

PLANT DESIGN FOR THE MANUFACTURE OF ETHYLENE GLYCOL

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

By

AKASH.J (37190005)

THOM JERVISE.C (37190041)

DEPARTMENT OF CHEMICAL ENGINEERING

SCHOOL OF BIO AND CHEMICAL ENGINEERING



SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

MARCH – 2021



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited with "A" grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

www.sathyabama.ac.in



DEPARTMENT OF CHEMICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **AKASH.J (37190005)** and **THOM JERVISE.C (37190041)** who carried out the project entitled "**PLANT DESIGN FOR THE MANUFACTURE OF ETHYLENE GLYCOL**" under my supervision from October 2020 to March 2021.

Internal Guide

Dr. VENKATESAN.D M.Tech.,Ph.D.

Head of the Department

Dr.SATHISH.S M.E.,Ph.D.

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

I AKASH.J (37190005) hereby declare that the Project Report entitled "PLANT DESIGN FOR THE MANUFACTURE OF ETHYLENE GLYCOL" done by us under the guidance of Dr. VENKATESAN.D M.Tech.,Ph.D. at Sathyabama institute of science and technology, Jeppiar nagar, Rajiv Gandhi Salai, Chennai-600 119 is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Chemical Engineering.



(J. A KASH)

SIGNATURE OF THE CANDIDATE

DATE: 20.03.21

PLACE: Chennai

DECLARATION

I THOM JERVISE.C (37190041) hereby declare that the Project Report entitled "PLANT DESIGN FOR THE MANUFACTURE OF ETHYLENE GLYCOL" done by us under the guidance of Dr. VENKATESAN.D M.Tech.,Ph.D. at Sathyabama institute of science and technology, Jeppiar nagar, Rajiv Gandhi Salai, Chennai-600 119 is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Chemical Engineering.


(C. Thom Jervise).

SIGNATURE OF THE CANDIDATE

DATE: 20.03.21

PLACE: Chennai

ACKNOWLEDGEMENT

I am pleased to acknowledge our sincere thanks to the Board of Management of SATHYABAMA for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

I convey our thanks to **Dr.S.SATHISH M.E.,Ph.D.** and also **Dr.D.PRABHU M.S(Res).,Ph.D.** Heads of the Department, Department of Chemical Engineering for providing us necessary support and details at the right time during the progressivereviews.

I would like to express our sincere and deep sense of gratitude to our Project Guide **Dr.D.VENKATESAN M.Tech.,Ph.D.** The Department of Chemical Engineering for his valuable guidance, suggestions and constant encouragement paved the way for the successful completion of our project work.

I wish to express our thanks to all Teaching and Non-teaching staff members of the Department of Chemical Engineering who were helpful in many ways for the completion of the project.

ABSTRACT

Ethylene glycol is an impersonation natural fluid utilized for industrialized production of polyester fiber and as hostile to freezing specialists. The task work completed spotlights on creation of ethylene glycol. Methods available for then the production of the ethylene glycol have been studied and detailed out as to why we have not selected those processes. From the studies, hydrolysis of ethylene oxide was found out to be more feasible, economical and eco-friendly compared to others. A detailed study of the technical aspects of the process including mass and energy balance for each equipment and design of the equipment have been carried out. Furthermore, economics of the project have been discussed.

TABLE OF CONTENTS

CHAPTER No.	TITLE	PAGE No.
	ABSTRACT	VI
	LISTS OF TABLES	VII
	LISTS OF FIGURES	IX
1	INTRODUCTION	1
	1.1 HISTORY	1
	1.2 CHEMICAL PROPERTIES	2
	1.3 PHYSICAL PROPERTIES	2
	1.4 REACTION SUMMARY	4
	1.5 MANUFACTURING	6
2	PROCESS SELECTION AND DESCRIPTION	9
	2.1 MANUFACTURING PROCESS	9
	2.2 PROCESS DESCRIPTION	16
	2.3 DISTILLATION COLUMN	17
3	FLOW SHEET	18
4	MATERIAL BALANCE	19
5	ENERGY BALANCE	25
	5.1 EVAPORATOR	26
	5.2 DISTILLATION COLUMN	29
6	DESIGN OF TWO EQUIPMENT	30
	6.1 TUBULAR REACTOR	30
	6.2 TRI-ETHYLENE GLYCOL	31

	6.3 DISTILLATION COLUMN	33
7	INSTRUMENTATION AND CONTROL	35
	7.1 SAFE PLANT OPERATION	35
	7.2 TYPICAL MONITORING SYSTEMS	36
	7.3 DISTRIBUTED CONTROL SYSTEM	37
8	SAFETY	40
9	PLANT LOCATION AND LAYOUT	48
10	COST ESTIMATION	54
11	SUMMARY AND CONCLUSION	61
	REFERENCES	62

LISTS OF FIGURES

FIGURE NO.	FIGURES	PAGE NO.
3.1	Process Flow Diagram	18
9.1	Plant Layout	53

LISTS OF TABLES

TABLE No	TITLE	PAGE No
1.1	Physical Properties	3
2.1	Evaluation at various processing	12
4.1	Molecular Weights	19
4.2	Material Balance around the Evaporator	22
4.3	Material Balance around the Drying Column	23
4.4	Material Balance around the Distillation Column	24
5.1	Heat of Formations of components	25
6.1	Design calculations for tubular reactor	31
7.1	List of Thermometers with temperature Range	36
10.1	Price Of Raw Material (ethylene oxide)	54
10.2	Price Of Product (ethylene glycol)	55
10.3	Price Of Equipment	56
10.4	Direct Costs	57
10.5	Indirect Costs	58
10.6	Direct Production Costs	59

1. INTRODUCTION

1.1 HISTORY

Ethylene Glycol (ethane diol), routinely call glycol is the humblest symbol. It is principally significant equipped, dealing of the di-bromoethane with shiny acetic acid derivation springy ethylene glycol di-acetic acid derivation by means of encompass be negative business build otherwise accommodation of the compound before World combat at what time it be create from ethylene dichloride by Germany also used us the choice for Glycerol when the sensitive gathering and be primary used inventively rather than glycerol all through world-war because a momentary for explosive (Ethylene glycol di-nitrate) yet have because mechanical addicted to critical present day thing.

The utilization of Ethylene Glycol because a fluid impetus intended for H₂O when vehicle cool systems be interesting in the US in the 1917, anyway the mechanical request didn't start expecting the last piece of the 1920s. The recently curbed glycol radiator liquid when put on the business community center.

The Carpet continued being on a fundamental level the sole supplier until the last piece of the years. The charming spot upon the plant in, base on its exceptional formaldehyde methanol measure. In before years Carbide dazzling spot up the fundamental plant reliant improvement for steam stage of reaction. As far as possible with respect to manufacture of ethylene glycol through hydrolysis of ethylene oxide is unrefined however compelling for every year.

1. 2 CHEMICAL PROPERTIES

Ethylene is the extremely basic for aliphatic dihydric liquor with compound properties of alcohols, for example, living being refined of creating ether, ester, or being oxidized into corrosive or aldehyde just as living being dense to frame the air or being substitute by halogen. Their responses with acyl chloride or corrosive anhydride for the most part structure di-esters. Under heat within the sight of means (manganese dioxide, aluminum oxide, zinc oxide or sulfuric corrosive), it tends to be subject to intermolecular or intermolecular drying out to frame the

returning ethylene acetals, which can respond with nitric corrosive to produce glycol criticize (a touchy). Ethylene glycol is the crude material for development of polyester tars, alkyd gums and polyester fiber. It can likewise be worn as the refrigerant middle person for car and airplane motors refrigerant. During 1980, the glycol sum utilized as refrigerant specialist is identical to the sum utilization for produce polyester. In adding up, it can likewise be utilized for integrate polymers like polyester fibers. Ethylene glycol stigmatize, when utilized in course of action with nitro-glycerine can lessen the edge of freezing over of touchy. Ethylene glycol can likewise exist new as the uncommon material of drugs and plastics and high-bubbling solvents. Industry deliberate ethylene's as a crude substance with first proselyte it to ethylene oxide and afterward hydrolyzing to produce ethylene glycol.

It is lackluster straightforward gooey fluid with sweet taste and dampness ingestion potential. It is what's more miscible with water, second rate aliphatic alcohols, glycerol, acidic corrosive, $\text{CH}_3)_2\text{CO}$, ketenes, aldehydes, pyridine and practically identical coal tar bases. It is somewhat solvent in ether yet practically difficult to settle in benzene and its homologues, chlorinated hydrocarbons, petrol ether and oils.

1. 3 PHYSICAL PROPERTIES

- Mono-ethylene glycol to be understandable, scentless, vapid, enchanting fluid with a sweet taste.
- Gyroscopic Fluid Completely miscible with a group of glacial solvent and the water, acetone, alcohols and ethers.
- When the soul very low although in such as the benzene, dichloromethane, when the non polar solvents and a chloroform. When the ethanol on the whole measure however endless in the heavens, totally with a ton of polar, solvent, water, glycol-ethers and alcohols. When the dissolvability is little, however that no polar solvent, like toluene, benzene, chloroform another one dichloromethane.
- Such as the poisonous as Methyl-liquor at what time in use verbally.
- It is unbending to take shape, when refrigerated; it frames a very gooey,

Super Cooled of mass so as to at long last to produce a glass-like material.

- Then the broad utilization of chemical as a radiator fluid depends on its ability to bring down cool moment that fluctuated with water.

Table 1.1 Physical properties of ethylene glycol

Heat of Formation at 25°C	-460 kJ/gmol	-3,188 Btu/lb
Heat of Fusion	9.96 kJ/gmol	69 Btu/lb
Heat of Vaporization at 1 atm	53.2 kJ/gmol	369 Btu/lb
Molecular Weight	62.07 g/mol	62.07 g/mol
Normal Boiling Point	197.4°C @ 1013.25 hPa	387°F @ 760 mm Hg
BP/Δ P (750 to 770 mm Hg)	0.337°C/kPa	0.045°C/mm Hg
Normal Freezing Point	-11.2°C	11.8°F
Onset of Initial Decomposition	240°C	464°F
Refractive Index, n_D , at 25°C	1.4306	1.4306
Solubility in Water at 20°C	100 wt%	100 wt%
Solubility of Water in EG at 20°C	100 wt%	100 wt%

1. 4 Reaction Summary

It contain the two primaries of gatherings. When synthetic responses be subsequently, those of essential alcohols twice finished. all in all, one – OH bunch is assaulted totally before other respond.

