CERTIFICATION

I, hereby certify that I supervised, read and approved this design work presented by IFABIYI ADEJUMOKE MONISHOLA (93/3592) in partial fulfilment of the award of bachelor degree in chemical engineering

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project supervisor   Date

....

Head of Department   Date

....

External Examiner   Date

DEDICATION

This design work is dedicated to my dear uncle Mr. J. A. IFABIYI for his concern and assistance rendered to me in the time of needs.

ACKNOWLEDGEMENT

My earnest gratitude to Almighty God for his divine grace, enablement and strength given to me throughout the course of this programme.

I am using this opportunity to appreciate my dear parents, Mr and Mrs J.B. IFABIYI for their care, love and supports given to me throughout my stay in school.

My special thanks goes to Mr Jide Lawal, who tried his possible best to see that this design work was properly done and corrected me where necessary.

I wish to express my tremendous gratitude to Mr Yusuf of River Basin Minna for his words of advice and encouragement given to me.

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A big thanks also to Engr. And Mrs Olayinka for their moral supports given to me.

Final, my millions thanks to all my colleaques, and all and sundry, who have contributed in one way or the other to the successful completion of this design work. My God will reward you all. Remain blessed in the Lord.

DESIGN OF A BATCH REACTOR FOR SOAP PRODUCTION.

BY

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ABSTRACT

The aim of this "design project" is to come up with the design of a batch reactor for the production of soft soap.

This work centered on the material balance about the entire plant and a streamlined and detailed design of the saponification vessel. The areas of interest are the material and energy balance, the geometry of the reactor, the heat-exchanging mechanism, control, costing, and safety as well as some aspect of mechanical design, which include the wall thickness.

The vessel designed has a production capacity of $4.3m^3$, a mixer with 67 rotations per minute with a power requirement of 5.96kw/batch.

This reactor is recommended for use in soap production industries because of its strength and safety.

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CHAPTER ONE

1.0 INTRODUCTION

Since Engineers are concerned with the application of technology to satisfy human needs, the essence of Engineering is characterised by the design powers, through which raw materials are transformed into required products. This transformation starts with the recognition of some needs and progress to the physical implementation, which satisfies these needs.

This design work aimed at designing a batch reactor of $4.3m^3$ capacity for production of soft soap. The product, soap have different uses in homes, offices, industries and soon on. Soap in its simple term can be defined as a substance which when dissolve in water has its ability to remove dirt's from clothes, equipment, material and so on.

T he construction of the batch reactor was done using a carbon steel materials which are believed to have high resistance to corrosion. The soap produced in this project using batch reactor is soft soap and this is because it is the nature of the potassium salt soap to be soft. The active ingredient being used for specification process are palm kernel oil and potassium carbonate (K_2CO_3) from plantain peels, after the completion of the saponification, the soap undergoes analysis after which additives such as aloe vera extract, lemon grass oil, colourant are added, the quality of the output (product) using these materials conforms favourably with Nigerian Standard Specification for soap in terms of the free alkalinity, Total Fatty matter, % moisture in soap and also the lather volume.

The short coming of the quality of soap produced is the inability to separate the by–product glycerol present in the soap, since the soap was produced using semi–

boiled process and also the unavailability of a multiple effect evaporator to make the glycerol separation easy by the use of a suitable salt known as $Nacl_2$.

Reasons for choosing batch reactor.

1 Cheapness of the reactor

2 Easy to maintain and less auxiliary units

3 Easy to operate

4 Simplicity that is involved in a single unit

5 Less labour requirement

Factors of selection of batch reactor

1 Controllability and convertibility of the process flow

2 Quality of the unit in terms of the cost

3 Availability of the equipment

4 Feasibility of the techniques of the process- line

5 Safety

1.1 Problem statement

This equipment design is required to produce $4.3m^3$ of soft soap per batch of 6hours from caustic potash and palm kernel oil.

1.2 Scope of work

The design work is divided into 5 areas

1. Material balance across the plant
2. Energy balance around the reactor

3. Detailed design of reactor used in the production of the soft soap
4. Cost estimation of the reactor
5. Detailed drawing of the whole product and the reactor section

1.3 Limitation

The properties of the additives like aloe vera and lemon grass oil are difficult to come by and as such is subjective.

CHAPTER TWO

Literature Review

Soap 'per se' was probably never actually discovered both evolved rather from various crude mixture alkalis and fatty materials.

The word soap was derived from the latin 'sapo' first used by the pliny the elder about A.D 75. Although pliny is credited with the first written reference to sap, its use is believed to have begun long before recorded history.

Soap has been known for at least 2,300 years according to pliny the elder, Phoenicians prepared soap from goat tallow and wood ashes in 600 B.C and sometimes used it as an article of barter with the Gauls.

The ash used for making soap could be gotten from palm frond ash, plantain peel ash, cocoa pod and soon.

The burning of the plantain peel is to enhance the removal of all carbon/organic compound so that inorganic component will be exposed.

It was discovered that the major compound in the ash is potassium carbonate (K_2CO_3). This, when heated to a high temperature may dissociate to liberate (KOH) potassium hydroxide which is readily reactive with fatty acid in the vegetable oil to form soap of potassium.

Any of the available vegetable oil could be used for soap making for instance, the palm kernel oil, coconut oil, tallow and so on. Soap, which is usually a salt of sodium of fatty acids from vegetable oil is obtained by saponification process between NaOH and the oil which releases fatty acids for the neutralization will now in this project become potassium salts of fatty acids because a solution (concentrated) extracted from the ash, that is K_2CO_3 will be used for the saponification.

