

CONFIGURATION OF VARIOUS PROCEDURES INVOLVED IN PRODUCTION OF TRICHLOROETHYLENE

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

By

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**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

APRIL – 2021



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DEPARTMENT OF CHEMICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **ALFIN ROMERIO JM (37190006)** who carried out the project entitled **"CONFIGURATION OF VARIOUS PROCEDURES INVOLVED IN PRODUCTION OF TRICHLOROETHYLENE"** under our supervision from October 2020 to April 2021.

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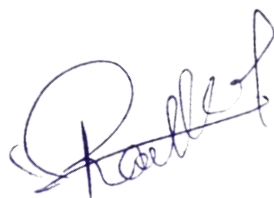
Submitted for Viva voce Examination held on

Internal Examiner

External Examiner

DECLARATION

I ALFIN ROMERIO JM (Reg.No.37190006) hereby declare that the Project Report entitled "CONFIGURATION OF VARIOUS PROCEDURES INVOLVED IN PRODUCTION OF TRICHLOROETHYLENE" done by us under the guidance of Dr. J. ARAVIND KUMAR M.E,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:

PLACE:

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.

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I would like to express our sincere and deep sense of gratitude to our Project Guide **Dr. J. ARAVIND KUMAR M.E., Ph.D.**, **Department of Chemical Engineering** for her 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

To create 100 tons of Trichloroethylene (TCE) each day, it is conveyed out by the interaction of response of ethylene and chlorine. The principle reaction combined with a side response. Trichloroethylene is shaped from the start of the venture by the combination of ethylene and chlorine. The HCl is then responded and forms Trichloroethylene which is a side response. The fundamental response is completed in a CSTR, afterward it is stripped and refined by means of a refining segment.

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LIST OF SYMBOLS AND ABBREVIATIONS

ABBREVIATIONS

TCE – Trichloroethylene

MCL – Maximum Contaminant Level

CSTR – Continuous Stirred Tank Reactor

HCl – Hydrochloric Acid

SYMBOLS

C_P – Specific Heat Capacity

Q – Heat Of Reaction

ΔH_r – Heat Of Absorption

λ – Latent Heat Of Vaporization

X_A – Percentage Conversion

CHAPTER 1

1. INTRODUCTION

The substance compound trichloroethylene may be a halocarbon ordinarily utilized as a mechanical dissolvable. It's an inexpensive non-combustible fluid with a sweet smell. It ought not be mistaken for the comparable 1,1,1-trichloroethane, which is ordinarily referred to as chloroethene. The IUPAC name is trichloroethene.

Groundwater defilement by TCE has gotten a significant natural worry for human openness. Mechanical truncations incorporate TCE. TCE was still utilized as an inward breath pain relieving in labor given without help from anyone else organization. TCE responded with carbon dioxide retaining frameworks (soft drink lime) to create dichloro dichloroacetylene and phosgene.

1.1 USES

Trichloroethylene may be a viable dissolvable for an assortment of natural materials. Significant use is to separate oil from plant materials, for instance ,soy, coconut, and palm utilized for drying the last piece of water to the creation of 100 percent ethanol. Different utilizations within the food business involving espresso decaffeination, therefore the readiness of seasoning removes from bounces as well as species. Electroplating Industries for cold cleaning and fume lubing solvents. Coordinated Iron and Steel Manufacturing Industries. Apparatus Assembling and Repair. Mash and Paper Manufacture for de-inking paper. Elastic Manufacture. Semiconductors for oxidation of wafers.

Trichloroethylene was promoted as ' ECCO 1500 Anti-Static Film Cleaner and Conditioner' till 2009, to be used in programmed film and cleaning machines, furthermore, with manual cleaning built up free wipes. Maybe the simplest utilization of TCE has been a degreaser for metal and parts. TCE has been utilized within the US to wash kerosene powered rocket motors (TCE wasn't wont to clean hydrogen-filled motors, for instance ,the spacecraft Main Engine). During static ring, the RP-1 fuel would go away hydrocarbon stores and fumes within the motor. These stores must be flushed from the motor for taking care of a strategic distance from the prospect of blast during motor dealing.

TCE utilized the Flush Engines fuel framework preceding after each test ring. Flushing system included siphoning TCE through motor's fuel framework and letting dissolvable flood to a period going from a couple of secs to 30–35 mins, Contingent on the motor. surely motors, the motor's gas generator and LOX arch additionally flushed to the TCE before testing. The F1 rocket motor with its LOX arch, gas generator, push chamber fuel coat flushed with TCE during dispatch arrangements.

TCE likewise utilized within the assembling scope with fluorocarbon refrigerants like 1, 1, 1, 2-Tetrafluoroethane all more ordinarily referred to as HFC 134a. TCE additionally utilized mechanical refrigeration and its applications due to its increased warmth move capacities also, its coldness specification.

1.2 ADVANTAGES

It is a gigantic benefit of TCE's that it has a high edge of boiling over (87°C) for example it doesn't consume without any problem. It is particularly significant due to its cleaning properties, low combustibility and absence of quantifiable glimmer points. TCE's is moreover utilized as a synthetic cycle moderate in PVC creation as an atomic weight control specialist. High-immaculateness evaluations of TCE's are utilized as feedstock in the combination of refrigerant hydro fluorocarbon.

In this interaction, TCE's compound is annihilated to shape a new fluorinated compound. Among the properties that have added to trichloroethylene's wide acknowledgment as a metal cleaner and degreaser are the accompanying:

- Low combustibility
- Non-destructiveness
- High solidness
- Low explicit warmth
- Low edge of boiling over
- Low inactive warmth of vaporization
- High dissolvability

1.3 TRAITS OF TCE

TCE may be a chlorinated hydrocarbon regularly utilized as an degreasing specialist for metals and as extraction dissolvable for oils, waxes, as well as tars. It's utilized within the assembling cycle having various synthetic substances and it's found in customer items, for instance , paint with removers, glues, mat cleaners etc (U.S.EPA, 2000).

Due to widespread use of TCE in pollution groundwater may be a typical issue and may be especially irksome for those networks that depend on groundwater for his or her beverage . Last assessed by EPA in 2000, somewhere within the range of 9 and 34% of beverage supply sources within the U.S. are debased to TCE.

Different wellsprings of openness for the general population incorporate utilizing items that contain TCE, dissipation from removal locales, and mechanical openness to production line laborers and individuals living in territories around manufacturing plants where TCE has been utilized (U.S.EPA, 2000). Wellbeing impacts with both intense as well as protracted openness are accounted for and to be include:

- ❖ Harmed focal apprehensive, insusceptible and endocrine frameworks;respiratory tract,kidney and pancreas harm;
- ❖ Increased occurrences of unsuccessful labors;
- ❖ Inborn cardiac illness with youngsters; as well as different kinds of diseases (U.S.EPA, 2000).

On account of the real wellbeing hazards related with TCE, the national government has put the foremost extreme foreign substance level (MCL) for beverage at 5 sections for every billion.The state MCLs in California and Washington are like govt standard, be that because it may, a couple of states has more tough guidelines.

Table 1.1 : List of chemical and physical properties of TCE

Parameter	Value	Reference
Chemical Formula	C_2HCl_3	U.S.EPA (2000)
Molecular mass	131.40 gram/mole	U.S.EPA (2000)
Aroma threshold	28 parts per million	U.S.EPA (2000)
Vapor Equilibrium Pressure at 25 degC	74 millimetre Hg	U.S.EPA (2000)
K_H at 25 degC	0.011 atm-metre ³ /mol	U. S. Dept. of H.H.S(1997)

Water Solubility at 25 degC	1.366 gram/L	U. S. Dept. of H.H.S(1997)
ρ (density) at 20 degC	1.465 gram/mL	U. S. Dept. of H.H.S(1997)
Logarithm P	2.42	U.S.EPA (2000)
Atmospheric Boiling Point	86.7 degC	U. S. Dept. of H.H.S(1997)
C _{max} (half life) in air	7 days	U.S.EPA (2000)
Federal Max.Contaminant Level(M.C.L) in DrinkingWater	5 μ g/Litre	U.S.EPA (2000)
O.S.H.A PermissibleExposure Limit (PEL)Time WeightedAverage (TWA)	100 parts per million	Agency for TSDR (2007)

Having fume pressure, where much bigger fume pressure about (>0.01 atm) corresponds more volatilization. Octanol water apportioning coefficient(log P) is identified with lipophilicity (special dividing into oils,fats,non-polar solvents over water as well as lipids) of compound which indicates potential to parceling them in soil natural matter .It's conversely identified with water dissolvability of compound.

