TEAM-C (capstone project)

Ragulasangeerthian.S || Yogeshwaran.R.S || Sai Akshatha || Yanapu. Sharmila || Nandini A Garg

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Dear mentors,

Through this letter, we would like to present our capstone project report entitled" *Design and study of carbon capturing plant using regenerable solvents"*. This report incorporates the working of team members with different parts of the report. Our report begins with the introduction of carbon sequestration and post combustion carbon capturing technology in nutshell. The capstone project is completed as per the guidelines in capstone project memo provided by 310i technologies. Several base cases were investigated by using ProTreat® software to achieve 90% carbon-di-oxide absorption from given post combustion flue gas stream.

Different process parameters and process variations (from capstone memo) were used to perform the simulation process and this report includes our observations. Safety analysis were carried out for different base cases and the observations are documented. This report also cities the usage of ProTreat® software in documenting the observations. Process checklist for different simulation cases have been attached and remarks for the same is also documented in this report.

Throughout this project, we were able to learn and observe the features of ProTreat® software and its appropriateness in carbon-capturing. The references for the utilised information to prepare this report is provided accordingly at the end of the report.

We hope our project work satisfies the capstone project requirements.

Thanks in advance for reviewing this report.

Sincerely

TEAM C

Roles of team members:

Report:

S.NO	CONTENT	NAME OF THE PERSON RESPONSIBLE FOR RESPECTIVE CONTENT
1	**Introduction**	Yanapu Sharmila Sai Akshatha
2	**Project basis**	Ragulasangeerthian yogeshwaran Nandini Sai Akshatha
3	**Safety sheet preparation**	Yanapu Sharmila Yogeshwaran
4	**Process flow diagram**	Ragulasangeerthian Nandini
5	**Process simulation**	Ragulasangeerthian
6	**Process checklist validation**	Yogeshwaran
7	**Conclusion**	Sharmila
8	**Recommendations**	Sai Akshatha
9	**Appendix**	Yanapu Sharmila
10	**References**	Nandini
11	**Executive summary**	Ragulasangeerthian

Project:

S.NO	TASK	NAME OF THE PERSON RESPONSIBLE FOR THE TASK
1	Simulating base case using MEA with and without wash section (Generic valve trays) with process checklist validation	Yogeshwaran
2	Simulating base case using MEA with and without wash section (Mellapakplus packing) with process checklist validation	Sai Akshatha
3	Simulating base case using MEA with and without wash section (Rashich super ring packing) with process checklist validation	Yanapu Sharmila
4	Simulating base case using MDEA with and without wash section (Generic valve trays) with process checklist validation	Nandini
5	Simulating base case using MDEA with and without wash section (Mellapakplus packing) with process checklist validation	Ragulasangeerthian
6	Simulating base case using MDEA with and without wash section (Rashich super ring packing) with process checklist validation	Ragulasangeerthian
7	Preparation of process checklist	Ragulasangeerthian yogeshwaran Nandini Sai Akshatha Yanapu Sharmila
8	Preparation of the safety metrics	Sharmila and Yogeshwaran
9	Report work	Ragulasangeerthian yogeshwaran Nandini Sai Akshatha Yanapu Sharmila
10	Presentation	Ragulasangeerthian yogeshwaran Nandini Sai Akshatha Yanapu Sharmila

