CONFIGURATION OF VARIOUS PROCEDURES INVOLVED IN PRODUCTION OF TRICHLOROISOCYANURIC ACID

Submitted in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Chemical Engineering

By

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SCHOOL OF BIO AND CHEMICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with “A” grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600119

MARCH 2021

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **GIRITHARAN.J (37190020)** and **MOHAMED ASIQ.A(37190027)** who had done the project work as a team. They carried out the project entitled "**CONFIGURATIONS OF VARIOUS PROCEDURES INVOLVED IN THE PRODUCTION OF TRICHLOROISOCYANURIC ACID**" under my supervision from October 2020 to March 2021

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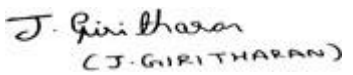
DECLARATION

I **GIRITHARAN.J** (37190020) hereby declare that the Project Report entitled "CONFIGURATIONS OF VARIOUS PROCEDURES INVOLVED IN THE PRODUCTION OF TRICHLOROISOCAYNURIC ACID" done by me under the guidance of Dr.D. Venkatesan at Sathyabama Institute of science and Technology is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Chemical Engineering



DATE: 20-03-2021 **SIGNATURE OF THE CANDIDATE**

PLACE: Chennai

DECLARATION

I **MOHAMED ASIQ.A**(37190027) hereby declare that the Project Report entitled "CONFIGURATIONS OF VARIOUS PROCEDURES INVOLVED IN THE PRODUCTION OF TRICHLOROISOCAYNURIC ACID" done by me under the guidance of Dr.D. Venkatesan at Sathyabama Institute of science and Technology is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Chemical Engineering

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DATE: 20-03-2021 **SIGNATURE OF THE CANDIDATE**

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ABSTRACT

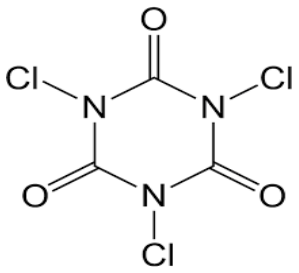
The project work carried out focuses on the production of Trichloroisocyanuric acid and various procedures for starting the process plant. The detailed study about the production and application of Trichloroisocyanuric acid is done. The overall material and energy balance was carried out and also for individual equipment's are also done. Design of some process equipment such as fluidized bed dryer and agitator is made for detailed understanding. Cost estimation is done to enable feasibility studies and to provide information for planning and appropriation of capital. The plant layout criteria's are also discussed. The safety aspects include hazards posed by Trichloroisocyanuric acid, safety methods, first aid methods and waste disposal methods are discussed in detail. Furthermore, the general process and instrumentation control information is given. In this project we listed all major technical aspects involved in the production of Trichloroisocyanuric acid

Keywords: Chlorination, Sodium hydroxide, Reducing agent, hazards, Utilities

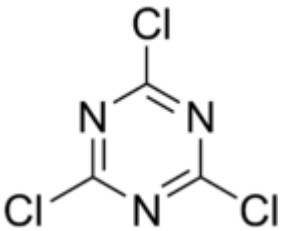
CHAPTER 1

INTRODUCTION:

Trichloroisocyanuric acid (TCCA) is an organic compound which is commonly used as an Industrial disinfecting agent, bleaching and organic synthesis reagent with the chemical formula ($C_3Cl_3N_3O_3$) and IUPAC name 1,3,5-Trichloro-1,3,5-triaziane-2,4,6-trione. Trichloroisocyanuric acid has some regularly utilized trademarks, Symclosene, ACL-85, or Chloreal,1.At first it was detailed in 1902 by Chattaway and Wadmore. The creators depict that trichloroisocyanuric acid is acquired in a quantitative yield from the response of the potassium salt of cyanuric acid along with chlorine gas. Later Birckenbach and Linhard depicted the production of trichloroisocyanuric acid through cyclization of N′-carbonyl-N, N-dichlorourea. After the microbiological action of trichloroisocyanuric was found, Hands and Whitt detailed the blend of trichloroisocyanuric through chlorination of cyanuric corrosive with chlorine gas in liquid NaOH. From there on, trichloroisocyanuric acid and its monosodium salt dichloroisocyanuric acid turned out to be significant. In 1952 Monsanto got a patent on the combination of trichloroisocyanuric acid.In 1960 W.R. Effortlessness got a second patent on the production of trichloroisocyanuric acid. Purex acquired in 1958 a patent on a strategy for the cleansing of trichloroisocyanuric acid through disintegration in concentrated H2SO4 and weakening with ice water. Over the years there has been some disarray about the right design of trichloroisocyanuric acid. In prior volumes of Fieser and Fieser the design of trichloroisocyanuric acid was mistaken for cyanuric chloride the corrosive chloride of cyanuric corrosive.



(a)



(b)

Fig 1.1: a) Structure of Trichloroisocyanuric acid, b) Structure of Cyanuric chloride

As seen from the construction, trichloroisocyanuric has a place with the enormous gathering of nitrogenous chlorimides and amides which is a subgroup of the more broad nitrogenous chloramines. Nitrogenous chloramines are inorganic or natural nitrogen compounds with in any event one chlorine molecule appended to nitrogen, trichloroisocyanuric acid has the most elevated measure of dynamic chlorine with 92%. Chloramines are typically utilized as bleaching specialists, sanitizers, and bactericides, because of their capacity as chlorinating specialists and oxidants

CHAPTER 2

LITERATURE SURVEY

Ziegler and associates in 1942 revealed the utilization of trichloroisocyanuric acid as a reagent in natural blend for the R-chlorination of alkenes. During an itemized learn about the allylic halogenation with various reagents. Trichloroisocyanurates was likewise concentrated under standard response conditions. The creators revealed an extremely exothermic response with cyclohexene delivering a combination of items. The fundamental item 3-chlorocyclohexene was acquired in a yield of 30%. Juenge and others seen that trichloroisocyanuric corrosive liquid can be utilized for the chlorination of sweet-smelling frameworks under polar and free extreme conditions. At the point when half H2SO4 was utilized as impetus, it was feasible to get a genuinely decent yield of chlorobenzene (80%) after 4.5 hours. Juenge and others likewise detailed in 1966 the cyclic ethers chlorination. They researched the response between tetrahydrofuran or tetrahydropyran with trichloroisocyanuric corrosive liquid at zero degree celcius. The response managed chiefly trans-2,5 dichlorotetrahydrofuran in 27% or trans-2,6-dichloro-tetrahydropyran in 29% yield. By a straightforward change of the response conditions, specifically, the expansion of water, the response managed all things being equal γ-butyrolactone from tetrahydrofuran and δ-valerolactone from tetrahydropyran as the significant item after a R-methylene oxidation presumably through a hypochlorous corrosive oxidation. The release of hypochlorous corrosive liquid from trichloroisocyanuric acid in contact with water is notable. Hypohalogenation was additionally found by Juenge and others to happen with trichloroisocyanuric acid within the sight of water in the response with unsaturated cyclic ethers, for example, 2,5-dihydrofuran. By the response of trans-4-chlor-5-hydroxy-tetrahydrofuran was acquired in about 32% yield. For this situation no R-chlorination of the cyclic ether was noticed

J. Rosevear and J. F. K. Wilshire revealed in 1980 an investigation of the chlorination of some N,N-dimethylanilines with trichloroisocyanuric acid. Under the response conditions, Conc. sulfuric corrosive liquid at room temperature in one night, the response delivered a mind boggling combination of chlorinated items. No endeavor was made to improve the response conditions. Manschand and others in 1994 announced a particular chlorination

in the 7-position of the carbazole utilizing trichloroisocyanuric acid in di-methyl formide or triethylphosphate at standard temperature. Utilizing these conditions a moderate yield of the chlorinated carbazole was gotten. The creators asserted this to be the most specific chlorination framework for this substrate. H. Suzuki distributed in 1998 a technique for the chlorination of phenylphosphonic corrosive liquid with trichloroisocyanuric acid in concentrated sulfuric corrosive liquid. Utilizing this strategy it was additionally conceivable to plan tetrachlorophthalic anhydride from phthalic anhydride in 94% yield

