CONFIGURATION OF VARIOUS PROCEDURES INVOLVED IN PRODUCTION OF ETHYL BENZENE

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Technology degree in Chemical Engineering.

By

CRISPIN S (37190017)
MEHITHAN M (37190026)

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 **CRISPIN S (37190017)** and **MEHITHAN M (37190026)** who carried out the project entitled **“CONFIGURATION OF VARIOUS PROCEDURES INVOLVED IN PRODUCTION OF ETHYL BENZENE”** under our supervision from September 2020 to March 2021.

Internal Guide

Dr. A. ANNAM RENITA, Ph.D.,

Head of the Department

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

Submitted for Viva voce Examination held on________________________

Internal Examiner **External Examiner**

DECLARATION

I **CRISPIN S (37190017)** hereby declare that the Project Report entitled “**CONFIGURATION OF VARIOUS PROCEDURES INVOLVED IN PRODUCTION OF ETHYL BENZENE**” done by us under the guidance of **Dr. A. ANNAM RENITA, PH.D.**, at Sathyabama Institute of Science and Technology, Jeppiaar 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.

Crispin

SIGNATURE OF THE CANDIDATE

DATE: 20-03-2021

PLACE: CHENNAI

DECLARATION

I **MEHITHAN M (37190026)** hereby declare that the Project Report entitled "**CONFIGURATION OF VARIOUS PROCEDURES INVOLVED IN PRODUCTION OF ETHYL BENZENE**" done by us under the guidance of **Dr. A. ANNAM RENITA, PH.D.**, at Sathyabama Institute of Science and Technology, Jeppiaar 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.

SIGNATURE OF THE CANDIDATE

DATE: 20-03-2021

PLACE: CHENNAI

ACKNOWLEDGEMENT

I am pleased to acknowledge our sincere thanks to 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 **Dr. D. PRABHU, M.S., Ph.D.,** Head of the Department, **Department of Chemical Engineering** for providing us necessary support and details at the right time during the progressive reviews.

I would like to express our sincere and deep sense of gratitude to our Project Guide **Dr. A. ANNAM RENITA, Ph.D., Department of Chemical Engineering** for her valuable guidance, suggestions and constant encouragement paved 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

Ethylbenzene is a vital substance used in industry as a crude material for the creation of styrene monomer. The point of this work is the plan of a plant for the creation of 1000 tons/year of Ethylbenzene utilizing Y-zeolite as a fluid stage alkylation response impetus. Hardware plan of all the cycle units including reactors, heat exchangers, refining sections, and so forth is completed dependent on the information determined by energy and material balance. In financial examination of plant development and activity showed that the task is productive. At long last, the cycle control is set up to keep up the most secure and most conservative working conditions. Styrene monomer that is delivered from Ethylbenzene is then polymerized to polystyrene which is an exceptionally flexible polymer used to make a wide assortment of items, for example, food pressing, research centre product, hardware, auto parts. Its froth structure can likewise be utilized as a protecting material and lightweight defensive bundling.

TABLE OF CONTENT

CHAPTER NO. **TITLE** **PAGE NO.**

2. VARIOUS METHODS OF PRODUCTION AND CHOICE OF METHOD

3. MATERIAL BALANCE

4. ENERGY BALANCE

5. EQUIPEMENT DESIGN

6. PRICE ESTIMATION

8. SAFETY

9. INSTRUMENTATION AND PROCESS CONTROL

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Ethylbenzene remains a natural compound in the synthetic equation C_8H_{10}. This sweet-smelling compound (which is otherwise called phenyl ethane and ethylbenzol) has different applications; it is utilized in the creation of styrene which is additionally changed over to polystyrene. In addition, Ethylbenzene is utilized as a dissolvable in numerous enterprises like elastic assembling, paint fabricating, paper covering, and as a constituent of black-top and naphtha, and in powers. Ethylbenzene is produced by the corrosive catalyzed response of Benzene and Ethylene followed by refining to get the ideal Ethylbenzene and recuperate the unreacted Benzene.

1.1 HISTORY

As of now, practically all Ethylbenzene (EB) is created financially alkylation C_6H_6 with Ethylene, fundamentally by means of two courses: in liquid state with catalyst aluminum chloride, the fume stage is an engineered Zeolite catalyst. The alkylation of sweet-smelling hydrocarbons with olefins within the sight of aluminum chloride impetus first polished by M.Balshan in 1878. nonetheless, Charles Friedel and M. James creates spearheaded a large part in the early exploration on alkylating and catalyst aluminum chloride. In 1964 ca. 9% of the US Ethylbenzene creation are from the fractionation of blended xylenes stream delivered by synergist transforming of the naphtha. In 1985, the measure of C_8H_{10} got from the source was unimportant in view of heightening expense of energy.

Physical and substance properties of ethyl Benzene

There are different substance and actual properties of ethyl Benzene.

The actual properties of ethyl Benzene are appeared in (Table 1.1).

The most significant response of EB is its catalyzed dehydrogenation to styrene appeared in

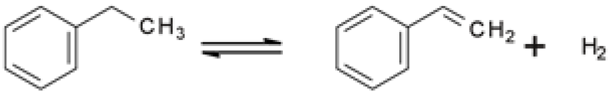

Table 1.1 Ethylbenzene Physical properties

Properties	Values
Molar mass	106.17 g/mol
Density	871.39 Kg/m^3
boiling point	136.186°C
heat of vaporization	335 KJ/Kg
heat capacity	1.169 KJ/Kg.K (ideal gas at 25°C)
	1.725 KJ/Kg.K (liquid at 25°C)
Vapor pressure	9.53 mmHg at 25°C

1.2.SUMMARY

In this part, the assembling interaction of Ethylbenzene by liquid phase alkylation of Benzene utilizing Y-zeolite catalyst is presented. Early cycles utilized aluminum chloride as an catalyst however it was supplanted by zeolites to dodge erosion issues. Ethylbenzene is the crude material for the assembling of styrene which is then polymerized to get ,the broadly utilized polymer, polystyrene. Physical and substance properties of Ethylbenzene are summed up. The poisonousness and wellbeing identified with each material present in the process are tended to. All the natural materials accessible are combustible, Benzene is cancer-causing, ethyl and Di-ethylbenzene are additionally cancer-causing yet are less dynamic and offer lower hazard than Benzene. The impetus is protected to use all the while and offers no natural effect on removal.

CHAPTER 2

VARIOUS METHODS OF PRODUCTION AND CHOICE OF METHOD

2.1 METHODS OF PRODUCTION:

The different process for manufacturing of Ethyl Benzene are:

- Liquid phase process - catalyst aluminum chloride
- Vapor-phase process - catalyst zeolite
- Liquid phase process - catalyst zeolite
- Mixed Liquid-Vapor Phase process - catalyst zeolite

2.1.1 LIQUID PHASE PROCESS - CATALYST ALUMINUM CHLORIDE

- Liquid phase process - catalyst aluminum chloride have been the dominant source of Ethyl Benzene since the 1930s to about 1985.

2.1.1.1 DESCRIPTION

Benzene Alkylation within the sight of an Aluminum chloride impetus complex is exothermic. In the traditional $AlCl_3$ measure three stages are available in the reactor. Fragrant fluid, Ethylene gas, and a fluid impetus complex stage. A combination of impetus intricate, dry Benzene, and reused poly-alkyl Benzenes is constantly taken care of reactor and upset to scatter the impetus complex stage in the sweet-smelling stage. Ethylene and impetus advertiser are infused into the response blend through spargers. The fluid reactor emanating is cooled and released into a pilgrim, where the substantial impetus stage is emptied from the natural fluid stage and reused. The natural stage is washed and acidic to eliminate broke up $AlCl_3$ and advertiser. The watery stage from treatment steps in first killed and afterward recuperated as a soaked aluminum chloride arrangement and wet aluminum hydroxide slop. Un-responded Benzene is recuperated by the principal sections as overhead distillate. Subsequent section isolates the ethyl Benzene item from heavier poly-alkylated parts. The bottom result of subsequent section is taken care of last segment, where the recyclable polyalkyl-Benzenes are taken from unrecyclable high sub-atomic mass buildup compounds. Buildup or motion oil, comprising essentially of polycyclic - aromatics, is singed as fuel.

