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PROJECT RESEARCH WORK ON A COMPARATIVE STUDIES OF
YIELD OF ETHANOL FROM DIFFERENT CEREALS (MILLETS &
MAIZE) AND ROOT CROPS (YAMS & CASSAVA)

AND

A DESIGN OF DISTILLATION EQUIPMENT FOR THE PRODUCTION
OF ETHANOL FROM LOCALLY
AVAILABLE RAW MATERIALS.

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IN PARTIAL FULFILLMENT OF THE REQUIREMENT
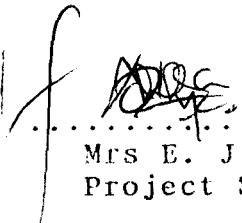FOR THE AWARD OF BACHELOR OF ENGINEERING

DECEMBER, 1998.

DEDICATION

This project research work is dedicated to Allah for his ONENESS and more so to:

(1) Sheik Ibrahim Niyass (RAA) who has been the most remarkable influence in my life.

(2) Late Alhaji Dauda Sidi Aliyu (I am in tear) Sad, my heart goes out to him, he does not deserve to depart this world the way he did. But then what Allah has ordained no man can change it.

(3) My lovely mother, Mallama Onyioyibo Audu for her contribution toward my success and finally;

(4) My colleagues Maulds and Mauldats whose prayer I enjoyed most.

CERTIFICATION

This is to certify that this project titled a comparative studies of yield of ethanol from different cereals and root crops was fully carried out by I, Audu I. Jimoh (92/2471) under the supervision of Mrs E.J. Eterigho (Engr) and submitted to chemical engineering department, F.U.T., Minna in partial fulfillment of the requirement for the award of Bachelor of Engineering (B. Eng) degree in chemical engineering.

....

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ABSTRACT

This Project is directed toward a comparative studies a yield of ethanol from different cereal (eg millers &Maize) and root crops (Yam & Cassava).

Analysis of the cereals and root crops using (laboratory test) showed that each highest quantity of starch, quantity of protein and fat and some trace quantities of fibre and mineral matters.

Ethanol was in this research work prepared using hydrolysis method. The acid (Hcl) used acted as though it was a catalyst. The mixtures, that is 129 of grist, 125ml to both distilled water and $2N HCl$ was gelatinized to saccharifying starchy content to fermentable sugar.

Established fermentation process employed media, WORT whose constitution was obscure.

Disapperance and accumulation which occured at the end of fermentation process whose mass was almost equal to the masses of sodium chloride and unhdyo-lyzed glucose in the wort initially made the end solution to be treated as binary misture.

From the graph, the feed entered the column at plate number 13. For maximdum/highest purity of ethanol production for engineering application the number of stages could be increased tc about 26.

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CHAPTER ONE

1.0 INTRODUCTION

The importance of alcohol in engineering applications in particular and its immense contribution to life itself in general can not be over emphasized. Alcohol is the second only to water in solvent value and employed in nearly all industries, that is one of the most important synthetic chemicals used by men and which finds wide use in the industries (e.g as solvent for liquor, varnishes, perfumes, and flavouring etc).

Alcohols in free form are not a common occurance in nature, they are found mainly in the essential volatile oils obtained from flower leaves and stems of plant chiefly, these are groups of monolyoric primary alcohols with carton 7-12 atoms. In nature, alcohols are many times more present in combined formed than as the compounds. Fats, for instance are esters of trihydric alcohol, glycerols and certain waxes oils which are esters of fatty of alcohols. Many sterols occur in nature in esterified form.

Alcohol in the past have been prepared by various method such as destructive distillation of wood, fermentation, and other natural sources. Synthetic production is gradually replacing other methods because of the purity ascertained from it. On the other hand specified raw materials e.g cereals and roots crops are consumed in enormous amount for literarily thousand of applications. These cereals and root crops are sources of carbohydrate – which are quantatively the most important constituent forming 78 – 87% of the total dry

matter. Alcoholic are made from almost every kind of sugar or starch - containing plant material. Generally, the alcoholic percentage composition of these cereals and root crops are in varied degrees. One of the numerous uses of cereals for example, is in nutrition. "The amount of iron in the US food supply has been increasing 1935 - 1939, partly because of enrichment of cereal grains since 1941. This enrichment may have increased the amount of iron in the food supply by about 1/5th" (Principle of Nutrition, reference).

Therefore, in order to meet the demand of consumers, and to be economically wise and principle for alcohols of many description in pure form, low cost, this projects is carried out with aim to have a comparative studies of yield of ethanol from the specified raw materials under carefully controlled condition.

1.2 AIM AND OBJECTIVES:-

This research work is directed toward a comparative studies of yield of enthanol from different cereals (e.g Maize, Rice, Millet, and Guinea Corn) and Root Crops (e.g Maize, Cassava, Cocoa, and Yam).

1.3 ECONOMIC IMPORTANCE OF ETHANOL

1.3.1 ETHANOL SOLVENT USE

Ethanol ranks second only to water as an industrial solvent. Solvent applications include resins, pharmaceticals, cosmetics, household cleaning products and industrial solvent; 50 - 55% of US industrial (non-fuel) alcohol use is for solvent applications.

1.3.2 ETHANOL USE AS CHEMICAL INTERMEDIATE

This is shown in figure 1.0. It summarize several of the
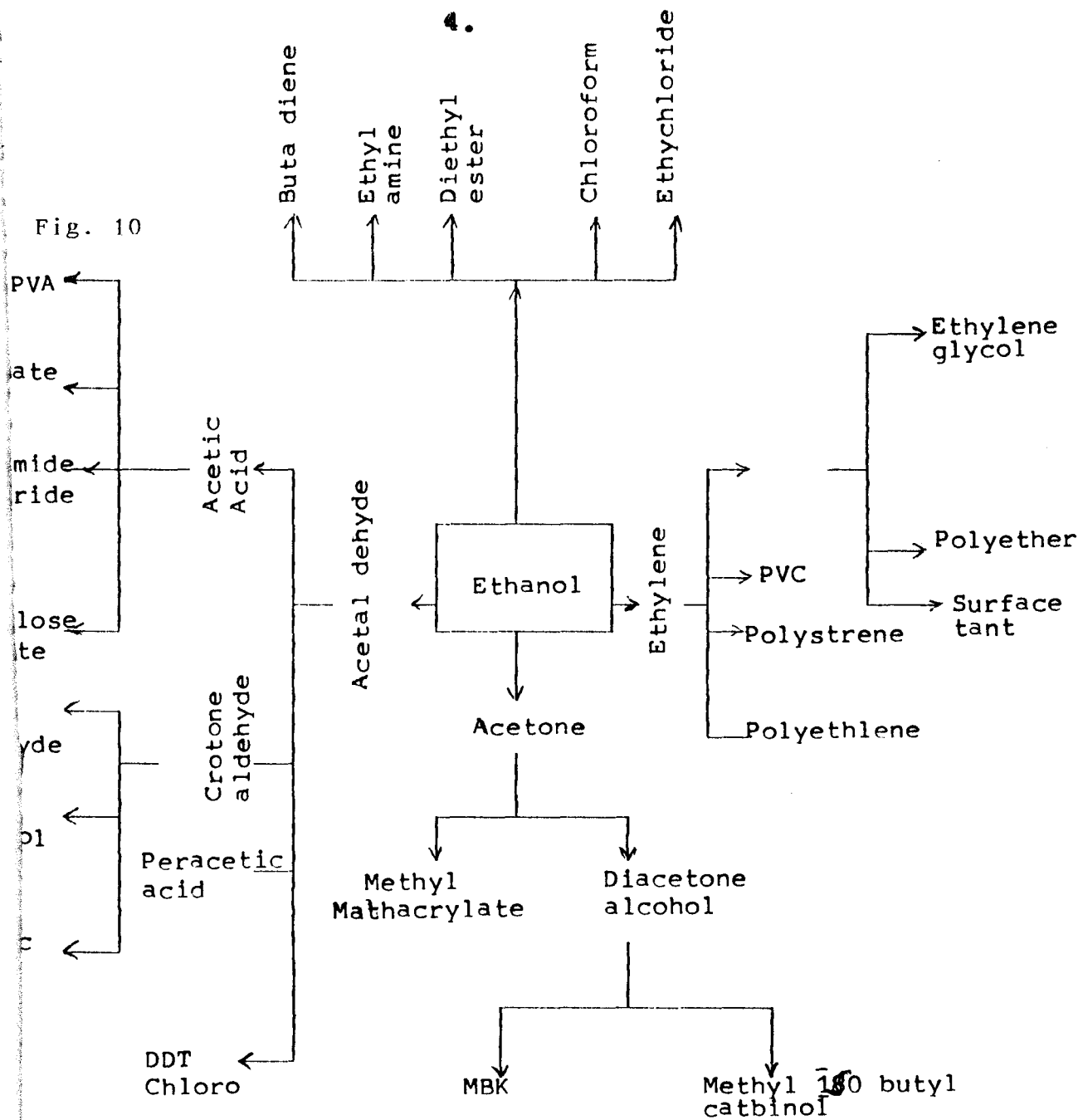
Fig. 10

Fig. 1.0 Chemical Products derived from ethanol.

more important chemical that can be derived from ethanol.
This implies that there is potential to produce practically
all petrotein derived chemicals from ethanol.

1.3.3 ETHANOL FUEL USE

Fuel use in internal combustion engines is the fastest
growing application for fermentative ethanol. The original
otto engine was developed using unhydrons ethanol fuel.
Ethanol use in blends of up to 20 vol % with gasoline was
widespread during World War II induce petroleium shortages.
Also addition of 10 Vol% ethanol to gasoline results in three
point increase in average octane rating. Tetraethylead is
being withdrawn in the US as an octane booster to meet new
pollution standard.

1.3.4 ETHANOL AS BEVERAGES

Ethanol is a constituent of alcohol beverages such as
wine and beer which when taken in controlled quantity is
claimed to give pleasure to the drinker.

1.4. PROPERTIES OF ETHANOL

1.4.1 PHYSICAL LPROPERTIES.

(i) Ethanol is a colourless, volatile liquid with a characteristic taste and smell.

(ii) It is readily soluble in water in all proportion (due to presence of the hydroxyl group)

(iii) It has a boiling point of 78^0C

(iv) Has no action on litimus.

