in some instances bad design.

The study is aimed at investigating some properties of reinforcing steel bars from Katsina Steel Rolling Mill and the objective are;

(i) To see the possibilities of improving the mechanical properties by heat treatment (Higgins, 1999)
(ii) To check metal composition
(iii) To asses numerically the fundamental mechanical properties of yield strength, tensile strength, ductility and hardness which gives an indications of wear resistance (Rajput, 2007).

2.0 MATERIALS AND METHOD

2.1 Materials

The samples were 12mm reinforced steel rods obtained from Katsina Steel Rolling Mill.

Three samples were labeled 1, 2, and 3 for as-received and tempering respectively.

2.2 Chemical Composition

The specimens were cut to the size of the machine die. The surfaces of the specimens were ground using surface grinding machine. The specimens were slightly heated to remove impurities for accurate and reliable result. Emery cloth was used to clean the testing point on the specimens. Samples were placed in the metal analyzer and the requisite commands were punched into the computer keyboard. After a time lapse of 2 minutes the result was displayed on the screen. A print out was obtained for the specimens. This procedure was followed until all the specimens of the samples under study were subjected to the test.

2.3 Tempering

Three tempered samples from the manufacturer were tied together using binding wire for easy handling. The samples were taken into electric chamber furnace Degossa Deurferrit with the aid of tongs and safety hand gloves. The electric chamber furnace was switched on and set to a temperature of 650^0C for charging. The furnace was charged until it reached the temperature of 650^0C, after which it was allowed to soak for 30 minutes and the samples were removed and quenched in oil by stiring continuously for rapid cooling, the samples were untied and cleaned up (Khanna, 2005).

2.4 Hardness Test

Rockwell hardness test was used, on Otto wolpert hardness tester. It differ from the Brinell's test that is in this test, the loads for making indent are smaller, and thus make smaller and shallower indents. It is because of these reasons that the Rockwell hardness test is widely used in the industry (Khurmi and Sedha, 2008). The specimens were ground to provide smooth flat surface prior to testing. The "C" scale, which is recommended for hardened steel was, adopted (Raghuwanshi). The prepared specimens were secured on the machine platform and diamond cone penetrator with a load of 250kg was applied gradually onto the specimen.

Four readings were taken for each specimen and the average value was obtained as the hardness value.

2.5 Tensile Test

The length used for the test was 300mm and the gauge length for the test specimens was 105mm. One end of the specimen was gripped in the jaws provided in the adjustable cross head and then after lifting this crosshead to the appropriate height of 105m, the other end of the specimen was fixed in jaws in the top crosshead.

The tensile load was now applied hydraulically to the specimen by turning the hand wheel provided in the control unit. The load measuring gauge incorporated in the control unit shows the magnitude of the applied load. The load was increased gradually until the specimen breaks and the corresponding extensions were recorded and plotted by the machine during the test.

The same procedure was repeated for three samples as-received and tempered specimens. The graphs can be seen in Appendix III plotted by the Universal Tensile Testing Machine.

3.0 RESULTS AND DISCUSSION

Table 1: Metal Composition of Specimens

S/N	Sample Test	C %	Si %	Mn %	P %	S %	Cr %	Mo %	Ni %	Al %
	1	**0.312**	**0220**	**0.323**	**0.052**	**0.85**	**0.075**	**<0.0055**	**0.301**	**0.210**
	2	**0.311**	**0.201**	**0.312**	**0.044**	**0.079**	**0.80**	**<0.0060**	**0.310**	**0.180**
	3	**0.315**	**0.200**	**0.314**	**0.60**	**0.080**	**0.085**	**<0.0070**	**0.303**	**<0.201**

Co %	Cu %	Nb %	Ti %	V %	W %	Pb %	Sn %	Zn %	Fe %
0.020	**0.205**	**0.0050**	**0.0082**	**<0.0055**	**0.022**	**<0.032**	**0.043**	**0.0083**	**98.1**
0.019	**0.292**	**0.0047**	**0.0090**	**<0.0067**	**0.024**	**<0.040**	**0.039**	**0.0075**	**98.0**
0.030	**0.300**	**0.0052**	**0.0089**	**<0.0071**	**0.030**	**<0.031**	**0.035**	**0.0085**	**97.9**

Test Average	C %	Si %	Mn %	P %	S %	Cr %	Mo %	Ni %	Al %
Result	**0.313**	**0.207**	**0.316**	**0.052**	**0.081**	**0.080**	**<0.0062**	**0.305**	**0.197**

Co %	Cu %	Nb %	Ti %	V %	W %	Pb %	Sn %	Zn %	Fe %
0.023	**0.266**	**0.0049**	**0.0087**	**<0.0064**	**0.025**	**,0.034**	**0.039**	**0.0081**	**98.0**

Table 2: Tensile and Hardness Test Results for As-received and Tempered Specimens.

SAMPLE	YIELD LOAD (KN)	MAXIMUM LOAD (KN)	YIELD STRENGHT N/mm^2	ULTIMATE TENSILE N/mm^2	PECENTAGE REDUCTION IN AREA (%)	PERCENTAGE ELONGATION (%)	HARDNESS (HRC)
AS-RECEIVED							
1	**55**	**62**	**487**	**548**	**40.58**	**53.33**	**4**
2	**55**	**63**	**487**	**557**	**52.50**	**52.38**	**5**
3	**55**	**64**	**487**	**566**	**44.25**	**54.29**	**6**
AVERAGE TEST RESULT	**55**	**63**	**487**	**557**	**45.78**	**53.33**	**5**
TEMPERED							
1	**51**	**57**	**451**	**504**	**62.89**	**43.81**	**7.38**
2	**49**	**57**	**433**	**504**	**55.89**	**40.2**	**6.13**
3	**50**	**57**	**422**	**504**	**62.39**	**40.95**	**6.75**
AVERAGE TEST RESULT	**50**	**57**	**442**	**504**	**60.39**	**41.59**	**6.75**

3.1 Chemical Composition Test

The results obtained from chemical composition test of samples from the manufacturer under investigation are as shown in Table 1. The carbon compositions for the specimens are as follows: 0.312%, 0.311% and 0.315% respectively. An average value of 0.313% was obtained for the samples.

The maximum carbon composition for steel bars for reinforcement of concrete for steel grade 420HD as given by Nigeria Industrial Standard NIS 117 of 2004 is 0.35% $\pm$0.02. The company conforms to this standard.

Silicon content of carbon steel varies from 0.05% to 0.30%. The composition of silicon present in significant amount of 0.220%, 0.201%, and 0.200% respectively in the samples under study. An average value of 0.200% was obtained for the samples. The silicon content for all the specimens falls within the acceptable limit (HoneyCombe 1982).

The compositions of manganese present in the specimens are 0.323%, 0.312%, and 0.314% respectively. An average value of 0.314% was obtained for the samples. Manganese is normally present in all commercial steels and in plain carbon steel it varies from about 0.30 to 0.80%, but in special steels it may run as high as 25%. Manganese combines readily with sulphur in the steel, forming manganese sulphide (MnS), and preventing sulphur from combining with iron, which would lead to hot shortness (Allen, 1979).

3.2 Tensile Test

Table 2 shows the tensile properties as well as the hardness values of the specimens under investigation. From the results obtained, the properties investigated from the tensile test were yield strength, tensile strength, percentage reduction in area and percentage elongation at fracture. The result gave an average yield strength value of 487N/mm^2. The result show that the specimen from the manufacturer met with the standard of 420N/mm^2 yield strength recommended by the Standard Organization of Nigeria (NIS 117:2004). It can be observed that the higher the carbon contents of the steel, the higher the yield strength. As pointed out by (Allen, 1979), the influence that carbon has in strengthening and hardening steel is dependent upon the amount of carbon and the micro structure.

As for the heat treated samples there was a general increase in their strength values compared to As-received samples. It can be seen in APPENDIX I of Fig 1 chart highlighting variation in average yield strength for the sample.

Percentage elongation of the samples from the manufacturer exceeds the minimum value of 12% (NIS 117:2004).

As for the tempered samples there was a general decrease in percentage elongation compared to that of the received samples.

While there was a general increase in percentage reduction in cross sectional area of the tempered samples compared to the received samples. It can be seen in APPENDIX I of Fig 2 chart highlighting variation in average percentage reduction in cross sectional area for the sample.

3.3 Hardness Test

Hardness test were performed on the samples. From the result of the hardness test conducted on the samples as shown in table 2 an average test result of 5HRC was obtained for as-received samples. While for the tempered samples an average test result of 6.75HRC was obtained. The tempered samples exhibit higher hardness values than as-received samples. This is an indication that there is an increase in hardness values after tempering was carried out on the samples. It can be seen in appendix II of figure 3 chart highlighting variation in Hardness values for the sample.

4.0 CONCLUSION

The results from the tempering show that there is an improvement in hardness values from 5HRC to 6.75HRC. Ultimate tensile strength decreases with tempering from 557 N/mm^2 to 504 N/mm^2. This indicates improvement in hardness values while decrease in ultimate tensile strength.

5.0 REFERENCES

Allen, D.K (1979), Metallurgy, Theory and Practice, American Technical Society, Chicago, Page 168-281 Volume 1

Higgins, R.A (1999), Engineering Metallurgy, for Applied Physical Metallurgy, Edward Arnold Publisher Ltd., London, Page 252 Sixth Edition.

Honeycombe, R.W.K (1982), Steels: Microstructure and Properties, Edward Arnold Publisher Ltd., London, Page 28-55.

Khanna, O.P. (2005), A Text book of Production Technology, Dhanpat Rai Publications Ltd.; New Delhi, Page 37

Khurmi, R.S. and Sedha, R.S (2008), Materials Science, S. Chand and Company Limited, New Delhi, India, Page 163

Raghuwanshi, B.S. (2006), A Course in Workshop Technology, Volume 1, Manufacturing Processes, Dhanpat Rai and Company, Delhi, India, Page 96 9th Edition.

Rajput, R.K. (2007), Material Science and Engineering, S.K. Kataria and Sons, Publishers of Engineering and Computer Books, Delhi, Page 180

Standards Organization of Nigeria, Nigerian Industrial Standard, NIS 117: 2004, Steel bars for the reinforcement of Concrete.

Vernon, J. (1992), Testing of Materials McMillan Educational Limited, Page 5-43.

APPENDIX 1: AVERAGE YIELD STRENGHT

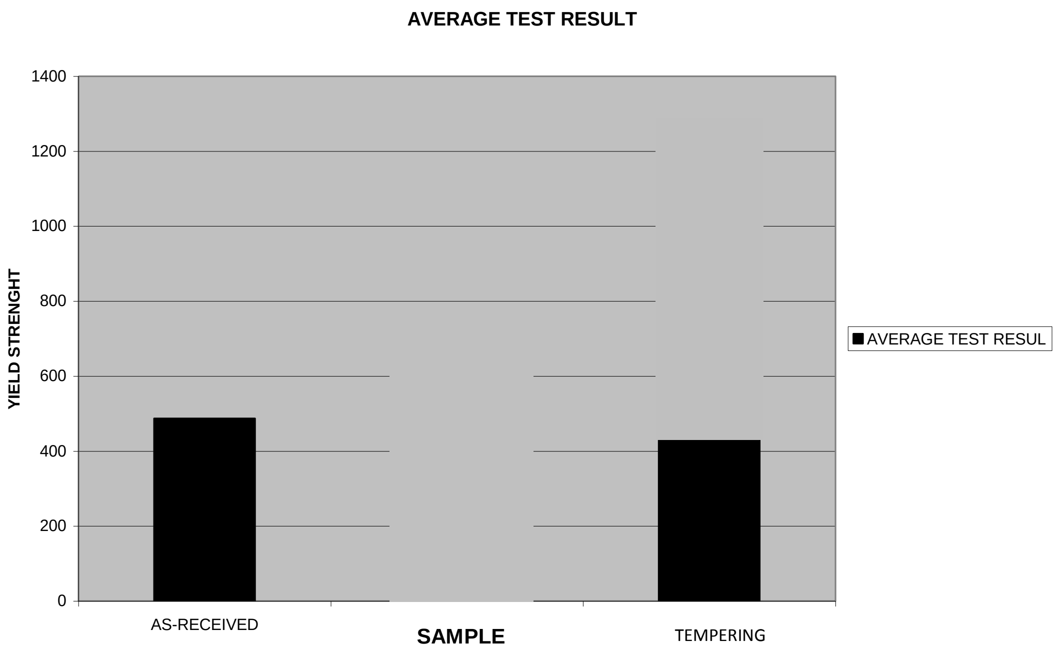


Fig 1: Charts Highlighting Variation in Average Yield Strength for the sample

APPENDIX 1: PERCENTAGE REDUCTION IN AREA

TEMPERING

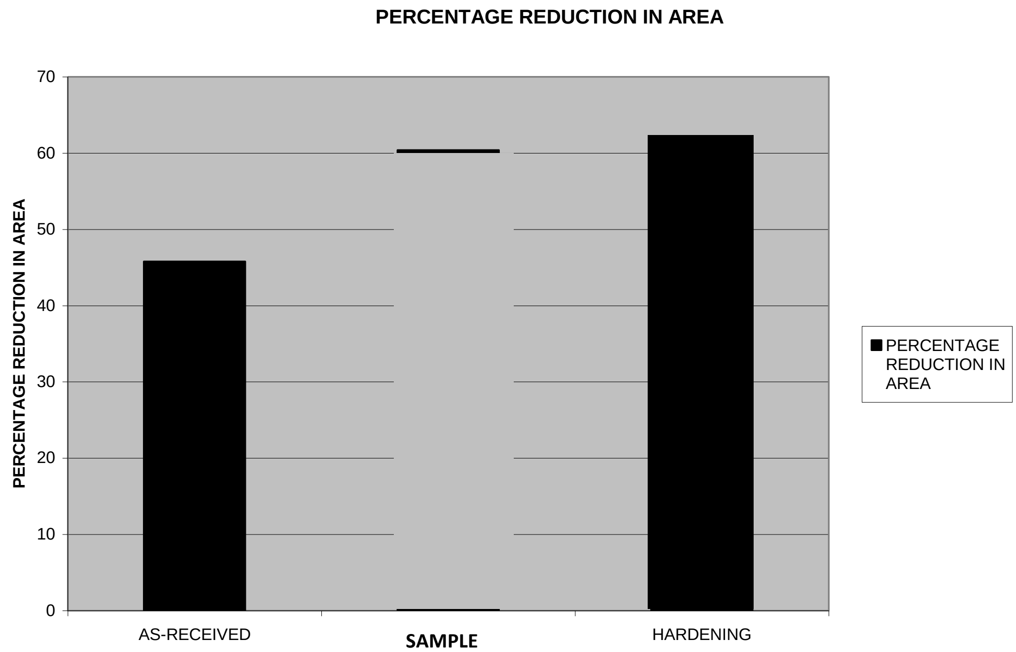


Fig 2: Charts Highlighting Variation in Average Percentage Reduction in Cross Sectional Area for the sample.

APPENDIX II: HARDNESS VALUE

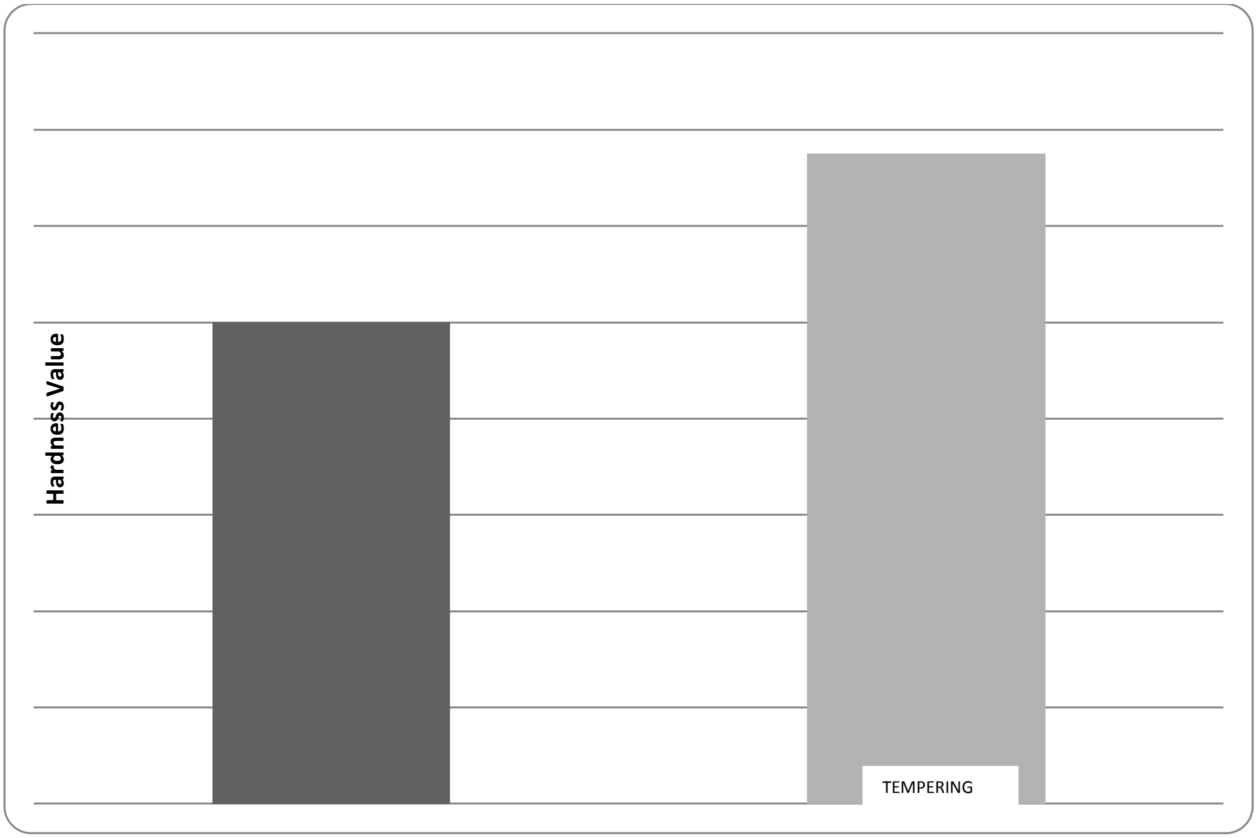
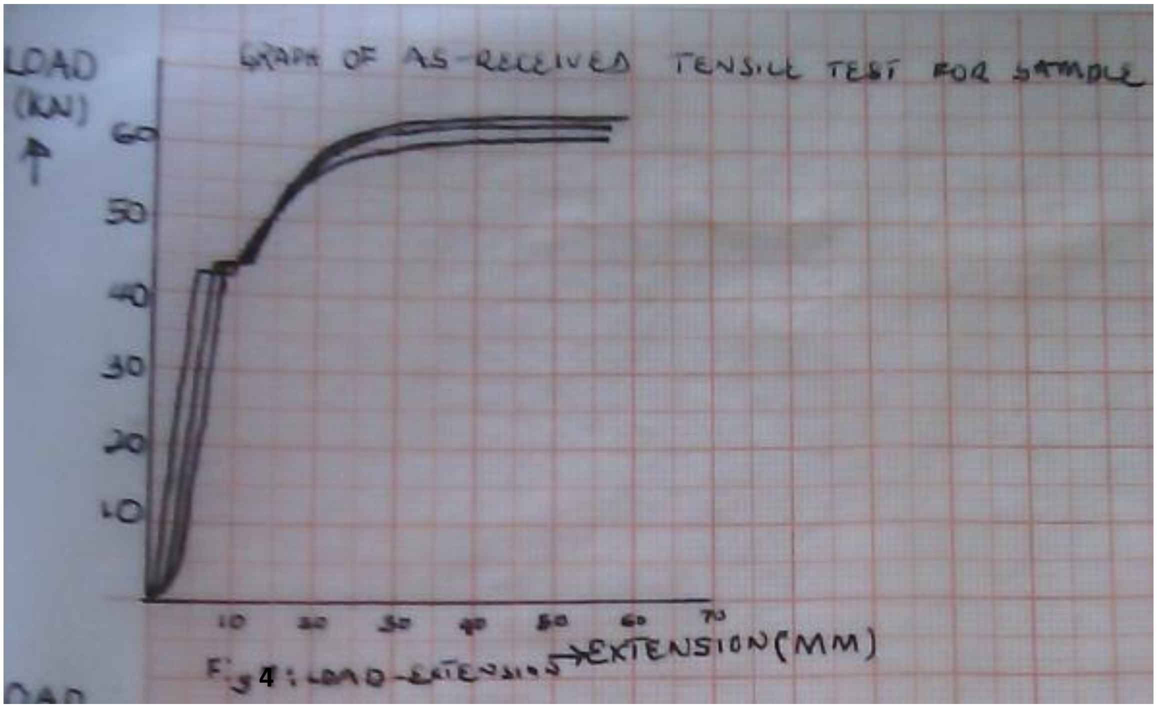
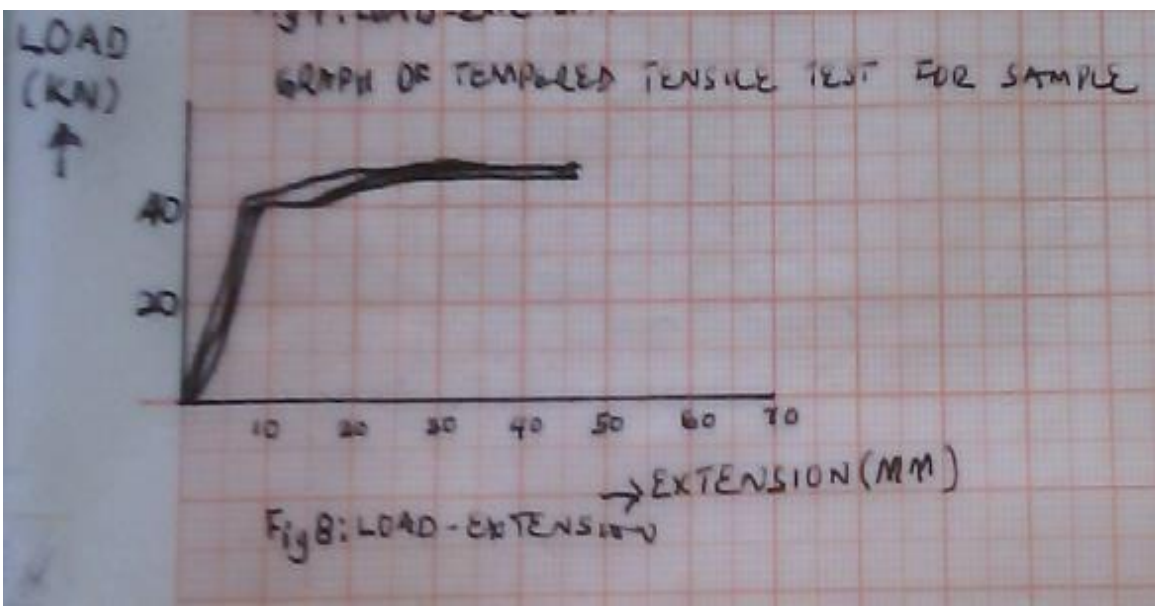


Fig 3: Charts Highlighting Variation in Hardness values for the samples

APPENDIX III: GRAPH OF TENSILE TEST



LOAD
(KN)
GRAPH OF AS-RECEIVED TENSILE TEST FOR SAMPLE
60
50
40
30
20
10
10
20
30
40
50
60
70
EXTENSION (MM)
Fig 4: LOAD-EXTENSION



LOAD
(KN)
GRAPH OF TEMPERED TENSILE TEST FOR SAMPLE
40
20
10
20
30
40
50
60
70
EXTENSION (MM)
Fig 8: LOAD-EXTENSION

THE INFLUENCE OF HARDENING ON THE MECHANICAL PROPERTIES OF 12mm REINFORCEMENT STEEL RODS PRODUCED BY KATSINA STEEL ROLLING MILL

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Kaduna, Nigeria

ABSTRACT

Reinforcement steel bars from the manufacturer were tested. Chemical analysis, tensile and hardness test were conducted. From the results obtained compared with standard values set by the Standards Organization of Nigeria (SON). Samples from the manufacturer satisfy the standard of 420N/mm^2 yield strength. Heat treatment (hardening) was carried out to enhance the mechanical properties of all the reinforcement steel bars from Katsina Steel Rolling Mill. It was found that all the samples responded favourably to the heat treatment as indicated by the improved tensile strength, ductility, and hardness after heat treatment.