2.1.1.2 ADVANTAGES

- The aluminum chloride present in alkylation reactor effluent catalyst transalkylation response
- Rapid reaction takes place when aluminum chloride present in it and delivers practically stoichiometric products of Ethylbenzene.
- In essence 100% of Ethylene is changed over.

2.1.1.3 DISADVANTAGES

- Handling and removal of aluminum chloride impetus and waste has become progressively pricelier and more confounded due to natural contemplations
- Equipment and funnelling erosion and fouling alongside related natural issues prompted advancement of EB measure dependent on strong corrosive heterogeneous impetuses
- Major hardware pieces should have been supplanted on normal timetable due to erosion which brings about broad turnarounds helpless plant on-stream proficiency and hence are essential supporters of the high working expenses related with aluminum chloride

2.1.2 LIQUID PHASE PROCESS - ZEOLITE CATALYST

2.1.2.1 DESCRIPTION

The alkylator is kept up in fluid stage and uses numerous beds of catalyst for Ethylene infusion. The Ethylene transformation is basically 100% in the alkylator and reactor almost works isothermally. The exothermic warmth of response is recuperated and used to create steams or as warmth obligation in the refining sections. The alkylator and transalkylator emanating stream are shipped off the refining segment which comprise of basically of three refining segments. The main segment is Benzene section and that isolates overhead stream of unconverted Benzene is reused in reactor. Benzene section base stream takes care of the Ethylbenzene segment. The Ethylbenzene section recuperates the Ethylbenzene item in the overhead stream and the base stream of the Ethylbenzene segment takes care of the Di-Ethylbenzene segment where Di-Ethylbenzene is fractionated overhead and reuse to the transalkylator. The base stream of the Di-Ethylbenzene segment is eliminated as the build up stream and is for the most part utilized as fuel in a coordinated styrene.

2.1.2.2 ADVANTAGES

- The fluid stage zeolite impetus measure works at generously lower temperature which diminished side responses drastically bringing about super high immaculateness EB item.
- The plant accomplishes high on stream proficiency frequently more noteworthy than 99% which brings about low turnaround and upkeep price.
- Catalyst recovery is mellow carbon consume methodology that is moderately modest

2.1.3 MIXED LIQUID-VAPOUR PHASE PROCESS - ZEOLITE CATALYST

The cycle depends on blended fluid fume stage alkylation reactor area. The plan of business plant is like the fluid stage innovations aside from the plan of the alkylation reactor which joins synergist response with refining into a solitary activity.

2.1.3.1 DESCRIPTION

This interaction works under alkylation reactor, which consolidates synergist response with refining into a solitary activity. Response temperature is 150-195 and working pressing factor of 1.7-2.2 MPa. Selectivity was above 83% (just Benzene feed) and much higher than 99% (Benzene in addition to transalkylation feed). The interaction can be helpfully part into 3 significant segments: Alkylation, transalkylation and refining area.The alkylation reactor comprises of two areas synergist refining and standard refining segment. Benzene is taken care of at the highest point of the reactor and Ethylene is taken care of as a fume at the base in synergist refining area making counter current progression of reactants to synergist refining segment. Ethylene breaks up into the fluid stage quickly warmth of response makes the vaporization important to influence the refining. The alkylation items mostly Ethylbenzene, di-Ethylbenzene and different items are persistently fractioned and taken out from the synergist refining area. In base area standard refining happens and base stream exits containing Ethylbenzene, Di-Ethylbenzene and different items. Transalkylation response happens on fixed beds of the impetus utilizing a fume fluid combination of Benzene and different pollutions like cyclohexane. Transalkylation happens at the temperature in the scope of 230-260 C. Benzene utilized in stoichiometric abundance which gives half transformation of Di-Ethylbenzene to Ethylbenzene per pass. The fundamental response is the alkylation of Benzene to give Ethylbenzene. The above response is done at 190 within the sight of Zeolite Catalyst. At long last, Di-Ethylbenzene and Ethylbenzene continue to Benzene stripping segment which works in the temperature scope of 295-325 relying on the pressing factor. Terminated radiator (or hot oil) gives warmth to warm obligation. The stripping heat input likewise diminishes the alkylation temperature in this manner improving the alkylation pace of response and limits the utilization of impetus required.

2.1.3.2 ADVANTAGES

- Purity of item is more than other assembling measure.
- Less unadulterated Ethylene and Benzene is utilized.
- Low working conditions.

2.2 CHOICE OF METHOD

The fluid stage alkylation measure was discovered to be more savvy and more secure to work than different cycles. In this manner, it was picked for additional examination. An examination among fluid and gas stage alkylation is appeared in (Table 2.1)]. In the accompanying parts the fluid stage interaction will be seriously researched

Table 2.1 Comparison between the two modes of operation for alkylation reaction

Liquid phase Production Using Zeolite Catalyst	Gas phase Production Using Zeolite Catalyst
Moderate operating temperatures and pressures between 420-460 K and 60-160 psig	Extreme operating conditions between 665-750 K and 200-400 psig resulting in higher risk.
Benzene/Ethylene alkylator feed ratios range from 1.4-2.5 on a molar basis	Benzene/Ethylene ratio is approximately 8-16 by mole fraction.
Requires both alkylation and trans-alkylation reactors put in series.	Two reactors in parallel are used, Alkylation and transalkylation take place in the same reactor, while the other is for regeneration
Large savings available in operational prices.	Higher price of operation
catalyst life is approximately from 2-5 years for the alkylator and the transalkylator	The catalyst requires regeneration every 2-4 weeks

All the processes that had been proposed for the production of Ethylbenzene are reviewed. The processes are categorized based on the catalyst used and/or the reactants' phase in the alkylation reactor into five processes. Two processes utilize aluminum chloride as catalyst for the reaction in liquid or gas phase. The three remaining processes utilize zeolite as catalyst for the reaction in liquid phase, gas phase or mixed phases in a reactive distillation system. The process selection is carried out between the liquid phase alkylation using zeolite catalyst and the mixed phases process, other processes are eliminated. The liquid phase process is chosen over the mixed phases process because the reactive distillation system in the mixed phases process is extremely difficult to control which can lead to the formation of many undesired by- products; greatly decreasing selectivity and increasing the complexity of the process.

2.2.1 LIQUID PHASE METHOD - ZEOLITE CATALYST

2.2.1.1 PROCESS DESCRIPTION

Ethylbenzene is being delivered from Benzene and Ethylene by fluid stage alkylation in a stuffed bed reactor, fitted with a fixed bed of zeolite utilized as catalyst. Vaporous Ethylene is sparged into the fluid period of Benzene combination (new Benzene and reused Benzene from Benzene refining section) in the main reactor (alkylator). The two reactors work at high pressing factor (20 atm) to keep up the fluid stage in the reactor at high temperatures needed for sensible response rates. Alkylator works at 210°C and Ethylene change is 100%. The response is exothermic under isothermal condition. The emanating from first reactor (alkylator) and second reactor (trans alkylator) are taken care of to Benzene refining segment. It isolates a distillate that is combination of Benzene and Ethylbenzene however it is generally Benzene (virtue 99.9%) which is reused to alkylator and trans alkylator. Base stream ,a combination of Ethylbenzene and Di-ethylbenzene, is taken care of to a second refining segment. It produces Ethylbenzene as a distillate (immaculateness 99.88%) and a Di-Ethylbenzene base is reused back to transalkylator. In the trans alkylator Di-Ethylbenzene responds with Benzene to create Ethylbenzene which is blended in with the emanating from the alkylator and sent for cleaning in Benzene and Ethylbenzene sections.