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Executive Summary

Increasing levels of carbon-di-oxide in the atmosphere contributes to global warming. This report documents the findings from a basic design investigation of a post-combustion carbon capture plant with amine-based solvents. The design of carbon capturing plant and by using Protreat® simulation software. The design requirement was to remove 90% of CO_2 from the incoming flue gas from a post combustion source. This study incorporated three column internals - generic valve trays, Mellapak Plus Packing (metal M352Y) and Raschig Super Ring Packing (Metal No. 2). Two solvents were examined - methyl diethanol amine (MDEA)activated with piperazine and monoethanol amine (MEA). Several process parameters such as the reboiler duty, circulation rate, solvent strength, and operating conditions were varied to achieve the design condition of 90 % CO_2 capture while adhering to the process check list guidelines as issued in the design memo [1] Based on the screening options, a matrix of 12 cases were created and key results are documented in the report. Certain safety metrics such as toxicity, and National Fire Protection Association (NFPA) of the solvents were also gathered and documented. The results from simulations are documented in process checklist sheet attached in this report. Key observations include low circulations rates of solvents was not ideal for approaching appropriate value of carbon-di-oxide loading and the increase in regenerator reboiler duty does not meet the desired regenerators diameter as per design memo. It is observed from the simulations that increase in weight percentage of solvent eventually decrease the carbon-di-oxide loading with reference to design memo. The observations documented in this report can be used to achieve 90 % absorption with respect to the base cases. The conclusion and recommendations suggest possibility of screening the simulation cases based on cost estimation and inherent safety design.

1.Introduction:

The largest contributors of greenhouse gas (GHG) emissions are the energy, agricultural, automotive, industrial, and waste sectors. Fossil fuel burning in the energy sector contributes significantly to GHG emission emissions, which increases carbon dioxide (CO2) emissions and causes global warming. The total amount of energy consumed worldwide is predicted to increase by 75% by 2025 compared to the energy consumption pattern in 1996, which would result in higher CO2 emissions. The primary goal right now is to find ways to cut emissions from various chemical industries while utilizing CO2-capturing devices and technologies. The current research and development (R&D) activities are focused on improving the already available capture technologies and developing new capture technologies that have the potential to be very beneficial. [2]The techniques that can capture CO2 from various chemical industries are outlined as follows:

- Post-combustion carbon capture
- Pre-combustion carbon capture
- Oxy-fuel technology
- Chemical looping combustion

1.1 Post-Combustion Carbon Capture

Post-combustion capture (PCC) removes CO2 from the flue gas emitted by power plants and industrial facilities after the combustion of fossil fuels. The process involves separating the flue gas from the combustion process and treating it with a solvent or sorbent material that selectively absorbs CO2. The most used solvent for post-combustion capture is monoethanolamide (MEA) followed by the separation of the carbon dioxide from the solvent and then the recovered carbon dioxide is compressed and stored for further use. This method is widely used because it can be retrofitted to existing power plants and industrial facilities without major modifications to the combustion process. Yet the process does have drawbacks, it requires additional energy for the capture and separation processes, which can lead to increased operating costs and reduced overall plant efficiency [2]

1.2 Pre-combustion carbon capture

Pre-combustion capture refers to the removal of CO_2 from fossil fuels before combustion is completed. The process involves gasification, where the fossil fuel is reacted with oxygen or steam to produce a mixture of hydrogen (H2) and carbon monoxide (CO), known as synthesis gas or syngas. The syngas is then processed in the water-gas shift reactor followed by the separation and capture of the CO2 before combustion occurs. The major advantage that Pre-combustion carbon capture over the PCC is the formation of more concentrated carbon dioxide, pre-combustion capture typically is more efficient but the capital costs of the base gasification process are often more expensive than traditional pulverized coal power plants [3] [4]

1.3 Oxy-Fuel Technology:

Oxy-fuel combustion is a carbon dioxide (CO2) capture technique used in power plants and industrial processes. This process involves burning fossil fuels in an oxygen-rich atmosphere instead of air, resulting in a flue gas predominantly composed of CO2 and water vapor. Oxy-fuel combustion offers the advantage of producing a flue gas with a high CO2 concentration, which simplifies the CO2 capture process but, it requires additional steps for oxygen separation, which adds complexity and energy consumption to the overall system. [4]

1.4 Chemical Looping Combustion:
The Chemical Looping Combustion (CLC) concept is based on the transfer of oxygen from the combustion air to the fuel by means of an oxygen carrier in the form of a metal oxide, avoiding the direct contact between fuel and air. CLC minimizes the formation of nitrogen oxides (NOx) and simplifies CO2 capture and provides a high-purity stream of CO2, making it suitable for utilization in various applications or direct storage but the development of suitable oxygen carrier materials is costly and complex [5] [6]

These techniques offer viable solutions for capturing and storing carbon dioxide (CO2) from various sources and by implementing efficient carbon capture technologies, the impact of greenhouse gases on the environment can be reduced. However, challenges such as cost, scalability, and the need for complementary mitigation strategies must be addressed to maximize the effectiveness of these techniques.