SIGNIFICANCE: It is of extreme importance that the user of materials be able to obtain reliable information on the properties of those materials (Vernon, 1992).

Material testing is widely used during research and development programmes and also for the compilation of general design data files. Materials specifications are given to uniquely define the qualities of a material necessary to serve, most efficiently, a given need. The specifications generally indicate the material composition as well as relevant properties such as mechanical properties as well as heat treatment given the material upon which the engineer can base his design.

This work has shown that some mechanical properties of reinforcement steel rods can be improved by heat treatment. It is of great benefit especially to those into construction.

KEYWORDS: Reinforced steel rod, chemical composition, heat treatment, hardening, yield load, maximum load, yield strength, ultimate tensile strength and percentage elongation.

1.0 INTRODUCTION

Reinforced Steel Rods play a vital role in concrete project such as building, bridges, dam construction, suck away slabs and columns. It helps the column and beam to withstand tensile and axial load, it prevent cracking, collapsing, deflection and it holds the building firmly.

It gives an extra strength to a project which makes it to last long. For example in bridge construction where it is designed to carry high load and strength and where the rate of load that it will accommodate depend on the number of vehicles, people, animal and heavy trucks that pass or cross over it everyday and night. It is very important to consider this load and the tensile strength of the column and beams of the bridge which make up the whole structure, that is why when constructing a bridge adequate reinforced steel rod, cement and sand are casted together in order to give extra strength to the casting, the reinforced steel rod hold the mixture together.

A look at reinforcement steel bars available in the market, shows that most if not all do not carry any specification. Visit to many of the local manufacturers also revealed that many of them do not undertake any serious measure of quality control testing. Material testing has not been accorded its importance in Nigeria, which has lead to problems of over loading resulting in failure and in some instances bad design.

The study is aimed at investigating some properties of reinforcing steel bars from Katsina Steel Rolling Mill and the objectives are;

(i) To see the possibilities of improving the mechanical properties by heat treatment (Higgins, 1999)
(ii) To check metal composition
(iii) To asses numerically the fundamental mechanical properties of yield strength, tensile strength, ductility and hardness which gives an indication of wear resistance (Rajput, 2007).

2.0 MATERIALS AND METHOD

2.1 Materials

The samples were 12mm reinforced steel rods obtained from Katsina Steel Rolling Mill

2.2 Chemical Composition

The specimens were cut to the size of the machine die. The surfaces of the specimens were ground using surface grinding machine. The specimens were slightly heated to remove impurities for accurate and reliable result. Emery cloth was used to clean the testing point on the specimens. Samples were placed in the metal analyzer and the requisite commands were punched into the computer keyboard. After a time lapse of 2 minutes the result was displayed on the screen. A print out was obtained for the specimens. This procedure was followed until all the specimens of the samples under study were subjected to the test.

2.3 Hardening

Three samples from the manufacturer were tied together using binding wire for easy handling. The samples were taken into electric chamber furnace Degossa Deurferrit with the aid of tongs and safety hand gloves. The electric chamber furnace was continuously charged until it reached the temperature of 920^0C and it was allowed to soak for 30minutes. The temperature was read off the display unit of the furnace and the time was auto set. The specimen were removed from the furnace and quenched in water by stiring continuously for rapid cooling (Khanna, 2005).

2.4 Hardness Test

Rockwell hardness test was used, on Otto wolpert hardness tester. It differ from the Brinell's test that is in this test, the loads for making indent are smaller, and thus make smaller and shallower indents. It is because of these reasons that the Rockwell hardness test is widely used in the industry (Khurmi and Sedha, 2008). The specimens were ground to provide smooth flat surface prior to testing. The "C" scale, which is recommended for hardened steel was adopted (Raghuwanshi, 2006). The prepared specimens were secured on the machine platform and diamond cone penetrator with a load of 250kg was applied gradually onto the specimen.

Four readings were taken for each specimen and the average value was obtained as the hardness value.

2.5 Tensile Test

The length used for the test was 300mm and the gauge length for the test specimens was 105mm. One end of the specimen was gripped in the jaws provided in the adjustable cross head and then after lifting this crosshead to the appropriate height of 105m, the other end of the specimen was fixed in jaws in the top crosshead.

The tensile load was now applied hydraulically to the specimen by turning the hand wheel provided in the control unit. The load measuring gauge incorporated in the control unit shows the magnitude of the applied load. The load was increased gradually until the specimen breaks and the corresponding extensions were recorded which had been plotted by the machine during the test.

The same procedure was repeated for three samples of As-received and hardened specimens. The graphs can be seen in Appendix III plotted by the Universal Tensile Testing Machine

3.0 RESULTS AND DISCUSSION

Table 1: Metal Composition of Specimens

S/N	Sample Test	C %	Si %	Mn %	P %	S %	Cr %	Mo %	Ni %	Al %
1	**1**	**0.312**	**0220**	**0.323**	**0.052**	**0.85**	**0.075**	**<0.0055**	**0.301**	**0.210**
2	**2**	**0.311**	**0.201**	**0.312**	**0.044**	**0.079**	**0.80**	**<0.0060**	**0.310**	**0.180**
3	**3**	**0.315**	**0.200**	**0.314**	**0.60**	**0.080**	**0.085**	**<0.0070**	**0.303**	**<0.201**

Co %	Cu %	Nb %	Ti %	V %	W %	Pb %	Sn %	Zn %	Fe %
0.020	**0.205**	**0.0050**	**0.0082**	**<0.0055**	**0.022**	**<0.032**	**0.043**	**0.0083**	**98.1**

0.019	**0.292**	**0.0047**	**0.0090**	**<0.0067**	**0.024**	**<0.040**	**0.039**	**0.0075**	**98.0**
0.030	**0.300**	**0.0052**	**0.0089**	**<0.0071**	**0.030**	**<0.031**	**0.035**	**0.0085**	**97.9**

Test Average	C %	Si %	Mn %	P %	S %	Cr %	Mo %	Ni %	Al %
Result	**0.313**	**0.207**	**0.316**	**0.052**	**0.081**	**0.080**	**<0.0062**	**0.305**	**0.197**

Co %	Cu %	Nb %	Ti %	V %	W %	Pb %	Sn %	Zn %	Fe %
0.023	**0.266**	**0.0049**	**0.0087**	**<0.0064**	**0.025**	**,0.034**	**0.039**	**0.0081**	**98.0**

Table 2: Tensile and Hardness Test Results for As-received and Hardened Specimens.

SAMPLE	YIELD LOAD (KN)	MAXIMUM LOAD (KN)	YIELD STRENGHT N/mm^2	ULTIMATE TENSILE N/mm^2	PECENTAGE REDUCTION IN AREA (%)	PERCENTAGE ELONGATION (%)	HARDNESS (HRC)
AS- RECEIVED							
1	**55**	**62**	**487**	**548**	**40.58**	**53.33**	**4**
2	**55**	**63**	**487**	**557**	**52.50**	**52.38**	**5**
3	**55**	**64**	**487**	**566**	**44.25**	**54.29**	**6**
AVERAGE TEST RESULT	**55**	**63**	**487**	**557**	**45.78**	**53.33**	**5**
HARDENED							
1	**145**	**151**	**1283**	**1331**	**15.81**	**24.76**	**41.25**
2	**130**	**135**	**1150**	**1194**	**7.04**	**35.24**	**41.25**
3	**160**	**166**	**1415**	**1469**	**17.95**	**27.62**	**41.25**
AVERAGE TEST RESULT	**145**	**151**	**1283**	**1331**	**13.60**	**29.21**	**41.25**

3.1 Chemical Composition Test

The results obtained from chemical composition test of samples from the manufacturer under investigation are as shown in Table 1. The carbon compositions for the specimens are as follows: 0.312%, 0.311% and 0.315% respectively.

The maximum carbon composition for steel bars for reinforcement of concrete for steel grade 420HD as given by Nigeria Industrial Standard NIS 117 of 2004 is 0.35% ±0.02. The company conforms to this standard.

Silicon content of carbon steel varies from 0.05% to 0.30%. The composition of silicon present in significant amount of 0.220%, 0.201%, and 0.200% respectively in the samples under study. The silicon content for all the specimen falls within the acceptable limit (HoneyCombe 1982).

The compositions of manganese present in the specimens are 0.323%, 0.312%, and 0.314% respectively. Manganese is normally present in all commercial steels and in plain carbon steel it varies from about 0.30-0.80%, but in special steels it may run as high as 25%. Manganese combines readily with sulphur in the steel, forming manganese sulphide (MnS), and preventing sulphur from combining with iron, which would lead to hot shortness (Allen, 1979).

3.2 Tensile Test

From the results obtained, the properties investigated from the tensile test were yield strength, tensile strength, percentage reduction in area and percentage elongation at fracture. The results show that the specimen from the manufacturer met with the standard of 420N/mm^2 yield strength recommended by the Standard Organization of Nigeria (NIS 117:2004). It can be observed that the higher the carbon contents of the steel, the higher the yield strength. As pointed out by (Allen, 1979), the influence that carbon has in strengthening and hardening steel is dependent upon the amount of carbon and the micro structure.

As for the heat treated samples there was general increase in their strength values compared to As-received samples. It can be seen in APPENDIX I of Fig 1 chart highlighting variation in average yield strength for the sample.

Percentage elongation of the samples from the manufacturer exceeds the minimum value of 12% (NIS 117:2004).

As for the hardened samples there was a general decrease in percentage elongation compared to As-received samples.

While there was a general decrease in percentage reduction in cross sectional area of the hardened samples compared to As-received samples. It can be seen in APPENDIX I of Fig 2 chart highlighting variation in average percentage reduction in cross sectional area for the sample.

3.3 Hardness Test

For the hardness test conducted, the hardened samples from the manufacturer exhibit higher hardness values than As-received samples. An average test result of 5HRC was obtained for as-received samples. While for the hardened samples an average test result of 41.25HRC was obtained. It can be seen in appendix II of figure 3 chart highlighting variation in Hardness values for the sample.

4.0 CONCLUSION

From the results of this study, the chemical composition and tensile test show that the samples met the required standards set out in Nigeria Industrial Standard for steel bars for the reinforcement of concrete.

The hardening heat treatment carried out on the specimens indicates improvement in the mechanical properties compared to As-received samples as shown in the table of results.

5.0 REFERENCES

Allen, D.K (1979), Metallurgy, Theory and Practice, American Technical Society, Chicago, Page 168-281 Volume 1

Higgins, R.A (1999), Engineering Metallurgy, for Applied Physical Metallurgy, Edward Arnold Publisher Ltd., London, Page 252 Sixth Edition.

Honeycombe, R.W.K (1982), Steels: Microstructure and Properties, Edward Arnold Publisher Ltd., London, Page 28-55.

Khanna, O.P. (2005), A Text book of Production Technology, Dhanpat Rai Publications Ltd.; New Delhi, Page 37

Khurmi, R.S. and Sedha, R.S (2008), Materials Science, S. Chand and Company Limited, New Delhi, India, Page 163

Raghuwanshi, B.S. (2006), A Course in Workshop Technology, Volume 1, Manufacturing Processes, Dhanpat Rai and Company, Delhi, India, Page 96 9th Edition.

Rajput, R.K. (2007), Material Science and Engineering, S.K. Kataria and Sons, Publishers of Engineering and Computer Books, Delhi, Page 180

Standards Organization of Nigeria, Nigerian Industrial Standard, NIS 117: 2004, Steel bars for the reinforcement of Concrete.

Vernon, J. (1992), Testing of Materials McMillan Educational Limited, Page 5-43.

APPENDIX 1: AVERAGE YIELD STRENGHT

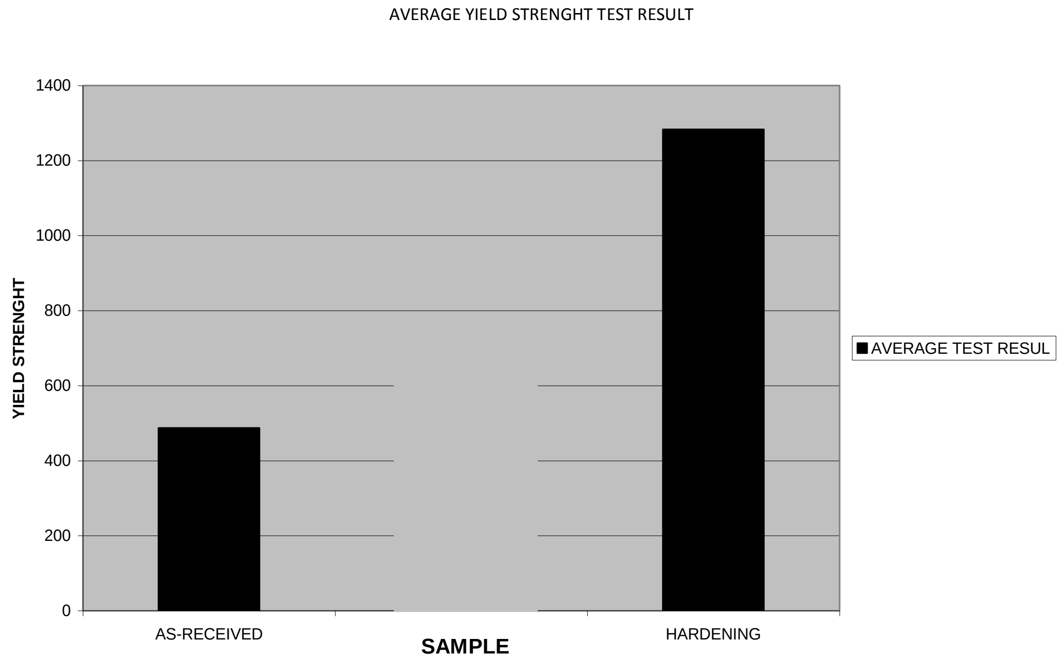


Fig 1: Charts Highlighting Variation in Average Yield Strength for the sample

APPENDIX 1: PERCENTAGE REDUCTION IN AREA

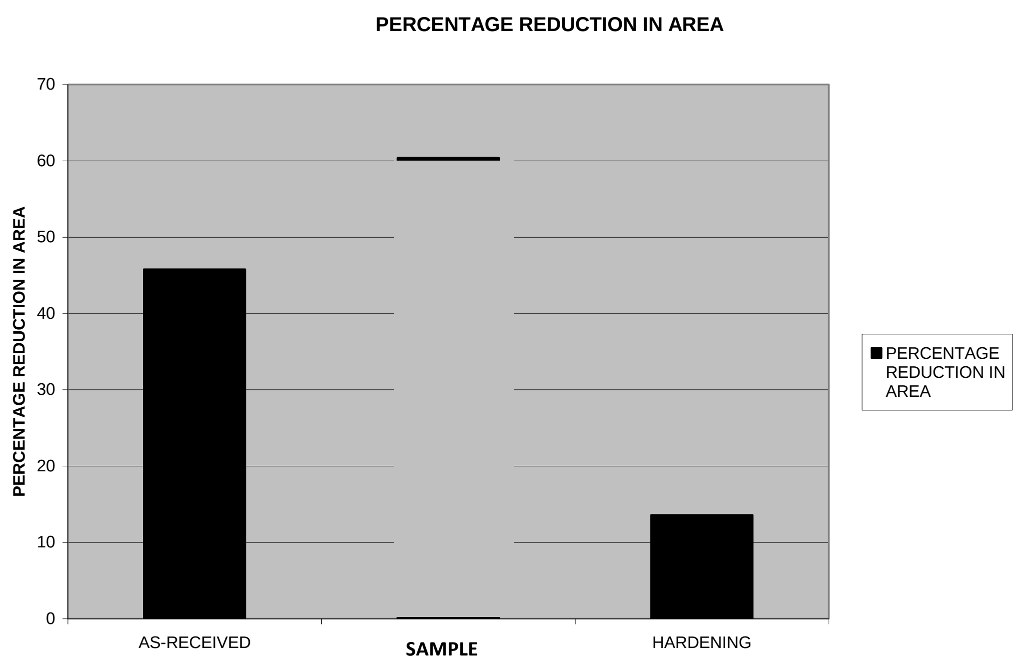


Fig 2: Charts Highlighting Variation in Average Percentage Reduction in Cross Sectional Area for the sample.

APPENDIX II: HARDNESS VALUE

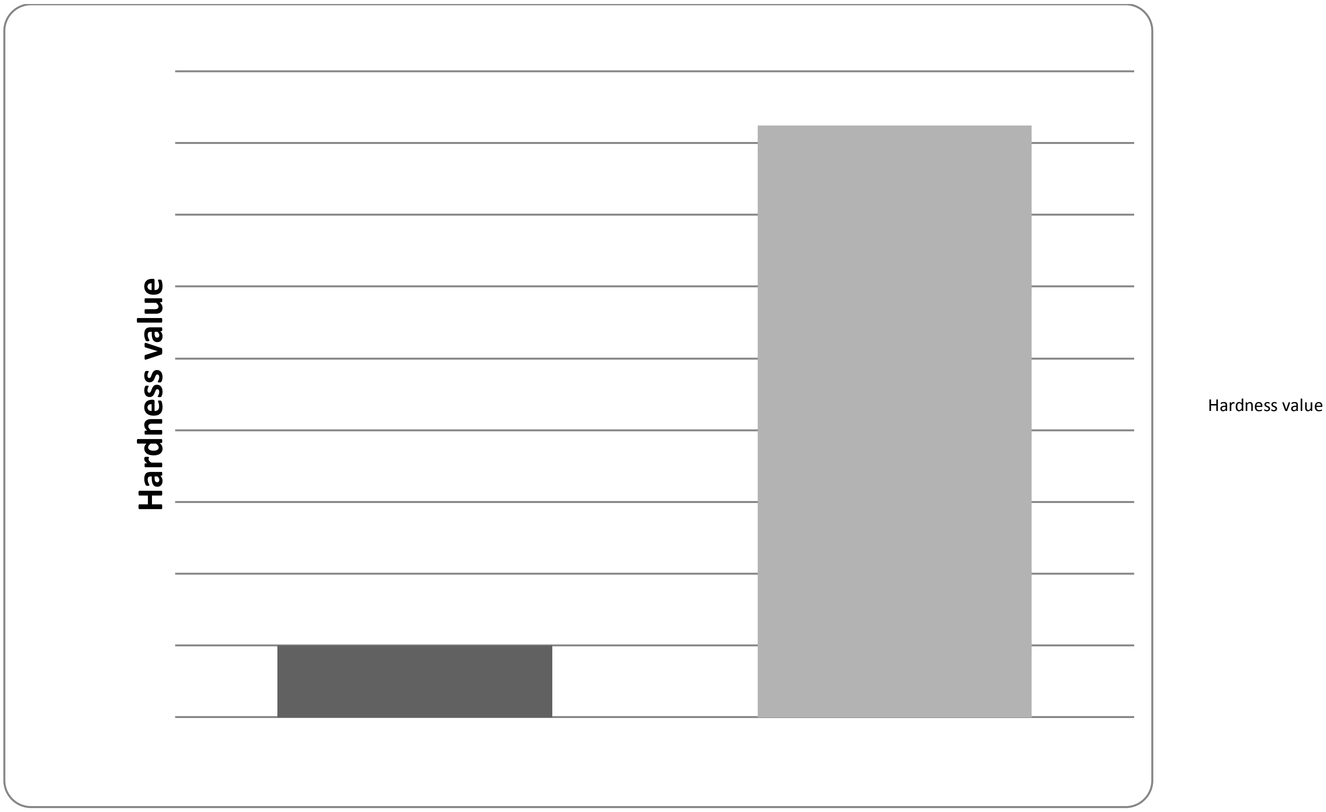
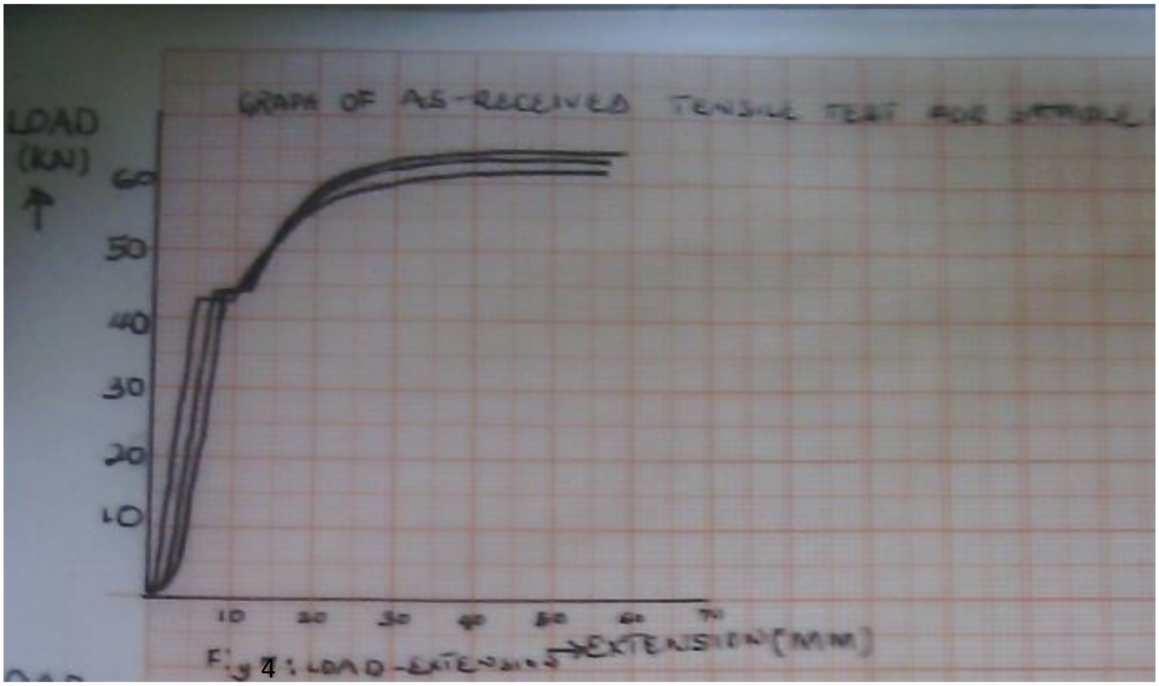
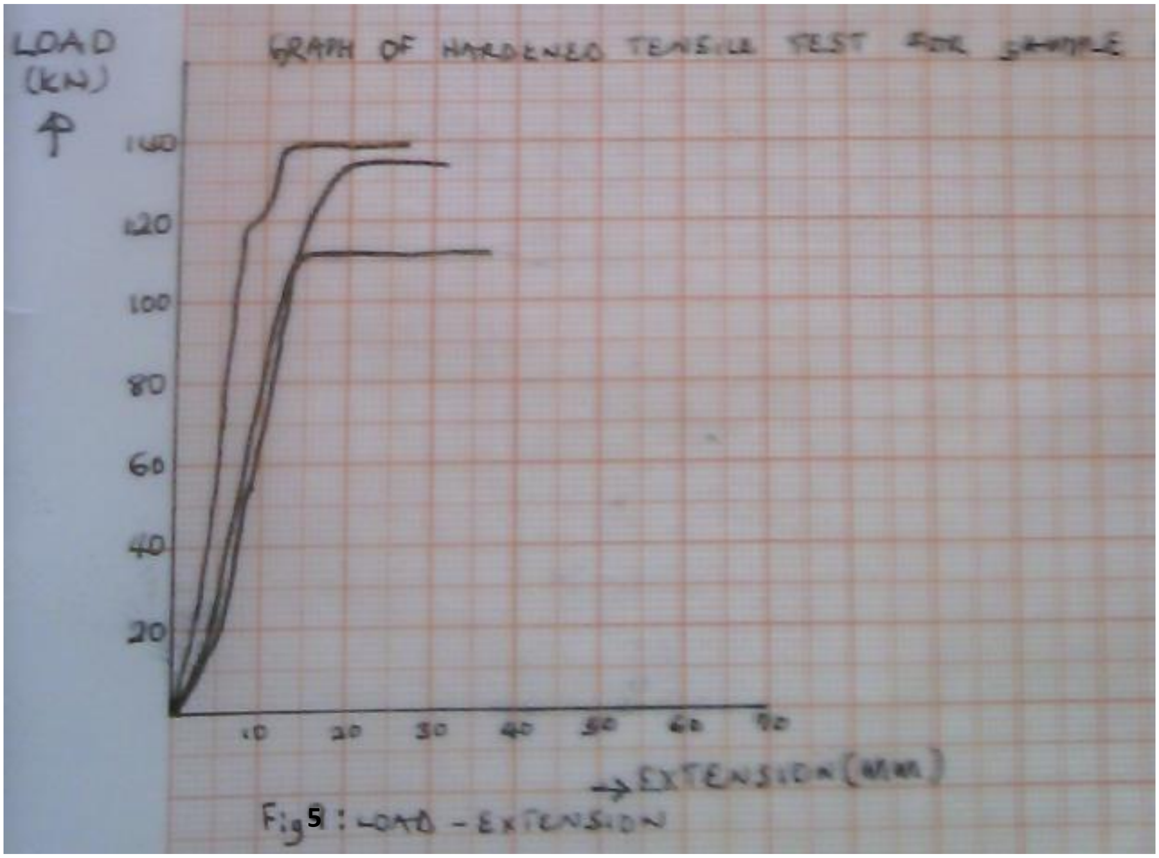