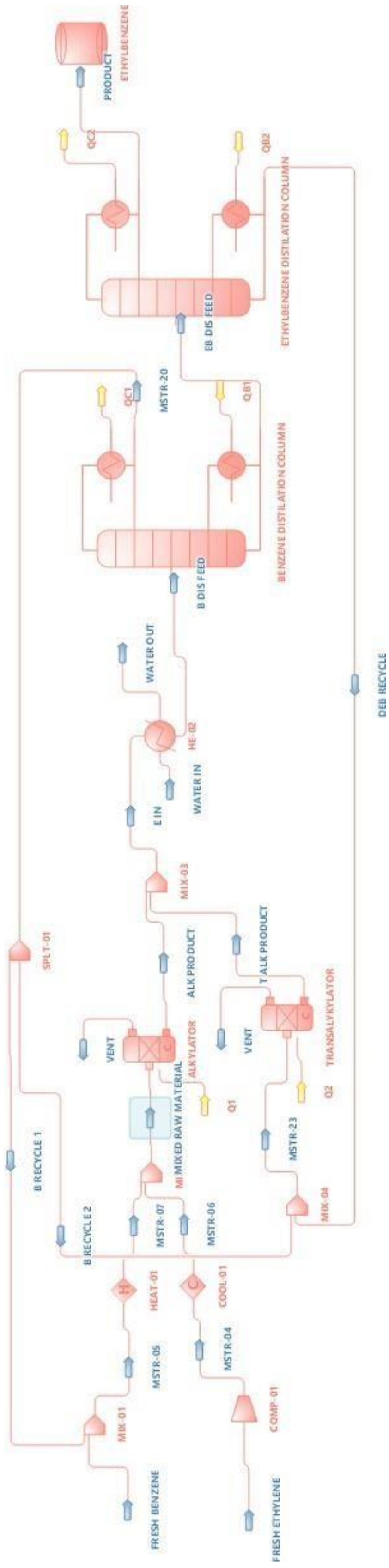

Fig 2.1 Process Flow Diagram

CHPATER 3

MATERIAL BALANCE

3.1 MATERIAL BALANCE DATA

- Basis:
- Production of 1000 TPA of Ethyl Benzene
- The process is planned and processed as a continuous process. The plant is operated for 330 days per year.
- Number of Working days: 330
- Plant maintenance: 35days
- Reaction:

  $C_6H_6 + C_2H_4 \longrightarrow C_6H_5C_2H_5$

  $C_6H_5C_2H_5 + C_2H_4 \longrightarrow C_6H_4 (C_2H_5)_2C_6H_4$

  $(C_2H_5)_2 + C_6H_6 \longrightarrow C_6H_5C_2H_5$

- ASSUMPTIONS:

  100% conversion of limiting reactant

  Limiting reactant is Ethylene

  The conversion rate is 90%

Weight basis=1000*1000/330*24=126.26kg/hr

Mole basis=126.26/106=1.191kmol/hr

3.1.1 OVERALL MATERIAL BALANCE

Assuming 100% conversion

126.6 kg/hr of Ethyl Benzene=90%of Ethyl Benzene formation x kg/hr of Ethyl Benzene=100%of Ethyl Benzene formation

X=126.26*100/90

X=140.28 kg/hr of Ethyl Benzene

FROM STOICHIOMETRY

106 kg/hr of EB required 84 kg/hr of Ethylene

140.28 kg/hr of EB required x kg/hr of Ethylene

X=84*140.28/106

X=111.16 kg/hr

TOTAL AMOUNT REQUIRED

84 g/mol EB= 210 g/mol Total reactant

111.6 kg/hr EB =?

X = 210 * 116.16/84=317.6

Amount of Benzene required = 317.6 – 111.16

Benzene is required = 206.44

$2C_6H_6 + 3C_2H_4 \longrightarrow C_8H_{10} + C_{10}H_{14}$

156 + 84 = 106 + 134

240 = 240

Total content of product = 240 g/mol

$C_6H_5C_2H_5$ -> 106 g/mol

$C_6H_4(C_2H_5)_2$ = 134 g/mol

Amount of $C_6H_5C_2H_5$ formed

134 g/mol DEP → 240 g/mol total

X → 317.61 g/mol of total

X= 134*316.6/240 = 177.32 kg/hr

Table 3.1 Overall material balance

Component	Input		Output	
	Kg/hr	g/mol	Kg/hr	g/mol
Benzene	206.4	156	-	-
Ethylene	111.16	84	-	-
Ethylbenzene	-	-	140.27	106
Diethyl Benzene	-	-	177.32	134
Total	317.60	240	317.59	240

3.1.2 ALKYLATOR MATERIAL BALNCE

Assuming 100% conversion

126.6 kg/hr of Ethyl Benzene=90%of Ethyl Benzene formation

x kg/hr of Ethyl Benzene=100%of Ethyl Benzene formation

X=126.26*100/90

X=140.28kg/hr of Ethyl Benzene

FROM STOICHIOMETRY

106 kg/hr of EB required 28 kg/hr of Ethylene

140.28 kg/hr of EB required x kg/hr of Ethylene

X=28*140.28/106

X=37.05 kg/hr

TOTAL AMOUNT REQUIRED

28g/mol E= 240 g/mol Total reactant

37.05kg/hr E EB =?

X = 240 * 37.05/28=317.57 kg/hr

Amount of Benzene required = 317.57 –37.05

Benzene is required = 280.52 kg/hr

106kg/hr of Ethyl Benzene=184 g/mol of total

X=182.94 kg/hr

78 g/mol of Benzene=184 g/mol of total

X=78*317.57/184

X=134.62 kg/hr

Table 3.2 Material balance for alkylator reactor

Component	Input		Output	
	Kg/hr	g/mol	Kg/hr	g/mol
Benzene	280.53	156	134.62	78
Ethylene	37.05	28	-	-
Ethylbenzene	-	-	182.94	106
Total	317.57	184	317.56	184

3.1.3 BENZENE DISTILATION COLUMN MATERIAL BALANCE

Benzene = 134.6 kg/hr

Ethyl Benzene=182.94 kg/hr

F=D+B

317.56=D+B

$FX_f = X_D.D + X_B.B$

133.38=0.998D+0.002B

On Calculating

D=133.64 Kg/hr

B=183.92 Kg/hr

Table3.3 Benzene distillation column material balance

Component	Input	Output	
	Kg/hr	Distillate (Kg/hr)	Bottom (Kg/hr)
Benzene	134.62	133.6	1.02
Ethylene	-	-	-
Ethyl Benzene	182.94	0.98	183.92
Diethyl Benzene	-	-	-
Total	317.56	134.58	184.94

3.1.4 ETHYLBENZENE DISTILATION COLUMN MATERIAL BALANCE

Benzene = 1.02 kg/hr

Ethyl Benzene=183.94 kg/hr

F=D+B

202=D+B

$FX_f = X_D.D + X_B.B$

181.8=0.998D+0.002B

On Calculating

D=182.12

B=19.88

Table 3.4 Ethylbenzene distillation column material balance

Component	Input	Output	
	Kg/hr	Distillate (Kg/hr)	Bottom (Kg/hr)
Benzene	1.02	1.02	-
Ethylene	-	-	-
Ethyl Benzene	183.92	182.1	1.82
Diethyl Benzene	18	1.8	19.88
Total	202.94	184.92	21.7

CHAPTER 4

ENERGY BALANCE

4.1 ENERGY BALANCE DATA

BOILING POINTS

Benzene = 80.1^{o} C

Ethylene = -103.7^{o} C

Ethyl Benzene = 136^{o} C

Diethyl Benzene = 184^{o} C

SPECIFIC HEAT CAPACITIES

Benzene = 133 J/mol K

Ethylene = 67.4 J/mol K

Ethyl Benzene = 186.6 J/mol K

Diethyl Benzene = 115 J/mol K

ENTHALPY VALUES

Benzene = -3267.6 kJ/mol

Ethylene = 13.6 kJ/mol

Ethyl Benzene = -12.55 kJ/mol

Diethyl Benzene = -73.2 kJ/mol

4.1.1 ALKYLATOR ENERGY BALANCE

Q=mCpdt

Input

Benzene=280.53*133*(210-25) =6.9*10^6 KJ/hr

Ethylene=37.05*67.4*(210-25) =0.4*10^6 KJ/hr

Output

Benzene=134.62*133*(107-25) =1.4*10^6KJ/hr

Ethyl Benzene=182.94*186.6*(107-25) =2.8*10^6 KJ/hr

ΔH_f=ΔH of products - ΔH of reactants

ΔH_f=-3.1*10^6

Table 4.1 Energy balance for alkylator

Component	Input kJ/hr	Output kJ/hr
Benzene	6.9*10^6	1.4*10^6
Ethylene	0.4*10^6	-
Ethyl Benzene	-	2.8*10^6
Di ethyl Benzene	-	-