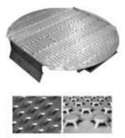
2. Design Basis:

The aim of this project is to design carbon capture plant that absorbs 90 % of carbon-di-oxide from the given flue gas (as mentioned in table 1) by simulating it using the different screening options as provided in the design memo, and explained later in this section. All simulation work is done using ProTreat® software.

Table 1: Flue gas specification [1]

Temperature	100 F
Flow rate	16500 cum/hr
Pressure	14.7 psig
Component	**Volume %**
Co_2	17.8
N_2	56.5
O_2	7.5
H_2O	18.2

Table 2: Column internals [1]

<table>
<tr><td rowspan="3">Column internals</td><td>Generic Valve Trays
</td></tr>
<tr><td>MellaPakplus Packing (Metal M352Y)
</td></tr>
<tr><td>Raschig Super-Ring Packing (Metal No 2)
</td></tr>
</table>

Solvent concentration:

Table 3: Solvent concentration [1]

Solvent	Strength
MDEA	30-45 wt%
MEA	20-30 wt%
Piperazine	0.5-7 wt %

*The blended amine concentration was not allowed to exceed 45 wt% (ie MDEA + piperazine)

Temperature limits at key points in the process loop as per design checklist:

- The maximum absorber liquid temperature was maintained below140 F.
- The lean amine that entered the absorber was maintained above 90 F
- The regenerator top temperature was maintained below 230 F
- The carbon-di-oxide loading was maintained under 0.45 mole of Co_2 per mole of amine.-

Column internal specifications as per design checklist:

- Tray pressure drop was maintained below 0.2 psi/tray
- Trayed towers system factor was 0.8.
- The maximum weir height was maintained to below 3 in
- Tray spacing was maintained at 2 ft
- The design flooding point was maintained below 75 % for both trayed and packed towers.

This work reports the base cases by employing the screening options above, and in addition, studying the impact of water wash section in the absorber for solvent recovery.

3. Process Description:

Much of this information is based on [7]

Raw gas (flue gas) is feed to the absorber from the bottom and flows against a counter-current stream of lean amine solution. The carbon-di-oxide in flue gas is absorbed by the solution and the treated gas leaves at the top. The rich amine solution flows from the bottom of the absorber to the lean-rich heat exchanger where it is heated by the recycled lean amine solution coming from the regenerator (amine – regenerator).

After heating the, rich amine is feed to the regenerator where Co_2 is stripped. After the entry into the stripper the rich amine is exposed to counter-current water vapor stream from reboiler; that strips maximum amount of Co_2 from the rich stream.

The overhead mixture leaves the condenser, where the most of the water vapor is condensed and returned to the stripper as reflux. The lean solution, that is leaving the regenerator exchanges heat with the rich amine and gets its temperature reduced and further this temperature is reduced by the cooler and the solution is recycled and fed back to the absorber. To reduce any volatile solvent losses, a water wash is also employed in all the simulations and its impact investigated. Loss of solvent is prevented by recycling back the solvent vapors into the absorber back again.

Figure 1 extracted from [7] and reproduced as it is here is an illustrative sample process flow diagram for CO2 capture using amines.

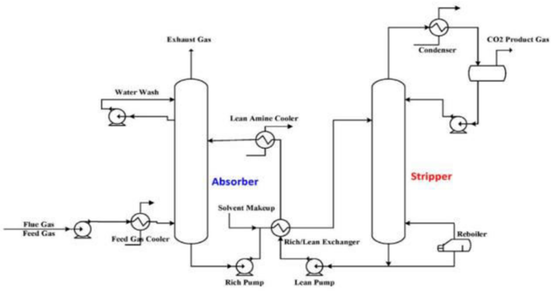


Fig 1- Typical amine-based carbon capture plant flow diagram

4.Process simulation:
Figure 2 and 3 represent the process flow diagrams as set up in ProTreat® for without and with wash section respectively.

