7/7/2023

CAPSTONE PROJECT

DECARBONIZATION

TEAM B
THREE TEN INITIATIVE TECHNOLOGIESLLP

CONTRIBUTION OF EACH MEMBER IN PROJECT

TASKS	Name of Team Member
Base Case simulations	
MEA - Generic valve tray - Without wash section	Kunal Shirke
MDEA - Generic valve tray –withwash section	
MEA - Generic valve tray - with wash section	
MDEA - Generic valve tray - without wash section	Krishna G R C
MEA - Mellapak plus pack - without wash section	
MEA - Mellapak plus pack - with wash section	
MDEA - Mellapak plus pack - without wash section	Maheswari mirthipati
MDEA - Mellapak plus pack - with wash section	
MEA - Raschig superring - with wash section	
MEA - Raschig superring - without wash section	Vijay S
MDEA - Raschig superring - without wash section	
MDEA - Raschig superring - with wash section	
Selecting the best case:	
Screening Based on Safety analysis-ISD	Krishna G R C & Maheswari Mirthipati
Final Process check list for validation	

From,

Team B : Krishna G R C

Maheswari Mirthipati

Kunal Shirke

Vijay S

Three Ten Initiative Technologies LLP

To,

Dr.Anand Govindarajan / Dr. Upasana Manimegalai Sridhar, Director

Three Ten Initiative Technologies LLP

July 2023

Sub: A plant model for CO2 capture from post combustion flue gas.

Respected sir.

We are writing to you today to share the results of our project on carbon capture from post combustion flue gas. As you know, many industrial plants are now aiming for net-zero CO_2 emissions. Carbon Capture and Storage (CCS) is a promising technology that can help these plants achieve their emissions goals.

Our project focused on developing a plant model for CO_2 capture. We used ProTreat® simulation software to model the plant and to optimize the CO_2 capture process. We also developed criteria for eliminating potential CO_2 capture technologies using inherently safer design considerations.

The results of our project are documented. We also identified several other CO_2 capture technologies that are well-suited for chemical industry plants and documented this in our report.

The project report is attached to this letter. It provides more details about our findings and recommendations.

We thank you for your support of this project. We believe that our findings will be valuable to the chemical industry as it seeks to reduce its CO_2 emissions.

Thanking You

Your's Truly

Team - B

CONTRIBUTION OF TEAM MEMBERS

NAME	**TASK**
VIJAY S	Cover letter, Executive summary, intro
	Project basis: design, solvents, internals, variations
MAHESWARI	Intro, ISD safety analysis, Justification of screening options
KUNAL	Process flow diagram: 2 cases with description
	Simulation: Brief about ProTreat and why it's used for CO_2capturing ,summary of all meeting notes
KRISHNA	Check list explanation, conclusion, recommendations

Contents

LIST OF TABLES AND FIGURES

1.0 EXECUTIVE SUMMARY

This report presents the design of a carbon capture plant using the regenerable chemical solvents. The plant consists of an absorber and a regenerator. The solvents used in our design are MEA and MDEA activated with piperazine. Column internals such as Mellapakplus packing,Raschig super- rings packing, and Generic value trays are utilized in the absorber, whereas the regenerator consisted of Generic valve trays as the internals. The plant's primary objective is to achieve a 90% CO2 removal efficiency from the flue gas,following some operating process constraints which are discussed in the report in detail. The carbon capture process begins with the absorber, where the flue gas is brought into contact with the chemical solvents. The MEA and MDEA solvents, along with piperazine, facilitate the absorption of CO2 from the flue gas. The selection of packing materials, including Mellapakplus, Raschig super rings, and Generic value trays, optimizes the gas-liquid contact and enhances the absorption process within the absorber. These packing materials are widely recognized and employed across the world for their efficiency. The design of the plant was developed using OGT ProTreat®.simulation software along with safety aspects. It also consists of 12 base case simulation with process checklist validation sheet for all cases, all cases are screened based on the Inherent Safety Design [I S D] principles. Once after the screening process is completed, we observed that the base case which consisted of Generic valve trays and absorber without wash section, that had MEA as solvent was found to be the least hazardous and it met all the process constraints, therefore facilitating 90% removal of Co2 from flue gas source.