Hiegel and others in 1985 detailed interestingly about the utilization of trichloroisocynurates for the R-chlorination of ketones. The chlorination was done under corrosive catalysis utilizing Boron tri fluride-etherate as impetus. Under these conditions a monochlorination of the most subbed side chain was acquired in moderate-to exceptional returns. A downside of this strategy is that the ketone must be utilized in huge overabundance

CHAPTER 3

METHODS OF PRODUCTION

3.1 PROPERTIES OF TCCA

It is steady, hygroscopic, and may deteriorate in contact with dampness. When in contact with ignitable material may prompt fire. Inconsistent with acids, decreasing specialists, water, solid oxidizing specialists

Table 3.1: Trichloroisocyanuric acid properties

PROPERTIES	
Chemical formula	$C_3Cl_3N_3O_3$
Molar mass	232.49 g.mol
Appearance	Colourless solid
Thickness	2.19 ± 0.1 g/cm^3
Liquefying point	246 to 247 °C
Boiling point	Decomposes
Dissolvability in water	1.2%
Dissolvability in different solvent	Soluble in chlorocarbons, acetone, and acetonitrile

3.2 APPLICATION

The worldwide production of trichloroisocyanuric acid is about 1lakh ton per year. The interest is expanding by 8-10% each year for pools and 3-5% for food handling

The compound is a sanitizer, algicide and bactericide principally for pools and dyestuffs, and is additionally utilized as a bleaching specialist in the material business. It is generally utilized in common disinfection for pools and spas, forestalling and restoring illnesses in creature farming and fisheries, products of the soil protection, wastewater treatment, as an algicide for reused water in industry and cooling, in anti-shrink treatment , for treating seeds and in natural synthetic combination. It is utilized in synthetic combination as a

simple to store and ship chlorine gas, it isn't dependent upon risky gas delivering limitations, and its response with hydrochloric corrosive liquid creates generally unadulterated chlorine

3.3 MANUFACTURING METHODS

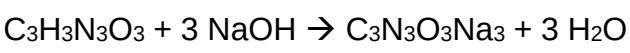
3.3.1 Preparation Method 1:

Cyanuric acid and lime carbonate are stirred well to form a liquid suspension, liquid chlorine is fed into the suspension through surge tank gasification at 20 to 25°C for 3-5 hrs will give Dichloroisocyanuric acid(DCCA). The obtained DCCA is dried and mixed with excess base for 3 to 10 min will give metal dichloroisocyanuric acid(MDCCA). The MDCCA is supplied into chlorination reactor, purified water, metal ion masking agent and dispersion agent are added.The Ph value is controlled at 2.5 to 3.5 and temperature is maintained at 10-25°C, TCCA suspension liquid is obtained from chlorination reaction.

3.3.2 Preparation Method 2:

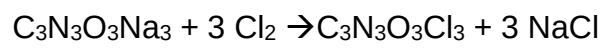
The Salification reaction between sodium hydroxide and cyanuric acid in the molar ratio 3:1 will give Sodium salt of trichloroisocyanuric acid. It is then filtered and sent for two stage reaction where successive prechlorination and chlorination of Trisodiumisocyanuric acid will give Trichloroisocyanuric acid (TCCA).

1) Salt of Cyanuric Acid



$C_3H_3N_3O_3 + 3\ NaOH \rightarrow C_3N_3O_3Na_3 + 3\ H_2O$

2) Chlorination



$C_3N_3O_3Na_3 + 3\ Cl_2 \rightarrow C_3N_3O_3Cl_3 + 3\ NaCl$

The preparation method 2 is chosen

3.3.3 Justification:

In method 1 there is more chance of forming nitrogen tri-chloride compared to method1. nitrogen tri-chloride is an explosive byproduct. More number of processing steps are there in method 1 which requires more processing equipments. These are the main reason for choosing method 2 instead of method 1.