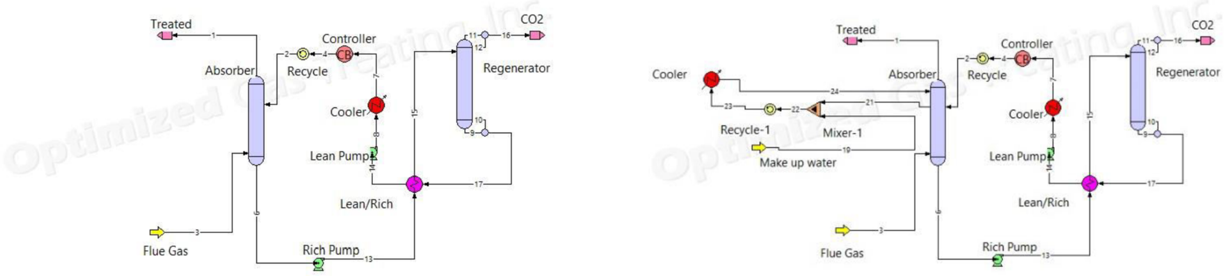


Fig 2 and 3 representing without and with water section respectively

5. About ProTreat®:
ProTreat® is a simulation software product developed by OGT (Optimised Gas Treating) Inc., USA. It is one of the extremely powerful simulation tools for gas treating that provides accurate and reliable results. OGT software began with gas treating in 1992 and strictly upholds mass and heat rate-based simulations. [10]ProTreat® is completely capable of simulating with single, multiple and speciality 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.

*The above furnished information regarding ProTreat® software is reproduced from OGT Inc., website. [8]

5.1 Protreat and its accuracy in carbon capture:
ProTreat® simulation software provides us the most sophisticated and convenient platform to derive best results regarding the post-combustion gas treating plant design. It has several advantages over other simulation software's in terms of its built-in mass transfer rate-based modelling rather than using conventional ideal stage-based modelling, which deliberately provides a path to reach the real-world scaling of this plant with high end accuracy. This software studies the chemical reaction kinetics of different amine based and physical solvents and several column internals which provides the user an accurate estimate of how much carbon-di-oxide is absorbed during the process.

[9]ProTreat® model can be used to closely calculate steady-state CO2 absorption and desorption processes, because it accurately accounts for simultaneous physical transit of CO2 between gas and liquid phases as well as chemical reaction kinetics of Carbon-di-oxide in the liquid phase. ProTreat® is the only gas treating simulator capable of performing accurate calculations for packing mass transfer performance. Its mass- and heat-transfer rate-based model makes extensive use of tower internals not just for hydraulic rating but also for thorough absorption and stripping rate estimates. [10] ProTreat® is particularly reliable in carbon capture applications due to its ability to forecast separation, utilising random and organised packing. There are no residence times, ideal stages, or translation to actual packing and that enables us to conduct hassle free use of this software