4.1.2 BENZENE DISTILLATION COLUMN ENERGY BALANCE

Inlet temperature=107° C

Distillate temperature=86 ° C

Bottom temperature=110 ° C

Input

Benzene=134.62*133*(107-25) =1.4*10^6 KJ/hr

Ethylbenzene=182.94*186.6*(107-25) =2.8*10^6 KJ/hr

Output

Distillate

Benzene=133.62*133*(86-25) =1.08*10^6 KJ/hr

Ethylbenzene=0.98*186.6*(110-25) =1.1*10^4 KJ/hr

Bottom

Benzene=1.02*133*(110-25) =1.1*10^4 KJ/hr

Ethylbenzene=183.92*186.6*(110-25) =2.9*10^6 KJ/hr

Diethyl Benzene=18*115*(110-25) =1.7*10^5 KJ/hr

Table 4.2 Energy balance for Benzene distillation column

Component	Input	Output	
	KJ/hr	Distillate (KJ/hr)	Bottom (KJ/hr)
Benzene	1.4*10^6	1.08*10^6	1.1*10^4
Ethylene	-	-	-

Ethyl Benzene	$2.8*10^6$	$1.1*10^4$	$2.9*10^6$
Diethyl Benzene	-	-	$1.7*10^5$

4.1.3 ETHYLBENZENE DISTILLATION COLUMN ENERGY BALANCE

Inlet temperature=151° C

Distillate temperature=146 ° C

Bottom temperature=200 ° C

Input

Benzene=1.02*133*(151-25) =1.7*10^4 KJ/hr

Ethylbenzene=183.92*186.6*(151-25) =4.3*10^6 KJ/hr

Diethyl Benzene=18*115*(151-25) =2.6*10^5 KJ/hr

Output

distillate

Benzene=1.02*133*(146-25) = 1.6*10^4 KJ/hr

Ethylbenzene=182.1*186.6*(146-25) =4.1*10^6 KJ/hr

Diethyl Benzene=1.8*115*(146-25) =2.5*10^4 KJ/hr

Bottom

Ethylbenzene=1.82*186.6*(200-25) =1.1*10^4 KJ/hr

Diethyl Benzene=19.88*115*(200-25) =1.7*10^5 KJ/hr

Table 4.3 Energy balance for Ethylbenzene distillation column

Component	Input	Output	
	KJ/hr	Distillate (KJ/hr)	Bottom (KJ/hr)
Benzene	$1.7*10^4$	$1.6*10^4$	-
Ethylene	-	-	-
Ethyl Benzene	$4.3*10^6$	$4.1*10^6$	$5.9*10^4$
Diethyl Benzene	$2.6*10^5$	$2.5*10^4$	$4*10^5$

CHAPTER 5

EQUIPEMENT DESIGN

5.1 DISTILLATION COLUMN DESIGN

The parameters necessary for the design are,

- Vapour load
- theoretical No of stages
  - Feed stage
  - Rectifying stages
  - Stripping stages
- Actual number of stages
- Column height

1.Vapour load,

V = D(R+1) MV/3600*ρv

D = Number of moles of distillate

MV = Average molecular weight

ρV = Density of vapour

D = 133.6/78 = 1.712 moles

Where,

MV = Molecular weight * xi

Mole fraction:

Mv = 78 * 0.998+ 106* 0.002 = 78.056 g/mole

$\rho = P\ M_{avg} / RT$

Operating pressure

=131.72*78.056/8.314*(275+86)

= 3.425 kg/m3

Vapour load,

V =1.712*(8+1)*78.056/3600*3.425

V = 0.097 m3/sec

2. Minimum number of theoretical stages are calculated using Macabe–Thiele Method

Step 1: Convert the data in mole basis

Amount of Benzene = 134.62 Kg/hr

Amount of EB = 182.94Kg/hr

Total amount of feed entering the Distillation column = 329.68 Kg/hr

Mole Basis:

Amount of Benzene = 0.42

Amount of EB = 0.58

Step 2: Material Balance for Distillation column

F = D + W

$FX_f = X_D.D + X_B.B$

We calculated:

$X_F = 0.42$

$X_D = 0.998$

$X_w = 0.002$

Step 3: Determine VLE data

$y = \alpha x / 1 + (\alpha - 1)x$

Relative volatility $\alpha = 3.9$

$x = 0.2$

$y = \alpha x / 1 + (\alpha - 1)x$

$y = (3.9 * 0.2) / 1 + (3.9 - 1) * 0.2$

$y = 0.49$

Table 5.1 VLE data

X	y
0	0
0.2	0.49
0.4	0.72
0.6	0.85
0.8	0.93
1	1

Step 4: Plot a graph between x and y

Step 5: locating X_D , X_W , X_F on the diagonal line

Step 6 : From X_F draw the q line the q line is vertical here because the feed is in liquid state

Step 7: Joining X_D and the intercept point of q line and equilibrium curve and extent to Y axis

The Y intercept is X_D/Rmin+1 =0.54

X_D = 0.998

Rmin= (0.998 / .54) - 1 = 1.848

Ract = 2.6(0.1848) = 3.696

X_D/Ract+1 = 0.998/(3.696 + 1) = 0.21

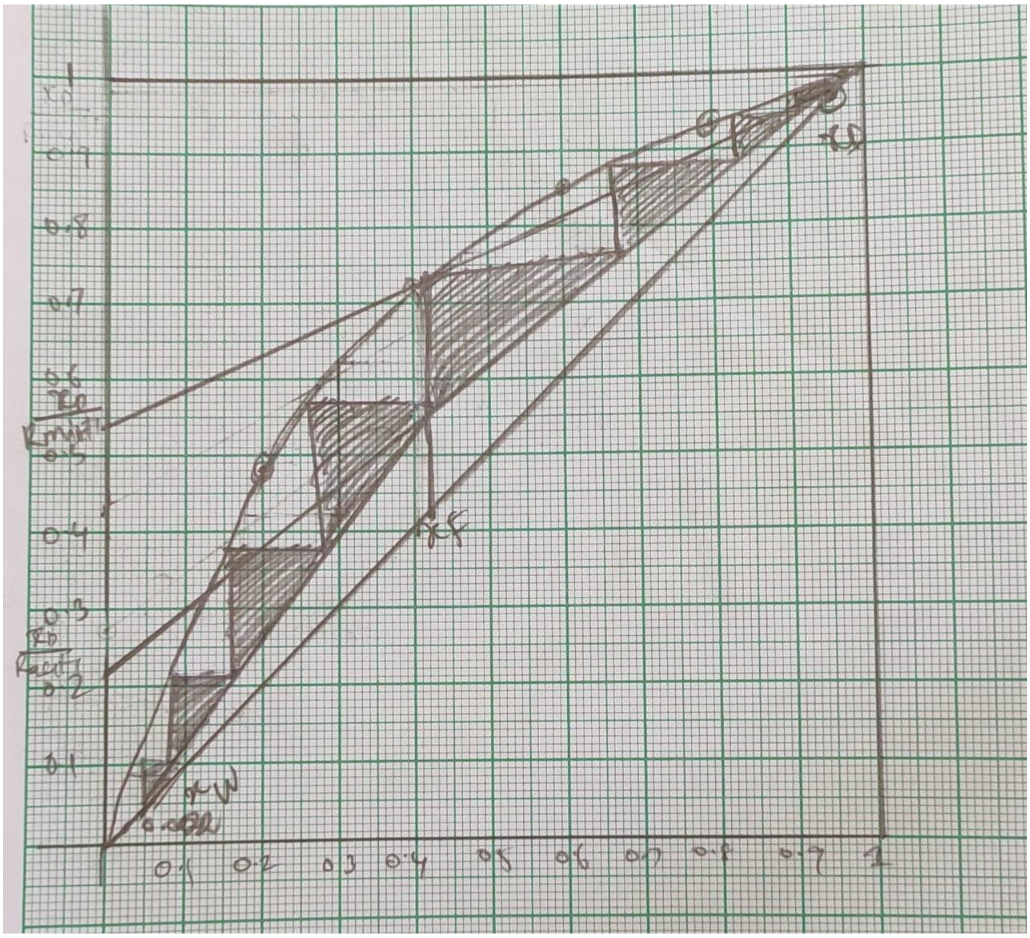

Fig 5.1 Graph from VLE data

Equilibrium curve – The line joining the VLE data

Diagonal line – The line Joining the X_D , X_W , X_F

q line is based on the feed condition(liquid)