CHAPTER 2

2. HISTORICAL DETAILS

2.1 INTRODUCTION

Trichloroethylene was available within 1949 as a degreaser, in food and within the drug industry. When harmfulness was realized it had been slowly eliminated from food and drug market within the 1969 and total deserting was reached within the 1979. There are a good range of cases in the pollution of ground, the initial two in Camp Lejeune, NC(1979), MA(1969), Woburn and therefore the military base.

Those episodes are caused by an improper removal of TCE. MA, Woburn numerous instances of leukemia thought connected to ill-advised removal of TCE with W.R. Effortlessness Company and Beatrice Foods, anyway nothing demonstrated at that time. In Camp Lejeune the groundwater various wellbeing impacts were caused by the TCE. Different occurrences happened in 1916 including the creature taking care of containing soybean supper defeated with TCE that caused a demise of cows.

CHAPTER 3

3. PROCESS & EQUIPMENT

3.1 CONTINUOUS STIRRED-TANK REACTOR (CSTR)

CSTR, otherwise called back mix reactor or tank, may be a typical ideal reactor in substance designing. CSTR alludes to a model wanting to assess the key unit activity factors when employing a nonstop unsettled reactor tank to reach a specified yield. (See Chemical reactors.) The numerical model works for all slurries, gases and liquid.

Conduct of a CSTR is usually approximated or modeled by that of Endless Ideally Stirred-Tank Reactor (CSTR). All calculations encountered with CISTRs expect amazing blending. During a perfectly mixed reactor, yield synthesis indistinguishable from organization of fabric inside reactor, which is capacity home time and reaction rate.

Off chance that house time is 5-10 times blending time, approximation is legitimate to designing purposes. The tank model usually wants to work on designing figurines and may be utilized to explain research reactors. It must be drawn nearer, specifically in industrial size reactors.

3.2 ABSORBER

In high energy physics tests, a safeguard may be a square of fabric wont to retain some of the energy of an event molecule.

1. Safeguards are made from a contingent upon the reason,an assortment of materials; tungsten,lead and fluid hydrogen,are basic decisions.
2. Most safeguards are utilized as a feature of a molecule accelerators,molecule indicators use safeguards to diminish radiation harm on gas pedal segments.

3.3 DISTILLATION COLUMN

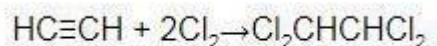
An interaction where a fluid or fume combination of at least two substances isolated into its segment parts of wanted virtue. In view of the fact that the fume of a bubbling blend will be more extravagant in the segments that have lower limits. A purchaser of huge measures of energy in wording of cooling and warming. A huge supporter of plant working expenses, possibly more than half. A refining section is a progression of harmony streaks with two feeds and two item streams. Leaving fluid is at bubble point. Leaving vaporis at dew point.

CHAPTER 4

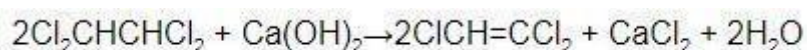
4. PROCESS DESCRIPTION

4.1 EXISTING PROCESS

Prior to 1969, most trichloroethylene was produced during a two-step process from acetylene. Acetylene treated with chlorine having ferric chloride catalyst at 90 °C to supply 1, 1, 2, 2-tetrachloroethane consistent with the chemical equation



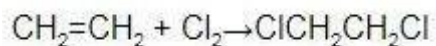
The 1, 1, 2, 2-tetrachloroethane is dehydro chlorinated to offer trichloroethylene. This will be cultivated with a watery solution of lime



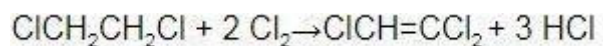
Opposite hand within the fume stage by warming to 300-500°C on salt impetus or barium Cl_2 .



Today, most trichloroethylene is made from C_2H_4 . Ethylene is chlorinated under a ferric chloride impetus which delivers 1, 2-dichloroethane.



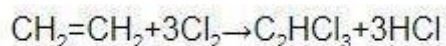
At the purpose warmed to $400^\circ C$ with extra Cl_2 , 1, 2-dichloroethane is modified over to trichloroethylene



Response is often catalyzed by an assortment of drugs. The foremost commonly utilized impetus may be a combination of KCl_2 and aluminium chloride. In any case, differing types of permeable carbon likewise have been utilized.

Reaction produces tetrachloroethylene. Result relying upon the quantity of chlorine taken care of response, tetrachloroethylene can be the main item. Regularly tetrachloroethylene and trichloroethylene and ethylene were collected together and afterward isolated by the process of refining.

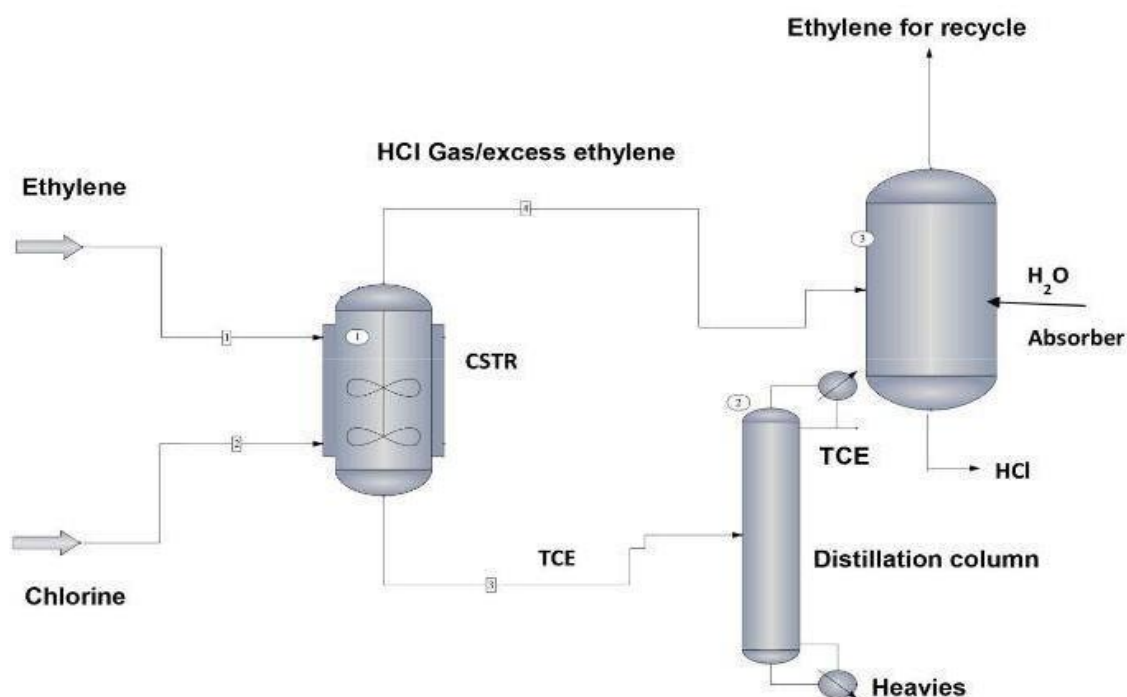
4.2 REACTION



Description

Trichloroethylene is made from C_2H_4 . Within the initial place, ethylene is chlorinated to deliver 1, 2-dichloroethane. When warmed to around $200^\circ C$ having extra chlorine, 1, 2-dichloroethylene modified over to trichloroethylene. This response is often catalyzed by an assortment of drugs. However, differing types of permeable carbon have been utilized.

Reaction as a side-effect, relying over quantity of chlorine taken care of by response, tetrachloroethylene be the main product. Ordinarily, tetrachloroethylene and trichloroethylene are collected together afterward, isolated with a process of refining.



4.1. Process Flow Diagram

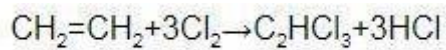
CHAPTER 5

5. MATERIAL BALANCE

5.1 INTRODUCTION

Interaction planning of any material begins with choosing the production rate, trailed by choice of cycle and the adjusting the stream sheet. Here We are adjusting the stream sheet for the production of trichloroethylene.