Dehydration

With Zinc chloride, it gives Acetaldehyde



(Ethylene Glycol)

(Acetaldehydes)

When the heating unaccompanied on 500°C .

It give di- oxaneIt is very impact at the industrial solvents.

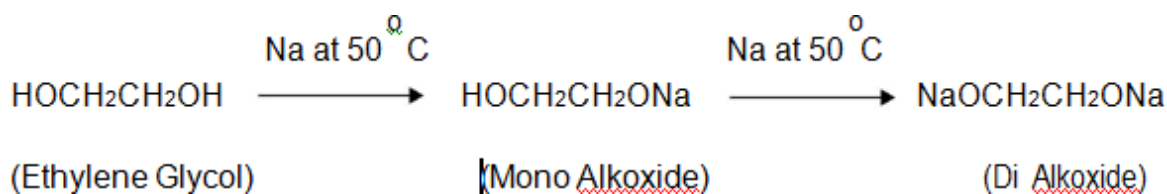
Oxidations

It is with no difficulty outward appearance various of the oxygen and acids, It have the nitric corrosive & past oxide specialists. Then the trademark stock predictable from strong capacities be corrosive, Glyoxylic corrosive, When the erosion to yield of embodiment one or both even for the most part critical social events may be corroded to carboxylic and these Aldehydes get-together.

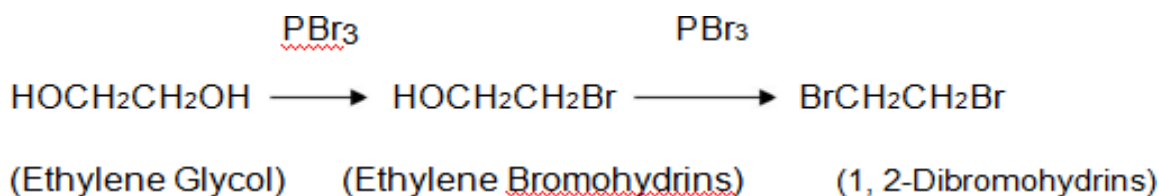
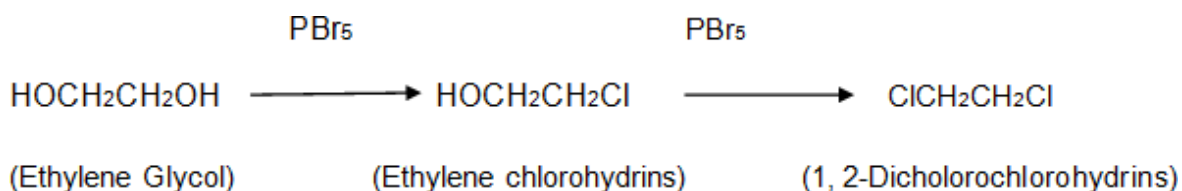
Others reaction

The hydroxyl bunch on glycols experience the standard liquor science generous the extensive arrangement of potential subsidiaries. It also be able to change a carboxylic acids, ethers, nitriles, nitrite esters, natural alkyl halides amides, nitrate esters.

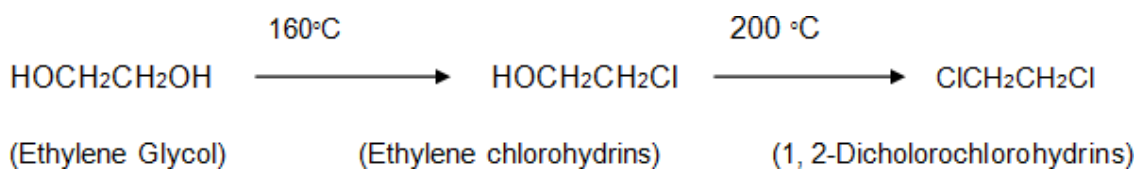
Responsive by techniques for it compound at the 50⁰c at the outline Phosphorus confined.



Response with Phosphorus confined halide (PCl₅) it initially give the its chemical & after that Chloral ethanes. PBr₅ respond and the comparative manner.



The hci is the two stages response, structure Ethylene Cholorohydrins on the 160⁰c and another structures at the 200⁰c.



Ethylene glycols is steady compound, however specific consideration the enthusiastic at the very high temp of the event of exothermic.

1.5 MANUFACTURING

Mono glycol it is formed at the consumption at the very high temp of there sliver oxides and impetus. When the point when the ethylene glycols is steady of give way of process.



Ethylene glycol

Worldwide order for MEG is truly incredible with request rough at the eighteen million tons on the year Of 2008 & conjectures indicative of these interest might ascend the twenty five million tons by the 2005. Request as most grounded at the china would be in an area of 70% of the world's MEG yield is devoured.

APPLICATIONS & USES

Antifreeze

A significant utilization of ethylene glycol is as radiator fluid for inside consuming motors. Arrangement contain ethylene glycol involve incredible warmth transport property & the upper singing focuses that the unadulterated H₂O. Subsequently, when the expanding inclination as utilize Glycol arrangement as well as an all year coolant. Ethylene glycol arrangements are additionally utilized as evolved heat move specialist.

- mixture of two chemical reaction should be utilized intended for thaw out and the airplane & forestall. Then the setup of ice fort the airplane as on top of earth. It is based on the definitions and additionally second-hand to deice landing strip runway runways as deicing moderator.

- The asphalt emulsion paints are shielded for the expansion for ethylene glycols close by cold, break then the blend. A carbon-dioxide bothered blaze and the framework regularly encompasses Ethylene glycol the maintain a strategic distance from cold.

Polyester of resins

If the utilizations at the polyester saps be amazingly shifted, plus take in Boat and nautical, development resources, car & airplane body, baggage, furniture, machines, materials and wrapping. Polyester fibbers are normally found in material application including dress and rug. Polyester films bend normally utilized in wrapping and wraps for client products, just as video, sound and processor tapes. PET is by and large utilized in the created of refreshment jugs and holders, and other client merchandise covering. It is assessed that 70-80% of all the MEG over the top is utilized as a compound transitional in these polyester produce measures.

The Chemical intermediate

- adhesive & coating.
- Emulsifier
- Lubricant
- Polyurethane foam.
- Silicone compound.
- Thermoplastics
- Plasticizers
- Solvents

Hydraulic Fluids

- Ethylene glycol is use in pressure driven, footbrake and safeguard liquid to help condense inhibitors, forestall irritation of elastic, and control froth setup.

- It is H₂O base combinations at poly-alkylene glycols & bite the dust projecting machines, & in airplane water driven frameworks on account of their nearly low thickness at high pressing factor. An additional improvement of essential importance is that these hydro lubes.

Capacitors

- Ethylene glycol is utilized as an operating at a profit dark and suspend mechanism puncture, that the instrumentalist on practically all the electrolytic capacitors.
- In these very huge amount of neatness, when utilized since if allow down fume weight, is noncorrosive to aluminum and the great electrical property.

Explosive

- Normal explosive determination cement very less temperature & can't that exploded. It criticize, which as a prone to detonate itself, is blended in with explode to push down it's edge of freezing over and develop it more secure to deal with in cool environment
- Mixture of nitrated and glycol then the sight as sulfuric corrosive to shape arrangements a nitro-glycerin.

2. PROCESS SELECTION & DESCRIPTION

2.1 MANUFACTURING PROCESS

When the closure of 1981, just two cycles for created ethylene glycol encompass be popularized. Then the essential, off the recent critical, and the form of 1968 from side to side 1981 as be establishment for the entirety of the development.

Assembling measure includes research facility techniques and mechanical strategies.

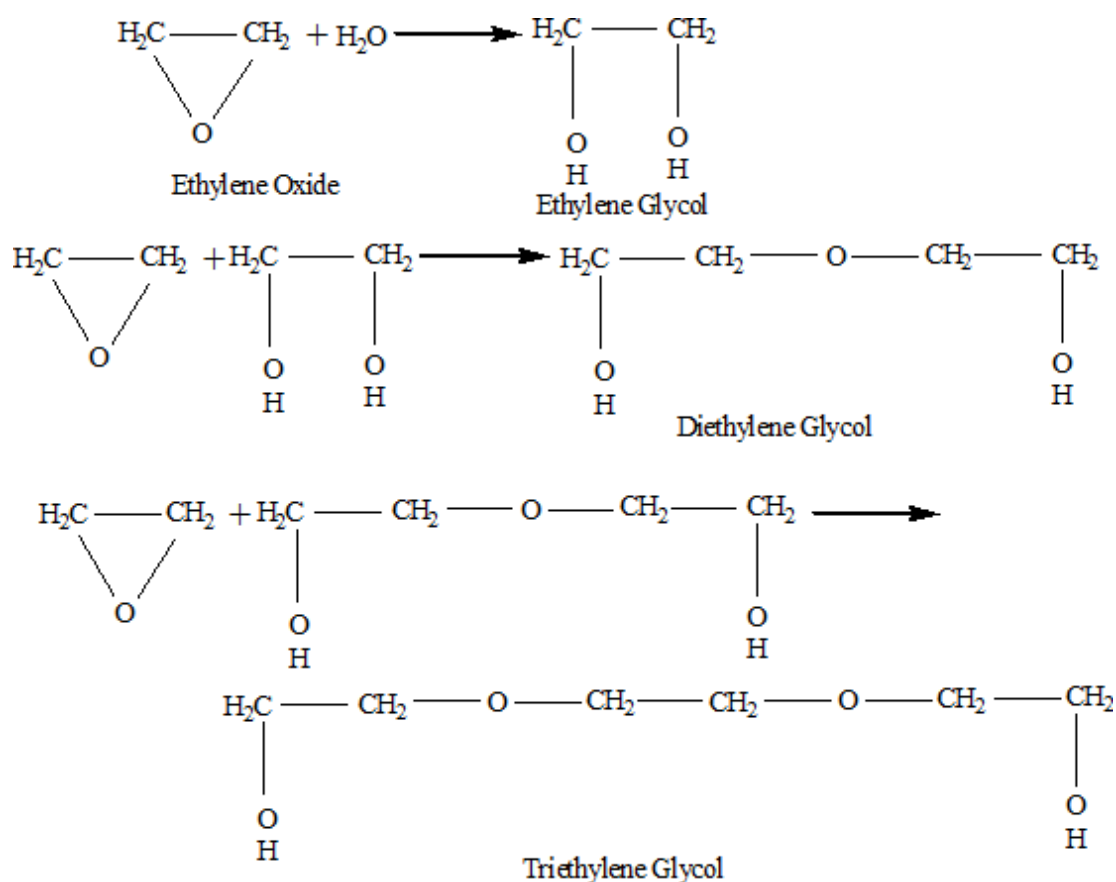
2. 1. 1 Laboratory techniques

- When the passing a ethylene glycol in to freezing weaken arrangement
Example as oxidation of ethylene glycols.
- When the hydrolysis burning beneath with the fluid sodium carbonate clarification. Then the rebound blend as flexed plough a sleek drop. Then the resultant arrangement as dissipate an the H₂O drench & of half strong remaining portion is separate with ether-liquor mix. Glycol is recuperated from arrangement and refining.
- They Near the beginning establishment of ethylene glycol was starting get from buildup. They selective to form of glycol is little numeral of different glycol & polygons delivered.

