

CONFIGURATION OF VARIOUS PROCEDURES INVOLVED IN THE PRODUCTION OF METHYLENE DIPHENYL DIISOCYANATE

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

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **ASWIN M NAIR(37190012)**, **RAKHIL E(37190032)** who carried out the project entitled **"CONFIGURATION OF VARIOUS PROCEDURES INVOLVED IN THE PRODUCTION OF METHYLENE DIPHENYL DIISOCYANATE"** under my supervision from February 2020 to April 2021.

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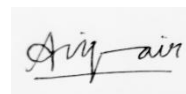
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DECLARATION

I, **ASWIN M NAIR (37190012)** hereby declare that the Project Report entitled **“CONFIGURATION OF VARIOUS PROCEDURES INVOLVED IN THE PRODUCTION OF METHYLENE DIPHENYL DIISOCYANATE”** done by me under the guidance of **Dr.D.JOSHUA AMARNATH M.Tech.,Ph.D.,** at Sathyabama Institute Of Science And Technology is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Chemical Engineering.

DATE:



PLACE:

SIGNATURE OF THE STUDENT

DECLARATION

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DATE :

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SIGNATURE OF THE CANDIDATE

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ABSTRACT

Methylene Diphenyl Diisocyanate (MDI) is the most important chemical used in polyurethane industry. It is of huge demand since the growth of polymer industries are nowadays increasing all over the world. It is considered as one of the highly imported chemicals in India. There are less manufacturers of MDI in our country. So, setting up the industry will definitely be a boom to Indian polymer industries who are dependent on other foreign countries. *The following report contains the method of manufacturing methylene diphenyl diisocyanate in a safe way. Currently, it is industrially produced in a way which involves phosgene. Phosgene is very toxic and hazardous. Considering the environmental safety and taking the industry standards to a greener way, the non-phosgene process is very desirable. This process involves thermal decomposition of carbamates to diisocyanates. First, the feedstocks involve DMC and aniline which leads to synthesis of MPC. Second, condensation reaction which leads to synthesis of MDC. Later, MDC thermally decomposes to give MDI as our product. These are the three main reactions. This brief concept is addressed thoroughly in the below description.*

TABLE OF CONTENT

CHAPTER NO.	TITLE	PAGE NO
	ACKNOWLEDGEMENT	V
	ABSTRACT	VI
	LIST OF TABLES	IX
	LIST OF FIGURES	X
1.	INTRODUCTION	1
	1.1 MDI	2
	1.2 PROPERTIES OF 4,4'-MDI	3
	1.3 TYPES OF MDI	3
	1.4 PROPERTIES OF MMDI	3
	1.5 PROPERTIES OF PMDI	3
	1.6 PROPERTIES OF MODIFIED MDI	4
	1.7 APPLICATIONS OF MDI	4
	1.8 SAFETY	4
	1.9 HEALTH HAZARD INFORMATION	5
	1.10 MANUFACTURERS OF MDI	8
2.	AIM AND SCOPE	9
3.	METHODS OF PRODUCTION AND ITS SELECTION	10
	3.1 PRODUCTION METHODS	10
	3.2 CHOICE OF METHOD	11
	3.3 DESCRIPTION AND PROCEDURE	11
4.	PERFORMANCE ANALYSIS	18
	4.1 MATERIAL BALANCE	18
	4.1.1 MATERIAL BALANCE OF REACTOR	23
	4.2 ENERGY BALANCE	24
	4.3 EQUIPMENT DESIGN	26
	4.3.1 REACTOR	26
	4.3.2 CENTRIFUGE	30

	4.4 INSTRUMENTATION AND CONTROL	31
	4.4.1 SENSORS	32
	4.4.2 VALVES	32
	4.4.3 SIGNAL TRANSMISSION FOR PROCESS CONTROL	33
	4.4.4 INSTRUMENTATION SAFETY	33
	4.4.5 CONTROLEQUIPMENT	33
	4.4.6 PROCESS DRAWINGS	34
	4.4.7 CONCLUSION	35
	4.5 COST ESTIMATION	36
	4.6 PLANT LAYOUT AND LOCATION	41
	4.6.1 PLANT LAYOUT	41
	4.7 PROCESS SAFETY	44
	4.7.1 PROCESS SAFETY AND ENVIRONMENT	44
5.	CONCLUSION	49
6.	REFERENCE	50

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
3.1	Abbreviation	15
3.2	Process Details	17
4.1.1	Physical Properties	19
4.2	Compound and its specific heat capacity	24
4.5.1	Project cost	36
4.5.2	Accessories cost	37
4.5.3	Raw material cost	37
4.5.4	Man power cost	38
4.5.5	Running cost	38
4.5.6	Production cost	39

LISTS OF FIGURES

FIGURE NO.	FIGURES	PAGE NO.
3.1	Process flow sheet	16
4.1.1	Reactor showing reactants and products	23
4.3.1	Reactor(CSTR)	29
4.3.2	Centrifuge	31
4.6.1	Plant layout	43

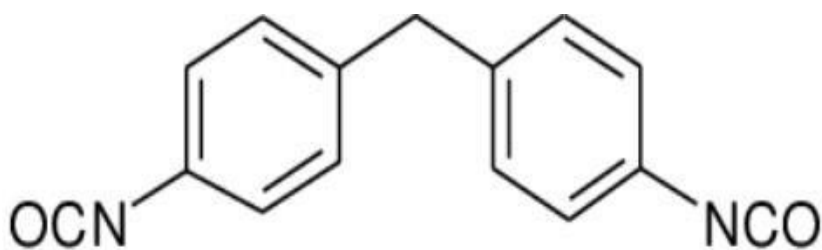
CHAPTER 1

INTRODUCTION

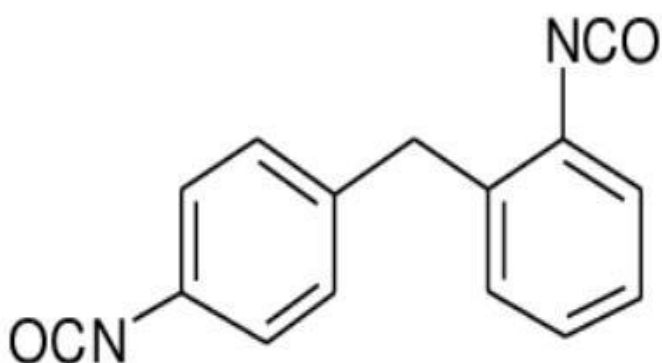
Methylene Diphenyl Diisocyanate (MDI) is the most important chemical used in polyurethane industry. It is of huge demand since the growth of polymer industries are nowadays increasing all over the world. It is considered as one of the highly imported chemicals in India. There are less manufacturers of MDI in our country. So, setting up the industry will definitely be a boom to Indian polymer industries who dependent on other foreign countries. There are different ways of manufacturing MDI. But we will only focus on the optimal method available according to literature. After looking at the different methods, the following method was chosen as the best. We will focus on the method of manufacturing. The method is designed for a plant which produces 1 ton/day of MDI . Plant life time is expected to be nearly 10 years. Handling of MDI is the most important part. The method involves various catalysts, solvents and other raw materials which are used in MDI production. But these have to be consulted with the experts during setting up the pilot plant. It is because, there can be different cost cutting methods involved in the production of MDI. Waste management and recycling processes in industry can improve the cost of production. So, consultation and experimenting are important. However, the growing technology has proven that tremendous research and there are substitutes to MDI in the present market but it is in very few quantities.

1.1 MDI

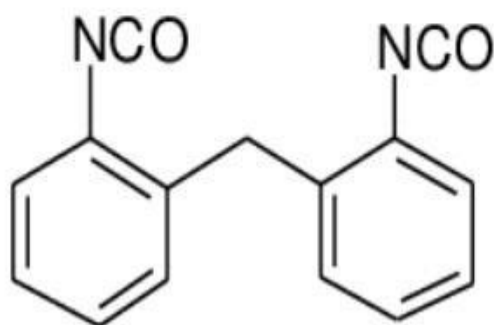
Methylene Diphenyl Diisocyanate (MDI) is an aromatic compound with isocyanate as the functional group.



4,4'-MDI



2,4'-MDI



2,2'-MDI

Most popular form of MDI is 4,4'-Diphenylmethane-diisocyanate(MDI). It's functional group (-R-N=C=O) makes the compound's reactivity special. The mixture of PMDI and MDI makes the crude MDI. HDI, TDI and MDI are the three main diisocyanates. Four largest producers of MDI are BAYER, DOW, BASF and HUNTSMAN.

1.2 PROPERTIES OF 4,4'-DIPHENYLMETHANE-DIISOCYANATE

It is a White or pale yellow solid at the room temperature. It is insoluble in water. But, soluble in organic compounds such as acetone, benzene, kerosene and nitrobenzene. When heated to decomposition it releases toxic fumes of nitrogen oxides and sulphur oxides. MDI is not much toxic as compared to other isocyanates. We surely remember the “Bhopal Gas Tragedy” of 1984 which is because of the leak of methyl isocyanate in the atmosphere. It has made many lives a tragic one. MDI comparing with other isocyanates doesn't catch fire quickly. It has vapour pressure of 0.000005 mmHg at 200° C.

1.3 TYPES OF MDI

The different types of MDI are:

- Monomeric MDI also known as MMDI
- Polymeric MDI or PMDI
- Carbodimide modified MDI or modified MDI

1.4 PROPERTIES OF MONOMERIC MDI

It is a purified material distilled from the MDI mixture. MMDI refers to both 2,4'-MDI and 4,4'-MDI. Above 45° C, pure 4,4'-MDI can be kept as a liquid for upto two weeks. It decomposes at a temperature of 230° C. Increasing amounts of 2,4'-MDI and 3-ring or greater PMDI into the 4,4'-MDI, results in a mixture that is a liquid at the room temperature.