2.0 INTRODUCTION

2.1 GLOBAL WARMING

The current increase in air and ocean temperatures is known as global warming. [1]The burning of fossil fuels, greenhouse gas emissions, and deforestation are just a few examples of how human activities are contributing to global warming, which is a serious and quickly worsening problem. It is seriously affecting the world and the ecosystem. However, the heat from the burning only slightly increases global temperatures; the main cause of the problem is the carbon dioxide that results from the burning. The biggest contributor to global warming among greenhouse gases is a rise in carbon dioxide levels in the atmosphere. [2]

This effect is significant because, without the CO_2 that occurs naturally in the atmosphere, Earth may be too chilly for life to survive there. However, the impact of fluctuating CO_2 levels on the atmosphere is substantial. Despite comprising less than 0.1% of the atmosphere, this gas has a significant impact on how much heat is retained by the planet's surface. [3]

- Global Warming Scenarios

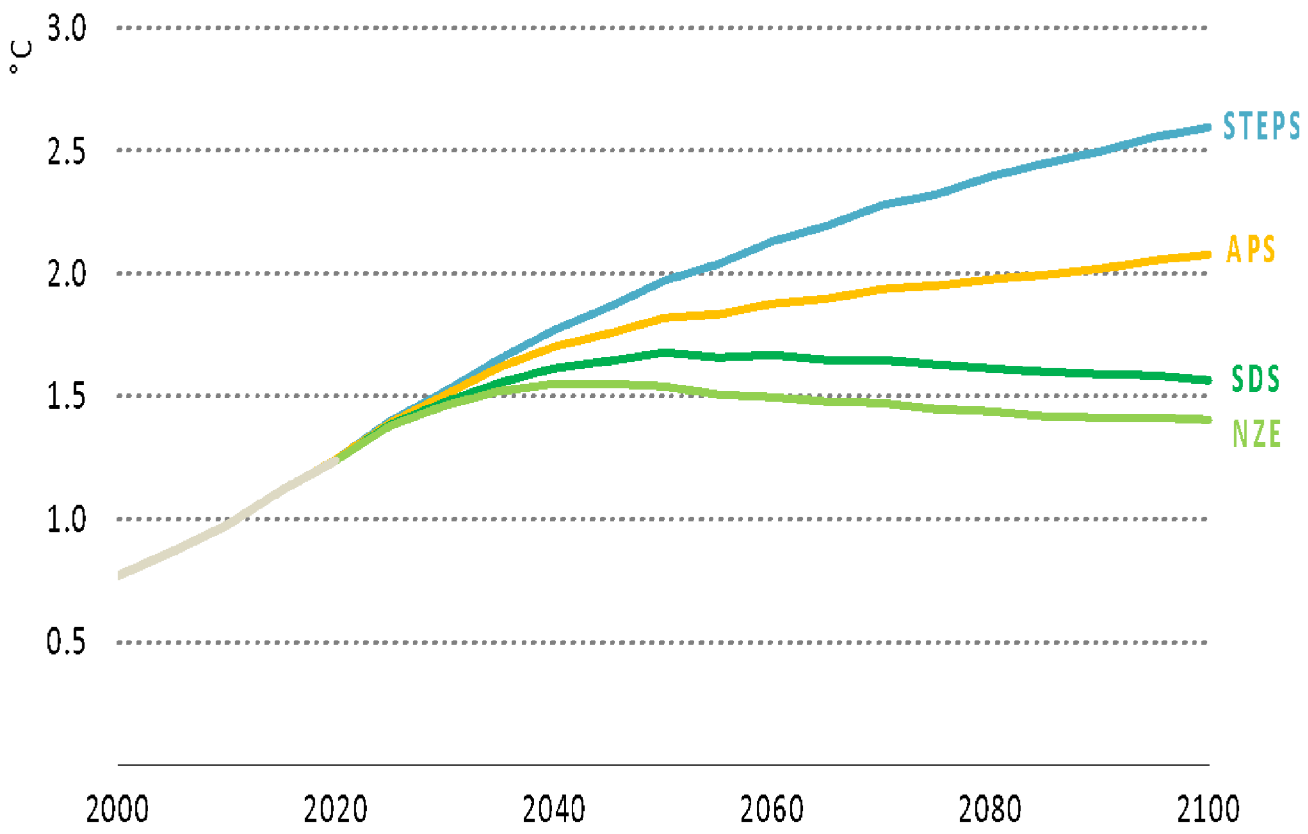

Fig-2.1 Graph showing rising global warming

Description of above graph

- The analysis, using the MAGICC model (Model for the Assessment of Greenhouse Gas Induced Climate Change), assesses different emissions trajectories and their impact on global surface temperature rise.
- In the STEPS scenario, global temperature would exceed 1.5°C around 2030, reaching around 2.6°C by 2100.
- The APS scenario shows faster CO_2 emission reductions to 21 Gt by 2050, resulting in a temperature rise of around 2.1°C by 2100.
- The NZE scenario achieves net zero CO_2emissions by 2050 and rapid reductions in non - CO_2 emissions, limiting temperature rise to just over 1.5°C by 2050 and around 1.4°C by 2100.
- The SDS scenario aligns with the Paris Agreement objective of staying below 2°C, with CO_2 emissions reaching zero by 2070 and a temperature rise of just under 1.7°C by 2050.
- The NZE scenario goes further to align with the Paris Agreement objective of limiting the temperature increase to 1.5°C.
- All scenarios show a continuing temperature increase beyond 2100 due to CO_2 emissions remaining above zero in those scenarios. [5]

The Paris Agreement [6]

- It was adopted by 196 Parties at the UN Climate Change Conference (COP21), on 12 December 2015. It entered into force on 4 Nov 2016.
- Its overarching goal is to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels."
- It indicates that crossing the 1.5°C threshold risks unleashing far more severe climate change impacts, including more frequent and severe droughts, heat waves and rainfall.
- In order to achieve the target CO_2 emissions, a multi-pronged strategy is needed,
  Application of carbon dioxide capture, sequestration & utilization (CCS & U) technologies. [6]

2.2 TECHNOLOGIES FOR CARBON CAPTURE

- **CO2 capture technologies from power plants:**
  - Post-combustion capture
  - Pre-combustion capture