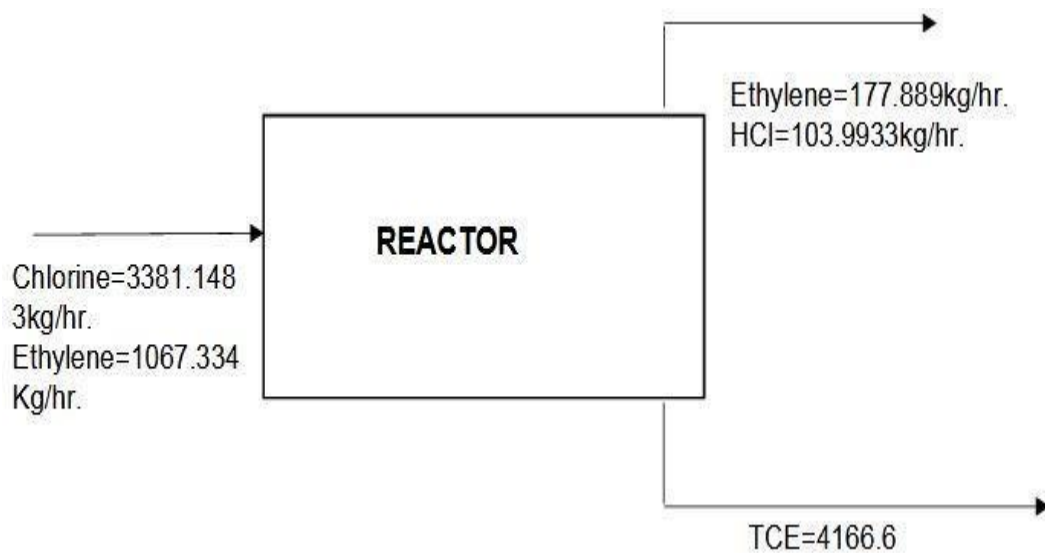
5.2 MAIN REACTION



MOLECULAR WEIGHT

- ❖ Ethylene – 28.05g/mol
- ❖ Chlorine–35.453g/mol
- ❖ HCl-36.5g/mol
- ❖ Trichloroethylene-131.4g/mol

REACTOR



Basis: 100 tons per day of trichloroethylene

$$100000 / 24 = 4166.66 \text{ kg/ hr.}$$

Ethylene required

Molecular weight of trichloroethylene = molecular weight of ethylene

$$131.4 \text{ g/mol} = 28.05 \text{ g/mol}$$

$$4166.6 = x$$

$$x = (28.05 * 4166.6) / 131.4 = 889.445 \text{ kg / hr}$$

For complete conversion of $\text{Cl}_2=20\%$

Excess ethylene was supplied

$$= 889.445 + (889.445 \times 20/100)$$

$$= 889.445 + 117.889$$

$$= 1067.334 \text{ kJ/ hr}$$

Chlorine

Molecular weight of trichloroethylene = 3*molecular weight of chlorine

$$131.4 \text{ g/mol} = 35.5432 \times 3$$

$$131.4 = 106.6296$$

$$4166.6 = x$$

$$x = (106.6296 \times 4166.6)/131.4$$

$$= 3381.1483 \text{ kg / hr}$$

Trichloroethylene

Molecular weight of trichloroethylene = molecular weight of trichloroethylene

$$4166.6 = x$$

$$131.4 \text{ g/ mole} = 98.96 \text{ g /mole}$$

$$x = (98.96 \times 4166.6) / 98.96 \quad x = 4166.6 \text{ kg/hr}$$

Hydrochloric acid

$$889.445 + 3381.1483 = 4166.6 + x$$

$$x = 4270.5933 - 4166.6$$

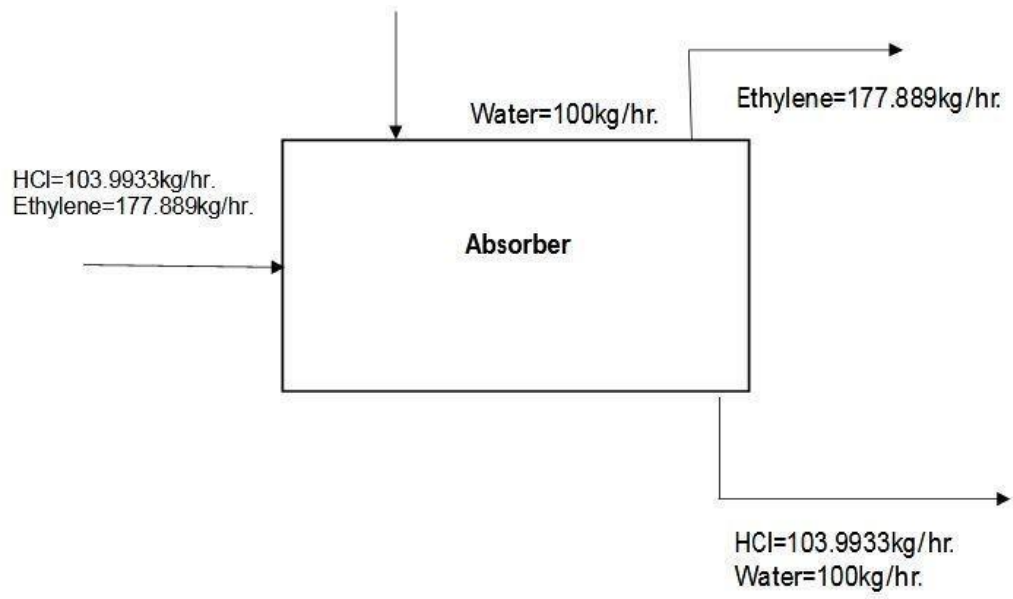
$$x = 103.9933 \text{ kg/hr}$$

Table for Material balance:

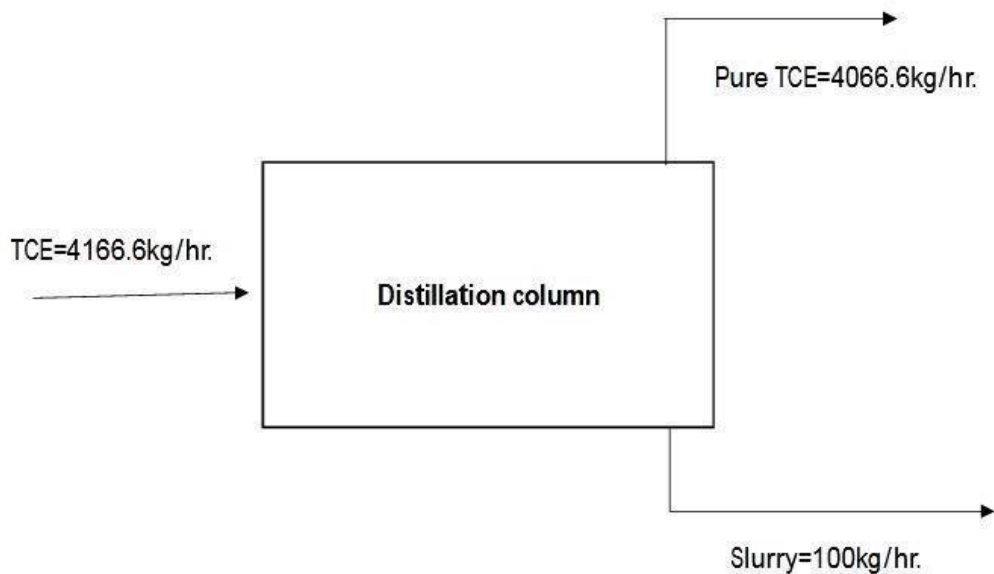
5.1 Table for Reactor

COMPONENT	INPUT (Kg / hr)	OUTPUT (Kg / hr)
Ethylene	1067.334	177.889
Chlorine	3381.1483	-
Trichloroethylene	-	4166.6
HCL	-	103.9933
Total	4448.4823	4448.4823

Absorber:



DISTILLATION COLUMN:



CHAPTER 6

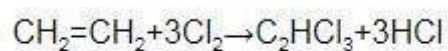
6. ENERGY BALANCE

6.1 INTRODUCTION

Energy balance is determined by adjusting the enthalpy of inlet and outlet streams alongside the heat provided or removed. The temperature of each stream is resolved from the bubble point and dew point calculations of feed, Bottom and Distillate divisions at the plant Pressure.

