DESIGN OF BLENDER (MIXER) TO BLEND ADDITIVE WITH BASE OIL

BY

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A DESIGN PROJECT SUBMITTED IN PARTIAL FULFILMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING (B. ENG) IN CHEMICAL ENGINEERING IN THE SCHOOL OF ENGINEERING TECHHNOLOGY FEDERAL UNIVERSITY OF TECHNOLOGY
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CERTIFICATION

This is to certify that I have read and approved this project work which I found adequate both in scope and quality for the partial fulfillment of the requirement for the award of bachelor of engineering in chemical engineering.

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DEDICATION

The design project is dedicated to Jehorah Jireh (My provider) and my fôster and step mother Madam Ismaila Mariyam. You are more than a Mother to me.

ACKNOWLEDGEMENT

My Lord and god, you are worthy to receive glory honour and power, for you created all things and by your will they were given existence and life. I thank you for your manifold blessing and continuous loving kindness in my life.

I gratefully acknowledge and remember my father who laid the foundation of my academic pursuit before his death.

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A mission fulfilled gives an ultimate satisfaction, no matter how rough the road might be,, because the toils of the road seem nothing when we get to the end of the way.

ABSTRACT

This is a design project work on a mixer to blend additive with base oil, in order to improve its physicochemical properties.

A mixer of diameter 1.84m and total height 3.0m was constructed with a turbine agitator. The productivity of the mixer was 5708kg/hr.

Moreso, the instrumentation and control strategies for the process, the material for the construction and the escalated equipment cost of the mixer were all determined.

Material and energy balance on which the material for construction depends were both determined. Lastly the plant layout and the flow sheet were include in the design work.

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CHAPTER ONE

1.0 INTRODUCTION.

Mixing can be defined as a process of achieving a desired degree of homogeneity or promoting heat and mass transfer in systems involving chemical reaction. Mixing can be classified on the phases of the mixing substances as liquid-liquid, liquid solid, Gas-liquid – solid, and so on.

In mixing, two possible types of problems are encountered which are: how to design and select mixing equipment for a given duty and how to assess whether a mixer is suitable for a particular application. In finding the solution to these problems, the following are consider: mechanism of the mixing, power consumption, flow pattern of substances to be mixed, and the equipment available and cost.

Mixing equipment is designed to adhere to a pre-determined level of homogeneity and also to improve heat transfer. The rotational speed of an impeller in a mixing vessel is selected so as to achieve a required rate of heat transfer but excessive or over mixing should be avoided to avoid wasteful of energy and destruction of the product quality of especially in biological processes. Also, where desirable .heological properties of some polymer solutions may be attributable to structured long chain molecules, excessive impeller speed over prolonged period may damage the structure of the polymer molecules thereby altering their properties. It is therefore important to try as much as possible to avoid over mixing as it does not only result to excessive energy consumption but may also impaired the product quality.

1.0 AIMS AND OBJECTIVES.

The aims and objective of this project is to design a mixer or blender to blend additives and lubricating oil together to improve the physiochemical properties of the lube oil .

1.2 PROBLEM STATEMENT.

A process design of blender with a mechanical agitator to carryout the process of a topical mixing of additives to base oil with a productivity of 5908kg/hr and total working hours of 8322 hours per annum.

CHAPTER TWO

2.0 LITERATURE REVIEW

Mixing is one of the most common operation in chemical and industrial processes. It involves a process of reducing the degree of non-uniformity or gradient of property in a system such as concentration, viscosity, temperature and so on. Mixing is achieved by moving material from one region to another.

2.1 MIXING MECHANISM

For mixing to be carried out successfully, it is very important to know the flow pattern of liquids. In liquid mixing devices, it is advantageous to prevent stagnant zone and create intensive mixing zone. Considering the fluid properties especially viscosity, the flow of mixing vessels may be laminar or turbulent.

2.1.1 IMPELLER REYNOLD NUMBER

Reynolds is defined as

$$N_{re} = \frac{Da^2 N \rho}{\mu} \qquad \text{------------------------(2.1)}$$

Where N= rotational speed (rev/s)

Da = Impeller diameter (m)

ρ = fluid density (kg/m^3)

μ = viscosity (kg/ms)

Reynold number is used to determine whether the flow in the impeller stirred tank is turbulent or laminar. When $N_{Re} > 10,000$, flow in the tank is turbulent. Between N_{Re} of 10,000 and 10 is a transition range in which flow is turbulent of the impeller and laminar in remote parts of the vessel. When $N_{Re} > 10$, flow is laminar.

2.1.2 LAMINAR AND TURBULENT MIXING

laminar mixing occurs in a high viscosity liquid in excess of $10NS/m^2$ which may be either Newtonian or Non-Newtonian. The inertia force therefore intend to die out quickly and the impeller of the mixer must cover a sufficient proportion of the cross section of the Vessels with rotation impeller is turbulent. The inertia imparted to the liquid by the rotating impeller is sufficient to cause the liquid to circulate throughout the vessel and return to the impeller.

2.2 MIXING EQUIPMENT.

The choice of mixer type and its design is governed by experience because there is no standardization of equipment and design code available.

2.2.1 VESSELS

These are usually vertical cylindrical tank up to 10m in diameter which typically are filled to a depth equal to about one diameter.

2.2.2 BAFFLES

To prevent gross vortexing which is detrimental to mixing, especially low viscosity systems, baffles are often fitted to the walls of the tank. These take the form of thin strips about one-tenth of the tank diameter width, and typically four equi-spaced baffles may be used. In some cases, baffles are mounted flush with the wall and occasionally, a small clearance is left between the wall and the baffle to facilitate fluidmotion on the wall region.

Baffles are however, generally not required for high viscosity liquid because the viscous shear is then sufficiently great to damp out the rotary motion.