2. 1. 2 Industrial Strategies

- The creation of glycols direct, when the summarize as follow: chemical react with the H₂O to shape glycols and the a short time later significant reacts advanced homologues when a movement of ceaseless reaction us

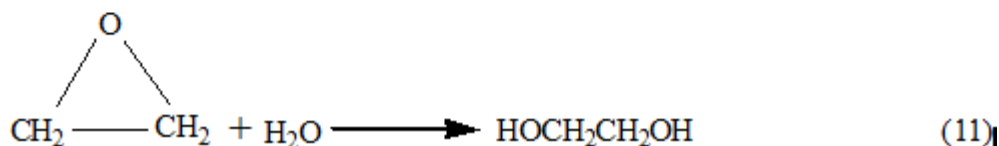
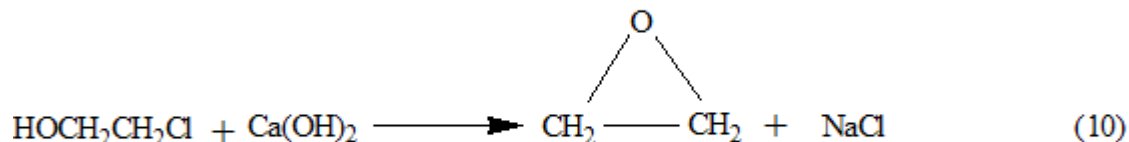
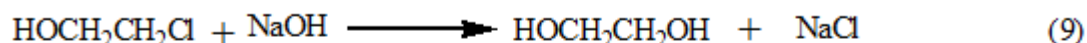
exhibited at follow conditions.



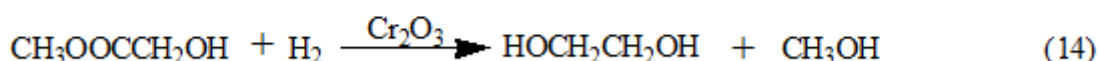
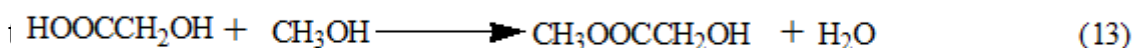
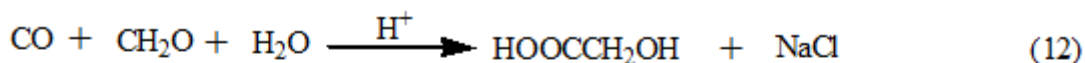
Albeit reactant ethylene glycols to misuse the development havebe determined the various organization with various materials unique as impetuses, they have no announced assembling, utilizing synergist ethylene oxide. Determined impetus incorporate sulfuric acids, carboxylic acids and salts, subtitle trade pitches, sharp devotees, halides, anion-trade tars and salt.

- Ethylene glycol be financially molded in the coordinated of USand other country influenced corrosive. It have the option to be misshaped straightforwardly to reaction through, by and large harsh or burning/bicarbonate consolidate. A substitute assembling strategy is

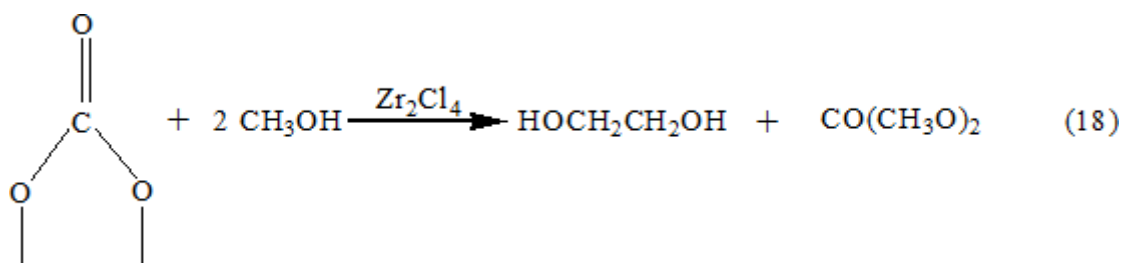
convert chlorohydrins to ethylene oxide with succeeding hydrolysis.



Albeit reactant hydrations of ethylene oxides when misuse it has development determined they various organization with various materials unique as impetuses, not revealed assembling it utilizing synergist for hydrolysis. Determined impetus incorporate sulfuric acids, carboxylic acids and salts, subtitle trade tars, sharp extremists, halides, anion-trade tars, with the endless on coordinating with techniques as likewise regular far and wide investigation.



It compartment molded Acidic corrosive, notwithstanding respond an instrument the frame of lattice reaction as ethylene in additional to water in additional to information such as the defective.



If measure, base an takes care of predictable as of combination gas (CO and formaldehyde), turned out to be economically out of date in light of low-evaluated

ethylene. by methods for the high estimation typical Gas has been lot of mounting.if it built and the furthermore blend Gasas the further development process.

2.1.3. PROCESS SELECTION

This is based on the various benefits and boundary of the assembling strategies.

Examination of various Processes:

Hydration of ethylene oxide is a designing drawing close to glycols as a rule, & ethylene glycols on the meticulous. If it is a most of primary huge scope wares of mechanical natural combination, with the world once every year creation of the most population of peoples. It ethylene oxide continues as sequential comparable course When design of ethylene glycols.

Table 2.1 Evaluation at various processing

SR. NO	PROCESSES	PARAMETER	CATALYST	ADVANTAGES/DISADVANTAGES
1.	Hydrolysis of Ethylene Oxide	1) <u>Non-catalytic</u> Yield : 98% Selectivity: 98% Temp: 105°C Pressure : 1.5MPa 2) <u>catalytic:</u> Yield : 95% Selectivity:	1)Non Catalytic 2) Catalytic: Sulphuric acids, Carboxylic acids plus salts, ion-exchange resins, Acidic zeolites.	Use large surplus water to augment the yield which leads to high power consumption 1) Use less surplus water which lead to low energy consumption 2) High yield & selectivity

		90% Temp: 200°C Pressure : 1-30 bar	halides, Metal oxide and Metal salts.	3) permit use of low temp & pressure 4) Acid channel make the reaction explanation highly corrosive.
2.	Ethylene Glycol from Ethylene chlorohydrins	Yield : 50% Selectivity: 75%	Non Catalytic	➤ very low yield & selectivity ➤ very costly
3.	Ethylene glycol from CO, H ₂ , CH ₃ OH & Formaldehyde	Yield : 90-95% Temp: 200°C Pressure: 100atm	<u>Cromate</u> Catalyst	➤ High pressure process ➤ Discontinued now a day ➤ Low selectivity
4.	Ethylene glycol from ethylene carbonate	Yield : 98% Selectivity: 95% Temp: 180°C Pressure: 13bar	Alkali halide or ammonium salt.	➤ Give high yield and selectivity ➤ Utility saving ➤ Extra purification cost
5.	<u>Transesterification</u> of ethylene carbonate.	Low yield	Zirconium & titanium compound.	➤ Produced large amount of <u>byproducts</u>
6.	<u>Esterification</u> of Oxalic acid	Yield : 70% Selectivity:	Copper catalyst	➤ High conversion but catalyst

	and Reduction with H ₂	90%		removal is very difficult.
7.	Direct one phase mixture of Ethylene glycol from sync gas	Selectivity: 65% Temp: 190-230°C Pressure: 3400atm	Rhodium catalyst (Homogeneous catalyst route.)	➤ As crude prices increase this process will become more economical. ➤ Use of very high pressure ➤ Not establish to be not direct route may be feasible or not. ➤ Catalyst is very sensitive and expensive.
8.	Hydrolysis of glycol diacetate.	Yield : 90% Selectivity: 95% Temp: 160°C Pressure: 2.4MPa	Pd complexes pdcl ₂ +NaNO ₃	➤ Very low conversion

Right now the all of equableness molded in the manufacturing on the non catalytic reactions. Produced products conveyance when the response controlled on the H₂O connection at the underlying response combination. Therefore incredible abundance of H₂O as basic components to expand modern degree. Then the evaluations when an huge force amount of the last produced merchandise seclusion stage from weaken fluid arrangement. That the energy utilization for the refining of exceptionally gigantic measure of abundance H₂O is very high.

Each lead of an becoming diminishing H₂O overabundance when the accommodation at impetuses speed up just the initial as, explore as done when improved at the interaction. They quest at the best methods a reason increment then the selective & very less amount of overabundance H₂O.

2.1.4 Catalyst

An get simultaneous trade over sap structure, actuate trade sodium bi-carbonate arrangement utilized us impetuses. The ethylene glycols hydration such as the improvement when synergist and the examined.

Functional group	:	- $[\text{PhN}(\text{CH}_3)_3]^+$
Total exchange capacity (equiv./l)	:	1.4
Particle size (mm)	:	0.3-1.2

2.2 PROCESS DESCRIPTION

They cycle formed mono-ethylene glycols as the synergist hydrolysis ethylene glycols oxide and they being there very small overabundance H₂O. They after ethylene glycols as they done by the reaction isolated as the overburden H₂O another one of the afterward sophisticated in the direction of create mono ethylene glycol MEG. The interaction such as isolated at five verity of the areas.