6.2 ENERGY BALANCE

Main Reaction



$$\Delta H_f \text{ at } 25^\circ\text{C} = \Delta H_p (\text{products}) - \Delta H_f (\text{reactants})$$

$$\begin{aligned} &= \Delta H_p (\text{C}_2\text{HCl}_3 + \text{HCl}) - \Delta H_f (\text{CH}_2=\text{CH}_2 + 3\text{Cl}_2) \\ &= (-24.3 \times 4166.6) + (-92.31 \times 103.9933) - (52.47 \times 889.445) \\ &\quad + (99.2 \times 3381.1483) \\ &= (-91648.75848) - 382079.0905 \\ &= -473727.849 \text{ kJ/hr} \\ &= -473727.849 / 3600 \\ &= -131.5910692 \text{ kJ/sec} \end{aligned}$$

Table for energy balance

6.1 ENERGY BALANCE OF REACTOR

COMPONENT	MASS	MOLECULAR WEIGHT	n=m/M.Wt
Ethylene	889.445	28.05	31.709
Chlorine	3381.1483	35.453	95.369
Trichloroethylene	4166.6	98.96	42.103
HCl	103.9933	36.5	2.864

Feed inlet is 50°C

Reaction temperature is 200°C

$$\begin{aligned}\Delta H (\text{CH}_2=\text{CH}_2) &= nC_p dt \\ &= 31.709 \times 0.053 \times (200-50) \times 1000 \\ &= 252086.5 \text{ kJ/hr}\end{aligned}$$

$$\begin{aligned}\Delta H (\text{Cl}_2) &= nC_p dt \\ &= 95.369 \times 0.0170 \times (200-50) \times 1000 \\ &= 243190.9 \text{ kJ/hr}\end{aligned}$$

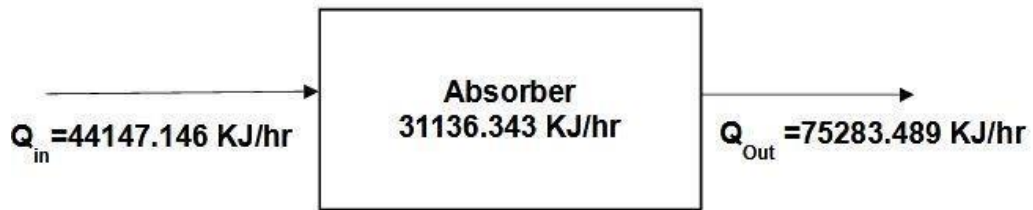
$$\begin{aligned}\Delta H (\text{C}_2\text{HCl}_3) &= nC_p dt \\ &= 42.103 \times 0.102 \times (200-50) \times 1000 \\ &= 757854 \text{ kJ/hr}\end{aligned}$$

$$\begin{aligned}\Delta H (\text{HCl}) &= nC_p dt \\ &= 2.864 \times 0.0214 \times (200-50) \times 1000 \\ &= 9193.4 \text{ kJ/hr}\end{aligned}$$

$$\begin{aligned}\Delta H &= 757854 + 9193.4 \\ &= 767047.4 \text{ kJ/hr} \\ &= 252086.5 + 243190.9 \\ &= 495277.4 \text{ kJ/hr}\end{aligned}$$

$$\begin{aligned}\Delta H_{\text{reaction}} &= \Delta H_p - \Delta H_r \\ &= 767047.4 - 495277.4 \\ &= 271770 \text{ kJ/hr} \\ &= 271770/3600 \text{ Q} \\ &= 75.4916 \text{ kW}\end{aligned}$$

Absorber



$$\begin{aligned}
 Q_{\text{in}} (\text{HCl}) &= m \cdot C_p \cdot dt \\
 &= 103.993 \cdot 0.0214 \cdot (400 - 298) \\
 &= 226.995 \text{ kJ/hr}
 \end{aligned}$$

$$\begin{aligned}
 Q_{\text{in}} (\text{ethylene}) &= m \cdot C_p \cdot dt \\
 &= 177.889 \cdot 0.0674 \cdot (400 - 298) \\
 &= 1222.951 \text{ kJ/hr}
 \end{aligned}$$

$$\begin{aligned}
 Q_{\text{in}} (\text{H}_2\text{O}) &= m \cdot C_p \cdot dt \\
 &= 100 \cdot 4.186 \cdot (400 - 298) \\
 &= 42697.2 \text{ kJ/hr}
 \end{aligned}$$

$$\begin{aligned}
 Q_{\text{out}} (\text{ethylene}) &= m \cdot C_p \cdot dt \\
 &= 177.889 \cdot 0.0674 \cdot (540 - 298) \\
 &= 2901.511 \text{ kJ/hr}
 \end{aligned}$$

$$\begin{aligned}
 Q_{\text{out}} (\text{HCl}) &= m \cdot C_p \cdot dt \\
 &= 103.993 \cdot 0.0214 \cdot (540 - 298) \\
 &= 382.778 \text{ kJ/hr}
 \end{aligned}$$

$$\begin{aligned}
 Q_{\text{out}} (\text{H}_2\text{O}) &= m \cdot C_p \cdot \Delta t \\
 &= 100 \cdot 4.186 \cdot (470 - 298) \\
 &= 71999.2 \text{ kJ/hr}
 \end{aligned}$$

$$\begin{aligned}
 Q_{\text{in}} &= 44147.146 \\
 Q_{\text{out}} &= 75283.489 \\
 Q_{\text{out}} - Q_{\text{in}} &= 75283.489 - 44147.146 \\
 &= 31136.343
 \end{aligned}$$

Distillation:

$$\begin{aligned}
 Q_{\text{in}} (\text{TCE}) &= m \cdot C_p \cdot \Delta t \\
 &= 4166.6 \cdot 0.1201 \cdot (470 - 298) \\
 &= 86070.289 \text{ kJ/hr}
 \end{aligned}$$

$$\begin{aligned}
 Q_{\text{out}} (\text{TCE}) &= m \cdot C_p \cdot \Delta t \\
 &= 4166.6 \cdot 0.1201 \cdot (523 - 298) \\
 &= 112591.948 \text{ kJ/hr}
 \end{aligned}$$

$$\begin{aligned}
 Q_{\text{out}} (\text{ethylene}) &= m \cdot C_p \cdot \Delta t \\
 &= 55 \cdot 0.0674 \cdot (523 - 298) \\
 &= 834.075 \text{ kJ/hr}
 \end{aligned}$$

$$\begin{aligned}
 Q_{\text{out}} (\text{chlorine}) &= m \cdot C_p \cdot \Delta t \\
 &= 45 \cdot 0.0170 \cdot (523 - 298) \\
 &= 172.125 \text{ kJ/hr}
 \end{aligned}$$



$$Q_{in}=86070.289$$

$$Q_{out}=113598.148$$

$$Q_{out}-Q_{in} = 113598.148 - 86070.289$$

$$= 27527.859$$

Mass of stream required to raise the temperature.

$$Q = m_s \lambda_s$$

$$\lambda_s = \text{Stream at } 120^\circ\text{C}$$

$$= 2205 \text{ kJ/kg}$$

$$= 75.4916 \text{ kJ/S}$$

$$\text{Stream required} = m_s = Q / \lambda_s$$

$$= 75.4916 / 2205$$

$$= 0.0342 \text{ kg/S}$$

$$= 123 \text{ kg/h}$$

CHAPTER 7

7. PROCESS EQUIPMENT DESIGN

7.1 EQUIPMENT DESIGN

Absorber

Basis: 100 tons per a day

$$L_S/G_S = Y_1 - Y_2/X_1 - X_2$$

$$\text{HCl} = 103.9933/36.5 \text{ kg/hr}$$

$$= 2.849 \text{ kmol/hr}$$

$$\begin{aligned}\text{Ethylene} &= 177.889/28.05\text{kg/hr} \\ &= 6.341 \text{ kmol/hr}\end{aligned}$$

$$\begin{aligned}\text{Water} &= 100/18\text{kg/hr} \\ &= 5.555 \text{ kmol/hr}\end{aligned}$$

$$\begin{aligned}L_S/G_S &= 5.555/9.19 \\ &= 0.6044\end{aligned}$$

$$\begin{aligned}Y_1 &= \text{moles of ethylene/total no.of moles} \\ &= 6.341/9.19 \\ &= 0.6899 \\ Y_1 &= 0.6899\end{aligned}$$

$$\begin{aligned}Y_2 &= 98\% \text{ recovery of } Y_1 \\ Y_2 &= 0\end{aligned}$$

$$\begin{aligned}Y_1 &= (98/100) * 0.6899 \\ &= 0.6899 - (0.98 * 0.6899) \\ &= 0.0138\end{aligned}$$

$$Y_1 = 0.0138$$

$$\begin{aligned}L_S/G_S &= Y_1 - Y_2 / X_1 - X_2 \\ 0.6488 &= 0.6899 - 0.0138 / X_1 - 0 \\ X_1 &= 0.6899 - 0.0138 / 0.6088 \\ X_1 &= 0.5\end{aligned}$$