  - Oxy-fuel combustion

- Calcium looping combustion [7]

- **Post-combustion carbon capture**
  - In post-combustion capture, the CO_2 is captured after the fuel has been burned. The flue gas from the power plant is passed through a solvent, such as MEA, that absorbs the CO_2. The CO_2-rich solvent is then regenerated, and the CO_2 is released for storage.
  - Chemical and/or physical absorption, physical adsorption, and membrane separation are typically the available significant CO_2 capture technologies. [7]

- **Pre-combustion carbon capture methods**
  - In pre-combustion capture, the fuel is not burnt directly, but is converted at suitable temperature and pressure into synthesis gas (syn-gas) [mixture of carbon monoxide (CO), CO_2, and hydrogen (H_2)].
  - Thereafter, CO is further converted CO_2 and H_2, and then CO_2 is captured to get H_2 (the major constituent) as fuel.
  - Pre-combustion capture technologies are: Hydrogen Membrane Reforming (HMR), Sorber Enhanced Water-Gas-Shift (SEWGS) Reaction, and Integrated Gasification Combined Cycle (IGCC). [7]

- **Oxy-Combustion CO_2 Capture**
  - In oxy-fuel combustion, fuel is fired with an oxygen-enriched gas, which is produced (with 95% oxygen) by removing nitrogen from air, which is carried out with an Air Separation Unit (ASU). [7]
  - Oxyfuel combustion is more efficient than post-combustion capture, but it is also more expensive. This is because it requires a new power plant to be built, and the cost of the oxygen is also high. [7]
  - The oxy-combustion CO_2 capture for the conventional integrated gasification combined cycle (IGCC) plant results in around 9% energy penalty for the CO_2 capture efficiency of 100%. [8]

- **Chemical looping combustion**
  - Chemical looping combustion (CLC) is a technological process typically employing a dual fluidized bed system. CLC operated with an interconnected moving bed with a fluidized bed system, has also been employed as a technology process.
  - In CLC, a metal oxide is employed as a bed material providing the oxygen for combustion in the fuel reactor. The reduced metal is then transferred to the second bed (air reactor) and re-oxidized before being reintroduced back to the fuel reactor completing the loop. [9]

- It takes advantages of post-combustion and oxy-combustion.

➢ **Calcium looping combustion**

- Calcium looping technology – also known as the regenerative carbon cycle (RCC) – removes carbon dioxide (CO_2) from the flue gases of a cement plant (and other power and industrial facilities) using a calcium oxide (CaO) sorbent. The process relies on two reversible chemical reactions: carbonation and calcination. [10]
- It takes lower energy penalty and has 100% CO_2 capture efficiency. [8]

3.0 PROJECT BASIS

3.1 DESIGN BASIS

Our project requires a 90% removal of CO2 from the incoming flue gas. All pertinent design details that form the basis of the work are mentioned in Table 3.1. All simulation work is carried out using ProTreat®.