1.5 PROPERTIES OF POLYMERIC MDI

It is usually a brown liquid. It consists of mixture of poly-aromatic isocyanates including 2 ring (MMDI), 3 ring and higher compound with higher molecular weight. PMDI is low viscosity liquid at atmospheric conditions. PMDI has density of 1.23 g/cm³ at 25° C. It decomposes at a temperature over 230° C to give out CO₂. It has low vapour pressure of 10⁻⁵ bar. It has low flammability risk due to its high flash point of above 200° C.

1.6 PROPERTIES OF MODIFIED MDI

These isocyanates are mostly liquids that are stable and clear at room temperature. A portion of MMDI reacts to yield a carbodiimide modified isocyanate with a free -NCO weight between 29.2 % and 29.5 %. The carbodiimide modification leads to formation of a tri-functional uretonimine species, by reaction with some of the remaining di-functional MMDI.

1.7 APPLICATIONS OF MDI

MDI foams are good thermal insulators and are used in freezers and refrigerators. 4,4'-MDI is an adhesive, it is also used in various departments such as transportation, insulation, packaging, furniture, textiles etc..

1.8 SAFETY

MDI is the least hazardous of the commonly available isocyanates, but is not benign. Its very low vapour pressure reduces its hazards during handling compared to the other major isocyanates. However, it, like the other isocyanates, is an allergen and sensitizer. Persons developing sensitivity to isocyanates may have dangerous systemic reactions to extremely small exposures, including respiratory failure. Handling MDI requires strict engineering controls and personal protective equipment. Compared to other organic cyanates, MDI has a relatively low human toxicity. It is a potentially violently reactive material towards water and other nucleophiles.

The business type of 4,4'-methylenediphenyl diisocyanate (MDI) is utilized to deliver polyurethane foams. Acute (present moment) inward of high groupings of MDI may cause refinement and asthma in humans. Acute dermal contact with MDI has prompted dermatitis and skin inflammation in workers. MDI has been seen to aggravate the skin and eyes of rabbits. Chronic (long haul) inward openness to MDI has been appeared to cause asthma, dyspnea, and other respiratory disabilities in workers. Respiratory impacts have additionally been seen in animals. No satisfactory data is accessible on the regenerative, formative, or cancer-causing impacts of MDI in humans. EPA has arranged MDI as a Group D, not classifiable as to human cancer-causing nature.

1.9 Health Hazard Information

Intense Effects:

Intense inward of high centralizations of MDI may cause refinement and asthma in people. Dermal contact with MDI has prompted dermatitis and dermatitis in workers. MDI has been seen to aggravate the skin and eyes of hares. Tests including intense openness of rodents and mice have exhibited MDI to have high to extreme acute harmfulness by inward and moderate acute poisonousness by oral openness.

Persistent Effects (Noncancer):

Openness to isocyanates is a main source of work related asthma. Persistent inward openness to MDI has been appeared to cause asthma, dyspnea, and other respiratory disabilities in workers. Some of the impacts of MDI might be because of resistant framework responses in people who have been sharpened to significant degrees of MDI, over the work related openness cutoff of 20 ppb. Such sharpened people may encounter impacts when presented to low degrees of MDI. Respiratory impacts like nasal and lung injuries, steady with openness to an aggravation, have been accounted for in persistently uncovered creatures. The Reference Concentration (RfC) for MDI is 0.0006 milligrams per cubic meter (mg/m^3) in light of disturbance of the nasal layers in rodents. The RfC is a gauge (with vulnerability crossing maybe a significant degree) of a persistent inward openness to the human populace (counting delicate subgroups) that is probably going to be without apparent danger of malicious noncancer impacts during a lifetime. It is anything but an immediate assessor of danger yet rather a reference highlight measure the potential effects. At openings progressively more noteworthy than the RfC, the potential for unfavorable wellbeing impacts increases. Lifetime openness above the RfC does not infer that an antagonistic wellbeing impact would essentially happen. EPA has medium trust in the RfC based on: high trust in the chief examination since it was all around planned, utilized a satisfactory number of creatures, and showed a fixation reaction relationship; and medium trust in the data set because of the absence of information on conceptive and formative endpoints and openness reaction information for asthma in people. EPA has not set up a Reference Dose

(RfD) for MDI. Nonetheless, it is far-fetched that people would be presented to MDI by the oral course.

Conceptive/Developmental Effects:

No data is accessible on the conceptive or formative impacts of MDI in people. Diminished placental and fetal loads and an expanded number of hatchlings per litter with skeletal varieties were accounted for in one inward concentrate in rodents. These impacts were noticed distinctly at the most noteworthy portion, and may have been identified with maternal poisonousness.

Malignancy Risk:

Data isn't satisfactory to decide the cancer-causing impacts of MDI in people. Aspiratory adenomas were accounted for in one strain of rodents presented to polymeric MDI. EPA has arranged MDI as a Group D, not classifiable as to human cancer-causing nature.

ACGIH TLV- - American Conference of Governmental and Industrial Hygienists' edge limit esteem communicated as a period weighted normal; the grouping of a substance to which most specialists can be uncovered without unfavorable impacts.

BMC- - Benchmark fixation.

LC 50 (Lethal Concentration 50)- - A determined grouping of a compound in air to which openness for a particular period of time is required to cause demise in half of a characterized exploratory creature populace.

NIOSH REL- - National Institute of Occupational Safety and suggested openness limit; NIOSH recommended openness limit for a 8-or 10-h time-weighted-normal openness or potentially roof.

NIOSH roof - NIOSH's suggested openness limit roof; the fixation that ought not be surpassed whenever.

NIOSH IDLH - - NIOSH's quickly risky to life or wellbeing fixation; NIOSH prescribed openness cutoff to guarantee that a laborer can escape from an openness condition that is probably going to cause demise or prompt or deferred lasting unfriendly wellbeing impacts or keep escape from the climate.

OSHA ceiling--Occupational Safety and Administration's passable openness limit roof esteem; the grouping of a substance that ought not be surpassed whenever. The wellbeing and administrative qualities referred to in this factsheet were acquired in December 1999.

- Health numbers are toxicological numbers from creature testing or danger evaluation esteems created by EPA.
- Regulatory numbers are values that have been consolidated in Government guidelines, while warning numbers are nonregulatory values given by the Government or different gatherings as counsel. OSHA numbers are administrative, though NIOSH and ACGIH numbers are warning. though NIOSH and ACGIH numbers are warning.
- The BMC is from the basic examination utilized as the reason for the RfC.

Actual Properties Of MDI:

- The compound recipe for MDI is $C_{15}H_{10}N_2O_2$, and its atomic weight is 250.3 g/mol.
- MDI appears as a light-yellow melded strong or gems.
- The smell edge for MDI is 0.4 ppm. The fume pressure for MDI is 5×10^{-6} mm Hg at 25 °C.

Conversion Factors:

To convert concentrations in air (at 25 °C) from ppm to mg/m³ : mg/m³
= (ppm) × (molecular weight of the compound)/(24.45).

For MDI: 1 ppm = 10.2 mg/m³.

1.10 World's Top Methylene Diphenyl Diisocyanate Manufacturers

- Covestro AG –Leverkusen, Germany
- The Wanhua Industrial Group- Yantai, China
- BASF SE- Ludwigshafen, Germany
- Huntsman Corporation- Texas,USA
- The Dow Chemical Company- Michigan,US
- Kumho Mitsui Chemicals- Seoul, South Korea
- Tosoh Corporation- Tokyo Japan

CHAPTER 2

AIM AND SCOPE

AIM:

To design the process for the production of Methylene Diphenyl Diisocyanate by thermal decomposition reaction.

SCOPE:

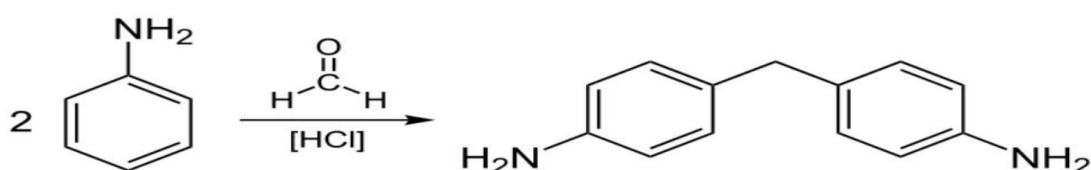
- The main aim is to obtain high yield of MDI with minimal cost.
- A simple and safe process for the development of isocyanates.
- Performing reactions at temperature which cannot create any harm.
- Minimizing the time of reaction.
- To avoid any accident during the reaction and
- To ensure safety.
- Helps to optimize the manufacturing of MDI.
- The production method prevents the formation of phosgene which is a toxic gas.

CHAPTER 3

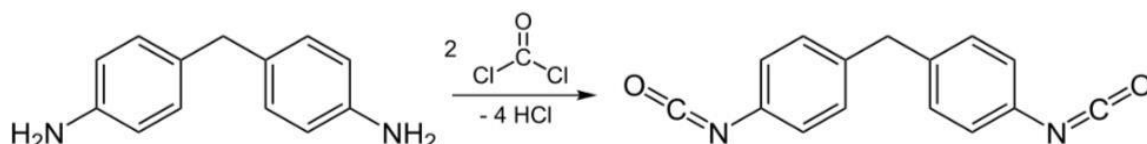
METHODS OF PRODUCTION AND ITS SELECTION

3.1 PRODUCTION METHODS

The main method of production of MDI is by responding aniline and formaldehyde to get a combination of diamine precursors.



These diamine antecedents are treated with phosgene to frame a combination of isocyanates, which on refining produce a combination of MDI and its isomers.

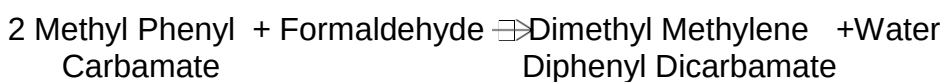


The second method is divided into 3 sections.

