ALTERNATIVE SOURCES OF FUELS USED IN AUTOMOBILES TOWARDS ZERO CARBON EMISSION

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Abstract:- *The problems currently confronting the world are the energy crisis and environmental pollution. Energy consumption in the world is rapidly increasing faster than its generation, thus, leading to environmental pollution. Vehicle pollution has been a serious concern for the past few decades all over the world because, combustion products of petroleum fuels, such as carbon dioxide, are a major contributor to greenhouse gases resulting to global climate change. The transportation sector completely depends upon petroleum products, such as the Premium Motor Spirit (PMS) and diesel and the demand for these products accelerates the crude oil production peaks as well as its cost. It is estimated that the existing petroleum oil and natural gas reserves will be sufficient for only another few decades due to the facts that the usage of the automobiles are growing at a faster rate than the petroleum products reserved. In view of this, the paper reviews the fuel alternatives available to plan for the future taking up by automobiles manufacturers and consumers and the longer term vision for where the automotive industry is likely to be going to deliver sustainable automobiles with zero carbon emission to include the Electric/fuel cell/hybrid vehicles and hydrogen fuel cell*

Keywords: *Hybrid Vehicles, Premium Motor Spirit, Hydrogen Fuel Cell, Zero Carbon Emission*

Introduction

Energy is the leading transporter for economic growth and development of any country and is fundamental to the sustenance of contemporary economy. The expectations of economic development significantly depend on the long-term availability of energy from sources that are environmentally pleasant, easily reached and reasonably priced. Fossil fuels (coal, natural gas and petroleum oil), nuclear and renewable energy (geothermal, hydro, marine, solar, wind energy as well as the combustible wastes, these include; animal products, biomass and industrial wastes) are the fundamental sources of energy in the world (Scott, 2015). These sources of energy are transformed into derived energy sources; for instance, coal and crude oil (petroleum) are converted into electricity and steam respectively. The former is the most essential source of energy for electric power generation whereas the latter is for the transport (automobile) sector. Automobiles, self-propelled vehicles, are used primarily on public roads for daily transportation from one destination to another. Depending on the designs, sizes and intended uses, the automobiles radically changed the face of a nation over centenary of years.

Today, the automobiles are getting intricate and the need for professional care is becoming imperative as the development of new technologies and mechanisms that have been taking place in the automobile and related industry to geared towards zero carbon emission (Mustapha, 2015). Automobile emissions are the byproducts of burning automotive fuels from CO, CO_2, NO_x, OH, and SO_x (Nkwoada, Emeka, Christopher, Agwaramgbo & Conrad, 2016). Some of these emissions are probable or having the potential to cause cancer including, benzene, acetaldehyde, formaldehyde and 1,3-butadiene. At the moment, the world is facing up to, with the crisis of fossil fuel reduction and environmental concern. The environmental pollution (air) is an essential public health predicament in nearly all cities of the emergent world (Ghorani-Azam, Riahi-Zanjani & Balali-Mood, 2016). According to the World Health Organization (2011), epidemiological studies show that pollution in developing countries accounts for tens of thousands of excess deaths and billions of dollars are spent on medical expenditures and lost productivity every years. These losses and the related degradation in the quality of life impose a significant burden on people in all sectors of society, but especially the poor (Faiz, Weaver & Walsh, 1996).

The Human Development Report of 2007/ 2008 says that developed countries should cut their carbon emissions by 20–30% before 2030 and at least 80% by the year 2050. If emissions continue to rise following current trends, then stocks of the greenhouse emissions will be increasing at 4–5 ppm per year; by the year 2035, it may almost double the current rate. An accumulated stock will have risen to 550 ppm even without further increases in the rate of emissions, stocks would reach over 600 ppm by 2050 and 800 ppm by the end of the twenty-first century (Hu & Qingyou, 2017). The foregoing clearly revealed that emission has become one of the critical environmental challenges; hence, there is the need for zero carbon emission by using improved technology so as to protect the global environment and reduce the number of harmful combustion gases released into the atmosphere.