6. Process checklist validation sheet:

Table 4: Process checklist validation sheet

W- without wash section W*- with wash section

PARAMETERS	*Guideline/ Reference Values*	Simulations											
Solvent	*MDEA-Pz/MEA*	MEA	MEA	MEA	MEA	MEA	MEA	MDEA-Pz	MDEA-Pz	MDEA-Pz	MDEA-Pz	MDEA-Pz	MDEA-Pz
Column internal specification	*Generic Valve Trays (GVT)/Raschig Super Ring (RSR)/Mellapak Plus (MP)*	GVT(W)	GVT(W*)	MP(W)	MP(W*)	RSR(W)	RSR(W*)	GVT (W)	GVT(W*)	MP (W)	MP(W*)	RSR (W)	RSR(W*)
Solvent strength total (wt%)	*30-45*	30	25	**20**	**20**	29	30	30	32	32	35	33	39
Blend (wt%)	*MDEA 30-45/Pz 0.5-7/MEA 20-30*	MEA-30%	MEA-25%	No Blending	No blending	No Blending	No Blending	MDEA-30/Pz-7	MDEA-32/Pz-2.5	MDEA-30/pz-2	MDEA-32/Pz-3	MDEA-33/Pz-3	MDEA-34/Pz-5
CO_2 removal (%)	*90*	90	91	90	90	90	90	90	90	91	91	92	91
CO_2 in treated gas (kmol/hr)	*< 27.28*	27.27	26.27	27.10	26.98	27.47	27.11	27.39	27.01	24.74	25.29	23.15	24.91
CO_2 capture (MT/day)	*> 261*	260	263	261	263	259	259	261	262	262	261	264	261
Rich amine loading (mol CO_2/mol amine)	*< 0.45*	0.33	0.33	0.39	0.42	0.45	0.43	0.16	0.28	0.43	0.42	0.34	0.32
Lean amine loading (mol CO_2/mol amine)	*No guideline*	0.009	0.009	0.094	0.219	0.052	0.217	0.003	0.006	0.003	0.003	0.005	0.008
Max. absorber liquid temperature (F)	*< 140*	136	139	128	116	129	123	116	118	122	126	120	120
Lean amine return temperature at top of absorber (F)	*> 90*	90	90	90	90	90	90	90	95	90	90	90	90
Absorber & regenerator system	*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

factor													
Absorber weir height (inch)	*< 3*	1.5	2	NA	NA	NA	NA	2	2	NA	NA	NA	NA
Design flooding point (%)	*75*	75	75	75	75	75	75	75	75	75	75	75	75
Absorber diameter (m)	*< 3*	2.59	2.60	2.60	3.00	2.28	2.33	2.81	2.67	2.63	2.61	2.27	2.27
Absorber trays (#) / Packing height (m)	*< 30*	20	15	2	3.5	7	7	10	17	5	6	7.5	7.5
Absorber pressure drop total (psi)/sectioned pressure drop for packing (psi)	*< 0.2 psi/tray No guideline for packing*	0.12	0.12	0.02	0.02	0.12	0.01	0.75	0.12	0.04	0.05	0.10	0.10
Absorber bottom stream temperature (F)	*No guideline*	136	139	128	116	153	123	116	118	122	126	120	120
Regenerator weir height (inch)	*< 3*	2	2	2	2	2	2	2	2	2	2	2	2
Regenerator diameter (m)	*< 3*	3.90	2.86	2.85	2.70	2.90	2.63	5.97	2.97	2.91	2.73	2.80	2.73
Regenerator trayed/packing height (m)	*< 30*	20	20	12	20	12	20	20	20	20	20	20	20
Regenerator pressure drop (psI)	*< 0.2 psi/tray No guideline for packing*	0.12	0.13	0.13	0.14	0.11	0.11	0.11	0.13	0.12	0.13	0.13	0.13
Regenerator feed temperature (F)	*No guideline*	180	225	170	199	180	180	180	180	118.4	149	149	149
Regenerator condenser temperature (F)	*No guideline*	120	120	90	90	80	120	120	90	120	120	120	174.2
Condenser duty (GJ/hr)	*No guideline*	50	52.00	12.82	8.15	7.77	4.81	23.2	17.97	15.47	20.23	3.15	3.38
Regenerator top temperature (F)	*< 230*	188	224.39	213	200.8	180	189.37	120	180	217.4	221	168	179
Regenerator duty (MW)	*No guideline*	40	25	23	20	32	20	25	23	25	22	20	20
Regenerator duty (Low pressure steam required for duty in kg/day)	*2.085 MJ/kg steam*	1657554	1035971	953094	828777	1326043	828777	1035971	953094	1035971	911655	828777	828777
Regenerator steam cost ($/day)	*$ 3.5 / 453.6 kg*	12790	7994	7354	6395	10232	6395	7994	7354	7994	7034	6395	6395
Lean cooler duty (GJ/hr)	*No guideline*	90	90	71	65	39	68	11	8	74	59	69	69