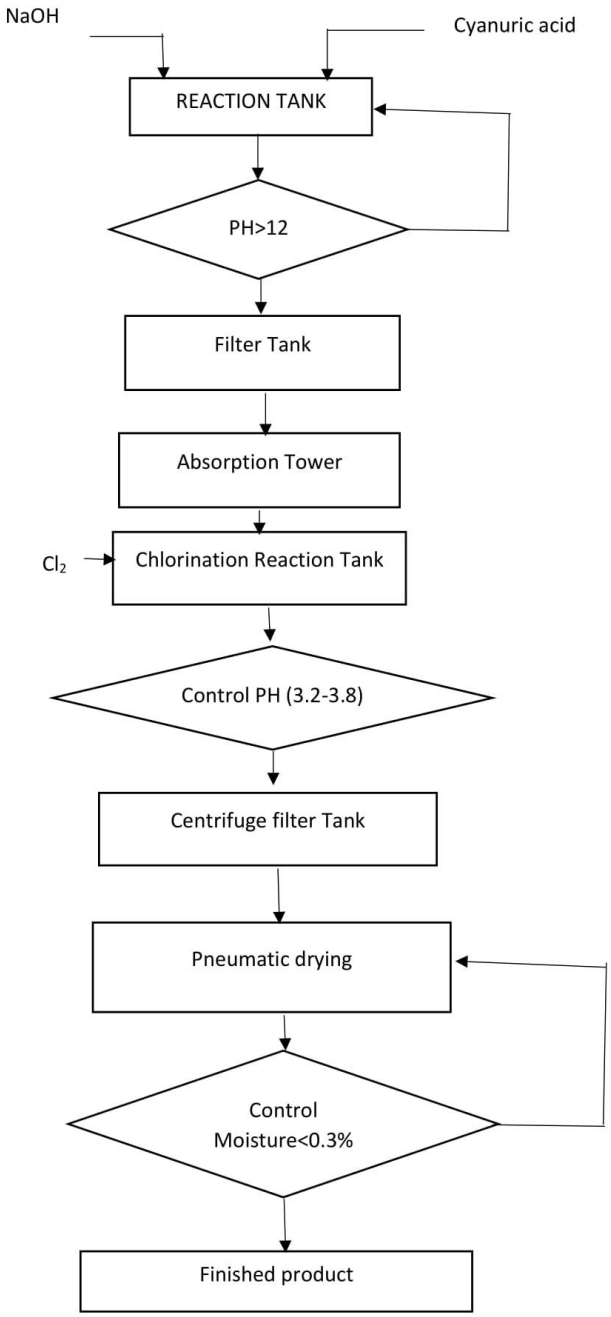


Fig 3.1 : Flow chart for the production of Trichloroisocyanuric acid

PROCESS FLOW DIAGRAM FOR THE PRODUCTION OF TRICHLOROISOCYANURATES

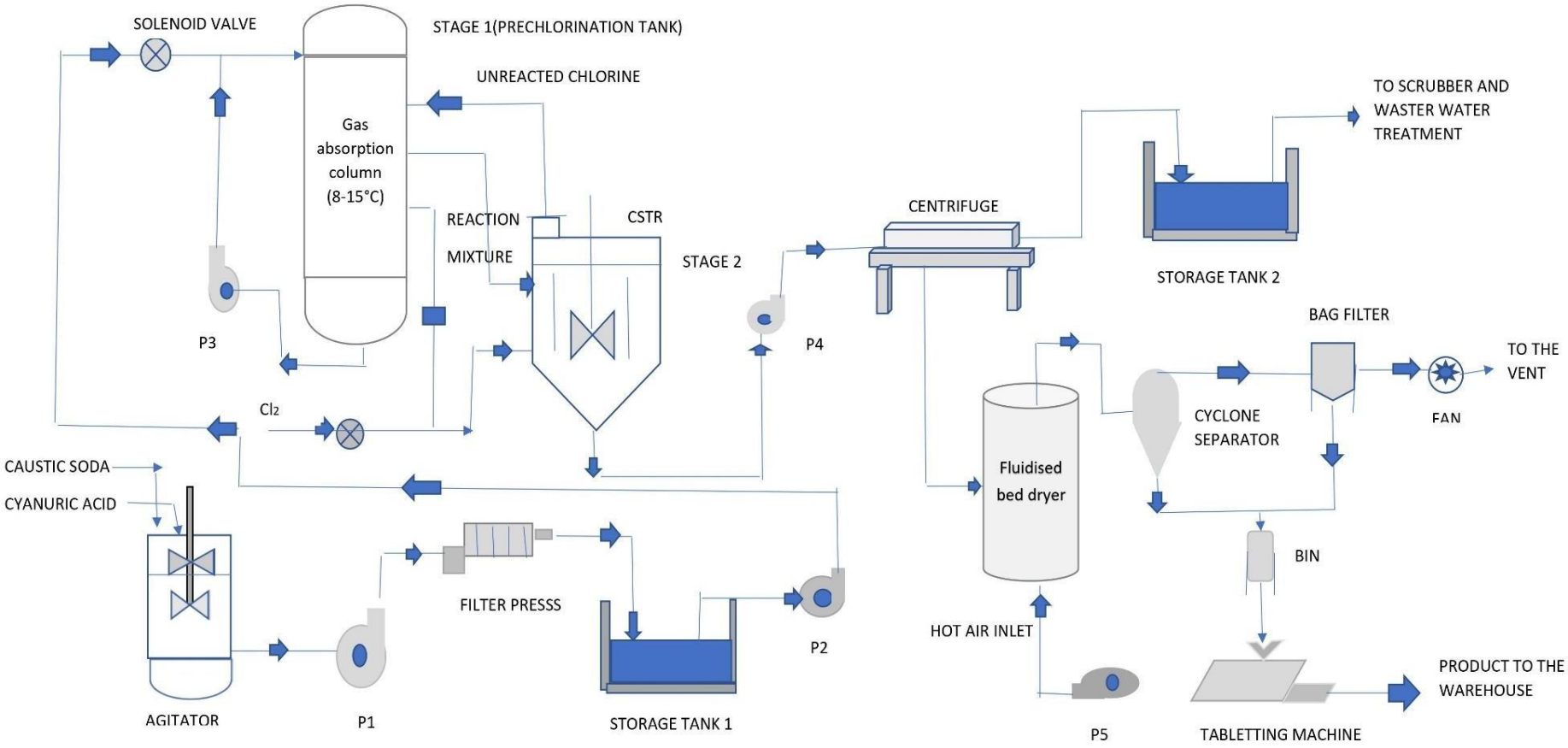


FIG 3.2: Process Flow Diagram for the production of Tricholroisocyanuric acid

CHAPTER 4

MATERIAL BALANCE

4.1 REACTOR 1

$C_3H_3N_3O_3$ + 3NaOH → $C_3N_3O_3Na_3$ + $3H_2O$

cyanuric acid + Caustic soda → trisodium salt of cyanuric acid + water

Table 4.1 : Component Molecular weight

COMPONENT	MOLECULAR WEIGHT (g/mol)
$C_3H_3N_3O_3$ cyanuric acid (CA)	129
NaOH	40
$C_3N_3O_3Na_3$ (trisodium salts of CA) (TSS)	195
H2O	18

BASIS:100 kg/hr

ASSUMPTION:

THE CONVERSION RATE = 96%

Then for 100% conversion

100 kg/hr OF TSS-→ 96% OF TSS

X kg/hr of TSS →100% of TSS

X=104.16 kg/hr of TSS

Reactants required:

195 g/mol of TSS → 129 g/mol of CA

104.15 kg/hr of TSS→ X kg/hr

X=(104.16x129)/195

X=68.905 kg/hr

The conversion efficiency of agitator =89.9%

68.905 kg/hr → 89.9%

X kg/hr →100%

X=76.44 kg/hr

Total amount of reactant required

129 g/mol of CA → 249 g/mol input to reactor

76.64 kg/h → X kg/hr

X=147.93 kg/hr

Amount of NaOH required = 147.93-76.64

= 71.28 kg/hr

Table 4.2: Reactant balance For Reactor 1

Components	Mass flow rate(kg/hr)	Molecular weight(g/mol)
NaOH	71.29	120
CA	76.64	129
	147.93	249

Total amount of product formed

Amount of TSS formed

249 g/mol of TSS → 195 g/mol of TCCA is formed

147.93 kg/hr of TSS → X kg/hr

x→115.89 kg/hr

Amount of water formed

249 g/mol → 54 g/mol of water is formed

147.93 kg/hr → 32.081 kg/hr

Table 4.3: Product Balance for Reactor 1

Compound	Mass flow rate(kg/hr)	Molecular weight(g/mol)
TSS	115.84	195
H20	32.081	54
	147.92	249

4.2 REACTOR -2 (two stage conversion)

$C_3N_3O_3Na_3$ + $3Cl_3$ → $C_3N_3O_3Cl_3$ + 3 NaCl

trisodium salt of cyanuric acid + chlorine → Trichloroisocyanuric acid + sodium chloride

Basis:115.84 kg/hr

Assumption

Conversion rate=99.3%

Trichloroisocyanuric acid =TCCA

Reactants required:

115.84 kg/hr of TSS→ 99.3% of TCCA

X kg/hr of TSS →100% of TCCA

X=116.256 kg/hr of TSS is required

195 g/mol of TSS → 408 g/mol of total reactant

116.656 kg/hr → X kg/hr

x= 244.080 kg/hr

Amount of cl2 = 244.08-116.656

=127.42 kg/hr of chlorine is required

Total amount of product formed

408 g/mol of reactants produced → 232.5 g/mol of product

244.080 kg/hr → X kg/hr

X=139.089 kg/hr of TCCA is produced

408 g/mol of reactants produced → 175.5 g/mol of products

244.080 kg/hr → X kg/hr

X= 104.990 kg/hr of Nacl is produced

Table 4.4 Reactant balance for Reactor 2

Components	Mass flow rate(kg/hr)	Molecular weight(g/mol)
TSS	116.656	195
Cl_2	127.42	213
	244.076	408

Table 4.5 Product balance for Reactor 2

Components	Mass flow rate(kg/hr)	Molecular weight(g/mol)
TCCA	139.089	232.5
NaCl	104.99	175.5
	244.07	408

4.3 MATERIAL BALANCE FOR CENTRIFUGE:

Feed for centrifuge = 244.079 kg/hr

Our final product moisture content should be 30% = 139.089*0.3

= 41.72 kg/hr

Total weight of product is = (solid +moisture)

= 139.089 + 41.72

= 180.815 kg/hr

waste removed = 244.079 – 180.815

= 63.26 kg/hr

4.4 MATERIAL BALANCE FOR DRYER

Feed for dryer =180.815 kg/hr

The moisture content should be removed from 0.3% to 0.01%

So, the final product moisture content will be = (0.01* 139.089)

=1.39 kg/hr

Weight of product is = 139.089+1.39

= 140.47 kg/hr

Waste water dried = 180.815- 140.47

= 40.347 kg/hr

4.5 MATERIAL BALANCE FOR FILTER PRESS

Feed for filter press=147.92kg/hr

The moisture content in the final product should be 1%

So, the final product moisture content will be= 0.01*115.84 = 1.158 kg/hr

Weight of product = 115.8 + 1.158 = 116.89 kg/hr

CHAPTER 5

ENERGY BALANCE

5.1 REACTOR 1:

$C_3H_3N_3O_3$ + 3NaOH → $C_3N_3O_3Na_3$ + $3H_2O$

cyanuric acid + Caustic soda → trisodium salt of cyanuric acid + water

Reaction occurs in the temperature of 30 ºC
Rate of flow of mass for CA = 76.64 kg/hr
Rate of flow of mass for NaOH = 71.29 kg/hr
Rate of flow of mass for TSS = 115.84 kg/hr
Rate of flow of mass for water = 32.081 kg/hr

Specific heat capacity
Thermal capacity of CA =1.007 kJ/kg K
Thermal capacity of NaOH = 2.152 kJ/kg K
Thermal capacity of TSS = 1.676 kJ/kg K
Thermal capacity of water = 4.2 kJ/kg K
Thermal capacity of Chlorine = 0.48 kJ/kg K
Thermal capacity of NaOH = 0.88 kJ/kg K