Need for Zero Carbon Emission

In 1947, attention was first directed to atmospheric pollution in Los Angeles. Five years later, it was asserted by Dr. Arie J. Haagen-Smit that the atmospheric pollution was due mainly to automotive exhaust emissions. Given complete combustion, each kg of hydrocarbon fuel when completely burnt produces mainly 3.1 kg of CO_2 and 1.3 kg of HO (Geoffrey, 2012). Most of the undesirable exhaust emissions such as oxides of nitrogen, NO_2, unburnt hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2x), lead salts, polyaromatics, soots, aldehydes ketones and nitro-olefins are produced in minute quantities (parts per million). Of these, only the first three are of major significance in the quantities produced. However, concentrations in general could become heavier as increasing numbers of vehicles on the roads. By the end of the 1980s, CO was beginning to cause concern, not because it is toxic but because it was suspected of facilitating the penetration of our atmosphere by ultra-violet (U-V) rays emitted by the sun. Controversy has raged over lead salts, but no proof has been found that, in the quantities in which they are present in the atmosphere, they are harmful. For many years, manufacturers of catalytic converters pressed for unleaded petrol because lead deposits rapidly rendered their converters ineffective. Geoffrey (2012) reinforced that carbon monoxide is toxic because it is absorbed by the red corpuscles of the blood, inhibiting absorption of the oxygen necessary for sustaining life. The toxicity of hydrocarbons and oxides of nitrogen, on the other hand, arises indirectly as a result of photochemical reactions between the two in sunlight, leading to the production of other chemicals. It is expected that burning hydrocarbon fuel in the presence of air produces carbon dioxide and water. But, internal combustion engines do not completely burn petroleum products. Hence, these engines release unburned or partially burned/oxidized gases and nitrogen oxides into the atmosphere. According to Sharaf (2013), the main pollutants of internal combustion engines include particulate matter, unburned hydrocarbons, carbon monoxide, particulates, oxides of nitrogen and sulphur. These pollutants have serious effects on human health resulting in throat, eye and lungs irritation and possibly cancer (Salami, 2007). The transport sector is a major contributor of air pollution particularly in cities and the vehicular pollution is the primary cause of air pollution in the urban areas (60%), followed by industries (20–30%), and fossil fuels (Ramadhas, 2016). The pollutants released into the atmosphere interact with other pollutants (like photochemical reactions) and disturb the ecological balance. Duffy and Smith (1992) highlighted the three basic sources to include;

1. Engine exhaust gases (EEG) (60%)
2. Engine crankcase blow-by fumes (FCB) (20%)
3. Fuel vapour (FV) (20%)

Alternative Sources of Fuels in Automobiles towards Zero Carbon Emission

A basic essential for the automobiles emission control is a carburetor or injection system capable of extreme accuracy in metering the fuel supply relative to the air entering the engine. Air pollution was mostly attributed to industrial emissions rathan than exhaust emission from the automobiles. Today, the concentration of carbondioxide in the atmosphere had increased leading to global warming. At this time, the automobiles are thought to be responsible for under 20% of total carbondioxide emission (Salami, 2007). As such, this demand for an alternative sources of fuels in automobiles towards zero carbon emission. Generally, alternative sources of fuels include all the fuel used in automobiles other than gasoline and diesel. There are various alternative fuels that can be used with the current petrol or diesel internal combustion engine with little or no modification. Ramadhas (2016) highlighted the merits with these fuels to include, among others, cleaner burning than petroleum-derived fuels, producing lower emissions, and if it is derived from renewable biomass sources it will decrease the dependency on nonrenewable petroleum.

However, alternative fuels, need not necessarily refer to a source of renewable energy. Each fuel has its own distinct advantages and disadvantages taking into cognizance, the associated cost, availability, environmental impact, vehicle/engine modification, safety and customer acceptance, and legislation. Presently, the cost of the most alternative fuels is a little bit higher than conventional fuel. However, the cost of biodiesel and Compressed Natural Gas (CNG) have cost competitive with petroleum. For the development of alternative fuels, government legislation and incentives are required to a certain extent. Ramadhas (2016) stated that the large-scale production of alternative fuel could make these alternative fuels cost competitive, hence, the alternative fuels are receiving attention because of the following reasons:

1. Alternative fuels generally reduce the vehicle exhaust emission and hence improve the environmental air quality.

2. Alternative fuels are capable of reducing the engine emissions as compared to petroleum products.

3. The molecular structure of alternative fuels (CH_3OH, C_2H_5OH, and CH) is much simpler than gasoline/diesel (the mixture of different molecules). Moreover, a low Carbon to Hydrogen (C: H) ratio of alternative fuels generates fewer hydrocarbon emissions on combustion.