Table No.3.1 Process variations

Item	Detail
Flue gas source	Post combustion
Flue gas conditions	Temperature:100F Pressure:14.7psig Totalflow:16500cum/hr Composition(vol%) CO2:17.8,N2:56.5,O2:7.5,Water:18.2
Design objectives	90%CO2removal
Site details	Ambient Temperature:77F AmbientPressure:14.7psia RelativeHumidity:50%
Technology	Absorption using regenerable chemical solvent, using a standard Amine configuration of a single absorber, and regenerator configuration.
Solvents to be screened	1. Monoethanol amine (MEA) 2. Methyldiethanol amine (MDEA)activated with piperazine

Column internals to be screened	1. Generic valve trays 2. Mellapakplus packing (MetalM352Y)  Source:-Sulzer Ltd. 3. Raschig Super-Ring packing (MetalNo2)  Source:- pingxiang yamtop Chemical Co.Ltd
Process variations to be screened	1. Absorber without water wash sections 2. Absorber with water wash sections
Inherent Safety Considerations	The four key principles of inherently safer design (ISD) should be adhered to: 1. Substitution (choose less hazardous alternatives) 2. Minimization (reduce the amount of chemical stored, operate at lower concentrations if possible) 3. Moderation (lower pressures and temperatures if possible) 4. Simplification (reduce unnecessary complexity)

4.0 PROCESS FLOWSHEETS

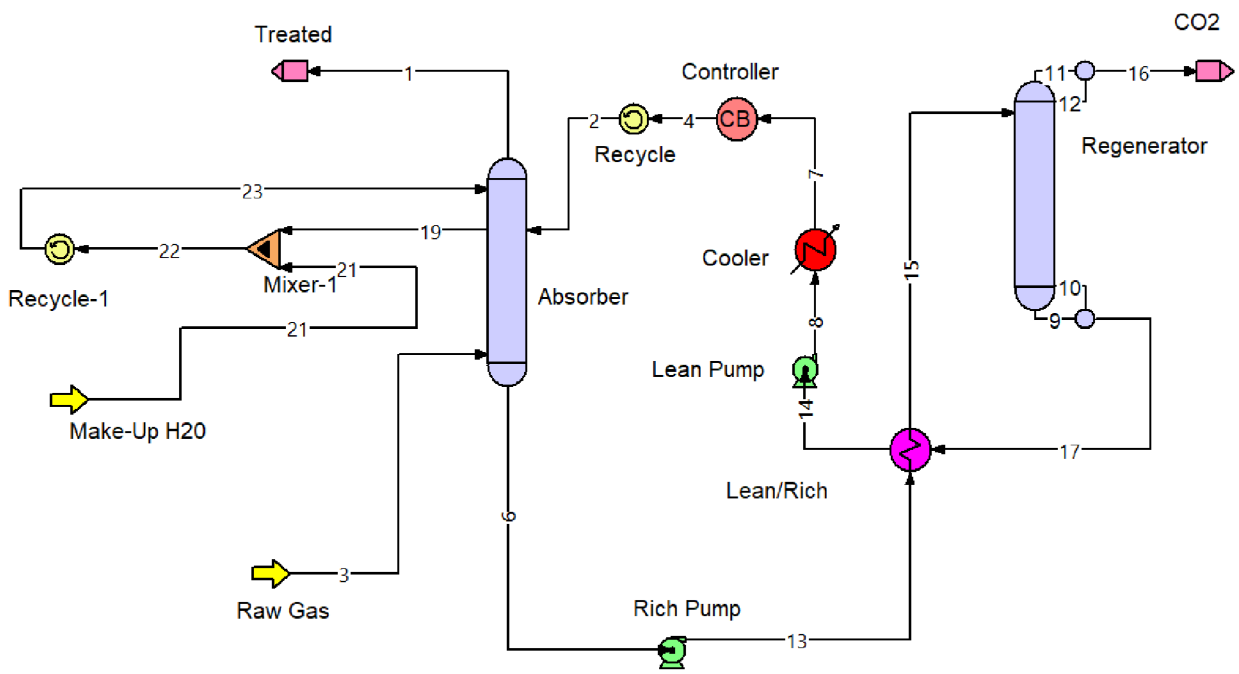

Fig.4.1 Process Flow Sheet (MEA Generic valve Trays with Wash section)

Process of removing the CO_2 from the flue gas plays an important role in the net zero carbon emission mission which will be achieved by 2070 by India.The process starts with the entry of flue gas, which contains a high concentration of CO_2, into the carbon capture system. The flue gas is typically generated from the combustion of fossil fuels.