7.2. Table for absorber

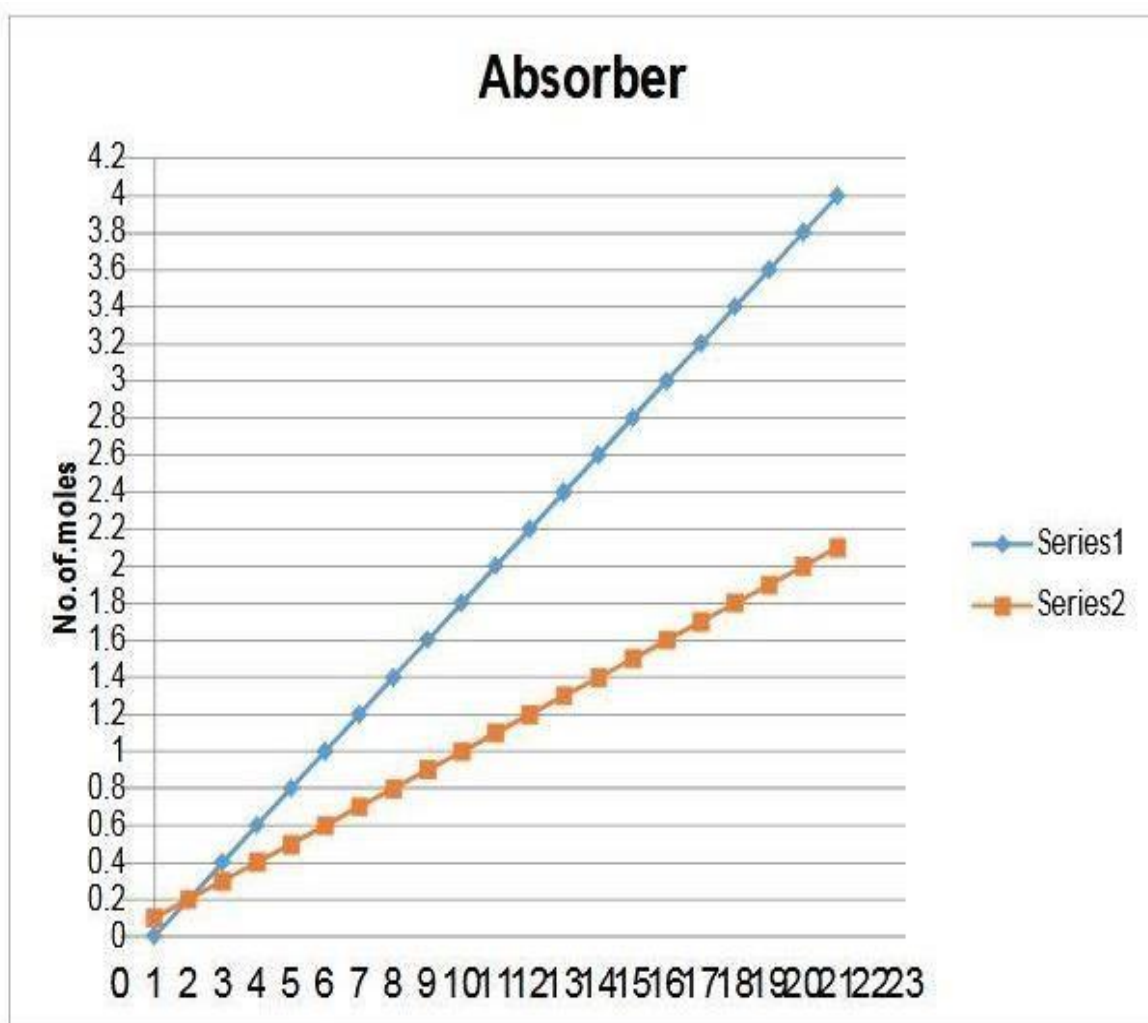
X	0.5	0
---	-----	---

Y	3.2	0.0138
---	-----	--------

7.3. Table for graph

$$Y=4X$$

X	0	0.2	0.4	0.6	0.8
Y	0	0.8	1.6	2.4	3.2



7.4. Graph of absorber

CHAPTER-8

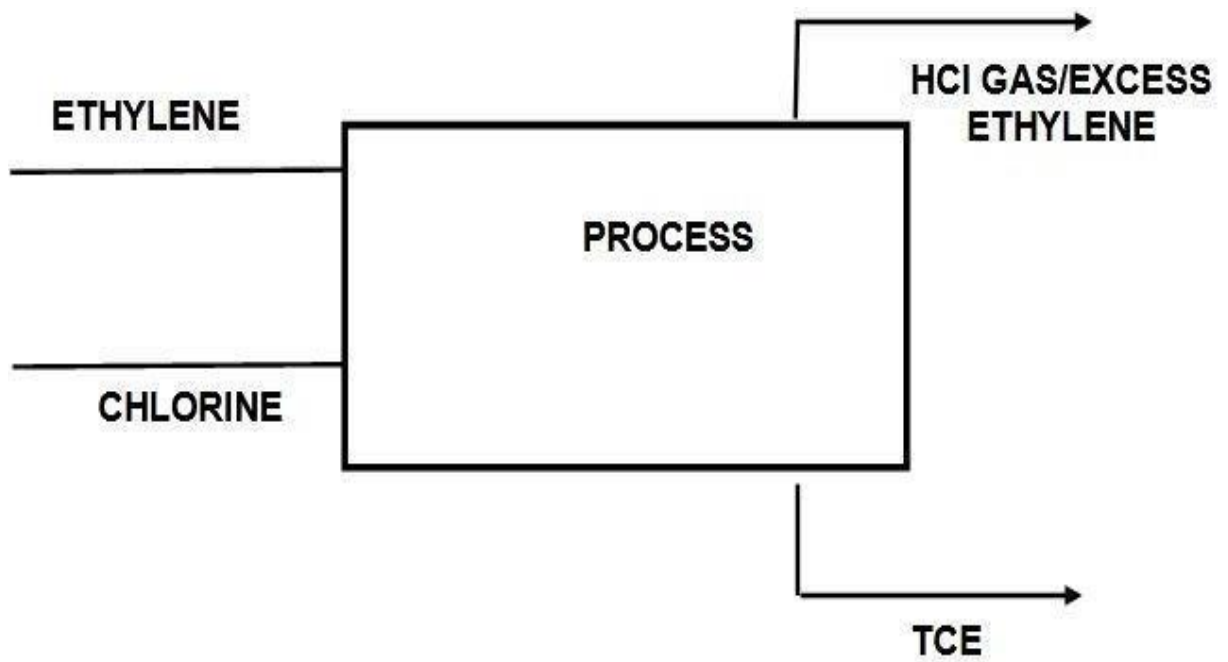
8. PROCESS INSTRUMENTATION AND CONTROL

8.1 PROCESS CONTROL

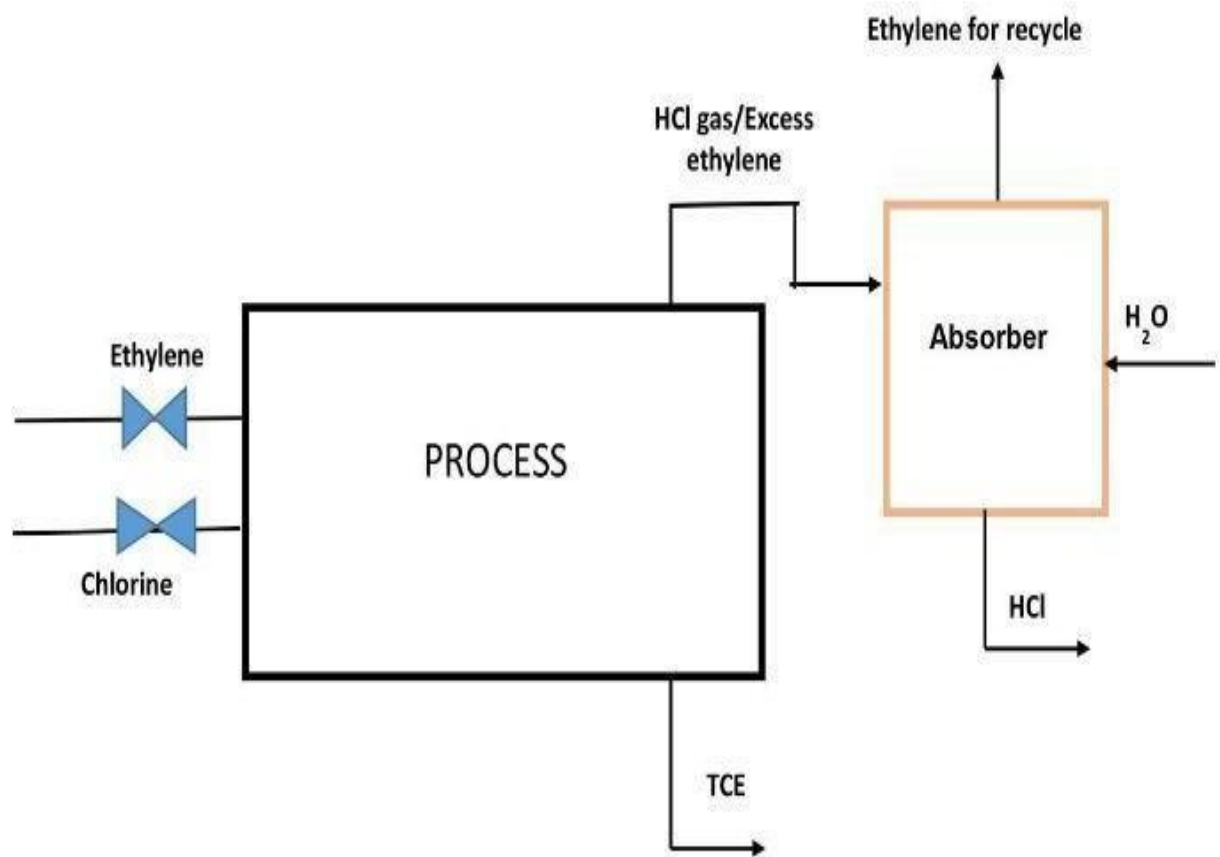
Cycle control is worried about the controls of unit activity, unit processes and those parts of the plant control which relate to processing objectives and adequacy. It isn't straightforwardly worried about such plant-level decisions as plant support, gear substitution, item shipment, etc. Sensors to quantify measure conditions and valves to impact process operations are fundamental for all parts of designing practice.

Engineers Want to plan and work measures that stay in safe conditions, produce the wanted measures of great items and are beneficial. Therefore, engineers should give estimating gadgets to key factors and valves (or other gadgets, like variable speed electric engines) to "steer" the measure. This site gives instructive material on sensors and valves for use in the process businesses. While sensors and