(v) Has chemical formula of C2H5 OH

(vi) Has molecular weight of 46.07g

(vii) Has a Density of 789kg/m^3

(viii) Has a metting point of 112^0C

1.4.2. CHEMICAL PROPERTIES.

i) Combustion:- Ethanol readily burn in air or oxygen with a pole blue flame, yielding water and carbon (iv) Oxide.

$$C2H5OH(dq) + 3 O_2(g) \longrightarrow 3H_2O(1) + C O_2(g)$$

ii) Oxidation:- Ethanol is readily oxidized to ethanol laleta/dehyde) by worming with potassium heptad oxide chromate (vi) solution which has been acidified with dilute tetra oxo sulphate

(vi) acid. The ethanol is given off as a pungent and irritating vapour, leaving behind a green liquid.

$$C2H5\ OH(aq) \xrightarrow{\ 0\ } CH_3CHO_{(g)} + H_2O\ (L)$$
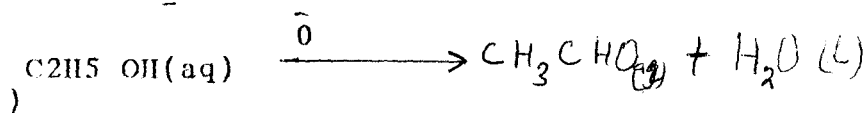
from potassium, hepta
oxidi chromate (iii)

iii) Esterification:- Ethanol reacts reversible with acids forming ethyl esters. This process is known as esterification, and can be represented generally as follows:

alkanol + acid $\rightleftharpoons$ ester + water

In the case of ethanol and ethanoic acid, the reaction is,

$$C2H5OH(aq) + CH3COOH(aq) \rightleftharpoons CH3COOC2H5(1)$$

ethanoic acid   ethylethandote
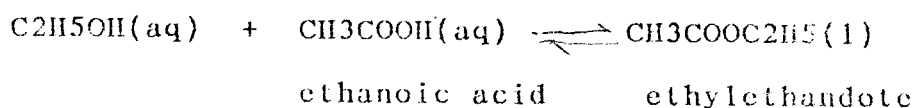
iv) Dehydration:- ethanol dehydrate in presence of an excess concentrated tetraoxosulphate (vi) acid at temperature above 170°C, ethanol react to form ethyl hydrogen tetraoxosulphate (vi), $C_2H_5HSO_4$, which then decomposes, yielding ethane.

(a) $C2H5OH(aq) + H2SO4(aq) \longrightarrow C2H5HSO4(aq) + H2O(1)$

(b) $C2H5HSO4(aq) \longrightarrow C2H4(g) + H2SO4(aq)$
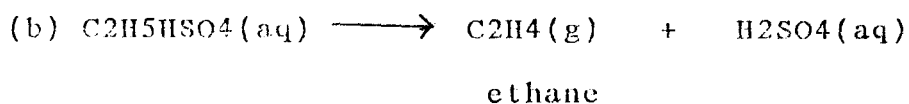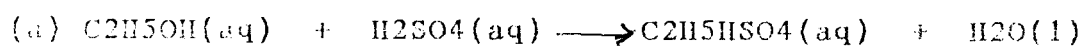
ethane

On the other hand, if the alkanol is present in excess, and the temperature is slower it will react with the concentrated acid to yield ethoxyethane (diethyl ether)

(a) $C2H5OH(aq) + H2SO4(aq) \longrightarrow C2H5HSO4(aq) + H2O(1)$

(b) $C2H5HSO4(aq) + C2H5OH(aq) \longrightarrow C_2H_5OC_2H_{5(g)} + H_2SO_{4(aq)}$
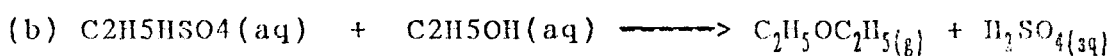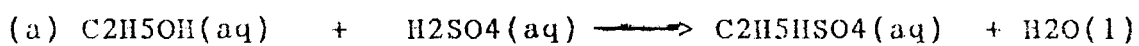
The formation of ethane and ethonyethane from ethanol is a dehydration reaction become molecule of water is lost.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ORIGIN OF CEREALS

The word, "Cereal" derives its name from the Roman grain or harvest goddess, cares (usually depicted with ears of barley braidded in her hair). The grains, from which cereals come, are Maize, G. Corn, Wheat, Rye, Oats Sorghum and barley. Cereals products made from grain include break fast foods, rice, flours, macaroni products, organic solvents, beverages, etc.

2.1.1 NUTRITIONAL VALUE

All cereals grains have high energy value mainly from the starch fraction, but also from the fat and protein.

2.1.2 CEREAL CHEMISTRY

The applied branch of biochemistry concerned with the analysis, characteristic, processing and uses of cereals and their constituents. Starch is the largest component of all cereals, much attention has been given to the chemistry of starch in the major crops, wheat and corn. Protein, the next largest component of cereals, is especially important in what because wheet gluten is unique in producing breed of good texture. Oil is present in relatively small amount.

2.1.3 CHEMICAL COMPOSITION OF CEREALS.

The chemical composition of the matured grains of the common cereals are shown in table 1.0

TABLE 1.0 PROXIMATE CHEMICAL COMPOSITION OF CEREALS
(g/100gd.b.)

Cereals	Protein	Fat	Crude Fibre	Mineral Matter	Soluble Carbohydrate
Wheat: Manitoba	16.0	2.9	2.6	1.8	74.1
HRW	14.6	1.8	3.0	2.0	74.6
English	10.5	2.6	2.5	1.8	78.6
Barley	11.8	1.8	5.3	3.1	78.1
Oats Whole	11.6	5.2	1.3	2.9	69.8
Groats	14.9	7.0	2.6	2.1	74.6
Rye	13.4	1.8		2.1	80.1
Triticale	15.0	1.7	2.6	2.0	78.7
Rice Paddy	9.1	2.2	2.1	7.2	71.2
Brown	11.0	2.7	1.2	1.8	83.2
Milled	9.8	0.5	0.3	0.6	88.9
Maize Flint	11.1	4.9	2.1	1.7	80.2
Dent	10.0	4.5	3.5	2.0	80.0
Sweet	12.1	9.1	2.2	2.0	74.5
Popcorn	11.6	4.0	2.4	1.6	78.2
Sorghum	12.4	3.6	2.7	1.7	79.7
Millet: Peart	13.6	5.4	1.3	1.8	77.9
Foxtail	13.9	4.8	9.0	3.7	68.6
Proso	12.8	4.0	12.7	2.0	67.7
Finger	8.4	1.5	4.1	3.1	82.9
Kodo	9.5	1.6	10.3	3.0	75.6
Japanese	7.0	2.5	11.1	5.0	74.3
Little	8.7	5.3	8.6	1.7	75.7

2.2 ROOT CROPS

2.2.1 CASSAVA (Mamhot esculenta)

Cassava is a staple food crop in many areas of the tropics, and it's capable fertility and low rainfall. Its tuber is composed of about 62% H2O, 35% carbohydrate, 1-2% protein, 0.3% fat, 1-2% fibre and 1% mineral matter. Cassava is produced as a source of starch and also for livestock feed.

2.2.3 YAM (Dioscora Spp)

Yam is the preferred food in tropical Africa, Cariban, Oceania and a small extent in south-east Asia. There are many types of Yam, all belong to genus Dyscoria. The most economically important are the white Yam, Yellow Yam and water yam. There are indigenous to West African except water yam which originated in South East Asia.

2.3 YEAST

Yeast forms one of the important classes of fungi. They are wide spread in nature, living usually in soil and regions of lower relative hummidity. Yeast unlike most fungi exist as single, small cells about 8 Um long and 5Um diameter.

Reference Baily and Ollis, Biochmeical Eng's fundamentals, Mcgraw Hill Kogakusha, Ltd.

Fig. 2.1. The Microstructure of Yeast.
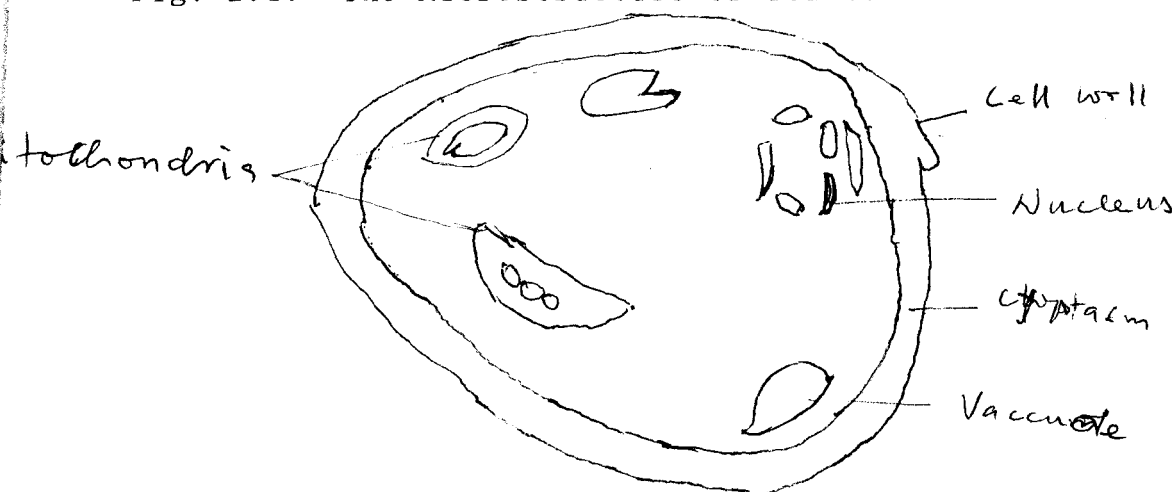
2.3.1 YEAST STRAIN SELECTION

Yeast strains are generally chosen from among saacharomyces cerevisiae, saccharonyces eclypsoidens s. carbsbergensis, s. fragilis and sch. zosacchiaromyces pombe. For when fermentation torula ceremoris or candida pscndotropicalis is used castillo et al 1982).

Yeasts are carefully selected for:

(1) High growth and fermentation rate

(2) High ethanol yield

(3) Ethanol and glucose tolerance

(4) Osmotolerance

(5) Low PH fermentation Optimum.

(6) High temp fermentation optimum.

(7) General hardness under physical and chemical stress.

2.3.2 ORIGIN OF ALCOHOL

What is fermentation?

The process now called fermentation was used by man long before there was any recorded history. Tribes of nomads must have learned that under certain conditions, milk would turn sour or would change to a solid or semi-solid material - · cheese. Part of these changes in milk resulted from fermentation by certain bacteria. For Centuries may have also been fermentating since by means of yeast to produce alcohol beverages. More recently, knowledge of the chemical details of fermentation has contributed to life itself.

Near the end of the eighteen Century, knowledge of chemistry was just beginning to develop. At that time the French Scientist, Antionie Lavoiseir, a founder of modern

chemistry, discovered that fermentation of glucose produce carbon (iv) oxide and alcohol. A little later, in 1810, another French chemist, Joseph Louis Gay-Lussac showed by a chemical equation the amount of carbon (iv) oxide and alcohol that are produce from glucose

$$C_6H_{12}O_6 \longrightarrow \begin{array}{l} 2C_2H_5OH \\ 2 \text{ moles of} \\ \text{ethyl alcohol} \end{array}$$
$$\searrow \begin{array}{l} 2CO_2 \\ 2 \text{ moles of carbon(iv) oxide} \end{array}$$
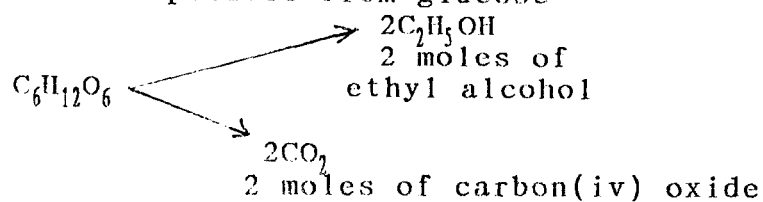
2.3.3 PREPARATION OF ALCOHOL

There are many ways by which alcohol can be prepared. The various methods are:

   i) Destructive distillation of wood

  ii) Synthetic production

 iii) Hydration of olegins

  iv) Hydrolysis of halides and sulphate

   v) Fermentation of natural sources of starch

Among the various methods of preparation, fermentation and the kinetic is described below.