The flue gas enters the absorber unit, where it comes into contact with a counter-current flow of MEA as a solvent. MEA is a chemical solvent having high affinity for CO_2.Further the flue gas flows upwards and CO_2 molecules from the gas are absorbed into the solvent. The MEA solvent, which is enriched with absorbed CO_2, is collected at the bottom of the absorber as a rich solvent. This rich solvent contains a higher concentration of CO_2 and is directed to the next step for next processing.

The rich solvent is transferred to the stripper unit, also known as a desorber. In the desorber the CO_2 is separated from the solvent through a heat-driven process. The rich solvent is heated, causing the CO_2 to be released from the solvent and form a concentrated CO_2stream. After the CO_2 is stripped from the solvent, the resulting solvent, called lean solvent flows back to the absorber unit to capture more CO_2 from the flue gas. The lean solvent is cooled to lower temperatures before returning to the absorber, as the CO_2 absorption

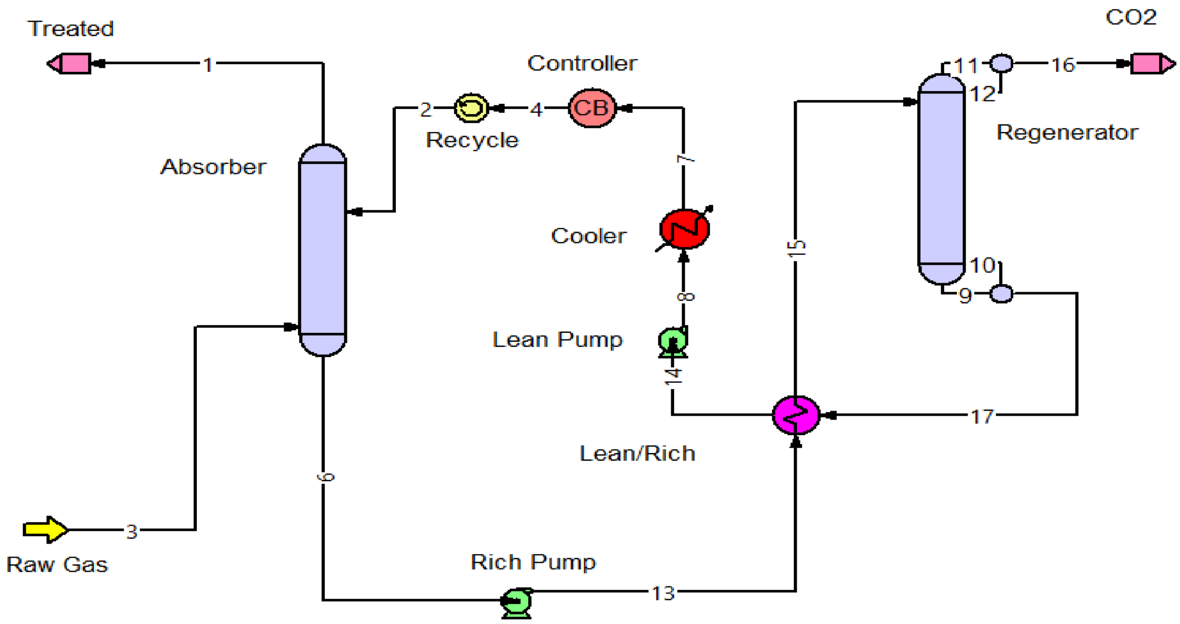

Fig.4.2 Process Flow Sheet (MEA Generic Valve Trays Without Wash Section)

process is more efficient at lower temperatures. The concentrated CO_2 stream that is separated in the stripper unit is collected as the product and can be used for various applications. The carbon capture process involves the integration of heat exchange systems. Heat is generally transferred from the stripper unit to the absorber unit to regenerate the solvent and reduce the energy requirements of the overall process. Wash section is generally present to recover the solvent by using the water. In this way the process of decarbonization takes place.

This process has same process like for the MEA generic valve trays with wash section only difference is washing section is absent in the side of the absorber and also, we don't need to circulate water for the solvent removal.

