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TABLE OF CONTENT

HAPTER ONE

HAPTER TWO

CHAPTER THREE

CHAPTER FOUR

APTER FIVE

ABSTRACTS

he design of a plant for the production of 2000kg/annun if caustic potash from gricultural waste ash has been carried out.

he work done include material and energy balance across the entire plant.

he process technological diagram and the plant layout for the production of caustic otash has been developed. Under the equipment design, the detailed Chemical ngineering design of evaporator with agitator which enhances crystallzation was arried.

The area of the evaporating heating surface obtained is $453m^2$ and the total number tube calculated is 1443.

The impeller design has lenght of 0.77m with diameter of 3.06m and the power required for it operation is 9.2kw.

The cost estimation of the evaporation with the impeller was carried out and the cost of the evaporator section was obtained

CHAPTER ONE

1.0 INTRODUCTION

Caustic Potash also called Potassium Hydroxide(KOH) is a nearly white solid, soluble in water ,a strong alkali, very hydroscopic and normally made by the electrolysis of aqueous KCl, either in diaphram cell or cells having a mecury electrode. It is normally market as dehydrated solid (90-92%KOH) and as a liquor(45-50%)

Caustic Potash have also been found in large amount in Agricultural wastes essentially because Potassium, one of the essential nutrient for higher plant is absorbed in larger amount than any other mineral except nitrogen.(Tisdate & Nelson 1975), All the potassium found in commercial fertilizer is derived from mineral reservoir which are bedded deposits of water-stable Potassium minerals and brines of ancient sea (Follet et al 1981)

The preparation of potash (potassium carbide) by leaching and concentration wood wastes goes back to 1790 USA patent (Follet et al, 1981) , much of the caustic Potash produced have found very wide spread industrial uses especially in the manufacture of soft soap etc.

A plant has successfully been design which can produce 2000kg of caustic potash from plantain peel ash with detained design of the evaporator which serve to crystallize the extract filtrate obtained after leaching

1.1 PROBLEM STATEMENT

In this project, it is required to Design a plant to produce 2000kg/year of caustic potash (when running at 100% capacity) from Agricultural waste especially plantain peel the production is based on leaching process.

Material Available

1 Plantain peel ash

Utilities

1 Electricity 440v 3phase 50Hz

2 Distilled water

3 Steam saturated at 26.5bar

1.2 SCOPE OF DESIGN WORK

This design project is divided into 4 scopes

(A) PROCESS DESIGN

1 A material balance across the whole plant on daily basis .

2 An energy balance across the plant on daily basis.

3 A process flow sheet showing all the major equipment used.

(B) CHEMICAL ENGINEERING DESIGN.

1 A detailed chemical engineering for the evaporator section

(C) INSTRUMENTATION AND CONTROL

1 Diagram showing instrumentation and control for the evaporation section of the plant.

(D) ECONOMIC EVALUATION OR COST ESTIMATION OF THE EVAPORATOR

(E) SAFETY CONSIDERATION

(a) To indicate all the possible safety problem of the plant and prepare a draft on safety regulation.

(b) Introduction to operability study of the plant.

APPLICATION OF CAUSTIC POTASH.

Much of the potassium hydroxide produced is used in the manufacture of "soft" soap. This is used in liquid soaps and other detergent specialties, textile application, greases, lithography and rubber fabrication.It is also used as electrolyte in alkaline battery, drugs, dyes, adhesive, fertilizer, scrubbing HF, drain pipe cleaner and for purifying industrial gases.

CHAPTER TWO

2.0 LITERATURE REVIEW.

Caustic potash is the usual commercial name for potassium hydroxide (KOH) and it solution.

Potassium, one of the essential nutrient for higher plant is absorbed in larger amount than any other mineral except nitrogen (Tisdale and Nelson 1976). Practically all the potassium found in commercial fertilizer is derived from mineral reservoir which are bedded deposit of water stable potassium mineral and brine of ancient sea (Follet etal 1981) when used in the connection with fertilizer, the word "potash" refer to potassium oxide (K_2O).

The preparation of potash (potassium hydroxide) by leaching and concentrations wood wastes dates back to 1790 USA patent (Follet etal 1981).

A market survey carried out at the Federal office of statistics shows that caustic potash is at present imported into Nigeria. No plant has be designed and sited anywhere to produce caustic potash from Agricultural waste or from ant other raw material.

Caustic potash has quite a lot of industrial and laboratory application.

In the industries, it is used to produce mainly soft soaps, fertilizer and explosive etc while in the laboratory, it is used to carried out experimental analysis. Caustic potash is mostly sold in crystallized form.

2.1 PROCESS DESIGN OPTIONS

The chemical engineer has many tools to choose from in the development of a profitable plant design the most useful tool in terms of optimization of the design is the use of high-speed computers.

Many problem which usually arise in the process development and design can easily be handled with a higher degree of completeness with computers. Other design and safety factor can be reduced with a substantial saving in capital investment.

In original design work, the engineer must deal with many differences types of experimental and empirical data. Some data can be obtained from literature such as physical and chemical properties. Many approximation also must be made in carrying out theoretical design calculations.

In the approach to design, it is necessary to make many assumption. Another important is cost. Another important aspect of design is course consideration must be given to cost Engineer throughout the project works.

2.2 PROCESS DESIGN PHILOSOPHY

The general term plant design includes all engineering aspect involved in the development of either a new, modified or expanded industrial plant. The economic evaluation and general economic analysis of process is called process engineering, while process design refers is the actual design of the equipment and facilities necessary for carrying out the process.

The design itself requires the use of engineering principles and theories combined with a practical realization of the limits imposed by industrial conditions. A plant design project moves to completion through a series of stages such as:

(1) Inception
(2) Preliminary evaluation of economic and market
(3) Development of data necessary for final design
(4) Final economic evaluation
(5) Detailed engineering design
(6) Procurement
(7) Erection
(8) Start up or trial runs
(9) Production

Plant-design project involves a wide variety of skills. Among these are research, market analysis, design of industrial process of equipment, cost estimation, computer programs and plant location surveys.