2.2.3 IMPELLERS

There are two types of impellers which are based on the angle the blade makes with the plane of impeller rotation. They are as follows:

2.2.3.1 AXIAL FLOW IMPELLER

These are impellers which the blades make an angle of less than 90° with the plane of rotation propellers and paddles are example of axial flow impeller. Propeller mixer man be clamped on the side of an open vessel in the angular off centre position or place on top of the closed vessel or mounted near the bottom of the cylindrical wall of a vessel especially to blend low viscosity fluid.

2.2.3.2 RADIAL FLOW IMPELLER

This system have blades which are parallel to the axis of the drive shaft. The smaller multiplied ones are known as turbine, larger slower-speed impeller with two or four blades are called paddles. The other type of radial flow impeller is called one which is used for some pseudoplastic fluid systems where stagnant fluid may be found next to the vessel walls in parts remote from the propeller or turbine impellers. The fluid flow is principally circular in the direction of rotation of the anchor.

2.3 POWER CONSUMPTION IN STIRRED VESSEL

Power consumption which can be viewed in too ways due to different flow pattern and making mechanism is the most important parameter in the design of stirred vessel.

2.3.1 VISCOSITY SYSTEM

Typically equipment for low viscosity liquid consist of a vertical cylindrical tank with a height to diameter ratio of 1.5 to 2 fitted with an agitator. Also high-speed propeller of diameter about one third that of the vessel are suitable.

Considering a stirred tank in which Newtonian liquid of viscosity μ, density ρ is agitated by an impeller diameter D rotating at a speed N; the tank diameter D_T and the other dimensions aforementioned, then the functional dependence of the power input to the liquid P on the independent variable (N, D, D_T, g, other geometric dimensions) may be expressed as

$$P = f(\mu, \rho, N, g, D, D_T, \text{other dimensions}) \quad \ldots\ldots\ldots \quad (2.2)$$

In equation (2.2) , P. is the impeller power that is the energy per unit time dissipated within the liquid. Clearly the electrical power required to drive the motor will be greater than P on account of transmission losses in the gear box, motor etc.

It is readily acknowledged that the functional relationship in equation 2.2 cannot be established from the first principle. However, by using dimensional analysis the number of variable can be reduced to give.

$$\frac{P}{\rho N^3 D^5} = f\left[\frac{\rho m D^2}{\mu}, \frac{N^2 D}{g}, \frac{D_I}{D}, \frac{W}{D}, \frac{H}{D}\right] \quad \ldots\ldots\ldots \quad (2.3)$$

Where the dimensionless group on the left hand side is called power number N_P, $\rho ND^2/\mu$ is the Reynolds number (Re), N^2D/g is the Froude number (Fr). Other dimensionless length ratios such as D_T/D, W/D etc, relate to specific impeller/vessel arrangement. For geometrically similar systems, these ratio must be equal and functional relationship between the power number and the other dimensionless group reduces to

$$N_P = f(R_e, F_r) \quad \ldots\ldots\ldots\ldots\ldots \quad (2.4)$$

The simple form of the function in equation (2.4) is the power law giving by $N_P = K' R_e{}^b F_r{}^c$ .... (2.5).

Where k', b, c must be determined from experimental measurement and are dependent on impeller/vessel configuration.

2.3.2 HIGH VISCOSITY SYSTEM

High viscosity liquid is slow both of the molecular scale on account of the low values of diffusivity as well as at the macroscopic scale due to poor bulk flow. Where as in low viscosity liquids momentum can be transferred from a rotating impeller through a relatively large body of fluid, in high viscous liquid only the flind immediate vicinity of the impeller is influenced by the agitator and the flow is normally laminar.

The proportionality constant in equation (2.5) is a function of the type of rotating member and the geometrical configuration of the system. A simple relationship exist between much of the data on power consumption with time independent non Newtonian liquid and Newtonian liquids in laminar region.

2.4 SCALE UP OF STIRRED VESSELS.

In designing a mixing equipment, the designer is faced with the problems of choosing the satisfactory arrangement for a large unit from experiment with small units. In order to achieve the same kind of flow pattern in two units, geometrical kinematics, and dynamics similarly and identical boundary conditions must be maintained. Power of the agitator can be related easily with the geometrical and mechanical arrangement of the mixer hence a direct indication of the change in power rising from alteration of any of the factor relations to the mixers.

2.4.1 GEOMETRIC SIMILARITY

Prevails between two systems of different sizes of all counterpart length dimensions have a constant ratio. Thus the following ratio must be the same in two systems, according to Coulson et al (1993)

$\frac{D_T}{D}, \frac{H_A}{D}, \frac{WB}{D}, \frac{W}{D}; \frac{H}{D}$ and so on

2.4.2. KINEMATICS SIMILARITY

Exists on two geometrically similar units when the velocities at corresponding point have a constant ratio. Also flow patterns of the liquid must be alike.

2.4.2 DYNAMIC SIMILARITY

Occurs in two geometrically similar units of different sizes of all corresponding forces at counterpart locations have constant ratio. The various type of forces encountered are inertia, gravitational, viscous, surface tension and normal stressed.

Some or all of these forms may be significant in a mixing vessel considering corresponding positions in system I and 2 which refer to the laboratory and large scale respectively when the different types of forces occurring are F_a, F_b, F_c and so on, dynamic singularity requires that

$$\frac{F_{a1}}{F_{a2}} = \frac{F_{b1}}{F_{b2}} = \frac{F_{c1}}{F_{c2}} = \text{constant} \quad \ldots\ldots\ldots\ldots (2.7)$$

Kinematics and dynamic similarities both require geometrical similarity so that the corresponding positions 1 and 2 can be identified in the two systems.