valves are significant in all parts of designing, they expect most prominent significance in the investigation of automatic control, which is named measure control when applied in the process businesses. Cycle control manages the guideline of cycles by applying the criticism rule utilizing different processing gadgets, principally digital calculation. Cycle control requires sensors for estimating variables and valves for executing decisions. Valves are utilized broadly for affecting the interaction; we regularly say that qualities are the "handles" by which we operate an interaction. We have numerous objectives in impacting the interaction; therefore, we utilize the stream and valve standards in numerous applications.

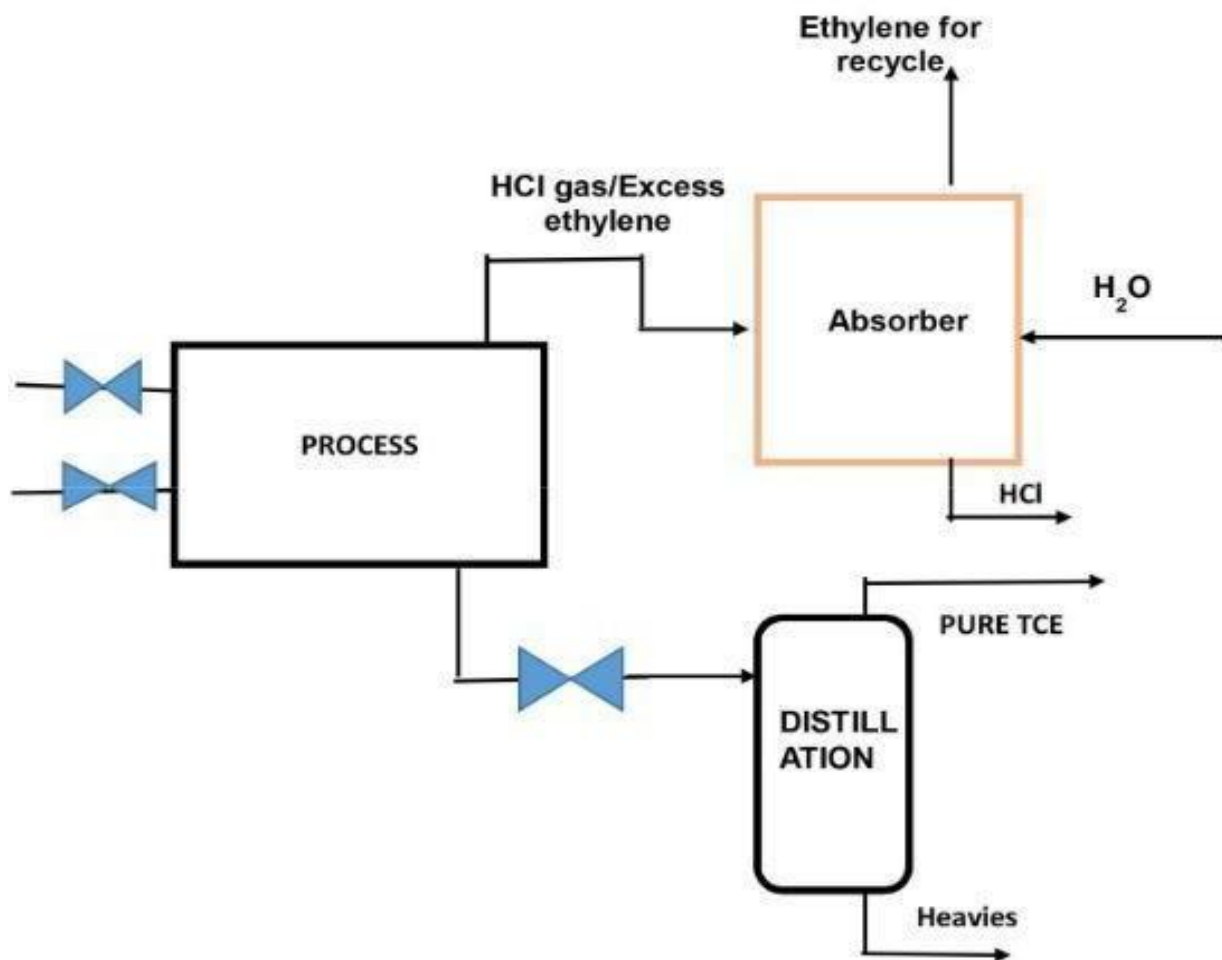
8.1.1 Input Output With Control-1



8.1.2 Input Output With Control-2

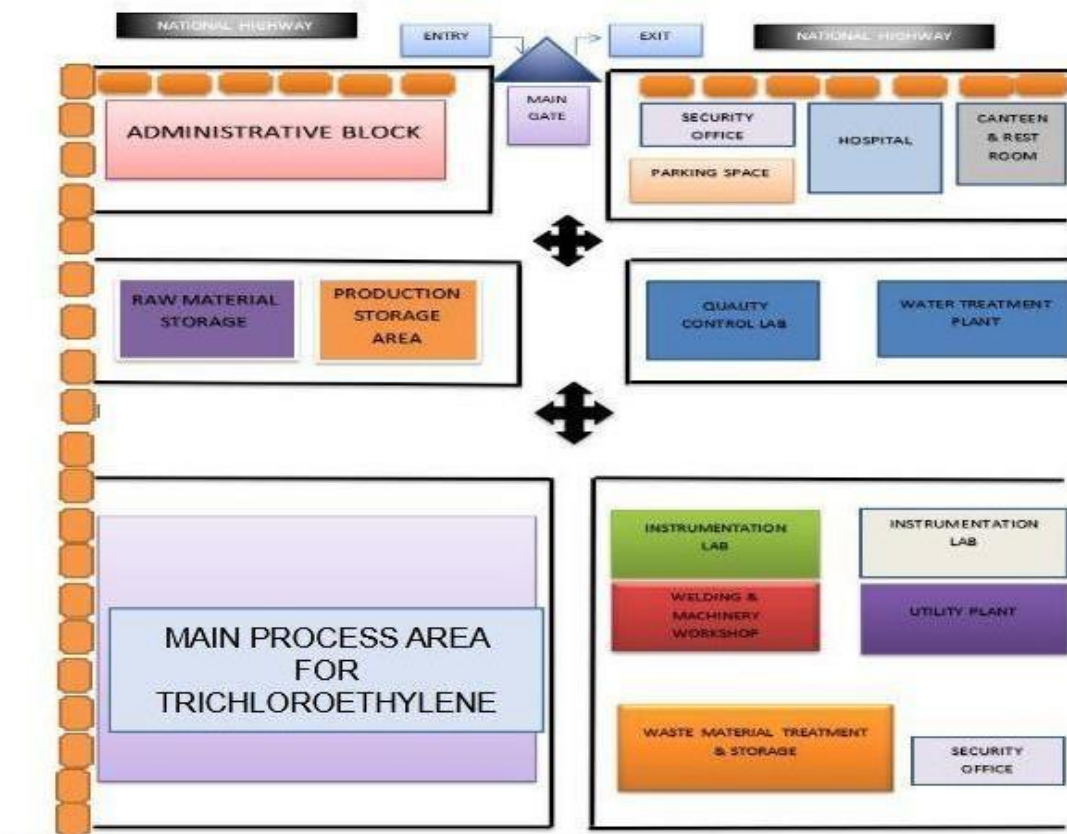


8.1.3 Separation Section



CHAPTER 9

9. PLANT LAYOUT



9.1 PLANT LOCATION

The area of a plant crucially affects the benefit of a project and the extension for future developments. Decision of area is regularly a national decision made after an evaluation of relative benefits of various for a particular business.