The general approach in any plant design involves a careful balance combination of theory, practice, originality and common sense.

2.3 JUSTIFICATION OF NEED

The demand for caustic potash (KOH) has been on the increase due to the many uses it can be put into.

The importance of caustic potash in the process industry and in the manufacture of many industrial products cannot be over emphasized.

From the preliminary studies carried out at Manufacturing Association of Nigeria

(MAN), it is found that most of the caustic potash used in the country mainly in the soap making industry, explosive industry, fertilizer industry etc are imported and has further lead to unfavorable balance of trade.

With the advent of clamor for local sourcing of raw materials and industrialization of the country, it is pertinent on chemical engineers to device a means of producing chemicals such as caustic potash from local sources.

With the complete plant design of the process it is now possible to produce caustic potash (KOH) for our industrial uses and thereby saving the country enough foreign exchange.

CHAPTER THREE

3.0 PROCESS DESIGN

3.1 PROCESS DESCRIPTION

Ashes of plant husk are known for the high concentration of potassium ion (K+) used for the production of caustic potash.

Once the ash of agricultural waste are collected especially plantain peel which has been found to have the highest concentration of caustic potash, it is sent into a dryer which operate at 100°c and from which the moisture content of the raw material is completely dried. The dried material is crushed using a crusher or grinder losing about 2.5% of the material feed into the crusher.

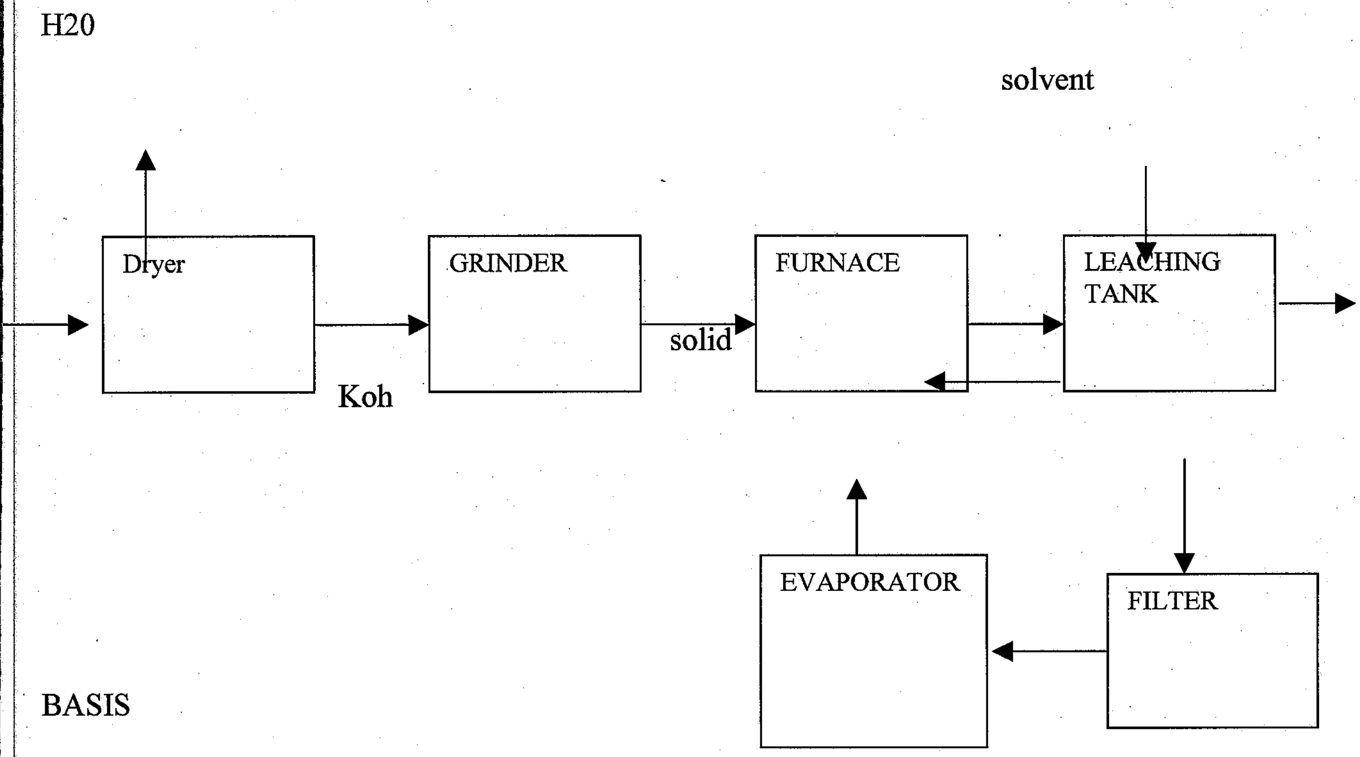
The crushed material is then transferred into the furnace operated at 500°c for 3 hours where ashing takes place and after complete combustion, the caustic potash was leached out from the ash using a distilled water as solvent in a two stage leaching tank.

The product mixture are then separated into extract and raffinate by method of filtration using filter press.

The extract in solution was then fed into an evaporator specifically crystallizing evaporator to evaporate all the solvent present with extract and obtain pure caustic potash crystal after purification.

3.2 MATERIAL BALANCE AROUND THE PLANT

THE SIMPLE FLOWSHEET FOR THE PRODUCTION OF CAUSTIC POTASH



BASIS

Taking into consideration of planned shutdown period of plant, 8000hr/Year is good enough for flowsheeting and material balance.