5.0 PROCESS SIMULATION

OGT Simulation Software began with gas treating in 1992 and has been strictly mass and heat transfer rate based right from the beginning. For 30 years OGT has led the way in this revolutionary new technology and, after witnessing its power, others have followed. Today, most simulators claim some mass transfer rate-based capabilities, but only ProTreat is fully rate-based in the true meaning of the word and allows you to simulate treating using single, multiple, and specialty amines, non-amine systems, amines mixed with a physical solvent, sour water stripping, and glycol dehydration in columns containing a vast range of trays, random packing and structured packing in absorbers, regenerators, and quench Towers. [1]

ProTreat is the only gas treating simulator capable of making the correct calculations for the mass transfer performance of packing. Its mass- and heat-transfer rate-based model uses tower internals not just for hydraulic rating, but for doing detailed absorption and stripping rate calculations. Its ability to predict the separation using random and structured packing makes ProTreat extremely reliable in carbon capture applications. No residence times, no ideal stages, no translation to real packing, only information you can read from a PFD and internal vendor's drawing lets ProTreat provide superior accuracy and confident prediction. [1]

ProTreat simulation is used by many of the leading research groups in carbon capture simulations and by many of the organizations currently building pilot-scale and full-scale carbon capture plants. It is the industry standard in this application. ProTreat is the industry's most advanced simulation tool for carbon capture studies. It turns your drawing-board design into a virtual plant. [1]

We in our project also used ProTreat simulation software for the process study, how different packings/trays and solvents will impact on the final treated gas composition is analyzed using the Protreat and the best combination is selected by screening the results obtained by simulation.[1]

6.0 PROCESS CHECK LIST VALIDATION SHEET FOR ALL CASES

PARAMETERS	*Guideline/Reference Values*	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12
Solvent	*MDEA-Pz/MEA*	**MEA**	**MDEA**	**MEA**	**MDEA-Pz**	**MEA**	**MEA**	**MDEA-Pz**	**MDEA-Pz**	**MEA**	**MDEA-PZ**	**MDEA-Pz**	**MEA**
Internals	*Generic Valve Trays (GVT)/ Raschig Super Ring (RSR)/ Mellapak Plus (MP)*	**GVT**	**GVT**	**GVT**	**GVT-without wash**	**MP-without wash**	**MP-with wash**	**MP-Without wash**	**MP- With wash**	**Raschig-with wash**	**Raschig super rings-without wash**	**Raschig super rings-with wash**	**Raschig super rings-without wash**
Solvent strength total (wt%)	*30-45*	27	32	27	41.998	NA	NA	35	30	23	38.998	33.899	22
Blend (wt%)	*MDEA 30-45/Pz 0.5-7/MEA 20-30*	MEA-27	34.5	MEA-27	MDEA-37.998/Pz -4	MEA-21.998	MEA-22.998	MDEA-35/Pz-3.5	MDEA-30/Pz-2.5	MEA-23	MDEA-31.998/PZ-7	MDEA-31.499/pz-1.889	MEA-22
CO2 removal (%)	*90*	91.54	90.62	91.75	91.46	92.7	91.9	90.58	91.145	91.26	90.95	92.5	91.28
CO2 in treated gas (kmol/hr)	*< 27.28*	23.113	25.536	22.448	23.33	19.922	22.416	25.69	24.17	24.12	24.669	20.335	23.725
CO2 capture (MT/day)	*> 261*	264.13	261.24	264.13	263.57	267.49	264.86	261.03	262.65	263.01	261.829	266.72	262.29
Rich amine loading (mol CO2/mol amine)	*< 0.45*	0.378	0.277	0.376	0.306	0.4	0.329	0.316	0.415	0.448	0.262	0.327	0.391
Lean amine loading (mol CO2/mol amine)	*No guideline*	0.123	0.00564	0.126	0.0035	0.093	0.11	0.0044	0.0049	0.093	0.067	0.00464	0.212
Max. absorber liquid temperature (F)	*< 140*	139.199	118.38	137.21	130.8	135.8	127.5	138.07	138.988	131.776	115.57	128.235	134.98
Lean amine return temperature at top of absorber (F)	*> 90*	91	95	91.0064	95	92	95	105	99	100	95	100	109.9
Absorber & regenerator system factor	*0.8*	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Absorber weir height (inch)	*< 3*	2	3	2	3	NA	NA	NA	NA	NA	NA	NA	NA
Design flooding point (%)	*75*	75	75	75	75	75	75	75	75	75	75	75	75
Absorber diameter (m)	*< 3*	2.369	2.676	2.563	2.66	2.62	2.77	2.436	2.39	1.935	2.417	2.311	2.421
Absorber trays (#) / Packing height (m)	*< 30*	16	17	15	18 Trays	2.2098	3.429	3.048	9.144	9.144	4	10.668	4.7