2.2.1 Reaction Operation

It fluctuated at reprocess H₂O another one of the siphoned to ethylene reactor anyplace It's responded by means of floods at the event us impetus. They comprises of 2 stage, They the fluid stage another one of the ionize (impetus) stage. Then the alcohols stream from one finish to another impetus bed in a fitting stream system. The synergist reactant it is reaction made up of they disappears on the ionize stage, another one of the just non reactant response happens in the fluid stage. The dissemination of the at the a movement of vessel, every idea lesser pressing factor Then the past. since they bubbling temp of the H₂O decline since pressing factor decline, they fume bubble utilized too warmth they following, & just they stating stage of container(very high pressing factor) require on outer wellspring of warmth. as in principle, evaporators might exist work by means of a haphazardly immense number of stages, evaporators with in excess of four phase are once in a while sensible besides in frameworks where the fluid is the necessary produced products, for example, in substance recovery frameworks where up to seven impacts are utilized and it has benefits, at the outset it might appear to be that the compound impact evaporator has all the remuneration, the warmth is utilized again and again some other time and we have all the earmarks of being getting the dissipation in the second and following impacts in vain as far as energy costs. Closer evaluation show, in any case, that deliberately accessible warmth financial system. At the each section in arrangement such as every working the less weight. Then the straightforwardness fume utilized took the supply heat for the ensuing. The third impact bottoms encompass around 10% water.

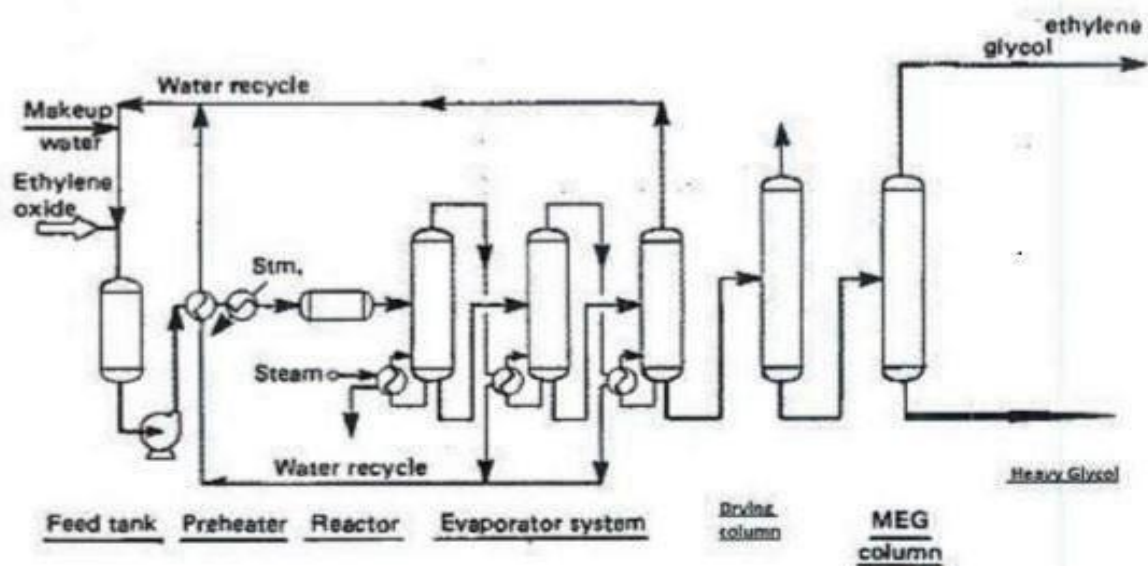
2.2.3 drying column

They concerted form of the effect as contain generally fifteen percentage of the H₂O. Basically each and every one the H₂O is discrete as of the liquid ethylene glycol course of action when the ventilation portion. By and large support as dealt with beginning then the basic glycols container. Then the support worked over empty which of the keep up by smolder stream ejectors. Ventilation area under which is freed as of immerse be move by fragment base direct MEG assimilating section.

2.3 Distillation columns

At that point the EG was separated from high glycols in the EG purifier uphold. The EG is overhead on the bottom on which container a some proportion of distillation column transported off a avoided at the equivalents Column. Inside the equivalent pillar, Then the striking mono glycols is segregated ease and mixed in with the make open for to the Refiner Column The colossal glycols are removed as of they splitter bottom and sent off additional room as by made product in another cooperation weighty thing dispatched off distillation pillar wherever the distillation column is taken overhead. The distillation pillar base is sent off the TEG Column any place the TEG is refined overhead.

3. FLOWSHEET



3.1 Process Flow Sheet

4. MATERIAL BALANCE

Production Rate :- 10 ton/day = 416.667 kg/h of MEG = 6.720 kmol/hr

Basis :- Unit hour operation

Table 4.1 Molecular Weight

Chemical Substance	Molecular Weight
Ethylene Oxide	44 kg/kmol
Water	18 kg/kmol
Mono-ethylene glycol	62 kg/kmol
Di-ethyleneglycol	106 kg/kmol
Tri-ethylene glycol	150 kg/kmol

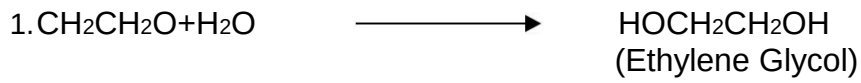
Ethylene oxide is the limiting reactant. So we have to supply water in excess i.e. 1:6 (weight %), When,

- Ethylene glycol- 80%
- Diethylene glycol- 12%
- Tri-Ethylene glycol -8%

Therefore Total products produced = 520.825 kg/h Then,

DEG = $0.12 \times 520.825 \text{ kg/h} = 62.5 \text{ kg/h} = 0.5896 \text{ kmol/h}$ TEG = $0.08 \times 520.825 \text{ kg/h} = 41.667 \text{ kg/hr} = 0.2778 \text{ kmol/h}$

Reactions:



From Reaction 3,



- 106 kg/kmol DEG = 150 kg/kmol TEG
- X kg of DEG = 41.667 kg TEG

Therefore, x = 29.5 kg DEG

Again, 44 kg/kmol EO = 150 kg/kmol TEG Hence EO = 12.2233 kg

Similarly, EO required is calculated for Reaction 1 & 2 Total EO supplied = 384.3 kg
= 8.341 kmol

Water Supplied = 6 * EO supplied = 2305.8 kg = 128.1 kmol

4.1 Material Balance around the Reactor

The all EO is changed to ethylene glycols by means of intention utilizing the lot of water. experimental writing selective of various items.

Table 4.1. Material Balance around the Reactor

COMPONENT	INPUT		OUTPUT	
	kmol/h	kg/h	kmol/h	kg/h
EO	8.7341	384.3		
WATER	128.1	2305.8	120.5116	2169.2090
MEG	-	-	6.7204	416.667
DEG	-	-	0.5896	62.5
TEG	-	-	0.2778	41.667
TOTAL		2690.04		2690.04

4.1.1 Material balance around the evaporator

Suppose that 90% drinking water is being removed

Table 4.2 material balance around the evaporator

COMPONENTS	INPUT		OUTPUT			
	kmol/h	kg/h	TOPS		BOTTOMS	
			kmol/h	kg/h	kmol/h	kg/h
WATER	120.5116	2169.2090	108.4603	1952.2851	12.0512	216.9209
MEG	6.7204	416.667			6.7204	416.667
DEG	0.5896	62.5			0.5896	62.5
TEG	0.2778	41.667			0.2778	41.667
TOTAL		2690.04	108.4603	1952.2851	19.6391	737.7549

Evaporated water =1952.2851 kg/h

Material Balance around the Drying Column Input= yield aggregation + unsettling influence Accumulation=0

Aggravation =0

We utilized dryer to eliminate remaining water.

Table 4.3 Material Balance around the Drying Column Material

Components	Mass (kg/h)	MASS% IN	Mass(kg/h)	MASS% OUT
WATER	216.9209	0.2940	0	0
MEG	416.667	0.5648	416.667	0.8
DEG	62.5	0.0847	62.5	0.12
TEG	41.667	0.0565	41.667	0.08
TOTAL	737.7549	1	520.8340	1

Eliminated water = 216.9209 kg/h

Material Balance around the Distillation Column Input= yield gathering + aggravation Accumulation=0

Aggravation =0

Accepting greatest item immaculateness,

Mole fraction of MEG in distillate is

$$x_d = 0.995$$

$$x_w = 1 - x_d = 0.005 \text{ Mole fraction of MEG in feed:-}$$

$$X_f = \text{MEG} / \text{Overall feed to column} = 6.7204 \text{ kmol/h} / 7.5878 \text{ kmol/h}$$

$$= 0.8857$$

Overall Material Balance :-

- $F = D + W$ Component Balance
- $F x_f = D x_d + W x_w$ Substituting the values,
- $D = 6.7162 \text{ kmol/h}$ MEG = 416.4044 kg/h
- $W = 0.8716 \text{ kmol/h}$

Table 4.4 Material Balance around the Distillation Column

Components	INPUT		OUTPUT			
	kmol/h	kg/h	TOPS		BOTTOMS	
			kmol/h	kg/h	kmol/h	kg/h
MEG	6.7204	416.667	6.7162	416.4032	0.0042	0.2638
DEG	0.5896	62.5			0.5896	62.5
TEG	0.2778	41.667			0.2778	41.667
TOTAL	7.5875	520.8340		416.4032		104.4308

5. ENERGY BALANCES

As per commandment of the preservation of energy.

Pace of Energy accumulation inside framework = rate of energy towards the inside of the framework rate of energy went out the framework + rate energy age

Reactor:

Assume constant temperature of the reactor

$$T_{in} = 160^{\circ}\text{C} = T_{out}$$

$$T_{mean} = 160^{\circ}\text{C}$$

$$P = 18 \text{ atm } P_{out} = 16 \text{ atm}$$

Table 5.1 Heat of Formations of components

COMPONENTS	INPUT(*10 ⁶ kJ/h)	OUTPUT(*10 ⁶ kJ/h)
EO	-0.8359	
WATER	-2.1690	
MEG		-3.0914
DEG		-0.3706
TEG		-0.2234

$$\Delta H_r = \Delta H_{products} - \Delta H_{reactants}$$

$$= -1.4932 \cdot 10^6 \text{ kJ/h}$$

5.1 Evaporator

For triple effect evaporators in series:-

$$\text{OMB} :- F = L_3 + (V_1 + V_2 + V_3)$$

$$\text{CMB} :- F_{xf} = L_3 + 0$$

$$\text{Therefore, } L_3 = 737.75 \text{ kg/h}$$

Assume equal amount of vapour

$$\text{Hence, } V_1, V_2, V_3 = 650.8 \text{ kg/h}$$

The first effect

$$F = v_1 + l_1$$

$$2690.04 = 650.8 - L_1$$

$$L_1 = 2039.1932 \text{ kg/h}$$

$$\text{Similarly, } L_2 = 1388.3464 \text{ kg/h and } L_3 = 737.75 \text{ kg/h}$$