2.4.0 FERMENTATION KINETICS

2.4.1 YEAST METABOLIC PATHWAY

In the anaerobic pathway, glucose is converted to ethanol and carbon dioxide via glycolysis. The overall reaction is as shown below.

$$C6H12O6 \longrightarrow 2C2HO + 2CO2 + (\text{energy stored as ATP})$$

Via this pathway, every gram of glucose converted will yield 0.511g of ethanol.

Table 2.2

Product	g/100g of glucose
Ethanol	48.4
Carbon dioxide	46.6
Glycerol	3.3
Succinic acid	0.6
Cell mass	1.2

Table 2.2, Optimum yields from Anaerobic fermentation by yeast.

2.4.1 EFFECT OF SUGAR CONCENTRATION

Sugar (Glucose, frutose, galatose or meltose) is the primary react in the yeast under fermentative condition, the rate of ethanol production is related to the available sugar concentration by a Monod type equation.

$$V = V_{max} \, C_s/(K_s + C_s)$$

where V = specific ethanol productivity (g ethanol/g ceutil)
  V_{max}
   C_s = sugar substrate concentration (g/l)
   K_s = Saturation constraint having a very low value,
typically   0.2 - 0.4g/l.

2.4.3 EFFECT OF PH

Fermentation rate is sensitive to PH, but most distiller's yeast show a broad PH Optimum from a least PH 4 - 6. This range is lower than that for typical bacteria. Furthermost, most yeast can tolerate exposure to acid solution of PH as low as 2 without range.

2.5.4 EFFECT OF TEMPERATURE

High temperature is a desirable characteristic selected for in distillery and most distillery yeasts have a temperature growth optimum of 30 - 35$_0$C (Ray et al 1942). The optimum fermentation at low alcohol concentrations is often slightly higher (up to 38^{c}C), but alcohol tolerance is

improved at reduced temperature. (Hayashida and Ohta, 1981).
Expressure to temperature above the optimum result in
excessive enzyme degradation and loss of yeast viability.

2.5.5 ADDITIONAL NUTRIENT REQUIREMENT.

Nutrients are chemicals which when in the environmental
of microbes can either act as food and favour growth or
prevent normal growth without killing or may kill the
organism. Micro-organisms, must have necessary nutrients for
their maintenance of their cell substance.

2.5.6 ENZYMES

Enzymes are protein which catalyze chemical reactions
taking place in living organisms. They are more efficient
than any other catalysts and may enhibit exceptional
properties of specificities. Though, they may undergo a
change in course of reaction, they remain unchanged at the end
of the reaction. A common measure of the activity of an
enzyme is the turnover number - the net number of substrate
molecule reacted per catalyst site per unit time.
Temperature, PH and concentration affect enzymic activities.

CHAPTER THREE

3.0 EXPERIMENTAL WORK

3.1 EQUIPMENTS AND APPARATUS USED

For the successful comparative studies of yield of ethanol from different cereals (e.g Maize and Millet grains) and root crop (e.g Yams and Cassavas). The below listed equipments and apparatus were employed. They are:

Measuring cylinder, Beakers, Conical flasks, Flat bottom flasks, weighing balance, hot plate, PH - meter, Stirrer, Set of distillation equipment, Shaker, Oven, Mortar and Pestal, Thermometer, Stop Watch, refregerator, pipatte, Scientific Calculator, filter - paper, fume, washing bottle, test - tubes.

3.2 MATERIALS AND REAGENTS

The research was carried out using the following materials and reagents. They are: Yam tuber (white), cassava tuber, maize grains, and millet grains, distilled water, 2 NHCL, vitamin - B - comlplex, iodine solution, Tehling solution, buffer solution, filter - paper, paper indicator.

3.3 EXPERIMENTAL

Ethanol was prepared from yam tuber, cassava tuber, maize and millet grains by acid treatment.

3.4 EXPERIMENTAL PROCEDURE

3.5 The following steps and methods were involved in preparation of ethanol from specified cereals and root crops for comparative reasons.

3.5.1 Gathering of the materials, reagents, apparatus and equipment:- Before the commencement of the experimental work,

the materials, reagents, apparatus and equipments as listed above were first gathered.

3.5.2 Cleaning:- The root crops and cereals grains meant for the experimental work, having gathered them, were subsequently given thorough cleaning by washing after which they were dried by solar energy.

3.5.3 Milling and Crushing:-

The maize grains which had hard test were first milled in motar and then winnowed. After the winnowing operation, it was then further milled to a suitable size. Millet grains was milled in the same manner but because of the millet grains was thin testa winnowing process was not carried out. As for yam and cassava tubers, they were first peeled and crushed in mortar to the most suitable size. After drying for some days the crushed and milled materials called 'grist' were weighed separately on electronic weighing balance and weights noted. They were then subject to further drying, but this time around in oven with oven temperature at 105°C for a period of one hour. After the stipulated time for drying had eluded, the oven was witched off. Subsequently each grist was re-weighed to determine whether moisture content has been evaporated. This process was repeated several times until the weights of each grist remained almost practically constant.

3.5.4 SIZE ANALYSIS:- Each grist was analysized into various sizes. This was done then sieved for about 10 minutes. The different sizes of each grist resulting after shaking were pan fraction, 250Jm, 500Jm, 750Jm, 1.00mm. The main of analyzing was to get size suitable for the experiment, hence for the purpose of research work 250Jm sizes of each grist was used.

3.5.5 MASHING

Before mashing of the grist, concentrated HCl (raw acid) was diluted by taking 177.ml of the raw acid and made it up to 1000.0ml with distilled water giving 2N HCL. Also, 3N NaOH solution was prepared by dissolving 90.0g of NaOH pallets in 750ml of distilled water. After thorough mixing the solutions were allowed to cool in their various conicel flasks. Then, 12.0g each of the four grist was weighed separately and then transferred into four different conceal flask of known weight 125.0ml each of distilled water and 2N HCL acid respectively into the four different conicel flasks. Each of the mixture was thoroughly and constantly agitated for 15 minutes.

After agitation, about 2.0ml of each mixture was pipetted into four test - tubes. Starch was tested for by adding one or two drops of iodine solution into each test - tube.

3.5.6 GELATINIZATION:

The mixtures in each separate conical flasks was place on four separate hot - plates and then gelatinized for about 20.0 minutes until the vapour pressure of each mixture became equal atmospheric pressure which was found to be 97^0C.
Gelatinization was done purposely for Saccharifying. Having gelatinized the mixture well enough, it was then dropped down and allowed to cool to the prevailing room temperature (34^0C). While the cooling was in process, PH - meter was standardized by using buffer solution. he standerdized PH meter was used to determine the PH of each cooled mixture and was found to be for - Maize 0.17; Millet, 0.18; Cassava, 0.20 and Yam, 0.21. PH of each mixture was then raised to 6.85 by petting 3N NaOH Solution in drop - wish until the equipment PH was attained.

Having raised PH of each mixture, a test for sugar was carried out. This was done by adding a few drops of Fehling's solution to about 4.0ml of each mixture in different test tube. On heating, a brick-red precipitated was obtained on boiling indicating presence of fermentable sugars which was probably glucose. The volumes and weights of each mixture were determined with the aid of measuring cylinder and weighing of balance.

3.6.0 FILTRATION: In order to get a uniformly and evenly distributed solution, each mixture was filtered into different conical flasks. The filtrates, 'wort' collected from each weighed and their volumes measured and their respective relative densities were calculated. After filtration, it was expected that some substantial amount of sugar (fermentable) was left behind in the residues and even filter - paper used for filtration. Therefore, to wash such sugar down into the collected wort, 100.0ml of distilled was used for sparging.

3.7.0 PITCHING: Before the wort was pitched (i.e inoculated) with yeast the wort was cooled to temperature of 15^0C and aerated. Then 5.0g of yeast, Saccharumyce Cerevisia was dissolved in 80.0ml of distilled water. (Luke - worm water) and then transferred into the Bucher flask. Subsequently, 2.5g of vitamin - B - complex (tablet of vitamin - B - complex grounded into powder form) was added to the flask. The mixture was then shaked for proper mixing. The same was done to the remaining three mixtures.

3.8.0 FERMENTATION: After pitching process, each buchner flask of wort inoculated with yeast and vitamin – B – complex as sustainer, was corked with rubber – cork and since the success of fermentation depend largely upon the condition requirement of the yeast used, the hole through which yeast exchanged oxygen for respiration was lighly blocked with cotton wool as shown in the figure. Each set – up was then kept on the table where the enzynic activities of each set – up was not distablized by shaking and then left to ferment for a period of 68 hours.

3.9.0 DISTILLATION:- The fermented mixtures was separately distilled batchwise to get ethanol. That was done with aid of a set of distillation equipment shown in figure. The whole experimental procedure was repeated twice and the averages are as shown in the table of value.

3.10.0 TEST FOR ALCOHOL, IODO-FORM TEST

1.0 ml of alcohol from each was measured into test tube. The alcohol was then treated with iodine and sodium hydroide (sadum hypoiodite, NaOI). The reagent is a solution of iodine in NaOH (I_2/NaOH). After treatment a yellow precipitation of iodo form (CHI_3 = iodoform) formed indicating that the sample tested was ethanol.

CHAPTER FOUR

4.0 EXPERIMENTAL RESULTS.

4.1 RESULTS OF DETERMINATION OF WEIGHT AND SIZE ANALYSIS

Table 4.1 Shows the result of weight of each four samples

	Total weight of grist after solar drying (g)	Constant weight obtained after drying in over for 90min.	Total weight retained in Pan-fraction (in g)	Total weight retained in 250Um	Total weight retained in 500 Um	Total weight retained in 750 Um	Total weight retained in 1.0mm
MAIZE	278.278g	270.422	60.203	58.119	50.207	53.981	47.430
MILLET	144.573	239.872	37.371	47.225	40.873	6.305	7.029
YAM	161.514	148.768	50.912	63.731	14.877	13.871	5.097
CASSAVA	95.765	88.46	17.603	31.171	4.003	2.418	33.147

4.2 MASHING RESULT AND ANALYSIS

Having dried the samples by the two possible means, mashing and analysis were followed immediately. The results obtained are summarised in table 4.2 below.

MEASUREMENTS	MAIZE	MILLET	YAM	CASSAVA
Weight of empty Con. flask (g).	183.919	175.407	183.919	178.410
Size of grist used	250μm	250μm	250μm	250μm
Weight of grist used Volumes of distilled water.	12.0g	12.0g	12.0g	12.0g
2N HCl (ml) wt of empty flask + wt of grist +	250	250	250	250
wt HCl + wt H_2O	445.919	440.41	445.919	440.41
Prevailing room tempera-ture.	31.0℃	31.0℃	31.0℃	31.0℃
Time for agigation (minutes). Test for starch.	15 Present	15 present	15 present	15 present

4.3 RESULTS OF GELATINIZATION AND ANALYSIS

Gelatinization process is the subsequent process after mashing.