CHAPTER THREE

3.0 PROCESS DESIGN

3.1 PROCESS DESCRIPTION.

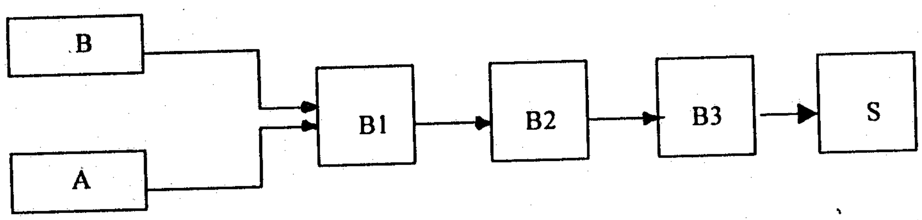
The process involved in the blending of additive with lube oil or base oil is a common mixing process. The additive and the base oil from tank A and tank B respectively will enter mixer 1. Steam in the gasket of the vessel will raise the temperature of the two substances which will aid in reducing their viscosity to enhance effective mixing. They will then be agitated by a turbine agitator to blend them to some certain degrees of mixing.

The product from mixer 1 will then enter mixer II and the same process will repeat itself to facilitate better mixing.

Moreso, the product will lastly be pumped to mixer III for completion of the blending exercise. The finished well-blended product will then be pumped to the storage tank.

This blended product can be filled into tankers or canned into different sizes for sale.

Block diagram for the process of blending is as shown below.



Where

A - Additive tank

B- Base oil tank

B1 Blender 1

B2 Blender 2

B3 Blender 3

S- Raw materials storage tank.

3.2 FLOW SHEETING (PROCESS)

This is key document in process design as its shows the arrangement of the equipment selected to carry out the process, stream connections, stream flow rate and operating conditions. Infact, it is the diagrammatic model of the process and the basis for designs and can be used to prepare operating manuals and operator training. Also during plant start up a subsequent operation the flow sheet form the basis for comparism of operating performance with design.

The process flow sheet must be clear, comprehensive accurate and complete since it is a key document as afore said. According to Ulrich (1984), there are about three types of process flow sheet presentation which are:

(a) Pictorial representation

(b) Presentation of steam flow rates

(c) Block diagram

Among these types, block diagram presentation which is the simplest form of presentation is used in this design project, since the process does not involve complex operation.

The flow sheet (block diagram) and the plant layout are both presented in this design work.

3.3 MATERIAL BALANCE.

Material balances are the basis of design process as it determines the quantities of raw materials required and the products produced. Some of the essence of material balance are:

1. To study plant operation and trouble shooting
2. To check performance against design
3. To check instrument collaboration
4. To locate the sources of material loss.

In accordance with the law of conservation of mass, mass cannot be destroyed or created during chemical reactions or processes, that is mass of the reactants must be equal to mass of the product. For continuous processes, material balance is calculated for a given period of time. The total mass of material in a reactor is constant. In designing, the productivity of the factory is usually given and consequently the quantity of raw material required can be calculated. The ratio of the quantity of raw material required to produce a unit mass of the product is referred to as utility coefficient. It expresses the amount of raw material to produce a unit of the product.

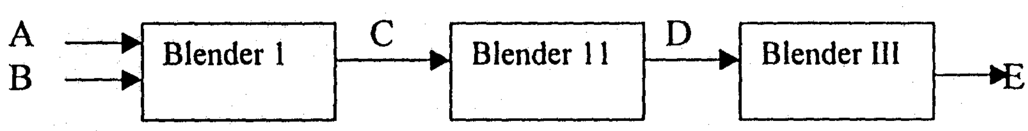
The general conservation equation for any process system can be written as Material out = material in + Generation - consumption – Accumulation.

For steady state process accumulation term will be zero, except in nuclear processes, mass is neither generated nor consumed, but if a chemical reaction takes place, a particular chemical species may be formed or consumed in the process. In this mixing unit where there is no chemical reaction, the steady state balance reduces to

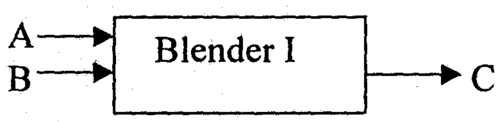
Material in = material out

Taking a basis of one hour (1hr), Annual production in mass of 50,000 tonnes and 95% of total hours in a year which is 8322 hours per year,

Productivity = $\frac{50,000,000}{8322}$ kg/hr = 5708 kg/hr



BALANCE FOR BLENDER 1



Where A = additive = 12% of the feed

B = Base oil = 88% of the feed

C = Blended oil

Input = Output

:- A + B = C = 5708 kg/hr

Since what goes in come out (mixing unit);

A + B = C = Feed

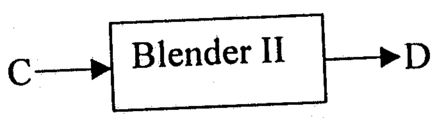
Hence A = 12% of C =

= (0.12 x 5708)kg/hr = 684.96kg/hr

B = 88% of C

= (0.88 x 5708)kg/hr = 5023.04kg/hr.

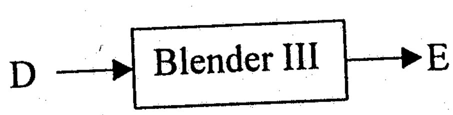
MATERIAL BALANCE FOR BLENDER II



Input = Out put

D = C = 5708kg/hr

MATERIAL BALANCE FOR BLENDER III



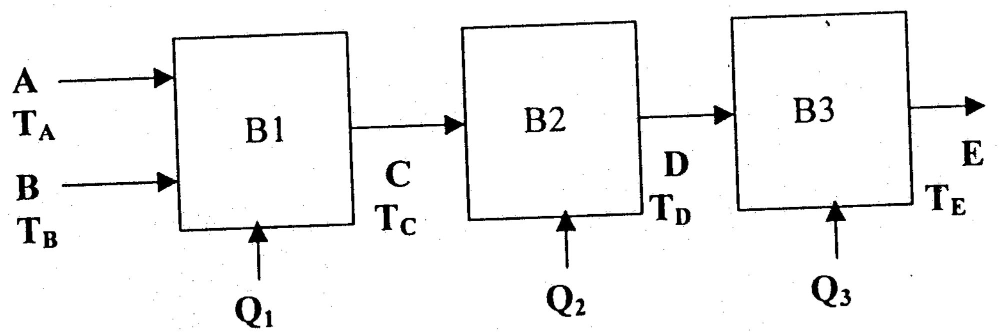
Input = Out put

E = D = 5708kg/hr

E is the finished product.