Theoretical number of stages = 8

Feed stage location = 4

Number of Rectifying stage = 4

Number of stripping stages = 4

3. Actual number of stages = (theoretical no of stages – 1)/efficiency) +1

Efficiency = 99.8% = 0.998

Actual trays = (8 -1)/0.998)+1 = 8

4. Column Height = (N-1)P + 2P

Where, The plate spacing P =0.4m

Column Height=(8-1)*0.4+2*0.4

= 3.6 m

DESIGN SUMMARY OF DISTILLATION COLUMN

Vapour load=0.096 m3/sec

Theoretical number of stages = 8

Actual number of plates=8

Feed stage location = 4

Column Height=3.6m

5.2 ALKYLATOR DESIGN

Reaction:

$2C_6H_6 + C_2H_4 \rightarrow C_6H_6 + C_8H_{10}$

Reaction Temperature=150°C-190°C

$-r_B = k_rC_E/1+k_{EB}\, C_{EB} \quad \frac{\text{kmol Bz}}{\text{kg catalyst.hr}}$

K_r=0.69*10^6exp(-6.344*10^4/RT)

k_{EB} =-1.5202*10^-2exp $\left(\frac{-3.933*10^{\wedge}3}{\text{RT}}\right)$

$-r_{EB}$=2.8 *10^-2exp $\left(\frac{-4.7030*10^{\wedge}4}{\text{RT}}\right)C_{EB}\, C_E \quad \frac{\text{kmol EB}}{\text{kg catalyst.hr}}$

$-r_E=-r_B - r_{EB}$

On calculating

$-r_E = \frac{1.33*10^{-15}Ce}{0.999Ceb}$ +1.0376*10^13$C_{EB}.\, C_E$

$C_E = C_{E_o}(1-X_E)$

$C_{EB}= C_{EB_o} +0.95\, C_{E_o}X_E -0.05\, C_{E_o}X_E$ dX0/dw=(1.33*10^15*C_{E_o}

/0.999*C_{EB_o})+1.2376*10^-13

W=134.62 kg/hr

The volume of solid catalyst =weight of the catalyst/density of catalyst

Density of zeolite catalyst = 740 kg/m^3

Volume of solid catalyst= 4.34 m^3

Bulk volume occupied by catalyst= volume of solid catalyst/(1-porosity of catalyst)

Porosity of zeolite catalyst= 0.15

Bulk volume occupied by the catalyst=5.1m^3

Distributing the catalyst onto 2 beds, 0.5 m is allowed between each bed and the same for entrance and exit of fluid.

So, the volume of the reactor available for feed flow (assuming the feed is introduced below the ellipsoidal head) = volume of the catalyst + volume between beds + entrance and exit volume

$(\pi/4)D^2L=5.1m^3+(0.5*(\pi/4)D^2)+(2*0.5*(\pi/4)D^2)$

On solving this we get D=2.08m

Using aspect ratio(L/D=1.25)   L=1.25*2.08=2.6m

Residence time(τ)=void volume /volumetric flow rate

Void volume=8.77-4.34=4.43m^3

Volumetric flow rate=110.93m^3/hr

Residence time(τ)=0.039   hr=25min

Choose 316 stainless steel due to its high corrosion resistance and good mechanical and thermal properties. The cylindrical wall thickness can be calculated from (Eq.5.40) based on the theory of thin cylinders

$t= (p_i*d_i/(2\ \sigma_{all}\ \eta_j-P_i))+C$ t

: Wall thickness. In mm

P_i : Design pressure. In MPa (taken as 2.2 MPa)

d_i : Inner diameter of the reactor. In mm

σ_{all} : Allowable tensile stress for the reactor material. It is based on the yield strength of the material with a suitable factor of safety. For 316 stainless steel the yield strength is equal to 205 MPa. For a factor of safety=1.5, the allowable tensile stress is equal to 205/1.5 = 136.667 MPa.

η_j: Longitudinal joints efficiency which depends on the efficiency of welding (Illustrated in figure)

C: Corrosion allowance(taken as 1mm)

t= (2.2*2080/(2*136.667*0.85-2.2))+1=20.88mm

$t_h= (K_f *pi*d_i/(2\ \sigma_{all}\ \eta_j-0.2P_i))+C$

Where:

t_h : Head thickness. In mm

Kf : Stress intensification factor $K_f =1/6(2+k_i^2)$

Where k_i is the ratio of the major axis to minor axis of the ellipsoidal head (commonly taken as 2). Therefore, $K_f = 1$

Take C= 0.3 (less susceptible to corrosion)

t_h= (1*2.2*2080/(2*136.667*0.85-(0.2*2.2)))+.3=20.03mm

Now the cooling configuration of the reactor is determined. First a cooling jacket is considered. In a previous study of a reactor for the same system and overall heat transfer coefficient of 850 W/m^2.k . Temperature profile of the reactor is shown in figure

The flow inside the reactor is assumed to be analogues to flow inside a one shell pass two tube pass reactor(co current in a section and counter current in other section). The overall heat transfer equation.

Q=UA

ΔTmF

Where

U: Overall heat transfer coefficient.

A: Heat transfer area required.

ΔTm: Logarithmic mean temperature difference.

F:Temperature correction factor, 0.98

The parameters required for the determination of F are:

S=(123.25-25)/(210-25)=0.531

R=(210-210)/(123.25/25)=0

F=0.98

ΔTm= ((210-123.25)-(210-25))/ln((210-123.25)/(210-25)))

= 129.73^{o} C

Q=3.1*10^{6} = 850* A* 129.73 * 0.98

A=28.68m^{2}

CHAPTER 6

PRICE ESTIMATION

Adequate plant configuration ought to introduce an interaction that's equipped for operating below conditions, which can come back profit. Since internet benefit approaches absolute price short all prices, it's basic that the compound specialist realizes the varied types of price includes within the grouping measures. Capital should apportion for the immediate, plant prices like those for crude material, work and hardware.

Other than direct prices various alternative aberrant prices are brought about, and these should be incorporated if a complete examination of the entire expense is to be acquired. many instances of those circuitous prices are authoritative compensation, item conveyance price and value for interplant correspondence. A capital speculation could be a required for every mechanical cycle and assurance vital} venture is a significant piece of plant configuration measure. The all out speculation for any interaction comprise fastened capital venture for helpful hardware and offices within the plant additionally to operating capital, that ought to be accessible to pay compensations keep crude materials and things available, and handle alternative distinctive things requiring the immediate expense diagram

At the purpose once the expense for a business interaction is to be resolved, adequate truth should be accommodated solid choice. There are various parts influencing speculation and creation price.

These are:

1. Source of equipment
2. Price fluctuation
3. Company policies
4. Operating and rate of production
5. Governmental policies

Beforea mechanical plant are often placed into activity ,a immense amount of money ought to be provided to shop for and introduce the very important hardware and gear. Land and administration offices should be acquired, and also the plant should be raised completely with all channeling, controls and administrations. The capital expected to produce the essential aggregation and plant offices is understood because the mounted capital speculation, whereas that important for the activity of the plant is called the operating capital. the quantity of the fixed capital speculation and the working is known as the absolute capital venture. by and large, the working capital total twenty - 30% of the entire capital venture. Following is that the breakdown of the mounted capital venture for an artificial cycle.