4. Hydrogen is the clean fuel and generates zero hydrocarbon emissions.

5. Some alternative fuels have the potential to operate at a lower cost compared to petroleum products.

6. Alternative fuels are mostly produced from domestic resources that reduce the energy dependence. Use of locally available resources for fuel purposes can reduce crude oil import bill. Most of the alternative fuels, for example, alcohols, biodiesel can be produced from biomass resources and agricultural wastes and electricity for battery operated vehicles can be produced from solar and fuel cells. Hydrogen can be produced
   from biomass gasification or electrolysis of water. Hence, even a small percentage substitution of different alternative fuels reduces the crude oil import significantly.

The suitability of each of these fuels for the automobile engines has been under investigation throughout the world. Some of the important fuels are alcohols (methanol and ethanol), Electric/fuel cell/hybrid vehicles, Ethers, Future fuels, Gaseous fuels (natural gas, hydrogen, and liquefied petroleum gas), Vegetable oils and biodiesel. For the purpose of this study, this paper focused on the Electric/fuel cell/hybrid vehicles fuels.

Electric/fuel cell/Hybrid Vehicles

Electric vehicles (EVs) are classified according to using their fuel electrically fueled such as battery EVs (BEVs) and the Hybrid Electric Vehicles (HEVs). The former was purely fed by batteries and propelled solely by an electric motor while the latter and was sourced by both batteries and liquid fuel and powered by both the engine and electric motor. According to the National Research Council (2013), with the advent of other energy sources, namely gas-electric hybrid renders this classification ill-suited due to the reduced number of batteries which weigh down a vehicle and thus reducing its load-carrying capacity and range causing it to use more energy.

Hybrid Electricity

Hybrid Electric Vehicles (HEVs) may be the best alternative vehicle for the near future, especially for the individual consumer. Hybrids are powered by two energy sources: an energy conversion unit (such as a combustion engine or fuel cell) and an energy storage device (such as the battery, flywheel, or ultracapacitor). The energy conversion unit can be powered by gasoline, methanol, compressed natural gas, hydrogen, or other alternative fuels. It offer many of the energy and environmental advantages of the dedicated electric vehicle. Among some of the merits include, HEVs have the potential to be two to three times more fuel-efficient than conventional vehicles, an HEV battery does not have to be recharged because it has a generator powered by the internal combustion engine to recharge the batteries whenever they are low. A regenerative braking system captures excess energy when the brakes are engaged. The recovered energy is also used to recharge the batteries.

Gas-Electric Hybrids: Biodiesel

In recent years, biodiesel has gained international attention as a source of alternative fuel due to characteristics like high degradability, no toxicity, low emission of carbon monoxide, particulate matter and unburned hydrocarbons (Dawodu, Ayodele & Bolanle-Ojo,[c]2014). Biodiesel is a mixture of alkyl esters and it can be used in conventional compression ignitions engines, which need almost no modification. As well, biodiesel can be used as heating oil and as fuel (Anju, 2014). So far, this alternative fuel has been successfully produced by transesterification of vegetable oils and animal fats using homogeneous basic catalysts such as the basic or acid. These catalysts have the merits of including complete conversion of high activity (within an hour) and mild reaction conditions (from 40 to 65 °C and atmospheric pressure). Besides, in the homogeneous process, the catalyst is consumed thus reducing the catalytic efficiency. This causes an increase in viscosity and the formation of gels. In addition, the method for the removal of the catalyst after reaction is technically difficult and a large amount of wastewater is produced in order to separate and clean the products, which increases the overall cost of the process. Thus, the total cost of the biodiesel production based on homogeneous catalysis, is not yet sufficiently competitive as compared to the cost of diesel production from petroleum. An alternative is the development of heterogeneous catalysts that could eliminate the additional running costs associated with the aforementioned stages of separation and purification. Therefore, development of efficient heterogeneous catalysts is important since it opens up the possibility of another pathway for biodiesel production. The efficiency of the heterogeneous process depends, however, on several variables such as type of oil, molar ratio alcohol to oil, temperature and catalyst type.