3.4 HEAT BALANCE OVER THE REACTORS.

HEAT BALANCE AROUND THE BLENDERS



Where

A = Additive (alkylated styrene)

B = Base oil

C = D = C = E = Mixtures at temperatures; 42^0C, 48^0C and 60^0C respectively

$B_1 = B_2 = B_3$ = Blenders

$T_A = T_B = 30^0C = 303k$

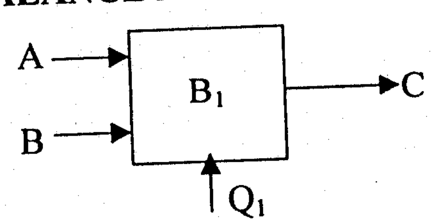
$T_C = 42^0C = 315k$

$T_D = 48^0C = 321k$

$T_E = 60^0C = 333k$

$Q_1 = Q_2 = Q_3$ = heat inputs.

HEAT BALANCE AROUND BLENDER 1



$$M_A\, CP_A\, DT_A + M_B\, CP_B\, DT_B + Q_1 = M_C\, CP_C\, DT_C$$

Where

M_A = Mass of additive = 684.96kg/hr

M_B = Mass of base oil = 5023.04kg/hr

M_C = Mass of mixture = 5708kg/hr

$DT_A = DT_B = 315 - 298 = 5K$ (using 25°C as the datume temperature).

$DT_C = 315 - 303 = 12$

CP_A = CP of the additive = 2.3556kJ/kgk

CP_B = CP of the base oil = 1.8925kJ/kgk

CP_C = CP of the mixture at 42°C

CP_{C1} = CP of additive at 42°C = 2.5111 kJ/kgk

CP_{C2} – CP of base oil at 42_0C = 1.9424 kJ/kgk

$$:- CP_C = \frac{CP_{C1} M_A + CP_{C2} M_B}{M_A + M_B}$$

$$= \frac{2.5111 \text{ X } 684.96 + 1.9424 \text{ X } 5023.04}{684.96 + 5023.04}$$

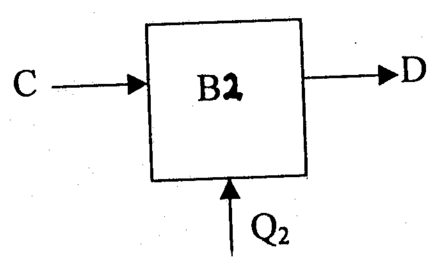
$$= 2.011 \text{ kJ/kgk}$$

hence $Q_1 = M_C\, CP_C\, DT_C - M_A\, CP_A\, CT_A - M_B\, CP_B\, DT_B$

$= 5708 \text{ X } 2.011 \text{ X } 12 - 684.96 \text{ X } 2.3556 - 5023.04 \text{ X } 1.8925 \text{ X } 5$