It is with the opinion that K_2CO_3 by chemistry will not saponify easily because of the energy needed to release K^+ (potassium ion) from covalent bonding nature of the compound and so, more heat is needed in the saponification process. The heat along with the addition of water to K_2CO_3 causes the potassium ion to be released or made available to saponify the fatty acids gotten by hydrolysis of the fats and oil used. $K_2CO_3 + 2H_2O - 2KOH + H_2CO_3$. The basic process of soap production now is the reaction of oil with the caustic potash at elevated temperature to give soap.

In this design project, a design of batch reactor made of carbon steel for the production of soap was done, the reactor consist of a stirrer inside. A batch reactor is a type of reactor in which all the reactants are taken in at the beginning, and processes then according which no material is ped into or removed from the reactor, usually a batch reactor is in form of tank with or without agitation.

Since all chemical processes are cantered around the chemical reactor, a most important factor in determining the overall process economy is the design of the reactor, there are a lot of factors that influence the selection of reactor type. In the design of an industrial reactor, the most important consideration is the selection of a reactor type putting in mind costs and profits. Accordingly, criteria for the selection would be such as to minimize cost and maximize profit.

These criteria are determined by factors, which may be put into 3 different categories, namely, technical, economic and social. The technical aspects refer to the chemical and physical process factors that control the product yield and quality, whereas the economic factors include the capital investment and the operating costs. The social factors include those that cannot be assigned duet monetary value, for example safety and satisfaction of the operation.

The batch reactor consists of a stirrer, which are used in mixing the reactants and also used in giving a smoother and homogeneous product. Mixing may be defined as the intermingling of two or more dissimilar portion of a material resulting in the attainment of a desired level of uniformity, either physical or chemical, in the final product.

Ideally, a mixing process begins with the components, grouped together in some container, but still separated as pure components. Thus if small samples are taken throughout the container, they will almost all consist of one pure component, the frequency of occurrence of the component being proportional to the fractions of these components in the whole container. As mixing then proceeds, samples will increasingly contain more of the compounds, in proportions approximating to the overall of the compounds in the same proportions as in the whole mixture.

Immediately after the completion of saponification process, additives are added to the soap inside the batch reactor and this again was properly mixed with soap with the aid of the stirrer. The additives used in this project are lemon grass oil for perfume, aloe vera extract, water and also colourant, all are added one after the other immediately saponification had come to completion.

Since the available potassium carbonate (K_2CO_3) was extracted in the ash using leaching process it is essential and very important to know the factors affecting the rate of extraction.

THEORY OF LEACHING OPERATION

Leaching is a process whereby a soluble constituent is extracted from a solid by means of solvent. This process may be used either for the production of a concentrated solution of a valuable solid material or in order to remove an insoluble solid such as pigment from a soluble material with which it is contaminated.

The method used for the extraction is determined by the proportion of soluble constituent present, its distribution of soluble constituent present, its distribution through the solid, the nature of the particle size.

The process of leaching can be explained to be in three parts.

I. The change of phase of the soluble as it dissolves in the solvent.

II. Its diffusion through the solvent in the pores of the solid to the outside of the particle.

III. The transfer of the solute from the solution in contact with the particle to the main bulk of the solution.

FACTORS AFFECTING THE RATE OF EXTRACTION.

I. PARTICLE SIZE : Influences the extraction rate in a number of ways. The smaller the size, the greater the interfacial area between the solid and liquid and therefore the higher the rate of transfer of materials and the smaller is the distances the solute must diffuse within the solid.

On the other hand, the surface may not be so efficiently, used with a fine material if circulation of the liquid is impeded and separation of the solid residue are made difficult.

It is generally desirable that the range of particle requires approximately the same time for extraction and in particular, the production of a large amount of fine material should be avoided as this may wedge in the interstices of the larger particle and impede the flow of solvent.

II. SOLVENT: the liquid chosen should be of a good selective solvent and its viscosity should be sufficiently low for it to circulate freely.

Generally, a relatively pure solvent will be a used initially, but as the extraction proceeds the concentration of solute will increase and the rate of extraction will progressively decrease, first because the solution will generally become more viscous.

III. TEMPERATURE: in most cases, solubility of the material which is being extracted will increase extraction, furthermore, the diffusion coefficient will be expected to increase will be expected to increase which will rise in temperature and this will also improve the rate of extraction. In some cases, the upper limit of temperature is determined by secondary considerations, for example, the necessity to avoid the enzyme action during extraction of sugar.

IV. AGITATION OF FLUID: agitation of the solvent is important this increases the eddy diffusion and therefore transfer of material from the surface of the particle to the bulk of the solution further, agitation of suspensions of the particles prevents sedimentation and more effective use is made of the interfacial surface.

2.2 DESIGN DATAS.

Cp of soap = 2.44kj/kgk

Cp of p.k.o =2.093kj/kgk

Cp of KOH = 0.682kj/kgk

Cp of glycerol = 2.428kj/kgk

Cp of H_2O ⟶ 4.216kj/kgk

Inlet temperature of oil into the reactor = 25^0C

Inlet temperature of K_2CO_3 into the reactor ⟶ 25^0C

Operating temperature of reactor ⟶ 70^0C

Density of oil ⟶ $930kg/m^3$

Density of K_2CO_3 ⟶ $927kg/m^3$

Density of water ⟶ $1000kg/m^3$

Density of lemon grass oil ⟶ 840kg/m3

Density of aloevera extract ⟶ $950kg/m^3$

Density of colourant ⟶ $720kg/m^3$

CHAPTER THREE

3.0 PROCESS DESCRIPTION.

The soap was produced using semi-boiled process.

The calculated amount of palm kernel oil was heated inside a carbon steel pan used as reactor to about 130^0C with addition of little quantity of water to hydrolyse the fats and oils to give fatty acid and glycerides, the oil was then cooled back to 70^0C.

The sample of alkali already calculated was added and stirred continuously. Water is being added along the way to give more surface area for easy or more reaction to take place. Also the sample on hot plate was heated continuously, so as to break or decompose K_2CO_3 to give necessary amount of potassium ion (k^+) needed to saponify the available fatty acid.