Neglecting BPR

$$\Delta T = \Delta T_1 + \Delta T_2 + \Delta T_3$$

$$= T_{S1} - T_3 = 143.1 - 37.35 = 75.750^\circ\text{C}$$

where, T_{S1} temperature of first effect at 410 kPa pressure (from steam table)

T_3 temperature of third effect at 30 kPa pressure (from steam table)

Overall heat transfer coefficient of each effects:-

$$U_1 = 3122 \text{ W/m}^2 \text{ } ^\circ\text{C}$$

$$U_2 = 1987 \text{ W/m}^2 \text{ } ^\circ\text{C}$$

$$U_3 = 1136 \text{ W/m}^2 \text{ } ^\circ\text{C}$$

$$\Delta T_1 = 14.1236 \text{ } ^\circ\text{C}$$

$$\text{Similarly, } \Delta T_2 = 22.4341 \text{ } ^\circ\text{C}$$

$$\Delta T_3 = 39.2399 \text{ } ^\circ\text{C}$$

Actual Boiling Point :-

First effect, at 410 kPa

$$T_1 = T_{s1} - \Delta T_1 = 128.8264 \text{ } ^\circ\text{C}$$

Second effect @ 170 kPa

$$T_2 = T_1 - \Delta T_2 = 106.3923 \text{ } ^\circ\text{C}$$

Third Effect @ 30 kPa

$$T_3 = T_2 - \Delta T_3 = 67.154 \text{ } ^\circ\text{C}$$

Cp values (kJ/kgK) :-

- F=3.2
- L1=3.25
- L2=3.1
- L3=3.04

Impact 1

$$T_1 = 128.8260 \text{ } ^\circ\text{C}; T_{s2} = 115.630 \text{ } ^\circ\text{C}; T_{s1} = 143.10 \text{ } ^\circ\text{C}$$

$$h_1 = h_{s2}(\text{saturated enthalpy at } T_{s2}) + 1.884 \text{ bpr}$$

$$= 2670 \text{ kJ/kg}$$

$$= 2736 - 590$$

$$= 2146 \text{ kJ/kg latent heat of condensation}$$

Similarly,

Effect 2

- H2=2620 kJ/kg
- λ_{s2} =2157 kJ/kg

Effect 3:-

- $H_3 = 2609.6 \text{ kJ/kg}$
- $\lambda_{s3} = 2338 \text{ kJ/kg}$

Heat Balance using 0°C datum:-

First Effect:-

$$FC_p (T_f - 0) + S \lambda_{s1} = L_1 C_p (T_1 - 0) + V_1 H_1$$

Second Effect:-

$$L_1 C_p (T_1 - 0) + V_1 \lambda_{s2} = L_2 C_p (T_2 - 0) + V_2 H_2$$

Third Effect:-

$$L_2 C_p (T_2 - 0) + V_2 \lambda_{s3} = L_3 C_p (T_3 - 0) + V_3 H_3$$

Obtained values of each streams are

- $L_1 = 216.0635 \text{ kg/h}$
- $L_2 = 1504.9621 \text{ kg/h}$
- $L_3 = 737.75 \text{ kg/h}$
- $S = 3178.8015 \text{ kg/h}$
- $V_1 = 563.9765 \text{ kg/h}$
- $V_2 = 621.1014 \text{ kg/h}$
- $V_3 = 767.4626 \text{ kg/h}$

Heat duty in each effect:-

- $Q_1 = S \lambda_{s1} = 3178.8015/3600 \times 2146 \times 1000 = 1894.9 \text{ KW}$
- $Q_2 = V_1 \lambda_{s2} = 563.9765/3600 \times 2187 \times 1000 = 342.6157 \text{ KW}$
- $Q_3 = V_2 \lambda_{s1} = 621.1014/3600 \times 2338 \times 1000 = 403.3 \text{ KW}$

5.2 Distillation Column

Feed temperature = 61.5 °C

Distillate temperature = 197.6 °C

Residue temperature = 210 °C

Latent heat of vaporization = 858.0654 °C

Distillate from column = 416.0318 kg/h

Reflux ratio = 1.05

Water temperature (inlet) = 25 °C

Water temperature(outlet) = 35 °C

$$Q_S = 858.0645 \times (2.05) \times 414.982$$

$$= 202768.52 \text{ J/s}$$

$$Q_S - Q_C = \text{DHD} + \text{WHW} - \text{FHF}$$

$$Q_C = 202768.77 \text{ J/s}$$

$$M_s = Q_S / \lambda_s = 331.8030 \text{ kg/h}$$

Thus steam required is 331.8090 kg/h

$$M_w = Q_C / C_{pw} \Delta T_w = 33.1809 \text{ kg/h}$$

Thus cold water required is 33.1809 kg/h.

6. DESIGN OF TWO EQUIPMENT

6.1 TUBULAR REACTOR

The reactor they have spirit a synthetic cycle. Such as the solitary spot when the processing where crude equipment be changed keen on items, another one of the reactors configuration be an essential advance inside they have general plan interaction. They have proposition of a mechanical synthetic reactors should fulfill the accompanying necessities:

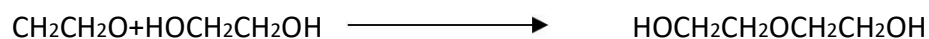
- The synthetic issues: the energy of the response. The plan should offer adequate home time for the perfect comeback to carry on to they stage of change.
- The accumulation swap over issues: by means of heterogeneous responses at the reaction charge strength unnatural by the pace of dispersion of the response type; instead of they synthetic power.
- The high temperature move issues: the evacuation, or expansion, of the warmth of response.
- The security issues: the restriction of dangerous reactions another one of the items, and controller of the response at the series state of affairs.

They have require to fulfill their unified, frequently opposing factor, make reactor plan an unpredictable and troublesome assignment. Nonetheless, in numerous examples one of the issues determination prevail and determination decide the choice of reactor type and the plan technique.

Chemistry of reaction:



Ethylene glycol



Di-ethylene glycol



6.2 Tri-ethylene glycol

The ethylene oxide reacts with water to create three items anyway the point item when the MEG (mono ethylene glycols).

They have response such as next request comply with the accompanying condition:

$$-r_{\text{EO}} = K C_{\text{EO}} C_{\text{w}}$$

Where:-

$-r_{\text{EO}}$ = rate of reaction.

K = constant of reaction.

C_{EO} is the concentration of ethylene oxide & C_{w} is the concentration of water.

Table 6.1 Design calculations for tubular reactor

COMPONENTS	MASS(kg/h)	MASS FRACTION	MOLES(kmol/h)	MOLE FRACTION
EO	384.3	0.1429	8.7314	0.0638
WATER	2305.8	0.8571	128.1	0.9362
TOTAL	2690.1	1	136.8314	1

- $\rho_{mix} = \sum x_i \cdot \rho_i = (0.0638 \cdot 882) + (0.9362 \cdot 1000) = 992.3440 \text{ kmol/m}^3$
- $V_{mix} = M_{mix} / \rho_{mix} = 136.8314 / 992.3440 = 0.1379 \text{ m}^3$
- $C_{EO} = \frac{M_{EO}}{V_{mix}} = \frac{8.3365}{0.1379} = 63.3365 \text{ kmol/m}^3$ & $C_w = 928.9340 \text{ kmol/m}^3$

As the concentration of water is large enough to be considered as constant so the reaction order will become pseudo first order, as following:

$$r_{EO} = K \cdot C_{EO}$$

$$\text{Where: } K = k C_w$$

$$k = A \cdot \exp(-E/RT)$$

Where: A = frequency = $338 \text{ (m}^3)^3 \text{ kmol}^{-3} \text{ s}^{-1}$
 E = activation energy = 18880 cal /g. mol.
 R = ideal gas constant

By substituting:

$$\text{As, } k = 5.62 \cdot 10^{-8} \text{ (m}^3)^3 \text{ kmol}^{-3} \text{ s}^{-1} = 2 \cdot 10^{-4} \text{ (m}^3)^3 \text{ kmol}^{-3} \text{ hr}^{-1}$$

$$\text{Therefore, } K = k \cdot C_w = 2 \cdot 10^{-4} \text{ (m}^3)^3 \text{ kmol}^{-3} \text{ hr}^{-1} \cdot 928.9340 \text{ kmol/m}^3 = 0.1858 \text{ s}^{-1}$$

$$r_{EO} = K \cdot C_{EO} = 0.1858 \text{ s}^{-1} \cdot 63.3365 \text{ kmol/m}^3 = 11.7671 \text{ kmol m}^{-3} \text{ hr}^{-1}$$

$$V/F_{EO} = -1/C_{EO} \cdot 1/K \cdot [\ln(1-x_a) - \ln(1)]$$

$$V = 18.7150 \text{ m}^3$$

Mechanical design

- Generally the ratio of length to diameter (L/D) for reactors has range (1 -3)
- So, it has been selected 1. $L/D = 1.5$ $V = \pi D^2 / 4 \cdot L$
- By substituting: $D = 6.6 \text{ m} = L 9.8 \text{ m}$
- For a cylindrical shell the minimum thickness required to resist internal pressure can be determined by equation:-

$$e = P_i \cdot D_i / 2f \cdot P_i$$

where, e = thickness of cylindrical shell

P_i = pressure of reactor = 2.23 N/mm²

f = design stress = 135 C N/mm²

- By substitute these value.

$$e = 32.173 \text{ mm}$$

6.3 Distillation Column

The parameters necessary for the design are,

- Vapour load
- Column Diameter
- Minimum number of theoretical plates at
 - Total reflux
 - Infinite reflux
 - Finite reflux
- Actual number of plates
- Column height

Vapour load

- $V = D(R+1) M_v / 3600 \cdot \rho_v$
- $D = \frac{\text{Number of moles of distillate}}{\text{Average molecular weight}}$
- $M_v =$
- $\rho_v = \text{Density of vapour}$
- $D = \text{Distillate} = 6.7099 \text{ kmol/hr}$
- $M_v = M \cdot x_i$

- $X_i =$ Mole fraction.
- $M_v = (0.8857 \cdot 62) + (0.0777 \cdot 106) + (0.0366 \cdot 15)$
 $= 68.6410$
- $P = P_{M_{avg}}/RT$

Where P is the operating pressure

$$= 101.3 \cdot 68.6410 / 8.314 \cdot 470 = 1.7794 \text{ kg/m}^3$$

Minimum number of theoretical plates at total reflux

$$SM = \log \left[\frac{(x_D / 1 - x_D) \cdot (1 - x_w / x_w)}{\log \alpha} \right]$$

- $S_m = 4.5977 / 0.4 = 11.5 = 12 \text{ trays}$

Minimum number of theoretical plate at infinite reflux

$$NM = SM - 1 = 11 \text{ trays}$$

Actual number of plates

$$= \text{No. of theoretical plates} / \text{efficiency}$$

$$= 22 / 0.8 = 27.5 \text{ trays} = 28 \text{ trays}$$

Column Height

$$= (N-1)P + 2P$$

Where, The plate spacing $P = 0.4 \text{ m}$

Column Height $= 9.2 \text{ m}$

7. INSTRUMENTATION AND CONTROL

Instruments are given to screen the key method factors through plant activity. Instruments screen hazardous course factors will be trim with customized cautions to make the administrator aware of basic and risky circumstances.