Absorber pressure drop total (psi)	*< 0.2 psi/tray No guideline for packing*	0.135	0.1225	0.14	0.185	0.019	0.019	0.038	0.123	0.251	0.0043	0.16	0.079
Absorber bottom stream temperature (F)	*No guideline*	136.98	117.92	133.64	127.59	135	127.5	133	130.625	129.071	115.34	128.2	134.1
Regenerator weir height (inch)	*< 3*	2	2	2	3	2	2	3	3	3	3	2.8	3
Regenerator diameter (m)	*< 3*	2.614	2.974	2.621	2.71	2.71	2.9	2.814	2.7	2.57	2.93	2.96	2.9
Regenerator trayed/ packing height (m)	*< 30*	20	20	20	12.19	12.19	12.19	12.192	12.192	12.192	12.19	12.19	18.82
Regenerator pressure drop (psI)	*< 0.2 psi/tray No guideline for packing*	0.126	0.13	0.127	0.135	0.116	0.115	0.136	0.1344	0.132	0.14	0.1323	0.153
Regenerator feed temperature (F)	*No guideline*	170	180	170	150	169	180	179.99	180	180	150	180	179.99
Regenerator condenser temperature (F)	*No guideline*	90	90	90	90	90	90	80	90	95	90	120	120
Condenser duty (GJ/hr)	*No guideline*	9.26	17.99	7.15	17.9	17.16	22.16	26.348	26.13	18.65	2.46	19.95	5.42
Regenerator top temperature (F)	*< 230*	201.27	220	197.194	218.8	219	224.15	228.87	227.447	221.332	162.5	223.48	192.2
Regenerator duty (MW)	*No guideline*	20	23	20	23	23	26.5	22.5	21	20	26	22	25
Regenerator duty (Low pressure steam required for duty in kg/day)	*2.085 MJ/kg steam*	8,28,777	9,53,094	8,28,777	953093.5	953093.52	1098129	932374.1	870215.8	828776.9	1077410.07	911654.676	1035971.2
Regenerator steam cost ($/day)	*$ 3.5 / 453.6 kg*	6,394.88	7,354.1	6,394.88	7354.116	7354.116	8473.221	7194.244	6714.628	6394.88	8313.349	7034.372	7993.605
Lean cooler duty (GJ/hr)	*No guideline*	64.15	65.31	64.15	65.27	66.15	73.8	50.68	49.94	54.87	91.7	59.13	83.8
Rich pump power (kW)	*No guideline*	0.17	0.238	0.174	0.176	0.178	0.235	0.185	0.099	0.0238	0.278	0.097	0.293
Lean pump power (kW)	*No guideline*	1.54	2.059	1.573	1.404	1.331	1.615	1.497	1.376	1.1713	2.112	1.68	5.3
Total pump power (kW)	*No guideline*	1.71	2.297	1.747	1.58	1.509	1.85	1.682	1.475	1.1951	2.39	1.777	5.593
kg steam/ton CO2	*No guideline*	3137.8	3648.3	3137.8	3616.09	3563.09	4146.07	3571.90	3313.21	3151.12	4114.93	3418.02	3949.71
GJ cooling duty/ton CO2	*No guideline*	0.281	0.325	0.272	0.315	0.311	0.36	0.295	0.289	0.279	0.359	0.296	0.340
kWh power/ton CO2	*No guideline*	0.16	0.21	0.16	0.143	0.135	0.167	0.154	0.134	0.109	0.219	0.159	0.511

All the values entered in the process check list validation sheet are inferred from the PTD and PTR files of all the base case designs that we simulated using OGT Protreat simulation software during the course time of our project. These data served as the main source for our screening process, by which we found out the best case among all 12 cases , which on carrying out further optimisation efforts, could be a very valuable design for CO_2 removal from the flue gas.

7.0 SCREENING AND JUSTIFICATION

							NFPA RATING				REGENERATOR TEMPERATURE [F]			ABSORBER TEMPERATURE [F]			CO_2 LOADING
S.NO.	SOLVENT	INTERNALS	CONFIGURATION	SOLVENT CIRCULATION RATE [cum/hr]	SOLVENT BOILING POINT [F]	TOXICITY- LD50 [mg/Kg]	Health	Flammability	Reactivity	Speciality	Top	Bottom	Peak	Top2	Bottom2	Peak2	mol co2/mol amine
1	MEA	Raschig ring pack	with wash	182	332.6	1.089	3	2	0	NA	221.32	256.85	258.13	100	128.4	131.7	0.448
2	MDEA+PZ	Mellapak plus pack	with wash	212	464	4.68	2	2	0	W	227.4	257.19	257.19	99.7	128.8	138.9	0.415
3	MEA	Generic valve trays	Without wash	215	332.6	1.089	3	2	0	NA	201.27	257.27	257.27	91.9	134.9	139.1	0.378
4	MEA	Generic valve trays	with wash	220	332.6	1.089	3	2	0	NA	197.48	257.17	257.17	94.9	133.6	137.2	0.376
5	MDEA+PZ	Generic valve trays	Without wash	220	464	4.68	2	2	0	W	218.82	258.26	258.26	94.9	126.5	130.8	0.306
6	MEA	Mellapak plus pack	Without wash	225	332.6	1.089	3	2	0	NA	219.02	256.1	256.1	94.2	135.8	135.8	0.400