Enthalpy of reactants

For $C_3H_3N_3O_3$

$Q = m*C_P* dt$= 76.64 kg/hr *1.007kJ/kg K * (303-273) K

= 2315 kJ/hr

For NaOH

$Q = m*C_P * dt$ =71.29*2.152*30=4602.48 kJ/hr

Enthalpy of products

For $C_3N_3O_3Na_3$

$Q = m*C_P * dt$

=115.84*1.676*30

=5824.4 kJ/hr

For water

$Q = m*C_P * dt$

=32.082*4.2*30

=4042.33 kJ/hr

Heat used for reaction= Enthalpy of products – Enthalpy of reactants=9866.73-6917.48

=2949.25 kJ/hr

5.2 REACTOR 2:

$C_3N_3O_3Na_3$	+	$3Cl_3$	→ $C_3N_3O_3Cl_3$	+	3 NaCl
trisodium salt of cyanuric acid	+	chlorine	→ Trichloroisocyanuric acid		sodium chloride

(reaction temperature=52℃)

Rate of flow of mass for Trisodiumisocyanuric acid = 116.656 kg/hr

Rate of flow of mass for Chlorine = 127.42 kg/hr

Rate of flow of mass for trichloroisocyanuric acid = 139.089 kg/hr

Rate of flow of mass for NaCl = 104.99 kg/hr

Enthalpy of Reactants

For $C_3N_3O_3Na_3$

$Q = m*C_P * dt$

=116.656*1.676*285

=55721 kJ/hr

For Chlorine

$Q = m*C_P * dt$

=127.42*0.48*285

=17431 kJ/hr

Enthalpy of products

For $C_3N_3O_3Cl_3$

$Q = m*C_P * dt$

=139.089*1.458*285

=57795.65 kJ/hr

For NaCl

$Q = m*C_P * dt$

=104.99*0.88*285

=26331.49kJ/hr

Heat used for reaction = Enthalpy of products – Enthalpy of reactants

=84126.6-73152

=10974.65kJ/hr

5.3 ENERGY BALANCE FOR DRYER

Enthalpy of inlet stream

Rate of flow of mass for water = 41.71 kg/hr

Specific heat of water = 2.137 kJ/kg K

Enthalpy of water in = 41.71*2.137*128

= 11409.18 kJ/hr

Enthalpy of TCCA = 57795.65 kJ/hr

Total enthalpy of inlet stream= 69204.8 kJ/hr

Enthalpy of outlet stream

Enthalpy of water out = 1.8*2.137*128

= 492.36 kJ/hr

Enthalpy of TCCA = 57795.65 kJ/hr

Total Enthalpy of outlet stream = 58288.01 kJ/hr

Enthalpy of water removed = 69204.8 – 58288.01

=10916.79 kJ/hr

CHAPTER 6

PROCESS EQUIPMENT DESIGN

6.1 DESIGN OF FLUIDISED BED DRYER

Data:

Wet solid from centrifuge (S) = 110 lb/hr

Water content in the solid w_o = 0.3lb H_2O/ lb dry solid

liquid content in the solid outlet (w) = 0.01lb H_2O/lb dry solid

Temperature of sold inlet (T_{si}) = 68°F

Temperature of solid outlet (T_{so}) = ?

Temperature of air inlet(T_{ai}) = 122°F

Temperature of air outlet(T_{ao}) = ?

Diameter of particle (D_p) =0.3 micrometre = 0.0118 inches

Viscosity of the particle(μ) =0.01825 Cp

Density of air (ρ_f) =0.048 lb/ft^3

Density of solid(ρ_s) =150 lb/ft^3

Humidity of air going inside(H_{ai}) = 0.015 lb water/lb dry

Humidity of air coming outside(H_{ao}) = ?

Humidity of solid coming out(H_{so}) = ?

flow rate of air (A) = ?

heat capacity of solid C_s = 0.45 btu/(lb)(°F)

Minimum fluidization rate according to leva's formula $(G_{mf}) = \frac{6.88(D_p)^{1.83}(\rho_f(\rho_s - \rho_f))^{0.94}}{(\mu)^{0.88}}$

$$= \frac{688*(0.0118)^{1.83}(6.393)}{(0.01825)^{0.88}}$$

$$= \frac{1.3019}{0.0295}$$

$$= 44.132 \text{ lb/hr ft}^2$$

Let fluidization rate $G_f = 2G_{mf} = 2*44.132 = 88.264$ lb/hr ft^2

Expanded bed ratio= average height of fluidized bed/static bed height(L/L_O)

$$\Rightarrow (G_f / G_{mf})^{0.22} = 2^{0.22} = 1.16$$

Mc.cabe et al suggested that void range at minimum fluidization is (0.4 to 0.45) for spherical granular particles

We assume void range at minimum fluidization $(\varepsilon_{mf}) = 0.40$

and $(\varepsilon_f) = 0.464$

The drying rate is represented by the equation:

$$-dW / d\theta = 60(H_{so} - H_{ao})$$

Drying time $\theta = w_o - w / 60(H_{so} - H_{ao}) = (0.3-0.01)/60(H_{so} - H_{ao})$ (1)

humidity balance:

$$A(H_{ao} - H_{ai}) = S(w_o - w)$$

$$H_{ao} = 0.015+0.29(S/A) \quad (2)$$

Average capacity of heat:

$$C_{ao} = 1/2 (C_{ai} + C_{ao}) = 0.24 + 0.45[(0.015 + H_{ao})/2]$$

$$= 0.2434 + 0.225H_{ao}. \quad (3)$$

Heat balance:

$$A\ C_{ao}\ (T_{ai} - T_{ao}) = S\ [(\ C_s + w)(T_{so} - T_{si}) + \lambda(w_o - w)]$$

where λ= latent heat of vapourization of water = 900 calories / gram

$$(A/S)\ C_{ao}\ (122 - T_{ao}) = 0.46(T_{so} - 68) + 900*(0.29) \qquad [4]$$

adiabatic saturation line:

$$T_{ao} - T_{so} = \lambda / C_{ao}(H_{so} - H_{ao}) \qquad (5)$$

Vapour pressure:

$$P_s = \exp\ (11.917 - 7174\ /\ (T_{so} + 390) \qquad (6)$$

salturation humidity:

$$H_{so} = 18/29(P_s/(1-P_s)) \qquad (7)$$

Eliminate Tao between equation 4 and 5

$T_{ao} = 122 - [(0.46(T_{so} - 68)+261)/RC_{ao}]$

$T_{ao} = T_{so} + (900(H_{so} - H_{ao})/C_{ao})$ For specified values of R = (A/S) solving the above equations we get

Table 6.1: Calculations of Fluidized bed dryer

R	T_{ao}(º F)	T_{so} (º F)	H_{ao}	H_{so}	(min)θ
5	144.16	120.64	0.073	0.0803	0.662
6	177.12	120.52	0.063	0.0800	0.289
8	220.09	120.46	0.051	0.0797	0.170
10	245.72	120.33	0.044	0.0795	0.136
12	262.98	120.23	0.039	0.0794	0.120

Taking R=12 lb air/ lb solid

A= 12*S = 12*110 = 1320 lb /hr

θ = 0.120 min

cross sectional area of bed = A/G_f = 1320/88.264 =14.95 ft diameter

linear velocity of particles u = $G_f /\rho * \varepsilon_f * 60$

= 88.264/ (0.048) *(0.464) *(60)