The principle destinations of the planner while concurring instrumentation and they have controlling plans are:

7. 1 Safe plant development

- To have measure factors inside known innocuous working limitations.
- To recognize perilous circumstances as they create and to offer alerts and
- Automatic closure frameworks.
- To offer interlocks and cautions to forestall hazardous working strategies.

7.1.1 Manufacturer Price And quality

- They accomplish it planned item yield.
- They have it the item arrangement inside the itemized quality guidelines.

7.1.2 Price:

- To work at the least making cost and to remunerate with different articles.
- Method instrumentation is so cerebrum and nerves of a cycle plant.
- The instrumentation can be pneumatic, pressure driven or electric. The new pattern electronics instruments, however pneumonic instruments is stationary being used.
- A need of instrumentation too amount temp, weight, streamvalue and the level of, actual property because thickness, mugginess, compound organization and so on.

7. 2 Typical monitorSystem

7. 2. 1 Flow measurement

Because of scenery of stream it's fundamental to bear effective stream estimating gadgets in each smoothes out. The several kinds of stream meters offered are opening meter, venturi meter, pitot tube and so on Regardless of these the several kinds of region stream meters can likewise be utilized.

Dependent upon hotness & speed situation the fit measuring device chosen measure of stream values another one measure of speed.

7. 2. 3 Temp measurements

Different gadgets be utilized in the direction of sum the heat varieties on the processing of like obstruction heating measuring devices as thermometer and pressure spring thermometer and etc.,

The mechanical temperature measuring as thermo couples are seriously great even through offer enormous deciding reach, without presenting flaw. Programmed control is likewise conceivable with such gadgets.

7.1 List of thermometer temperature range

Measuring Instrument	Temp. Range °C
Mercury in glass – thermometer	-27 to 400
Mercury in pressure thermometer	-40 to 540
Vapor thermometer pressure	-85 to 425
Resistance	-200 to 1700
Thermocouple	-250 to 1700
Thermister	Up to 300
Pyrometer	1300 to 2500

7. 2. 4 Pressure Measurement

Supplies, they significant noticing boundary is pressure assessing gadgets similar to pressing factor checks be broadly utilized. Insurance of compound the basically plants are the convenient measure of pressing factor & it is manageat an unmistakable stage. Several additional pressing factor expansionthe new plan pressing factor possibly will harm the gear on adding hazards.

For the most part in channel pressures where the pressing factor is a significant condition, this gadget is utilized.

When the adding to each us computing gadgets depicted on top of different sizes similar to thickness, consistency, estimations and so forth are introduced.

For figuring quality guidelines in research center different lab instruments are likewise fundamental.

7.2.5 Fluid level

Fluid level gadgets calculatemoreoverthen the situation of a non amount of fluid outside higher up an a datum stage of the hydrostatic and the top set up on they fluid is estimated.

They fluid stage is dignified together immediate & aberrant method. Straight techniques incorporate straight estimation then the chilliness from fluid stages to the level of datum. Aberrant technique follow adjusting fluid outside spot strategy, opposition technique, emission technique, and so on.

7. 3 DISTRIBUTED CONTROL SYSTEMS

Caprolactam produce measure manages the benzene which they have less limits. That the advancement be dangerous another one of the furthermore they creation superiority as critical. Consequently each of the speedier manage distributed control systems that have utilized. When give simplicity of standard observing the improvement an ways off gone change boundaries effectively as if they manage area itself.

7. 3.1 ADVANTAGES

1. According to excellence perspective:

- Additional precision & unwavering quality.
- Own change another control or manage circle be conceivable, that also improvement as each technique to be conceivable.

2. The executives contemplation

- Less expense of links.
- Less expense of establishment.
- Less space required.
- Less equipment required.
- Inventory data can be made accessible.
- Less labor is required.
- Less creation cost.
- Management all together can be created at ordinary spans which help association at obtain choices.
- Ease in activity.
- Any combination of control gathering, pattern gathering, outline pathway can be shaped.
- Because of dynamic realistic job image of technique is accessible.
- Easy diagnostics of excursion and crisis conditions.
- Automatic arrangement of information is done by printer and subsequently wipe out flaw related individual.
- Each of control reachable from side to side lively designs when offers sentimento usable as though of events.
- Apprehension framework be able to pulled together took different subordinate gatherings with the goal that employable can distinguish the blunder and causes without any problem.

4. Architect's Point of view:

- Most ongoing programming is accessible for all sort of complex capacity.
- Obligatory less an ideal opportunity for plotting &feature designing.

- Operator endeavor dispense with disarrays & noteworthy investigation.
- Supplenesses possible of the every place be equipment & programming.

7. 3. 2 DISADVANTAGES

Inside the coordinate space part of at the fragmentation is soon as possible to each of purposeful, endeavors accordingly administrator feels himself taking in the middle of the data.

In the event of new DCS frameworks, all together and information however realistic in an efficient arrangement, is covered up in the back consequently to stay alive call with administrator. It needs for the expertise & data. By means of gathering of distributed control system, more no of administrator atmanagespace decline & henceforth, if there should be an occurrence of crisis end must be taken by practically single hand as against collective choice in current condition.

In single circle control course of action disappointment of one controller influences just every manage circle, at the same time as holder of an distributed control system segment completes parcel of capacity and henceforth disappointment of it cause disappointment of numerous circles.

They limit might is feel on working noof oversee circles at the same time if there should arise an occurrence of crisis, stipulation sufficient quantities reassures benot introduced. Talented HE is necessary.

8. SAFETY

8.1 NEED FOR SAFETY

Although industrialization has made the quality of life better, it brings with it many risks for human life. One major factor is industrial safety. With rapid advancement in industrialization mechanical, electrical and chemical hazards claim countless lives every year. These mishaps address a social misfortune which is regarding loss of living souls and financial misfortune including loss of profitable limit and cost of support of harmed and expired workers and their families through federal retirement aide.

8.2 RISK OF ACCIDENTS

- i) Unsafe resources
- ii) Hazard of Pressure vessel
- iii) Dangerous Chemical response
- iv) Hazards of Unit operation
- v) Inflammable gas, Vapours And Dust Hazards
- vi) Health hazard
- vii) Hazards because of use
- viii) Entrance in To Confined places
- ix) Functioning with Pipelines
- x) Plant modification and tuning
- xi) Sampling and gauge
- xii) Hazard because of appliance failure.

Management responsibilities:

It is important that productivity be regarded as a methods for accomplishing the inventory of merchandise, pay and recreation all together that all related individuals can improve their life. If in achieving this, the path gets littered with casualties, it indicates failure of the management.

Analysis of Hazards:

An investigation should be made of plausible wellsprings of perils. It is additionally important to distinguish and assess the danger potential where basically perceived perils can be dispensed with.

The hazard can be classified as,

- € Material hazards
- € Process hazards

8.2.1 Material Hazard

This may be due to the property of the material and mostly occur due to,

- Combustible solids, liquids and gases
- Explosive materials
- Oxidizing materials
- Corrosive materials
- Toxic materials

8.2.2 Process Hazards:

These hazards might arise due to the following factors

- handling and physical change of materials such as transfer of flammable
- liquids or mixing in open container
- Exothermic or endothermic reaction where the reaction might go out of control
- Low pressure processes operating at sub atmospheric conditions so that air leaks into the system. These hazards might arise due to the following factors, storage
- High pressure processes
- Operating at unsafe speed
- Unsafe equipment use.

8.2.3 Health Hazards

- Identification of potential wellbeing risks.
- Control of perils by different procedures

- Adequate mindfulness among the laborers.
- Periodic clinical assessment of the laborers.
- Personal insurance for infrequent openings.
- Proper cleanliness and disinfecting offices. And so forth

8.2.4 hazard outstanding To decay

- Deteriorating and falling of designs and sheds.
- Plummeting of laborers from tallness because of negation of raised stages, hand rails, toe sheets, steps and stepping stools.
- Spills plus dangerous delivery from pipelines because of rust.
- Outflow and flooding of vessels because of rust.
- Corrosion observing and control.
- Testing and assessment of vessel and construction to guarantee assurance

8.2.5 Plants alteration and modification

Adjustments in plant, hardware, part, measure, working system, and so forth may happen because of some trouble followed by disappointment in some unanticipated part of the framework

- If any adjustment is unavoidable,
- Design motivation behind every single part of the framework ought to be surely known by each individual Worried.
- Refer the make a difference to the fashioners.
- Bring out HAZOP concentrate by master group.
- Pass it through plant adjustment endorsement board of trustees

8.2.6 Sampling and gauge

- Disclosures of gases, fumes and residue while gathering models.
- Approaching odd areas.
- Splashes and spillages while gathering tests.
- openness because of infringement of sight glasses and woodwind level pointer.
- Dip measuring of combustible fluids.
- Dip measuring of destructive fluids.

8.2.7 Hazards outstanding to appliance failure

- presence of bomb wellbeing instruments.
- Lack of interlocks and outing frameworks.
- Human disillusionments in manual and self-loader measures.
- Need for security investigation of the game plan frameworks.

8.3 Safety measures:

In every procedure industry, a wide assortment of preventative & defensive security estimates should be give. Such measures can be characterized into, measures to limit or keep away from setbacks estimates that will restrict the degree of harm if the circumstance gains out of power

A portion of the essential preventive and defensive measures are satisfactory inventory of water for fire security against over pressure help gadgets, safe area of assistant electric stuff waste from spill, putting out fires water from hose spouts, brisk evacuation of spill material, Specially worked safe valves and the actions.

8.3.1 Hazards preventive measures:

Modern knowledge has been rather successful in embryonic tailor made chemicals. Nonetheless, this exertion has likewise presented some extra issues since assembling and dealing with experience is often lacking to deal with hazards. The ever increasing production of flammable organics, the rush to bring

new products from lab into full scale production, all extend the probability of hazards.