$= 82147.83$ kJ/hr

HEAT BALANCE AROUND BLENDER 2



$$M_C\, CP_C\, DT_C + Q_2 = M_D\, CP_D\, T_D$$

Where

$M_D = M_C$ = 5708kg/hr

$DT_D = 321 - 315 = 6k$

CP_D = CP of the mixture at 48^0C

CP_{C1} = CP of additive at 48^0C = 2.9424kj/kgk

CP_{D2} = CP of base oil at 48^0C = 1.9676kj/kgk

$$CP_D = \frac{CP_{D1} + CP_{D2} M_B}{M^A + M_B}$$

$$= \frac{2.9424 X 684.96 + 1.9676 X 5023.04}{684.96 + 5023.04}$$

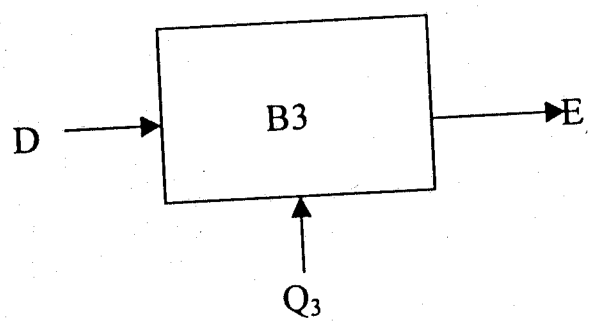
$$= 2.0846 kj/kgk$$

hence $Q_2 = M_C CP_C DT_C - M_C CP_C DT_C$

$= 5708 X 2.0846 X 6 – 5708 X 2.011$

$= 13999. 44 Kj/hr$

HEAT BALANCE AROUND BLENDER 3



$$M_D CP_D DT_D + Q_3 = M_E CP_E DT_E$$

Where

$M_E = M_A = M_C = 2708 kg/hr$

$DT_E = 333 – 321 = 12k$

CP_E = CP of the mixture at 60^0C

Cp_{E1} = CP of additive at 60^0C = 2.932kj/kgk

CP_{E2} = CP of base oil at 60^0C = 2.018kj/kgk

$$CP_E = \frac{CP_{E1} M_A + CP_{E2} M_B}{M_A + M_B}$$

$$= \frac{2.932 X 684.96 + 2.018 X 5023.04}{684.96 + 5023.04}$$

$$= 2.1277 kj/kgk$$

hence $Q_3 = M_E CP_E TE - M_D CP_D T_D$

$= 5708 X 2.1277 X 12 - 5708 X 2.0846 X 6$

$= 74345.56$ kj/hr

The total heat required for the process is

$Q = Q1 + Q2 + Q3$

$= 82147.48 + 13999.44 + 74345.56$

$= 170492.48$kj /hr

$= 170.49$MJ /hr

3.4 According to the law of energy conservation, the total energy in a closed system is constant. In chemico technological process, the law of energy conservation is the base on which energy balance is computed, the total amount of energy released to a system must be equal to that expended. Heat balance is computed using material balance, heat of physical and chemical changes occurring in the reactor, taking to account the external heat sources and losses through the products and reactor wall. Heat balance is very necessary because it is the basis for the selection of the material for construction.

In this design, heat losses through the products and the reactor wall are negligible.

CHAPTER FOUR

4.0 EQUIPMENT DESIGN

4.1 SPECIFICATION OF EQUIPMENT.

The design and specification of blender needed for the blending of additive with base oil is carried out base on the physiochemical properties of the tube oil.

Total working hour- since no plant will operate continuously without shutdown which is necessary for maintenance, inspection, equipment cleaning and renewal of raw materials and column packing,. This plant was designed to operate for 95 per cent of the total hours in a year (8760 hrs/year). This is equivalent to 8322 hours per year.

Time basis – 1 hour.

- annual production in mass = 50,000 tones
- productivity of blended oil = $\frac{(500,000,00)}{8322}$ kg/hr
- = 5708kg/hr.

- Reactor yield and conversion- since it is a mixing unit the equipment performance could be assumed to be equal to 100 percent as the material in (additive and base oil) tend to be in equilibrium with the material out (blended oil).

  Hence the amount of reactants going into the reactor is approximately equal to 5708kg/hr
- Specific gravity (SG) of the mixture from experimental analysis = 0.874.
- Density of the mixture = SG x 1000) kg/m^3
- = (0.874 x 1000) kg/m_3

  = 874kg/m_3

- Volume of the reactor vessel – to calculate the volume (V_T) of the reactor, since density and mass of the mixture are known, the

$V_T = \frac{mass}{} = m/\rho = \frac{5708}{874} = 6.53\ m^3$

Volume of the reactor vessel = volume of cylindrical section (Vc) + volume of the hemispherical section (Vn)

$V_T = Vc + Vh$

$Vc = \pi r^2 h = \frac{\pi D^2 H_L}{4}$

Using the relationship $H_L = D_T$

$Vc = \frac{\pi D_T^3}{4}$

$V_h = 2/3\ \pi r^3 = 2/3 \pi (\frac{D_T^3}{8}) = \frac{\pi D_T^3}{12}$

hence $V_T = \frac{\pi D_T^3}{4} + \frac{\pi D_T^3}{12} = \frac{\pi D_T^3}{3}$

$\therefore D_T = \sqrt[3]{\frac{3V_T}{\pi}} = \sqrt[3]{\frac{3x6.33}{3.142}} = 1.84m$

Using the relationship Da = DT/3

Da = The diameter of impeller = 0.61m

Giving a tolerance of 1.63 to the height, the real height i.e the height of the reactor vessel H. becomes;

$H = (1.63)\ H_L = 1.63 \times 1.84$

$= 2.999\ \ 3.0m$

Impeller height (HA) from the tank bottom given by this ratio

$H_A = \frac{D_T}{3} = \frac{1.84}{3} = 0.61m$

Width of the blade (w) given by this ratio.

$$W = \frac{Da}{5} = \frac{0.61}{5} = 0.12m$$

Impeller length (L) given by this ratio

$$L = \frac{Da}{4} = \frac{0.61}{4} = 0.15m$$

Assuming the speed of the agitator = 180rpm (since the mixture is a viscous liquid)

N = speed = 180rpm = $\frac{180}{60}$ = 3rps

The power requirement = $P = \frac{N_p n^3 \; Da^5 \; \rho}{g_c}$

where n = speed of agitator = 3rps

Da = Diameter of impeller = 0.61m

ρ = Density of the misture = 874kg.m^3

gc = Gravitational constant = 9.81m/s^2

Np = Power number an can be determined using the graph of Reynolds number versus power number and

Where μ = viscosity.

At 400C, kinematics viscosity = 140cst = 1.4st

= 1.4cm 2/s = 0.00014m 2/s

but kinematic viscosity = $\frac{\text{viscosity}}{\text{density}}$.

i.e. kv μ / ρ

μ = kv x ρ = 0.00014 x 874 $\left(\frac{m^2}{3} \times \frac{kg}{m\acute{s}}\right)$

= 0.1236kg/ms

$$N_{Re} = \frac{3 \times (0.61)^2 \times 874}{0.1236} = 7973.57$$

$\doteq$ 7974.