Section 1:

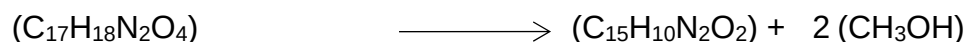


Section 2:



Section 3:

Dimethyl Methylene Diphenyl Dicarbamate $\rightarrow$ MDI + 2Methanol



3.2 CHOICE OF METHOD

- The first process of producing MDI involves phosgene.
- Large amount of HCl is a waste by-product in the first method. Hence its increases cost of production.
- Phosgene is very toxic, hazardous and injurious to health.
- The best way of producing MDI in a green way is by 'Thermal Cracking', therefore we chose the second method of production.

3.3 DESCRIPTION AND PROCEDURE

Stage 1: MPC synthesis

In first step, at 150⁰ C, DMC is fed into the reactor feed stream, which is in the gaseous phase. MPC is produced by the reaction of DMC with organic compound aniline in the presence of Zn(OAc)₂/Ac catalyst system. This segment has two channel streams, one is DMC and the other is aniline. These two feed stock items are compressed, blended, warmed and took care of into the reactor. The proportion of DMC: Aniline is 7: 1. The cycle comprises of 13 reactors, every reactor works at a temperature of 150⁰ C, a pressing factor of 10 bar and is loaded with Zn(OAc)₂/Ac catalyst. 8 hours is the residence time, henceforth the huge volume of the reactors is needed. The power source of the reactor comprises of MPC, DPU, Aniline, DMC, NMA, Methanol and CO₂. This is straightforwardly taken care of into the refining section, 2 segments, where the hefty segments; MPC, aniline, NMA and DPU are isolated from the light segments; DMC, methanol and CO₂. The CO₂ in the top, containing the light segments, is streaked off instantly to the drum. The CO₂ is shipped to the OSBL vent scrubber before it is delivered in the environment. The other light parts, methanol and DMC are azeotropes. They must be isolated on the grounds that, DMC can be reused and methanol can be utilized in the on location, however OSBL, creation cycle of DMC. A semi-porous film is utilized to isolate them. The base of refining segment containing the substantial parts is taken care of into a huge segment, which has 3 leave streams.

The top contains predominantly aniline and is reused to the start of this part. At that point there is a side that principally contains the result NMA, this is taken care of into the incinerator, before removal. The base contains MPC and DPU, this is taken care of into the last segment. The segment is worked at a pressing factor of 0.13 bar, this is to bring down the temperature and forestall DPU decay. Deterioration happens at temperature over 262⁰ C and results in a dark, unprocessable, tacky material. The base contains all DPU and is additionally siphoned to the incinerator, before removal. The top contains MPC of high immaculateness, that is shipped to the subsequent segment. There is likewise a little waste from the vacuum ejector bundle, which is moved to the incinerator. As per research, 2% selectivity is of NMA. 4% MPC is changed over into DPU. DPU selectivity is 100 %. It is accepted that the reactor is warmed with low pressing factor (LPS) and it is loaded with a fixed strong impetus bed. DMC can be delivered nearby. It tends to be created in high return from methanol and urea when dimethyldimethoxytin is utilized as catalyst in blend with triglyme.

Stage 2: MDC synthesis

In this segment MDC is delivered by the buildup response of HCHO and MPC over an upheld ZnCl₂/Ac catalyst framework. It is a non-spilling catalyst. This response is normally directed over a corrosive catalyst. MDC is broken up in appropriate dissolvable. There are three feed streams in this part; the first is the bay of MNB, the second is the MPC from the primary area, the third is the bay of formalin, containing HCHO. The MPC and MNB are both brought to a pressing factor of 5 bars and afterward blended in a 1 : 1 weight proportion to break up MPC in MNB. The blend is warmed to 140⁰ C and took care of into the reactor. The formalin is compressed and warmed to a pressing factor of 10 bar and temperature of 140⁰ C. This is likewise taken care of into the reactor. The reactor is worked at 140⁰ C, 5 bar and a residence time of 3 hours. The power source of reactor is taken care of into a evaporation crystallizer. Crystallizer is worked at a pressure of 0.1 bar to keep the temperature under 200⁰ C, temperatures over 200⁰ C will influence MDC quality. In crystallizer MDC solidifies and is isolated from the dissipated , MNB, MPC combination. The MDC is blended in with unadulterated MNB. The combination is moved to the following segment, where it is changed into MDI. The top item is dense in a condensor and most of the water

is isolated by two decanters. The water is moved to the OSBL treatment for additional treatment and removal. The non watery is reused constantly. This interaction expects the inventory of unadulterated HCHO, as a general rule it will be provided in a 37 W % blend with (formalin), H₂O is eliminated after the response, the formalin blend can without much of a stretch be added to the fluid response combination, and will even build the waste . 2,4'- MDC selectivity more than HCHO is 2 %. Cooling cooled reactor with fixed strong catalyst bed is utilized. 4,4'- MDC and 2,4'- MDC are a processable slurry.MDC yield is 99 %. proportion for MPC : Catalyst in this response is 10 : 1. Weight proportion of MPC : HCHO is 20 : 1.

MDC Seperation:

In the first place, nitrobenzene is isolated by steam refining. Partition of MDC should be directed at temperature lower than 200⁰ C. MDC solidifies just in crystallizer. MDC is isolated by crystallization measure in which CH₃OH is utilized to break up MPC and results. Higher virtue is gotten by additional crystallization steps and washing with CH₃OH.

Section 3: MDI synthesis

In this part the MDC is thermally deteriorated to MDI over an upheld Zn/Ac impetus. The segment has 6 inlet streams. The last four are taken care of straightforwardly into the incinerator for additional treatment and removal. The other two are feed streams the delta of the MNB, MDC blend from the past area to lower part of the reactor and N₂ is imported from OSBL to top. Break up MDC in a dissolvable. It is on the grounds that MDC is an inprocessable fluid strong slurry. Because of high temperature of response, dissolvable's limit should be atleast 150⁰ C. The MNB blend is compressed and warmed to 15 bar and 280⁰ C and is taken care of into the highest point of reactor . The N₂ is likewise compressed and warmed to 15 bar and 280⁰ C and is taken care of into the lower part of reactor . The reactor is worked at 280⁰ C, 15 bar and residence time of 1 minute. The warm decay response is an exceptionally endothermic harmony response; thusly, the N₂ is acquainted from the base with work as a warmth transporter, it likewise eliminates CH₃OH to keep the response balance at the MDI side. The blend containing mostly N₂, methanol, and MNB coming from the top area outlet of

reactor, is cooled, and took care of into a flash drum. The N_2 is streaked off and reused. The base result of glimmer drum is taken care of into refining segment. Methanol is the top item and is consolidated and moved OSBL. The base result of refining segment, primarily MNB, is reused, moved and reused for dissolving of MDC . From the lower part of reactor another is eliminated, this principally contains MDI and it's subordinates and MNB. To forestall further responses of MDI to undesirable items it is important to keep the temperature in the process under $180^{\circ}C$. In this way, the partition among MDI and MNB is performed at a pressing factor underneath barometrical pressing factor. MNB is isolated in a section, rotator and a glimmer drum. The segment is worked at a pressing factor of 0.1 bar and the glimmer drum at 0.05 bar. From condensor the excess is brought into a rotator where unadulterated strong MDI is again isolated from nitrobenzene and is brought into a blaze drum where nitrobenzene is determined. The MDI is the base item and moved OSBL for additional utilization, the MNB is the top item and is reused a lot. Because of the vacuum ejector bundles, there are some little waste streams that are additionally treated in the incinerator. Incinerator likewise has two leave streams, these are moved OSBL for additional treatment and removal. Counter current, stuffed reactor configuration is utilized and is warmed by low temperature warming oil. The reactor in this response has a vaporous top and a fluid base outlet . 2,4'- MDI selectivity more than 4,4'- MDC is 10 %. Monomeric MDI is acquired from PMDI by consistent meager film refining. Market split is around 80 % polymeric and 20 % unadulterated MDI. MDI, PMDI and subordinates are finally cleaned by the Vacuum refining measure.

Usefulness is the normal number of receptive gatherings. PMDI usefulness lies somewhere in the range of 2.3 and 3.0. Unadulterated MDI has 2. The evaluations that are utilized in the creation of inflexible froths have a usefulness of 2.6 to 2.7 and regularly contain 30% - 40% of unadulterated MDI. The most extreme permissible temperature of waste in sewage frameworks is $30^{\circ}C$.

Table 3.1: Abbreviation

MDI	Methylene Diphenyl Diisocyanate
MMDI	Monomeric MDI
PMDI	Polymeric MDI
DMC	Dimethyl Carbonate
MPC	Methyl Phenyl Carbamate
MDC	Dimethyl Methylene Diphenyl Dicarbamate
NMA	N-Methyl anilene
DPU	Diphenyl urea
MNB	Nitrobenzene
ISBL	Inside battery limits
OSBL	Outside battery limits
X _n	Harmful
T	Toxic
N	Dangerous for environmeent
CAS	Chemical Abstract service
F	Highly inflammable
TDI	Toluene Diisocyanate