Rich pump power (kW)	*No guideline*	0.54	0.16	0.20	0.28	0.73	0.24	2.00	0.28	0.16	0.15	0.19	0.18
Lean pump power (kW)	*No guideline*	4.20	0.16	0.20	0.38	0.76	0.24	4.14	2.06	1.23	0.23	0.25	0.23
Total pump power (kW)	*No guideline*	4.74	0.32	0.40	0.66	1.49	0.48	6.14	2.30	1.40	0.38	0.44	0.41
kg steam/ton CO2	*No guideline*	6375	3946	3651	3155	5117	3205	3965	3634	3953	3488	3141	3173
GJ cooling duty/ton CO2	*No guideline*	0.54	0.54	0.32	0.28	0.18	0.28	0.35	0.34	0.34	0.30	0.28	0.28
kWh power/ton CO2	*No guideline*	0.44	0.03	0.04	0.06	0.14	0.04	0.56	1.10	0.13	0.03	0.04	0.04

6.1 Critical remarks:

Here are some few remarks that was observed from the process checklist during the simulation process:

1.For the case with generic valve trays (without wash section) – MEA, the regenerator diameter was greater 3 m i.e it was not meeting the design memo guidelines because the value of 40 MW regenerator heat duty, increased the diameter of the regenerator greater than 3 m and efforts to decrease the heat duty was futile as the 90 % absorption rate could not be achieved.

2. For the case with generic valve trays (without wash section) – MDEA, the regenerator diameter was greater 3 m i.e it was not meeting the design memo guidelines because the value of 25 MW regenerator heat duty, increased the diameter of the regenerator greater than 3 m and efforts to decrease the heat duty was futile as the 90 % absorption rate could not be achieved.

6.2 Simulation observations:

Increasing the flow rate of the solvent in the absorber reduces the carbon loading while increasing the absorption capacity. This happens because a higher flow rate improves contact between the solvent and the flue gas, resulting in increased absorption and decreased carbon loading. Reducing the number of trays in the absorber, on the other hand, reduces absorption capacity. Furthermore, increasing the heat duty in the regenerator reduces the amount of CO_2 in the treated gas. However, to avoid negative consequences, this increase in heat duty should be kept within certain parameters. Similarly, increasing the packing depth in the absorber increases pressure drop. The water wash section necessitates monoethanolamine rather than methyldiethanolamine. The provision of heat duty is determined by the solvent flow as well as the temperature of the rich amine. Finally, increasing the absorption Weir height within permissible limits improves both the rich amines' absorption capability and carbon loading.

7. Safety analysis sheet:

Table 5: Safety metrics sheet

Solvent	MEA	MEA	MEA	MEA	MEA	MEA	MDEA+Pz	MDEA+Pz	MDEA+Pz	MDEA+Pz	MDEA+Pz	MDEA+Pz
Internal	Generic Valve Trays	Generic Valve Trays	Raschig Ring	Raschig Ring	Mellapak plus	Mellapak plus	Generic Valve Trays	Generic Valve Trays	Mellapak plus	Mellapak plus	Raschig Ring	Raschig Ring
With/without wash section	Without wash	With wash	With wash	Without wash	With wash	Without wash	With wash	Without wash	With wash	Without wash	With wash	Without wash
Solvent circulation rate (cum/hr)	200	200	225	302	360	250	300	470	190	205	230	235
Boiling point of solvent 1 (ºC)	170	170	170	170	170	170	247	247	247	247	247	247
Boiling point of solvent 2 (ºC)	0	0	0	0	0	0	146	146	146	146	146	146
Toxicity of solvent 1 (mg/kg)	1.089	1.089	1.089	1.089	1.089	1.089	4680	4680	4680	4680	4680	4680
Toxicity of solvent 2 (mg/kg)	0	0	0	0	0	0	2600	2600	2600	2600	2600	2600
Health	3	3	3	3	3	3	1	1	1	1	1	1
Flammability	2	2	2	2	2	2	1	1	1	1	1	1
Instability	0	0	0	0	0	0	0	0	0	0	0	0
Special hazards	0	0	0	0	0	0	0	0	0	0	0	0
Health	0	0	0	0	0	0	2	2	2	2	2	2
Flammability	0	0	0	0	0	0	2	2	2	2	2	2
Instability	0	0	0	0	0	0	0	0	0	0	0	0
Special hazards	0	0	0	0	0	0	0	0	0	0	0	0
Absorber Top Temperature (ºC)	32	32	32	32	32	32	32	32	32	32	32	32
Regenerator top temperature (ºC)	82	66	82	82	93	77	82	82	66	49	65	66
Absorber Peak Temperature (ºC)	33	32	32	33	33	34	35	33	32	33	32	33
Regenerator peak temperature (ºC)	89	49	93	87	94	101	105	119	106	104	80	75
Rich loading mol CO2/mol amine	0.33	0.38	0.37	0.43	0.42	0.39	0.28	0.16	0.42	0.43	0.32	0.34