= 66 fpm

Bed depth L = u θ = 66*0.120 =7.926 ft

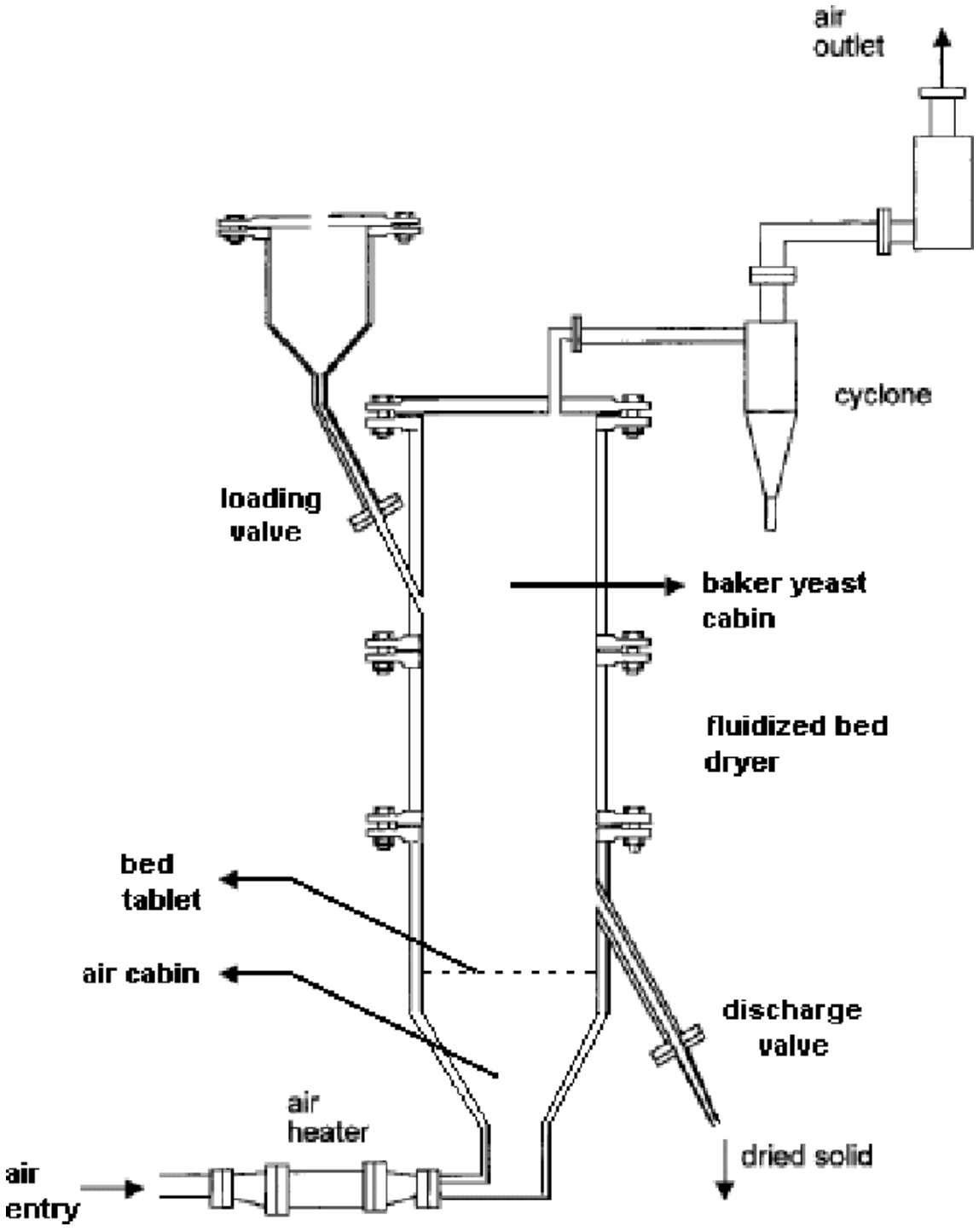


FIG 6.1: Fluidized bed dryer

6.2 DESIGN OF AGITATOR

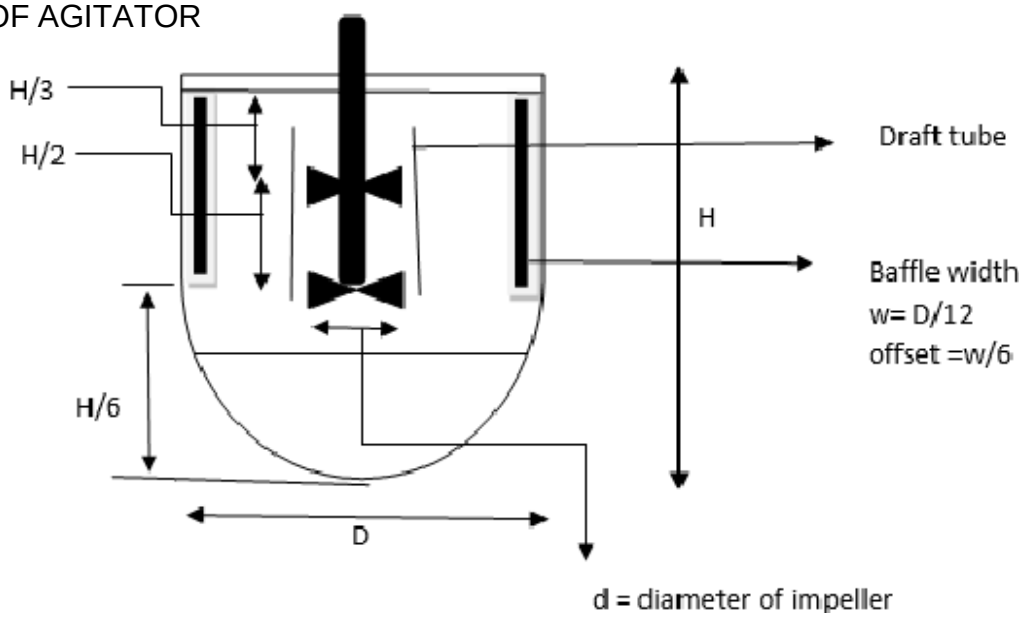


FIG 6.2: Diagram for Stirred Tank Reactor

Basis : 200 L

Volume=0.2m^3 (200 L)

Volume of cylinder= $\pi r^2 H = \pi D^2 H/4$

Hemisphere Volume= $2\backslash 3*\pi*r^3 = 2\backslash 3*\pi*D^3\backslash 8$

$=2\ \pi D^3/24$

ASSUMPTION

H/D=1.5 (HEIGHT TO DIAMETER RATIO=1.5)

H=1.5*D

Total volume = $\pi D^2 H/4 + 2\pi D^3/24$

$0.2= \pi D^2(1.5D)/4 + 2\ \pi D^3/24$

$0.2=4.71D^3/4 + 6.283D^3/24$

$0.2=(28.267D^3/24 + 6.283D^3/24)$

$0.2=D^3/24(28.26+6.283) \rightarrow 34.543D^3/24$

$4.8/34.54=D^3$

$\sqrt{0.1389} = D$

D=0.5719m➔517.9mm

H=1.5x0.5179

=0.7769m➔776.9mm

BAFFLES:

They are expected to forestall the vortex and pivot of fluid mass overall

Baffle diameter = D/12 D=> diameter of tank

= 517.9/12

= 43.15mm

Baffle offset = w / 6 = 7.19 mm

IMPELLER:

Impeller diameter ➔ diameter of impeller(d) / diameter of tank (Dt)=0.5

d=0.5 x 517.9

=258.95mm

We are considering two impellers so,

The distance between the surface of liquid level and first impeller

Should be = H / 3

= 776.9/3

= 258.96 mm

Distance between two impellers = H/2

=388.45 mm

Height of impeller = d/8

= 258.95/8

= 32.36 mm

Distance between second impeller and bottom surface = H/6

= 129.4 mm

Power required for impeller

Assumption;

N(speed) = 68 rpm

Power no =4.2

` density of liquid = 2130 kg/m^3

Viscosity of liquid = 0.023 centipoise

Power required for impeller = N^3 * power no * density * d^5

= $(68/60)^3$ * 4.2 * 0.258^5 *2130

= 14.88 HP

Froude no = 7.454*(10^{-4})*N^2*d

= 0.000247

(This number is pertinent when gravitational effects are significant)

Reynolds no = d^2*N*ρ/μ

= 0.258^2 * (68/60) * 2130 / (0.023)

= 6986.3 (dimensionless)

CHAPTER-7

COST ESTIMATION

7.1 DETAILED VS APPROXIMATE

Detailed cost estimates are quite accurate and are usually carried out by specialists in a cost estimating department in the preparation of a final tender. Such estimates are based on the detailed plant design in which all the equipment is sized, the pipe-work layouts have been prepared and the instruments are completely specified.

A rapid estimation of cost is vital in the initial stages of any outlining. Approximate cost estimates are often adequate for process evaluation and optimization procedures. It is possible, from a knowledge of the proposed plant location, a sketch of the process flow-diagram, the size of the equipment pieces and the service requirements, to estimate capital and operating costs with reasonable accuracy (say about ±15 to 20%).