Direct price

1. Purchased instrumentation
2. Purchased equipment installation
3. Instrumentation and control
4. Piping
5. Electrical equipment and material
6. Building
7. Yard improvement
8. Land

Indirect price

1. Engineering supervision
2. Construction process
3. Contractor’s fees
4. Contingency

6.1 PRICE ESTIMATION

Estimation of present plant price

From operation price and economic analysis,

Consider,

The present plant price can be given as 1000 tons per annum of the propylene glycol is

=>Rs 250 L

6.1.1 DIRECT PRICE

A Direct price = Purchased instrumentation + Purchased equipment installation + Instrumentation and control + Electrical equipment and material + Land Building + Yard improvement +Piping

1. Price for purchased equipment (15-40% of fixed capital investment):

   Assume 30% of fixed capital investment

   => Rs 75 L

2. Installation price, including insulation and painting (25-55% of purchased price)

   Assume 40% of purchased price

   => Rs 30 L

3. Instrumentation price and control price (6-30% of purchased price)

   Assume 13% of purchased price =

   => Rs 9.75 L

4. Piping installation price (10-80 % of purchased price)

   Assume 45% of purchased price =

   => Rs 33.75 L

5. Electrical price (10-40 % of purchased price)

   Assume 15% of purchased price =

   => Rs 11.25 L

6. Building process and auxiliary (10-70 % of purchased price)

   Assume 40% of purchased price =

=> Rs 30 L

7. Service facilities (30-80 % of purchased price)

   Assume 50% of purchased price =

   => Rs 37.5 L

8. Yard improvement (10-15 % of purchased price)

   Assume 12% of purchased price =

   => Rs 9 L

9. Land (4-8 % of purchased price)

   Assume 6% of purchased price =

   => Rs 4.5 L

DIRECT PRICE => Rs 240.75 L

6.1.2 INDIRECT PRICE

A. Indirect price = engineering and supervision + construction expenses and contractor fees + contingency

1. Engineering and supervision (5-30 % of direct price)

   Assume 15% of purchased price

   => Rs 36.11 L

2. Construction expenses & contractors feed (6-30 % of direct price)

   Assume 10% of purchased price =

   => Rs 24.07 L

3. Contractor fee (2-7 % of direct price)

   Assume 4 % of purchased price =

=> Rs 9.63 L

4. Contingency prices (5-15 % of present price)

Assume 12 % of present price =

=> Rs 28.89 L

INDIRECT PRICE => Rs 98.7 L

6.1.3 TOTAL CAPITAL INVESTMENT

FIXED CAPITAL INVESMENT = DIRECT PRICE + INDIRECT PRICE

=>

Working capital (10-20 % of fixed capital investment)

Assume 15% of fixed capital investment =

=> Rs 50.91 L

TOTAL CAPITAL INVESMENT = TOTAL FIXED CAPITAL+ WORKING CAPITAL INVESMENT

=> Rs 390.36 L

6.1.4 MANUFACTURING PRICE

FIXED PRICE

1. Depreciation:

10% fixed capital investment for machinery and 3% of building value for

Building => Rs 33.94 L

2. Local taxes:

3-4% fixed capital investment

Assumed value, 0.6% of fixed capital investment

=> Rs 13.578 L

3. Insurances:

0.4 -1% of fixed capital investment

=> Rs 2.03 L

4. Rent:

8-12% of the rented land and building

=> Rs 3 L

TOTAL PRODUCT PRICE = Rs 52.54 L

6.1.5 DIRECT PRODUCTION

i. **Raw materials:** 10-50% of total product price

Assumed value, 30% of total product price =

=> Rs 15.76 L

ii. **Operating labor:**

10-20% of total product price

Assumed value, 15% of total product price = Rs 7.88 L

iii. **Direct supervisory and electrical labor:**

10-20% of operating labor

Assumed value, 12% of total product price =

=> Rs 0.94 L

iv. **Utilities:**

10-20% of total product price

Assume, 13% of total product price =

=> Rs 6.83 L

v. **Maintenance and repairs:**

2-10% of fixed capital investment

Assumed value, 0.8% of fixed capital investment

=> Rs 27.15 L

vi. **Operating supply:**

10-20% of price of the maintenance and repair

Assumed value, 15% of total product price =

=> Rs 4.07 L

vii. **Laboratory charges:**

15% of operating labor

Assumed value, 15% of operating labor = Rs 1.182 L

viii. **Patents and royalties:**

2-6% of total product price

Assumed value , 5% of total product price = Rs 2.62 L

Direct production price = sum of 1+2+3+4+5+6+7+8

=> Rs 66.43 L

Plant overhead prices

60-70% of operating labor + direct supervisory + maintenance price

Considering 60%, overhead plant price = Rs 20.8 L

Total manufacturing price **=>** Rs 141.82 L

6.1.6 GENERAL EXPENSES

i. **Administration price**

60-70% of operating labor price

Considering 50% administration price = Rs 3.94 L

ii. **Distribution price**

2-20% of total product price

Assumed value, 10% of total product price = Rs 5.25 L

iii. **Research and development price**

Assume 3% of the production price =3.20 L

General expenses = Rs 1.57 L

6.1.7 TOTAL PRODUCT PRICE AND OTHER EXPENSES

= manufacturing price + general expenses

=> Rs 152.58 L

i. **Current selling price**

Price of Ethyl Benzene= Rs 178.28 / kg

Total selling price per annum=

=> Rs 292.43 L

ii. **Gross earning**

= total selling price –total product price

=> Rs 139.85 L

iii. **Tax**

Assume local tax rate 30%

Tax on gross earning = Rs 41.95 L

iv. **Net profit**

=gross earning –tax

=> Rs 97.9 L

v. **Rate of return** = (net profit /fixed capital investment) * 100

=> 28.84%

vi. **Payback period** = total capital investment/ net profits

=3.98 years

CHAPTER 7

SITE LAYOUT

Cycle units and subordinate designs should be fanned out to give the most reasonable movement of materials and workforce around the location. Perilous cycles ought to be arranged at a shielded division from various designs. Thought ought to in like manner be given to the future improvement of the site. The assistant constructions and organizations required on a site, despite the standard dealing with units incorporate:

- Storage for crude materials and items: tank homesteads and stockrooms;
- Maintenance workshop;
- Stores, for upkeep and working supplies;
- Labs for measure quality control;
- Fire stations and other crisis administrations;
- Utilities: steam boilers, compacted air, power age, chilling, transformer stations;
- Effluent removal plant: wastewater treatment, strong or potentially fluid waste assortment;
- Offices for general organization;
- Canteens and other convenience structures, like clinical focuses;
- Parking parcels.

Right when the starter site design is roughed out, the cycle units are consistently sited first and organized to give a smooth movement of materials through the distinctive taking care of adventures, from unrefined material to outcome accumulating. Collaboration units are consistently scattered at any rate 30m isolated; more unmistakable separating may be needed for risky cycles. The zone of the significant helper constructions should then be picked. They should be coordinated to restrict the time spent by staff in going between structures. Association working environments and exploration offices, in which a by and large colossal number of people will be working, should be discovered well away from possibly dangerous cycles. Control rooms are conventionally found bordering the getting ready units, yet those with potentially unsafe cycles may should be sited at a safer distance. The siting of the essential collaboration units chooses the configuration of the plant roads, pipe back entrances, and channels. Access roads to each building are needed for improvement and for movement and upkeep. Utility designs should be sited to give the most reasonable run of lines to and from the cooperation parts. Cooling apexes should be sited so that, under the overwhelming breeze, the peak of condensate sprinkle skims from the plant zone and bordering properties. The essential accumulating districts should be set between the stacking and unloading workplaces and the collaboration units they serve. Limit tanks containing perilous materials should be sited in any occasion 70m (200 ft) from as far as possible.