The result obtained are as shown in table 4.3. The equation of starch conversion is as shown below. On hydrolysis $(C_6H_{10}O_5)n + H_2O \longrightarrow nC_6H_{12}O_6$
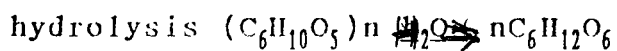
4.3 RESULT OF GELATINIZATION

In order to obtain a homogenous solution which will be suitable fermentation process, each mixture was subjected to filtration.

The results of filtration and wort arc tabulated in table 4.4

	Ave. time gelatini-zation (mins)	Temp. of mixture before gelatini zation	B. PL of mix-ture.	Test for starch gelatini-zation.	Colour of mixture after gela-tinization.	Ave. wt of mix. after gelatini-zation.	PH of mixture after gelatin	PH each mixture was raised.	Ave. Vol. of mixture after PH raised (ml)
MAIZE	20.0	31.0oC	98oC	absent	light yellow	243.751	0.17	6.85	324.044
MILLET	20.0	31.0oC	98oC	absent	light yellow	238.921	0.18	6.85	321.819
YAM	20.0	31.0oC	98oC	absent	light yellow	224.565	0.20	6.85	329.0
CASSAVA	20.0	31.0oC	98oC	absent	pale	225.642	0.20	6.85	340.0

Table 4.3

4.4 RESULT OF FILTRATION AND WORT ANALYSIS

	Taste for mix. after raising	Average water for Vol. of sparing 90min.	Prevailing Temperature.	Ave. wt of work collected (g)	Ave. Vol. of work collected (ml)	Ave. Density of work.	Ave. Density of H_2O
MAIZE	Salty	wt 100ml	34oC	355.921	350	1.0169	0.923
MILLET	Salty	(wt 99.44g) 100ml	34oC	338.649	359	1.0492	0.991
YAM	Salty	100ml	34oC	341.564	340	1.0046	0.9437
CASSAVA	Salty	100ml	34oC	351.134	345	1.0178	0.9944

Table 4.4

Table 4.5, 80.0ml H_2O were for sparing 79.55g The equation of reactions that was involve from

hydrolysis and finally fermentation is as shown below.

$$C_6H_{10}O_5 + H_2O \xrightarrow{\text{HCl}} C_6H_{12}O \quad \text{--------}(1)$$

$$C_6H_{12}O_6 \xrightarrow{\text{Yeast}} 2C_2H_5OH + 2CO_2 + Energy \quad \text{--------}(2)$$
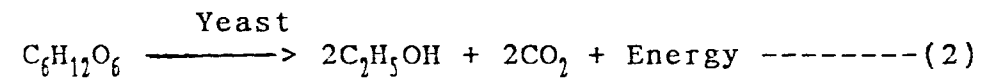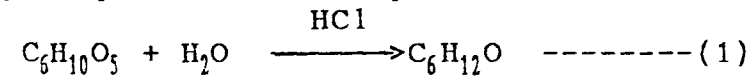
4.5 PITCHING AND FERMENTATION RESULT

	Ave. Vol. & work to be ferment	Average wt of Yeast added (g)	Ave. wt of Vit. B complex added (g)	Ave. Vol. of distilled H_2O for dissolving Yeast.	Ave. Vol. of ferment mixture (ml)	Ave. wt of ferment mixture (g)	Temp. of ferment mixture (^0C)
MAIZE	350	5.0g	2.5	wt 297.55g 80.0ml	355.0	365.95g	28^0C
MILLET	359	5.0	2.5	80.0	370.0	378.992	28^0C
YAM	329	5.0	2.5	80.0	338.0	343.219	28^0C
CASSAVA	345	5.0	2.5	2.5	351.0	357.010	28^0C

Table 4.5 80.0ml H_2O mix for sparing 79.55g

4.7 <u>TODO FORM TEST RESULT</u>

The reaction involves oxidation, halogenation and cleavage. The equations are shown below.
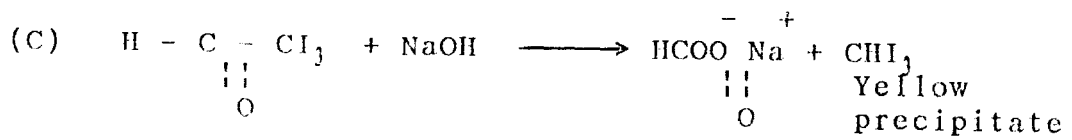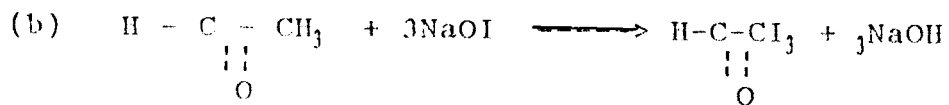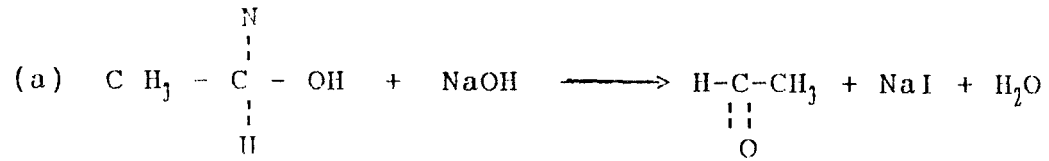
(a)

$$CH_3 - \underset{\underset{H}{||}}{\overset{\overset{N}{|}}{C}} - OH \ + \ NaOH \ \longrightarrow \ H-\underset{O}{\overset{||}{C}}-CH_3 \ + \ NaI \ + \ H_2O$$

(b)

$$H - \underset{O}{\overset{||}{C}} - CH_3 \ + \ 3NaOI \ \longrightarrow \ H-\underset{O}{\overset{||}{C}}-CI_3 \ + \ _3NaOH$$

(c)

$$H - \underset{O}{\overset{||}{C}} - CI_3 \ + \ NaOH \ \longrightarrow \ HCOO^- Na^+ \ + \ \underset{O}{\overset{||}{C}}HI_3$$

Yellow precipitate

FERMENTATION STAGE

A — MILLET
B — MAIZE
C — TAPU
D — CASSAVA

PIPE FOR WATER COOLING

BEAKER

COTTON WOOL

BOTTLE FOR COLLECTING C_2H_5OH (ETHANOL)

CONDENSER

THERMOMETER

RUBBER CORK

ROUND BOTTOM FLASK

HEATING MANTLE

REGULATOR

POWER INDICATOR

POWER SOURCE
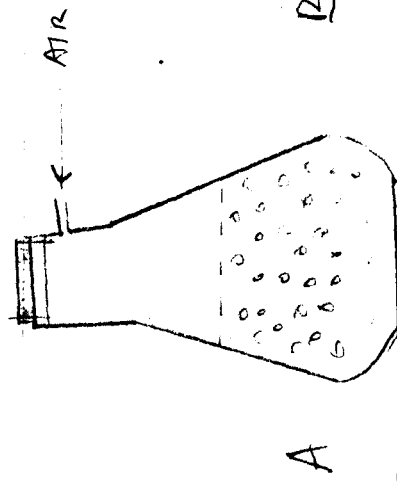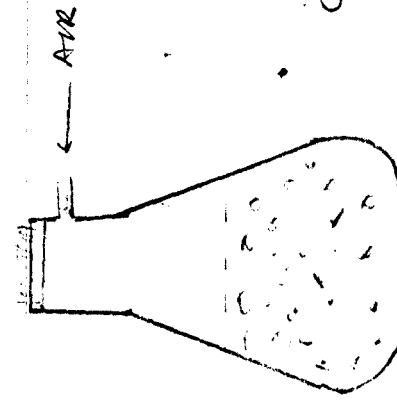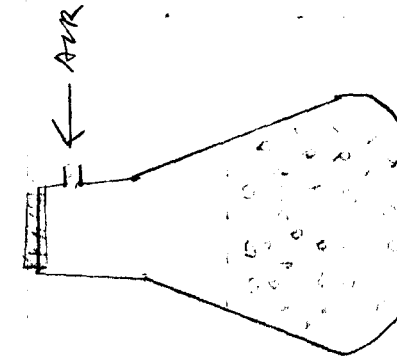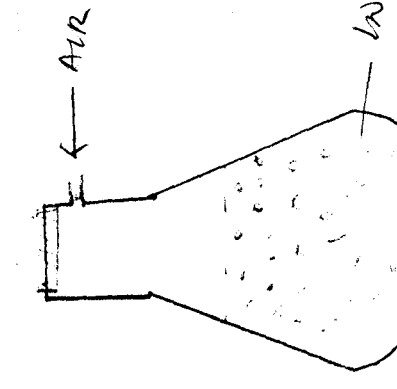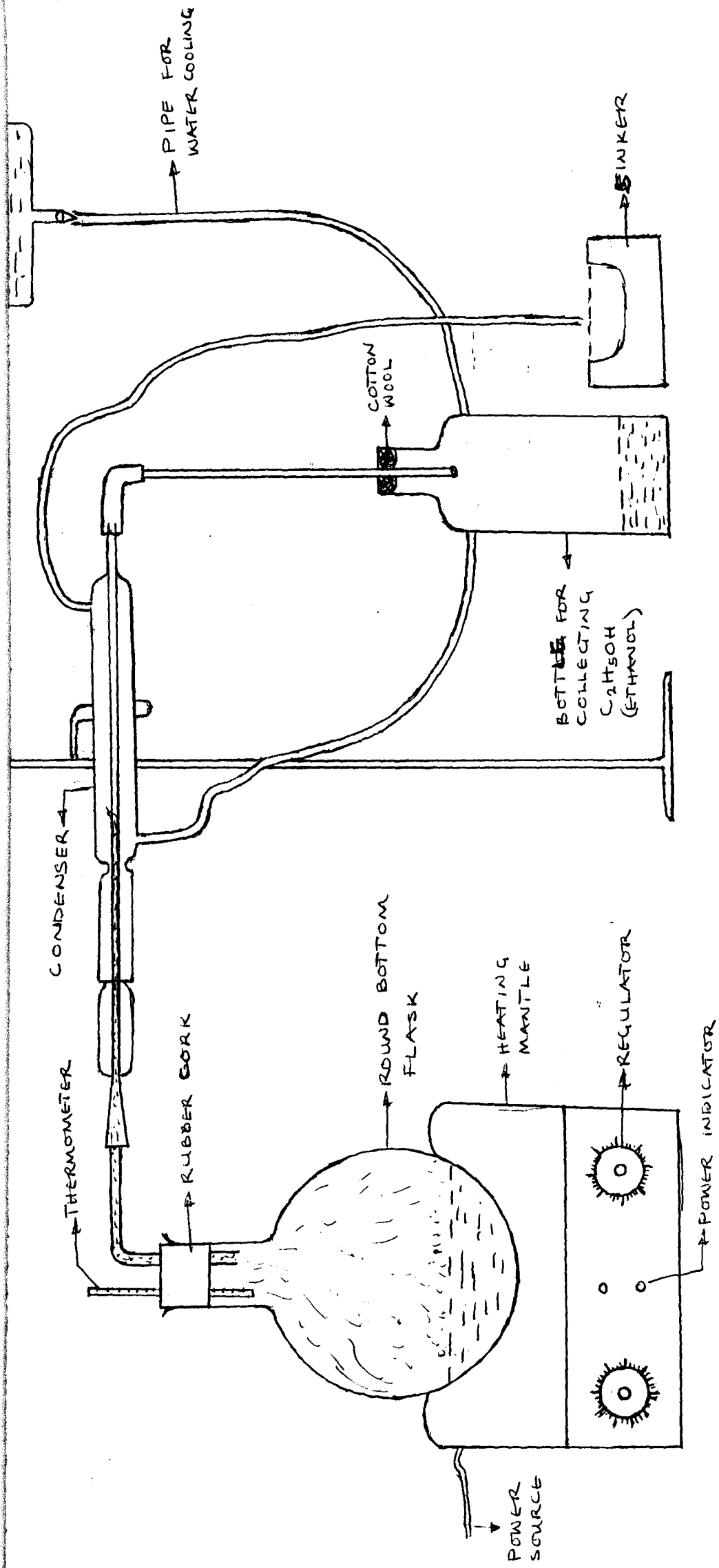
A SET OF DISTILLATION EQUIPMENTS