Before a process plant can be built, a huge amount of money must be accessible to:

- Land purchase
- Purchase and installing the necessary apparatus and equipment
- Build utility
- Construct and erect plant
- Pay all expenses for plant operation before sales revenue is available

7.2 CAPITAL INVESTMENT:

Classification Fixed capital investment (FCI): The capital expected to supply the necessary assembling and plant offices. This represents the complete expense of planning, developing, and introducing a plant and the related alterations expected to set up the plant site. It is a once-just expense that isn't recuperated toward the finish of the task life, other than the junk value

Working Capital (WC): The money required for maintaining the plant.

Total capital Investment (TCI): FCI + WC

The Fixed Capital is classified into:

- Manufacturing fixed capital investment also known as direct cost
- Nonmanufacturing Fixed Capital Investment also known as indirect cost

7.2.1 Manufacturing fixed-capital investment

Direct cost represents the money required for the process equipment installation that is required for completing process operation. Examples:

- Process equipment installation
- Preparation of site
- Foundations
- Utilities

7.2.2 Nonmanufacturing Fixed Capital Investment

Indirect cost represents the money needed for

1. All plant segments that are not straightforwardly identified with the process operations
    - Land, main Processing blocks, Administrative and different workplaces
    - Warehouses, Laboratories
    - Transportation, dispatching and loading facilities
    - Auxiliary and effluent disposal facilities,
2. Construction overhead
    - Supervision costs, Miscellaneous construction costs and field office cost
    - Contractors' fees and contingencies

    Working Capital The working capital maintains the operation of the plant and represents the total amount of money invested in:
    - Start-up operation
    - inventories for maintaining input, outputs and spare parts
    - Receivable accounts
    - Payable accounts

Table 7.1: Process equipment cost

S.NO	EQUIPMENTS	NO OF EQUIPMENTS NEEDED	COST PER EQUIPMENT (in Lakhs)	TOTAL (in Lakhs)
1	GAS ABSORPTION COLUMN	1	2.4	2.4
2	TANK TYPE REACTOR	2	0.5	1
3	CENTRIFUGE	1	3	3
4	FLUIDISED BED DRYER	1	2.5	2.5
5	STORAGE TANK	2	0.528	1.056
6	CYCLONE SEPARATOR	1	0.9	0.9
7	BAG FILTER	1	0.8	0.8
8	TABLETTING MACHINE	1	3.5	3.5
9	STORAGE BIN	1	0.3	0.3
10	FILTER PRESS	1	0.8	0.8
				16.256

Table 7.2: Accessories Cost

S.NO	EQUIPMENTS	NO. OF EQUIPMENTS NEEDED	COST PER EQUIPMENT (in lakhs)	TOTAL (in lakhs)
1	PUMPS	6	0.1265	7.59
2	SOLENOID VALVE	2	0.055	0.11
3	FLOW CONTROL VALVE	1	0.045	0.045
4	PIPES	-----	------	30
5	FAN	1	0.04	0.04
6	INSTRUMENTATION	-----	------	15
7	ELECTRICAL DEVICES	------	------	12
8	SERVICES	------	-----	8
9	CONTINGENCIES	------	------	20
			TOTAL	92.785

Table 7.3: Project Cost

S.NO	TYPE	COST (in lakhs)
1	LAND	950
2	DRAWINGS	1
3	CONSULTANCY	3.5
4	CONSTRUCTION	85
5	START UP EXPENSES	50
		1089.5

Table 7.4: Man Power Expenses

S.NO	POSITION	NUMBER OF PERSON	SALARY (PER MONTH) (in lakhs)	TOTAL (in lakhs)
1	MANAGING DIRECTOR	1	1.5	1.5
2	GENERAL MANAGER (HR)	1	0.9	0.9
3	GENERAL MANAGER (PROCESS)	1	0.9	0.9
4	ASSISTANT MANAGER	1	0.7	0.7
5	SENIOR ENGINEER	3	0.45	1.35
6	JUNIOR ENGINEER	4	0.32	1.28
7	PLANT OPERATORS	8	0.22	1.76
8	LABORATORY CHEMISTS	3	0.29	0.87
9	ADMINISTRATIVE PERSONNEL	20	0.20	4
10	MEDICAL STAFFS	3	0.35	1.05
11	SECURITIES	5	0.15	0.75
12	SAFETY PERSONS	2	0.25	0.5
13	CLERICAL AND OFFICE STAFFS	10	0.12	1.2
			TOTAL	16.76

Table 7.5: Raw Material Costs

S.NO	RAW MATERIALS	QUANTITY (kg/day)	COST (per kg)	TOTAL COST (in lakhs) (per year)
1	CYANURIC ACID	1840	110	667.92
2	CAUSTIC SODA	1711	45	254.08
3	CHLORINE GAS	100	1150	379.5
			TOTAL	1301.5

Table 7.6: Running Cost

S.NO	TYPE	TOTAL COST (in lakhs)
1	ELECTRICITY	10
2	WATER CHARGES	1
3	TRANSPORTATION	3
4	MISCELLANEOUS	4
	TOTAL	18

7.3 CALCULATIONS:

AMOUNT OF TRICHLOROISOCYANURIC ACID PRODUCED

PER YEAR = 1101584 kg/year

AVERAGE PRICE PER KG = 190 Rs/kg

GROSS ANNUAL SALES =209300960 Rs/year

=20.93 Cr/year

MAN POWER EXPENSES = 16.76 lakhs/month = 2.0112 Cr/year

RAW MATERIAL COST = 1301.5 lakhs/year = 13.01Cr/year

RUNNING COST = 18 lakhs/month = 2.16 Cr/year

TOTAL PRODUCTION COST= MAN POWER EXPENSES+RAW MATERIAL COST+

RUNNING COST+EXTRA STORAGE

=2.0112+13.015+2.16+2

=19.1862 Cr/year

PROFIT BEFORE TAX = 20.93-19.1862=1.74Cr/year

INCOME TAX =15%=0.15*1.74=26.15 Lakhs/year

NET PROFIT =1.482 Cr/year

CEO SALARY =2% OF NET PROFIT= 0.02*1.482 = 2.9 Lakhs/month

FIXED CAPITAL

INVESTMENT=EQUIPMENTCOST+ACCESSORIESCOST+PROJECT COST

=0.16256 + 0.92785 +10.89

=11.98 Cr

TURN OVER RATIO = GROSS ANNUAL SALES/FIXED CAPITAL INVESTMENT

=20.93/11.98

=1.747(SUITABLE FOR CHEMICAL INDUSTRIES AS PER LITERATURES)

RETURN ON INVESTMENT = ANNUAL NET PROFIT/ TOTAL CAPITALINVESTMENT

=1.45/19.1

=0.075 = 7.5% (WITHOUT LAND VALUE)

PAY BACK PERIOD = FIXED CAPITAL INVESTMENT/ NET PROFIT

= 11.48 / 1.45

= 7.9 YEARS (WITHOUT ADDING DEPRECIATION)