8. Conclusion:

The report highlights our team's efforts in constructing a process flow sheet that effectively absorbs carbon dioxide (CO_2) from flue gases. We achieved a remarkable absorption rate of 90% using the OGT ProTreat® modelling programme. The study used with 12 base cases to investigate various eventualities. In these circumstances, amine solvents are used to capture the carbon dioxide from flue gas, particularly MEA (Monoethanolamine) as a benchmark solvent and MDEA (Methyl Diethanolamine), which are mixed with piperazine as an alternative solvent. To optimise the absorption process, various column internals are used, such as generic valve trays, Mellapakplus, and Raschig super ring packings. Some base-case instances included a water wash section to improve the solvent recovery. As a result, the best combinations of solvents, column internals, and water wash emerged from this investigation. Upon completing the simulation, we created a safety metric sheet that included various important parameters. The NFPA (National Fire Protection Association) rating of the solvents used, as well as the column internals, was an important consideration. According to the inherent safety design, include appropriate parameters from the design memo, such as solvent flow rate, toxicity of solvent, NFPA rating, temperature, and carbon loading in rich amine. We gained significant insights into the overall safety profile of the process simulation design by analysing these safety characteristics. This knowledge lays the groundwork for future expansions and enhancements, providing a safer and more efficient carbon capture process.

9. Recommendations:

This study has offered an executive summary of the safety of all base cases and the findings derived from the simulation of those scenarios. If any person or group wishes to proceed with this study as their foundation, they may do so by screening the base cases by the safety analysis additionally by following the procedure checklist and carrying out an analysis on the optimization of the chosen case or cases. The economics and process performance should be considered in the optimization analysis. Before finalizing the base case, the individual/team should try to adjust in the base scenarios that have some inaccuracies that are highlighted in the process checklist critical remarks section and then fix to a specific base they are prepared to move with further. The team or individual should summarise their results, the equipment list and associated costs, and utility data and quantities needed by the equipment. Following a summary of the selected case(s), a design adequacy check should be performed. This design adequacy checklist should include all the summary checks as well as the selected examples' compliance with those conditions. Following this study, the team/individual could go on to a summary of the equipment costing, which will offer capital and operating expenses. All these summaries and analysis would aid an individual or team in further research and screening of the basic instances. It also aids in determining the best basic cases for further improvisation.

10.Appendix:

Team meeting notes:

Date: 20.6.23

1.The meeting was held at 6 pm.
2.The meeting was attended by all the team members.
3.RagulaSangeerthian started the meeting with a quick recap of the capstone project and briefed us about the project essentials.
4.Sai Akshatha led the discussions and reviewing of the planning memo.
5.The selection of tasks and the finalization of the dates were made by the team.
6.Sharmila and Yogesh Waran gave us a head start on how to access the pretreat software and the basics of simulation.
7.Nandini gave us an overview of the solvents, and the advantages, and disadvantages were mentioned.