4.6 DISTILLATION RESULT AND DETERMINATION OF ETHANOL YIELD

	Average wt of fermented mixture (g)	average vol. of fermented mixture (ml)	Average of wt elthanol colected (g)	Average of wt of Distilled Used (H$_{20}$	Average Vol. of ethanol Collected (ml)	Percentrage (w/w)
MAIZE	365.75	355	2.239	2.349	2.2	27.10
MILLET	378.992	370	6.652	2.652	2.6	28.62
YAM	343.219	338	2.885	2.885	2.80	25.16
CASSAVA	357.010	351	1.923	1.923	1.8	26.52

Table 1.6

5.4 TECHNOLOGICAL SCHEME OF PRODUCTION

The technology is the science on the modes and processes of manufacturing industrial products from raw materials. The mode of manufacture is a combination of all the operations which the raw materials pass through until the product is obtained from it.

A mode of manufacture consists of consective unit operations proceeding in the corresponding machine and apparatuses. A set of unit operations forms a chemical technological system. A description of chemical technological system is called flow sheet. An operation can occur in one more apparatueses (machines). It is a combination of various technological (production).

Technology is divided into mechanical and chemical. Mechanical technology deals with processes that changes the shape, appearance or the physical properties of a material, whereas chemical technology deasl with processes when the composition, properties and internal structure of a substance change.

5.5 MATERIAL BALANCE

In the design of a distillation apparatus, one usually knows in advance the composition and quantity of feed and of the over head product, and the composition of the bottom product.

Material in = material out.

Proceeding from the material balance equation, one can than find the flow rate of the overhead and bottom products the internal material flows will depend on the value of the reflux ratio, R:

5.6 ENERGY BALANCE

In distillation apparatus, the energy is thus:-

Energy Input = Energy out put of the follow notations are used:

Q_1 = heat input to the reboiler of the distillation column with   heating steam, kj/hr.

Q_2 = heat input with the feed kj/hr

Q_3 = heat leaving with the vapour kj/hr

Q_4 = heat leaving with the bottom product kj/hr

Q_5 = heat input with reflux, kj/hr

Q_6 = heat lost to the surrounding kj/hr

heat balance equation can then be written:-

$$Q_1 + Q_2 + Q_5 = Q_3 + Q_4 + Q_6$$

Schematic Process Flow sheet

| Mashing | 100g/b | Milling | 157.2 Drying | Weighing | Oven |

Feed
g/batch
200gbatch

Test for
Starch

| Heater Measurement | Stirring | Mashing | Weighing | Sieving | Weighing |

| Gelatn | Neut. | Filt. | Ferm. Pitch. & Ferm | Distillation | Alcohol |
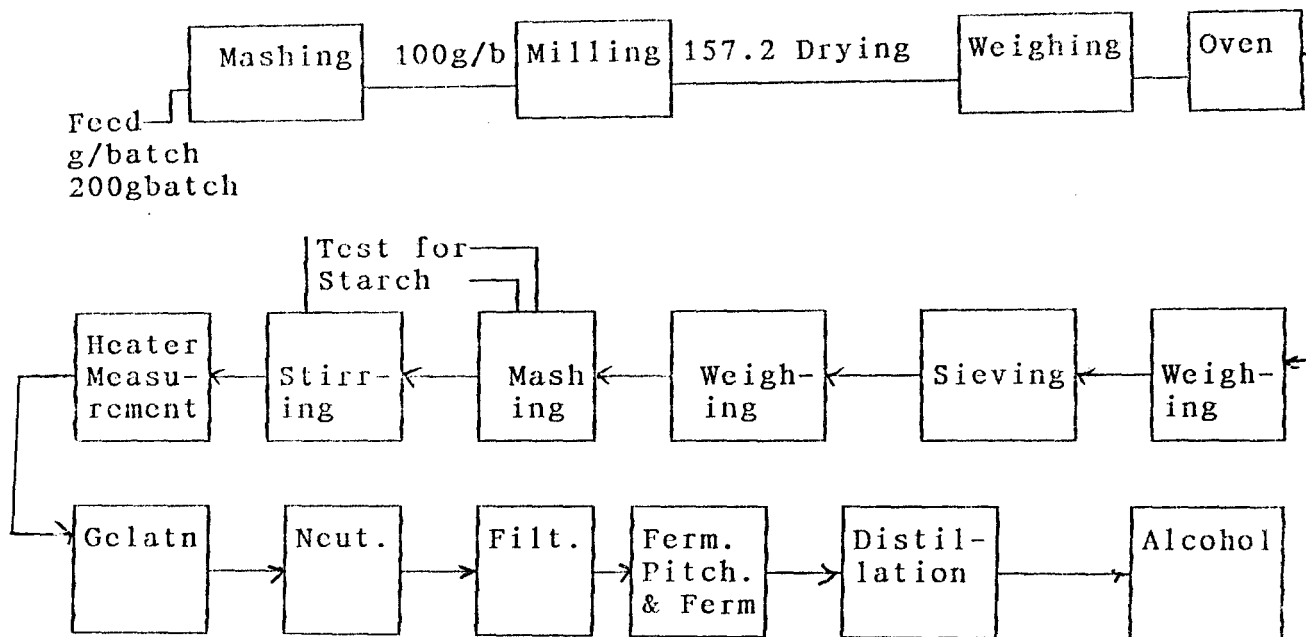
5.7.1 BALANCE OVER EACH STAGE
Scale up factor:- This design of equipment distillation

column to distill 50 litre of ethanol/Batch. Volume of ethanol produced from practical experiment = 2.60ml = 2.60 x 10^{-3} 1.

. . to produce 50 litres.
Scale up factor:-
$$\frac{50}{2.60 \times 10^{-3} \text{ l.}} = 19230.76923 = S.I$$

Basis: 1 batch.

5.8 MATERIAL BALANCE OVER WASHER
Material in = Material out
Material in, Miw = 200 X 10^{-3} x 19230.76923kg
= 3846.15kg
Material out Mow = 160 x 10^{-3}kg x 19230.76923
= 3076.92kg
Mass of containminant Mc = ?
Material in = Material out
Miw = Mow + Mc
Mc = 3846.15 - 3076.92
= 769.23kg

5.7.2 **MATERIAL BALANCE OVER MILLER**
Material in = Mim = 3076.92kg
Material out = 3023.08kg = Mom
Loss in the miller = Lm
Mim = Mom + Lm
Lm = Mim - Mom
   3076.92 - 3023.08kg
Lm = 53.84kg

5.7.3 **MATERIAL BALANCE OVER SOLAR DRYING**
Material in, MiD = 3023.08kg
Material out, MoD = 2780.25kg
Losses due to evaporation Le
MiD = MoD + Le
Le = 3023.08 - 2780.25
   = 242.83kg

5.7.4 **MATERIAL BALANCE OVER WEIGHING 1**
Material in = Material out
Material in = 2780.25kg
Material out = 2780.25kg
2780.25kg = 2780.25kg
Negiligible.

5.7.5 **MATERIAL BALANCE OVER OVEN**
Material in, Miov = 2780.25kg
Material out = Moov 2689.85kg
Mass of water lost due to evaporation = Mwe
Material in = Material out + Mwe
Miov = Moov + Mwe
Mwe = Miov - Moov
   2780.25 - 2689.85
   = 90.40kg.

5.7.6 **BALANCE OVER WEIGHING 2.**
Material in = Material out
Material in = 2689.85kg
Material out = 2689.85kg
No losses.

5.7.7 **BALANCE OVER SHAKER**
Material in, Mik = 2689.85kg
Material out, Mok:
Material retained in Pan fraction = 718.67kg
Material retained in 250Um plate = 908.17kg
Material retained in 500Um plate = 375.25
Material retained in 750Um plate = 564.33kg
Material retained in 1.00m plate = 102.87kg
Material loss in the plates = ?
Material in   Material out = Loss
   = 2689.85 - 2669.29 = 20.55kg

5.7.8 **MATERIAL BALANCE OVER MASHING**
Material in, Mim:
Mass of grist = 230.77kg = M.g
Mass of 2403.851 distilled H2O added 2390.44kg
Mass of 2403.851 of HCl = 2475kg
Material in, Mim = Material out, Mom.
230.77 + 2390.44 + 2475 = Mom
Mom = 5096.21kg = Solution.