Since the plant is to produce 2000kg/year of running at 100% capacity utilization.

$$\therefore \text{ Caustic potash production per hour } = \frac{2000\text{kg/year}}{8000\text{hr/year}}$$

$$= 0.25\text{kg/hr}$$

Data's

(1) Amount of caustic potash in feed = 10%

(2) Amount of caustic potash in product = 98%

(3) 25% of the product of leaching was filtered of i.e. the residue

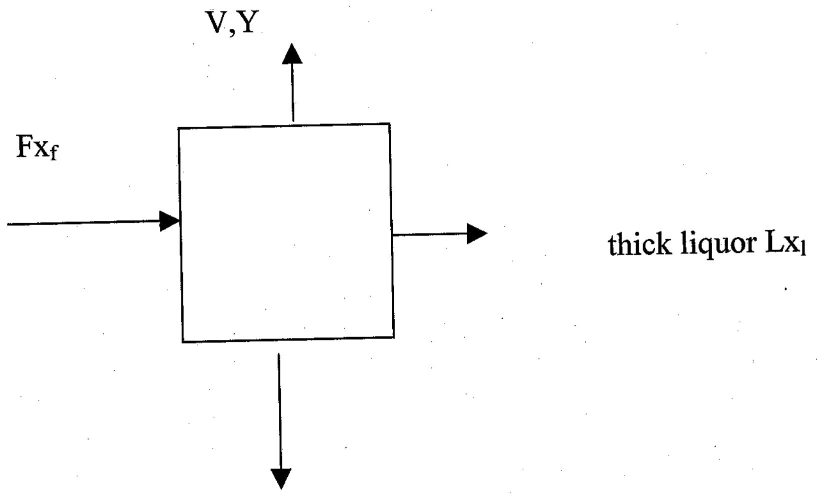
(4) 45% of the feed to the furnace was lost into the atmosphere after as hours

(5) 2.5% of the material that was fed into grinder was lost after grinding

(6) 20% of $H2O$ was completely removed from the original wet material dried

(7) 10% feed into the leaching tank was obtained as raffinate.

MATERIAL BALANCE AROUND THE EVAPORATOR



Assumption: the vapour leaving at V is a pure water-vapour at the temperature of the boiling solution and pressure employed.

Total material balance across the evaporator

$$F = L + V \quad \text{----------------------} \; 1$$

where F = Feed

L = thick liquor (product)

V = Vapour generated

Component balance for the solute (caustic potash)