Complete saponification in this project work takes about 6hours after which the soap was analysed to know the quanlity.

Equation of reaction:

Hydrolysis of fat using water

$$(C_{17}H_{35}COO)_3\ C_3H_5 + 3H_2O \longrightarrow 3C_{17}H_{35}COOH + C_3H_5(OH)_3$$

stearic acid glycerine.

The K_2CO_3 used are heated continuously with addition of water to give the necessary amount of potassium hydroxide needed for saponification process.

The equation is:

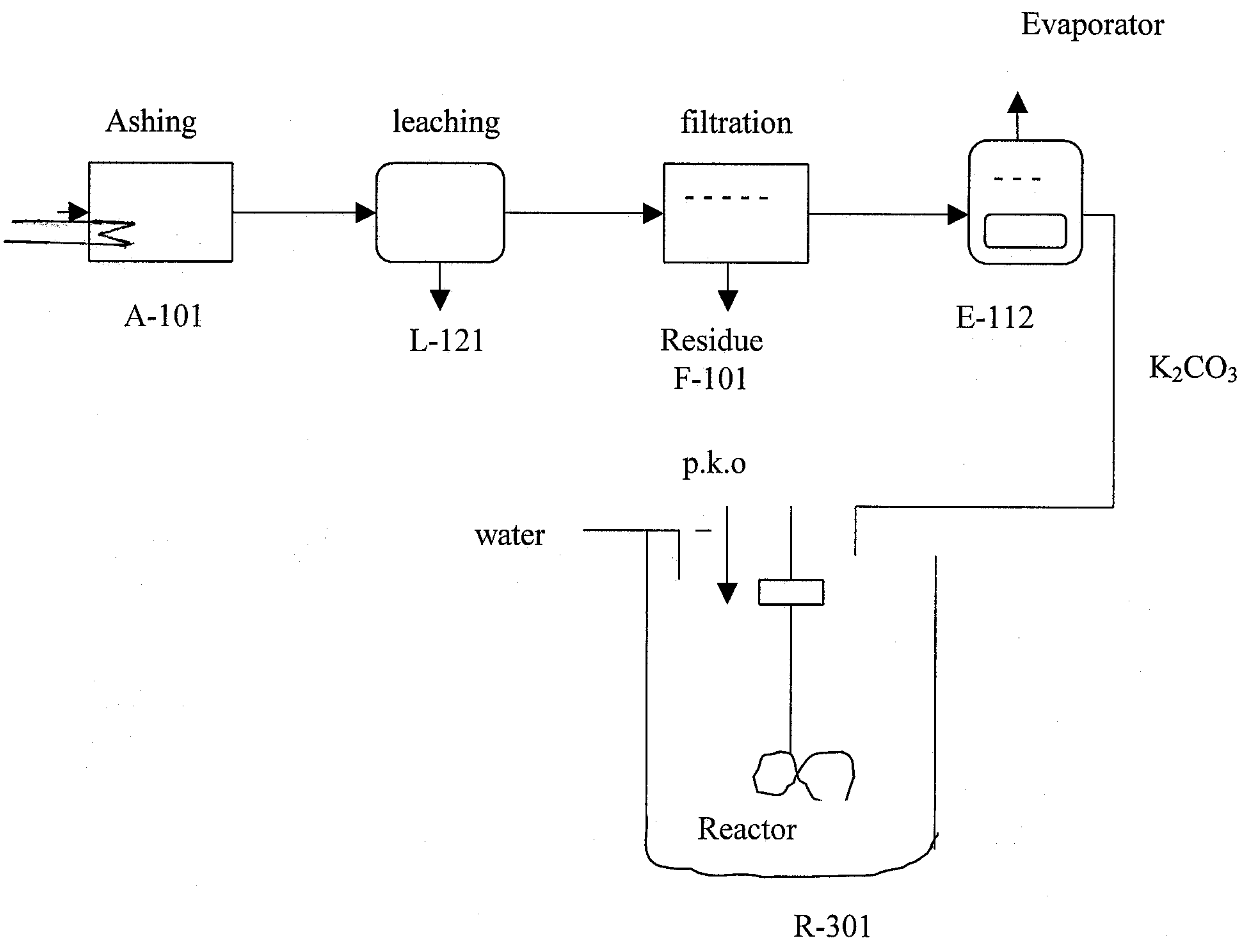
$$K_2CO_3 + 2H_2O \longrightarrow 2KOH + H_2CO_3$$

The potassium hydroxide released now react wwith the available fatty acid in the oil to give soap.

$$
\begin{array}{l}
CH_2COOC_{17}H_{35} \\
\quad | \\
CHCOOH_{17}H_{35} \\
\quad | \\
CH_2COOC_{17}H_{35}
\end{array}
\quad + \quad 3KOH \longrightarrow 3C_{17}H_{35}COOK^{+} +
\begin{array}{l}
CH_2OH \\
\quad | \\
CHOH \\
\quad | \\
CH_2OH
\end{array}
$$

Propan 1,2,3 triol.

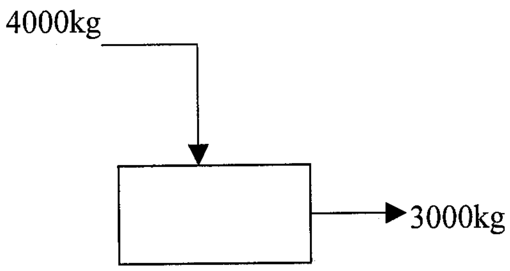
3.1 FLOW DIAGRAM OF THE ENTIRE SOAP PLANT



3.1.1 MATERIAL BALANCE OVER THE ENTIRE PLANT

ASHING PROCESS A-101

Ashing is carried out at a temperature of 550^0C



The starting raw material (plantain pod) is reduced into ashes. The starting material is 4000kg (0.4T) of plantain pod, which is reduced to 3000kg (0.03T) of ashes.