5.7.9 <u>MATERIAL BALANCE OVER STIRRING PROCESS</u>
Material in Mis = 5096.21kg
Material out Mis =
Material use in testing for starch = 57.69kg = Mot
Mis = Mos + Mot
$$= 5096.21 - 57.69$$
$$= 5038.52kg$$

5.7.10 <u>MATERIAL BALANCE OVER GELATINIZATION</u>
Material in MiG = Material our MoG
MiG:
Starch   - 181.15kg
Protein   - 30kg

Fat   - 12.40kg
Others   - 7.15kg
H_2O - 2390.44kg
HCl   - 2475kg
MiG   = 5096.2kg

Material out MoG:
Loss in gelatinization = LG.
Qu = 89.11kg
Y = 92.04kg
Protein = 30.kg
Fat   = 12.46kg
Others = 7.15kg
Quantity of H2O that liberated = 490.45kg.
Quantity of HCl used = 2470 - 490.45
$$= 1979.55kg$$
Quantity of H2O used for hydrolysing = 10.227kg
Quantity of H2O left in solution
$$= 2390.44 - 10.227 = 2380.21kg.$$
MoG = 89.11 + 92.04 + 30 + 12.46 + 7.15 + 2470 +
2390.44 -
$$490.45 - 10.227 + La.$$
$$= 4590.52kg = Mass.$$

. . 5096.2 = 4590.52 + LG wt of Mixture after heating =
4590.52

<u>MATERIAL BALANCE OVER NEUTRALIZATION REACTION.</u>
Equation:
NaOH + HCl $\longrightarrow$ $NaCl_{(g)}$ + H2O ----------(1)
Volume of NaOH uSED = 1284.98
Con. of NaOH = 3mol/dm^3
Volume used = ?
V_A x C_A = V_B x C_B
3 X 1284.98 = 2 X V_A
V_A = 1927.47 Litres
where V_A = volume of HCl that was neutralized.
The ramaining volume of HCl was liberated during
gelatinization
$$2403.85 - 1927.47$$
$$2403.85 - 1927.47 = 476.38L$$
The volume of HCl liberated due to gelatinization = 476.38L
Mass of NaCl formed
from (1) above
V_{NaOH} = 1284.98L
C_{NaOH} = 3Mol/dm^3
No of mole of $_{NaOH}$ used = 1284.89 x 3
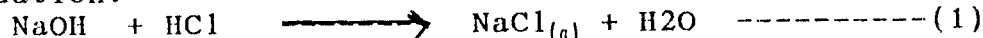
No of NaCl formed = 3854.67 Mol   Hence mass of NaCl produced
= 3854.67 x 58.5710^{-3}kg
   225.50kg
   Mass of NaCl produced = 225.50kg
Equation of fermentation process.
         Yeast
$C_6H_{12}O_6$ $\xrightarrow{\hspace{2cm}}$ $2C_2H_5OH$ + $2CO_2$ ---------------(4)
from (4) 1 mole of $C_6H_{12}O_6$ was fermented to gas 2 moles of
C_2H_5OH.
Mass of C_2H_5OH = 2.718 x 10^{-3}kg x scale up factor
               = 2.718 x 10^{-3} x 19230.76923
               = 52.27kg C_2H_5OH
Quantity x, of C_2H_5OH that produce 52.27kg C_2H_5OH
        x = $\frac{52.27 \times Mol\ mass\ of\ C_6H_{12}O \times 1}{2 \times Mol.\ mass\ C_2H_5OH}$
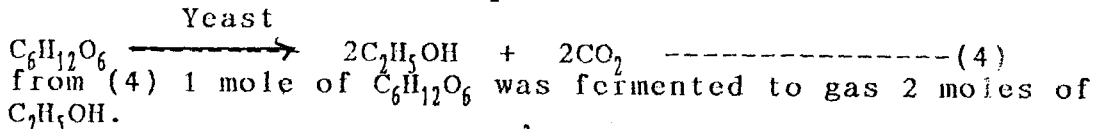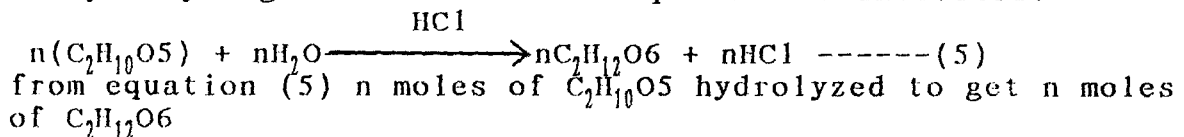   = $\frac{52.27 \times 180g}{2 \times 46g}$ = 102.27kg $C_6H_{12}O$ = x.

On hydrolyzing starch the below equation is invovlued.
                    HCl
$n(C_2H_{10}O5)$ + nH_2O $\xrightarrow{\hspace{2cm}}$ $nC_2H_{12}O6$ + nHCl ------(5)
from equation (5) n moles of $C_2H_{10}O5$ hydrolyzed to get n moles
of $C_2H_{12}O6$
Quantity of $C_2H_{10}O5$ hydrolyzed = Y
Quantity of $C_2H_{12}O6$ produced = x = 102.27kg.
Quantity of Y hydrolyzed = $\frac{162g \times 102.27 \times nkg}{180g \times n}$ = 92.04kg
                        = Y = 92.04kg
from equation (5), quantity used for ger hydrolyzis = $\frac{102.27 \times 18}{18}$

                                                            180

But from analysis,
Quantity of starch Qs in grains of grist = 78.5%
Quantity of starch W in the 12g of grist
        = $\frac{78.5}{100}$ x $\frac{12g}{1000}$ x 8.I
        = 0.785 X $\frac{12}{1000}$ x 19230.76923kg
        W = 181.15kg
Unhydrolyzed starch, $C_6H_{10}O5$, Qu
        Qu = Qs - Y = 181.15 - 92.04
              Qu = 89.11kg
Percentages composition of protein in 1 gram grist = 13%
Percentages of protein Qn in the grist $\frac{13}{100}$ x 230.77kg

                                             Qp = 30.00kg.
Percentage composition of fat in gram of grist = 5.4%
Quantity of fat Q_f in 230.77kg
              Q_f = 230.77 x $\frac{5.4}{100}$ = 12.46kg
Percentage composition of others in 1 gram grist = 3.19
Quantity of other Qo = 230.77 x $\frac{3.1}{100}$ = 7.15kg
Material in for neutralization MiN = Material out after
                                        neutralization
Material in MiN = Grist + NaOH + HCl
Total Quantities of MiN = 376.665g (from table 4.4)
     MiN = 376.665 x 10^{-3}kg x S.F
         = 2743.56kg.

Material out after neutralization MoN:-
  Quantity of Grist + Quantity NaCl formed + Quantity H_2O
  (230.77 + 225 + 2390.44)kg
where 230.77kg = Quantity of grist L
     225kg Quantity of NaCl.
     2390.44kg Quantity of H_2O.
  Material out = 2846.21kg.

5.7.11 MATERIAL BALANCE OVER FILTER
Material in:- mass of mixture after gelatinization = 4590.52kg
          mass of H_2O for sparing = 1912.33kg
Material out:-
  Mass of filtrate + Mass of Residue
  Residue:- Mass of:- Fet + Protein + Others +
          Unhydrolyzed starch = 138.72kg
Material in = Material out
    4590.52 + 1912.35 = Mass filtrate + Residue
      6502.87   =   Mass filtrate + 138.72
      Mass of filtrate = 6364.15kg

5.7.12 MATERIAL BALANCE OVER FERMENTATOR
    Material in:-
    Mass of filtrate = 6364.15kg
    Solution of Yeast, vitamin B-complex and H_2O
           = 1674.11kg.
Material out:-
    Disappearance
    Accumulation = 1180.30kg
    Remain refermented mixture = 6108.0kg.
Material in = Material out.
    6364.15 + 1674.11 = 1180.31 + 6108.01 + D = 749.95kg.

5.7.1.2 ENERGY BALANCE OVER BOILER
    Basis 31^0C
    Heat of reboiler Qr = heat record by feed. Q_F.
    Heat input = Heat output
    Head input into Feed = Heat out with product.
    Qr = Q_F
  Q_F = Mean heat capacities Grist + heat of H_2O + heat of Heat
                  HCl.
from analysis of grist
  Starch 78.5%, Cp = 1.58KJ/kgk
  Protein = 13%, Cp = 1.35KJ/kgk
  Fat = 5.4%, Cp = 1.46KJ/Kgk
  Other = 3.1, Cp = 2.12KJ/Kgk (Assumed)
Mean heat capacity CpmQ of grist
Cpma = 0.13 x 1.35 + 0.785 x 1.58 + 0.054 x 1.465 + 0.03 x 2.1.2
    = 0.1755 + 1.2403 + 0.07911 + 0.065472.
Cpma = 1.560382KJ/kgk = 1.56KJ/Kgk
Quantity of grist = 230.77kg.
Quantity of H_2O used for hydrolyzed = 2390.44kg
Cp H_2O = 4.2KJ/kgk
Quantity HCl used = 2475kg
Cp   HCl = 1.92KJ/kgk
Q_F = $M_F C_{PF}$ T
    Where   T = 97^0C - 31^0C, and is constant since the feed
mixture was heated from 31^0C to 97^0C.
Q_F = [2475 x 1.92 + 2390.44 x 4.2 + 230.77 x 1.56]
    = 66[15151.85]

CHAPTER FIVE

5.0 DESIGN PROJECT

Design is a creative activities and is one of the most rewarding and satisfying activities undertaken by an engineer. It is the synthesis that put together to achieve a goal.

The design of a plant for a large scale production of materials is one of the major responsibilities of chemical engineers. The designers is creating a design for an article or manufacturing process to fulfil into a particular need. The choice of a design procedure depends on the type of contacting device used in a given plant.

5.1 DESIGN OF A DISTILLATION COLUMN FOR THE DISTRIBUTION/PURIFICATION OF ETHANOL.

The separation liquid mixture into their several components is one of the major operation in the chemical and petroleium industries, and distillation, the most widely used of achieving the end is the key operation of breweries and oil refineries. Throughout the chemical industry the demand for purer products, coupled with a relentless pursuit of greater efficiency, has necessitated continued research into the technique of distillation. On engineering side, distillation columns have to be designed with a larger range in capacity than any other type of processing equipments with single column from 0.30 to 10.0m in diameter and from 3 to upward 75m in height. The demand on designers is not only to achieve the desired product quality at minimum cost, but also to provide constant purity of product even though there may be some varieties in composition.

5.2 THE PRINCIPLE OF DISTILLATION

For insight in the principle of distillation, consider as an example the separation of binary mixture (binary distillation), in this operation, the starting mixture called the feed, is separated into two parts, one part enriched in the more volatile component (called the distillate, overhead or top product) and the other part low in the more volatile component called waste, residue, or bottom product.

Let us adopt the following notation

GF = amount of feed, kmol

GP = amount of overhead product kmol

GB = amount of bottom product kmol

Uf = mole fraction of the more volatile component in the feed.

Up = mole fraction of the more volatile component in the overhead product.

Ub = mole fraction of the more volatile component in the bottom product.

Using the above notation, the material balance on distillation may be described by two equation

(h) in terms of the entire feed

$$Gf = Gp + Gb \quad ------------(1)$$

(n) in terms of the more volatile component in the feed

$$Gf\ Xf = Gp\ Xp + Gb\ Xb --------(2)$$

proceeding from the two equations

$$Gp = Gf\ \frac{Xf - Xb}{Xp - Xb}$$

$$Gb = Gf\ \frac{Xp - Xf}{Xp - Xp}$$

A complete distillation tower or column consist of an upper enriching or rectifying section and a lower stripping

section. Each section is in effect a contacting surface between liquid and vapour.

The vapour required for the operation of a distillation tower is produced by repeated vaporizing the liquid of the required liquid is produced by repeatedly condensing home or all of the vapour of the same composition oas the overhead product.

In the analysis of the interaction between the vapour and the liquid in a distillation device we will proceed from the following assumptions.

(a) The metal heats of vapourization are the same for all components, therefore each kilogram - mole of vapour on condensing will evaporate one kilogram - mole of liquid and, in consequence, the metal flow of vapour moving upwards in the device is the same at any level of the device.

(b) As the vapour condenser if a distillation device, no change occurs in its composition and, as a consequence, the vapour leaving the distillation device has the same composition as the overhead product, $Y_p = X_p$.

(c) As the liquid vapourizes in the reboiler of a distillation device, no change occurs in its composition and, as a consequence the vapour produced in the reboiler has the same composition as the bottom product. $Y_b = X_b$.