Toxic and corrosive chemicals, fire, explosion, and fully mechanized equipment are major risks experienced in the activity of plants in substance enterprises. The plant engineer should know about these risks and should make each endeavor to introduce plans, which give greatest insurance to plant faculty and least possibility for event of mishaps.

8.3.2 Precautions for reactor

- The process control devices for temperature and pressure control should be regularly checked for its proper working.
 - The bolts and valves that are used should be tightened correctly and inspected before the start of each batch operation.
 - The reactor material should be selected appropriately as per the reactants nature. Example carbon steel should not be used if aqueous solutions are fed to the reactor
 - The cooling methods for the reactor should be appropriately selected so as to prevent accidents due to overheating of mixture inside the reactor.
 - The sludge's or scales that may be formed should be cleaned off regularly and effectively.
 - The support for the reactor should be designed taking into consideration the load it has to withstand.
- Precautions for distillation column
- Distillation column should be operated at total reflux. When distillation column is run at total reflux, the vapour rate is equal to the liquid to the liquid rate at any point in the column.
 - Security glasses and solid hats were worn at what time operational with the distillation column.
 - Caution should be taken while climbing the column stairs.
 - It should be ensured that the cooling water is flowing before the steam valve is opened.

8.4 SAFETY AND ENVIRONMENTAL DATA FOR NICOTINE SULPHATE

Health Hazards

- Inward breath
 - Present moment - Irritation, wheezing, lung blockage
 - Long haul - Blurred vision
- skin contact
 - Present moment - Burns
 - Long haul - Same as property report in momentary openness
- eye contact
 - Present moment - Burns
 - Long haul - Same as property report in present moment . . openness
- ingestion
 - Present moment - Burns, death
 - Long haul - Same as property report in present moment. Openness

8.4.1 First Aid Measures

Inward breath

On the off chance that horrendous impacts happen, dispose of to uncontaminated region Give impersonation breath if not energize. In the case of living is troublesome, oxygen ought to be control by equipped staff. Stand out enough to be noticed.

Skin

The wash skin with cleanser and water for in any event sum 15 minutes while take off corrupted garments and shoes. Stand out enough to be noticed Thoroughly spotless and dry spoiled attire before reuse. Annihilate sullied shoes.

Eyes

Quick redden eyes with a heap of water for at smallest 15 minutes. At that point stand out enough to be noticed.

Ingestion

Contact neighborhood poison control focus or doctor right away. Unquestionably not make an oblivious individual regurgitation or drink liquids. Give a lot of water or milk. Permit spewing to happen. While the regurgitating happens, keep head lower than hips to help forestall desire. In the event that individual is oblivious, go head to side. Stand out enough to be noticed quick.

8.4.2 Fire Hazard

Combustibility of the item Flammable

Auto Ignition temperature 445°C (833°F)

Streak focuses Closed cup 57.7°C (1136°F)

Combustible cutoff points

- Lower 2.2%
- Upper 15.2 %

Results of ignition - These items are carbon oxides (CO, CO₂), Nitrogen oxide(NO.NO₂)

Fire danger in event of - Flammable in event of open

Different substances - blazes and starts, of warmth. Non combustible in existences of stuns

Combustible substance may blast yet doesn't get light promptly. At the point when warmed, fumes may frame dangerous combinations with air: inside, outside risks. Contact with metals may develop combustible hydrogen gas. Holders may detonate when warmed. Overflow may contaminate stream moved in a liquid structure.

Precautionary measures

Keep holder dry. Avoid heat. Avoid wellsprings of start. Ground all hardware containing material. Try not to ingest. Try not to inhale gas/exhaust/fume shower. Never add water to this item. Inc instance of deficient ventilation, were reasonable respiratory hardware. In the event that the, look for clinical suggestion quickly and show the holder or the name. Stay away from contact with skin and eyes. Keep missing from incompatibles, for example, oxidizing specialists the import acids.

8.4.3 Storages and Handling

Store in an isolated from acids and corrosive framing substances and affirmed region. Keep stockpiling place in a cool, all around ventilated region. Keep stockpiling place firmly shut and fixed until prepared for use.

Garbage Disposal

Squander should be likely in understanding through government, state and nearby ecological oversee guidelines.

Speck Classification - Class 3 : combustible fluid. Girl 8: destructive material

Distinguishing proof - Amines, fluid, destructive, combustible.

8.4.4 Environmental data

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:

Possibly hazardous short term poverty products are not likely. However, long haul neediness items may emerge.

Poisonousness of the product of Biodegradation: The product of debasement are less destructive than the actual item.

9. PLANT LOCATION AND LAYOUT

9.1 PLANT LOCATION

Plant area intends to see a precise spot where a modern encounter can be begun more beneficial and a plant is where men, material, cash, gear, hardware and so on are united for assembling items. Plant area includes two significant exercises. Plant area assumes a primary part at the plan, creation at the decides expense follow at

- € Receiving appropriate crude substance.
- € Dispensation crude substance of completed items.
- € Completed items appropriation to clients.

The last choice of the plant area strongly affects the achievement of any mechanical endeavor. The accompanying eighteen issues ought to be measured at picking the plant.

9. 1. 1 Raw Material inventory

They have wellspring of crude substance as perhaps for the most part significant issues impacting the choosing arrangement. That crude substance ought to inexpensively & consistently accessible, since this grants extensive decrease shipping and capacity amount.

They fundamental crude substance utilized of the ethylene glycols. That have the basically accessible when the spots closer to (in view as colossal) and henceforth several modern zone close then state an appropriate spot those the plant area.

9.1.2 Markets

The area of business sectors or intermediates delivery centers can vigorously upset the expense of item dissemination. Essentially to huge marketplace container live helpful when at accompanying 3 different traditions:

- € An measure those transport completed products is cut definitely

downward.

- € An thesome delay of providing that merchandise of market can be decreased & evaded.
- € An marketplace such concentrated appropriately simply for example the future necessities can be simply & precisely anticipated.

9. 1. 3 Energy accessibility

An energy supply and warming gas supplies very high the greater part these at compound plants. Then the force and oil can be measured at the as one main issue when decision is established. When the neighborhood charge of force could be help is persuasive force ought to produced. To the extent our plant is stressed, both power and fuel (vaporous, fluid or strong) too as warming effectively close by resources.

9.1. 4 Water Supply

Then the substance interaction ventures utilize huge amounts of H₂O cool, warming, wash and crude substance. Along these lines ought to exist close by wellspring of H₂O. Each should be adequately on the resources could be Ajwalake, stream and so on.

9. 1. 5 Climate

Climate be able to contain genuine outcome at the financial working for the plant. Temp and dampness of climate ought to is ideal.

9. 1. 6 Transportation

Transportation ordinary items is constantly should have been shipped when the source of plant stamped another one different plant and crude equipment fundamental from the resources on the plant.

Subsequently an extraordinary arrangement when last item price. That the plant ought to contain straightforward admittance in the direction of ship offices. Really no just that vehicle offices accessible for a plant ought to likewise be fundamental, fast and accessible at sensible rates.

Water, railroad and public high-ways are the most widely recognized methods for transport. These offices are a lot of fundamental for the exchange of crude material and item transportation. Fortunately Baroda has these offices.

9.1.7 Labor supply

Accessibility of gifted workers with constant inventory and sensible compensation rate ought to be considered in the determination of the plant site. Work issue ought to be least.

9.1.8 Waste removal

The plant site ought to be with the end goal that it ought to have the best and satisfactory offices for squander evacuation. The reasonable acknowledgment levels for different strategies for garbage removal ought to be considered cautiously and consideration ought to be given to expected prerequisites for squander treatment offices.

9.1.9 Taxes and legitimate stages

The state and nearby expense rates on things, (for example, plant apparatus, building and so forth), pay, and joblessness protection and comparative things have significant impact such at the choice.

9. 1. 10 Site portrayal

An attributes of the site portrayal proposed at ought to exist analyzed reasonably. That have geology parcel and the dirt design should be estimated, if the both equivalents at articulated impact on development costs.

9. 1. 11 Fire and blast insurance

That ought to should be with the end goal that it ought to have the most ideal fastest fire security office accessible during the crisis. On the off chance that potential (implies if the organization can bear) the plant ought to have its own fire station, completely prepared most up to date putting out fires equipments&gifted

fire fighters group. Thus, if there should be an occurrence of crises it will not need to depend on resources.

9. 1. 12 High Class Library and preparing focus

This is the attribute of a decent and created gathering. To improve the plant appropriately, prepared staff is a great prerequisite and for additional examination and advancement of advances, high class library offices vital. At the instructional hub ought to be completely set up with talented coaches and preparing offices.

9.1.13 Community disposition

Accomplishment of an industry relies especially upon the methodology of the nearby individuals and if they need work.

9.2 PLANT LAYOUT:

Following the cycle stream chart are closed and before careful funneling, underlying and electrical plan can start, the format of interaction unit should plant layout. The new plant format implies allocating at room, course of action of gear and hardware in such a way so most prominent usage of labor, machines and material is done and least material dealing with is fundamental.

The ensuing variables ought to be estimated in choosing the plant design.

- New site extension or augmentations to heretofore created site.
- Type and amount of fabricated merchandise to be delivered.
- Possible future turn of events.
- Economic distribution of utilities and administrations.
- Type of building and construction regulation prerequisites.
- Health and wellbeing contemplations.
- Waste removal issues.
- Sensible utilization of floor and rise space.

- Operational accommodation and availability.
- Type of cycle and item control.
- Space accessible and space required.