From lab work 400g of plantain pod is reduced to 300g therefore the scale-up factor is thus

$$4000kg = \frac{4000000g}{400g} = 10000$$

the scale-up ratio is 1:10,000

LEACHING L-121

The leaching is carried out by adding 725.6kg (0.7256) of water to the ash. This is well mixed and the product output gave about 1000kg ($1m^3$) of product (ash + water).

Material input		Material output	
		The extract contains	
Ash –	3000kg	(K_2CO_3 + water) =	630kg
Water –	725.6kg	wet ash =	3095.6 kg
	3725.6kg		3725.6kg

FILTRATION F-101

The product from the leaching forms the input to the filtration bed:

Material input		Material output	
(K_2CO_3 + water)	–630kg	(extract) K_2CO_3 + water	: 530kg
ash –	3095.6kg	wet ash =	3195.6kg
	3725.6kg		3725.6kg

3195.6kg of the wet ash (ash + water + K_2CO_3) is removed by the filter.

EVAPORATOR E – 112

The evaporator operating at about 110^0C removes 40kg of water leaving behind a concentrated amount of K_2CO_3 in water. Analysis at this stage gave 56% K_2CO_3 and 44% water.

Material input	Material output
(K_2CO_3 + water) – 530kg	K_2CO_3 + water = 490kg

Therefore (530 – 490)kg = 40kg of water is removed via the evaporator.

Analysis of the material output gave.

K_2CO_3 : 56% of 490

$: \frac{56}{100} \times 490 = 274.4kg$

H_2O : 44% of 490

44 x 490 = 215.6kg

490 kg

REACTOR R-301

This is the batch reactor through which the saponification reaction takes place.

Reaction equation

$$
\begin{array}{lcll}
CH_2COOC_{17}H_{35} & & & CH_2OH \\
| & & & | \\
CH_2COOC_{17}H_{35} + 3KOH & \longrightarrow & 3C_{17}H_{35}COOK^+ + & CH_2OH \\
| & & & | \\
CH_2COOC_{17}H_{35} & & & CH_2OH
\end{array}
$$

Pko alkali $\longrightarrow$ soap + glycerol

1 : 3 $\longrightarrow$ 3 : 1

and $K_2CO_3 + H_2O \longrightarrow 2KOH + H_2CO_3$

calculating the amount of oil to be used

$K_2CO_3 + H_2O \longrightarrow 2KOH + H_2CO_3$

$H_2CO_3 \longrightarrow H_2O + CO_2$

determing the amount of K_2CO_3 to give the required KOH.

138g of K_2CO_3 gives (39 x 2) of K^+, K^+ is a very reactive and is the active agent to react with the available fatty acid oil.

138g of K_2CO_3 gives (39 x 2) of K^+

138g $\longrightarrow$ 78g of $2k^+$

Xg $\longrightarrow$ 117g of $3K^+$

$X = \frac{138 \times 117}{70}$ = 207g of K_2CO_3 is needed

m. weight of p.k.o. = 742g

207g of K_2CO_3 react with 742g of oil and will give 3K+ which is 117g. with 56% conc. of K_2CO_3 from above calculation

$\frac{207 \times 100}{56}$ = 369.642g

therefore, 369.642g at 56% conc. K_2CO_3 is needed to saponify 742g of oil.

742 of oil ⟶ 369.64g of K_2CO_3

100g of oil ⟶ X

$$Xg = \frac{100 \times 369.64}{742}$$

$$= 49g \text{ of } K_2CO_3$$

therefore 49g of K_2CO_3 is required to saponify 100g of oil.

therefore 48g of K_2CO_3 is needed to saponify 100g of oil, therefore by using the scale-up factor

490kg (0.528m^3) of K_2CO_3 is needed to saponify 1000kg (1.075m^3) of oil, with the addition of 600kg (0.6m^3) of water.

From :	Specific Gravity
K_2CO_3	927kg/m^3
Oil	930 kg/m^3
Water	1000 kg/m^3
Lemon grass oil	840 kg/m^3
Aloe vera extract	950 kg/m^3
Colourant	720 kg/m^3

Therefore total volume material into the reactor.

Material input

	K_2CO_3 :-	490kg	= 0.528 m^3
	Pko :-	1000kg	= 1.075 m^3
	Water :-	600kg	= 0.6 m^3
Additives	Lemon grass oil:	100kg	= 0.119 m^3
	Aloe vera extract:	100kg	= 0.i05 m^3
	Colourant:	50kg	= 0.069 m^3
		2340kg	2.496 m^3

Therefore density of the feed = $\frac{2340kg}{2.496m^3}$ = $937.33\ kg/m^3$

Product :-

Pko + alkali $\longrightarrow$ soap + glycerin

1 : 3 3 : 1

1 mole of pko $\longrightarrow$ 3 mole of soap

therefore $1.075\ m^3$ of pko = $\frac{3}{1} \times 1.075\ m^3$

$= 3.225\ m^3$

therefore 1 mole of pko $\qquad$ 1 mole of glycerin

$1.075\ m^3$ of pko = $1.075m^3$ of glycerin

volume of soap produced = 3.225 + 1.075

$= 4.3m^3$

glycerin is added since it is not removed and thus goes in with the soap.

The soap produced is discharged for packaging.

Summary of the material balance

Material	A - 101		Kg L-121		Kg F-101		E-112		M^3 R-301	
	In	Out	In	Out	In	Out	In	Out		
ASH	4000kg	3000kg	3000	3000.0	3000					
WATER			725.6	451.2	451.2	255.6	255.6	215.6	0.6	
K_2CO_3				274.4	274.4	274.4	274.4	274.4	0.528	
OIL										
PKO									1.075	
LEMON GRASS OIL									0.119	
ALOVERA EXTRACT									0.105	
COLOURANT									0.669	
SOAP										4.3
	4000	3000	3725.6	3725.6	3725.6	530	530	490	2.496	4.3

3.2 Energy balance

Energy balance equation

Heat due to the reactant + Heat due to the steam

= Heat output (soap).