5.3 TYPES OF DISTILLATION EQUIPMENT

The distillation equipments used in chemical processing may be classed into the batch type and continous type.

In term, batch distillation equipment may be classed into units operation at constant reflux ratio and units operating at a constat overhead composition.
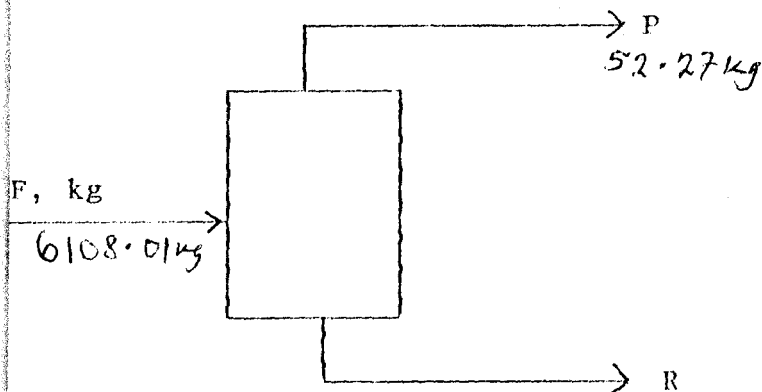
$$= 1000022.10 KJ/k$$
$$= 1000.02 \times 10^{-3} KJ/K$$

Since $Q_r = Q_F$

$$=$$

heat received by feed = 1000.02MJ/K which mean the quantity of headt generated by the reboiler.

5.7.12 MATERIAL BALANCE OVER DISTILLATION COLUMN

P

$52 \cdot 27 kg$

F, kg

$6108 \cdot 01 kg$

R

Material in = Material out
F = P + R
6108.01 = 52.27 + R
R = 6055.75Kg

5.7.13 ENERGY BALANCE OVER DISTILLATION COLUMN
Basic $31^0 C$
Energy Out = Energy In

$$Q_r + Q_F = Q_V + Q_R \ Q_{Air} + Q_C \ -$$

Q_r = heat input to the boiler of distillation
Q_F = heat input to the feed
Q_V = heat leaving with ethanol
Q_{air}= heat lost to the surrounding
Q_R = heat leaving with residue
Q_C = heat leaving with water for cooling
C_p of air = 1.005KJ/kgk

$$Q_r = Q_F = Q_R + Q_{Air} + Q_C + Q_F \ -$$
Mass of ethanol produced = 52.27kg
C_p of ethanol = 2.428KJ/kgk
Mass of feed input = 6108.01kg.
Mass of H_2O used for cooling = 110946.73kg
C_p of H_2O = 4.2KJ/kgk
Mass of residue = 6055.74kg

Q_F = MCP ΔT.
But feed contain = 0.86% ethanol,

H_2O = 99%, others which are sodium and unfermented and there neglected.

$$\therefore \quad C_{PMF} = 0.99 \text{ X } 4.2 + 0.0086 \text{ x } 2.428$$
$$= 4.158 + 0.021$$

$$C_{PMF} = 4.179 KJ/kgk.$$

Temperature of feed = 78^0C i.e final temp.

Initial temp of feed = 31^0C

$$\therefore \quad \Delta T = (78-31)^0C = \underline{47.31^0C}$$

$$\therefore \quad Q_F = MC_{PMF} \quad \Delta T$$
$$= 6108.01 \text{ x } 4.179 \text{ x } 47.31$$
$$= 1207605 . 43KJ/k$$
$$Q_E = MC_p \quad T$$
$$52.27 \text{ x } 2.428 \text{ x } 47.31$$
$$= 6004 . 19Kg/k$$

$$Q_R = MC_p \quad \Delta T$$
Residue is essentially H_2O
$$Q_R = 6055.74 \text{ x } 4.2 \text{ x } 47.31$$
$$= 1203287.65KJ/h$$
Q_{Air} is negligible and is therefore ignored (Insulated system)
$$Q_C = MC_p \quad \Delta T$$
$$110946.73 \text{ x } 4.2 (33 - 31)^0C$$

$$T_1 = 31^0C$$
$$T_2 = 33^0C$$
$$Q_C = 110946.73 \text{ x } 4.2 \text{ x } 2$$
$$931952.53KJ/k$$
$$Q_f = -1207605.43 + 6004.19 + 1203287.65 + 931952.53$$
$$= 933638.94$$
$$= 933638.94KJ/kg$$
$$= 933.64MJ/k$$

5.8 SIZING

For economic reason and for the fact that ethanol is less

corrosive, mild steel was used as material of construction and

sieve tray was also used as tray

Assuming: For the sake of size calculation the following assumption are made.

Ratio: $R = \dfrac{L_0}{D} = 2\ $--------(1)

Where D = distillate = 52.27

Substituting for D into equation---(1)
$$L_0 = 1.0 \text{ x } 52.27$$
$$= 52.27$$

But vapour flow rate Q_V

$\quad = Q_V = 54 + 52.27 = 104$

$\quad Q_V = 104.54$

Column diameter D, $= 4.5 \; Q_V^{0.5} \left(\dfrac{P_V}{P_L - P_V} \right)^{0.25}$ ----(2)

$\quad$ where P_L = Density of H_2O = 80^0C = $971.81 kg/m^3$

$\quad\quad P_V$ = Density of vapour = $0.002 kg/m^3$

$Q_V = 104.54$

$\quad$ from ----(II)

$\quad\quad D = 4.5 \times 104.54^{0.5} \left(\dfrac{0.00026}{971.81 - 0.0026} \right)^{0.25}$

$\quad\quad D = 3.0m$

5.8.1 PLATE CALCULATION

The method of calculating the number of stages in a distillation problem will depend upon the system itself and degree of accuracy required in the final answer.

Assumption:- In this design work, the feed entering the distillation column contain 28.6% and about 71.39% H_2O. The feed however contain. Very small quantities of unfermented glucose and some salts of sodium chloride. Because both sodium chloride and unfermented glucose are negligible, they are therefore neglected, and the solution is ethanol and water only.

Using the H well - known method of McCabe and Thiele[24], the X - Y equilibrium diagram is calculated as shown below

$\quad Ya = \dfrac{\alpha Xa}{1+(\alpha -1)Xa}$ ------(3)

where = Relative volatility of ethanol to water and is calculated from the equation

$\quad \alpha_{AB} = \dfrac{P^0_B}{P^0_A}$ = --------(4)

(C_2H_5H)

$\quad P^0_B$ = Vapour pressure of the more volatile liquid

$\quad P^0_B$ = Vapour pressure of the less volatile liquid H_2O

$\quad P^0_B$ = at 78.5^0C = 760mmttg

$\quad P^0_A$ at 78.5^0C = 327.3mmttg

$\quad \therefore \; \alpha_{AB} = \dfrac{760}{327.3}$ = 2.32

Putting values of Xa into equation (3) over the range Xa = 0
to Xa = 1.0, values of Ya are obtained as follows:

Xa	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Ya	0.0	0.205	0.367	0.499	0.607	0.699	0.777	0.844	0.903	0.954	1.00

From the grap, point is located using the following
formula.

$$N = \frac{Xd}{R+1} \quad ------(5)$$
$$= \frac{0.9}{2+1} = 0.30$$

From the graph, Numbers of ideal stages 23 ± 1
  Number of theoritical plates = 22 ± 1

5.8.4 HEIGHT OF COLUM DETERMINATION

Height of column Hc was obtained based on the following
relation

Hc = Tray spacing x (no of plate + 2) + diameter of column
+

allowance for feed distribution (0.3)
0.5 (22 + 2) + 3 + 0.3

5.8.6 COST ESTIMATION OF COLUMN.

The total cost of the distribution column was estimated
based on the 1982 data for materials of construction of sieve
trays.

The total cost was estimated as follows:
Total cost $C_T = C_b F_M + N_T C_{bT} F_{TM} F_{NT} + C_{PL} .....(4-2)$.
Where

C_B = base cost of shell (Table 7-7)
F_M = material of construction factor for the shell (Table
4-9)
N_T = number of trays.
C_{bT} = base cost of trays = ae^x (Table 4 - 10).....(4.9 - 2b)
F_{TM} = material of construction cost factor for the trays
= $b + cD_T$ (Table 4 - 9).
F_{TT} = tray type factor (Table 4 - 9)
F_{NT} = factor for number of trays (if less than 20 trays)
= $2.25/(1.0414)^{NT}$ .....(4.9 - 20)
C_{PL} = Cost of plat forms and ladders = $dD_T^y L_T^2$
(Table 4 - 11)........(4.9 - 3)

For economic reasons and for the fact that ethanol is less
corrosive, mild steel was used in the design of the
distillation column for the production of ethanol.
where $F_M = 1.0$, F_{TT}, = 0.8
$C_{bT} = ae^x =$
a = 340, x = 0.571D
= $C_{bT} = ae^x = 340e^{0.571x3}$
= 1885.49
$F_{TM} = b + cD_T$
b = 1, c = 0, $D_T = 3$

$\therefore F_{TM} = 1 + 0 \times 3$
= 1.
$F_{NT} = 20$ trays,

hence F_{NT} chosen to be 1.

$F_{TT} = 0.85$

$\therefore N_T C_{pT} F_{TM} F_{TT} F_{NT}$
$= 1885.49 \times 0.85 \times 23$
$= 36861.33$

$C_b [F(x)]^n$, $n = 1.76$
$c = 96.2 [(x + 3.048)]^{1.76}$
$= 2284.61$

$C_{PL} = dD^y_T L^2_T$
$1018.5 \times 3^{0.63} \times 22^2$

L_T = Theoritical height = 22
$y = 0.63$

$\therefore C_T = 36861.33 + 2284.61 + 984901.47$
$= \$1024047.41$

The cost of designing distillation column for distillation of 50 litres of ethanol

$C_T = \$1024047.41$

McCabe and Thiele Method of Calculating numbers of Stage of a binary mixture.