Fig 3: Charts Highlighting Variation in Hardness value for the samples

Appendix III: GRAPHS OF TENSILE TEST


GRAPH OF AS-RECEIVED TENSILE TEST FOR
LOAD (KN)
60
50
40
30
20
10
10
20
30
40
50
60
70
EXTENSION (MM)
Fig 4: LOAD-EXTENSION


LOAD (kN)
GRAPH OF HARDENED TENSILE TEST
160
120
100
80
60
40
20
10
20
30
40
50
60
70
EXTENSION (mm)
Fig5 : LOAD - EXTENSION

POLYTECHNIC ENGINEERING STUDENTS AND ENTREPRENEURSHIP EDUCATION: PERCEPTION, ATTITUDES AND OUTCOMES

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ABSTRACT

Background: *Entrepreneurial learning, or the acquisition of entrepreneurial skills, in engineering at the tertiary level has become an important topic of discussion. The labour market needs technicians, technologists and engineers who are prepared to adapt to changing market conditions and enhance innovations that offer new value to customers and society as a whole. An entrepreneurial mindset, knowledge, skills and attitudes are closely related to innovation and creativity as enablers of entrepreneurial actions that are essential to prepare students for a successful professional life. The study sought to assess how engineering students in the Polytechnic sector perceive and/or experience studying entrepreneurship education course and how important it is to the engineering discipline and the probable outcome of such study. The data were collected using a well-structured questionnaire and were analyzed using a descriptive research approach. Result of the analyses revealed that 74% of the students believed that entrepreneurship education is an important component of their programmes of study. However, the content and mode of delivery of the curricula are shabby and does not promote an effective and efficient teaching and learning process. Thus, the knowledge and skills learned is not adequate and cannot produce the desired entrepreneurs. The study showed that students had a positive attitude towards the course. This should be encouraged by managing and delivering the course in such a way that will provoke students' inquisition, knowledge and greater performance. There is no doubt that the effective and efficient implementation of entrepreneurship education curriculum will help learners in Nigerian Polytechnics to develop entrepreneurial capacities and the ability to be self-reliant and self-employed after graduation.*

Keywords: Entrepreneurial learning, curricula, entrepreneurs, attitude, performance.

1.0 INTRODUCTION

The need for engineers to obtain entrepreneurial skills to meet economic and workforce needs has been well documented. This means that institutions of higher learning are under pressure to graduate engineers who are not only able to invent new products but who also have the knowledge and skills to identify opportunities, understand market forces, commercialize new technologies and advocate for them.

The need for entrepreneurship education started emerging in Nigeria in the mid-1980s. This is because before this period, unemployment and poverty were not a national concern as it is presently. However, political instability and inconsistencies in the social-economic policies of successive government led to the emergence of high level unemployment in Nigeria (Ojeifo, 2013). In the face of this situation, entrepreneurship, which would have salvaged the situation, was not encouraged. Then, Akhuemonkhan *et al.*, (2013) observed that tertiary education has not been properly include philosophy of self-reliance such as creating a new cultural and productive environment that will promote pride in primitive work and self-discipline, encouraging people to take part actively and freely in discussions and decisions affecting their general welfare, promoting new sets of attitudes and culture for the attainment of future challenges.

Nwagwu (2007) opined that the failure of tertiary education to inculcate the above philosophy in students has led to wastages in terms of both human and natural resources. This is because the youth and graduate from tertiary institutions are not equipped with the skills with which to exploit the natural resources that abound in Nigeria. All these factors have rendered the pursuit of self-reliance among our graduates difficult to retain. In their own contributions, Ayodele (2006) identified inadequate capital to be one of the principal factors hindering entrepreneurship in the country. Other problems identified by Ayodele include irrelevant education that is bookish, theoretic and "white-collar job" oriented. Another problem is the fear of failure by the people to take risks on entrepreneurial activities, while an unstable and conducive political environment drives away investors that are planning to embark on entrepreneurial activities. The high rate of many business enterprises as winding up prematurely consequent upon the employable and unemployable youths and adults idle away. It is against this backdrop that this paper sets to look into entrepreneurship education as imperative for graduates' unemployment and sustainable development in Nigeria.

1.1 Concept of Entrepreneurship Education

The concepts of entrepreneur and entrepreneurship have been severally defined, as there is no consensus on the exact meaning of the two. Though definitions abound but the intention to start a business remains at the core of most definitions and it is commonly agreed that entrepreneurs form new business (Vasper, 1990) and that entrepreneurship is crucial for economic development.

Di-masi (2004) defined entrepreneur as a person who perceives the market opportunity and then has the motivation, drive and ability to mobilize resources to meet it. Basically, an entrepreneur is an individual who creates a new organization or found new venture (Gartner, 1989). The determinant factors for success of small and medium enterprises therefore, have been assumed to be the skills, ability and personal characteristics of owner-managers. Equally, existing definitions of entrepreneurship, according to Friijs, Christian, Thomas and Charlie (2002) often relate to the functional role of entrepreneurs and include coordination, innovation, uncertainty bearing, capital supply, decision making, ownership and resource allocation.

The term entrepreneurship education is thus used interchangeably with entrepreneurship training and skill acquisition. Conceptually, entrepreneurship education refers to a specialized knowledge that inculcates in learners the traits of risk-taking, innovation, arbitrage and co-ordination of factors of production for the purpose of creating new products or services for new and existing users within human communities (Acs and Storey 2004 and Kanothi, 2009).

Entrepreneurship education has also been described as a formal or informal structured learning that inculcates in students/trainees the ability to identify, screen and seize available opportunities in the environment in addition to skill acquisition (Sexton and Smilor, 1997). The deliverables of entrepreneurship education when properly imbibed by students and learners are: (a) ability to identify something happening in the environment (resources); and (b) ability to impart something new to trainees, so that their creativity, innovative abilities, beliefs and recombination skills would be enhanced (Sofoluwe, 2007). Anything that can be taught is education. Since entrepreneurship can be taught, entrepreneurship education refers to pragmatic and meaningful interaction between learner and instructor for the purpose of developing the ability of the learners to identify, evaluate and generate ideas and solving business problems in a unique way (Towobola and Raimi, 2011).

Entrepreneurship education, if effectively and efficiently taught has the likelihood to precipitates self-employment among learners and accelerating sustainable growth and development. This is evident in a number developed nations like Japan and America that utilized entrepreneurial (facilitative) education for improving their human capital as opposed to the traditional approach of teach-and-listen approach, which is prevalent in the developing third world nation (Raimi *et al.*, 2011).

Beside the several definitions of entrepreneurship provided above, Akudolu (2010) insisted that Entrepreneurship education is in fact the fundamental aim of education. It is the acquisition of knowledge, skills and attitude to enable the learner apprehend life challenges in whatever form and take decisive steps to realize new trends and opportunities for meeting those challenges in all aspects of human life.

Consequently, Ojeifo (2013) opined that Entrepreneurship education in Nigeria, amongst other things seeks to provide students in tertiary institutions with the knowledge, skills and motivation to encourage entrepreneurial success in a variety of ventures. He further said that the move by the government through the Federal Ministry of Education to make entrepreneurship education one of the compulsory general studies courses for students in institutions of higher learning across the country should be seen as a positive step in the right direction, as it will serve as a panacea for youth unemployment. Besides, the youths, when they are not gainfully employed either in the formal or informal sectors of the economy, they become vulnerable to criminal tendencies such as kidnapping, rape, armed robbery and many other social vices which are menaces to society (Nwachukwu and Nwamuo, 2010).

Apparently worried by the soaring unemployment rate, declining per capita income, youths restiveness in various parts of the country, the Federal government directed all higher education institutions in the country to run entrepreneurship studies programme as a compulsory course for all students irrespective of their disciplines with effect from 2007/2008 academic session (Okojie, 2009). It is, however heartwarming that government has made entrepreneurship studies compulsory in our tertiary institutions, it is also bad news that most of our higher institutions are not yet ready for full implementation of the programme. Although The National Board for Technical Education (NBTE) has made it a pre-requisite for all Polytechnics to establish entrepreneurship development and training centres in their respective institutions, for accreditation of new programmes and/or re-accreditation of the existing programmes, some Polytechnics are yet to comply with the directives, and for those that established such centres, they are mostly ill-equipped in terms of human and material resources.

In view of the above, Charlie (2013) corroborated that the country's universities were not prepared for entrepreneurship education when they were compelled to commence it. It is not clear whether any special fund has been made available to the universities for the prosecution of entrepreneurship education. The same conventional facilities for conventional education are being used in the universities. The same personnel for conventional courses are being used for the teaching of entrepreneurial studies in our universities.

1.2 Entrepreneurship education in engineering

Entrepreneurship education teaches engineering students in all disciplines the knowledge, tools and attitudes that are required to identify opportunities and bring them to life. Engineering courses are a good example of successful applications of project based learning (PBL) approaches. Consequently, Filomena *et al.*, (2013) asserted that these project approaches include designing, solving and improving solutions for real-world problems; a key goal for engineering students.

Economic growth of a nation depends on both high technology and entrepreneurship. If we agree with that proposition, then entrepreneurship education could be a good opportunity for engineers to access to top careers, by increasing their business and entrepreneurial skills. Engineers, being very effective and reactive problem solvers, already possess the analytical tools to succeed in business. Thus, in a multicultural, multifunctional operating environment, the need for flexibility points to an increasing role for entrepreneurial activity for the engineering students.

Léger-Jarniou (2006) corroborated that one of the most rapidly growing areas in entrepreneurship education involves the interface between entrepreneurship and such technical fields as the engineering disciplines, chemistry, physics, biology, and computer science. Especially in a technological age, these disciplines represent vital sources of entrepreneurs with high potential business concepts. And, as Cunningham (1991) noticed, if one accepts the professional performance as a function of the successful combination of knowledge, skills and attitudes, then typically entrepreneurship education have focused on the first, largely ignored the second and assumed the third.

By nature, engineers are problem solvers who take great pride in designing comprehensive solutions. They already possess the analytical tools necessary to succeed in business. Thus, by increasing those tools with business knowledge and strong communication skills, engineers can deliver optimal returns to their companies and also to themselves. Fortunately, engineering education provides an excellent basis for understanding entrepreneurship concepts. In addition to their technical and analytical expertise, they need to be flexible, resilient, creative, empathetic, and have the ability to recognize and seize opportunities [National Academy of Engineering (NAE), 2004; Sheppard *et al.*, 2008].

It is therefore becoming more commonly understood and accepted that engineers need business, social and interpersonal skills to operate effectively in the organizational environments in which they work. An engineer must also understand the interaction among technology, organization, and people critical to successful implementation of innovation.

Students in entrepreneurship programmes gain insights into designing for end users, working in and managing interdisciplinary teams, communicating effectively, thinking critically, understanding business basics and solving open-ended problems.

1.3 Technology Entrepreneurship

Technology Entrepreneurship (TE), a relatively new term is receiving increasing recognition from the scholars of various streams of business and science and technology disciplines, as well as from the industry players and business men practically (Abdullah, 2011). It is basically the merge of two words from two disciplines: technology from the innovation discipline and entrepreneurship from the business discipline. Through TE, learners/students can learn the process technology that entrepreneurs are using to startup companies. It involves taking a technology idea and finding a high-potential commercial opportunity, gathering resources such as talent and capital, figuring out how to sell and market the idea, and managing rapid growth.

Consequently, Bailetti (2012) proposed a definition for Technology Entrepreneurship as "an investment in a project that assembles and deploys specialized individuals and heterogeneous assets that are intricately related to advances in scientific and technological knowledge for the purpose of creating and capturing value for a firm". As argued, the Stanford University (2014) admitted that there is a difference between "regular" entrepreneurship and "technology" entrepreneurship. The latter must succeed at two major, but fundamentally different, tasks: (a) ensuring that the technology actually works in the target customer's environment, and (b) that it can be sold at a profit. The former typically worries only about the second part.

1.4 Goals and objectives of entrepreneurship education

Akudolu (2010) affirms that the major goal of entrepreneurship education is to promote creativity, innovation and self-employment among the citizens through the inculcation of entrepreneurial knowledge, competences and attitudes in the learners. She affirms that "the goal of entrepreneurship education is for learners to acquire entrepreneurial capacities and skills that will make them to be self-reliant and self-employed". While the objectives of entrepreneurship education clearly show that it is concerned with the development and survival of both the learners and society.

In other words, Alabi *et al.*, (2014) said it is a tool through which socio-economic and political development could be achieved if properly planned, funded and implemented. Among other things, according to Paul (2005), entrepreneurship education is organized to achieve the following objectives:

1. To create employment
2. To reduce high level of poverty
3. To create smooth transition from traditional to a modern industrial economy
4. To serve as a catalyst for economic development and growth of the GDP.
5. To provide the young graduates with enough training and support that will enable them to establish an occupation in small and medium sized businesses.

6. To inculcate the spirit of perseverance in the youths and adults which will enable them to persist in any business venture they embark on.
7. Entrepreneurship education reduces the high level of rural-urban migration.
8. To offer functional education for the people that will enable them to be self-employed and self-reliant.
9. To provide the youth with adequate training that will enable them to be more creative and innovative in identifying noble business opportunities.
10. To offer tertiary institution graduates with adequate training in risk management, etc.

Alabi, then opined that, from the above objectives, it is evident that this type of education, if it is given the necessary attention and properly implemented, will produce quality graduates that will foster job creation and reduce unemployment and alleviate poverty in Nigeria, and it could be realized when the graduates are self-reliant by establishing their own business small/medium scale enterprises. Entrepreneurship education, therefore seeks to provide students with the knowledge, skills and motivation to encourage entrepreneurship success in a variety of settings (Ayatse, 2013).

For the goal and objectives of entrepreneurial education to be achieved, the strategies for organizing content and learning experiences should be learner-centered. In this regard, effort should be made to help the learner understand the entrepreneurial dimension of the learning content through group works, role play, projects, games and simulations, field trips, traineeship, mentoring, brainstorming, exchange of visits and other forms of practical (learning by doing) and learner-driven methodologies.

1.5 Importance of entrepreneurship education

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2005), the "aims of various governments to combat poverty through the establishment and creation of poverty reduction programmes failed because graduates of the education system lack practical skills". Akpomi (2009) states that "entrepreneurial skills and attitudes provide benefits to the society even beyond their application to business activity". She further stated that "personal qualities that are relevant to entrepreneurship such as creativity and a spirit of initiative can be useful to everyone in their responsibilities and in their daily existence".

Entrepreneurship education among graduates will lay solid foundation for the emergence of a generation of innovators willing to apply necessary capital into the production process for new products, open and expand new markets, explore new sources of materials and ensure the organization of new industries (Alabi *et al.*, 2014).

It is therefore no longer enough to come out of school with a purely technical education; engineers need to be entrepreneurial in order to understand and contribute in the context of market and business pressures. For engineers who start companies soon after graduation, entrepreneurship education gives them solid experience in product design and development, prototyping, technology trends, and market analysis (Nelson and Byers 2010). These skills are just as relevant for success in established enterprises as they are in start-ups; students with entrepreneurial training who join established firms are better prepared to become effective team members and managers and can better support their employers as innovators.

1.6 Challenges of entrepreneurship education in Nigeria

Though entrepreneurship education has been part and parcel of educational activities in many countries of the world for over 100 years, it has just been introduced into the Nigerian tertiary institutions in the 2006/2007 academic session. Entrepreneurship education, therefore, as a new field of study is not without some challenges. There are several factors that hinder the study of entrepreneurship education in the Nigerian Polytechnics, these include but not limited to the following:

- Graduates of entrepreneurship education faced the challenges of raising funds (start-up capital) to begin their own businesses. Ayatse (2013) corroborated that there is need for substantial funds for teaching in practical terms for entrepreneurship education; for financing startups and expansion of business ventures in order to produce successful entrepreneurs.
- The present curricula are not comprehensive enough to identify a wide range of entrepreneurship ventures. They require a holistic approach towards planning and implementation.
- Lack of sufficient, skilled and qualified teachers who have the appropriate knowledge and pedagogy to impart entrepreneurial skills and competences on the engineering students, by linking the entrepreneurial knowledge with the engineering skills of the learners/students.
- Poor state of infrastructure – ill-equipped entrepreneurship training centres, information technology, electricity, classrooms, regurgitated libraries, hostels, sports and recreation centres.
- Faulty Foundation- Education is a continuous process, but the introduction of entrepreneurship education in the universities without first doing so at the secondary and primary levels, tend to suggest that the new curriculum lacks the necessary foundation. Entrepreneurship education should have commenced at the lower levels before moving to the tertiary level, so that their products, skills and experiences should form the fulcrum of the university entrepreneurship education (Alabi *et al.*, 2014).
- Lack of practical realities and poor curriculum implementation
- Erroneous perception of students that entrepreneurship education as a GNS course forced on them just to increase their academic workloads.

2.0 METHODOLOGY

The research design used was a quantitative method. The population consisted of all ND and HND full-time engineering students of Nuhu Bamalli Polytechnic, Zaria and Kaduna Polytechnic, Kaduna (State and Federal Polytechnic respectively). The sample was drawn using stratified random sampling technique from the only two Polytechnics in the State. From the two Polytechnics that participated in the study, forty ND and thirty HND students were randomly selected from the Kaduna Polytechnic while thirty ND and twenty HND students were randomly selected from the Nuhu Bamalli Polytechnic, Zaria. This is because Kaduna Polytechnic offers more engineering courses than Nuhu Bamalli Polytechnic and have higher carrying capacity as the second largest Polytechnic in Nigeria.

The students from each of the seven engineering programmes (i.e. Agricultural, Automotive, Chemical, Civil, Computer, Electrical and Mechanical) offered by the two Polytechnics were randomly selected to fill the structured questionnaire titled **"Entrepreneurship Perception Investigation – (EPI)"** (see appendix A). The questionnaire was developed, validated and administered to a total of 120 students

(90 males and 30 females) that participated in the study. However, only 115 out the 120 questionnaires (96%) were fully filled and returned by the respondents.

The questionnaire was made up of four parts: Part A was demographic; Part B was on the perception and attitudes of engineering students of Nigerian Polytechnics on entrepreneurship education; Part C was on the relevance of entrepreneurship education to the students while Part C was on the outcomes of studying entrepreneurship education by the engineering students. The fourteen formulated questions concerned on the content, materials, delivery of curriculum, students' attitude, perception, relevance and performance of the respondents in entrepreneurship education courses as well as their readiness to establish their own businesses after graduation. The data were obtained on a 5-point Likert scale, starting from 1 as strongly disagree, to 5 as strongly agree and they were analyzed using a simple Microsoft Excel to calculate the mean scores and the sample standard deviations.

Decision rule: Any item with a mean response of 3.00 and above was accepted as agree; a mean score of 2.50 – 2.99 as neutral (indifference) while a mean score of 2.49 and below signifies that the respondents disagree with the item completely, as postulated by Morenikeji (2006), with the following cut-off points:

1. Agree = 3.00 – 5.00
2. Neutral (indifference) = 2.50 – 2.99
3. Disagree = 2.49 – 1.00

The responses were then classified as agree, neutral and disagree, being the performance measurement outcomes.