CHAPTER 8

PLANT LAYOUT

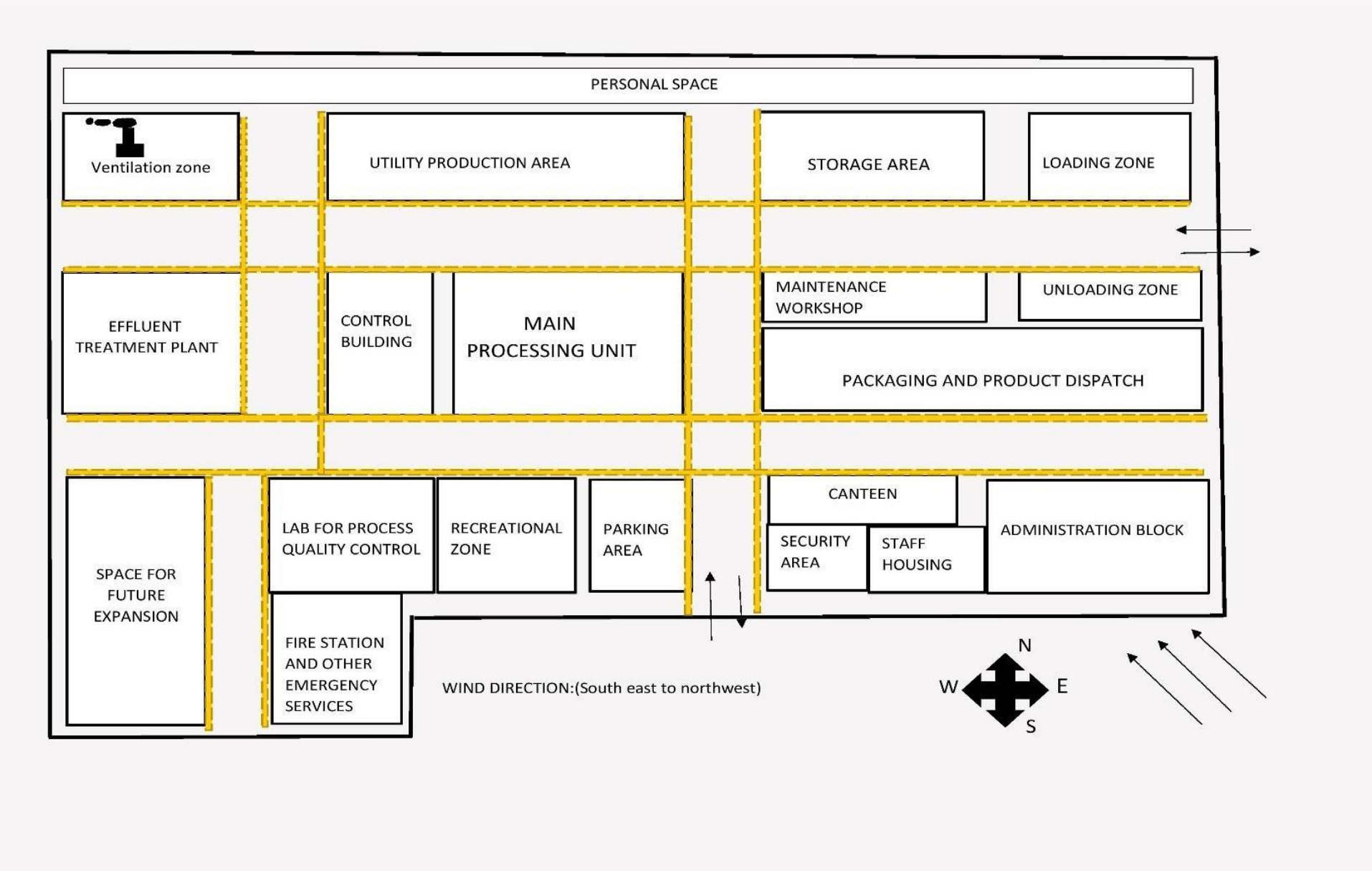


FIG 8.1 : PLANT LAYOUT

8.1 SITE LAYOUT CRITERIA's

- No two plant destinations are by and large something similar. There is no single ideal plant format. Nonetheless, legitimate design for each situation will incorporate plan of preparing zones, stockpiling regions, and taking care of territories for proficient coordination underway and the executives.
- First decide the course of the predominant breeze. All hardware that may spill combustible materials ought to be found with the end goal that if a spill happens the common breezes can't convey any fumes over the plant, where they could be lighted by an open fire or a hot surface.
- Consider every single adjoining office. There are accounted for situations when one plant has been gravely harmed in view of spills at another adjoining organization.
- The measure units and subordinate structures ought to be spread out to give the most conservative progression of materials and faculty around the site.
- The distance between involved structures and plant structures will be administered by the need to lessen the perils of blast, fire and poisonousness. Involved structures ought not be sited downwind of unsafe plant regions
- The units for processing are regularly sited first and masterminded to give a smooth progression of materials through the different preparing ventures, from crude material to eventual outcome stockpiling.
- Process units are ordinarily divided at any rate 30 m separated from different structures - more noteworthy dispersing might be required for risky cycles.
- Next, choose the area and arrangement of the essential utility structures in order to limit the time spent by faculty in going between structures.
- Many individuals will work at Administration Offices and Laboratories. They ought to be found well away from possibly unsafe cycles.
- Main Control rooms are ordinarily situated close to the handling units, however those with possibly risky cycles may must be sited at a more secure distance.
- The area of the fundamental cycle units decides the design of the plant, streets, pipe rear entryways, and channels.

- Good access streets to each building are required for development, activity and upkeep.

8.2.1 Plant Layout :considerable factors

I. Consideration of Economics:
II. Process requirements
III. Operation convenience
IV. Maintenance convenience
V. Safety considerations
VI. Considerations for Future Expansion
VII. Flexible/integrated Construction

8.2.2 Plant Location: Factors to be considered

I. Raw materials availability
II. Labour supply
III. Prospective Markets for products
IV. Energy Availability: Power and Fuel
V. Transportation Facilities
VI. Climatic conditions
VII. Water supply
VIII. Environmental impact and Effluent disposal
IX. Taxation, Legal restrictions and Strategic issues
X. Local Community considerations
XI. Land Characteristics
XII. Flood and Fire protection

CHAPTER 9

SAFETY ASPECTS

There are large variety of hazards in a Process plant. It includes mechanical hazards which causes abrasions from falling and during transportation of equipment's and so on. Second, there are hazards caused by chemicals. These incorporate fire and blast risks, reactivity perils, and harmful dangers. Hazard is a situation which is having high potential for human injury, property damage, damage to environment or a combination of all of these.

9.1 HAZARDS

Various Hazards posed by TCCA

- It May escalate fire; oxidizer
- Harmful whenever gulped
- Causes eye disturbance
- Cause respiratory disturbance
- Very poisonous to aquatic organisms with durable impacts

9.1.1 HEALTH HAZARDS

Inhalation of TCCA causes sniffling and hacking. Residue contact makes moderate disturbance the eye and tingling issues and furthermore redness of skin. swallowing causes mouth burn and stomach burn Not burnable but rather improves ignition of different substances. Produce disturbing and poisonous exhaust (or gases) in a fire. Danger of blast on warming. There is a huge explosion risk when in contact with combustible substances or substances with incompatibility.

9.1.2 Fire Hazard

Special Hazards: Formation of poisonous chlorine or nitrogen trichloride in contact with fire

Behavior when in contact with fire: heating causes explosion of containers

9.1.3 First Aid Measures

Toxic Exposure First Aid measures:

- Inhalation First Aid:

(Natural air, rest. Half-upstanding position. Counterfeit breath might be required. Allude for clinical consideration.)

- First Aid for skin

(flushing with a lot of water for the minimum of 15 minutes, evacuation of sullied garments and again wash with water).

- Eye First Aid

(Flush with a lot of water for a few minutes . Allude quickly for clinical consideration..)

- swallow First Aid

(Flush mouth. Give a couple of glasses of water to drink. Try not to actuate regurgitating. Allude for clinical consideration).

9.2 FIRE FIGHTING

Fire Extinguishing Agent: H_2O in vast amounts

If there is a fire or explosion: keeping drums nearby and cooling by spraying with water will reduce fire. No direct contact with water.

9.2.1 Fire Fighting Procedures

Approach fire from upward wind direction in order to maintain a strategic distance from unsafe fumes and items from harmful decay. Battle fire from ensured area or most extreme conceivable distance. Use flooding amounts of water ablaze included compartments. In the event that essential use water shower to keep fire-uncovered compartments cool. Keep away from utilization of water on non-included material at every possible opportunity.

In the event that material associated with fire: Cool all influenced compartments with large amounts of water. Use water in large amounts as mist. Apply water from as far a distance as could really be expected. Fire can be stifled utilizing appropriate specialist for encompassing fire type.

9.2.2 Accidental Release Measures

Isolation and Evacuation

As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids.

LARGE SPILL: Consider initial evacuation for a minimum of 100 meters in downwind direction.

FIRE: If rail car or tank truck is involved in fire, ISOLATE for at least half a mile in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

9.3 DISPOSAL

9.3.1 Spillage Disposal

Personal protection: wear particulates channel respirator adjusted to the airborne convergence of the substance. Try not to allow those synthetic to enter the general climate. Clear spilled substance into covered dry, sealable holders. Cautiously gather remaining portion. At that point store and discard as indicated by nearby guidelines.