7.1 PLANT LAYOUT

The monetary development and productive activity of an interaction unit will rely upon how well the plant and hardware determined on the cycle stream sheet is spread out. The chief variables to be considered are:

- Economic contemplations: development and working expenses;
- The interaction necessities;
- Convenience of activity;
- Convenience of support;
- Safety;
- Future development;
- General thought

7.1.1 PRICES

Expense of development can be limited by receiving a design that gives the briefest run of associating pipe among gear and minimal measure of primary steel work; in any case, this won't really be the best game plan for activity and upkeep.

7.1.2 PROCESS REQUIREMENTS

An illustration of the need to consider measure contemplations is the need to hoist the base of sections to give the important net positive pull head to a siphon

7.1.3 OPERATION

Hardware that necessities to have successive administrator consideration ought to be found advantageous to the control room. Controllers, test focuses, and tools ought to be situated at advantageous positions and statures. Adequate working space and dynamic headroom should be given to permit simple admittance to gear. On the off chance that it is foreseen that hardware will require substitution, adequate space should be permitted to allow access for lifting gear.

7.1.4 MAINTENANCE

Warmth exchangers should be sited so the cylinder packs can be handily removed for cleaning and cylinder substitution. Vessels that require successive substitution of impetus or pressing ought to be situated outwardly of structures. Hardware that requires destroying for upkeep, like blowers and enormous siphons, ought to be set under cover.

7.1.5 SAFETY

Impact dividers might be expected to separate conceivably unsafe gear and keep the impacts of a blast. At any rate two break courses for administrators should be given from each level in interaction structures.

7.1.6 PLANT EXPANSION

Hardware ought to be found so it very well may be advantageously connected to any upcoming extension of cycle. Space ought to be left on line racks for upcoming necessities, and administration lines ought to be curiously large to take into account future prerequisites.

7.1.7 GENERAL CONSIDERATIONS

Open, underlying steelwork structures are ordinarily utilized for measure gear. Shut structures are utilized for measure activities that require insurance from the climate, for little plants, or for measures that require ventilation with scouring of the vent gas. The game plan of the significant things of hardware regularly follows the grouping given on the interaction stream sheet: with the sections and vessels orchestrated in columns and the auxiliary gear, for example, heat exchangers and siphons, situated along the outside.

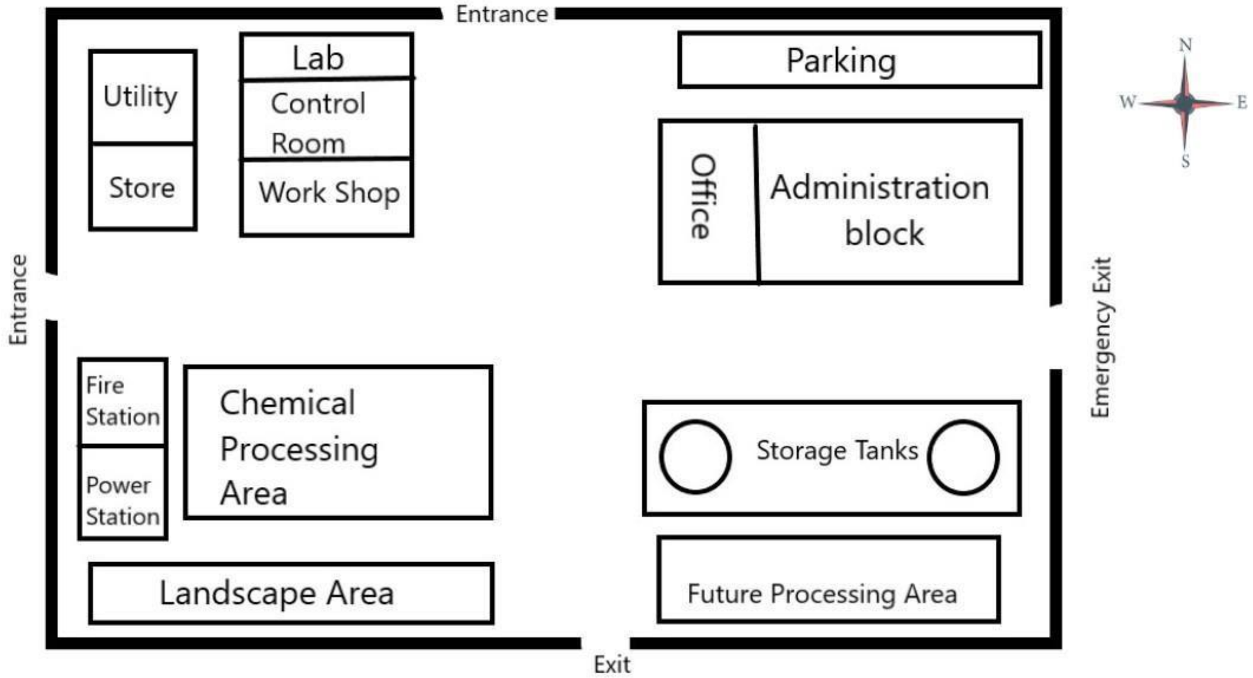

Fig 7.1 Plant Layout

CHAPTER 8

SAFETY

8.1 ETHYLENE:

- Ethylene may be a colorless gas at standard temperature and pressure, it is extraordinarily flammable.
- Ethylene contains a lower and higher blast cutoff of 3.1% and 32% by volume in air separately.
- Undeniable degrees of wellbeing should be set up in the pressure and response of this gas. Ethylene is viewed as a basic asphyxiant, it’s neither poisonous nor cancer-causing.
- There’s no wellbeing concern whenever delivered into the environment how ever it detonates if gift in the combustible reach. Capacity under high tension which present higher dangers of blast.

8.2 BENZENE:

- Benzene is clear fluid at degree centigrade and pressing factor and creates. Benzene fumes are combustible, it’s a lower and higher blast breaking point of 1.0% and 6.7% by volume in air separately.
- Benzene will cause extraordinary wellbeing worries to the plant laborers if not took care of appropriately. Benzene is accounted for to be cancer-causing. Edge of boiling over of Benzene underneath normal conditions is 80.1°C and it is unmixable with water.
- Thus, a firefighting framework utilizing froth or CO2 as the dousing liquid should be introduced at where ever high measures of Benzene is found just like the alkylator and capacity tanks.

8.3ETHYLBENZENE

- Ethylbenzene is an unmistakable dull fluid at standard temperature and pressing factor, it has fundamentally the same as properties of Benzene.
- It has upper limit than Benzene that implies it has a border possibility of catching to the climate. Intense (present moment) openness to Ethylbenzene in people brings about respiratory impacts, like throat aggravation and chest tightening, disturbance of the eyes, and neurological impacts like dazedness.
- 1 mg.m^{-3}. The resource portion for Ethylbenzene is 0.1 mg per kg body weight each day.

8.4 DI-ETHYLBENZENE

- Diethyl Benzene is shows in a similar properties of Benzene and Ethylbenzene.
- indeed, every one of the three sweet-smelling compounds have a similar fire jewel and very much like wellbeing effects and number of ethyl bunch associated with the Benzene ring expands the edge of boiling over and incredibly lessens the unpredictability.

8.5 Y ZEOLITE CATALYST

- The catalyst utilized in this cycle has a place with the Y-zeolite family.
- It is named EBZ-500 and EBZ-100 for alkylation and trans alkylation individually.
- The catalyst does not represent any wellbeing concerns;
- It is inert, steady and protected to arrange into the climate.

CHAPTER 9

INSTRUMENTATION AND PROCESS CONTROL

9.1 INSTRUMENTATION OF ALKYLATION REACTOR

Fixed bed reactors control is testing, particularly on account of unequivocally exothermic responses. These reactors can't be worked in extreme temperatures, since aggravations in channel conditions can create problem areas, with undesired outcomes, for example, warm decontrolling, result arrangement from optional responses and impetus deactivation. In fixed bed reactors where emphatically exothermic responses are done, it is important to control the temperature pinnacle and leave fixations all the while, to forestall exorbitant temperature heights along the reactor and to ensure the item details. Keeping up the reactor at the necessary interaction temperature requires the checking of this variable in some key positions.