3.0 RESULTS

For the purpose of this conference paper, and in view of space limitations imposed, the authors have adopted a descriptive method rather than empirical style to summarize the most salient results emerging from this research study.

3.1 Perception and attitudes of Polytechnic students on entrepreneurship education:

The mean scores of 3.86 and 3.55 relative to the perception/attitudes of students and entrepreneurship education as a tool to reduce graduates' unemployment respectively show that the respondents have agreed that they have good perception and attitude of entrepreneurship education since they are greater than 3.00 based on Morenikeji's cut-off point. Similarly, the mean score of 4.52 indicates that the respondents agreed that they have very high awareness about entrepreneurship education. However, a mean score of 2.61 placed the respondents on a neutral (indifferent) position about being exposed and their preparedness towards being self-reliant.

3.2 Relevance of entrepreneurship education and performance of students in the course

Mean scores of 2.35 and 2.40 relative to the relevance of entrepreneurship education curricula and performance of the respondents in the course respectively show that they disagree with the curricula being relevant to them and their performance is below average (50%). Then, a mean score of 1.35 on the extent of C.A. administration indicates a very poor administration of the C.A. component of entrepreneurship education. On the other hand, the mean scores of 4.50, 4.75 and 4.60 on the effect of workloads on students' performance, the importance of practical projects in the study of entrepreneurship education and the type of projects to execute respectively confirmed that the respondents have strongly agreed that the workloads of their core courses affect their performance and that practical projects based on individual is a very essential component of learning entrepreneurship education.

3.3 Outcomes of studying entrepreneurship education by engineering students

On this aspect, the mean score of 2.30 on the acquaintance of the respondents with the concept and terms of entrepreneurship education implies their disagreement with the claim. Then, a mean score of 2.11 indicates that the respondents disagreed with the claim that entrepreneurial knowledge and skills acquired is adequate for them to startup their own business. However, the mean scores of 4.55 and 4.80 on the significance of excursion towards better understanding of entrepreneurship education and that lack of startup capital is a very serious impediment for engineering graduates to establish their own enterprises.

4.0 DISCUSSION

From the analysis of data presented in section 3.1 through 3.3 above, students have good perception and positive attitudes towards Entrepreneurship Education and very high awareness also. This is consistent with the previous works of Chenube *et al.*, (2011) that majority of university students in Delta State have moderate and high entrepreneurial inclination; Kiadese (2008), who found that students in tertiary institutions in Ogun State have high entrepreneurial inclination and Ariyibi (2006), who found that, students in tertiary institutions in Lagos State have positive attitude towards entrepreneurship education.

However, it can be seen from table1 (appendix B) that the grand mean score, X_G = 3.64 while the corresponding sample standard deviation, S = 2.20. This shows a wide deviation from the X_G, which can be attributed to the effect of outliers (i.e extremely high and extremely low values of the individual mean scores).

On the relevance of entrepreneurship education and performance of students in it, they affirmed that the entrepreneurship education presently given seems to lack good management and acceptable content. Many students seem not to grasp the importance of the course. There seems to be no seriousness among many students in the participation of the course based on their results. One can rightly say that many students see the course as one of those unnecessary courses imposed on them to fulfill graduation requirements. The content and delivery of the course lack proper knowledge, preparation and attainment of the aimed goals and objectives. Also workloads of their core courses significantly contribute to their low performances. Then, they also agreed that practical projects based on individuals are very essential components of learning entrepreneurship education. This is consistent with the work of Ifedili (2011) on Managing Entrepreneurship Education in Nigerian Universities, where she found that about 52% of the students score below average. Many students seem not to put in their best, but aim at a minimum pass mark of 40%.

However, the only project given as part of the examination score was a group project. Too many students were grouped together with the result that not all of them made input to the project. All the names of the group members were included in the award of marks. The implication of this is that, those students who did not participate in writing the project have failed to learn the expected knowledge from the project writing. Also, one can rightly say that the students' performance evaluation did not show the true performance of students in the course. The continuous assessment (C.A.), which is very important in students' performance evaluation was difficult to administer due to large class size. The Students' rating, which showed that no continuous assessment was ever administered is very implicating. One wonders if the students were properly evaluated or not or whether they can defend the scores given to them. However, there is room for better performance if the course is packaged and delivered well, so that the aims and objectives of the course are met.

Nevertheless, the X_G of 3.33 from table 2 (appendix B) deviate a little, about 1 point from the S of 2.00. This is due to the skewing of the individual mean scores, with 4.75 as maximum and 1.35 as the minimum and also the generalization of the issue from the most intelligent to the less intelligent.

On the outcomes of studying the course by engineering students, the respondents did not agree that they are well acquainted with the concept and terms of entrepreneurship education. They equally affirmed the inadequacy of the entrepreneurial knowledge and skills acquired. Perhaps, due to the fact that the course runs for only one out of the four semesters duration of their programmes and probably the learning model, which is pure knowledge transfer and theory instead of learning models, which are based on real experiences that will allow to develop those competencies required today to make professionals able to seize new opportunities and transform them into marketable solutions.

They also stressed the need for field trips/excursions to industries and successful entrepreneurs to enhance their understanding of the course. Finally, the respondents strongly agreed that lack of startup capital hinders graduates of engineering from establishing their own enterprises. This is consistent with the observation of Odjegba (2005) that careers in technical education have been blind alleys and the few technical entrepreneurs are frustrated due to lack of funds and incentives.

However, the S of 2.14 deviated a bit wide from the $X_G = 3.44$, which was due to the wide variation in the individual mean scores.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The Entrepreneurship Education delivered in Nigerian Polytechnics is not very challenging. The major students' performance evaluation inform of continuous assessment is neglected. This is because of so many challenges faced by the lecturers. The study showed that students had a positive attitude towards the course. This should be encouraged by managing and delivering the course in such a way that will provoke students' inquisition, knowledge and greater performance.

There is no doubt that the effective implementation of entrepreneurship education curriculum will help learners in Nigerian tertiary institutions to develop entrepreneurial capacities and the ability to be self-reliant and self-employed after graduation. Similarly, shifting from the conventional "regular" entrepreneurship to the modern "technology" entrepreneurship for the engineering students will facilitate the much need Academia – Industry collaboration and will address the critical areas of research and education in technology development, licensing and commercialization of technological innovations and new business development.

Industry, society and engineering schools can—and should—collaborate to ensure a sufficient number of such qualified and capable engineers to meet industry and society needs. By working closely together, Industry and Academia can develop engineers who are not only technically strong, but also creative and able to work well in teams, communicate effectively and create useful products.

5.2 Recommendations

The following recommendations are made to improve the packaging and delivery of Entrepreneurship Education to engineering students for better outcomes:

- ❖ The National Board for Technical Education (NBTE) should ensure that all Polytechnics have well established and well-equipped Entrepreneurship Education Development and Training Centres.
- ❖ Instructors of entrepreneurship education should upgrade their knowledge through in-service training or use of the internet and also try to be reviewing their instructional materials in line with the current global trends for effective and efficient teaching and learning process.
- ❖ Engineering-based lecturers should be selected and trained on entrepreneurship and subsequently take over the teaching of the course for better linkage of entrepreneurial skills with the core engineering courses.
- ❖ Entrepreneurship Education curricula should be reviewed to a more popular format that will involve teaching the practicalities, development and monitoring of business plans as the most important features. They should also assume the format of "technology entrepreneurship".
- ❖ Class size should be broken down into manageable size, instructional materials should be adequate and in good condition and better provision of infrastructural facilities.
- ❖ Continuous assessment should be properly administered to students without failure and intensive field trips/excursions should be carried out.
- ❖ There should be individual project writing. Even if the students had to be grouped, it should not be of more than three students per group.
- ❖ There should be School-based enterprises where students identify potential business, plan, create and operate a small business by using the school as mini-incubators.
- ❖ The government should develop entrepreneur internship programmes by matching students with local successful entrepreneurs with clearly established education programmes;
- ❖ Federal and State Governments should increase the budget for the implementation of this government policy on mandatory Entrepreneurship Education and the budgeted sum should be released in order to actualize the purpose of the fund. Part of this fund should be provided to graduates in form of soft loans to startup their own business ventures and reduction of taxes on small scale businesses.

BIBLIOGRAPHY

Abdullah, S. and Ahcene, S. (2011), The Understanding of Technology Entrepreneurship According to Shariah Principles, *International Conference on Business and Economics Research IPEDR,* 16: 144–150. IACSIT Press, Singapore.

Acs, Z.J. and Storey, D.J. (2004), Introduction: Entrepreneurship and Economic Development, *Regional Studies*, 38(8): 871–877.

Akhuemonkhan, I.A., Raimi, L. and Sofoluwe, A.O. (2013), Entrepreneurship Education and Employment Stimulation in Nigeria, *Journal of Studies in Social Sciences,* 3(1): 55–79.

Akpomi, M.E. (2009), Achieving Millennium Development Goals (MDGs) through Teaching Entrepreneurship Education in Nigerian Higher Education Institution, *European Journal of Social Sciences*, Vol. 8(1): 152–159.

Akudolu, L-R. (2010), A Curriculum Framework for Entrepreneurship Education in Nigeria, *Unizik Orient Journal of Education*, Vol. 5(2): 1–16.

Alabi, T., Alanana, O.O. and Bahal, M. (2014), Entrepreneurship Education: A Panacea to Graduate Unemployment in Nigeria, *Journal of Sustainable Development in Africa*, 16(4): 35–43.

Ariyibi O.A. (2006), Attitude and Awareness of Students in Tertiary Institutions in Lagos State Towards Entrepreneurship Education. Unpublished seminar paper.

Ayatse, F.A. (2013), Driving Entrepreneurship Education in Nigeria: Issues and Challenges, *International Journal of Business and Management Review*, 1(4): 83–90.

Ayodele, J.B. (2006), "Obstacles to Entrepreneurship Development in Nigeria". In F. Omotosho, T.K.O. Aluko, O.I. Wale-Awe and G. Adaramola (Eds). "Introduction to Entrepreneurship Development in Nigeria", Ado-Ekiti, UNAD Press.

Baba, G.K. (2013), The Challenges of Entrepreneurship Development in Nigeria and Way Forward, *Journal of Business and Organizational Development*, Vol. 5(1): 54–64.

Bailetti, T. (2012), Technology Entrepreneurship: Overview, Definition and Distinctive Aspects, Technology *Innovation Management Review.*

Byers, T., Seelig, T., Sheppard, S. and Weilerstein, P. (2013), Entrepreneurship: Its Role in Engineering Education; *The Bridge Linking Engineering and the Society*, 2013 Summer Engineering Education, National Academy of Engineering, Washington DC., Pp. 36–38.

Charlie, N. (2013), Entrepreneurship Education and Challenges to Nigerian Universities, *Journal of Education and Practice,* 4(3): 51–56.

Chenube, O.O., Saidu, R.F., Omumu, F.C. and Omomoyesan, M.B. (2011), Assessing the Entrepreneurial Inclination of University Students in Delta State, *Ife PsychologIA*; 19(2): 426–436.

Cunningham, A.C. (1991), Developing Managers: A Study of the Training and Educational Needs of Public Enterprise Managers, Working paper prepared for the Economic Development Institute of the World Bank.

Di-masi, P. (2004), Defining Entrepreneurship. Retrieved online from www.maito:hsrinivas@gdvs.org on 20/04/2011.

Duval-Couetil, N., Reed-Rhoads, T. and Haghighi, S. (2012), Engineering Students and Entrepreneurship Education: Involvement, Attitudes and Outcomes, *International Journal of Engineering Education,* 28(2): 425–435.

Federal Republic of Nigeria (2004), National Policy on Education. Lagos, NERDC Press, Pp. 29–35.

Filomena, O.S., Manuel, J. S., Sérgio, M., Rui, M. L. and José, D.C. (2013), An Integrated Project of Entrepreneurship and Innovation in Engineering Education, *Mechatronics*, 23: 987–996.

Friijs, C., Thomas, P. and Charlie, K. (2002), Entrepreneurship and Economic Growth: A Critical Review of Empirical and Theoretical Research. Ostersun, Sweden: Institute for Liccvaxt Politiska Studier.

Gartner, W. (1989), “Some Suggestions for research on Entrepreneurial traits and Characteristics”, *Entrepreneurship Theory and Practice*, (14): 27–37.

Ifedili, C.J. and Ofoegbu, F. (2011), Managing Entrepreneurship Education in Nigerian Universities, *European Journal of Educational Studies*, 3(1): 101–109.

Kanothi, R.N. (2009), The Dynamics of Entrepreneurship in ICT: Case of Mobile Phones Downstream Services in Kenya. Working Paper, No. 466, Institute of Social Science, The Netherlands.

Kennedy, O.O., (2013), The Viability of Entrepreneurship Opportunities in Delta State: An Assessment of the Perception of Prospective Graduates, A*frican Journal of Social Sciences,* 3(2): 168–176.

Kiadese, A.K. (2008), Decision Making and Risk Taking Behaviour as Correlates of Entrepreneurial Aspiration of Ogun State Tertiary Institution Students . An Unpublished Seminar Paper.

Léger-Jarniou, C. and Georges, Y.K. (2006), Entrepreneurship and Engineers: How to Develop the Spirit, *Estudios Deeconomíaaplicada*. 24(2): 525–544.

Morenikeji, W. (2006), Research and Analytical Methods for Social Scientists, Planners and Environmentalists. Jos University Press Limited, Jos.

NAE – National Academy of Engineering (2004), The Engineer of 2020: Visions of Engineering in the New Century, Washington: National Academy Press.

Nelson, A.J. and Byers, T. (2010), Challenges in University Technology Transfer and the Promising Role of Entrepreneurship Education. Kauffman: Emerging Scholars Initiatives.

Nwachukwu, L.C. and Nwamuo, P. (2010), Entrepreneurship Development for Sustainable Livelihood among Youths in Imo State: Implications for Counselling, *Conference Proceedings,* CASSON.

Nwagwu, I.O. (2007), Higher education for self-reliance: An Imperative for the Nigerian Economy, NEAP publication, Pp. 1–8.

Odjegba, E. (2005), Building Nigeria’s Entrepreneurship: What Stakeholders Say about Essential Ingredients. Sunday Vanguard, July 3, P. 12.

Ojeifo, S.A. (2013), Entrepreneurship Education in Nigeria: A Panacea for Youth Unemployment, *Journal of Education and Practice,* 4(6): 61–66.

Okojie, J.A. (2009). Imperative of the Federal Government Directive on the Establishment of Entrepreneurship Studies in Nigerian Universities; A Paper Presented at the 1st Conference on Effective Implementation of Federal Government 7-Point Agenda Held at NUC, Abuja, Feb. 4–6.

Raimi, L. and Towobola, W.L. (2011), Open Distance Learning (ODL): A Catalyst for Educational and Entrepreneurship Development in Nigeria, *Continental Journal of Education Research,* 4(3): 1–11.

Sexton, D.I., Smilor, R.W., (1997), "Entrepreneurship", Upstart Publishing Company, Chicago Illinois.

Sheppard, S.D., Sullivan, W.M., Macatangay, K. and Colby, A. (2008), Educating Engineers: Designing for the Future of the Field, San Francisco: Jossey-Bass.

Sofoluwe A.O. (2007), University Education and Youth Entrepreneurship in Nigeria, *International Journal of Educational management*, (IJEM), 5(1): 117–126.

Stanford University (2014), Is Technology Entrepreneurship for You? – A Programme of National Centre for Engineering Pathways to Innovation, accessed online on 03/11/2014, available on: http://dreamdesigndeliver.org/i2v/is-technology-entrepreneurship-for-you/

UNESCO (2005), Entrepreneurship Education and its benefits.

Vesper, K. H. (1990), New Venture Strategies, Englewood Cliffs, NJ: Prentice Hall.

APPENDIX "A"

ENTREPRENEURSHIP PERCEPTION INVESTIGATION (EPI)

SECTION A: Demographic

Department: ………………………………………….……………   Level: ND/HND

Age: ……………   Gender: Male/Female.   Institution: KadPoly/NBPZ

SECTION B: Perception and attitudes of Polytechnic students towards Entrepreneurship Education

S/N	ISSUES	RESPONSES				
		SD	D	N	A	SA
1	Students of Engineering have good perception of **Entrepreneurship Education** and their attitudes towards it is also good					
2	Students of Engineering are aware and informed of the numerous benefits of studying **Entrepreneurship Education**					
3	**Entrepreneurship Education** skills expose students to the numerous available opportunities and prepare them towards being self-reliant					

4	**Entrepreneurship Education** can serve as a tool to reduce graduates' unemployment and reduce poverty					

SECTION C: Relevance of Entrepreneurship Education to students and their performance in the course

S/N	ISSUES	RESPONSES				
		SD	D	N	A	SA
1	The contents of **Entrepreneurship Education** curricula are relevant to the engineering students					
2	The instructors administer the Continuous Assessment (CA) component of the course properly					
3	Performance of Engineering students in **Entrepreneurship Education** courses are generally above average					
4	Workloads of core engineering courses affects students' performance in **Entrepreneurship Education**					
5	For more effective and efficient learning of **Entrepreneurship Education,** practical projects need to be carried out by students:					
6	The projects should be individual-based					

SECTION D: Outcomes of studying Entrepreneurship Education by Engineering students

S/N	ISSUES	RESPONSES				
		SD	D	N	A	SA
1	Students become more familiar with the entrepreneurship concept and terms and have broaden career prospects					
2	Study tours and excursions assist towards better understanding of **Entrepreneurship Education**					
3	The knowledge and skills acquired are adequate for prospective entrepreneurs to startup a small business after graduation					
4	Lack of startup capital can be a serious barrier for graduates of Engineering courses to establish their own enterprises.					

APPENDIX "B"

Table1: Mean rating of the perception and attitudes of students towards entrepreneurship education

S/N	ITEM	X	X_G	S	REMARK
1	The Students of have good perception of entrepreneurship education and their attitudes towards it is also good.	3.86	3.64	2.20	Agree
2	The Students are aware and informed of the numerous benefits of studying **Entrepreneurship Education**	4.52			Agree
3	**Entrepreneurship Education** skills expose students to the numerous opportunities and prepare them to be self-reliant	2.61			Neutral
4	**Entrepreneurship Education** can serve as a tool to reduce graduates' unemployment and reduce poverty	3.55			Agree

X = Mean; X_G = Grand mean; S = Sample standard deviation.

Table2: Mean rating of the Relevance of Entrepreneurship Education to students and their performance in the course

S/N	ITEM	X	X_G	S	REMARK
1	The contents of **Entrepreneurship Education** curricula are relevant to the engineering students	2.35	3.33	2.00	Disagree
2	The instructors administer the Continuous Assessment (C.A.) component of the course properly	1.35			Disagree
3	Performance of Engineering students in **Entrepreneurship Education** courses are generally above average	2.40			Disagree
4	Workloads of core engineering courses affects students' performance in **Entrepreneurship Education**	4.50			Agree
5	For more effective and efficient learning of **Entrepreneurship Education,** practical projects need to be carried out by students:	4.75			Agree
6	The projects should be individual-based	4.60			Agree

X = Mean; X_G = Grand mean; S = Sample standard deviation.

Table3: Mean rating of the outcomes of studying Entrepreneurship Education by the students

S/N	ITEM	X	X_G	S	REMARK

1	Students become more familiar with the entrepreneurship concept and terms and have broaden career prospects	2.30	3.44	2.14	Disagree
2	Study tours and excursions assist towards better understanding of **Entrepreneurship Education**	4.55			Agree
3	The knowledge and skills acquired are adequate for prospective entrepreneurs to startup a small business after graduation	2.11			Disagree
4	Lack of startup capital can be a serious barrier for graduates of Engineering courses to establish their own enterprises.	4.80			Agree

X = Mean; X_G = Grand mean; S = Sample standard deviation.

INNOVATIONS IN ENGINEERING AND TECHNOLOGY

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ABSTRACT

Innovation in engineering is the creation of new indigenous methods, approach, processes, tools and machines to solve designated problems after series of researches and experimentations. Innovation leads to development of sustainable technology by creating the ability to detect problems, desire to create feasible solutions and lastly practical implementation of the solutions. Understanding the process of innovations determines the type of approach and tool to apply when handling problems. The use of modern tools such as CAD/CAM enables innovators to design and simulate concepts with minimum cost. University plays a major role in technological innovation because it develops potential innovators, hence creating the need for universities to harness these opportunities through continuous research and commercialization of developed projects. These will excite future innovations; generate funds for further researches and most importantly satisfy the end user with the promoted product. Due to globalization, there are trends in technological demand that guide innovations.

Keywords: Develop, Problems, Solutions, tools, Commercialize

1: INTRODUCTION

1.1 Overview

This paper discusses the prospects of innovations in engineering highlighting the advantages, ways and tools of innovations and lastly motives that can lead to creativity as key parameters for innovation.

The world is in constant demand of new technological innovations due to high demand for perfection, simplification of processes, better productivity, efficiency, and quality of goods and services. This drives the engineering industry to innovate solutions to cater for the ever growing human needs. Nigeria as a nation is suffering from many challenges, mostly engineering problems, such as power, roads, railways, automobiles, manufacturing, mechanized agriculture etc. These problems persist because of lack of innovations and motives to innovate. As a nation there is a need to understand that no other country will solve the technological deficiencies except Nigerians. Hence there is a need for Engineers/Technologists to rise up to the challenge and cater for the technological needs to enable various industries to prosper.

Okpara (2007) stated that innovation is the process of bringing the best ideas into reality, which triggers a creative idea, which generates a series of innovative events. Innovation is the process that transforms new ideas into new value- turning an idea into value. Innovation in engineering is

the creation of new indigenous methods, approach, processes, tools and machines to solve designated problems after series of researches and experimentations.
To innovate, one requires the ability to detect problems, the desire to create/design a feasible solution, actualization of the proposed solution into practice and further development of existing technologies. These few steps in summary complete the circle of innovation.
Innovation has numerous advantages which includes development of sustainable technology. When technology is developed locally using local resources to suit local needs gives the comparative advantage to imported technology in terms of sustainability. That is maintenance, fabrication of parts, further research and development to improve the efficiency. Most importantly, innovating locally leads to development of human capital and creation of sustainable wealth.

Appropriate tools are required for innovation to prosper and yield the desired output. Because innovation is a result of continuous research and experimentation; therefore modern tools such as CAD/CAM are of great essence. CAD/CAM allows the innovator to design and simulate concepts, develop models to ensure conformity with design before actual fabrication. This saves money, time and resources. To complement the CAD/CAM applications, other tools such as laboratories and workshops are required to enable development of concepts into feasible solutions.