Date:21.6.23

1.The meeting was held at 6 pm
2.The meeting was attended by all the team members.
3.Yogesh Waren and RagulaSangeerthian helped with the doubts regarding the changing of parameters for different base cases and clarified issues regarding the utilization of the software.
4.Sharmila and Sai Akshatha continued the discussions on how these changing parameters affected the absorption of Carbon dioxide.
5.Nandini gave suggestions on how the intermediate deliverables could be managed based on the timelines.

Date: 22.6.23

6.The meeting was held at 6 pm
7.The meeting was attended by all the members
8.Sharmila and Nandini shared their thoughts on the base case with generic valves and clarified doubts regarding the same.
9.Ragula Sangeerthian addressed the difficulties regarding the addition of the water wash section in the simulation
10.Yogesh Waran discussed the optimization of the absorber section, controller block, etc
11.Sai Akshatha addressed how warning blocks could be approached
12.Discussions regarding the submission of the progress memo were made.

* *Ragulasangeerthian held meeting with anand to improve optimisation for his base case and that was shared to the team members and further doubts were clarified*

4. Date: 23.6.23

1.The meeting was held at 5 pm
2.The meeting was attended by all the members.
3.Ragula Sangeerthian clarified the common mistakes being made.
4.Sharmila and Nandini addressed the mistakes in the progress memo.

5.YogeshWaran and Sai Akshatha addressed the errors being faced during the running of the simulation.

<u>Date:26.06.23</u>
Team meeting duration : 6.30 pm to 7.30 pm
1.Discussion were made on preparation of process checklist
2.Aksatha and sharmila noticed that the system factor was not 0.8 and changes were made by the team members
3.Members debated against solvents and column internals to be used for final simulation
4.Nandini and Yogeshwaran undertook the briefing of 27-06-23 progress memo submission
5. Ragulasangeerthian revised the process checklist parameters for different base cases and revisited base cases that required changes on them.

** Sai aksatha held a text conversation with anand regarding the diameter of regenerator as part of process checklist and anand informed that one should cross check process parameters with respective their cases , provided parameters to be checked as per the capstone memo.*

<u>Date 27.06.23</u>
1.Ragulasangeerthian addressed the issue with the base cases, that regenerators diameter was also to be maintained less than 3 m.
2.Yogeshwaran helped team members to resolve this issue.
3.Aksatha and nandini prepared the process checklist issued by anand
4.After preparation of process checklist, sharmila looked for possible errors in the checklist
5.Scheduled a meeting with Anand @ 1 pm to receive feedback regarding the checklist

**Held meetings with Upasana to find solution regarding the unconverging results for different base cases.*
Details regarding the meetings:
Yogeshwaran – Morning – Block warnings in absorber column
Nandini-Evening-Block warnings in both absorber and regenerator column

<u>Date 28-6-23</u>

1.Yogeshwaran faces challenges in reducing the carbon load within the limit. He discussed it with a teammate.
2.Akshatha noticed that she did not achieve the appropriate value.
3.All the team members were starting their process of matric sheet correction and started to write the report simultaneously.
4.Ragulasageerthian discussed the further steps in the report's part.
5.Sharmila and Nandini clarify their doubts in the team meeting.

<u>Date 29-6-26</u>
1.Saiakshatha was discussing her issues with solving base case issue regarding very low packed depth
2.Yogeshwaran and sharmila tried to solve aksatha's base case.
3.Nandini started report work by researching about solvents properties
4.Ragulasangeerthian discussed the design basis, that is to be made as a part of the report.

Date 30-06-23
1.Discussions regarding ISD (Inherent safety design) was carried out by Yogeshwaran
2.Ragulasangeerthian briefed how to fill the safety metric sheet provided by Anand

3.Sai aksatha started to collect data from process checklist for completing Safety metric sheet
4.Nandini explained about the solvent properties
5.Sharmila assisted Sai akastha in completion of the safety metric sheet by looking upon every team member base cases.

** Team meeting (except Sai akastha) was conducted at 1 pm were, team members were briefed with how safety analysis is done and factors to be included while choosing design basis and process parameters.*

Date: 03-07-23 & 04-07-23
Team members actively involved in preparing the report
**Team meetings on these dates was with Anand regarding clarifying doubts regarding report*

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