9.3.1.1 Cleanup Methods

Wastewater from toxin concealment zone, defensive dress/hardware cleaned water, or defiled locales should be contained first and assessed for subject substance or deteriorated items concentration level. Concentration should be lower than the relevant natural release or removal measures. Then again, pretreatment as well as release to an allowed wastewater treatment office is worthy just when overseeing authority evaluated everything and confirmation ought to be given that "go through" infringement won't happen later on. Due contemplations additionally ought to be given to remediation specialist openness (inward breath, dermal and ingestion) to the defiled site just as destiny during moving, treatment and removal. In the event that it isn't practicable to deal with the compound in this style, it should be assessed explicitly to decide the appropriate neighborhood, state and government needs for removal.

keep water far from discharge. Approach discharge from upwind side. Disconnect holders which are spilling, if this should be possible without the danger of unjustifiable. Brief cleanup and evacuation is vital. Digging tool into appropriate dry compartment. control spillover and confine released material for legitimate disposal.

9.3.2 Disposal Methods

Land treatment or internment removal standards' practices are dependent upon critical amendment. Prior to beginning area removal of waste buildups, meeting with natural administrative offices for direction on adequate removal rehearses is obligatory.

Add substance into weaken arrangement of NaOH with blending step by step and killing that arrangement with the assistance of decreasing specialists, for example, sodium sulfite and sodium thiosulfate.

pH ought to be changed with sulfuric corrosive liqud or hydrogen chloride to make nonpartisan arrangement and removal.

9.3.3 Preventive Measures

defensive garments which are polluted ought to be isolated in a way in which there ought not be any immediate individual contact by an individual who handle it, arrange it, or who clean the garments. Quality confirmation strategies to affirm the adequacy of cleaning methodology should be carried out before disinfected defensive dress being returned by the specialists for reuse. Defiled apparel (counting shoes/socks) ought not be conveyed to home toward the finish of move, yet ought to stay at laborers place for cleaning.

Table 9.1: General Clearances and Permissions

S.NO	CLEARANCES/PERMISSIONS
1	Factory License
2	The Factories Act,1948
3	The water (prevention and control of pollution) Act, 1974 and Rules, 1975, as amended to date
4	The water (prevention and control of pollution) Cess Act, 1977 and Rules, 1978, as amended to date
5	The Air (prevention and control of pollution) Act, 1981 and Rules, 1982, as amended to date
6	The Manufacture, storage and import of hazardous chemical rule,1989, as amended to date
7	The Hazardous waste (Management, handling and Trans boundary movement) Rules, 2008, as amended to date
8	The Environment(protection) Act,1986 and Rules, as amended to date
9	Chemical accidents (Emergency Planning, preparedness and response) Rules, 1996
10	The motor vehicles Act,1988 & The central motor vehicle rules, 1989
12	The Biomedical waste (Management and handling) Rules,1998 as amended to date
13	The Batteries (Management and Handling) Rules, 2001, as amended to date
14	The Noise Pollution (Regulation and Control) Rules, 2001, as amended to date
15	E-waste (Management and handling) Rules,2011 as amended to date
16	Electricity Rule, 2005
17	Consents From GPCB
18	Environmental Impact Assessment Notification, 2006 as amended to date
19	The Bureau of Indian Standard Acts
20	Public Liability Insurance Act, 1991 and Rules, 1991 as amended to date
21	The Custom Act, 1962
22	The petroleum Act, 1934 & Rules, 2002.
23	The Explosive Act, 1884 and rules,1983 as amended to date
24	The Gas cylinders Rules, 2004

CHAPTER 10

PROCESS CONTROL AND INSTRUMENTATION

Instrumentation are given to discover primary interaction factors while the process plant is running. Instruments that screen basic cycle factors will be furnished with instinctual cautions to alarm administrators at basic and hazardous circumstances.. The main activity of the designer are while indicating instrumentation and control conspire are:

Safe Plant Operation:

- To keep measure factors inside known safe working cutoff points.
- To distinguish risky circumstances as they create and to give alerts and
- Automatic closure frameworks.
- To give interlocks and cautions to deter risky working systems.

Rate of production and Quality:

- To accomplish the planned item yield..
- To keep up the item creation inside the predetermined quality norms.

cost

- To work at the least creation cost and to repay with different targets. Process devices are the nerves of the processing plant.

The gadgets can be pneumatic, pressure driven or electric The new pattern is to go to electronic gadgets, yet airborne gadgets are as yet being used. The instruments are utilized to quantify temperature, pressure, stream rate, level, and actual properties like thickness, pH, moistness, substance piece, and so forth

10.1 MEASUREMENTS:

Estimation. Assessment is a fundamental basic to deal with control. Either the control can be affected therefore, semi-normally or genuinely. The nature of control conceivable furthermore bears a relationship to the precision, re-producibility and reliability of the assessment procedures, which are used. Hence, decision of the best strategies for assessments is a huge beginning stage in the arrangement and specifying of any cyclic control system.

10.1.1 Temperature Measurement and Control

Estimation of temperatures is used to control the outlet temperature and bay streams in heat exchangers, tank type reactors, and so on Most temperature assessments are made by strategies for thermo-couples to urge conveying the assessments to fused zone. For close by assessments at the stuff bi-metallic or filled structure thermometers are used to a lesser extent. Normally, for high assessment accuracy, check thermometers are used. All of these meters are presented with thermo-wells when used locally. This gives protection against environment and other real parts. Various contraptions are used to check the temperature assortments in the plant process like mercury in glass thermometer, opposition thermocouples, pressure spring thermometer are used.

10.1.2 Pressure Measurement and Control

Like temperature pressure is a significant indication of material state and blend. In reality, these two assessments considered together are the fundamental surveying devices of current materials. Siphons, blower and other cycle gear related with pressure changes in the process material are furnished with pressure assessing contraptions. Distinctive pressing factor assessing contraptions are

- U – Tube Manometer
- Differential Manometer
- Inclined Manometer

Hence pressure estimation turns into a sign of energy increment or decline. Most pressing factor estimation in industry are flexible component gadgets, either straightforwardly associated for nearby use or transmission type to brought together area. Most broadly utilized mechanical pressing factor component is the Bourderi Tube or a Diaphragm or Bellows measures.

10.1.3 Flow Measurement and Control

Stream pointer regulators are utilized to control the measure of fluid. Additionally all physically set streams require some stream sign or some simple methods for incidental example estimation. For bookkeeping purposes, feed and item stream are metered. Moreover utilities to individual and assembled gear are additionally estimated

Most stream measures in the business are/by Variable Head gadgets. Less significantly Variable Area is utilized, just like the numerous accessible sorts as uncommon metering circumstances emerge. The different kinds of stream meters accessible are hole meter, venturi meter, pitot tube and so forth Regardless of these the different sorts of region stream meters can likewise be utilized.

10.1.4 Level Measurement and Control

The fluid level is estimated both by immediate and circuitous methods. Direct techniques include direct estimation of the separation from the fluid level to a datum level. Aberrant technique follows changing fluid surface situation on bubble tube strategy, opposition strategy, radiation technique, and so on

10.1.5 DISTRIBUTED CONTROL SYSTEM (DCS):

For the quicker control DCS can be utilized. It gives simplicity of steady checking the cycle a good ways off much far away from the site and the progressions can be made in the process boundaries precisely from the main control room .directly

CHAPTER 11

CONCLUSION

. Trichloroisocyanuric acid (TCCA) is extensively used as a disinfectant, algicide and bactericide. The worldwide overall production of trchloroisocyanuric acid is 100.000 ton per year. The interest is expanding by 8-10% each year for pools and 3-5% for food preparing. Despite the fact that TCCA has been created for huge scope for use in family and industry since the 1950s, it has never had a genuine achievement in natural science research centers. We chose this because there is a great demand for this product in market. In this report we successfully configured various technical aspects such as Material and Energy balance, process equipment design, cost estimation (in which the payback period is found to be 7.5 years), and even safety aspects was studied in detail.

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