Lastly the ability to innovate is driven by the motives to solve problems. These motives can induce upcoming and practicing engineers to be more creative and solve our technological deficiencies within our various industries as stated earlier. The motives includes desire to achieve/solve problems by offering solutions were needed, the patience to keep researching and experimenting after series of failures until the desired result is obtained and desire to build a profitable business by offering technical solutions to industrial problems. The universities have to play a leading role in providing the necessary support to innovators through creation of avenues to commercialize researches. They can achieve this by synchronizing industrial demands with academia, through researches that are result oriented to serve local industrial needs commercially.

1.2 Aims

The aim of this paper to provide a guide in refocusing academia into research hubs that are resolved to providing sustainable solutions by taking the lead in research and development of new and more efficient technology to serve our industrial needs and aid the prosperity of the nation through wealth creation. This will enable proper utilization of our natural and human resources.

1.3 Objectives

1. Develop local traditional methods into mechanized processes.
2. Nurture and motivate future innovators.
3. Identify and prioritize industries to aid with researches.
4. Create channels through which feasible projects can be commercialized.

1.4 Challenges

1. Lack of power
2. Inconsistent policies.

1.5 Strength

1. To build technology less dependent on power which could be well compensated with available labor hence creating employment.
2. At the market level national policies do not really reflect, while market forces (demand and supply) take control. If suitable products could be developed through innovative technology the market will absorb the products.

2 DISCUSSIONS

2.1 Principles of Innovation

Innovation as any other technique has its principles which guide the process of implementation. According to Peter (2002), innovation has the following principles:

1. Purposeful, systematic innovation begins with the analysis of the sources of new opportunities.
2. Innovation is conceptual and perceptual, innovators must go out and look, ask, and listen to get good concepts and feedbacks.
3. To be effective, an innovation has to be simple and focused.
4. Effective innovations start small.
5. Innovation is work rather than genius; hence knowledge, ingenuity and focus are essential.

2.1.1 Types of Innovation

Innovations can take several types depending on where it is targeted and the goals expected to achieve. There are two major forms in engineering, which are:

1. Processes innovation, this is the development of new ways, methods and processes that will change and improve current ones to increase the general productivity and efficiency. This in return reduces cost while increasing demand by increasing supply.
2. Product or Service innovation, either by further developing existing products to enhance market reach or creation of a new non existing product thereby opening up an entire new market.

2.2.2 Advantages of Innovation

1. Mass production: innovating to develop our local technology will improve the volume of production and standard. This improves market share drastically due to increase in supply.
2. Developing available resources: innovation creates the opportunity to develop local resources efficiently and improve their value.
3. Cost reduction: innovation brings about reduction in cost of production through development of more efficient technology to serve the industries better.

4. Wealth creation: innovation creates wealth through understanding and exploring untapped resources. Creating new ways to process local resources and add to their value.
5. Employment: innovation leads to job creation by creating/developing industries that did not exist before.
6. Innovation leads to continuous growth of businesses and attainment of greater heights hence gives the competitive edge. Tidd et al. (2006) stated that innovation contributes to achieving a competitive advantage in several aspects, which are:

I. A strong relationship between market performance and new products.
II. New products help maintain market shares and improve profitability.
III. Growth also by means of non-price factors (design, quality, individualization, etc.).
IV. Ability to substitute outdated products (shortening product lifecycles).
V. Innovation of processes that lead to production time shortening and speed up new product development in comparison to competitors.

2.3 Elements of Innovation

The key factors for successful sustainable innovations are referred to as the elements. Using simple terms, Okpara (2007) identified the following elements of innovations;

1. Challenge: What we are trying to change or accomplish-the “pull”
2. Customer focus: Creating value for your customers – the “Push”
3. Creativity: Generating and sharing the idea(s) - the “brain”
4. Communication: The flow of information and ideas –the “life blood”
5. Collaboration: People coming together to work together on the idea(s) – the “heart.”
6. Completion: Implementing the new idea-the “muscle”.
7. Contemplation; Learning and sharing lessons lead to higher competency-the “ladder”
8. Culture: The playing field of innovation includes
9. Context: Innovation is shaped by interactions with the world..

2.4 Cycle of Innovation

Innovation starts with the identification of the problem, the opportunity to innovate. To ensure it’s a feasible opportunity we state the problem fully while identifying who benefits from solving the problem and the need to solve the problem.

Then understanding the problem another fully by identifying all characteristics of the problem and how to approach the problem.

Compile all related researches and information to serve as the bedrock of your innovation. Then state all assumptions and problem parameters.

Innovate ideas and concepts.

Develop the ideas and concepts, select suitable concepts and test. If successful, proceed to develop the innovation and ensure conformity to standards before commercialization.

The cycle of innovation does not stop with commercialization, hence breaks the cycle. Existing technologies are further developed as there is always room for improvement. Figure 1 in the appendix shows the schematic diagram of cycle of innovation.

2.5 Tools and Motives for Innovation

Innovation is a very technical process that requires continuous research and trials hence could be capital intensive. Having the right tools will aid innovation as it reduces time of developing concepts, gives the opportunity to prototype easily and motivate innovation. Tools and innovation are directly related as having the appropriate tools will boost creativity to its optimum. Urbancova (2013) stated that individuals who are holders of knowledge represent a tool for the generation of innovations. Thanks to their personal creativity, their knowledge, skills and abilities it is possible to generate new innovative ideas that will help organizations to achieve a competitive advantage.

2.5.1 CAD/CAM as Tool for Innovation

Abubakar (2010) stated that CAD is the use of computer technology for design and design documentation. CAD/CAM applications are used to both design a product and program manufacturing processes, specifically, CNC machining. CAD presents the possibility for making instantaneous changes when the need is identified without having to create new designs and develop new designs documents.

According to Bilalis (2000) CAD systems can shorten the design time of a product. Therefore the product can be introduced earlier in the market, providing many advantages to the company.

2.5.1.1 Computer Aided Engineering Tools

Engineering analysis is concerned with analysis and evaluation of engineering product designs such as FEA, tolerance analysis, design optimization, mechanism analysis, and mass property analysis are some of the computer aided techniques available to engineers for the purposes of analysis and evaluation of the engineering product designs. They are used to complement the output of CAD applications to ensure feasibility of designs.

2.5.1.2 3D Printing

3D printing is the process of additive manufacturing where a material is deposited layer by layer to develop a solid part from a CAD application. This process brings about flexibility in production of prototypes from a click of a button. This boosts innovation by providing the opportunity to visualize concepts and analyze for improvements. 3D printing has other applications such as; Healthcare (Dentistry), Architecture and civil engineering modeling, metal casting, toys etc.

2.5.2 University as a Tool for Innovation

As discussed earlier innovation requires effort, knowledge and focus hence universities are identified as a major tool and a high source of inspiration for innovation through development and nurturing of innovators, providing the desired atmosphere for innovation to prosper and ensure proper utilization of research outputs through commercialization. For the universities to achieve the goal of leading technological revolution through innovation, they have to strongly adapt the following strategies and model them to their various field of expertise.

2.5.2.1 Collaboration

Christina (2008) identified Collaboration can increase the quality of research and education with respect to its relevance for society, which hence contributes to an increased economic growth. Collaboration can greatly be achieved through the concept of knowledge transfer; universities being the home of knowledge should constantly collaborate with industries to transfer knowledge into improved technology. Collaboration could be achieved with the use of tools like idea bank and open innovation. Idea bank is a platform, were professionals, researchers and investors meet share, and share ideas for easy access by all stakeholders. Open innovation is a system designed to allow sharing of ideas between different organizations researching in areas of common interest. Therefore, the act of innovating with partners by sharing risk and sharing reward.

2.5.2.2 Commercialization

This is the act of introducing new feasible products and methods into the market after careful development of the product to serve a purpose. This is a very critical aspect of innovation as it completes the cycle of innovation by ensuring the technology serves its purpose by reaching the end user. Commercialization creates the opportunity to re-innovate by generating feedback on existing technology and the needs of the market for further development. For universities to sustain innovation they have to devise appropriate channels to commercialize developed technologies and prioritize completion, and perfection of researches to marketable standards. Figure 2 & 3 in the appendix shows the rate of contribution of licensed products from the universities to US GDP and industrial output. Therefore the figures were used to defend the need for universities to innovate feasible solutions. This indicates the importance of innovations from our universities.

2.5.2.2.1 Channels for Commercialization

According to OCE (2005) there are three broad channels for the commercialization of your technology:

1. Selling or assigning ownership of the technology to an existing company
2. Licensing the technology to an existing company
3. Starting a new company

The choice of the right channel is critical. Key variables that can affect this decision include the nature of the technology itself, the industry it will be applied to, and the objectives of the inventor. Figure 4 in the appendix shows the chart indicating the steps to commercialization of innovation.

Even though, the most profitable channel is starting up a new company but it comes with so many challenges such as startup capital and other experiences. Therefore most universities tend to license out there innovations.

Based on this argument the concept of licensing was considered. Licensing is the act of selling rights to technology development or commercialization companies to develop and market the newly innovated technology. Licensing could either be exclusive or non-exclusive depending on the terms of agreement. Licensing generates funds to further develop the research while reducing the risk on innovator by sharing responsibilities with the investor. Figure 5 in the appendix shows the survey on US universities using a table to indicate the amount of innovations per universities, how many are licensed, how many were started up and how much each university generated from their innovations. The figure indicates the importance of licensing in innovation.

2.5.2.3 Idea Development Competitions

These are competitions designed to harness and bring out the best out of innovators by giving them the platform to showcase what they can offer to the technology industry. This will serve as an avenue to bring together innovative minds to offer solutions to specific problems. Feasible innovations are further developed to standard products Incentives are rewarded to winning innovators to acknowledge their effort and motivate future participants. The competition could be designed to serve the industry in terms of types of criteria for innovation to be set and the participation of industry stakeholders at the planning and development aspects.

2.5.2.4 Patenting/Intellectual Property

An invention is a solution to a specific technological problem and is a product or a process. Patents are a form of intellectual property protecting the effort of the inventor. To promote innovation within the university a form of protection must be provided through sourcing of patents on innovations with market potentials.

2.5.2.5 Incentives

Innovation prizes, incentive pay, faculty bonuses, and seed funding have been proposed that reward outstanding ideas. The view is that universities can create monetary award prizes that go to the best idea. This would give inventors and institutions of higher education financial incentives beyond the market value of their ideas to commercialize their discoveries we can see an applicable system of promoting innovations and rewarding systems.

2.5.2.6 Technology Transfer

In order to expedite innovation, some universities have developed "proof-of-concept centers" that provide funding and commercialization expertise to early-stage innovators so that they can get advice on promising inventions (Allen, 2010).

2.5.2.7 Diverse Innovation

Innovate across all fields/departments of the institution as technology cuts across all fields simplifying and perfecting methods. Universities should understand the dynamics of innovation vary considerably across academic disciplines. With current advancements in technology every discipline demands for more efficient tools to aid their work. Therefore makes it necessary for universities to research and innovate broadly.

2.5.2.8 Continuous Research and Development

To maximize innovation in the university the habit of continuing previous researches must be strongly adopted. Instead of issuing new researches or projects always, emphasis should be placed on development and improvement of existing researches thereby perfecting them and raising their standard. This will add to their commercial value and more attractive to investors. Figure 6 in the appendix shows the importance of research in wealth creation and as it creates opportunity for other researches.

2.6 Current Trends in Global Innovations

As time changes, the needs of the world tend to differ due to change in population, climate, globalization and trade demands. Hence the technology required to cater for the world needs changes, new innovations are required to suit the demands. According to Meieran (2011), a slight comparison between the technological demands of the 20th Century and 21st Century in Table 1, indicating the area of prioritized innovations.

	20th Century Innovation Topics	**21st Century Innovation Topics**
1.	Electrification	Energy conservation
2.	Automobile	Resource protection
3.	Airplane	Food and water production and distribution

4.	Water supply and distribution	Waste management
5.	Electronics	Education and learning
6.	Radio and television	Medicine and prolonging life
7.	Agricultural mechanization	Security and counter-terrorism
8.	Computers	New technology
9.	Telephone	Genetics and cloning
10.	Air conditioning/refrigeration	Global communication
11.	Interstate highways	Traffic and population logistics
12.	Space flight	Knowledge sharing
13.	Internet	Integrated electronic environment
14.	Imaging	Globalization
15.	Household appliances	AI, interfaces and robotics
16.	Health technologies	Weather prediction and control
17.	Petrochemical technology	Sustainable development
18.	Laser and fiber optics	Entertainment
19.	Nuclear technologies	Space exploration
20.	High-performance materials	Virtualization" and VR
21.		Preservation of history
22.		Preservation of species

Table 1: Comparison between 20th century and 21st century innovation (Meieran, 2011)

The technology industry has transferred drastically in the last few decades due to advancement in information technology. Information technology has created the opportunity to innovate as it simplifies processes and methods. Hence, makes the innovation process easier and less hectic. Ngak (2013) reported that the top ten technology trends to watch in the year 2014 are as discussed below;

1. Space tourism, the idea of shooting tourist to space is being developed by Virgin Atlantic, the “Space liner”.
2. Wearable tech, Google is expected to ship its groundbreaking augmented-reality glasses to the public in 2014, expanding the wearable tech market. Smart watches like Samsung's Galaxy Gear watch and the Pebble Smart watch will continue to be more useful.
3. Internet of things, Philips demonstrated a concept called the Home Cooker Next that could time cooking, change temperature and stir food using a smart phone
4. Robots on the rise, the development of more intelligent machines through artificial intelligence.
5. Machines in the sky, that is unmanned aerial vehicles or drones are about to become a big part of the airspace.
6. Bigger, smarter TVs, A growing market of smart TVs will continue to expand, with more households having the option to browse the Internet, launch apps and have social interactions through their TV sets.
7. 3D printed everything; the future of 3D printing is bright and may hit the mainstream soon. According to growth projections by IDC, 3D printers units will have a compound growth rate of 59 percent and revenue growing by 29 percent from 2012 to 2017.
8. Multi-screen world, TV shows is now a thing. As more mobile devices hit the market in 2014, so will more opportunities for a second-screen experience.
9. The fight for privacy,
10. Smart phones.

3: CONCLUSION

In conclusion innovation is a very vital factor in engineering and technology as it serve as the back bone for the development of any nation, organization or enterprise. To achieve this we have to create the appropriate environment for it to prosper and make its targeted impact.
The talent to innovate will remain dormant unless it is harnessed and transmitted into real value thereby creating massive wealth with high level of human development. Prioritizing the development of relevant technology that will make the most impact in the generation of wealth should be the first step. Emphasizing on the need to innovate ways to develop our local methods into mechanized processes, hence creating new markets with the introduction of better processed goods in mass. Concentrating efforts on developing researches that are of direct input to our local

industries and the need to develop ways to mass produce innovations for commercialization purposes is key to sustainable development.

If student innovations are being further developed for commercial purposes, then this will serve as huge source of inspiration and motivation for innovations within the university. Some of the undergraduate projects identified with high market potentials due to the industry they serve are as listed; Dandy Horse Machine, Water Dispensing Machine, Bio Fuel Distiller, Windmill Blades, Refrigerating System, Grain Sieving Machine, Feather Plucking Machine, Aluminum Bending Jig, Juice Extractor, Rice Milling Machine etc. These projects could be further developed by engaging the end user efficiently and getting feedbacks to upgrade the standard of the product.

According to Petre (2003), companies do not just wait for inspiration to strike, and they do not just wait for customers to deliver problems to them. They actively seek opportunities for the sort of innovation that will produce intellectual property that they can sell.

3.1 Recommendations

1. Prioritize the need to further researches on feasible projects.
2. Improve access to research facilities (i.e. laboratories, libraries etc.).
3. Make both local and international grants accessible to innovators.
4. Promote commercialization of developed projects through symposiums and trade fairs.
5. Attract investors to buy into developed projects or invest in the development of projects related to them.
6. Should develop a system to protect intellectual property through patenting and licensing agreements.
7. Develop project development competitions with attractive incentives for feasible projects.
8. Develop appropriate systems to nurture innovators that will solve our technological deficiencies.
9. Set achievable targets for various faculties/ departments, workshops, laboratories and research centers.
10. Using the system of Cambridge Enterprise of Cambridge University, London as case study, a proper **,** suitable commercialization system could be adopted. **www.enterprise.cam.ac.uk/**.

REFERENCE

Abubakar A. (2010), Computer Aided Design: The role of CAD in innovation, quality improvement and standardization of engineering design for machinery, process equipment, general design and manufacturing.

Allen, D. (2010), 'University Technology Transfer Effectiveness', University of Colorado.

Barrow A, La Royce B, Alex B, Nathalie D, Latanya S, Jeffrey S, Phyl S, Phil W, (2014) 'AUTM Technology Transfer Practice Manual', an AUTM Primer.

Bilalis N. (2000) 'INNOREGIO: Dissemination Of Innovation And Knowledge Management Techniques by Computer Aided Design CAD', Technical University of Crete.

Christina J. (2008) ‘University strategies for knowledge transfer and commercialization - An overview based on peer reviews at 24 Swedish universities 2006’, VINNOVA Report VR 2008:17, VINNOVA - Swedish Governmental Agency for Innovation Systems / Verket för Innovations system.

David R, Jennifer B, Sumiye O, and Mark P (2009) Final Report to the Biotechnology Industry Organization the Economic Impact of Licensed Commercialized Inventions Originating in University Research, 1996-2007.

Darrell, M. W (2012) ‘Improving University Technology Transfer and Commercialization’, Issues in technology innovation. 20 .

Goran R. (2007). The management of knowledge creation of innovation through an intellectual capital lens. VIT

The Ontario Centres of Excellence, OCE and the Intellectual Property Management Offices of Ontario’s Post-Secondary Research Institution (2005) ‘Commercialization Handbook, An Introductory Guide for Researchers’, 1ST ed.

Meieran E S. (2011), Grand challenges for engineering, National Academy for Engineering of the National Academies. http://www.engineeringchallenges.org/cms/7126/8275.aspx

Ngak C., (2013). 10 technology trends to watch in 2014, CBS News, CBS Interactive Inc. http://www.cbsnews.com/news/10-technology-trends-to-watch-2014/

Okpara F. O.(2007) ‘The Value Of Creativity And Innovation In Entrepreneurship’, Journal of Asia Entrepreneurship and Sustainability, 3(2).

Peter F. D. (2002), The Discipline of Innovation. Harvard Business Review, August issue.

Petre M. (2003). Disciplines of innovation in engineering design, Design studies, http://www.creativityandcognition.com/cc_conferences/cc03Design/papers/16PertreDTRS6.pdf

Tidd, J., Bessant, J. & Pavitt, K. (2007). Řízení inovací – zavádění technologických, tržních a organizačních změn. Brno: Computer Press.

Urbancova H. (2013), ‘Competitive advantage Achievement through innovation and technology’, Journal of Competitiveness, 15(1) 1 pp 82-86.

APPENDIX

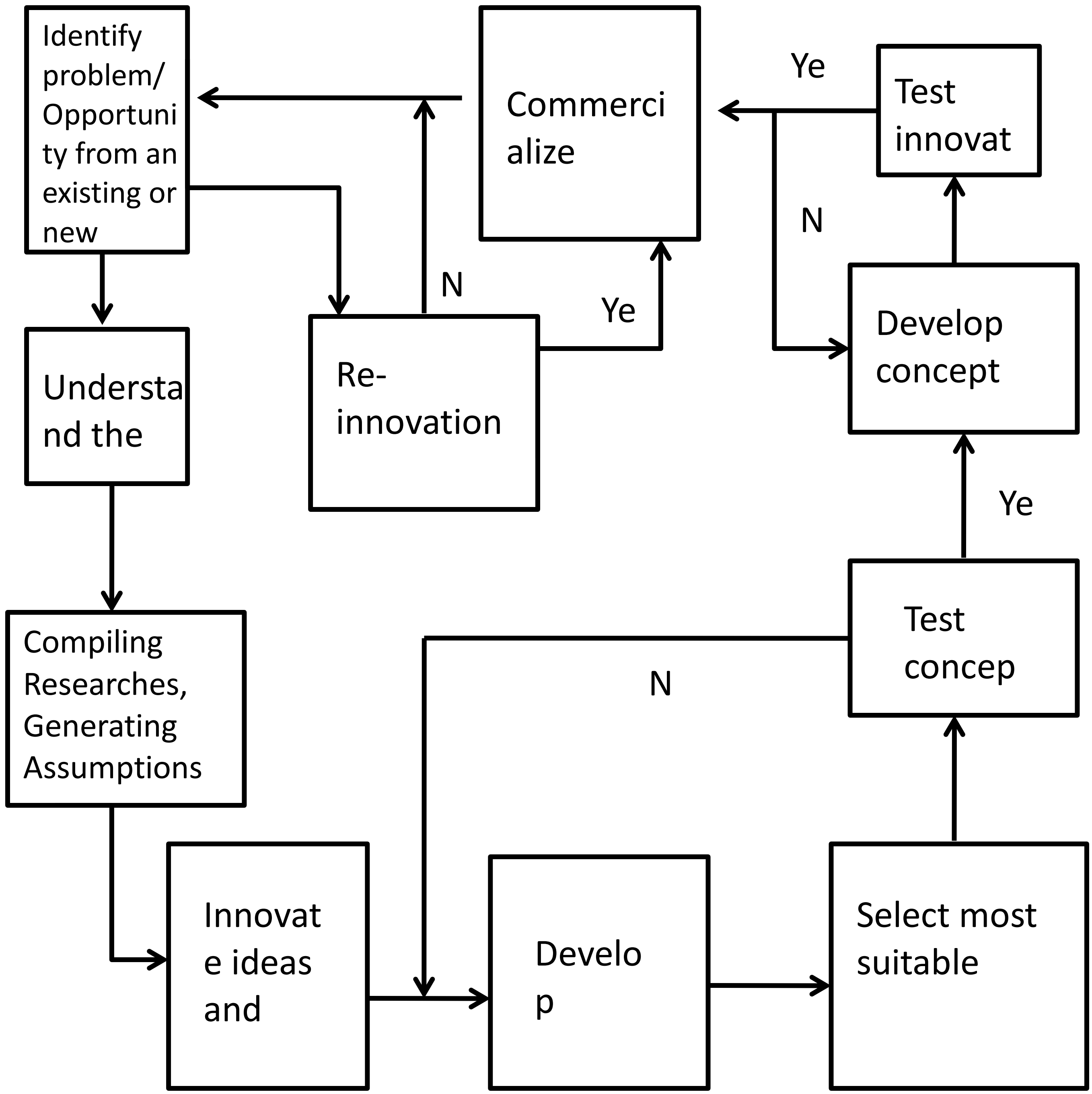

Figure 1: Cycle of Innovation

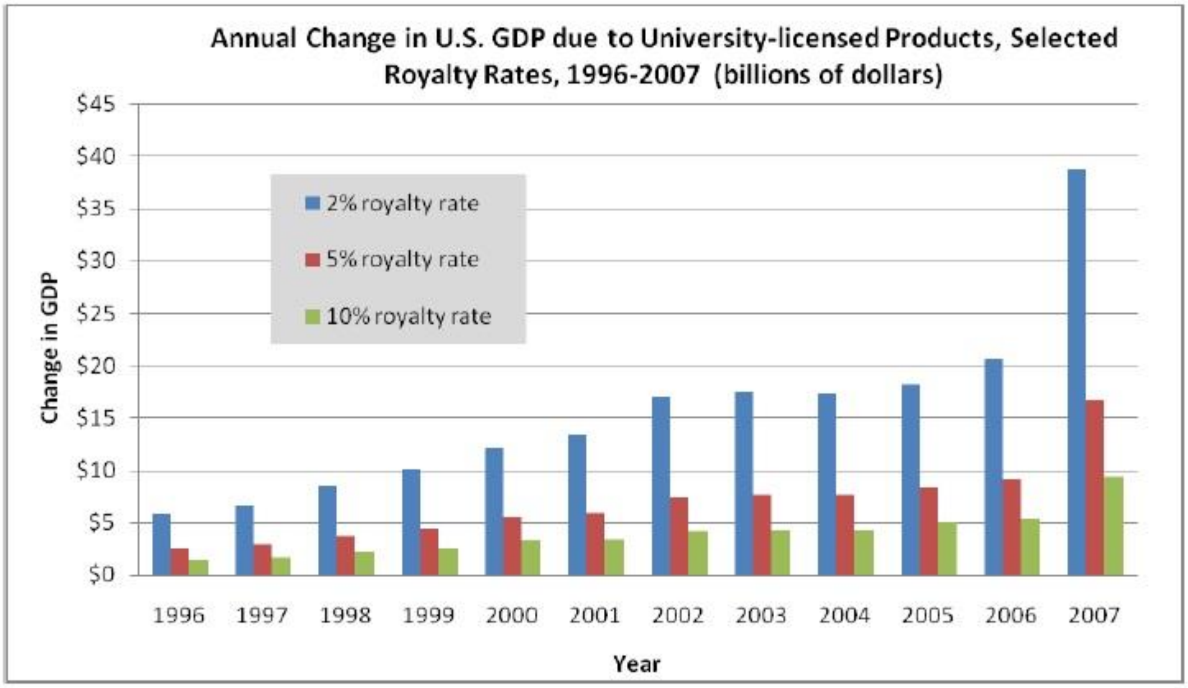

Figure 2: Change in GDP to University Licensed Products in USA (David, 2009)