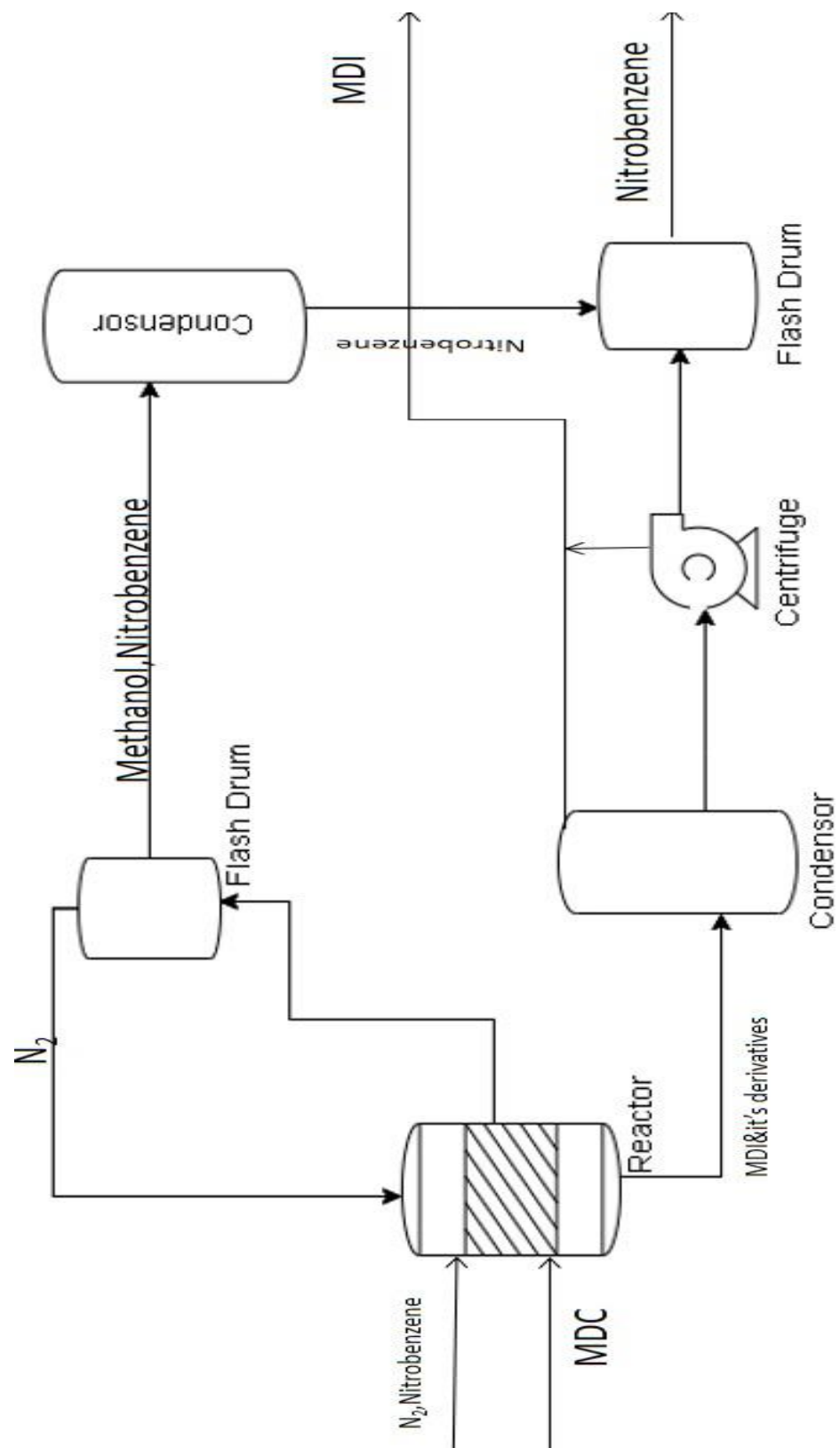


Fig 3.1: Flow sheet showing MDI synthesis

Table 3.2: Process Details

	MPC synthesis	MDC synthesis	MDI synthesis
Phase	Liquid	Liquid	Liquid
Temperature(⁰ C)	150	140	280
Pressure(bar)	10	5	15
Residence Time(min)	480	180	1
Feedstock ratio(molar)	Anilene:DMC-1:7	MPC:HCHO-4:1	
Catalyst	Zn(OAc) ₂ /Ac	ZnCl ₂ /Ac	Zn/Ac
Catalyst type	Heterogeneous	Heterogeneous	Heterogeneous
Conversion	80%	92%	100%
Selectivity	98%	98%	90%
Energy	Endothermic	Exothermic	Highly endothermic
Feedstock	Anilene,DMC	MPC,HCHO	MDC
Product	MPC	MDC	MDI
By-products	CH ₃ OH,NMA,DPU,CO ₂	H ₂ O,MDC derivatives	CH ₃ OH,MDI derivatives
Solvent		Nitrobenzene	Nitrobenzene
Solvent Feed ratio(mass)		MPC:MNB-1:1	MDC:MNB-1:2
Heat carrier			N ₂
Heat carrier feed ratio(mass)			MDC:N ₂ -1:0.5

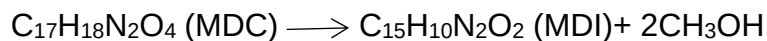
CHAPTER 4

PERFORMANCE ANALYSIS

4.1 MATERIAL BALANCE

Basis: 1 Ton/day of Methylene diphenyl diisocyanate

Stage 3: MDI synthesis



Molar mass of $\text{C}_{15}\text{H}_{10}\text{N}_2\text{O}_2$ (MDI): 250.25 Kg/Kmol

Therefore, number of moles = $\frac{\text{mass of the compound}}{\text{molar mass of the compound}}$

Number of moles of MDI = $1000/250.25 = 3.996$ kmol/day of MDI

From the chemically balanced equation it is clear that the conversion of the reaction is 100% and selectivity is 90%.

Considering both conversion and selectivity,

Number of moles of MDC required = 8.502 kmol/day (X=100%, S=90%)

Therefore,

$$\begin{aligned}\text{Mass of MDC required} &= \text{Number of moles of MDC} \times \text{Molar mass of MDC} \\ &= 8.502 \times 314.34 \\ &= 2672.51 \text{ Kg/day of MDC} \\ &= 2.67251 \text{ tons/day}\end{aligned}$$

Since the molar ratio of MDI: methanol = 1:2 (from balanced chemical equation)

Therefore,

$$\begin{aligned}\text{Moles of methanol} &= 2 \times \text{moles of MDI} \\ &= 2 \times 3.996 \\ &= 7.992 \text{ kmol/day}\end{aligned}$$

$$\begin{aligned}\text{Mass of methanol formed} &= \text{moles of methanol} \times \text{molar mass of methanol} \\ &= 7.992 \times 32.04 \\ &= 256 \text{ Kg/day} \\ &= 0.256 \text{ ton/day}\end{aligned}$$

Table 4.1.1: Physical Properties

Compounds	Formula	Molecular weight	Density at 15.6 ⁰ C (Kg/m ³)	Boiling point (⁰ C)	Freeze point (⁰ C)	CAS number	Danger symbol(s)
2,4'-MDI	C ₁₅ H ₁₀ N ₂ O ₂	250.3	1203	335.9	38.1	5873-54-1	X _n
4,4'-MDI	C ₁₅ H ₁₀ N ₂ O ₂	250.3	1203	335.9	38.1	101-68-8	X _n
Aniline	C ₆ H ₇ N	93.1	1017	184	-6.0	62-53-3	T, N
CO ₂	CO ₂	44.0	815	-78.5	-56.6	124-38-9	None
DMC	C ₃ H ₆ O ₃	90.1	1060	90.3	0.0	616-38-6	F
DPU	C ₁₃ H ₁₂ N ₂ O	212.3	1292	431.4	232.0	102-07-8	-
HCHO	CH ₂ O	30.0	732	-19.1	-92.0	50-00-0	T
MDC	C ₁₇ H ₁₂ N ₂ O	314.3	1905	595.3	179.0	7450-63-7	-
MDC24	C ₁₇ H ₁₈ N ₂ O ₄	314.3	1905	631.9		78948-89-7	-
CH ₃ OH	CH ₄ O	32.0	801	64.7	-97.7	67-56-1	F, T
MNB	C ₆ H ₅ NO ₂	123.1	1195	210.8	5.8	98-95-3	T, N
MPC	C ₆ H ₉ NO ₂	151.2	1241	244.5	47.0	2603-10-3	-
N ₂	N ₂	28.0	519	-195.8	-210.0	7727-37-9	None
NMA	C ₇ H ₉ N	107.2	983	195.9	-57.0	100-61-8	T, N
H ₂ O	H ₂ O	18.0	1000	100	0.0	7732-18-5	None

Stage 2: MDC Synthesis



From the above stage the number of moles of MDC= 8.502 kmol/day

Therefore,

$$\begin{aligned}\text{Number of moles of MPC} &= 2 \times \text{number of moles of MDC} \\ &= 2 \times 8.502 \\ &= 17.004 \text{ kmol/day}\end{aligned}$$

but we have ,conversion=92% and selectivity=98%

After considering both conversion and selectivity,

$$\begin{aligned}\text{Number of moles of MPC} &= 17.004 / (0.92 \times 0.49) \\ &= 37.7196 \text{ kmol/day}\end{aligned}$$

Therefore,

$$\begin{aligned}\text{Mass of MPC required} &= \text{moles of MPC} \times \text{molar mass of MPC} \\ &= 37.7196 \times 151.16 \\ &= 5701.7 \text{ Kg/day} \\ &= 5.7017 \text{ ton/day}\end{aligned}$$

From the chemically balanced equation,

$$\begin{aligned}\text{Number of moles of formaldehyde} &= \text{moles of MPC} / 2 \\ &= 37.7196 / 2 \\ &= 18.8598 \text{ kmol/day}\end{aligned}$$

Therefore,

$$\text{Mass of Formaldehyde required} = \text{moles of formaldehyde} \times \text{molar mass of formaldehyde}$$

$$\begin{aligned}\text{Mass of formaldehyde} &= 18.8598 \times 30.031 \\ &= 566.3786 \text{ Kg/day} \\ &= 0.5663786 \text{ ton/day}\end{aligned}$$

Stage 1: MPC synthesis



From stage 2,

$$\text{Number of moles of MPC} = 37.7196 \text{ kmol/day}$$

Therefore,

$$\text{Number of moles of anilene} = 37.7196 \text{ kmol/day (from balanced chemical equation)}$$

Here the conversion is 80% and selectivity is 98%.