Biodiesel is a fuel made by chemically reacting alcohol with vegetable oils, fats, or greases, such as recycled restaurant greases. It is most often used in blends of two per cent or 20 per cent (B20) biodiesel. It can also be used as neat biodiesel (B100). Biodiesel fuels are compatible with and can be used in unmodified diesel engines with the existing fueling infrastructure. It is the fastest growing alternative transportation fuel in the U.S. Biodiesel contains virtually no sulfur, so it can reduce sulfur levels in the nation’s diesel fuel supply.

Removing sulfur from petroleum-based diesel results in poor lubrication. Biodiesel is a superior lubricant and can restore the lubricity of diesel fuel in blends of only one or two per cent. Biodiesel can also improve the smell or diesel fuel, sometimes smelling like french fries.

Hydrogen Fuel Cell

Hydrogen is an important chemical material that is utilized in a large scale in synthetic chemical industries in modern society. The utilizing hydrogen as clean source of energy are considered to assume a vital position in order to overcome problems of lack of energy and environment in future. Hydrogen is the most attractive and ultimate alternative for a future fuel and an energy carrier. It is recognized as the environmentally desirably clean fuel of the fututе since it can be used directly in different types of hydrogen fuel cells. Such fuel cell is a battery which is actuated by gas by the reaction of hydrogen and oxygen into electric energy. Thus, fuel cells that store hydrogen and operate using it as fuel are developed (Bent, 2011). Fuel cells offer a significant advantage over traditional combusting-based thermal energy conversion, so they provide efficiencies of electrical power supply in the range of 35 to 55%, causing very low level of pollutant emission. They can be used in a wide variety of applications from miniaturized portable power to stationary power stations (Shripad & Pradip, 2016).
In hydrogen fuel cells, the electrical energy will be derived from the reaction of hydrogen and oxygen gases within the fuel cell to make water by spliting it into hydrogen and oxygen (water electrilizer). A fuel cell is an electrochemical energy conversion device which converts the chemical hydrogen and oxygen into water, and in the process it produces electricity as most fuel cells today use hydrogen and oxygen as the chemicals (Shripad & Pradip, 2016).

$2H_2O \rightarrow 2H_2 + O_2$ (-285 kJ/mol)……(1)

In the reverse of the above reaction, production of water, heat, light and sometimes sound takes place when normally hydrogen burns reacting with oxygen from air.

$2H_2 + O2 \rightarrow 2H_2O$ (+285 kJ/mol)……..(2)

Most fuel cells directly generate electricity using the chemical reaction between a fuel (hydrogen) and an oxidant (oxygen).
İn the hydrogen fuel cell, the chemical reaction is exactly same to reaction (2), but instead of producing light and heat, electrical current is produced. Fuel cell provides a DC (direct current) voltage that can be used to power motors, lights or number of electrical appliances. The existing fuel cells are usually classified by their operating type and the type of electrolyte they use.
In the future, hydrogen may provide a significant contribution to the alternative fuel mix. The space shuttles use hydrogen for fuel. Fuel cells use hydrogen and oxygen to produce electricity without harmful emissions; water is the main by-product. Hydrogen is a gas at normal temperatures and pressures, which presents greater transportation and storage hurdles than liquid fuels. No distribution system currently exists. Today, the predominant method of producing hydrogen is steam reforming of natural gas, although biomass and coal can also be used as feedstocks.

Conclusion

The need for an integrated holistic approach to controlling automobile emission cannot be overemphasized owing to increased environmental protection and also to reduce dependency on petroleum. Consequently, the paper has extensively reviewed an alternative sources of fuels used in automobiles towards zero carbon emission. In addition, the physicochemical properties of these fuels, their sources and technological aspects of production, as well as recent data on Research and Development (R&D) work and application were examined.

Recommendations

1. The Federal Government of Nigeria should set-up stringent exhaust emission standards for different categories of vehicles in use on the Nigerian roads such as the old automobiles that do not conform to emission standards.

2. Inspection, maintenance and certification programmes by authorized service stations mandatory should be carried out at regular interval by the Vehicle Inspection Officers (VIOs) and other road marshals so as to reduce environmental emission.

3. Efforts should be made through print and visual media through workshops and seminars to sensitize the public in the effects and ways of reducing automobiles pollutions

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