In a few modern cycles, it is difficult to gauge the controlled variable with adequate speed. This is the situation, for instance, for the grouping of synthetic species in the exit of a fixed bed reactor. The estimation of this variable progressively is generally pricely and requests occasional alignment and support of analyzers. Additionally, examining rates are moderately delayed because of the time needed to cleanse the line associated with the reactor and the fundamental opportunity to the chromatography investigation. Consequently, the focus can be constrained by carefully keeping up the stream pace of Ethylene and the reactor temperature close to consistent state conditions. The selectivity is improved by keeping low Ethylene to Benzene proportion in the reactor.

The pressing factor of the reactor should likewise be controlled on the grounds that expanding the pressing factor will prompt clasping and may prompt blast of the reactor and diminishing it will prompt converse stream. At the point when the pressing factor diminishes the stream pace of Ethylene should be expanded to take the pressing factor back to consistent state. Then again, if the pressing factor expands, the valve opening is decreased to build the pressing factor drop and take the pressing factor back to consistent state.

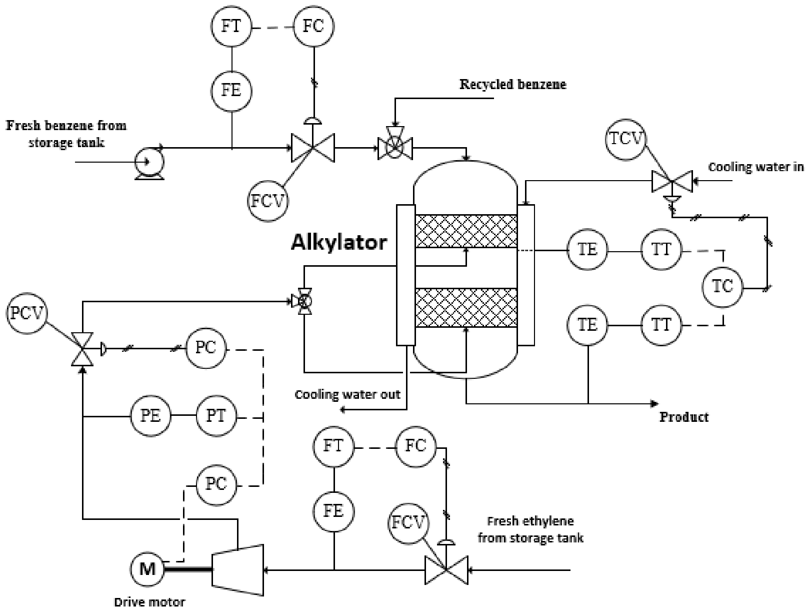

Fig 9.1 Instrumentaion of alkylation reactor

9.2 INSTRUMENTATION OF DISTILLATION COLUMN

The primary errand in the activity and control of refining segments is the guideline of the items distillate and leftover structure notwithstanding load aggravations. Practically speaking, creation guideline is drawn nearer by means of circuitous techniques where a predefined plate temperature is controlled at a given set point, which, on a basic level, compares to the ideal organization esteem. It is attractive to augment the immaculateness of the top and additionally base items. Ordinarily in industry, the control factors are set physically by human administrators. Control is done utilizing double organization control, (for example programmed control for top and base). The section pressing factor and re-heater and condenser levels should be controlled cautiously to keep up stable activity.

The LV design is the most well-known technique that is utilized in controlling the creation of top and base items, where the reflux stream rate (L) is utilized to control the structure of the top item and the bubble up (V) is utilized to control the creation of the base item. For this situation, the distillate stream rate and base item stream rate are utilized to control the levels of the condenser and reboiler individually. Section pressure directly affects the overall unpredictability of the critical segments in the segment. Accordingly, changes in the section pressing factor can essentially influence item creations

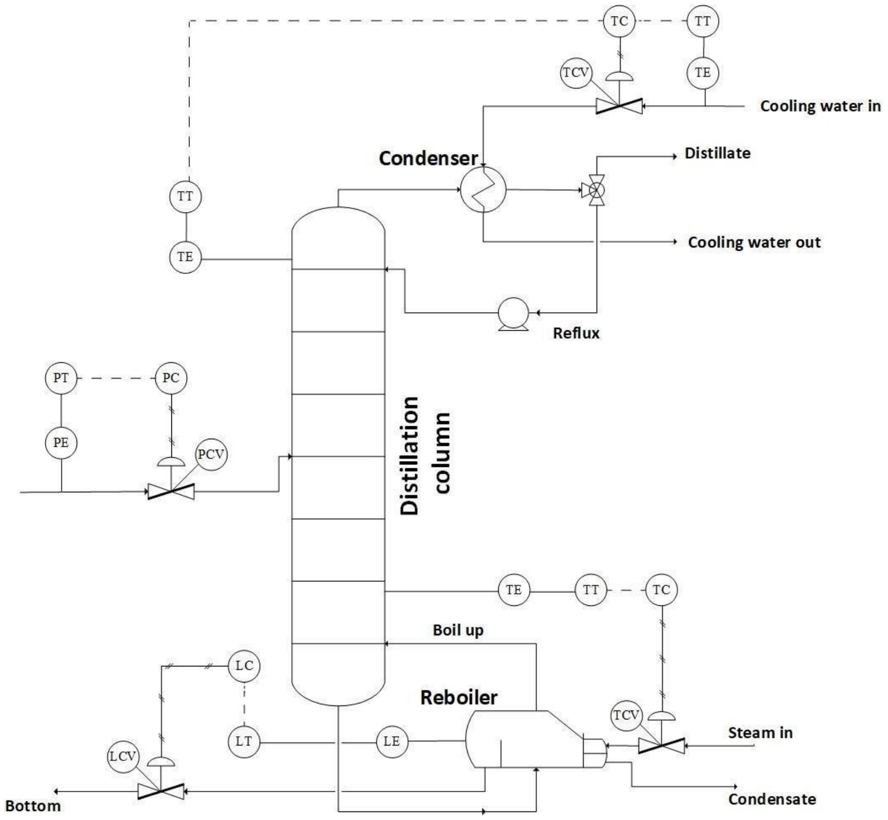

Fig 9.2 Instrumentation of distillation column

CHAPTER 10

SUMMARY AND CONCLUSION

Ethyl Benzene is a very important product which is extensively used for the manufacture of styrene It is also used as Hydrocarbon Solvents in paint manufacture. There is a great demand for this product in the market. The Ethylbenzene method exhibits a stimulating style feature in terms of the engineering trade-offs. The fundamental elements of the Ethylbenzene process are the reactor and also distillation column Among the different methods of manufacture of Ethyl Benzene, Production of ethyl Benzene in a liquid phase alkylation of Ethylene and Benzene in zeolite catalyst used fixed bed reactors is found to be the most economic and viable method. We have done the project report in industrial type manufacturing. The various equipments required for its production were designed. The material and energy balances have been discussed for the entire plant. Finally economic analysis for the entire plant has been carried out and the feasibility of the project has been determined in terms of the payback period. The project has a payback period of 3.8 years with huge profit.

CHAPTER 11

REFERENCES:

1. Production of Ethylbenzene by liquid alkylation of Benzene using zeolite catalyst, June 2019
2. Modelling and Simulation of Benzene Alkylation Process Reactors For Production Of Ethylbenzene Hamid Ganji*, Jafar S. Ahari, Amir Farshi, Majid Kakavand, 2004
3. Green, D.W., & Southard, M. Z. (2018). Perry’s chemical engineer’s handbook. Mc Graw Hill Professional.
4. Chou, Y. S., Wu, C. H., 2007, Passivity-based control of the phthalic anhydride fixed-bed reactor, Chemical Engineering Science, 62, 1282-1297.
5. Luyben, W. L. (2011). Design and control of the ethyl benzene process. AIChE journal,57(3), 655-670.

6. ICIS (2018, Apr 13). Ethyl Benzene Methodology . Retrieved from https://www.icis.com/ compliance/documents/ethyl-benzene-methodology-13-april-2018/.
7. Budman, H. M., Webb, C., Holcomb, T. R., Morari, M., 1992, Robust inferential control for a packed-bed reactor, Industrial & Engineering Chemistry Research, 31, 1665-1679.