After calculating both conversion and selectivity,

$$\begin{aligned} \text{Number of moles of anilene} &= 37.7196 / (0.80 \times 0.49) \\ &= 96.2234 \text{ kmol/day} \end{aligned}$$

Therefore,

$$\begin{aligned} \text{Mass of anilene needed} &= \text{moles of anilene} \times \text{molar mass of anilene} \\ &= 96.2234 \times 93.13 \\ &= 8961.2852 \text{ Kg/day} \\ &= 8.9612852 \text{ ton/day} \end{aligned}$$

since we know that the molar feed ratio of anilene:DMC = 1:7 (Process details)

Therefore,

$$\begin{aligned} \text{Number of moles of DMC required} &= 7 \times 96.2234 \\ &= 673.5638 \text{ kmol/day} \end{aligned}$$

Mass of DMC required = moles of DMC x Molar mass of DMC

$$\begin{aligned} &= 673.5638 \times 90.08 \\ &= 60,674.6271 \text{ Kg/day} \\ &= 60.6746271 \text{ ton/day} \end{aligned}$$

At stage 3 we are adding nitrobenzene as solvent to MDC at a Ratio of 1:2
therefore

Moles of nitrobenzene required = $2 \times 8.502 = 17.004$ kmol/day

Mass of Nitrobenzene = $17.004 \times$ molar mass of nitrobenzene

$$= 17.004 \times 123.11$$

$$= 2093.36 \text{ kg/day}$$

$$= 2.09 \text{ ton/day}$$

At stage 3,

N₂ act as heat carrier and ratio of MDC: N₂=1:0.5

Therefore,

moles of N₂ required = $0.5 \times 8.502 = 4.251$ kmol/day

Mass of N₂ required = $4.251 \times$ molar mass of N₂

$$= 4.251 \times 28$$

$$= 119.028 \text{ kg/day}$$

$$= 0.119 \text{ ton/day}$$

4.1.1 MATERIAL BALANCE OF REACTOR

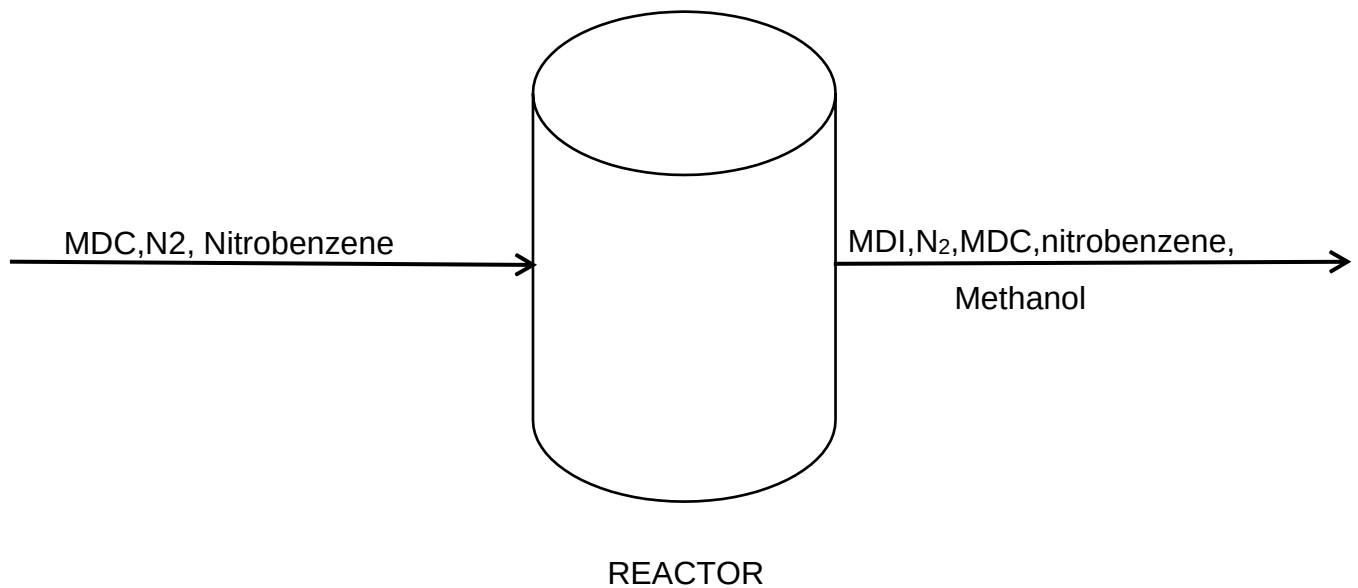


Fig 4.1.1: reactor showing its reactants and products

Mass in :

$$\text{MDC} = 8.502 \times 314.34 = 2672.5186 \text{ kg/day}$$

$$\text{N}_2 = 4.251 \times 28 = 119.028 \text{ kg/day}$$

$$\text{Nitrobenzene} = 17.004 \times 123.11 = 2093.36 \text{ kg/day}$$

$$\text{Total Mass entering the reactor} = 4884.9066 \text{ kg/day}$$

Mass out:

$$\text{MDI} = 3.996 \times 250.25 = 1000 \text{ kg/day}$$

$$\text{N}_2 = 4.251 \times 28 = 119.028 \text{ kg/day}$$

$$\text{Nitrobenzene} = 17.004 \times 123.11 = 2093.36 \text{ kg/day}$$

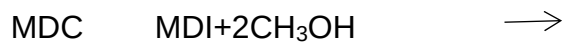
$$\text{MDC} = (8.502 - 3.996) \times 314.34 = 1416.41 \text{ kg/day}$$

$$\text{Methanol} = 7.992 \times 32 = 255.744 \text{ kg/day}$$

$$\text{Total mass leaving the reactor} = 4884.542 \text{ Kg/day}$$

$$\text{Error} = 0.0036\%$$

4.2 ENERGY BALANCE



Standard heat of formation of MDI= -56.3 KJ/mol

Standard heat of formation of MDC= 678.21 KJ/mol

Standard heat of formation of CH₃OH= -238.4 KJ/mol

heat of reaction at 25°C = $\Delta_{\text{rxn}}H = \text{Heat of reaction of Products} - \text{Heat of reaction of reactants}$

$$= (-56.3 + 2 \times -238.4) - (-678.21) \text{ KJ/mol}$$

$$= 145.11 \text{ KJ/mol.}$$

Table 4.2: Compound and its specific heat capacity

COMPOUND	VALUE OF C_p (KJ/mol. K)
CH ₃ OH	0.03864
MDC	0.0312
N ₂	1.0390
MDI	0.0307
Nitrobenzene	0.184

Reactants at 140°C should be brought to 25°C after the reaction,

$$\text{Heat gained} = (140 - 25) \times [8.502 \times 0.0312 + 4.251 \times 1.039 + 17.004 \times 0.184]$$

$$= 898.241 \text{ KJ/day}$$

we know that heat of reaction= 145.11 KJ/mol

No of moles reacted=3.996 kmol/day

therefore $\Delta H_{\text{reaction}} = 145.11 \times 3.996 = 579859.56 \text{ KJ/day}$

Heat needed= $mC_p \Delta T$

$$= (280-25)[1.039 \times 4.251 + 0.184 \times 17.004 + 3.996 \times 0.0307 + 7.992 \times 0.03864 + (8.502 - 3.996) \times 0.0312]$$

$$= 255 \times 8.1176$$

$$= 2069.98 \text{ KJ/day}$$

$Q = \text{heat needed} + \text{heat of reaction} - \text{heat gained}$

$$= 2069.98 + 579859.56 - 898.241$$

$$= 581031.299$$

$$= 581.031 \times 10^3 \text{ KJ/day}$$

$Q_{\text{reactor}} = 581.031 \times 10^3 \text{ KJ/day.}$

4.3 EQUIPMENT DESIGN

4.3.1 REACTOR

BASIS: 3000 L

Diameter of the reactor = D

Height of the reactor = H

Volume of the reactor = 3000 L = 3m³

Volume of cylindrical shell $V = \pi/4 \cdot d^2 \cdot H$ □ □ □ □

Volume of the elliptical head $V = \pi/24 \cdot d^3$

Assume $H = 1.0 \cdot \text{diameter of vessel}$

Sub h in above we get $V = \pi/4 \cdot d^2 \cdot d + 2 \cdot \pi/24 \cdot d^3$

Sub $V=3$, $3 = \pi/4 \cdot d^2 \cdot d + 2 \cdot \pi/24 \cdot d^3$

$d^3 = 6.8927 \text{m}^3$

$d = 1.789 \text{m}$

$D = 1789 \text{mm}$ □ □ □ □

Height of reactor $H = 1.0 \cdot D = 1.0 \cdot 1.789 = 1.789 \text{ m}$

$H = 1789 \text{ mm}$

THICKNESS OF ELLIPTICAL HEAD

$t = pDV/2fj$

p = Internal design pressure

D = Major axis of ellipse

V = stress intensification factor $= 1/4 (2+k^2)$

k major axis /minor axis

common value of k is 2

it should not be greater than 2.6

J – joint efficiency

f - Allowable stress

Assuming, efficiency = 0.9

Atmospheric pressure = 1 kg /cm²

Design pressure = 1.5 * atmospheric pressure
= 1.5 kg/cm²

Assuming $k = 2.0$

$$V = \frac{1}{4} (2 + (2.0)^2) \\ = 1.5$$

D- major axis of ellipse = 1789 mm

Assuming F allowable

Stress = 1090 kg/cm^2

Thickness of elliptical head $t = pDV/2fj$

Sub the values in above equ. $T = 1.5 \cdot 1327 \cdot 1.5 / (2 \cdot 1090 \cdot 0.9) = 2.052 \text{ mm}$