Heat due to the reactant:

K_2CO_3: Mcp dT

dH = 490 x 125.18 x (26 – 25)

= 61338.2 kg

pko mcpdt

H = 1000 x 2.093 x (70 – 25)

= 94185 kg

Additives M_{mix} Cp_{mix} DT_{aw}

(100 + 100 + 50) x 0.1584 (25 – 25)

0 kj

Heat due to the reactant = 61338.2 + 94185

= <u>155523.2 kj</u>

Heat output

Mcp DT

Mass of soap produced $= 4.3M^3 \times \frac{1210kg}{M^3}$

T1 = 70 + 25/2 = 5203kg

Therefore H = 5203 x 2.446 x (80 – 47.5)

= 413612.48 KJ.

Therefore Heat due to the steam

By difference

Heat due to the steam = Heat output – Heat input

= 413612.48 – 155523.2

= 258089.2 KJ

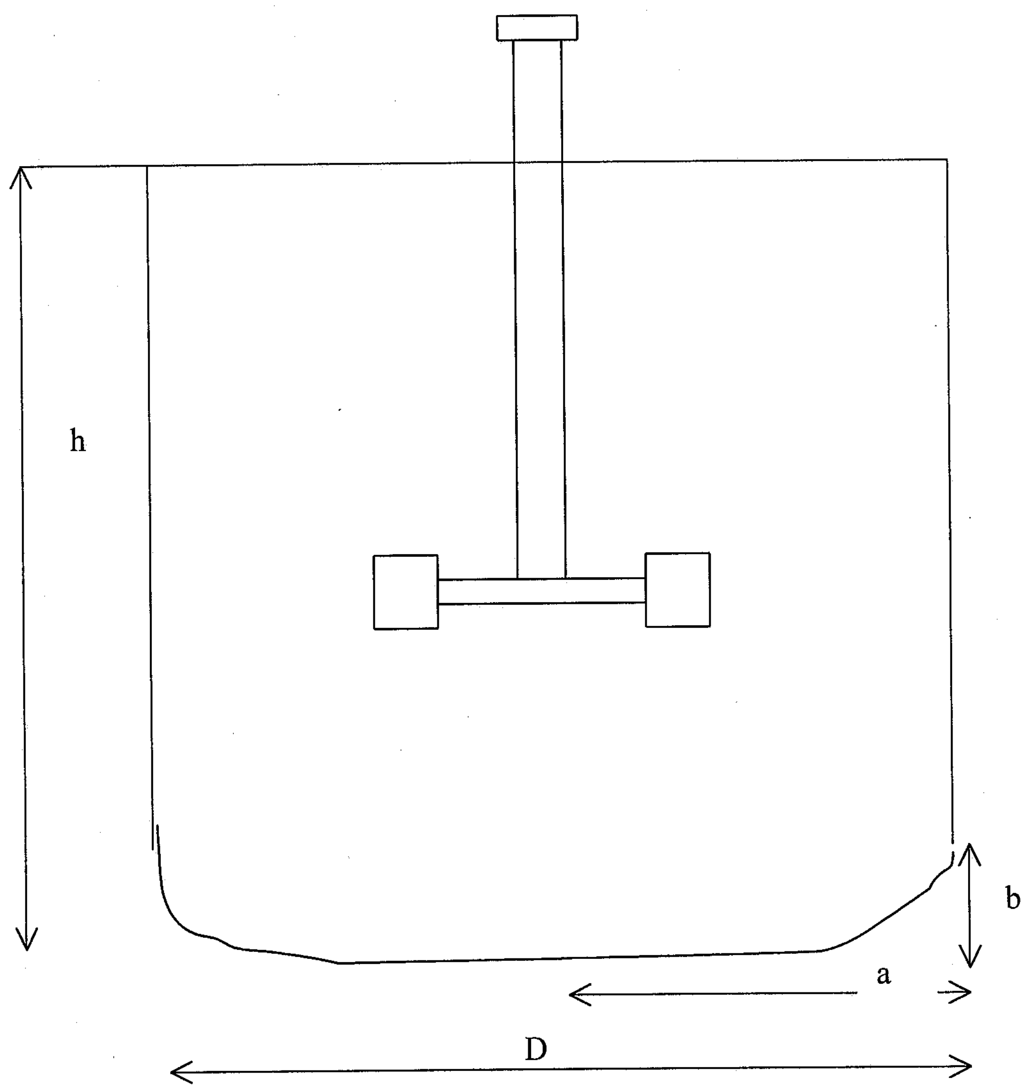
therefore summary of energy balance

Heat Input		Heat output	
Reactant :		Product	
K_2CO_3 :	61338.2	Soap :	413612.48
Pko :	94185		
Additives :	0		
Steam :	258089.28		
	413612.48 KJ		413612.48 KJ

CHAPTER FOUR

4.0 Detailed design of a reactor

4.1 Sizing



The above diagram represents the batch reactor.

where:

D = diameter of the reactor

H = height of the reactor

Vy = volume of the reactor

Vx = capacity of the reactor

S = safety factor = (10% of Vx)

$\therefore$ Vy = Vx + (Vx x s)

$\therefore$ Vy = Vx + 0.1Vx 4.1

Vy = 1.1Vx

But $Vx = D^2 \pi L/4 + 4\pi ab^2/6$ 4.2

And L = 1.3D, a = 0.5D and b = 0.5D/3

Substituting these into equation 4.2, we have;