$$Fx_f = Lx_l + V_y \quad \text{----------------} \; 2$$

but X_f = 10% X_l = 98%

=> $0.1F = 0.98L + Vxo$

$0.1F = 0.98L$

But $L = 2000kg$

$0.1F = 0.98 \times 2000$

$F = \frac{0.98 \times 2000}{0.1}$

$F = 19600kg$

Vapour generated $V = F - L$

$V = 19600 - 2000$

$V = 17600kg$ of water was evaporated

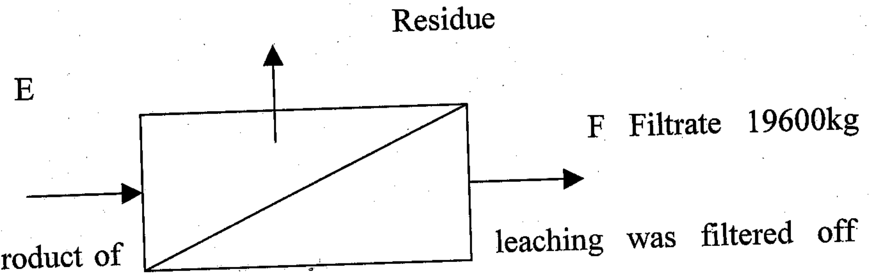
The material balance become

$F = L + V$

$19600 = 17600 + 2000$

$19600kg = 19600kg$

Material balance across the filter



25% of the product of leaching was filtered off i.e. the residues

$E = R + F$

But $R = 25\%$ of E

$E = 0.25E + 19600$

$E - 0.25E = 19600$

$075E = 19600$

$E = \frac{19600}{0.75} = 26133kg$

$E = 26133kg$

$R = 0.25E$

$R = 0.25 \times 26133$

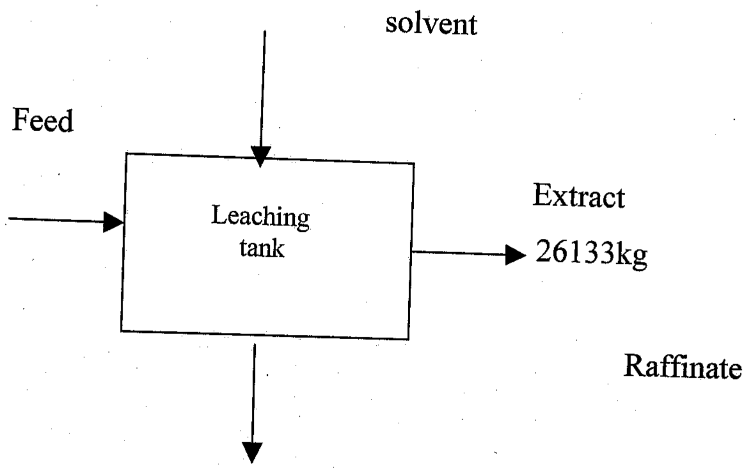
$R = 6533kg$

The material balance become

$26133 = 6533 + 19600$

$26133kg = 26133kg$

MATERIAL BALANCE ACROSS LEACHING TANK



Total balance across the leaching tank

$F + S = E + R$

where $R = 10\%F$

$F+S=E+0.1Es$

$F+500=26133+0.1F$

$F-0.1F=26133-500$

$0.9F=256133$

$F=\frac{256133}{0.9} =28481kg$

$F=28481kg$

$\therefore R=0.1F=0.1X28481$

$R=2848kg$

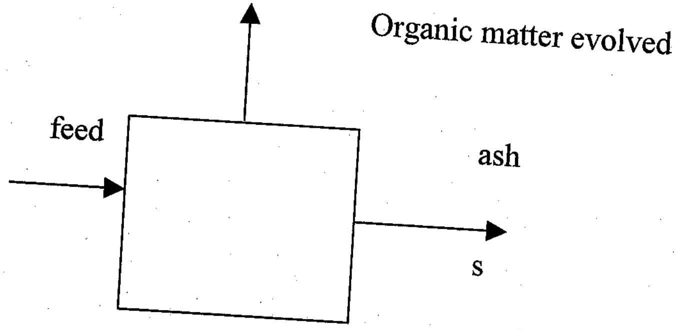
therefore the balance become

$F+S=E+R$

$28481+500=26133+2848$

$28981kg=2981kg$

MATERIAL BALANCE ACROSS THE FURNACE



Material balance

F=A+M

but M=45% of F=0.45F

F=28981+0.45F

F-0.45F=28981

0.55F=28981

F=28981/0.55

=52693

F=52693kg

M=0.45X52693

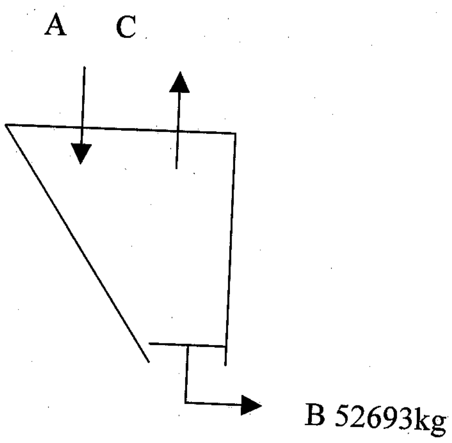
M=23712kg

The material becomes

52693=28981+23712

52692kg=52693kg

Material balance around the grinder



Material balance

A=B+C

But C=2.5%A =0.025A

A=52693+0.025A

A-0.025A=52693

0.975A=52693

$$A=\frac{52693}{0.975}$$

A=54044.10kg

but C=0.025A=0.025X54044.10

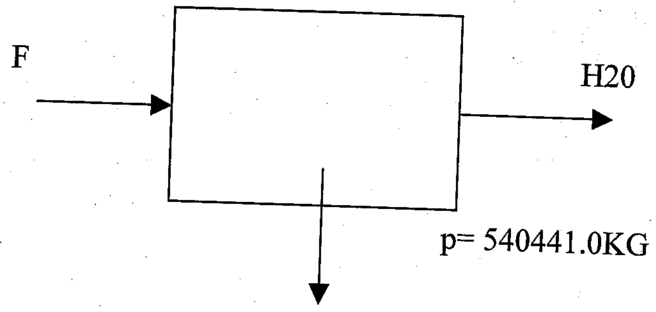
C=1351.10kg

:. Material balance becomes

54044.1=52693+1351.10

54044.10kg=54044.10kg

MATERIAL BALANCE AROUND THE DRYER



Material balance

F=H+P

But H=20% of F

F=54044.10+0.2F

F-0.2F=54044.10

0.8F=54044.10

F=54044.10/0.8

=67555.13kg

H=0.2A=0.2X67555.3=13511.03kg

:. Material balance becomes

67555.13=13511.03+54044.10

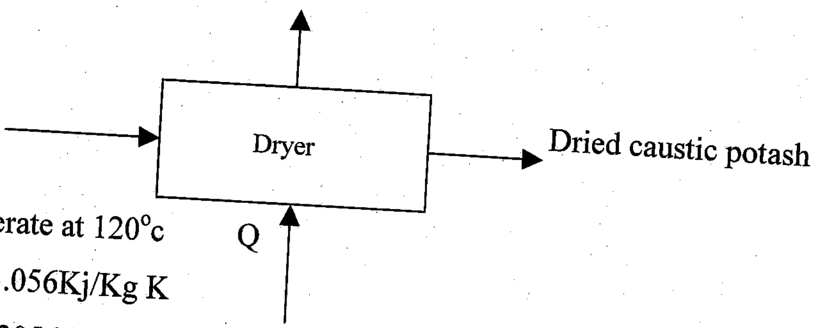
67555.13kg=67555.13kg

3.3 ENERGY BALANCE AROUND THE PLANT

ENERGY BALANCE AROUND THE DRYER

H_{KOH}

25°c=298K



The Dryer operate at 120°c

C_p of KOH =3.056Kj/Kg K

C_p of H_2O =4.2056 kj / kg K

H_{H2O}=Sensible+Enthalpy of water

But for 1kg of water at 100°c, the enthalpy is 2675.8

H_{KOH1} = heat input into the dryer

H_{KOH2} = heat absorbed by the dried KOH

C_p = total energy supplied to the dryer

Calculating the respective heat input and output into the system

$H_{KOH1} = M\,C_pt$

From material Balance carried out

Mass of wet caustic potash = 67555.13kg

$\therefore$ H_{KOH1} = 67555.13 X 3.056 X 298

=61521646.23kj

$H_{KOH2} = M\,C_p\,T$

M=54044.10kj

H_{KOH2}=54044.10X3.056X393

=64.907396.45kj

H_{H20} =MCP DT +MH

= 13511.03 (from material balance)