Corrosion allowance = 2 mm

Thickness of elliptical head $t = (2.052 + 2) \text{ mm}$

Thickness of elliptical head $t = 4.052 \text{ mm}$

THICKNESS OF THE BOTTOM SS PLATE

$$T_{\min} = pD_i / 2 \cdot f \cdot j - (pD_i)$$

Where, $T_{\min}$ = the minimum thickness for the sheet

pD_i = internal pressure of the vessel

f = the allowable stress

j = the welding joint efficiency

Operating pressure = 1.0 kg/cm^2

Design pressure = $1.5 \cdot \text{operating pressure} = 1.5 \text{ kg/cm}^2$

Allowable stress = 1000 kg/cm^2

Joint efficiency = 90 %

Corrosion allowance = 2 mm

Type of enclosure = Elliptical head

Calculation

$$T_{\min} = pD_i / 1 \cdot f \cdot j - (pD_i)$$

$$T_{\min} = 1.5 / 2 \cdot 1000 \cdot 0.9 - (1.5) = 1.495 \text{ mm}$$

Corrosion allowance = 2 mm + 1.495 mm

$$T_{\min} = 3.45 \text{ mm}$$

DESIGN OF AGITATOR

Diameter of the agitator $D_a = 1/3 \cdot D_t$

Diameter of the tank $D_t = 1789 \text{ mm}$

$$= 1/3 * 1789$$

$$D_a = 596.33 \text{ mm}$$

$$\text{Width of the blade } w = 1/5 * D_a$$

$$\text{Diameter of the agitator } D_a = 119.266 \text{ mm}$$

$$\text{Width of the blade } w = 265.4 \text{ mm}$$

$$\text{Length of the blade } L = 1/4 * D_a$$

$$= 1/4 * 596.33 \text{ mm} = 149.083 \text{ mm}$$

$$\text{Clearance between agitator} = 1/3 * D_a$$

and bottom of reactor

$$= 1/3 * 596.33 = 198.78 \text{ mm}$$

$$\text{Thickness of the baffles } J = 1/12 * D_t$$

$$= 149.083 \text{ mm}$$

POWER REQUIRED FOR AGITATOR

$$N_{Re} = D_a^2 * N * P / u$$

N_{Re} = Reynolds no.

D_a = Diameter of the agitator

N = Speed of the agitator

Q = Density of liquid

U = viscosity of liquid

$$N_{Re} = (D_a^2 * N * p / u)$$

$$= (596.33/1000)^2 * (90/60) * 1840 / 2.4 * 10^{-2}$$

$$N_{Re} = 40,895.1$$

$$N_p = 4.5$$

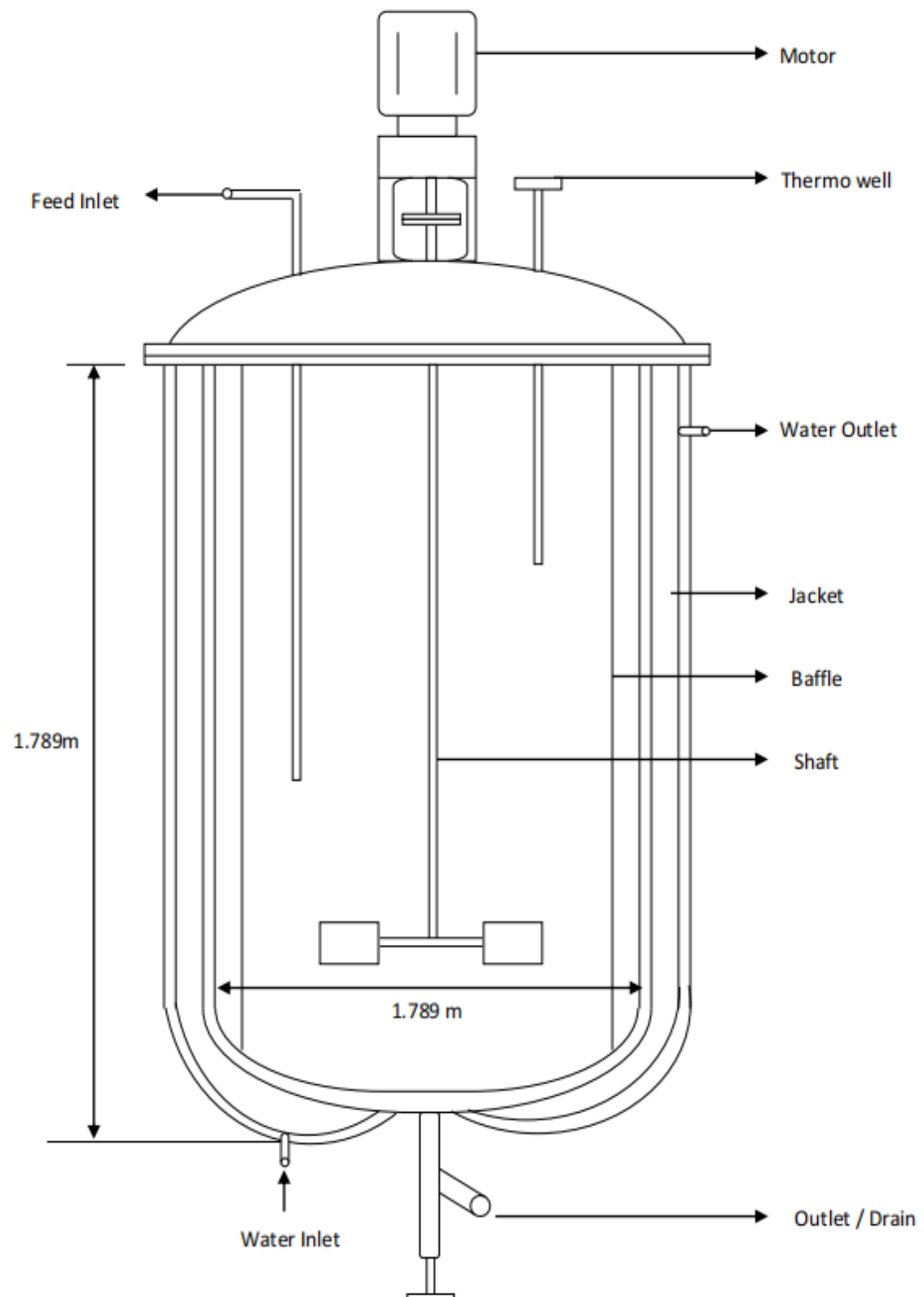


Fig 4.3.1: Reactor

4.3.2 CENTRIFUGE

Centrifugal force acting on particle,

$$C.F = m\omega^2 r$$

m- mass of particle

ω – spinning of particle

r- radius from axis of rotation

$$\omega = 2\pi N/60$$

N = no.of revolution per min

Terminal settling velocity $u_0 = d_p^2 (\rho_p - \rho_f) g / 18\mu$

d_p = particle size μm

ρ_p – density of the particle kg/m^3

ρ_f - density of the fluid kg/m^3

g - gravity force m/s^2

μ -viscosity of the fluid $N\ m/s$

Q – flow rate m/s^2

$$u_0 = d_p^2 (\rho_p - \rho_f) g / 18\mu$$

$$\begin{aligned} \mu &= (0.6 \times 10^{-6})^2 (1635 - 1000) \times 9.81 / (18 \times 10^{-3}) \\ &= 1.24 \times 10^{-5} \text{ m/s}^2 \end{aligned}$$

$$\omega = 2\pi N/60$$

$$= 2 \times 3.14 \times 600 / 60$$

$$= 62.8 \text{ r.p.m}$$

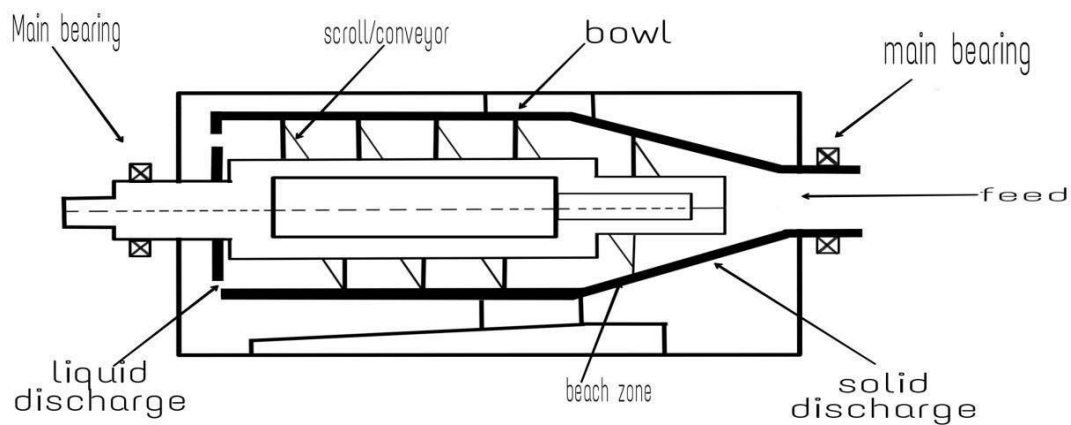


Fig 4.3.2 CENTRIFUGE

4.4 INSRTUMENTATION AND CONTROL

Introduction

Sensors to quantify measure conditions and valves to impact measure activities are fundamental for all parts of designing practice. Specialists need to plan and work measures that stay in safe conditions, produce the ideal measures of great items and are beneficial. Hence, engineers should give estimating gadgets to key factors and valves (or different gadgets, like variable speed electric engines) to impact of "steer" the interaction. This site gives instructive material on sensors and valves for use in the process enterprises. While sensors and valves are significant on the whole parts of designing, they accept most prominent significance in the investigation of programmed control, which is named measure control when applied in the process ventures. Interaction control manages the guideline of cycles by applying the input standard utilizing different processing gadgets, basically computerized calculation. Interaction control requires sensors for estimating factors and valves for executing choices. Accordingly, the introduction of this material is intended to supplement other learning subjects in measure control.

Sensors

Valves

Signal transmission for process control
Instrumentation safety
Control equipment cost
Process Drawings
Conclusions

4.4.1 Sensors

Sensors are utilized for measure checking and for measure control. These are fundamental components of protected and beneficial plant activity that can be accomplished just if the legitimate sensors are chosen and introduced in the right areas. The significant issues in sensor determination are summed up in the accompanying. The general significance of each issue relies on the particular application; for instance, one application may require superb precision, while another might require just moderate exactness, yet high unwavering quality. By and large, we track down that the more noteworthy the necessities for great execution, the higher the expense for buy and support. Accordingly, we should track down the legitimate equilibrium of execution and cost, instead of consistently indicate the best performing sensor.