0 x_w 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 x_q

x_f x_d
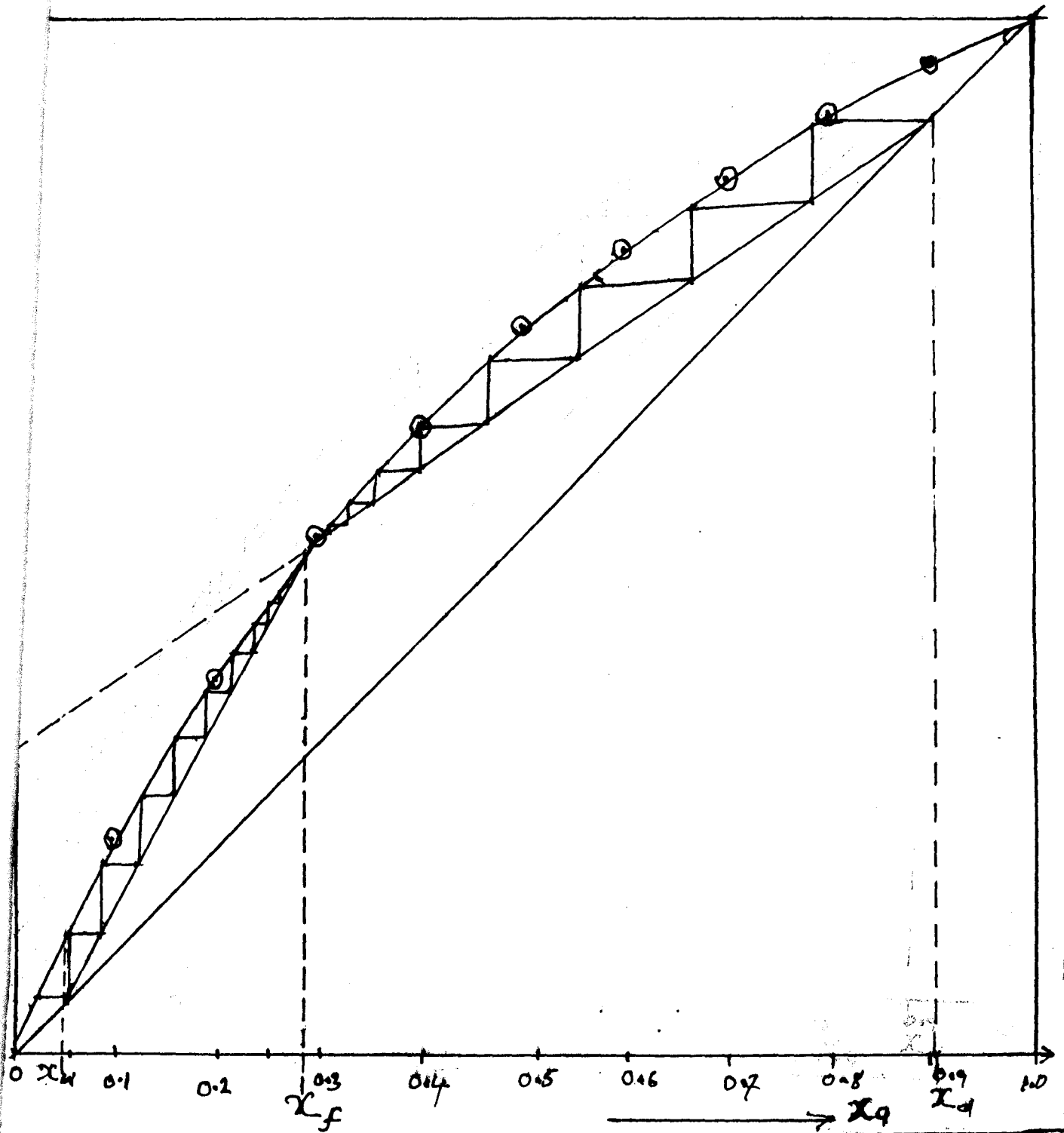
A DISTILLATION COLUMN DESIGN

FOR DISTILLATION OF ETHANOL.

RECYCLE

TOP PRODUCT
90% C_2H_5OH
10% H_2O

1. A — PLATE
2. B — CONDENSER

Feed, kg
28.61% C_2H_5OH

A

BOTTOM PRODUCT
$x_W = 5\%$ C_2H_5OH
95% H_2O
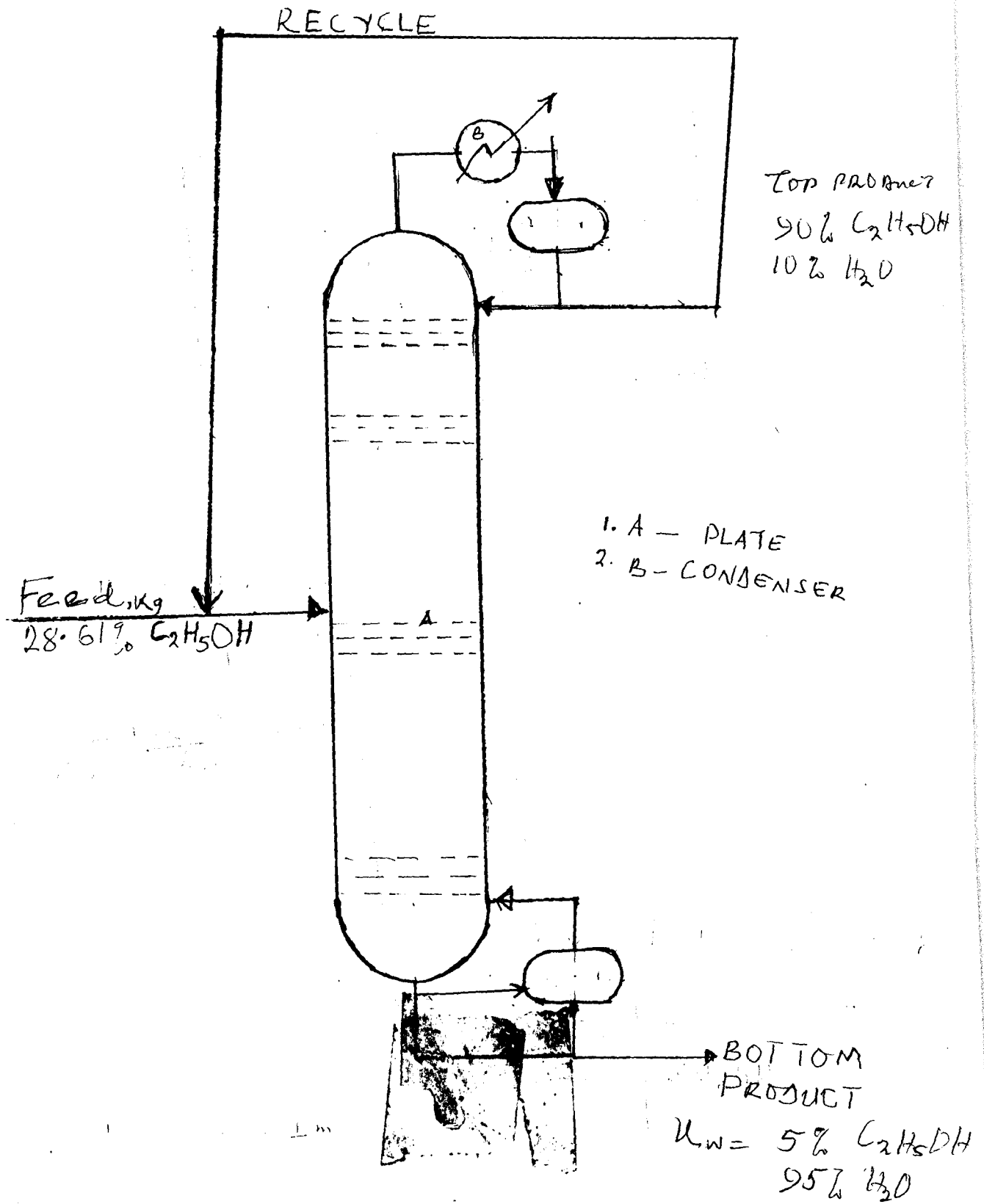
CHAPTER SIX

DISCUSSION

DISCUSSION OF RESULT A research on A' comparative studies of
yield of ethanol from different cereals (millet & maize) and
Root Crop (yam & cassava) has been carried out.

The result of research step undertaken are as shown in
table 4.1, table 4.2, table 4.3, table 4.4, table 4.5 and
table 4.6.

From gelatinization result of millet is that out of
2403.851 of HCL used, 476.38 litre was liberate remaining only
1927.47 which was later neutralized by NaOH. By calculation,
it was found that 252.50kg of sadium chloride was formed.
Also, out 181.15kg starch that was to be hydrolyzed, only
89.11kg was actually converted it glucose. This quantity of
glucose was hydrolyzed by 10.227kg of distilled water. The
result of distillation of the four fermented mixutes as
follows: 28.61%, 27.10%, 25.16% and 26.5% were obtained from
millet, maize, yam and cassava respectively. From literature,
millet give the highest percentage composition of soluble
carbohydrate, followed by maize, cassava and then yam. The
higher than quantity of soluble carbohydrate present in any
substance the higher the possible ethanol yield. Based on
this fact, it implies that the result of this research is in
comformity with literature.

From the equilibrium curve, the number of stage require for
the production of 50liters of ethanol/batch is 23 + 1. The
total cost of $1024047.41.

CHAPTER SEVEN

7.1 CONCLUSION

From practical analysis which is in comformity with literature, it is therefore concluded that cereals generally give a high yield of ethanol than root crops.

For highest purity of ethanol 50 litre per batch of ethanol production from millet the minimum of plate of the distillation equipment should be at least 26 stages.

The total cost for designing a equipment using mild steel, sieve tray with 22 stages, 0.5 tray spacing, with height of the column of 15.30m and approximately 3.0m in diameter was $1024047.41.

7.2 RECOMMENDATION

(1) Some necessary precautions have to be taken in order to obtained meaningful results. For instance, the hydrolysis has to be properly done to make sure there is enough glucose to sustain yeast. Larger quantity of grist, as exposed to large volume taken this experiment should be taken and the hydrolysis should be carried out at about 95^0C as against 97^0C used in this projected.

(2) Quantity of grist relative to distilled water could be increased since there will still be enough to hydrolyze the starch.

(3) Since the fermentation take place under an aerobic conditions, there should be a provision for exchange of air for the microbial activities.

(4) The stipulated time for fermentation could be increased
     to say 72hrs as against 68 hrs used in this experiment.
     This is to enhance complete fermentation.

(5) Since the purity of the product depends largely on the
     numbers of plates, therefore in further research for the
     distillation of ethanol plate number could be increased
     to 26.

APPENDIX

1.0 <u>APPENDIX</u>

1.1 <u>REFERENCES</u>

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8.3   NUMENCLATURE

S.F   - Scale H up factor
F   - Feed
d.b   - dry basis
l   - litre
Miw   - Material in washer
Mow   - Material out of washer
Mc   - Mass of containant
Lm   - Material into miller
MiD   - Material going to dryer
MoD   - Material out of dryer
Le   - Loss due to evaporation
Miov   - Material going to oven
Moov   - Material out of oven
Mik   - Material going to shaker
Mim   - Material going for mashing
Mom   - Material going out after mashing
Mis   - Material entering stirrer
Mos   - Material leaving stirrer
Mot   - Mass material used in test for starch
V_A - Volume of acid used
C_A - Concentration of acid used
Q_F - Heat supplied to the feed
T   - Change in temperature
C_{pm} - Specific Mean heat capacity
P   - Top product
R   - Residue (Bottom product).

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8.2 SAMPLE CALCULATION

Percentage composition of ethanol %

$$\% = \frac{\dfrac{V_E \times P_E}{M_E}}{\dfrac{V_E \times P_E}{M_E} + \dfrac{V_W \times P_W}{M_W}} \times 100$$

where V_E = Volume of ethanol produced
V_W = Equal volume of H_2O
P_E = Density of ethanol
P_W = Density of water

for Maize

P_W = 1g/ml
M_E = 46g
M_W = 18g
Volume H_2O = Volume of ethanol = 2.80ml.

$$\% = \frac{\dfrac{0.8846 \times 2.80}{46}}{\dfrac{0.8846 \times 2.8}{46} + \dfrac{1 \times 2.8}{18}} \times 100 = 25.16$$

Percentage of ethanol
= 25.16%
======