H_{H20} = 13511.03 x 4.2056 x (120 - 25) + 13511.03 x 2675.8

=41358884.15kj

Hence Energy balance becomes

$H_{KOH1} + Q = H_{H20} + H_{KOH2}$

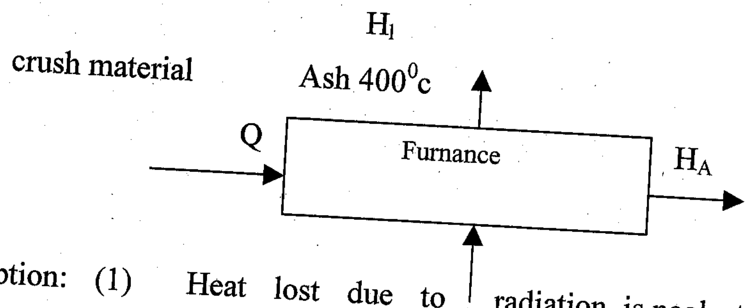
$Q = H_{H20} + H_{KOH\,2} - H_{KOH1}$

Q=41358884.15+64987396.45-61521646.23

Q=44744634.87kj

Q=44745.6Mj = Total heat supplied that must be supplied to the dryer

ENERGY BALANCE AROUND FURNANCE



H_{c1}

Assumption: (1) Heat lost due to radiation is neglected

HC1 = heat input into the furnance

=

from material balance

MCPt

M = 52693kj

H_{c1} = 526930x3.056x298

H_{c1} = 47986882.78kj

H_A = heat absorbed by the material to become Ash

=MCPDt

M = 28981kj, Cp of Ash = 2795kj/kgK

H_A = 28981 x 2795 x 375

=30375710-63

H_L = heat absorbed by the evolved organic material

M=23712 Cp of organic matter = 3.172kj/kg

H_L = 23712 x 3.172 x(673-298)

=28205424

Therefore Energy balance

$H_C+Q=H_L+H_A$

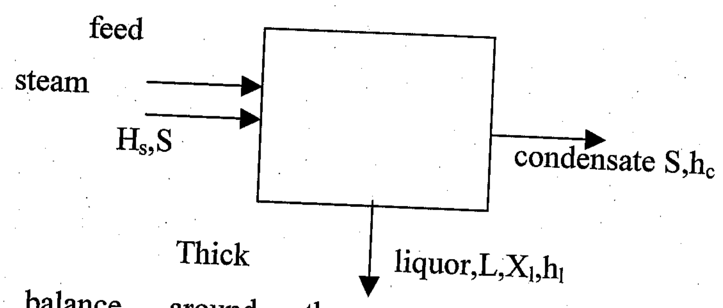
$Q=H_L+H_A-H_C$

Q=28203424+30375710.63-47986882.78

Q=10594251.85kj

Q=10594.3Mj

ENERGY BALANCE AROUND EVAPORATOR



Heat balance around the evaporator

Heat leaving = heat entering

or

heat in feed + heat in steam = heat in thick liquor + heat in vapour + heat in Condensate + heat lost by radiation

Assumptions:_ (1) heat lost by radiation is neglected.

(ii) the effect of Boiling point rise is negligible.

(iii) Assume steam is dry and saturated

(iv) The evaporator operate at a pressure of 1 atm in vapour space

Using symbolic representation

$Fh_f + Sh_s = VH + Lh_c + Sh_c$.

where F = feed = 19600kj material balance

tF = temperature of feed 37.8 ^{0}c

hF = Heat in feed = 71.75kj (steam table)

S = amount of steam requirement

Hs = Heat in steam at 227^{0}c = 1219.69kj

V = amount of vapour evolved = 17600kg from material balance

Hv = heat in vapour at 212^{0}c = 1213.4kj (steam table)

L= thick liquor or product formed = 2000kg

hc = heat in thick liqour at 212^{0}c = 189.91kj (steam table)

hc = heat of condensate at 227^{0}c = 205.7kj

Substitute into the energy balance equation

$Fh_f + Sh_s = VH + Lh_c + Sh_c$

19600x 71.75 +1219.0695=17600.1213.4x2000x189.91+205.75

1406300+1219.695=21735660+205.75

1219.695-205.75=21735660-14063090

1013.995=20329360

S=20329360/1013.99

S=20048.89kj

The total heat to be transferred through the heating surface is given as S(Hs - Hc)

Q = 20048.89(1219.69-205.75)

Q=20328MJ

CHAPTER FOUR

4.0 DETAILED DESIGN OF EVAPORATING UNIT

4.0.1 Evaporator Selection.

The selection of the most suitable evaporator type for a particular application will depend on the following factors.

(1) The throughput required

(2) The viscosity of the feed and the increase in viscosity in evaporation.

(3) The nature of the product required; solid, slurry or concentrated solution.

(4) The heat sensitivity of the product

(5) Whether the material are fouling or non-fouling

(6) Whether the solution is likely to foam

(7) Whether direct heating can be used.

Having considered all these factor and from the fact, the evaporator is to crystallized the caustic potash extract solution. Short-tube evaporator with a agitator is chosen for the operation.

Short-tube vertical evaporator also called "calandria" evaporator consist of a relatively squat vertical cylinder and it has horizontal tube sheet that go right across the shell. The tube are relatively large in diameter but short. The tube are expanded into tube sheets. The larger tube diameter are used for crystallizing Evaporator. The evaporating liquid fills the lower part of the vessel and come part way up the tubes. The tube are heated from the outside, usually by considering steam the liquid bools in the tubes. As the liquid is then returned to the lower part of the evaporated through a large central hole (or "well"). The large hole typically has roughly the same cross sectional area as that available for flour in all tubes. The means, in practice, that central hole has a diameter which is about half the diameter of the tube alternatively, down corner around the outside of the bundle can be used.

For unit used as crystallizing evaporator, it is important to keep the circulation rate high. Assisted circulation is used by putting a large impeller in the central down corner. Crystallization is not wanted in the tubes and so the liquid level is increased. The advantage of short-tube vertical evaporator are:

(1) They give good heat transfer performance particularly at large temperature difference

(2) They are relatively cheap to construes and can be built as large unit.

(3) They are suitable for crystallizing liquid if assisted circulation is user.