4.4.2 Valves

Valves are utilized widely for influencing the cycle; we frequently say that qualities are the "handles" by which we work an interaction. We have numerous objectives in affecting the interaction; hence, we utilize the and valve standards in numerous applications. There are numerous sorts of valves. The four most unmistakable sorts of valves are summed up beneath.

4.4.3 Signal transmission for process control

Most interaction control frameworks include a construction of circulated gear, with sensors and valves at the cycle hardware and the control computations and showcases situated in a distant, incorporated . Subsequently,

estimations of key factors should be conveyed between the sensors, computations and valves (or other last components).

4.4.4 Instrumentation safety

Normally, we should securely achieve estimation, control counts, and process modulation through changing the last component. Control frameworks add to safe cycle activity through fundamental control plan, valve disappointment positions, alerts, wellbeing interlock frameworks, and pressing factor help frameworks (e.g., Marlin, 2000; AIChE, 1993; Lees, 1996). This segment tends to one significant perilous condition, fire and blast that is influenced by the plan and execution of control and transmission hardware. The material in this part is relevant to a wide scope of cycles and ventures utilizing either simple or advanced transmission.

4.4.5 Control equipment cost

Financial matters are consistently an issue in designing practice. In a regular venture, we cause expenses and gain incomes after some time, and we face the test of deciding the best task choices, where best methods accomplishing the most elevated net benefit. Luckily, strategies for monetary investigation are promptly accessible. These techniques consider the time-estimation of cash and give fitting proportions of benefit, like net present worth (NPV). This segment presents some valuable data for assessing the expense of control gear. We should perceive the expense incorporates the accompanying parts.

Purchase

Transportation from supplier to user

Installation and documentation

Calibration

Maintenance over the equipment lifetime

4.4.6 Process Drawings

Specialists record their work utilizing numerous integral techniques. Surely, composed documentation is significant. In any case, drawings play a similarly significant spot in documentation in view of the intricacy of the frameworks being recorded and the exact and effectively read nature of interaction drawings.

The significant classes of drawings are presented in the accompanying.

Block Flow

This drawing shows just the significant units and interaction streams. The overall objective is to give an outline of the interaction to fabricate understanding. A whole plant can be appeared in a solitary drawing. Normally, every unit is appeared as a square shape (block), and the squares are associated by strong lines with the heading demonstrated with bolts. No unique images or rules are utilized in building up these drawings.

Process Flow Diagram (PFD)

This drawing shows all significant gear and interaction streams in a solitary drawing. Images and recognizable pieces of proof (e.g., T-201) are utilized to address unit activities, and each 33 is assigned with a number. The properties are given in related tables, however utility rates (e.g., air, steam, fuel, and so on) are normally not given. In certain drawings, a couple of essential control circles are given to demonstrate how interaction streams and other key factors are kept up at wanted qualities. The drawing isn't proportional.

Piping and Instrumentation Drawing (P&ID)

These drawings give subtleties on all channeling, including valves (robotized and manual), by-pass lines, pipe sizes, test focuses, and so forth Likewise, all instrumentation is appeared. A moderate degree of mechanical detail is accommodated measure gear, so the channeling

and instrumentation can be unequivocally reported. Worldwide image norms are utilized for channeling, hardware and instruments (ISA, 1992). Numerous pages of drawings are needed for a solitary unit. The drawings are not to scale.

Equipment Mechanical Drawings

Every equipment (e.g., drum, terminated radiator, and so on) is developed to the details in the Equipment Mechanical Drawings and related content clarifications.

Three-dimensional Layout

Equipment should be found so they don't meddle with one another thus that space is accessible for individuals to go through the interaction and perform assignments, like support. To guarantee the format is sufficient, a three dimensional portrayal is required. Previously, actual models were developed to scale; in any case, a 3-D graphical portrayal is the standard procedure utilized today.

4.4.7 Conclusion

Essential standards of physical and give the premise to understanding interaction instrumentation, while the determination of the legitimate gear relies upon the necessities of the particular application. This segment has presented a considerable lot of the more normal instruments utilized in the process ventures. The material in this part gives the peruser adequate agreement to start mechanical practice yet ought not be utilized for modern practice; dependable and state-of-the- data on measure instrumentation is accessible from gear producers and expert social orders. The ISA information sheets (ISA, 1992) give a supportive agenda of the data required while determining gear in anticipation of communications with hardware providers.

4.5 COST ESTIMATION

Cost Estimated based on the following factors for the above plant capacity.

1. Equipment Cost
2. Project Cost
3. Accessories
4. Raw material Cost
5. Manpower Cost
6. Running Cost
7. Production Cost.

Equipment and installation cost= 161 lakhs

Project Cost:

Table 4.5.1: Project Cost

TYPE	Total Cost (₹ in Lakhs)
Land purchase	150
Drawing Preparation	1
Consultancy	5
Construction Charges	75
Start Up	25
Total	256

Accessories Cost:

Table 4.5.2: Accessories Cost

Type	Total Cost (₹ in Lakhs)
Piping	85
Pumps	75
Valves	62.5
Instrumentation	80
Electrical	80
Service Faciliator	40
Total	422.5

Raw Material Cost:

Table 4.5.3: Raw Material Cost

Raw Material	Quantity (Kgs)	Price/Kg (₹)	Total cost (₹ in Lakhs)
Anilene	9000	130	11.7
DMC	60000	70	42
Nitrogen	120	25	0.03
Nitrobenzene	2100	74	1.554
Total			55.284

Man Power Cost

Table 4.5.4: Man Power Cost

S.No	Designation	No. of Employees	Salary (Rs.)	Total Cost (Rs. in lakhs)
1	Managing Director	1	2,00,000	2.0
2	General Manager	1	1,00,000	1.0
3	Works Manager	2	60,000	1.2
4	Plant Manager	3	50,000	1.5
5	Shift Engineers	12	25,000	3.0
6	Shift Operators	30	15,000	4.5
7	Maintenance	10	15,000	1.5
8	Skilled Process (utility)	40	7,000	2.8
9	Administrative Personnel	20	12,000	2.4
10	Security	20	4,000	0.8
11	Lab In charge	5	12,000	0.6
12	Safety Persons	4	10,000	0.4
TOTAL (Rs. in lakhs)				21.7

Running Cost:

Table 4.5.5: Running Cost

Type	Total Cost(₹ in Lakhs)
Electricity Charges	7
Water Charges	1.5
Transportation	2.5
Miscellaneous	2.5
Total	13.5

Production Cost:

Table 4.5.6: Production Cost

Type	Total Cost(₹ in lakhs)
Raw Material Cost	55.284
Man Power Cost	21.7
Running Cost	13.5
Miscellaneous	7
Total	97.484

Total Production Cost = 97.484 Lakhs/day

Total Investments:

Equipment Cost=161 lakhs

Project Cost = 256 lakhs

Accessories = 422.5 lakhs

Total Investments = 839.3 lakhs.

Profit:

Total Production Cost = 97.484 Lakhs/day

= 97.484 x 365 days

= 35,581.66 lakhs/year

Margin = 40%

= 40% of 35,581.66

Profit after taxes = 14,232.664 lakhs/year

Pay Back Period:

$$P. B.P = \frac{\text{Total Investment} + \text{Total Production Cost}}{\text{Profit After Taxes}}$$

$$= \frac{839.3 + 35,581.66}{14,232.664}$$

$$= \frac{36420.96}{14232.664}$$

$$= \mathbf{2.56 \text{ Years}}$$

4.6 PLANT LAYOUT AND LOCATION

4.6.1 PLANT LAYOUT

A plant format study is a designing examination used to break down various actual setups for a modern plant. The effectiveness of creation relies upon how well the different machines, creation offices and worker's conveniences are found.

Definition:

It alludes to the plan of actual offices like hardware, gear furniture and so on, with in the industrial facility working in such a way to have fastest progression of material at the most minimal expense and with minimal measure of taking care of in preparing the item from the receipt of material to the shipment of the completed item.

As indicated by "Riggs", the general goal of plant format is to plan an actual course of action that most financially meets the necessary yield amount and quality.

Importance:

It is a significant choice as it addresses long haul responsibility. An ideal plant format ought to give the ideal relationship among yield, floor zone and assembling measure. It encourages the creation interaction, limits material taking care of, time and cost and permits adaptability of activities, simple creation , utilizes the structure advances compelling use of labor and accommodates representative's comfort, security, comfort at work, greatest openness to regular light and ventilation. It is additionally significant on the grounds that it influences the progression of material and cycles work productivity, management and control, utilization of room and development prospects and so on,

Essentials:

An efficient plant layout is one that can be instrumental in achieving the following objectives:

- a) Appropriate and proficient usage of accessible floor space.
- b) To guarantee that work continue starting with one point then onto the next point immediately.
- c) Give sufficient production capacity.
- d) Diminish material taking care of expenses.
- e) Lessen danger to work force.
- f) Use work productively.
- g) Addition delegate soul.
- h) Decrease accidents.
- i) Accommodate volume and item adaptability.
- j) Give ease of oversight and control.
- k) Accommodate representative security and wellbeing.
- l) permit ease of maintenance.
- m) Permit high machine (or) hardware usage.
- n) Improve efficiency