From the graph when Nre = 7974, Np = 4.9

Hence $P = \frac{N_P n^3 Da^5 \varrho}{} = \frac{4.9 \times (3)^3 \times (0.61)^5 \times 874}{9.81}$

$= 996kg\ 5^3/m^3$

Divide by 737.25 to get power in kilowatts (kw)

$P = \frac{996}{737.25} = 1.35kw$

Residence time $= \varnothing = 12000 \left(\frac{\mu v}{\varrho}\right)^{1/2} \left(\frac{V}{1.0m^3}\right)^{1/5}$

where μ = Viscosity = 0.12236kg/ms = 0.1226 pa.s

ϱ = density = $874kg/m^3$

v = volume = $6.53m^3$

$\varnothing = 12000 \left(\frac{0.2236 \times 6.53}{874}\right)^{1/2} (6.53)^{1/5}$

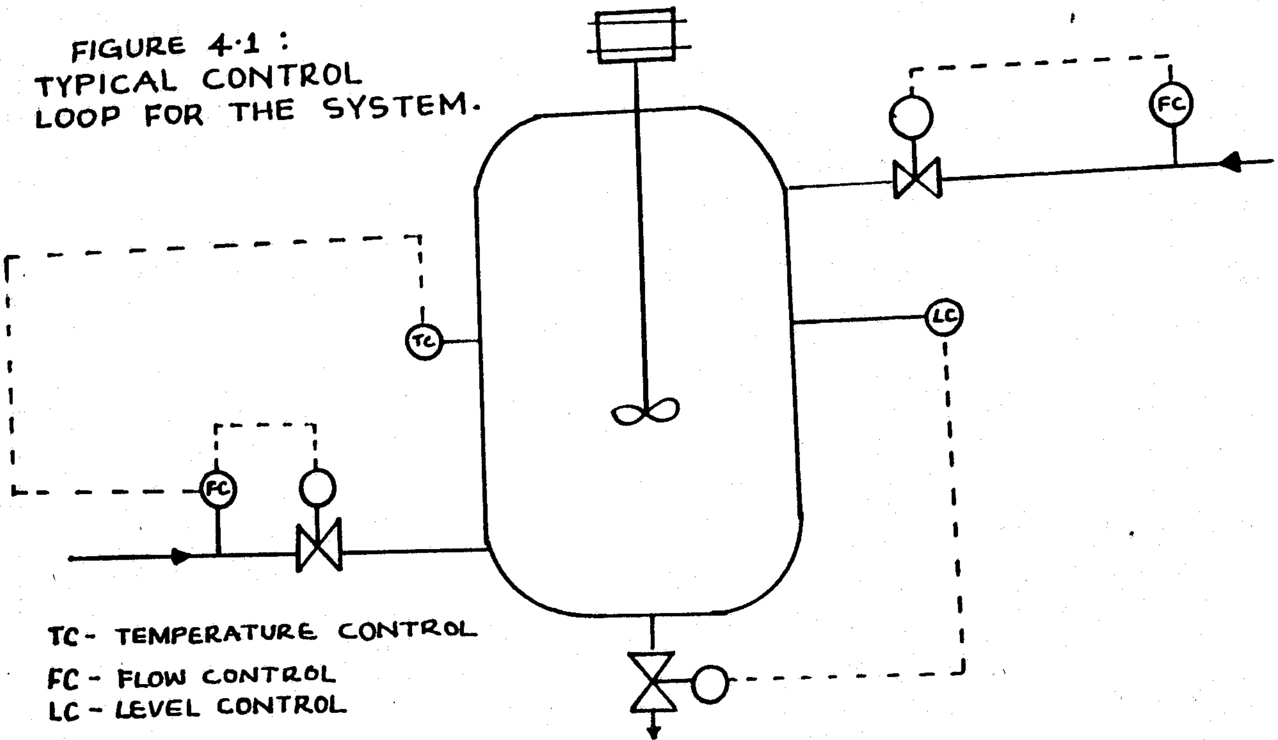
= 472 secs = 7.87 mins

= 0.13hours.

4.2 INSTRUMENT AND CONTROL

Control is an essential part of any chemical Engineering operation. It is proposed that most of the plant equipment in this blending processes be operated using automatic control with the indicating instrument being located in a central control room, making the plant not labour intensive. The plant operate at atmospheric pressure hence instrumentation and control will be based upon flow, temperature and level measurement. The control system of the plant is as shown below.

FIGURE 4·1 : TYPICAL CONTROL LOOP FOR THE SYSTEM.



4.2.1 MEASUREMENT AND CONTROL LOOP FOR THE SYSTEM

Liquid level is normally determined either by the use of float method, measurement of the static head or capacitance bridge method In this blending plant, capacitance bridge method was used which is generally employed with large cylindrical tank. One electrode is inserted down the cenre of the tank whilst the enter wall is used as the other. The vessel then acts as a concentric cylindrical capacitor having a capacitance which alters with liquid level. The capacitance (and hence the liquid level) is measured using a stablised capacitance bridge. This is transmitted the level transmitter and the control value is then switched to action.

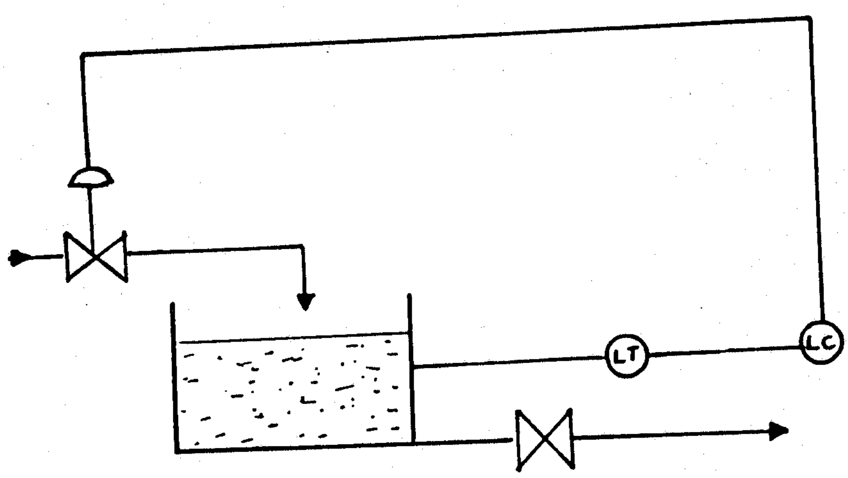


Fig. 4.2 **A level control loop**

4.2.2 MEASUREMENT AND CONTROL OF FLOW.

One class of flow measurement which is becoming of increasing importance (particularly in the form of sensor for control system) is monitoring of mass flow. This is rapidly superseding the movement of volumetric flow especially where it is required to determine accurately the transfer of large quantities of liquid in oil industries. Two principal approaches are employed to measure mass flow. One is indirect and uses a combination of volumetric flow and density and other is direct in that it involves the measurement of properties which are sensitive to variation in mass rate of flow itself. In this project, the indirect method is used as explain below.