(4) They require low headroom

CHEMICAL ENGINEERING DESIGN OF EVAPORATING SECTION

DESIGN DATA FOR EVAPORATOR DESIGN

1.0 Feed temperature 378^0c

(ii) Steam will be used as source of heat at 26.5 bar

(iii) Steam temperature = 227^0c

(iv) Proposed internal tube diameter d_i = 5cm

(v) Proposed external tube diameter d_o = 6cm

(vi) Length of tube = 2m

(vii) The metal thermal conductivity = 5000W/m^2k

(viii) Evaporated water flow rate = 17600kg/hr

(a) The solution i.e the feed is very dilute and aqueous, therefore the liquid can be assumed to have the properties of pure water at 1 bar. In particular, the latent heat of vaporization of the solution will be 2256kj/kg

Also Assume the feed liquid to the evaporated, the heat load for the evaporator will be given by

Heat load = evaporation rate x latent heat

= 17600 x 2256

= 39.71MW

(b) The heat supplied into the evaporator is by a condensing steam at 2270c (pressure 26.5bar) with a latent heat of vaporization of 1829.3kj/kg.

The steam flow into the evaporator is then given by

Steam flow necessary = heat load/Latent heat

= 39.7056x106/1829.3

=21705.02kg/hr

(c) The log mean temperature difference can now be calculated

DTm = (Ts-T2)-(Ts-T!)/In (Ts-T2/Ts-T1

Where TS= Condensing steam temperature = 227^0c.

T2 = Feed temperature = 37.8^0c

T1 = Evaporating liquid temperature = 100^0c

DTm = (227-37.8) - (227-100)/In 227-37.8/277-100

DTm = 189.2-117/In 189.2/117 = 150.2^0c

Using Kern (1950) design method by correcting the logarithmic mean temperature

Using two shell pass and four tube passes

R = 227-100/100-37.8= 117/62.2

R = 1.88

$S = 100\text{-}37.8/227\text{-}100 = 62.2/117$

$S = 0.53$

From the chart of temperature correction factor plot of Kern 1950 (Richardson and Coulson Vol.6 page 600)

Ft = 0.8

DTm = 0.8x150.2

$= 120.16^0C$

(d) Going now to the heat transfer coefficient. The tube to be used is fairly thin walled and so the curvature of the tube wall will be neglected.

The difference in area between the inside and outside of the tube will also be neglected.

Reasonable estimate of the various heat transfer coefficient are then as follows:

Condensing heat transfer Coefficient = $10000W/m^2k$.

Outside fouling heat transfer coefficient = $10000W/M^2k$,

tube metal heat transfer coefficient = tube thickness/metal thermal conductivity

$=50/0.0025 = 20000W/M^2k$

Inside fouling heat transfer coefficient = $1000W/M^2k$

Evaporating transfer coefficient = $8000W/M^2k$

The overall heat transfer coefficient U is then given by

1/U = 1/10000+1/10000+1/20000+1/1000+1/2000

$1/U = 1.375x10^{-3}$

Hence U = $730W/M^2k$

(e) Therefore the required total heat transfer area is given by Q = UADTm

Where

Q=heat load (Calculated above)

A = Q/UDTm

A =39.71x106/730x120.16

A = $452.7m^2$

Therefore Area of the heating surface can be taken as $.453m^2$

(f) The area provided by each tube can now be calculated balance the dominant heat transfer coefficient is an inside heat transfer coefficient

Therefore Area per tube = π x inside diameter x lenght

= π x 0.05 x2m

= $0.314m^2$

(g) The required number of tube is number of tube = total area/area per tube

= 453/0.314 = 1443

(h) The cross sectional flow area of these number of tube calculated is

flow area = no of tube xπx (inside diameter)2/4

=1443xπ x (0.05)2/4

$=2.83m^2$

(i) The down corner area of the vertical, short-tube evaporated can now be calculated

The down corner area should be equal to the total tube cross - sectional area which $2.83m^2$

Hence the diameter of the down corner is then calculated as

$A = \pi D^2/4$

$4A = \pi D^2$

$D = \sqrt{4A/\pi}=2\sqrt{A/\pi}$

$D = 2\sqrt{2.83/3.142}$

D = 1.90m

(j) tube pitch is given by Pt = 5do/4

= 5x0.06/4 = 0.075m

Calculate the pitch to outside diameter ratio = Pt/do = 0.075/0.06 = 1.25

= 1.25

Then each tube takes up an area of tube sheet

of $(1.29x0.06)2 = 5.62x10\text{-}3m^2$

The total tube sheet area for 1443 tube is thus approximately 5.62 x10 -3 x 1443 = $8.12m^2$

Allowing for central down corner area \, the necessary outside diameter of the calendria is 7.66m

DESIGN OF AGITATOR

Since the evaporator is to serve as crystallizing evaporator, it is very important to keep circulation rate very high. To assisted in the circulation, large impeller in installed in the central down corner.

The impeller diameter is calculated from the relationship.

Da/Dt = 1/3

Where Dt = Diameter of the calendria = 7.66m

Da = impeller diameter = Dt/3 = 7.66/3

= 2.55m

Using a safety factor of 20%, we have Da = 2.55+20/100 x 2.55

Da = 3.06m

Impeller height from the evaporator bottom to impeller

E/Dt = 1/3

E = Dt/3 = 7.66/3 = 2.55m

Width of the blade is given by the ratio W/Da = 1/5

W = Da/5 = 3.06/5 = 0.61m

The impeller length is given by the ratio

L/Da = 1/4

L= Da/4 = 3.06/4 = 0.77m

Agitator power consumption is given as

P= Npn3Da5λ/g

Np = is obtain using the graph of required number versus power number

RE = N Daλ/N

@ = viscosity = $0.006 Ns/m^2$

N = agitator speed = 240 2pm (assumption)

= 240/60 = 4rps

Re = $4x(2.55)^2$ x 1525/0.006.