Major site location factors:

While numerous components are significant in choice of a plant site, three are usually thought to be the most significant. These are

1) Location of Raw Materials

One conceivable area is a site close to the wellspring of the material. This helps in decreasing the transportation charges significantly.

2) Location of Market

Consumer items ought to be delivered to the circulation habitats located near the populace zones. From the plant, the item ought to be transported by truck to singular clients. This sort of office helps in speedy conveyance and better client care.

3) Transportation

Lower expense for transportation happens if the organization has good opportunities for acquiring a full burden on the bring trip back. The least expensive method of delivery is normally by water and the most costly is by road.

Few other significant area factors

- a) Climatic conditions
- b) Water source quality and quantity
- c) Pollution problems
- d) Corporation vital arranging

9.2 LAYOUT

The spreading out of a plant is even a greater amount of a workmanship than a science.

It involves putting off types of gear and structures with the goal that the accompanying are minimized.

- 1) Damage to people and property in the event of fire, blast or toxic release.
- 2) Maintenance cost
- 3) The quantity of individuals to work the plant.
- 4) Other working costs
- 5) Construction costs
- 6) The expense of arranged future correction and development

9.3 NEW PLANT LAYOUT

The principal thing that ought to be done is to decide the heading of the prevailing wind.

Wind course will decide the overall area of manythings.

All combustible supplies ought to be situated on the downwind side.

9.3.1 PROCESSING AREA

There are two different ways of spreading out a handling region.

- ❖ Gathered design – format puts all comparative bits of equipment adjacent. This accommodates instances of activity and Switching from one unit to the other.
- ❖ Flow line design – Uses the train or line framework, which finds all the equipment all together in which it happens on the stream sheet. This Minimizes the length of the exchange lines and thus decreases the energy expected to move materials.

9.4 PLACING OF EQUIPMENT

Now, the area of the control room ought to be chosen. Usually this ought to be a focal area. This allows those watching regulators to quickly examine and decide the reason for any difficulty that may arise. The regulator room ought to be as far conceivable away from all the heating equipment.

9.5 CONSTRUCTIONS AND BUILDINGS

Appropriate putting of types of gear can bring about enormous reserve funds during the construction of the plant. For example, enormous segments that are field erected should be situated toward one side of this site so they can be constructed, welded and tested without impedance of the plant.

9.6 PROCESSING BUILDINGS

Quality control labs are a compulsory piece of any must be included together quotes. Sufficient space should be given to such laboratories to play out a wide range of essential tests and for cleaning and storing lab examining and testing containers. As a standard, an alluringly spread out plant with gear in column is an economically spread out plant.

Legitimate thought ought to be given for future expansion of both hardware and line work, so increases can be erected and tried with least obstruction to plant activity.

9.7 IMPORTANT PRINCIPLE

Significant hardware ought to be set in helpful locations. Importance is dictated by how basic a piece of gear is in wording of achieving the errand or objectives of the framework. Crisis hardware ought to be placed in promptly available positions (some place inside the overall workspace), yet not really in the ideal workspace.

9.8 GROUPING PRINCIPLE

Gear ought to be assembled by its capacity. For example, equipment that is identified with a specific errand, for example, temperature displays and temperature controls ought to be gathered. This gathering can be highlighted by the utilization of shading, marking, division lines or essentially by placing gatherings of things in lines. Look on your console - text keys, numeric keys, and cursor control keys are completely situated together in gatherings.

CHAPTER 10

10. COST ESTIMATION

10.1 ESTIMATION

PRESENT PLANT COST

Cost of a 10TPD trichloroethylene plant at 1966 was Rs.45.56 x10⁶

Therefore, the present plant cost can be given as Rs.250 x10⁶

DETAILED ANALYSIS OF COST

10.2 DIRECT COSTS

InstallationCost+Electrical Installation+service facility+building process
and auxiliary+yard improvement+land+Purchase
cost+piping+Instrumentation and controls installation

PurchasedEquipmentCost

(15-40% of Fixed Capital Investment).

Assume 35 you look after Fixed Capital Investment

$$= 0.35 * 250 \times 10^6$$

$$= \text{Rs.}87.5 \times 10^6$$

InstallationCost containing installation & painting

(25-55% of purchased cost)

40% of purchased cost to be considered

$$= 0.40 * 87.5 \times 10^6$$

$$= \text{Rs.}35 \times 10^6$$

Instrumentation&ControlsCost

(6-30% of purchased cost)

15% of Purchased cost to be considered

$$= 0.15 * 87.5 \times 10^6$$

$$= \text{Rs.}13.125 \times 10^6$$

PipingInstallationCost

(10-80% of PurchasedCost)

45% of PurchaseCost to be considered

$$= 0.45 * 87.5 \times 10^6$$

$$= \text{Rs.}39.375 \times 10^6$$

ElectricalCost

(10-40% of PurchasedCost)

15% of PurchasedCost to be considered

$$= 0.15 * 87.5 \times 10^6$$

$$= \text{Rs.}13.125 \times 10^6$$

Building Process & Auxiliary

(10-70% of PurchasedCost)

40% of PurchasedCost to be considered

$$= 0.40 * 87.5$$

$$= \text{Rs.}35 \times 10^6$$

Yard Improvement

(10- 15% of PurchasedCost)

13% of PurchasedCost to be considered

$$= 0.13 * 87.5 \times 10^6$$

$$= \text{Rs.}11.375 \times 10^6$$

Service Facilities

(30-80% of PurchasedCost)

50% of PurchasedCost to be considered

$$= 0.50 \times 87.5 \times 10^6$$

$$= \text{Rs.}43.75 \times 10^6$$

Land

(4-8% of PurchasedCost)

6% of PurchasedCost to be considered

$$= 0.06 \times 87.5 \times 10^6$$

$$= \text{Rs.}5.25 \times 10^6$$

$$\text{DirectCosts} = \text{Rs.}282.75 \times 10^6$$

10.3 INDIRECT COSTS

ContingencyPlan+EngineeringSupervision+ContractorFee+Construction
Expenses

Engineering&Supervision

(5-20 % of DirectCosts)

15 %of DirectCosts to be considered

$$= 0.15 \times 282.75 \times 10^6$$

$$= \text{Rs.}42.412 \times 10^6$$

ConstructionExpenses & ContractorsFee

(6-30% of DirectCost)

15 % of DirectCost to be considered

$$= 0.15 \times 282.75 \times 10^6$$

$$= \text{Rs.}42.412 \times 10^6$$

ContractorFee

(2-7% of DirectCost)

4% of DirectCosts to be considered

$$= 0.04 \times 282.75 \times 10^6$$

$$= \text{Rs.} 11.31 \times 10^6$$

ContingencyCosts

(5-15% of PresentCost)

13% of Direct costs to be considered

$$= 0.13 \times 282.75 \times 10^6$$

$$= \text{Rs.} 36.757 \times 10^6$$

$$\text{IndirectCosts} = \text{Rs.} 132.891 \times 10^6$$

FixedCapitalInvestments = Direct + Indirect Costs

$$= \text{Rs.} 415.641 \times 10^6$$

WorkingCapital

(10-20% of Fixed Capital Investment)