$Vx = 1.3D^3\pi/4 + 0.5\pi D^3/54$..eqn 4.3

FROM THE MATERIAL BALANCE

Mass of the soap produced = 5203kg

Density of the soap produced = $1210kg/m^3$

$\therefore$ Capacity of the reactor Vx = 5203/1210 = $4.3m^3$

From equation 4.1

Vy = Vx + 0.1Vx

= 43 + 0.1(4.3)

= $4.73m^3$

$\therefore$ The volume of the reactor = $4.73m^3$

From equation

$Vx = 1.3D3\pi/4 + 0.5\pi D^3/54$

$43 = 1.3D^3\pi/4 + 0.5\pi D^3/54$

$43 = 1.021D^3 = 0.029D^3$

$43 = 1.05D^3$

$D^3 = 43/1.05 = 40.94$

$D = 3.446m$

Vessel height = h = L = 1.3D = 1.3 x 3.446 = 4.4808m

Radius of vessel = a = 0.5D = 0.5 x 3.446 = 1.723m

b = 0.5D/3 = 1.723/3 = 0.5743m

HEATING COIL DIMENSIONS

Tube diameter = D/30 = 3.446/30 = 0.1148m

Height of coil = 0.65D = 0.65 x 3.446 = 2.2399m

The coil pitch = 2 x tube diameter

= 2 x 0.1148 = 0.2296m

Number of turns = height of coil/ coil pitch = 2.2399/0.2296 = 9.75 $\approx$ 10 turns

Coil diameter = 0.7D = 0.7 x 3.446 = 2.4122m

Total height of coil = L_{TC} = π x 10 x coil diameter

= 3.142 x 10 x 2.4122

= $75.79m^2$

DESIGN OF MIXER

DETERMINATION OF IMPELLER DIAMETER (di)

di = 1/3 D where D = reactor's diameter

di = 1/3 x 3.446 = 1.1486m

IMPELLER'S HEIGHT FROM BOTTOM OF THE REACTOR (hi)

hi = 1.0 di or D/3

= 1.0 x 1.1486

= 1.1486m

DETERMINATIONS OF IMPELLER'S BLADE WIDTH (wi)

wi = 1/5di

= 1/5 x 1.1486

= 0.2297m

DETERMINATION IMPELLER BLADE LENGTH (Li)

Li = 1/4di

= ¼ x 1.1486 = 0.2871m

DETERMINATION OF CENTRAL DISK DIAMETER (s)

s = 1/4D

=1/4 x 3.446

= 0.8615m

DETERMINATION OF LENGTH OF BLADE FROM CENTRAL DISK (Ls)

Ls = Li/2 or 1/8di

= 0.2871/2 = 0.14355m

DETERMINATION OF THE REACTOR'S HEIGHT

1.3d = 1.3 X 3.446 = 4.4798m

DETERMINATION OF BAFFLE THICKNESS (Th)

$Th = 1/10D = 3.446/10 = 0.3446m$

DETERMINATION OF LIQUID HEIGHT (H_L)

$H_L = D$

$H_L = 3.446m$

MIXERS ROTATIONAL SPEED (W)

Condition : U_T for low agitation = 2.5 – 3.3m/s

U_T for medium agitation = 3.3 – 4.1m/s

U_T for high agitation = 4.1 – 5.6m/s

A medium agitation is needed for the operation.

$U_T = 4.0m/s$

$N = U_T/\pi di$

$= 4.0/\pi \times 1.1486 = 1.1085rps$

= 1.1085 rotation per seconds

$= 1.1085 \times 60$

$= 66.51rpm$

POWER REQUIREMENT OF THE MIXER

For simplicity of design and calculation, the content of the reactor is assumed homogeneous. The viscosity is between 60cp-70cp. Therefore; the power requirement can be obtained.

From the equation: $Np = K_T$ eqn.4.4

where: Np = power number and K_T = constant

For flat paddle (two blade) K_T = 1.70

i.e $N_p = K_T = 1.70$ ....eqn 4.5

The power requirement is given as:

$$P = \frac{K_T n^3 D^5 a P_{mix}}{g_c}$$ ....eqn 4.6

where:

n = number of revolution = 66.51rpm = 1.1085rps

Da = diameter of the paddle = 1.1486m = 3.815H

g_c = 9.81m/s2 = 32.17ft/s^2

P_{mix} = density of mixture = 1210kg/m^3 = 75.53 ib/ft^3

$$\text{i.e } P = \frac{1.7 \times (1.1085)^3 \times (3.815)^5 \times 75.53}{32.17}$$