Re = .6610875 > 10^4

NP = 6.3 (fluid flow for chemical Engineer pg 175)

The required power by the agitator is

P = NP $n^3Da^5\lambda/g$

$P=6.3x4^3x(2.55)^5x1525/9.81x737.25$ KW

P=9172.60KW

4..1 ECONOMIC ANALYSIS

For any industrial plant to be put into operation, huge sum of money must have been invested in it to purchase and install the necessary machinery and equipment. The capital required to have the necessary manufacturing and plant facilities is called the fixed capital investment and that which is necessary for plant operation is called working capital the summation of the two gives the total capital investment [Tcl] and there are different in estimating the capital lost estimate. This include:

[1] Order-of-magnitude estimate [ratio estimate] based on similar previous lost data, probable accuracy of lost estimate_+30%

[2] Study estimate [factored estimate] based on the knowledge of major items of equipment; probable accuracy of estimate up to 30%

[3] Definite estimate [project control estimate]based on almost complete data but before completion of drawing and specification.

[4] Detail estimate based on complete engineering drawing,specification and site surveys. Probable accuracy of estimate within +5%.

The cost estimation in the design project will be restricted to the cost of the evaporating section only.

The cost of the equipment is used as the basis of the factorial method of lost estimation and must be determined as accurately as possible. It should be based on the most recent price of the equipment.

For any type of equipment,the relationship below holds $Ce=CS^n$ where

Ce=Purchased equipment

S=Characteristic size parameter

C=Cost constant

n=Index for that type of equipment.

For the purpose of the work, crystallizing evaporator cost estimation is to be performed. For the evaporator section

C=E6000 [Richard & coulson vol 6]

$S=453m^2$, n=0.53 [For carbon steel]

$Ce=6000x[453]^{0.53}$ Ce=E153420.46 [the base date is mid 1992].

Using the current currency exchange of Naira to pound sterling

#150=E1

Ce=153420.46x150

Ce=#23013669.90k.

Calculating the cost escalation as a result of inflation.

Cost in 2000=Cost in 1992 x cost index in 2000/cost index in 1992.

Cost index in 1992=108

Cost index in 2000=148.96

Therefore Ce = 153420.46x148.96/108

Ce in 2000 = #3174.216414k

Cost of the agitator is

$Ce = Cs^n$

where

C = E1000

n = 0.5

S = 9.2

$Ce = 1000x[9.2]^{0.5}$

Ce = E3033.15 in 1992

Calculating the lost escalating upto is 2000

Ce in 2000= cost in 1992 x cost index in 2000 /cost index in 1992

= 3033.15x148.96/108

Ce = E4183.50

Converting to naira

Ce = 4183.50x150

= #627525.03

Therefore total cost of the evaporating section

= 31742164.14+627525.05

=#32369689.17k

4.2 SAFETY CONSIDERATION AND PLANT LOCATION

4.21 SAFETY CONSIDERATION:

The preparation and undertaking of safety measure is part and parcel of any chemical engineering design.

In the production of caustic potash the main hazard easily faced are fire and risk of injury firm the toxic and corrosive potassium hydroxide. Safety consideration will be briefly be considered under the heading "principal safety problem and safety regulation.

1. CORROSION.

Caustic potash is considered a very corrosion chemical substance which can easily corrode storage equipment and pipes , if the material for the construction of the plant are properly chosen and utilized.

2 TOXIC

Potassium hydroxide is highly toxic chemical and when dissolved in solution can cause irreparable scaring of tissue of the eye, mouth etc. Any solution containing more than half caustic potash should be considered toxic and handled very carefully.

3 FIRE

Ashing of the agricultural waste used in the production of caustic potash in electric furnace can be very dangerous, if the operation is not well monitored to control the temperature and not exposing the process to possibility of fire outbreak.

4.22 SAFETY REGULATION

1 Control of hazards

Strong care must be taken in handling caustic potash to avoid spilling to the skin, mouth e.t.c, or even breathing the vapour during leaching. Material for construction should be the type that can easily resist corrosion especially aluminum or steel alloys. Rubber glove and goggle must be used during the leaching of caustic potash. caustic potash should not be kept in the plant for so long and should normally be kept in a special storage area.

2. FIRE PREVENTION.

a. Static electricity -: The movement of any non conducting material e.g. liquid can generate static electricity, producing sparks. Adequate precaution must be taken to ensure proper earthling of all the communication pipes.

4.2.4 PLANT LOCATION

SITE CONSIDERATION FOR PLANT TO PRODUCE 2000KG / YEAR OF CAUSIC POTASH FROM AGRICULTURAL WASTES.

The location of a plant can have a crucial effect on the profitability of a project and the scope for future expansion, many factor must be considered when selection a suitable site and brief of these factor will be considered in the project.

1. Raw material - the availability and price of suitable raw material will often determine the site location the plant producing caustic potash from agricultural waste such as plantation peel should be sited in a area where there is massive4 production of plantation and it utilization. In Nigeria, the southern part has a conducive environment for the production of plantain peel and if the plant is sited there availability of the raw material won't pose any problem.
2. Availability of labour - labour will be needed for the construction of the plant and its operation skilled construction workers can be brought from outside the site area ,but there should be an adequate pool of unskilled labour available locally.
3. Transport- the transport of material and product to and from the plant will be an overriding consideration in site selection.

Caustic potash plant should be sited close to at least two form of transport road or rail.

4.3 INSTRUMENTATION AND CONTROL OF THE EVAPORATOR SECTION

It is proposed that most of the plant equipment in the caustic potash process be operated using automated control with the indicating instrument being located in a central control room.