15% of Fixed Capital Investment to be considered

$$= 0.15 \times 415.641 \times 10^6$$

$$= \text{Rs.} 62.346 \times 10^6$$

Total Capital Investment = Total FixedCapitalInvestment + WorkingCapital

$$= \text{Rs.} 477.987 \times 10^6$$

10.4 MANUFACTURING COST ESTIMATION

FixedCost

Depreciation

10% FixedCapitalInvestment for machinery and 3% building value,

Building

= Rs.42.32 x10⁶

LocalTaxes

(3-4% of FixedCapitalInvestment)

4% of FixedCapitalInvestment to be considered

= 0.04*415. 641x10⁶

= Rs.16.625x10⁶

Insurances

(0.4%-1% of FixedCapitalInvestment)

0.4% of FixedCapitalInvestment to be considered

= 0.04*415.641 x10⁶

= Rs.16.625x10⁶

Rent

(8-12% of RentedLand and Buildings)

6% of BuildingValue to be considered

= Rs.673.5 x10⁶

FixedCharges = 18% of ProductCost to be considered

= Rs.6.956 x10⁶

Total product Cost = Rs.41.15 x10⁶

10.5 DIRECT PRODUCTION

Raw Materials

(10-50% of Total Product Cost)

30% of Total Product Cost to be considered

$$= 0.3 \times 41.15 \times 10^6$$

$$= \text{Rs.}12.345 \times 10^6$$

Operating Labor

(10-20% of Total Product Cost)

15% of Total Product Cost to be considered

$$= 0.15 \times 41.15 \times 10^6$$

$$= \text{Rs.}6.1725 \times 10^6$$

Direct supervisory & Electrical labor

(10-25% of Operating Labor)

12% of Operating Labor to be considered

$$= 0.12 \times 6.1725 \times 10^6$$

$$= \text{Rs.}740.7 \times 10^6$$

Utilities

(10-20% of Total Product Cost)

13% of Total Product Cost to be considered

$$= 0.13 \times 41.15 \times 10^6$$

$$= \text{Rs.}5.349 \times 10^6$$

Maintenance & Repair

(2-10% of Fixed Capital Investment)

8% of Fixed Capital Investment to be considered

$$= 0.08 \times 256.124 \times 10^6$$

$$= \text{Rs.}18.48 \times 10^6$$

Operating Supplies

(10-20% of Maintenance&Repair)

15% of Maintenance&Repair to be considered

$$= 0.15 \times 18.48 \times 10^6$$

$$= \text{Rs.} 2.772 \times 10^6$$

Laboratory Charges

(0-20% of Operating Labor)

15% of Operating Labor to be considered

$$= 0.15 \times 6.1725 \times 10^6$$

$$= \text{Rs.} 925.875 \times 10^3$$

Patents&Royalties

(2-6% of Total Product Cost)

5% of Total Product Cost to be considered

$$= 0.05 \times 41.15 \times 10^6$$

$$= \text{Rs.} 2.0575 \times 10^6$$

Direct Production cost = Sum of (1), (2), (3), (4), (5), (6), (7), & (8)

$$= \text{Rs.} 48.842 \times 10^6$$

10.6 OVERHEAD PLANTS PRODUCTS

(Maintenance Cost+Direct supervisory+50-70 of Operating Labor)

60% to be considered, Overhead Plant cost = $\text{Rs.} 14.12 \times 10^6$

Total Manufacturing Cost = I+ II +III

Total Manufacturing Cost = $\text{Rs.} 109.42 \times 10^6$

General Expenses: (containing R&D costs, distributing prices and also administration expenses)

Cost of Administration A

(40-60% of the Operating Labor Cost)

50% of administration cost to be considered

= Rs.2.823 x10⁶

Cost of Distribution B

(2-20% of Total Product Cost)

10% of Total Product Cost to be considered

= 0.1*41.15 x10⁶

= Rs.4.115x10⁶

Cost of R&D C

(2-7% of Production Cost)

3% of administration cost to be considered

= Rs.1.58 x10⁶

Expenses in General = A+B+C

= Rs.8.518 x10⁶

Total Product Cost = ManufacturingCost + GeneralExpenses

Total Product Cost =Rs.117.938x10⁶

Present Selling price:

Cost of trichloroethylene= 250/kg

Overall selling price per Annum = Rs.9.125 x10⁶/Annum

Gross per Earnings = Overall Selling price – Overall product Cost

Gross per Earnings = Rs.108.813 x10⁶

Taxation

Local Tax rate 40% to be considered

Tax over gross earning

$$= 0.4 \times 108.813$$

$$= \text{Rs.} 43.5252 \times 10^6$$

Net Profits: Gross per Earnings -Taxation

$$\text{Net Profits} = \text{Rs.} 65.2878 \times 10^6$$

Rate of Return= NetProfit/FCI

$$\text{Rate of return} = 15.70 \%$$

CHAPTER 11

11. SAFETY AND ENVIRONMENTAL ENGINEERING

11.1 SAFETY

With fast progression in modern cycles, mechanical, electrical, and synthetic dangers guarantee innumerable lives each year. It's absolutely impossible to prevent mishaps from occurring. Notwithstanding, a ton should be possible to lessen the number of mishaps and the harm that they do.

These mishaps address a social loss of extraordinary size in front of loss of lives and unsettling influence to financial effectiveness. At the point when a fire or explosion occurs, two sorts of monetary harm happen to the plant.

❖ Destruction of hardware

11.2 MEASURES FOR EMERGENCY MEDICAL AID

Guidance in General:

View this security information sheet to those specialists in attendance.

Quick clinical consideration is required.

Eye measures in contact:

Wash out promptly with tons of water, likewise under eyelids, at any rate quarter-hour. On account of contact, rinse immediately with tons of water and appearance for clinical advice.

Skin measures in Contact:

Wash out quickly with tons of water for any event quarter-hour . Prompt clinical consideration needs to be required.

Inhalation:

Move on to outside air. Not breathing well, give counterfeit respiration. Don't use artificial respiration strategy if casualty ingested or breathed within subpocket veil provided with one direction valve or any other medical gadget. Quick clinical consideration needs to be required.

Ingestion:

Don't initiate regurgitating. Call upon a doctor or other Help line center immediately.

Significant manifestations:

None sensibly foreseeable. May cause hypersensitive skin response.

Inward breath of high fume fixations may cause indications like migraine, wooziness, sleepiness, sickness and vomiting.

Symptoms of hypersensitive response may incorporate rash, tingling, expanding, trouble in breathing, shivering of hands and feet, tipsiness, unsteadiness, pain , muscle agony etc.

Notes to Physician: Take care apparently

11.3 MEASURES FOR FIRE FIGHTING

Reasonable Extinguishing Media: Use H₂O shower, liquor foam, dehydrated compound or CO₂ .

Unsuitable Extinguishing Media: data not found

Auto ignition Temperature: 410 °C / 770 °F

Explosion Limits: Top 10.5 vol %, Bottom 8 vol %

Oxidizing Properties: No oxidizing properties

11.4 HAZARDOUS AND PROTECTIVE:

Dangerous Igniting Products:

HydrogenChloride gas ChlorinePhosgene CarbonMonoxide (CO)

CarbonDioxide (CO₂)

ProtectiveEquipment and Safety measures for Firefighters:

Fire occurs, wear independent respiration apparatus,pressure demand,M.S.H./N.I.O.S.H (affirmed) with full defensive stuff.

Thermal decomposition can prompt arrival of disturbing gases and fumes.

11.5 MEASURES FOR ACCIDENTAL RELEASE

Individual Measures:

Ensure sufficient respiration.Utilize PP gear. Bring individuals far from and upwind of spill.Evacuate staff to away from the accidental areas.

Environmental Precautions:

Shouldn't be delivered in an environment.Not to flush into water or a sewage system .

Steps for Containment and CleanUp:

Soak up in an inert absorbent . confine reasonable, shut compartments for removal.

11.6 HANDLING AND STORAGE

Handling:

Wear individual defensive hardware. Try not to get in eyes, ownskin, or on apparel. Utilize just under a compound smoke hood. Don't breathe vapors or shower fog. Don't ingest.

Storage:

Keep compartments firmly shut in a dehydrated, cooled and very much respiratory spot. Prevent exposing in light. Avoid storing in aluminum compartments

CHAPTER 12

12. SUMMARY AND CONCLUSION

The mechanical strategy for Manufacturing of Trichloroethylene is studied. Based on this interaction a stream sheet is drawn. Mass and energy adjustments are done for this stream sheet and the necessary safeguard is planned. Immaculateness level is also high. Monetary investigation was done, the rate return is about 15.70%, which is alluring. Plant design, Safety and natural issues has likewise been discussed.

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