P = 4393.8 ft-1bf/s

i.e P = 4393.8/550 = 7.988hp/batch

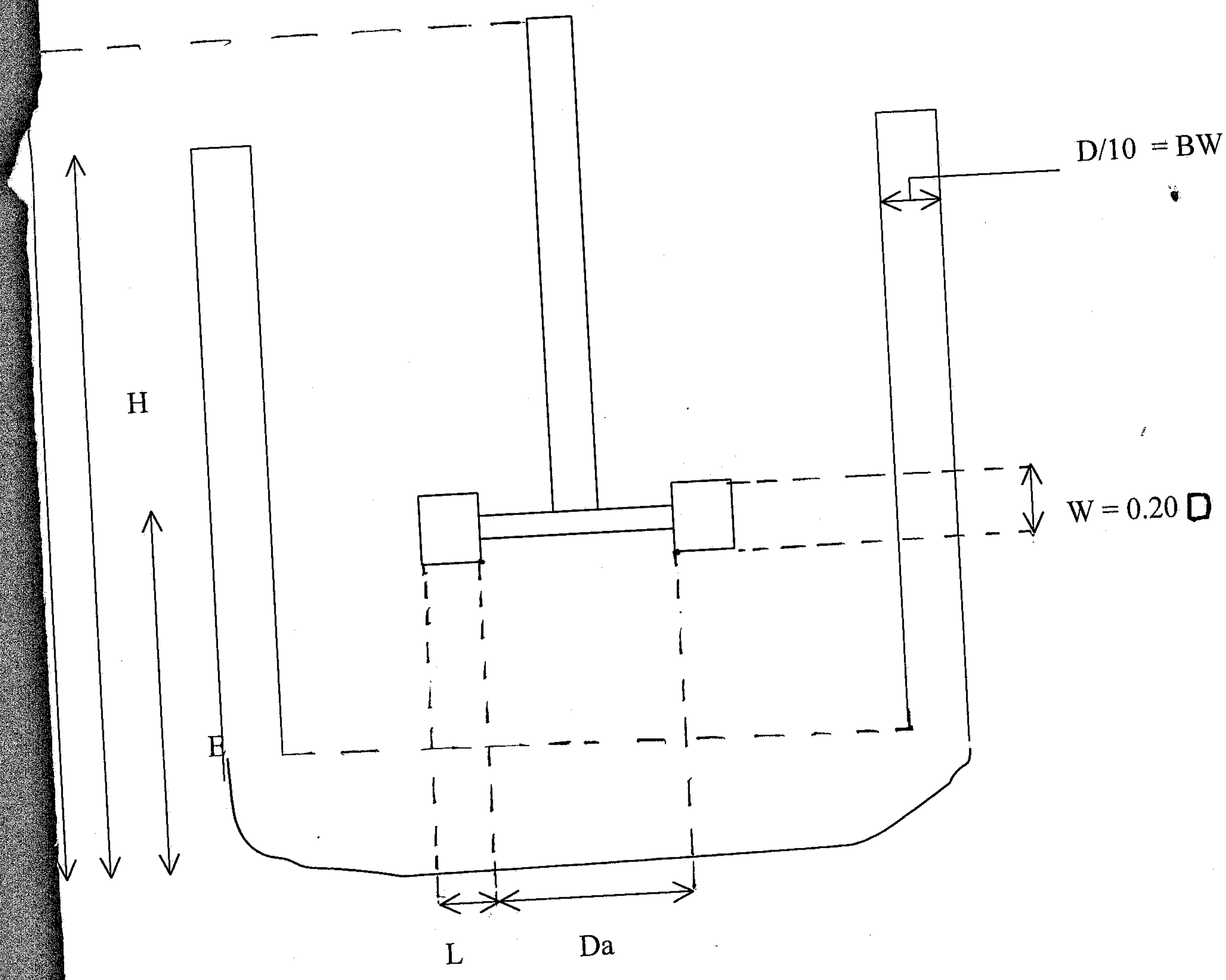
= 5.96kw/batch

and 1 batch = 6hours

∴ power requirement by the mixer per batch = 5.96kw

power required per hour = 5.96/6 ==0.9934kw/hr = 3.574MJ/hr

REACTOR DESIGN SPECIFICATION



E = H/3 = 0.114pm

D = 3.446

H = 3.446m

H_T = 4.4798m

W = 0.2D = 0.6892m

Bw = 0.3446

(diameter of paddle) Da = D/3 = 0.1148

PIPINGS

Determination of the optimum pipe diameters.

The optimum pipe diameter, d, $= 260G^{0.52}\ \rho^{-0.37}$

Where

G = flow rate (kg/s)

ρ = density (kg/m^3)

FEED INLET (OIL) PIPE DIAMETER

All the oil is expected to be discharged within 15secs.

Therefore G = 1000Kg/15 seconds.

G = 66.66 Kg/seconds.

P = 930 Kg/m^3

$d = 260\ (66.66)^{0.52}\ (930)^{-0.37}$

= 184.1mm say 185mm pipe

Feed inlet (K_2CO_3) pipe diameter

All the K_2CO_3 is expected to be discharged in 8 seconds after the oil is discharged.

G =490 Kg/ 8 seconds.

= 61.25 Kg/seconds.

P = 927Kg/seconds.

$D = 260\ (61.25)^{0.52}\ (927)^{-0.37}$

= 176.37mm say 178mm

Feed inlet (lemon grass oil) pipe diameter

The lemon grass oil is expected to be discharged in 10 seconds

G =100Kg/10 seconds

G =10Kg/seconds

$P = 840\ kg/m^3$

$d = 260 \times (10)^{0.52} (840)^{-0.37}$

$= 71.28mm$ say 72mm pipe

Inlet pipe diameter (aloe vera extract)

This is expected to be discharged in 8 secs.

$G = 100kg/8$ secs.

$G = 12.5\ kg/sec$

$P = 950\ kg/m^3$

$d = 260 \times (12.5)^{0.52} (540)^{-0.37}$

$= 76.49$ mm say 77mm pipe

Inlet pipe diameter (colourant)

The colorant is expected to be discharged in 5 secs.

$G = 50\ kg/5$ secs.

$G = 10$ kg/sec.

$P = 720\ kg/m^3$

$d = 260 \times (10)^{0.52} (720)^{-0.37}$

$= 75.46$ mm say 76 mm pipe

Outlet pipe diameter (soap)

The soap is discharged in 2 minutes (120 secs)

Therefore

$G = 5203$ kg/120 secs

$G = 43.358$ kg/secs.