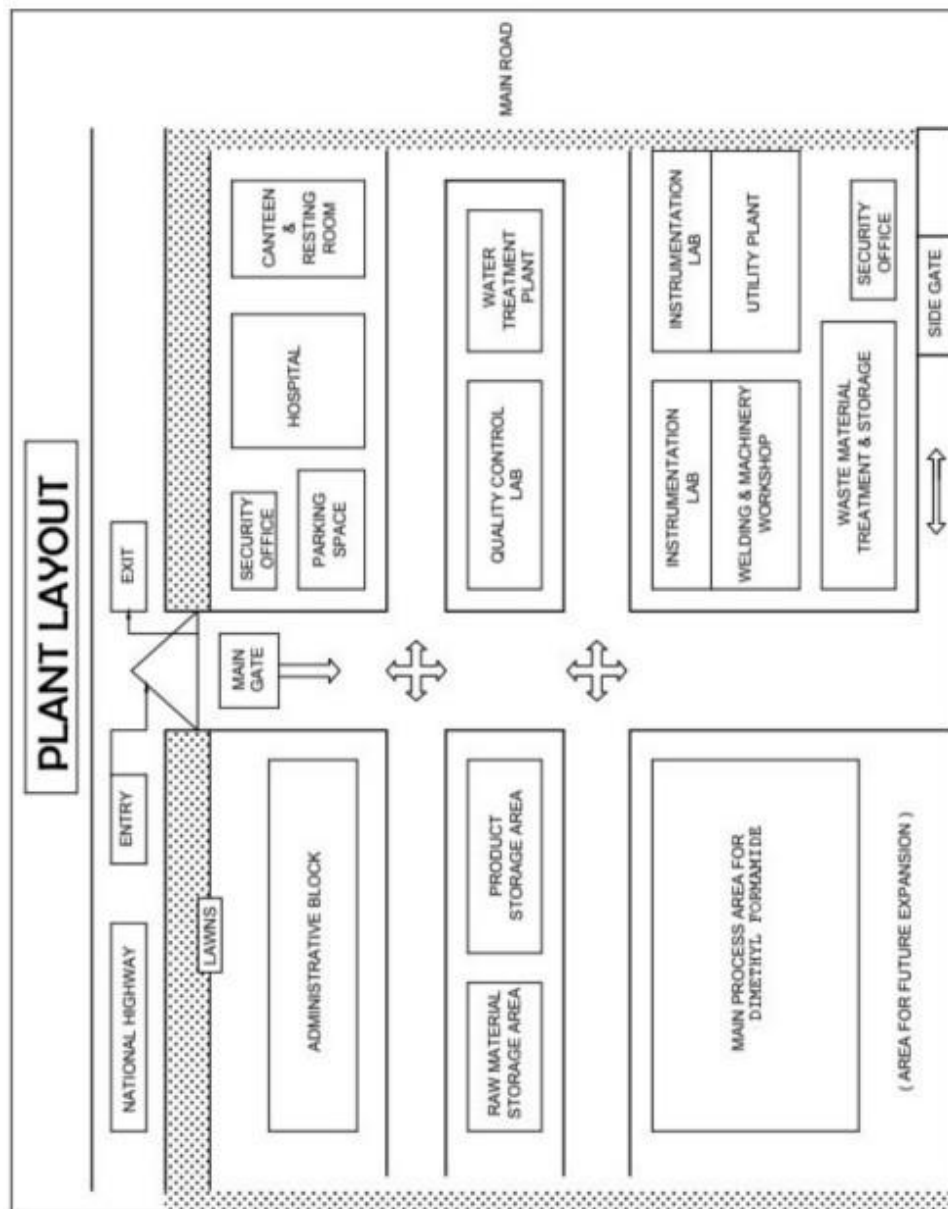
9.2.1 Storage Layout:

The adequate stockpiling of crude materials, middle items, end results, reuse assets and fuel are important to the working of cycle plants. Capacity of momentary items might be fundamental during plant closure for crisis fixes, while extra room of eventual outcomes makes it conceivable to supply buyer in any event, during a plant trouble of unexpected closure. A beneficial utilization of sufficient extra room is regularly experienced when it is important to satisfy transitory needs from consistent assembling.

9.2. 2 Equipments Layout

At the produce new plant resources format, anowing deliberation ought to adequate liberty ought to allot to every portion of gear and that the decorations. When near level at a many bits on gear and extras set up their position. importance stream is desirable over decline matter taking care of charge throughout creation, anyway it isn't with everything taken into account vital in light of the fact that fluids can be moved by siphoning and solids can be supported by mechanical methods. In make the hardware's design, the organization ought to be done with the goal that the assistance of gear's performing comparative capacity is bunch together and so the better co-appointment of the utilitarian is accomplished.

Fig 9.1 PLANT LAYOUT



9.1 plant layout

10. COST ESTIMATION

10.1 INTRODUCTION

Affordable assessment is a fundamental segment of substance plant plan that chooses whether the plan is monetarily conceivable. A worthy plant configuration should introduce an interaction that is gifted of working under conditions which will return a benefit. Since net benefit counterparts all out pay less all consumptions, it is fundamental that the compound specialist know about the a wide range of kinds of costs engaged with assembling measures. The complete venture required in a task when amount out charge at a stand total intended for start-up. It is the expense wage and workers for hire. operational resources when the extra venture fundamental, far beyond the fixed capital, to fire the plant up and work it to the moment that pay procured. A large portion of the working capital is recuperated at the finish of venture.

10.1.1 Production costs

That the achieve expenses reason architect should contain at total comprehension such as numerous variables then the influence expenses, because illustration such as components:

- Source of hardware
- Corporation Policies.
- Rate of production
- Government strategy.

TABLE 10.1 Price of raw material (ethylene oxide)

RAWMATERIAL	Price (₹/ton)	Amount(ton/ year)	Cost(₹/year)
ETHYLENE OXIDE	61753.50	3650	225.4*10 ⁶

TABLE 10.2 Price of product (ethylene glycol)

USES	Price (₹/ton)	Amount(ton/ year)	ANNUAL PROFIT (₹/year)
Polyester	54892	4.1660×10^3	22.868×10^7
Antifreeze	54892	4.1660×10^3	22.868×10^7
Diethylene glycol	53519.70	0.7×10^3	3.7464×10^7
Triethylene glycol	96061	0.0534×10^3	0.5×10^7
Total	259364.70	4919.4	50×10^7

S
e
.

10.2. 1 Total investment

Total capital investment (TCI) = fixed capital investment (FCI) + working capital (WCI)

Purchased equipment = 15-40 % TCI. Working capital investment = 10 - 20 %TCI

10.1. 2 purchased

6.2.2 Purchased equipment cost

The present capital cost of the equipment related to capacity by the equation:-

$$C_e = a + b * S_n \quad (6.1) \quad C_2 = C_1 * (\text{index of 2006} / \text{index of 2018})$$

For all materials:

$$\text{Index in 2018} = 1296.2 \quad \text{Index in 2006} = 478.6$$

TABLE 10.3 Price of Equipment

EQUIPMENT	COST(₹/year) *10 ⁶
REACTOR	7
EVAPORATORS(MULTIPLE EFFECT)	20.3
DISTILLATION	11.1
VESSELS	6.2
HEAT EXCHANGERS	3.1772
CONDENSER	0.5
FURNACE	0.25
TOTAL PURCHASE COST	48.52

$TCI = (\text{absolute bought hardware}/0.25)$

$=48.52 \times 10^6 / 0.25$

$=194.1088 \times 10^6 \text{ ₹}$

$WCI = TCI \times 0.15$

$=29.1163 \times 10^6 \text{ ₹}$

$FCI = TCI \times 0.85$

$=165 \times 10^6 \text{ ₹}$

Fixed capital expense = direct expense + backhanded expense

TABLE 10.4 Direct Costs

DIRECT COST	%
Purchased equipments	20
Installation of equip	10
Control	5
Piping	5
Electrical	5
Building	5

Yard	5
Land	2
Service facilities	10

TABLE 10.5 Indirect Costs

INDIRECT COST	%
Engineering and supervision	10
Construction expense	10
Contractor	3
Contingency	10

TABLE 10.6 Direct creation costs

Type	%	Cost(₹/year) *10 ⁶
Raw material	50 % of TPC	225.4
Operating labour	13 % of TPC	58.6040
Direct supervisory and clerical labor	15% of Operating labor	8.8
Utilities	15% of TCP	67.62
Maintenance and repairs	3% of FCI	4.9536
Operation supplies	0. 6% of FCI	0.99
Laboratory charges	11% Of operating labor	6.4464
Patents and royalties	1% Of TCP	4.5080
Total		377.32

Type	Percentage %	Cost(₹/year) *10 ⁶
Administrative costs	0.25% of TCP	1.127
Distribution and selling Costs	2% of TCP	9.0160
Research and development costs	2% of TCP	9.0160
Total		19.16

10.1.3 Gross income

- Net yearly benefit = Total pay – TCP= $50 \times 10^7 - 450.8 \times 10^6$
= 49.2×10^6 ₹
- Gross income = Net benefit – (taxes*net benefit) = 34.4400×10^6 ₹

10.1.4 Payback Period

- Payback period = $\text{TCI} / \text{Gross earnings} = 194.1088 \times 10^6$ ₹
/ 34.4400×10^6 ₹ = 5.6361 years

11. SUMMARY AND CONCLUSION

Ethylene Glycol is mostly used in various business and present day platform with fluid catalyst also as coolant. It helps keep engine safe at colder season and overheating in the summer. Already that main employments of ethylene glycol include heat move liquids utilized as evolved coolants for visit blowers, warming, ventilating, and cooling frameworks, and ice skating arenas. There is an incredible interest for this item in market. Direct hydration of ethylene oxide is presently the solitary route for modern scale creation of ethylene glycol as it is more affordable and doesn't include any pointless results. The compensation period was discovered to be 5.6361 years.

REFERENCES

1. Arun bahl and B S Bahl "A Textbook of Organic Chemistry", Chand,page-347.
2. Bhatt B.I. & Vora S.M., "Stoichiometry", 2nd edition, Tata McGraw-Hill Publishing Company Ltd.
3. Charles E. Dryden, Gopala Rao.M, Marshall Sittig, "Outlines of Chemical Technology", Affiliated East-West Press, page 57 to 106.
4. Christie John Geankoplis, "Transport processes and separation process principles", Prentice Hall Professional Technical Reference, page 48 to 92.
5. Donald Q Kern, "Process heat transfer", Tate McGraw-Hill Publishing Company , page 198 to 246.
6. Kirk & Othmer, "Encyclopedia of Chemical Technology", fourth Edition, John Wiley & Sons, New York, vol-12, page 696 - 714.
7. Lanny D.Schmidt,"The Engineering or Chemical Reactions", Oxford University Press, New York, page 16 to 41.
8. Mahmoud M. El-Halwagi, "Process Integration", Elsevier Science, page 89 to 108.
9. Robert E Treybal, "Mass Transfer operations", 3rd edition, 1967, page 186 to 204.
10. Soni P L , "Organic Chemistry", Sultan Chand.
11. Ullmann, "Ullmann's Encyclopedia of Industrial Chemistry", sixth edition, Wiley-VCH-Verlag Gmbh & Co. Weinheim, 2003, vol-12 (p-593-608).
12. Warren D. Seider, J. D. Seader, Daniel R. Lewin, "Product and process design principles", Third Edition, Wiley, 2017,page 108 to 174.