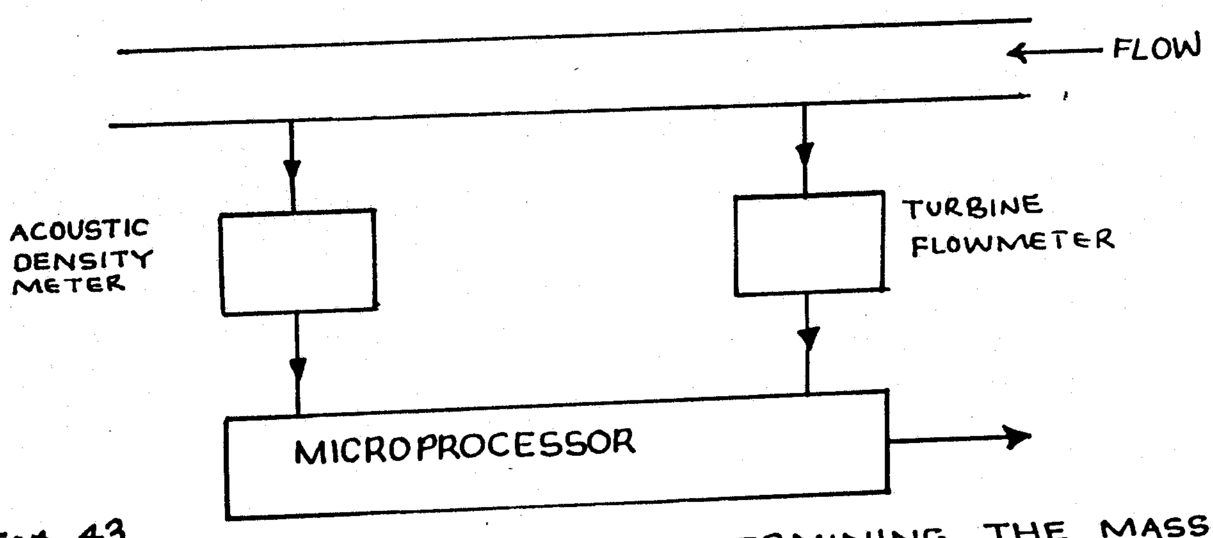


FIG. 4.3
COMBINATION OF SENSORS FOR DETERMINING THE MASS FLOW RATE OF FLUID.

4.2.3 TEMPERATURE CONTROL

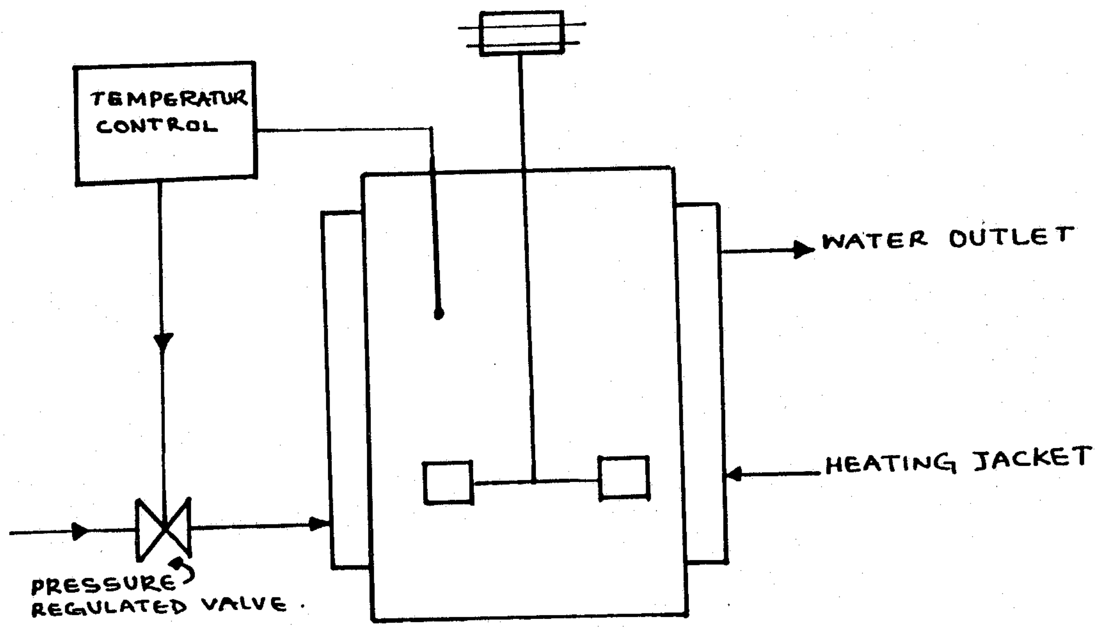


Fig 4.4 Temperature control loop

Temperature in a pipe or vessel is the most important parameter to be monitored and controlled in any process. It may be measured by mercury in glass thermometer, bimetallic, thermometer, pressure bulb thermometer, thermo couple, metal resistance thermometer or thermistor

In this design, bimetallic thermometer is used, it consist of a bimetallic helical coil surrounded by a protecting tube or wall. The coil winds or unwinds with changes in temperature and causes movement by a fixed pointer. A pen can be fitted to the pointer so that temperature changes can be monitored on a chart. They are less subject to breakage than glass thermometer but cost slightly more.