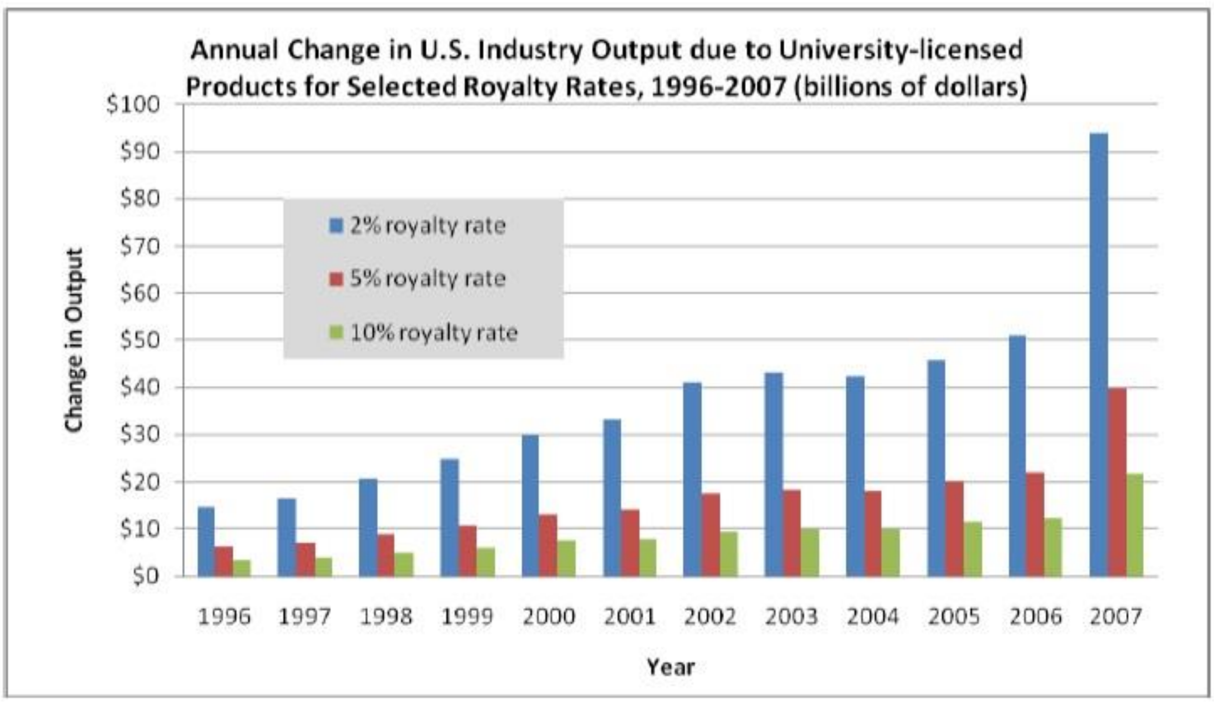

Figure 3: Change in GDP to University Licensed Products in USA (David, 2009)

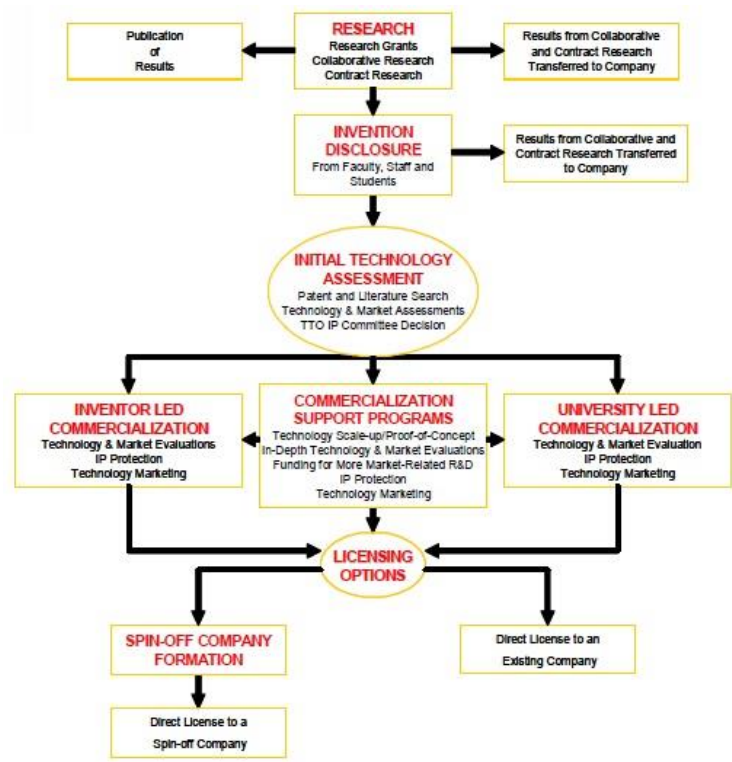

Figure 4: Research commercialization Cycle (OCE, 2005)

University	Invention Disclosures	Patent Applications	Patents Issued	License Agreements	Startups	Program Revenue in Millions
Wisconsin (2010)	350	200	130	61	2	$86.0
Princeton (2009)	77	107	38	33	N/A	$65.6
Stanford (2009)	443	N/A	N/A	77	9	$65.1
MIT (2010)	530	184	166	57	16	$60.1
Washington (2009)	349	262	40	220	10	$50.4
Cornell (2010)	338	420	140	114	N/A	$31.9
UCLA (2009)	333	179	60	37	N/A	$28.9
UC San Diego (2009)	373	286	64	85	9	$26.3
Michigan (2009)	350	151	72	78	8	$18.3
Johns Hopkins (2009)	352	579	46	99	10	$16.2
Harvard (2010)	301	133	38	37	7	$10.1
Wash U. (2009)	125	106	50	44	2	$7.9
Pittsburgh (2010)	225	69	33	54	N/A	$6.1
Colorado (2009)	258	204	24	61	11	$4.4
Source: University Technology Licensing Office Annual Reports						

Figure 5: Innovation by University and the Income generated USA (Darrell, 2014)

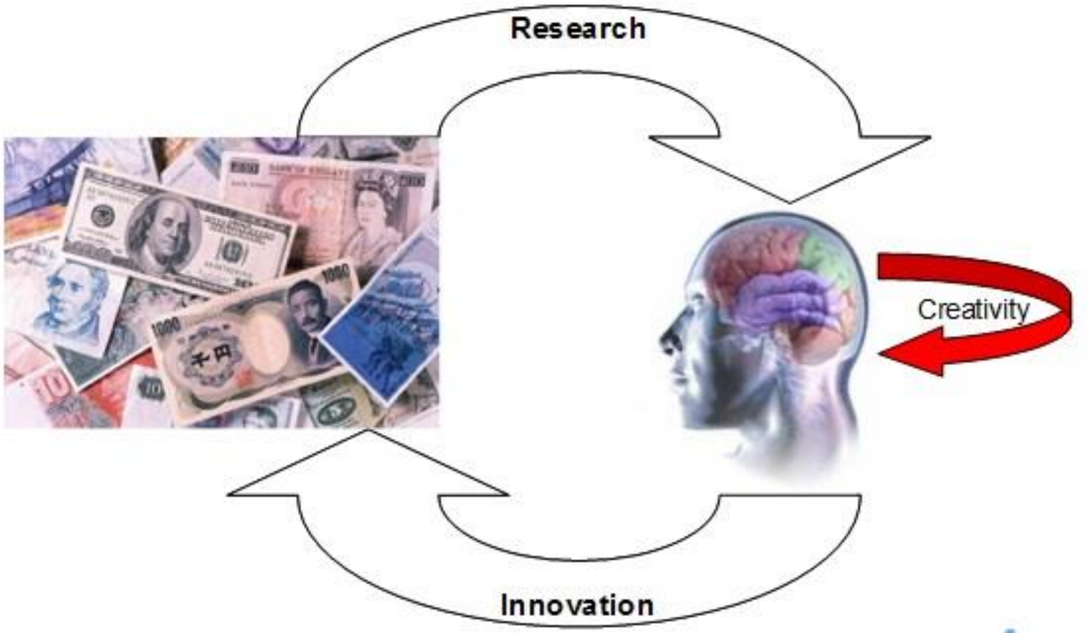

Figure 6: Importance of Continuous Research and Innovation (Goran, 2007)

A PRELIMINARY REVIEW OF THE PHYSIOCHEMICAL CHARACTERISTICS OF SUNFLOWER SEED OIL AS A POTENTIAL FEED STOCK FOR BIODIESEL PRODUCTION.

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ABSTRACT

Environmental concern and limited resources of petroleum oil has increased the demand of biodiesel. One way of reducing the biodiesel production costs is to use the less expensive feedstock containing fatty acids such as inedible oils, animal fats, waste food oil and by products of the refining vegetables oils. Sunflower seeds have oil content of between 38 and 48% on dry weight basis which assume it suitable for biodiesel. This paper analyzed the composition of sunflower seed oil as a potential feedstock for biodiesel production. The lipid fraction of Sunflower seed oil was extracted and analyzed for their chemical and physical properties such as acid value, percentage free fatty acids (% FFA), Iodine value, peroxide value and saponification value as well as viscosity, and density. The fatty acid and triacylglycerol (TAGs) composition of the extracted lipid was revealed using the gas chromatography (GC) and high pressure liquid chromatography (HPLC) method. Both oleic acid (21.1%) and linoleic acid (66.2) were detected as the dominant fatty acids while palmitic acid and stearic acid were the saturated fatty acids found in the Sunflower oil. By these results the sunflower seed oil has great potential as a feedstock for biodiesel production.

Keywords: Sunflower seed oil, Biodiesel, characteristics and Composition of sunflower seed oil.

1.0 INTRODUCTION

Currently due to gradual depletion of world petroleum reserves and the impact of environmental pollution from exhaust emissions, there is urgent need to develop alternative energy resources, such as biodiesel fuel. Sunflower as an annual plant, is one of the most important oilseed crops in the world. Sunflower seeds oil is derived from the seeds of *Helianthus annus* (sunflower plant). According to Raw Materials Research and Developement Council (RMRDC) sunflower crop can grow mainly in the savanna region of Kano, Kaduna, Bauchi Katsina and Gombe States.

Biodiesel is a monoalkyl esters of fatty acids derived from vegetable oils or animal fats. It is usually produced by the transesterification of vegetables oils or animal fats with methanol or ethanol. Biodiesel has many advantages some of which include: Its renewability,, safe for use in all conventional diesel engines, offers the same performance and engine durability as petroleum diesel fuel, non flammable and nontoxic, reduces visible smoke and noxious fumes and odors. The use of biodiesel has grown dramatically during the last few years. Therefore, in recent years several research have been conducted on vegetable oils as biofuel in internal combustion engines . (Pramanik, 2003; Bozbas, 2005). Furthermore, vegetable oil-based products hold great potential for stimulating rural economic development because farmers would benefit from increased demand for vegetable oils. Various vegetable oils, including palm oil, soybean oil, sunflower oil, rapeseed oil, and canola oil have been used to produce biodiesel fuel and lubricants (Demirbas, 2003)

However, in a bid to stem the tide of the growing anxiety over the future of the world's crude oil reserve, this paper intends to examine the technical potentials of biodiesel production using sunflower seed oil to reduce the inordinate reliance on petroleum products as fuel for automobile transport, and to mitigate the emission of greenhouse gas emission caused by the combustion of petroleum products, and also expand its agricultural potentials.

2.0 LITERATURE REVIEW

According to the US Standard Specification for Biodiesel (ASTM 6751), biodiesel is defined as a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. In this context, it can be used in diesel engines and heating systems (Mittelbach et al., 1983; Staat and Vallet, 1994). Biodiesel is an ecologically friendly fuel because it has a lower emission profile than petrodiesel and decreases the greenhouse gas emissions from combustion ignition engines (McCormick and Alleman, 2005). In addition, biodiesel is safer to handle (flash point above 110^{o}C), contains little or no sulfur or carcinogenic polyaromatic components, and decreases soot emission considerably, which is very advantageous in environmentally sensitive areas (Schuchardt et al., 1998; Knothe, 2005). Furthermore, biodiesel is a suitable outlet for the vegetable oil industry requiring little or no changes in current diesel engines when used in blends and also increases engine life due to its superior lubricity over petrodiesel (Knothe, 2005b; Ramos and Wilhelm, 2005). Usage of biodiesel will allow a balance to be sought between agriculture, economic development and the environment. Chemically the oils/fats consist of triglyceride molecules of three long chain fatty acids that are ester bonded to a single glycerol molecule. These fatty acids differ by the length of carbon chains, the number, orientation and position of double bonds in these chains. Because different fatty acids have different physical and chemical properties, the fatty acid profile is probably the most important parameter influencing the corresponding properties of a vegetable oil or animal fat. Thus, biodiesel refers to lower alkyl esters of long chain fatty acids, which are synthesized either by transesterification with lower alcohols or by esterification of fatty acids.(Srivastava A, Prasad R. ,2000)

Biodiesel can be produced from a variety of renewable lipid sources (Schuchardt et al., 1998; Knothe and Van Gerpen, 2005), including soybeans, canola, palm, peanut, physic nut (Jatropha curcas), cotton and sunflower oils. However, some of these oil sources are commodities whose prices are strongly dependent on the international market. Moreover, the food industry imposes a direct competition for this feedstock and this may be critical for a world whose population is increasing exponentially. For these and other reasons, non-edible oil sources are preferable for biodiesel production, particularly those requiring low agronomic demand for cultivation, a reasonable plant cycle, favorable geographic adaptability, high oil content and a low cost for cultivation and harvesting. (Domingos, A.K. et al., 2007)

2.1 Production of biodiesel: Transesterification Process.

The plant oils usually contain free fatty acids, phospholipids, sterols, water, and odorants and other impurities. Because of these, the oil can not be used as fuel directly. To overcome these problems the oil requires slight chemical modification mainly transesterification. Transesterification is the key and foremost important step to produce the cleaner and environmentally safe fuel from vegetable oils. Biodiesel is the monoalkyl esters of long chain fatty acids derived from renewable feed stocks, such as vegetable oil or animal fats, for use in compression ignition engine. Biodiesel, which is considered as a possible substitute of conventional diesel fuel is commonly, composed of fatty acid methyl esters that can be prepared from triglycerides in vegetable oils by transesterification with methanol. The resulting biodiesel is quite similar to conventional diesel fuel in its main characteristics. (Srivastava A, Prasad R., 2000) Transesterification or alcoholysis is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis, except that alcohol is used instead of water [Srivastava A, Prasad R.,2000).

This process has been widely used to reduce the high viscosity of triglycerides. The general transesterification reaction is shown below:

$$\text{Vegetable oil} + \text{Methanol} \xrightarrow{\text{Catalyst}} \text{Biodiesel} + \text{Glycerol}$$

$$\underset{\text{Ester}}{RCOOR^1} + \underset{\text{Alcohol}}{R^2OH} \underset{}{\overset{\text{Catalyst}}{\rightleftharpoons}} \underset{\text{Ester}}{RCOOR^2} + \underset{\text{Alcohol}}{R'OH}$$

Fig. 1. Transesterification reaction of vegetable oil by alcoholysis (Freedman, 1986)

It could be seen from the reaction in equation 1 that triglycerides, as the main components of vegetable oils, react with an alcohol to produce fatty acid mono-alkyl esters and glycerol. Alcohols are primary and secondary monohydric aliphatic alcohols having 1-8 carbon atoms (Sprules and Price, 1950). Among the alcohols that can be used in the transesterification process are methanol, ethanol, propanol and butanol. Methanol and ethanol are used most frequently used, However, methanol is most preferred because of its low cost and its physical and chemical advantages (polar and shortest chain alcohol). It can quickly react with triglycerides, and NaOH as catalyst has the advantage of easy dissolubity. . In this case, the reaction is referred to as methanolysis. The stoichometry of methanolysis reaction requires 3 mol of methanol and 1 mol of triglyceride to give 3 mol of fatty acid methyl ester and 1 mol of glycerol. This reaction, in turn, consists of three consecutive reversible reactions with intermediate formation of diglycerides and monoglycerides. After the reaction, the glycerol is separated by settling or centrifuging and the layer obtained is purified to be used in its traditional applications (the pharmaceutical, cosmetics and food industries) or in its recently developed applications (animal feed, carbon feedstock in fermentations, polymers, surfactants, intermediates and lubricants) (Claude, 1999). The biodiesel phase is washed and purified before being used as diesel fuel. The high viscosity component, glycerol, is removed and hence the product has low viscosity like the fossil fuels. The mixture of these monoalkyl esters can hence be used as a substitute for fossil fuels (Ma and Hanna, 1999)

The Department of Chemical and Process Engineering, Faculty of Engineering National University of Malaysia (UKM), conducted a research on Characteristic and Composition of *Jatropha Curcas* Oil Seed from Malaysia and its Potential as Biodiesel Feedstock, he found out that the major fatty acids in *Jatropha seed* oil were the oleic acid, linoleic acid , palmitic acid and the stearic acid. The most prominent TAGs of Jatropha seed oil were OLL(?) and OOL(?)). The oil extracts exhibited good physicochemical properties and could be useful as biodiesel feedstock and industrial application. Feedstock costs account for a large percent of the direct biodiesel production costs, including capital cost and return. The way of reducing the biodiesel production costs is to use the less expensive feedstock containing fatty acids such as inedible oils, animal fats, waste food oil and by products of the refining vegetables oils. With no competing food uses, this characteristic turns attention to *Jatropha curcas*, which grows in tropical and subtropical climates across the developing world.

Hossain and Boyce Bio-energy Laboratory, Programme of Biotechnology, Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur, Malaysia conducted a research on biodiesel production from waste sunflower cooking oil as an environmental recycling process and renewable energy. The optimum conditions for biodiesel production from WSCO??? &?? PSCO??? have been studied. Result shows optimal condition of sunflower oil biodiesel productions are 1:6 volumetric oil-to-methanol molar ratio, 1 wt. %KOH at 400C reaction temperature. This study has provided evidence that waste cooking sunflower oil may be employed as a substantial source of biodiesel as fuel in diesel engines. Because, the produced biodiesel is of good quality within the array of standard method specifications and the production yield is apt.- up to approximately 99% under optimum conditions. Moreover, this research represented that the production of biodiesel from PSCO??? &?? WSCO??? has no significant differences. Advance research is ongoing to reduce the production cost by developing a method to decrease the emulsification during basecatalytic transesterification and aqueous-washing of the product and readily recovery of glycerin byproduct. Biodiesel from used cooking sunflower oil could be used as a diesel fuel which considered as renewable renewable energy.

3.0 Methodology.

i. Physico-chemical characterization.

The physical and chemical properties of sunflower oil were determined according to standard procedure recommended by AOAC (1980); Pearson (1981), and Pa Qurt, (1979). The oil properties analyzed are: specific gravity, saponification, iodine, and free fatty acid values respectively

ii. Fatty acid determination.

The fatty acid of the oil sample was determined in accordance to the method described by Atasie *et al. (*2009). In this case, about 2 grams of the oil sample was weighed, in a small beaker and dissolved in 50 ml of chloroform, transferred into a hundred volumetric flasks and diluted to the mark with chloroform. 1 mL of the unknown sample was transferred into a 10 ml screw top culture tube with a Teflon liner. Exactly, 1.00 mL of a standard solution of 0.814 mg/mL pentadecanoic acid was then added. The glyceride in the oil sample was esterified as well as the pentadecanoic acid standard. The efficiency for the esterification of the standards is the same as that of the glycerides. Also, the response of the detector of each of the fatty acid methyl ester with the internal standard was the same. Hence, the amount of each ester in the fat was determined by comparing the integrated areas with the known concentration of the standard. Most of the chloroform was then evaporated under a stream of nitrogen until 100µl of the solution remained. 1 mL of interesterification reagent (25% volume of a 12% BF_3 methanol solution, 20 % volume of benzene and 55 % volume methanol) was added. The tube was flushed with nitrogen, sealed and heated in a 100^{o}C water bath for 30 minutes – after which the methyl esters was extracted with hexane and water, the final mixture of the reagent, hexane and water were in the ratio 1:1:1 (adding 1mL each of hexane and water to the reaction mixture). The mixture was shaken thoroughly for 2 minutes. A stable emulsion was formed which was broken by centrifugation. Half of the top hexane phase was transferred into a small text tube for injection.

4.0 Results and Discussion.

The result of the physco-chemical properties of sunflower oil is presented below in table 1.