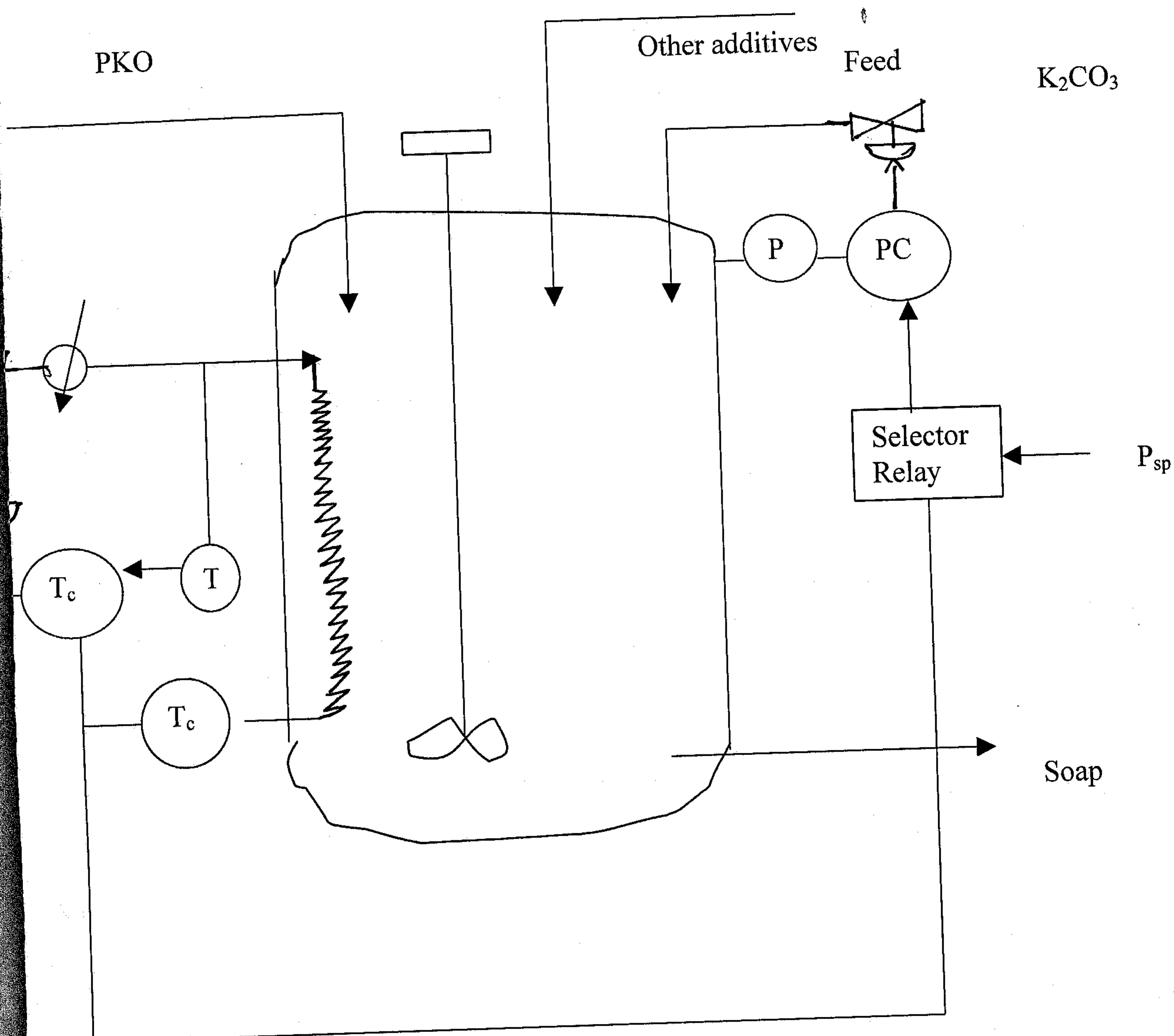
$P = 1210$ kg/sec.

$d = 260 \times (10)^{0.25} (840)^{-0.37}$

$d = 133.54$mm say 134 mm pipe.

CONTROL

CONTROL DIAGRAM



Where Tc = Temperature controller

T = Temperature

P = Pressure

PC = Pressure Controller

MATERIAL OF CONSTRUCTION

Many factors must be considered when selecting engineering materials. In chemical process plant construction, the most important consideration is usually the ability of the material to resist corrosion. The material of construction must be suitable for the process condition, meet mechanical requirement and safety. The material normally selected for reactor construction is low carbon steel (mild steel). Mild steel is most commonly used engineering material. It is cheap, available in wide range of standard forms and sizes; and can be easily worked on and welded. It has good tensile strength and ductility.

Carbon steel has resistance to oxidation at temperature of 120^0C. It is resistant to corrosion at specific conditions such as that of caustic alkali. As a result, the best materials out of the considered variety for the construction of this reactor is the carbon steel.

4.2 SAFETY CONSIDERATION

Design is an inexact art (an abstraction). Errors and uncertainities will arise from uncertiainities in the design data available in the approximations necessary in design calculations. To ensure that the design specification is met, factors are included to give a margin of safety, about 10% of the reactor volume to accommodate the error.

Design factors are also applied in the equipment design to give some tolerance of the design.

The materials selected for design must be tested to conform to the operating condition for the reactor, safety gadgets and control values are included in the design.

3 COST ESTIMATION OF THE REACTOR

Equipment Identification	**Capacity**	**Purchase equipment Cp($)**	**Base bare module F_{BM}**	**Base bare module C_{BM}**	**Total C_P x F_{BM}**
1. Process vessel jacketed batch reactor with internal coil.	4.73m^3	10,400	2.9	-	30160
2. Electric motor.	5.96kw	500	2.0		1000
3. Agitator.	5.96kw	10,450	2.0		20900
					$ 52,060

Total fixed cost = $ 52,060

Using 1.00 = N100.00

Total cost = N5206.000

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

CONCLUSION

It can be concluded from the design work that a suitable equipment could be evolved that will produce soft soap from caustic potash and palm kernel oil, this design incorporates quite a lot of factors like safety and control to protect the workers and to produce materials off construction, the reactor designed is assumed of adequate durability as the incidence of rusting could be eliminated.

RECOMMENDATION

1. This reactor is recommended for the production of soft soap on a large scale, based on its suitability and durability.
2. Apart from the batch reactor designed in this design work, other unit such as evaporator could also be designed.

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