4.3 SAFETY.

It is the obligation of the organization to safeguard the health and welfare of it workers and even the general public at large. Safety is also important as it ensure efficient and safety plant operation, operation at the lowest production cost, high product quality, good management and prevent loss financially and otherwise.

As safe operation of a process depends on design, this blender plant was designed in such a way to make it inherently safe by provisions of:

(i) automatic shut down system
(ii) duplication of key equipment services
(iii) alarm system
(iv) organization of safety training for all staff
(v) good control system
(vi) safety devices such as fire extinguishers, safety sign boards and posters
(vii) safety gadgets such as overalls, safety boots, safety heat resistance gloves etc.
(viii) and lastly by keeping the plant surrounding clean for healthy working conditions.

Alarm systems are used to alert operator of serious and potential hazardous deviations in process operations. Key instruments are filted with switches and relays to operate audible and visual alarms on the control panels.

4.4 EQUIPMENT COSTING.

Chemical plant are built to make profit and an estimate of the investment required and cost of production are needed before the profitability of a project can be accessed.

Here the cost for all the parts of the blender (mixer) are calculated using the following expression: accordingly to Ulrich (1984)

$Ce = CS^n$

Where Ce = purchased equipment cost ( )

S = characteristic size parameter in units specified

C = the cost constant.

n = index for that type of equipment.

<u>cost for the vessel (agitated vessel)</u>

$Ce = CS^n$

$C = 16000$

$S = 6.53m^3$

$n = 0.45$

$Ce = 16000 \times (6.53)^{0.45}$

$= £37224.67$

converting this to Nigerian currency (Naira)

1 £ = ₦ 150.

£37224.67 (37224.67X 150) ₦

₦ 5583700.50K

4.5 MATERIALS OF CONSTRUCTION

Many factors have to be considered when selecting materials for chemical processing plant. Some of these factors include"

1. The ability to resist corrosion
2. Sufficient strength and be easily worked
3. Material that give the lowest cost over working life of the plant.
4. Allowing for maintenance and replacement
5. Processes contamination and process safety

6. Mechanical properties

7. Availability in standard size

Putting all these factors into consideration, the following materials were selected for constructing the reaction vessel.

1. Low carbon steel (mild steel) – for the construction of the vessel
2. Polytetra fluro ethylene (PTFE) known under the trade name Teflon and Fluon for lining the vessel.
3. Protective coating – Epoxy based paints was used to paint the vessel to prevent atmospheric corrosion.

PUMP – for pumping of liquid from one vessel to an other or through a long pipes, some form of mechanical pump is usually employed. The energy required by the pump will depend on the height through which the fluid is to be raised, the pressure required on delivery, the length and diameter of the pipe, the flow rate together with the physical properties of the fluid especially viscosity and density. All these factors influence the choice of pump. The two main forms of pump are positive displacement type and the centrifugal pump.

Putting all the above mentioned factors into consideration, centrifugal pump was selected for this design work.

PIPING: - The capital cost of a pipe run increases with diameter where as the pumping costs decrease with increasing diameter. The most economic pipe diameter will be the one which gives the lowest annual operating cost. Since the fluid has to be pumped through the pipe, the size should be selected to give the least annual operating cost. Therefore a pipe with pipe velocity and allowable pressure drop of 3m/s and 0.5kpa/m respectively was chosen for the design. The material used in the construction of the pipe is plastic.

VALVE SELECTION: The valves used for chemical process plant can be devided into two broad classes depending on their primary functions. They are as flows:

1. Shut off valves (block valves) whose purpose is to close off the flow
2. Control valves both manual and automatic used to regulate flow. control and keeping the presur e drop as low as possible. The valve is also sized to avoid flashing of hot oils and super critical flow of vapour.

STORAGE VESSEL:- tanks are receptacles employed to hold, transport or store liquids. Preliminary design of a storage receptacle is direct and elementary, one merely needs to known the size and temperature, pressure and exposure conditions anticipated. Rules for determining size are based on common sense and experience.

In this design, cylindrical body tanks with hemispherical shape ends are used and natural rubber was used to line all the storage vessels.

CHAPTER FIVE.

5.1 CONCLUSION.

Following the standard specification for geometrical parameters of designing a reactor, a mixer or blender of diameter 1.84m and total height 3.0m was designed with a productivity of 5708kg/hr.

Turbine agitator was used with a motor of 1350 W power. Turbine agitator was used because the mixture is a very viscous liquid.

The blending plant was made inherently safe by providing safety devices and safety gadgets instrumentation and control which is an essential parts of any chemical engineering operation was not left out in the design work.

The materials for construction were carefully chosen, putting all the factors for selecting materials for chemical processing plant into consideration.

Lastly the escalated equipment cost for the blender was ₦5583700 and the total operating hours for the plant was 8322 hours per annum.

5.2 RECOMMENDATION.

I wish to recommend that further investigation on the control strategy of the blending plant should be made using comprehensive operability studies.

Also, lubricating oils manufacturer should converge and develop a blender or mixer that will be recycling used lubricating oil. This will aid in protecting our environmental pollution caused by used oils. Federal government should take this up and ensure mass collection of used oil into storage tank, located at strategic places, where users of lubricants can be draining their used oils.

I wish also to recommend double blade in a single shaft to make blending exercise easier and quicker hence reducing the number of blenders or mixers required in the process.

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APPENDIX

N_{Re} – Reynold number

e – Density

μ – viscosity

P – power

N_P – Power number

D_T – Diameter of the reactor

G – acceleration due to gravity

F_r – Froude number

C_P – specific heat capacity

Q – quantity of heat

T – Temperature

M – Mass

D_a – Diameter of impeller

N – Speed of agitator

H – height

T_C – Temperature control

P_C – Prssure control

L_C – level control

PTFE – Polytetrafluro ethylene

C_e – Purchase equilibrium

C – Cost constant