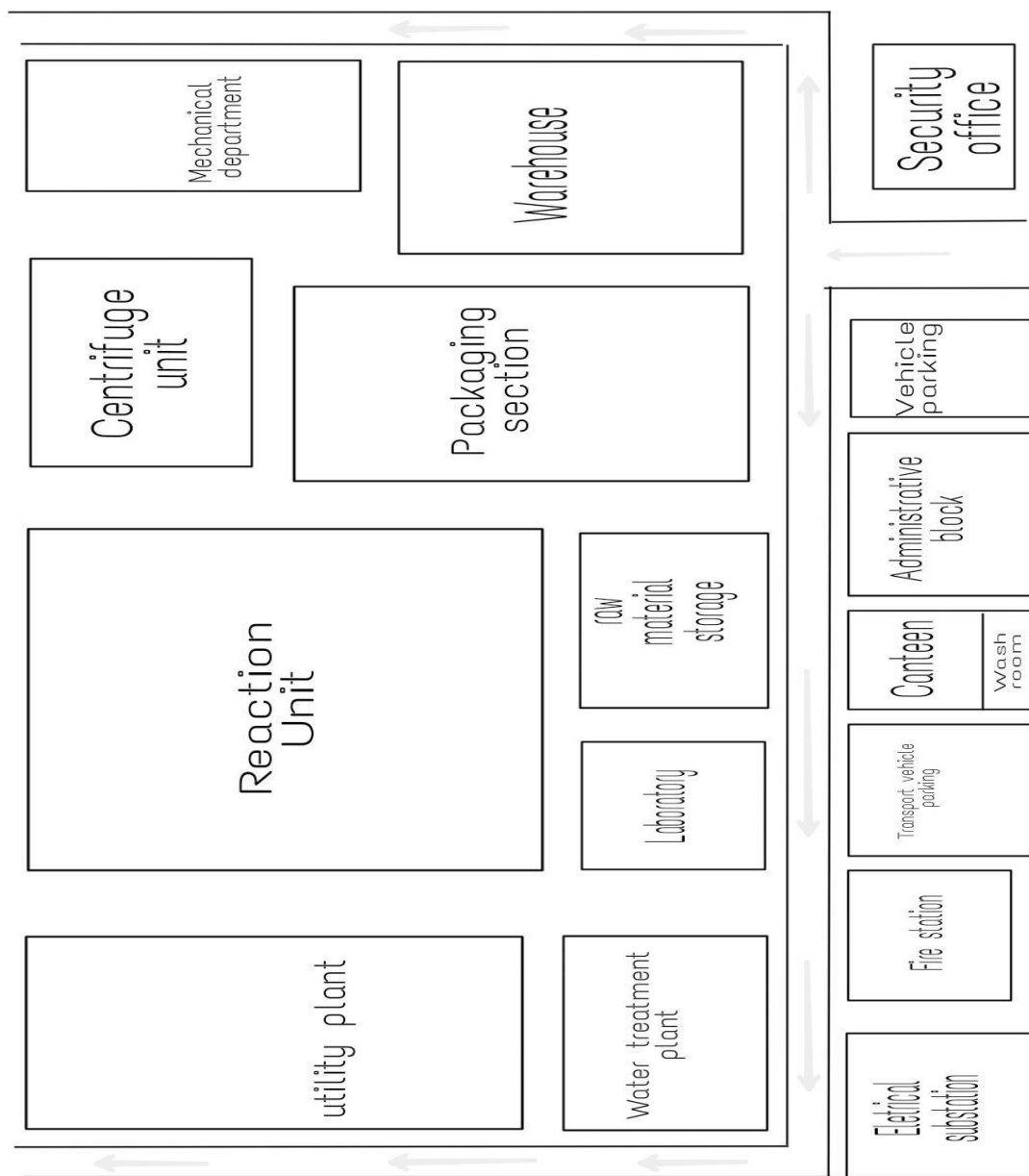


Fig:4.6.1: Plant Layout

4.7 PROCESS SAFETY

4.7.1 Plant Safety And Environment

Introduction:

Taking all things together of the elements that impacts the exhibition of the hardware and the plant there are components of vulnerability and the chance of mistake, including incorrectness of actual information, fundamental connections of conduct, for example, pipe grinding (or) plate proficiency (or) gas-fluid appropriation, important approximations of plan strategies and estimations not altogether known practices of materials of development, vulnerability of future stamped requests and changes in working execution with time.

Safety of Plant & Environment:

The plan of plant and hardware should limit possible mischief to staff and public if there should be an occurrence of mishaps of which the primary driver are,

- Human Failure.

- Failure of equipment & control instruments.

- Failure of supply of utilities & key process streams.

- Environmental events (wind, water & so on).

Instances of regular safe practices are pressure alleviation valves, vent frameworks, flare stacks, snuffing steam and fire , get away from hatches in dangerous territories, dams around tanks, putting away unsafe substance, turbine drives as extras for electrical engines if there should be an occurrence of force disappointment and others. Wellbeing contemplations are central in the design of the plant especially detachment of particularly unsafe activities and openness for remedial activity at whatever point vital.

In substance preparing plants of any size, misfortune avoidance audit is held intermittently by bunches that consistently incorporate a delegate of the wellbeing . Other work force on a case by case basis by the specific circumstance are from assembling, upkeep, specialized assistance and conceivably research, designing and clinical gatherings.

Safety Factors:

An accomplished designer will apply security all through the plan of the plant. Exactly how much a wellbeing factor is to applied can't be expressed as a rule terms on the grounds that the conditions change extraordinarily, wellbeing elements ought not be utilized to lacking (or) thoughtless plan work.

The plan ought to be that can be made in the time financially conceivable, and the wellbeing elements ought to assessed from a cautious thought of all variables going into the plan and the conceivable future deviations from the plan conditions.

Symbol	GHS07
Signal word	warning
Personal Protective	dust mask type N95 (us) Eye shields, gloves
Hazard code	Xi
Risk statements	36/37/38

Analysis of the hazard:

An analysis must be made of the source of hazards are classified into two major categories.

Material Hazard

Process Hazard

Material Hazard:

They are due to the nature & the property of the material & the reactions the materials are likely to undergo during their processing.

Combustible solids, liquids or gases.

Explosive agents.

Oxidizing materials.

Materials that react to form a combustible gas.

Corrosive materials.

Toxic materials.

Process Hazard:

Capacity taking care of (or) actual difference in the material like exchange of combustible fluid or blending in open compartment. Exothermic response where there is a solid chance of the response running wild. Low pressing factor measure where pollutants may spill into the cycle. High pressing factor measure which may include temperatures above streak point or the auto start point. Residue or fog blast dangers may emerge in measures which include treatment of material that make dust. Starting of electric engine, switches or alerts. Risks emerging out of gear or instrument disappointment.

DISASTER PREVENTION

Three significant assignments should be performed before a crisis reaction framework can start. The main assignment is to distinguish the key cycle and components of the creation interaction and how operational cycles are remained careful limits in ordinary conditions.

There are four zones recorded beneath that are normally found in substance plants..

1. An administration framework that incorporates the board staff, measure determinations, plant plan, standard activity methodology, and the composed crisis plan.
2. A work force subsystem that allocates and characterizes jobs, for both ordinary and crisis tasks, and gives fitting preparing. This may likewise incorporate work or the board security councils.
3. An actual subsystem that may incorporate transportation frameworks for materials, ventilation frameworks, squander expulsion frameworks, regulation frameworks, and other interaction related gear.
4. A crisis administrations subsystem including plant and local area parts.

A subsequent assignment is to see how basic disappointment focuses are distinguished, and what measures are utilized to guarantee safe tasks. This

incorporates evaluating the interrelation of the components and identifying which safety feature in the system should be backed up within safe limits.

The third errand is to distinguish the crisis reaction framework that is installed in the working framework. It is a dormant framework that is dynamic just when protection measures have fizzled and an occurrence has happened.

1. PLANT LAYOUT

The plant design has some particular wellbeing viewpoints

- Chemicals that may respond with each other are to be truly isolated; oxidizers are to be put away in independent regions from the fuel stockpiling place.
- Areas of potential blasts & explosive capacity area to be separated so if there is a blast, the harm, and danger to laborers is limited.

2. DRAINAGE

- Provisions ought to be made to keep the break or spill from funneling vessels.
- The organization should make arrangements to control surprising dangerous fume or gas discharges inside the channel lines

3. HOUSEKEEPING

- Work areas should be neat and tidy and well maintained.

4. ENCLOSED SPACES

- Some measures that are protected in outside may get risky whenever encased. On the off chance that regions of potential holes are encased, there ought to be satisfactory safeguards to ensure laborers.

CONTAMINATION CONTROL

- Responsive synthetic substances may have their responses catalyzed by normal materials that can without much of a stretch enter in frameworks at whatever point seals are opened. If such catalysts are identified, it is important to exclude them from the system.
- When frameworks are opened for upkeep purposes, precautionary measures should be taken to forestall defilement. The framework ought to

- be safeguard while it is open. Insurances ought to be taken to guarantee that new parts are liberated from pollutants.

PHYSICAL FACILITIES

The equipment used in any chemical plant is often considered secondary to the production processes. However, the equipment is important like:

- Emergency eyewash
- Fixed fire suppression equipment
- Portable fire fighting equipment

INSPECTION AND MAINTENANCE

All hardware should be put to a stop at a customary timespan. At the point when wellbeing frameworks are closed down, reinforcement frameworks ought to be accessible to give substitution insurance. On the off chance that shutoff valves can segregate security alleviation valves, legitimate measures ought to be taken so the framework is shielded from over-compression.

Pressing factor vessels likewise need intermittent review and testing as a result of ordinary wear and potential consumption either at welds or in the base material.

These are the wellbeing rules that should be followed wherever across the globe in the compound business. On the off chance that these actions are followed appropriately you can guard your laborers. You ought to likewise keep PPE set up to guard your laborers on a working site.

CHAPTER 5

CONCLUSION

The method involving phosgene for the production is so far quite profitable and highly developed. But, considering the environmental safety measures, this process is very harmful. Large amounts of HCl is produced in this process. In any production process, safety measures are very important. Technicians and ground level workers have to be highly skilled. However, the above mentioned non-phosgene process is the best current method from research and literature. It can further undergo R & D to encourage new catalysts and equipment to cut the cost of production. The main intention is to obtain higher yield of MDI with least cost involved. Any process becomes successful only if it is technologically and economically feasible.

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