Table 1: Physio-chemical properties

Parameter	**Value**
oleic acid(%)	21.1
Linoliec acid (%)	66.2
Palmitic acid (%)	4.67
Stearic acid (%)	1.2
Iodine value g/100g	92.2
Saponification value (mg/KOH/g)	192.1
Specific density(35 ºC)	0.918
Refractive Index (35 ºC)	1.4646
Viscosity@35 ºC (g)	58.5
Flash point (ºC)	316
Physical state at room temperature	Liquid

The data collected from the study of the physical and chemical properties of the test samples presented in table 1, shown oil content of Sunflower kernel at 66.2% linoliec acid. High percentage of fatty acid contents of Sunflower seed indicated that Sunflower seed oil are suitable in oleochemical industries (biodiesel, fatty acids, soap, fatty nitrogenous derivatives, surfactants and detergents, etc). The components that support combustion in oil are the basis for biodiesel. These components, called fatty acids, have different properties that can be characterized by the number of hydrogen and carbon atoms and the way these atoms are bonded together. Vegetables oils are usually composed of several fatty acids. This means that the properties of oil will be a mixture of the properties of the fatty acids it contains. It follows that the biodiesel made from the oil will also exhibit a mixture of these properties.

The major fatty acids in sunflower seed oil were identified as oleic acid, linoliec acid, palmitic acid and stearic acid and there structural formula of fatty acid in sunflower oil are presented in table 2.

Table 2. Structural formula of fatty acid in sunflower oil,

Fatty acid	No of carbon and double bonds	Chemical structure
Linoliec acid	C18:2	$CH_3(CH_2)4CH = CHCH_2 = CH(CH_2)7COOH$
Oleic acid	C18:1	$CH_3(CH_2)7CH = CH(CH_2)7COOH$
Palmitic acid	C16:0	$CH_3(CH_{2)}14COOH$
Stearic acid	C18:0	$CH_3(CH_2)$16COOH

Fatty acid with one or more double bond(s) is considered the best choice for biodiesel. From the composition of fatty acid in sunflower seed oil, it was observed that it has high value of linoliec acid followed by oleic acid with double bonds that makes it suitable for biodiesel production. Palmitic acid and stearic acid constituent of sunflower oil, with no double bonds are found to be in small quantities .

The iodine value is a measured of the unsaturation of fats and oils. Higher iodine value indicated that higher unsturation of fats and oils (Knothe, 2002; Kyriakidis and Katsiloulis, 2000). The iodine value of Sunflower oil was determined at 78.4g/100g, standard iodine value for biodiesel was 120 for Europe's EN 14214 specification. The fairly low percentage of fully saturated fatty acid, and poly-unsaturated linoleic and linolenic acids reducues the likelihood of the oil sample to oxidative instability, and provide longer shelf life (Asadauskas and Perez, 1997). However, the limitation of unsaturated fatty acids is necessary due to the fact that heating higher unsaturated fatty acids results in polymerization of glycerides. Nonetheless, it is pertinent to mention, that poor oxidation stability causes fuel thickening, gums and sediments formation, fuel filter clogging and injector fouling. Nonetheless, it is pertinent to mention, that poor oxidation stability causes fuel thickening, gums and sediments formation, fuel filter clogging and injector fouling.This can lead to the formation of deposits or to deterioration of the lubricating (Mittelbach, 1996). Fuels with this characteristic (e.g Sunflower oil, Soybean oil and Safflower oil) are also likely to produce thick sludges in the sump of the engine, when fuel seeps down the sides of the cylinder into crankcase (Gunstone, 2004). High iodine value of Sunflower is caused by high content of unsaturated fatty acid, such as; oleic acid and linoleic acid. It could be seen from table 1, that Sunflower seed oil consists of 66.2% unsaturated fatty acid. In addition, it could be seen from the physico-chemical properties of sunflower oil in Table 1 that; the oil's show high relative density (0.918), and saponification value (192.1 mg/KOH/g). This explains the oil's propensity for soap formation. However, according to Halling (1989), the formation of soapy film provides adequate boundary lubrication and reduces engine wear.

4.0 CONCLUSION.

Sunflower seed oil is mainly a triglyceride. The major fatty acids in sunflower seed oil were the oleic acid, linoliec acid, palmitic acid and stearic acid. The oil extract exhibit good physiochemical properties and could be useful as biodiesel processed by transesterification. It high relative density, saponification values, low content of saturated fatty acid, affordability and avaialability, make sunflower a promising candidate for biodiesel production.

REFERENCES

- Official Methods of Analysis. Association of Official and Analytical Chemist. 13th Ed. AOAC. Washington. D.C.,1980.

- Asadauskas, S and Perez, J.M. Lubrication properties of castor oil-potential base stock for biodegradable lubricants. Lubrication Engineering. 1997, 3p.
- Atasie, V.N., Akinhanmi, T.F. and Ojiodu . Proximate analysis and physico-chemical properties of groundnut (*Arachis hypogaea L.*). Pakistan Journal of Nutrition. 2009. Vol. 8 (2): 194-197.
- Halling, J. Principles of Tribology. Reprinted edn, Macmillan publishers, London. 1989, 116-230 pp.
- Chitra, P., P. Venkatachalam, and A. Sampathrajan 2005. *Optimisation of experimental conditions for biodiesel production from alkali-catalysed transesterification of Jatropha curcus oil*. Journal of Energy for Sustainable Development. 9(3), 13-18
- Demirbas, A. *Biodiesel fuels from vegetable oils via catalytic and non-catalytic supercritical alcohol transesterifications and other method:* A survey. Energy conversion and Management 2003, 44:2093-2109
- Emil Akbar 2209*Characteristic and Composition of Jatropha Curcas Oil Seed from Malaysia and its Potential as Biodiesel Feedstock* European Journal of Scientific Research 2009, 44:396-403
- Hossain, A.B.M.S. and Boyce, A.N. *Biodiesel Production From Waste Sunflower Cooking Oil As An Environmental Recycling Process And Renewable Energy* Bulgarian Journal of Agricultural Science, 2009, 4:312-317
- Lawal, B. A.1, Obigbesan, G. O.2, Akanbi, W. B.1 and Kolawole, G. O. *Effect of planting time on sunflower (Helianthus annuus L.) productivity in Ibadan, Nigeria* African Journal of Agricultural Research Vol. 6(13), pp. 3049-3054, 4 July, 2011
- Gubitz, G.M., Mittelbach M., Trabi M., 1999. *Exploitation of the tropical oil seed plant Jatropha curcas* L. *Bioresource Technology* 67:73-82.
- J. Van Gerpen, B. Shanks, and R. Pruszko, D. Clements, and G. Knothe, "*Biodiesel Production Technology"*, Report from Iowa State University
  for the National Renewable Energy Laboratory, NREL/SR-510-36244, July 2004.
- K. Shaine Tyson, Joseph Bozell, Robert Wallace, Eugene Petersen, Luc Moens, *"Biomass Oil Analysis: Research Needs and Recommendations",* National Renewable Energy Laboratory, NREL/TP-510-34796, June 2004.
- Kalam, M. A. and H. H. Madjuki**,** 2002. *Biodiesel from palm oil – an analysis of its properties and potential*. *Biomass & Bioenergy***,** 23**:** 471-479.

- Mohibbe Azam, M., Amtul Waris, N., and Nahar, M., *Prospects and potential of fatty acid methyl esters of some non-traditional seed oils for use as biodiesel in India.* Biomass and Bioenergy 2005, 29:293–302
- Niotou, A. A., E. K. Kantarellis and D. C. Theodoropoulos, 2008. *Sunflower shells utilizationfor energetic purposes in an integrated approach of energy crops:* Laboratory study pyrolysis and kinetics. *Bioresour Technol***,** 99: 3174-81.
- Pa Qurt, C. IUPAC Standard Methods for the Analysis of Oils, fats and Derivatives. Pergamon Press. Oxford. 1979. pp. 16-162.
- Pearson, D. The Chemical Analysis of Foods. 7th edn. Churchill Livingstone, Edinburgh. 1981. pp 504-530
- Peterson, C.L., R.O. Cruz, L. Perkings, R. Korus and D.L. Auld. 1990. *Transesterification of vegetable oil for use as diesel fuel*: *A progress report.* ASAE Paper No. PNWS90-610. ASAE St Joseph. MI 49085.
- Pramanik, K. 2003 Properties and use of jatropha curcas oil and diesel fuel blends in compression ignition engine. *Renewable Energy* 28: 239-248.
- Remington J.P. and Wood H.C. Fixed Oils. Olea Fixa. The Dispensatory of the United States of America Publications. www.yahoo.com. Retrieved on: 2/05/2006
- Sambo, A.S. 1981. Renewable energy technology in Nigeria: resource availability and potential for application to agriculture. J. Agric. Technol. 3(1):1-4
- Schwab, A.W., M.O. Bagby and B. Freedman. 1987. *Preparation and properties of diesel fuels from vegetable oils.* Fuel 66: 1372-1379.
- Steven Hobbs, *"Bio-diesel, farming for the future",* Presentation to the 11th Australian Agronomy Conference, 2003.
- Veljkovic´, V.B., Lakicevic, S.H., Stamenkovic, O.S., Todorovic, Z.B., Lazic, K.L., 2006. *Biodiesel production from tobacco (Nicotiana tabacum L.) seed oil with a high content of free fatty acids. Fuel* 85: 2671–2675.
- Weber, J.A., 1993. *The economic feasibility of community-based biodiesel plants*. Master's thesis, Department of Agricultural Economics. University of Missouri, Columbia.

DETERMINATION OF DISTRIBUTION GENERATION PLACEMENT IN A DISTRIBUTION NETWORK CONSIDERING STABILITY INDEX

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ABSTRACT

This paper present an approach to determining the most sensitive bus for distributed generation placement in a typical radial distribution network. The approach determined the most sensitive node using a stability index known as apparent power loss. In addition the effect of distributed generation placement on the system security is investigated. Simulation was carried out using a Matlab Script and was tested on a 33-Bus IEEE distribution network. Based on the result obtained distributed generation placement on a network reduces the tendency voltage instability, due to an improvement in active transfer loss of 8.1%, 14.26% and 18.15% when a DG was placed at locations 18, 33 and 32 as compared to the active transfer loss of 0.6667p.u prior to DG placement. While a minimum voltages of 0.9212, 0.9342 and 0.9421p.u was recorded, with DG placed at bus 18, 32 and 33 respectively as compared to minimal voltage of 0.9125p.u prior to DG placement

Keywords*: System Security, Stability Index, Distributed Generation (DG), Active Power transfer*

Introduction

With increasing growth in customer demand and consistent exploitation of the existing distribution network, the tendency of occurrence of voltage collapse or voltage instability has become more pronounced. Also, the high possibility of voltage instability in distribution network, has facilitated the need to control both active and reactive power, so as to mitigate the consequences arising from voltage collapse. Thus the need to identify the most sensitive node susceptible to the problem of voltage instability has become critical (Cutsem and Vournas, 1998). As a way of mitigating the problem of voltage instability, distributed generation is used to offer voltage support. However for the solution to be effective, there is need for identifying the most sensitive node susceptible to the problem of voltage instability.

The problem of voltage instability is characterized in such a way that the voltage magnitude of the system decreases gradually until the system reaches near the collapsing point. At this point the system reaches some maximum admissible load beyond which a power flow solution no longer exists (Eminoglu and Hacaoglu, 2007). For efficient operation and management of distribution networks, there is need to adequately prevent the occurrence of voltage collapse. Increasing connection of distributed energy source in the distribution network, the need to ascertain the effect of such distributed energy source in minimizing the problem of voltage collapse.

Earlier work on determining the voltage stability index as contained in (Venikov *et al.*, 1995), was based on performing load flow analysis. The major problem with this approach, is that it relied heavily on the need for convergence of the load flow solution, without necessarily acknowledging that divergence might not signify instability. In work of (Chebbo and Irwing, 1992), a bus stability indicator is presented by computing the ratio of thevenin equivalent impedance to the load impedance at a given bus. The work failed to acknowledge that computing the bus impedance matrix for a distribution network may not be obtained due to singularity of the admittance matrix. This approach in determining voltage stability is not suited for a distribution network. The work of (Gubbina and Strmcnik, 1997) formulated the problem of voltage stability using Jacobian matrix of the reduced system. The work of (Eminoglu and Hacaoglu 2007), formulated the use of transferred active and reactive power of the distribution line in a reduced form. Although, the work considered the effect of different static loads, but this added to the computational complexity of their approach. (Ettehedi and Vaez-Zadeh, 2012), presented the use of distributed generation placement to solve the problem of instability. The work of (Subramanyam, 2009), adopted the use of distributed generation penetration level to solve the problem of voltage stability index. This approach ranked the respective buses based on the computed voltage index to identify appropriate location for siting distributed generation. The problem with (Subramanyam, 2009), was its failure to identify heavily loaded bus. The main focus of this paper is to identify the most susceptible bus to voltage instability for distributed generation placement for mitigating the problem of voltage collapse using an index known as apparent power loss.

The rest of this paper is organized as follows: the next section explain the problem of voltage instability. Section III, present the fundamental derivation of apparent power. Section IV, gives a detail of the developed algorithm. Section V detail the analysis and result obtained from the test system.

II. Problem of Voltage Instability of a Distribution Network

The problem of voltage collapse occurs in a heavily loaded system that lacks sufficient reactive power sources and cannot provide adequate voltage profile to maintain the system. The shortage of reactive power often leads to wide area black out and voltage instability in the network (Ettehedi and Vaez-Zadeh, 2012). With increasing awareness and the use of distributed generation such as solar photovoltaic cell, other renewable energy source in distribution network, the problem of voltage instability can be reduced and enhance improve the performance of the network (system security).

III. Mathematical Model of the Stability Index

Consider a single-line model of a 2-bus distribution system as in Figure 1.

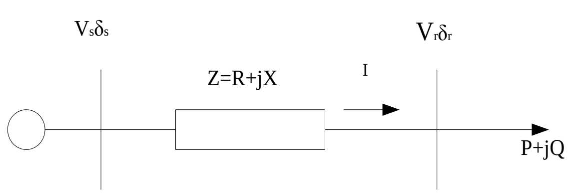

Figure 1. Shows a Single Line of a Two Bus network Distribution System

By applying Kirchhoff's voltage law

$$|V_r|\angle\delta_r = |V_s|\angle\delta_s - |I|Z \qquad (1)$$

$$|V_r|(\cos\delta_r + j\sin\delta_r) = |V_s|(\cos\delta_s + j\sin\delta_s) - |I|(\cos\theta + j\sin\theta)(R + jX) \qquad (2)$$

$$|V_r|\cos\delta_r + j|V_r|\sin\delta_r = |V_s|\cos\delta_s - |I|(R\cos\theta + X\sin\theta) + j[|V_s|\sin\delta_s - |I|(X\cos\theta - R\sin\theta)] \qquad (3)$$

$$|V_r|\cos\delta_r = |V_s|\cos\delta_s - |I|(R\cos\theta + X\sin\theta) \qquad (4)$$

$$|V_r|\sin\delta_r = |V_s|\cos\delta_s - |I|(R\cos\theta + X\sin\theta) \qquad (5)$$

Taking the square of equations (4) and (5), to obtain the magnitude of V_r

$$|V_r|^2\cos^2\delta_r = |V_s|^2\cos^2\delta_s - 2|I||V_s|\cos\delta_s(R\cos\theta + X\sin\theta) + |I|^2(R\cos\theta + X\sin\theta)^2 \qquad (6)$$

$$|V_r|^2\sin^2\delta_r = |V_s|^2\sin^2\delta_s - 2|I||V_s|\sin\delta_s(R\cos\theta - X\sin\theta) + |I|^2(R\cos\theta - X\sin\theta)^2 \qquad (7)$$

Adding equations (6) and (7)

$$|V_r|^2 = |V_s|^2 - 2|I||V_s|\cos\delta_s(R\cos\theta + X\sin\theta) - 2|I||V_s|\sin\delta_s(X\cos\theta - R\sin\theta) + |I|^2(R^2 + X^2) \qquad (8)$$

$$|V_r|^2 = |V_s|^2 - 2|V_s||I|R(\cos\delta_s\cos\theta - \sin\delta_s\sin\theta) + X(\cos\delta_s\cos\theta + \sin\delta_s\sin\theta) + |I|^2(R^2 + X^2) \qquad (9)$$

$$|V_r|^2 = |V_s|^2 - 2|V_s||I|[R\cos(\delta_s + \theta) + X\sin(\delta_s + \theta) + |I|^2 Z^2 \qquad (10)$$

$$|V_r|^2 = |V_s|^2 - 2|V_s||I||Z|[\cos\phi\cos(\delta_s + \theta) + \sin\phi\sin(\delta_s + \theta)] + |I|^2 Z^2 \qquad (11)$$

$$|V_r|^2 = |V_s|^2 - 2|V_s||I||Z|\cos(\phi - \delta_s - \theta) + |I|^2|Z|^2 \qquad (12)$$

Substituting the trigonometric function

$$\mathbf{\cos(\phi - \delta_s - \theta) \approx 1} \qquad (13)$$

Upon substituting |I| and simplifying the expression

$$|V_r|^4 + 2|V_r|^2(PR + QX) - |V_s^2||V_r^2| + (P^2 + Q^2)|Z|^2 = 0 \qquad (14)$$

The line receiving end active and reactive power, can be obtained from Equation (13)

$$P = |Z|^{-1} [-V_r^2 \cos\theta. \pm \sqrt{\cos^2\theta.V_r^4 - V_r^4 - |Z|^2\ Q - 2V_r^2QX + V_r^2V_s^2}\,] \tag{15}$$

$$Q = |Z|^{-1} [-V_r^2 \sin\theta. \pm \sqrt{\sin^2\theta.V_r^4 - V_r^4 - |Z|^2\ Q - 2V_r^2QX + V_r^2V_s^2}\,] \tag{16}$$

From equations (14) and (15), for the value of active and reactive power to be real

$$\cos^2(\theta).V_r^4 - V_r^4 - |Z|^2\ Q - 2V_r^2QX + |V_r^2||V_s^2| \geq 0 \tag{17}$$

$$\sin^2(\theta).V_r^4 - V_r^4 - |Z|^2\ Q - 2V_r^2QX + |V_r^2||V_s^2| \geq 0 \tag{18}$$

Adding equations (17) and (18) to obtain transfer active and reactive power

$$2|V_r^2||V_s^2| - |V_r^4| - 2|V_r^2|(PR+QX) - |Z|^2\ (P^2+Q^2) \geq 0 \tag{19}$$

The bus stability index can be computed using equation (19)

$$SI = 2|V_r^2||V_s^2| - |V_r^4| - 2|V_r^2|(PR+QX) - |Z|^2\ (P^2+Q^2) \tag{20}$$

IV. Distributed Generation placement Algorithm

The problem of distributed energy placement can be formulated as an optimization function with aim of minimizing loss, improving voltage profile, reliability etc. In this section, the problem is solved using successive power flow and stability index based on apparent power to identify the bus susceptible to voltage collapse (Ettehedi and Vaez-Zadeh, 2012). The most vulnerable node is regarded as a suitable position for distributed generation placement due to its high tendency of voltage instability. The developed algorithm for distributed generation placement is shown in Figure (2).

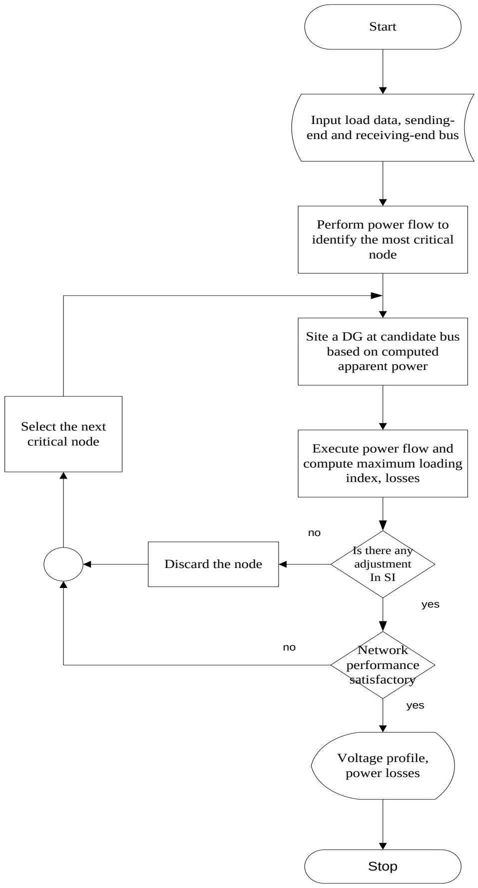

Figure 2. Algorithm for Distribution Placement Using Apparent Power Loss

V. Analysis and Result

The developed algorithm for distributed generation placement and the corresponding stability index is implemented using the IEEE 33-bus test system shown in Figure (3), with data as contained in (Srinivisa and Narasimham, 2009). Based on the result of simulation obtained as shown in Figure (4), the most critical node was identify to be buses 16, 17, 18, 32 and 33 with bus 18 being the bus with the lowest value of the stability index. With a distributed generation of 200kW, installed at the bus 18, an improvement in the active transfer loss (stability index) was recorded. With 200kW DG installed at node 33, an improvement in the stability index and voltage profile was also recorded and so on. Table 1 shows the summary of the result obtained for the standard 33-Bus IEEE Distribution network.

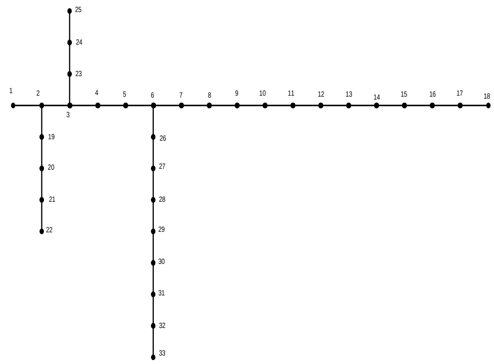

Figure 3. Single-Line Diagram of a 33-Bus IEEE Distribution Network

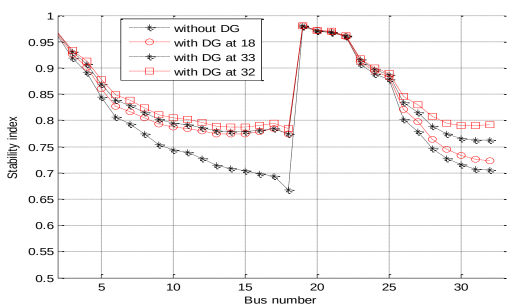

Figure 4. Shows the Variation of the Stability Index as a Function of Bus Number

Table 1. Summary of the Results Obtained

Case	With out DG	With DG at 18	With DG at 33	With DG at 32

Active power (kW)	202.2	166.95	136.04	118.23
Reactive power (kVAR)	135.02	110.25	89.64	77.36
Minimal Voltage (p.u)	0.9125	0.9212	0.9342	0.9421
Active Transfer Lossr (p.u)	0.6667	0.7207	0.7618	0.7877
% Active Transfer Loss		8.1	14.26	18.15

Conclusion

In this paper, a voltage stability index, was developed to determine the most critical node for distributed generation placement, within a distribution network. A continuous power flow was used to determine the best location for DG placement, so as to mitigate the consequence of voltage collapse or voltage instability. The placement algorithm was tested using an IEEE 33bus test feeder. The results reveals with distributed generation placed at node 32, a better performance was achieved with a minimal voltage of 0.9421p.u and active power transfer of 0.7877p.u. The improvement in voltage profile was as result of reduction in active and reactive power loss.