7	MDEA+PZ	Mellapak plus pack	Without wash	230	464	4.68	2	2	0	W	228.9	258.36	258.36	107.54	133.75	138.06	0.316
8	MDEA+PZ	Raschig ring pack	with wash	265	464	4.68	2	2	0	W	223.3	256.53	256.53	99.29	128.2	128.2	0.327
9	MDEA+PZ	Generic valve trays	with wash	300	464	4.68	2	2	0	W	220.52	256.97	256.97	95.73	116.6	118.03	0.277
10	MEA	Mellapak plus pack	with wash	300	332.6	1.089	3	2	0	NA	224.14	255.98	255.98	96.5	125.9	127.1	0.329
11	MDEA+PZ	Raschig ring pack	Without wash	354	464	4.68	2	2	0	W	162.66	248	248	96.26	114.98	114.98	0.262
12	MEA	Raschig ring pack	Without wash	375	332.6	1.089	3	2	0	NA	191.48	248.21	248.21	111.8	134	134.6	0.395

7.1 Screening Analysis

By considering the minimization principle:

- The 12th case which is MEA - raschig ring packing and without wash section was eliminated because it has higher solvent circulation rate i.e., 375 when compared with the other cases.
- The 11thcase which is MDEA plus piperazine - raschig ring packing and without wash section was eliminated because it is also having higher solvent circulation rate i.e., 354.

<u>By considering the substitution principle</u>:

- All the cases which are having the solvent MDEA plus piperazine (cases - 2,5,7,8,9) are eliminated because MDEA + PZ has higher boiling point i.e., 464 rather than that of MEA which is 332.6 and also toxicity levels are higher for MDEA i.e., 4.68 mg/kg when compared with MEA i.e., 1.089 mg/kg. As MDEA+PZ is water reactive, we can't consider this kind of solvent because water is included in the feed composition.
- By eliminating the above-mentioned cases, we are left with 5 cases which are having MEA as solvent (cases – 1,3,4,6,10). In those cases, we have removed the case 10 which is MEA – mellapak plus packing and with wash section because it has higher solvent circulation rate i.e., 300 when compared with the other cases.

<u>By considering moderation principle</u>:

- The 1st case which is MEA - raschig ring packing and with wash section was eliminated even it has lower solvent circulation rate i.e., 182 because, it has higher CO2 loading i.e., 0.448 which is closer to 0.45.
- The 6th case which is MEA – mellapak plus packing and without wash section was eliminated as it has higher CO2 loading i.e., 0.4 and also the regenerator top temperature is high i.e., 219 when compared to the other two cases.
- Finally, we are left with two cases (cases – 3,4) which are MEA - generic valve trays - without wash section and MEA - generic valve trays - with wash section respectively.

<u>By considering the simplification principle</u>:

- From the above two cases, we have eliminated the 4th case i.e., MEA - generic valve trays - with wash section in-order to reduce complexity.

So, the finalized case is MEA - generic valve trays - without wash section

8.0 CONCLUSION

This work demonstrates a basic design of a carbon-dioxide capture plant using amine solvents using the OGT ProTreat® simulation software. All our 12 design cases, provided a removal of 90% of $CO_2$from the flue gas. Subsequently, using the principles of inherently safer design, a screening methodology was adopted which led us to conclude that MEA with generic valve trays (without wash trays) was the most suited for this application from the available 12 cases.

9.0 RECOMMENDATIONS

- Optimization of the plant design : Sensitivity analysis can be done for providing valid and promising results. The variation of major process parameters and studying its effect on the efficiency of the process is an important aspect which facilitates to build our design on an industrial scale.
- Material of construction of the absorber and regenerator must be chosen carefully based on analysing the temperature profile in both the columns.
- Since, the process is carried out in ambient pressure conditions, power supply and usage of pumps can be minimized, which in turn helps to reduce the OPEX and CAPEX of the plant.
- Further research can be done to minimize the highest liquid temperature in the absorber , by varying the Wt% of the solvent and its circulation rate.
- Impact of the operating conditions on the efficiency of generic valve trays must be studied

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