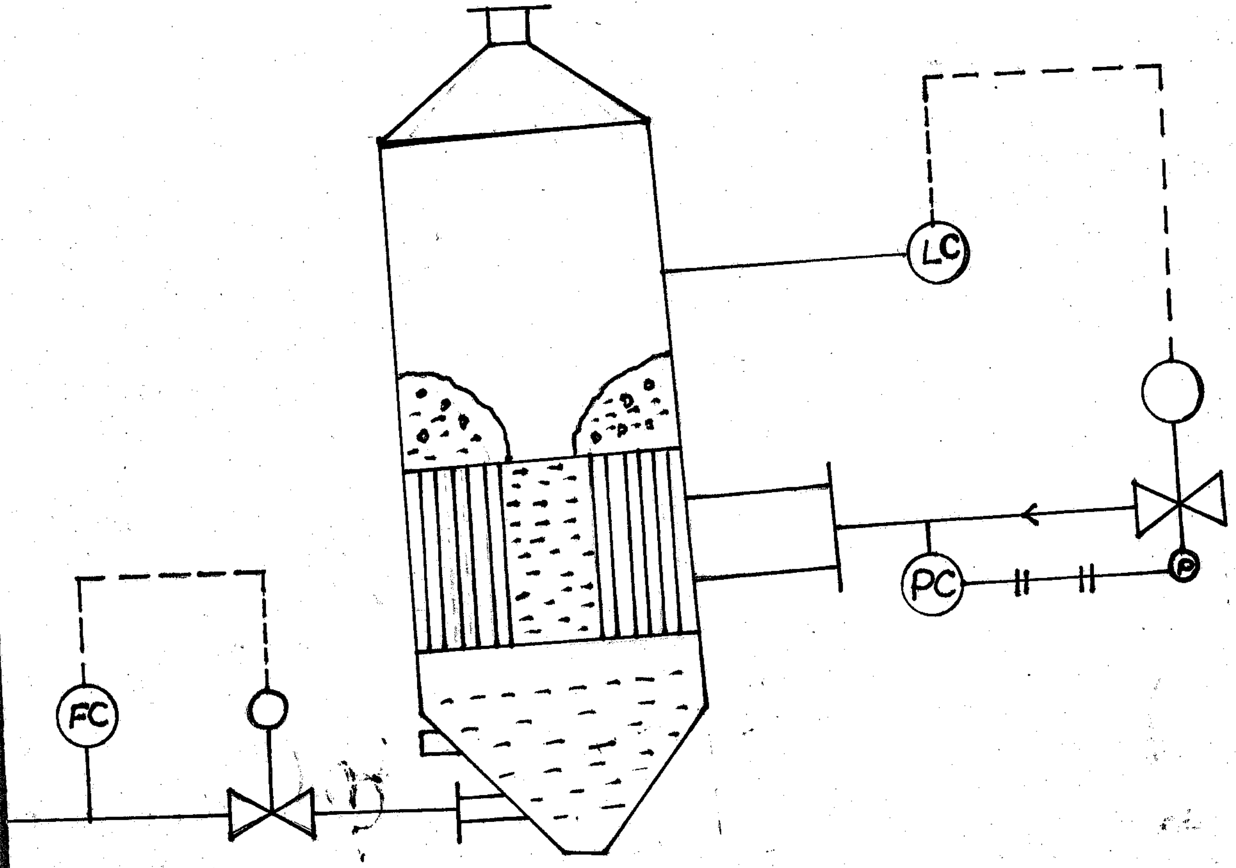
Since the evaporator operate at atmospheric pressure, therefore instrumentation and control will be based upon temperature , flow and level measurement.

Measurement of these parameter will made using thermocouples, orifice plate and float type indicators.

CONTROL OF THE EVAPORATOR.

The filtrate obtained after filtration was to be evaporated to get the crystallized caustic potash, these evaporator require considering steam as a heating medium in the shell side of the evaporator, the vaporization is controlled by the steam pressure the liquid level will be controlled also by the vaporization rate in the tube. The level will be adjusted by the control of flow of the reactant into the evaporator.

DIAGRAM SHOWING THE CONTROL OF THE EVAPORATOR.



Key
LC : Level Controller
PC : Pressure Controller
Fc : Flow Controller

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION .

A plant for the production of caustic potash from plantain peel ash has been carried out the major work include material and energy balance across the whole plant.
Detailed chemical engineering of the evaporating section was carried along with it agitator which make it a crystallizing evaporator.
Cost estimation if the evaporating section was also carried out. The total cost obtained for the purchase of the crystallizing evaporator is #32369689.00

Safety consideration was considered and all the necessary measure needed to have safety operation highlighted. .

RECOMMENDATION

This plant design project cannot be said to have encompasses all aspect of process design. Therefore alot still need to be done to obtain a complete plant design for the production of caustic potash.
It is recommended that other equipment used during the production be also designed.
This include the crusher , dryer furnace etc.
It is also recommended that for reduction in steam economy in the evaporator, double effect evaporator should be used for the evaporator of the caustic potash filterate.

REFERENCE

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[3] Max. S PETER AND KLA IMMERHAUS; plant design AND ECONOMICS for chemical Engineers page 63

[4] Sadik. Kakac; Bioler, Eva s and condenser page633-776

DEDICATION

he design project is dedicated to my Dear Mama, **MADAM HAJARAT YAKUBU**

APPENDIX A: TABLE OF TOTAL MATERIAL BALANCE OVER ALL THE EQUIPMENT

Evaporator		Filter		Leaching Tank		Furnace		Grinder		Dryer	
In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
19600											
	2000										
	17600										
					26133						
		261133									
			19600								
			6533								
				500							
				28981			28981				
					2848						
						52693			52693		
							23712				
								54044			
											54044.10
									1351.10		
										67555.13	
											13511.03
9600 g	19600kg	261133 kg	261133 kg	28981 kg	28981kg	52693kg	52693kg	54044 kg	54044 kg	67555.13kg	67555.13kg