References

CUTSEM T. V AND VOURNAS. C, 1998. *Voltage stability of Electric Power System, Power Electronics and Power system series Kluwer.*

EMINOGLU. U & HOCAOGLU. M. H 2007, *A Voltage Stability Index for Radial Distribution Network*, Gebze Institute of Technology, 408-413, 2007.

VENIKOV V. A., STROEV V. A., IDELCHICK V. I & TARASOV V. I, *Estimation of Electrical power system steady state stability in load flow calculation*, IEEE transaction, power Apparatus System PAS94,1034-1041. 1995.

CHEBBO. A. M., IRWING M. R., & STERLING M. J. H, *Voltage Collapse Proximity Indicator and Implications*, IEEE proceeding Vol 139(3), 241-252, 1992.

GUBBINA F & STRMCNIK B., *A Simple Approach to Voltage Stability Assessment in Radial Networks*. IEEE transaction on power system stability Vol 12(3), 1121-1128. 1997.

ETTEHADI. M & VAEZ- ZADEH. S, *DG placement in Distribution Networks Considering Voltage Stability*, IEEE transaction Vol 8(2),1-6, 2012.

SUBRAHMANYAM. J. B. V, *Distributed generator placement and sizing in Unbalanced Radial distribution system*, Journal of Theoretical and Applied Information Technology, Vol 13(2), 746-753. 2009.

SRINIVASA. R & NARASIMHAM . S. V. L 2009. *A New heuristic Approach for optimal reconfiguration in distribution system,* international journal of engineering and applied science. Vol 5(1), 18. 2009.

COMPARATIVE ANALYSIS OF VEHICULAR GASEOUS EMISSION AT SOME MAJOR ROAD INTERSECTIONS IN KANO METROPOLIS

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ABSTRACT

This study aimed at investigating vehicular gaseous emissions in some major road intersections in Kano metropolis, for a period of six weeks. Air quality measurements were carried out for three hours, with each hour devoted to morning, afternoon and evening peak periods. Concentrations of CO, NO_2, and SO_2 were measured in situ using Gasman TO air sampler. Results obtained were compared with National Environmental Standard and Regulatory Enforcement Agency (NESREA) guideline limits. The measured gaseous concentrations at the studied intersections were within NESREA guideline limits, except for CO concentration of 14.43 and 13.60 ppm, at Bata and Kantin Kwari intersections, respectively. NO_2 concentration ranged from 0.032 to 0.063 ppm whereas that of SO_2 ranged from 0.006 to 0.041 ppm. This suggests that transport-related pollution around Bata and Kantin Kwari is apparently unsafe. The findings in this study provide useful information towards formulation of effective air quality management strategy.

Keywords: Gaseous emissions, air quality, road intersections, Kano Metropolis

1. INTRODUCTION

Air pollution is the presence of substances in the atmosphere, resulting from the activity of man or natural processes, causing adverse effects to man and the environment. Air pollution stems from a multiplicity of sources: toxic gases, aerosols, particulates, foul smell, heat, ozone layer depletion, and radioactive emission. Bichi (1997) pointed out that the principal sources air pollution include noise in cities, , industrial gases, heat, and emissions resulting from automobile exhausts, radioactive chemicals, and refuse dump.

Increase in the number of vehicles in Nigeria coupled with the use of leaded fuels is likely to increase air pollution level with consequent release of harmful substances to the atmosphere. Vehicle emissions can be affected by fuel type, especially due to high sulphur content. Increase in sulphur content decreases fuel efficiency, with consequent increase in sulphur oxides, particulate matter, and volatile organic compounds (World Bank, 2003).

The use of leaded fuel with high sulphur content is prevalent in developing countries. In the United States of America, petrol has a standard of 15 ppm of sulphur, whereas in the EU, it has a standard of 50 ppm. In Nigeria, however, concentration of sulphur in fuels most often ranges from 500 - 2000 ppm, with a maximum allowable sulphur level of 5000 ppm (United Nations Environmental Protection, 2007). As such, it is expected that more pollution will result from the use of automobiles in Nigeria (Sikirulahi and Salam, 2013).

Air pollution is the presence of pollutants in the atmosphere resulting from anthropogenic or natural activities in quantities harmful to humans, plants, or animals. This can potentially damage structures, result in changes in weather and climate, and can have a negative impact on life expectancy (Elsom, 1987). The amount of pollutants released to the atmosphere by fixed or mobile anthropogenic sources is generally associated with the level of economic activity.

Meteorological and topographical conditions affect dispersion and transport of these pollutants with consequent high ambient concentrations; this has adverse effects on man and the eco system. In general, the effects on people are severe in large urban centers with considerable emission sources, unfavorable dispersion characteristics, and high population densities.

Although air quality has been controlled to some extent during the past two decades in industrialised countries, this is not the case with many developing countries as the situation is worsening and becoming a major threat to human health (WHO/UNEP 1999).

In developing countries, automobile population growth has been largely unchecked by environmental regulations, creating high levels of pollution. Traffic contributes more to ambient pollution in developing countries, accounting to at least 40-80% of NO_2 and CO concentrations (Olamijulo, *et al.*, 2013). This situation is alarming and is predicated on the poor economic disposition of developing countries. Poor vehicle maintenance culture and importation of old vehicles, which culminate to an automobile fleet dominated by a class of vehicles known as ‘’super emitters’’ with high emission of harmful pollutants, has raised this figure of emission concentration (Olamijulo, *et al.*, 2013). Furthermore, the super emitters contribute about 50% of harmful emissions in developing countries (Olamijulo, *et al.*, 2013)

Air pollution mainly comes from anthropogenic activities, particularly combustion of fossil fuel such as coal and natural gas, l which are used to power automobiles and other industrial processes. CO, NO_2, SO_2, ammonia oxide and tiny particulates are some of the harmful chemicals released to the atmosphere resulting from combustion of fossil fuel. . In Nigeria, the industrial cities of Kano and Lagos, for example, are characterized by a smoky atmosphere (Bilyaminu, 2005; Bishir, 2007).

With such an alarming situation, this study set out to determine and compare trends of vehicular gaseous emission in some major road intersections, within Kano metropolis. It was hypothesized that the quantity of CO, NO_2 and SO_2 emitted from vehicular exhausts at those intersections were the same and has similar emission trends.

2. Materials and Methods

2.1 Study Area

Kano is a city in Nigeria and the capital of Kano State in Northern Nigeria. Its metropolitan population makes it the second largest city in Nigeria. The Kano urban area covers 137 km^2 and comprises six local government authorities (LGAs): Dala, Fagge, Gwale, Kano Municipal, Nassarawa, and Tarauni, with a population of over 2 million people (National Population Commission, 2006). The metropolitan area covers 499 km^2 and comprises eight LGAs: Kumbotso and Ungogo plus the above-mentioned six LGAs.

2.2 Selection of Study Area

The criteria used for the selection of study sites included the following: presence of residential buildings in close proximity to the major road intersections, traffic density and population exposure. The road intersections located at Kabuga, Kofar Ruwa, Kantin Kwari, Bata, Hotoro and Aminu Kano Teaching Hospital were used in the study.

2.3 Air Quality Monitoring

Measurements of the of CO, NO_2, and SO_2 concentration as air pollutants at each intersection were performed *in situ* for the duration of 6 weeks, commencing from 21-10-2013 through to 18-12-2013. Measurements were carried out daily for 3 h with each measurement hour devoted to morning, afternoon and evening peak periods, respectively. Further, the air quality measurements were concurrently carried out with traffic counts.

2.4 Traffic Density Estimation

Traffic density was estimated via manual counting using tally sheet system. Four research assistants were recruited to count the number of heavy trucks, passenger cars, tricycles and motorcycles passing through the intersections with each enumerator taking charge of a separate movement for a period of 1 h and this was used to estimate the hourly traffic density. Traffic density measurement was conducted three times a day: morning (8:00 – 9:00), afternoon (13:00 – 14:00) and evening (16.30 – 17.30).

2.5 Wind Speed Data Collection

Daily mean wind speed data for the study period were obtained from Nigerian Meteorological Agency (NIMET), Aminu Kano International Airport. The wind speed index values, the rating set for determining mean wind speed, are classified into five categories ranging from calm to very high (Table 1).. In addition, the Kano State Environmental Pollution Control Unit premises, located within farm centre, was used as control site, based on a criterion that it is not in close proximity to any major road in the Metropolis. CO and NO_2 concentrations of 1.00 and 0.01 ppm, respectively, were recorded at the control site, whereas SO_2 was not detected.

Table 1 Wind Speed Index Values

Index range (m/s)	Descriptor
0 – 1.0	Calm
1.0 – 2.0	Normal
2.0 – 5.0	Moderate
5.0 – 7.0	High

7.0 – 10.0	Very high

2.6 Statistical Analysis

The total observed CO, NO_2 and SO_2 concentrations across the intersections were compared with each other. Secondly, the mean concentration values of CO, NO_2 and SO_2 were compared with the NESREA guideline limits to evaluate the air quality situation at each intersection. Statistical analyses were performed using IBM SPSS version 16.0.

3. RESULTS AND DISCUSSIONS

3.1 Results

3.1.1 Carbon Monoxide Emission (CO)

Fig 1 shows the concentration of CO emitted across the major road intersections. Over all across the study sites, it was observed that Bata road intersection has the highest CO emission. This was slightly followed by Kantin Kwari intersection. The least CO emission recorded was at Aminu Kano Teaching Hospital intersection. Similar amounts of CO emission were also recorded at Kabuga and Kofar Ruwa intersections.

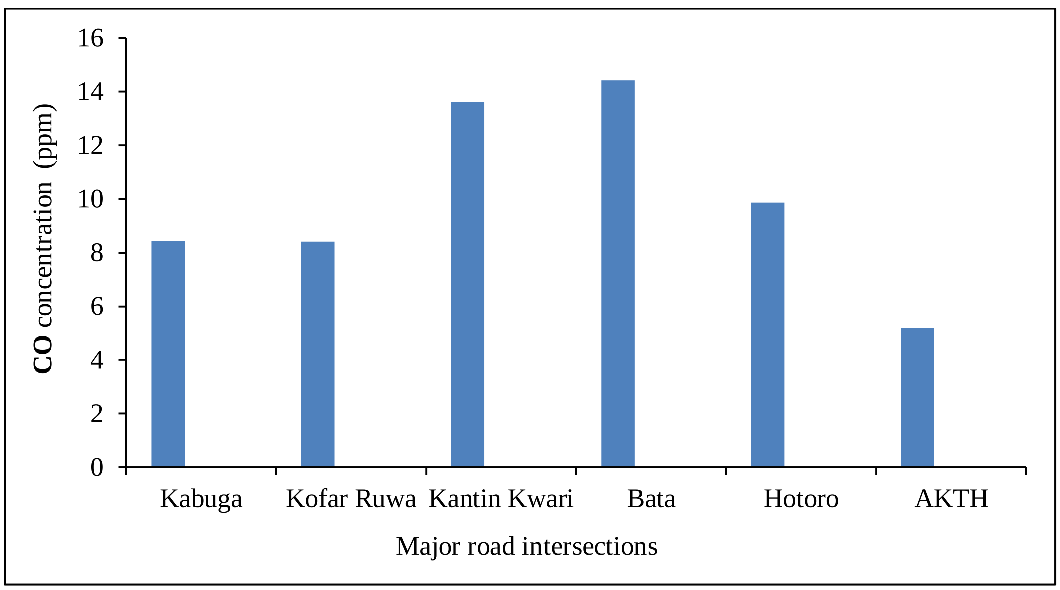

Fig 1: Mean CO concentration across the major road intersections

Compared with the NESREA guideline limit of 10 ppm, that the CO emission at Bata and Kantin Kwari traffic intersections exceeded this value. Interestingly, lower concentrations of CO were recorded at Kabuga, Kofar Ruwa, Hotoro and Aminu Kano Teaching Hospital traffic intersections, when paired with NESREA guideline limits.

3.1.2 Nitrogen dioxide emission (NO_2)

Fig. 2 shows the concentration of CO emitted across the major road intersections.

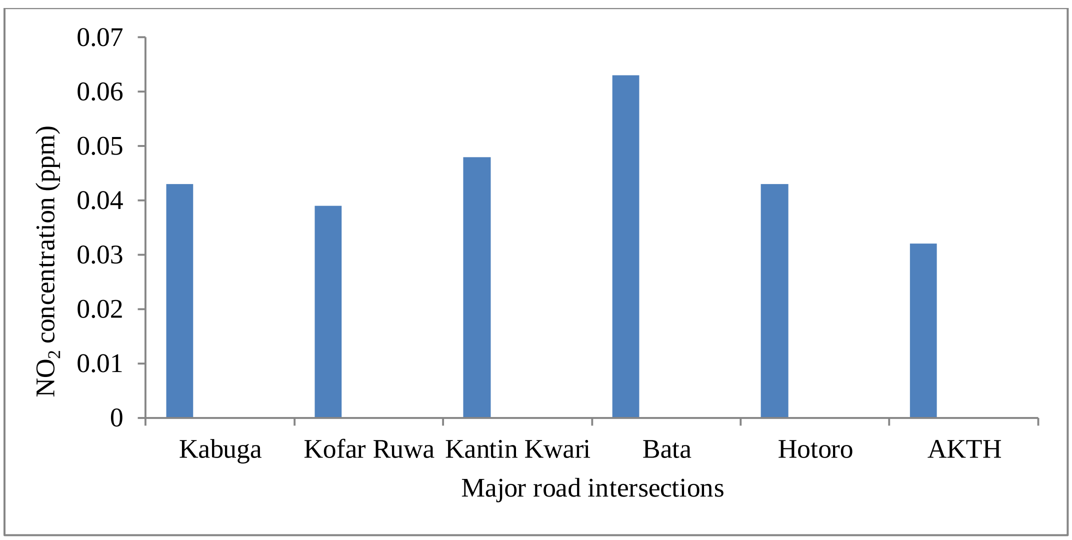

Fig 2: Mean NO_2 concentration across the major road intersections

NO_2 emission app ears to be higher at Bata road intersection than the other intersections. When compared with NESREA standard, (i.e. 0.04 – 0.06 ppm), it was discovered that all the observed mean values are within the normal NESREA guideline limits, except for Bata road intersection.

3.1.3 Sulphur dioxide Emission (SO_2)

Fig 3 presents the concentration of SO_2 emitted at the major road intersections. Over all, SO_2 emission was observed to be higher at Bata than at the other intersections. This was followed by Kantin Kwari road intersection.

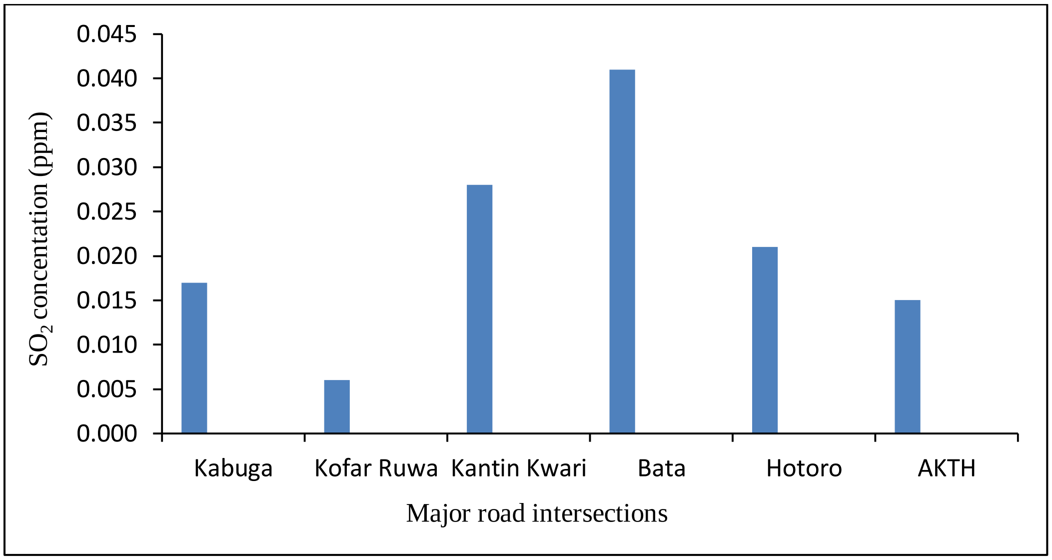

Fig 3 Mean SO_2 concentration across the major road intersections

When all of the observed mean values were compared with the NESREA guideline limits, they were found to be within the permissible range of 0.01 – 0.1 ppm.

3.2 Discussions

Results show that CO, NO_2 and SO_2 emissions at Bata and Kantin Kwari were higher than the NESREA guideline limits. The concentration of CO was also found to be higher than 1.6 – 3.8 ppm, an average range of atmospheric concentration of urban air pollution in Athens, Greece (Kalabokos et al, 1999). Similarly, the values found in this study were higher than the range of 0.7 – 1.9 ppm recorded in Jahara, Kuwait (Ettouney *et al.*, 2010).

However, the value in this study was lower than the range of 233 – 317 ppm reported in three other cities of Nigeria (Koku and Osuntogun, 1999). This finding was not unexpected as the wind speed observed throughout the observation periods was within the range of calm to moderate which slows the dispersion of pollutant in to the atmosphere.

Similarly, wind direction at Bata and Kantin Kwari was blowing towards north-east and north-eastern part of the intersections which app ears to have high density population and high rise buildings resulting in pollutant entrapment and delaying gaseous dispersion into the atmosphere.

It can, therefore, be concluded that the quantity of CO, NO_2 and SO_2 emitted at the studied intersections were different and the trend app ears to follow a consistent pattern with higher CO, NO_2 and SO_2 emissions both at one intersection and a lower CO, NO_2 and SO_2 emission at another location.

REFERENCES

Ahmed, M .I (2002), Introduction to Environmental Problems and Management, Wa'adallah Environmental Consult, pp 153-157.

Ajayi, A. B and Dosunmu, O.O (2002), Environmental Hazards of importing used Vehicles into Nigeria, *International symposium on Environmental Pollution Control and Waste Management*, 522-526.

Bichi, M.H. (1997), Consequences of Environmental Pollution on Man and Habitat, paper presented at the Conference on Environmental Education, organised by School of Postgraduate Studies, Bayero University, Kano, 4-14.

Davis, M.L and Master, S.J (2009) Principal of Environmental Engineering and Science 2nd edition, Mc Graw-Hill, New York.

Edward S. R. (2002), Introduction to Engineering and the Environment, McGraw-Hill Higher Education.

Eric W. (2009) Classification of Air Pollution Regimes in the Messouri Region, A Published Thesis, Graduate School, University of Messouri, Columbia.

Erica, M. (2009), Vehicle Emissions and Health Impacts in Abuja, Nigeria, retrieved from http://www.envstudiess.brown.edu/theses/archive2007_2008/ericamoenthesis.pdf in December, 2013.

Federal Republic of Nigeria Official Gazatte (2007), National Environment Standards and Regulations Enforcement Agency, 94, 639.

Gazali, S. A. and Kazeem, A. S (2013). Contribution of CO, NO_2 and SO_2 from automobile emission to Environmental Problems in Niger States Nigeria, *International Journal of Environmental Sciences*. 3(5), 1457-1464.

Isabell R. (1997) Motor Vehicle Air Pollution, Public Health Impact and Control Measures, World Health Organization and Ecotox, WHO/EOS/97.08.

John, D.L, Ambrose S.H, Bassett T.J, Bowel M.L, Crulli B.E, Iseecson T.S, John N.D, Lamp.P, Saw. M, Winter-Nelson A.E (1997). Meaning of Environmental Terms, *Journal of Environmental Quality*, 5, 581-589

Hassan, M. S., and Abdullahi M. E. (2012) Evaluation of Pollutants in Ambient Air: A Case Study of Abuja-Nigeria, *International Journal of Science and Research Publication*, 2(12).

Kafeelah A. Yusuf, Surukite Oluwole, Ibrahim O. Abdusalam and Gbenga R. Adewusi (2013) Spatial Patterns of Urban Air Pollution in an Industrial Estate, Lagos, Nigeria *International Journal of Engineering Inventions*, 2, 1-9.

Ndoke, P.N. and Jimoh O.D. (2004) Impact of Traffic Emission on Air Quality in a Developing City of Nigeria, *Anonymous*.

Ojo O.O. S and Awokola O.S. (2012) Investigation of Air Pollution from Automobile of Intersection on some Selected Major Roads in Ogbomoso, South-Western Nigeria, *Journal of Mechanical and Civil Engineering*, 1(4), 31-35.

Olamidulo J. O and Godson R.E.E. A (2013) Air Quality in Relation to Vehicle Traffic-Related Gaseous Emissions in Two Selected Local Government Areas in South-Western Nigeria, *International Journal of Environmental Monitoring and Analysis*, 1(4), 121-127.

Okelola Olumayokun Francies (2013). Vehicular Carbon Emissions ConcentrationLevels in Minna, Nigeria. African Technology Policy Studies Network. ATPS Working Paper No. 71, 3-8.

Okunola O.J, Uzairu A, Gimba C.E and Ndukwe G.I (2012) Assessment of Gaseous Pollutants along High Traffic Roads in Kano, Nigeria, *International Journal of Environment and Sustainability*, 1(1), 2-5.

Rafu H. P. el at (2012) Urban Mobile Air Quality Monitoring using GIS, GPS, Sensors and Internet, *International Journal of Environmental Science*, 3(4), 324-326.

Raul A. Deju, Roshan B. Bha u, Geoge C.Evans, and Armando P. Baez (2007), The Environment and Its Resources.

Tanimowo M.O. (2000) Air Pollution and Respiratory Health in Africa, *East Africa Medical Journal*, 77(2), 71.

U.S Environmental Protection Agency (2003) Air Quality Index, A Guide to Air Quality and Health, EPA-454/K-03-002, 1-7.

U.S Environmental Protection Agency (2009) Technical Assistance Document for the Reporting of Daily Air Quality, the Air Quality Index (AQI), 1-13

USEPA (2000) Guide to Environmental Issues Doc. No.520/B-94-01. United States Environmental Protection Agency, Washington, USA.

Weaver, L. K (2009) Clinical Practice Carbon Monoxide Poisoning, *The New England Journal of Medicine*, 27, 1217-1225.

W.H.O (2000), Air Quality Guidelines 2000, retrieved from htt://www.aro.who.int/document/aiq/7-1nitrogendioxide.pdf in December, 2013.