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CARBON CAPTURE ABSORPTION TOWER

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Abstract - Carbon capture is an essential technology for reducing carbon dioxide (CO_2) emissions from industrial sources and mitigating climate change. The absorption tower is one of the most widely used systems in carbon capture processes, where CO_2 is removed from flue gases using liquid absorbents such as monoethanolamine (MEA). This project focuses on the design, working principle, and performance analysis of a carbon capture absorption tower. The system operates by allowing flue gas to pass through a packed or tray column while the absorbent flows countercurrently, enabling efficient gas-liquid contact and CO_2 absorption. Key parameters such as temperature, pressure, flow rate, and concentration of absorbent significantly influence the efficiency of the process. The study also examines the advantages, limitations, and potential improvements in absorption tower technology. The results demonstrate that absorption towers can effectively reduce CO_2 emissions when optimized properly, making them a viable solution for sustainable industrial operations.

1.INTRODUCTION

Carbon dioxide is one of the major contributors to global warming and climate change, leading to serious environmental issues such as rising global temperatures, melting glaciers, and extreme weather conditions. Industrial sectors such as thermal power plants, cement industries, oil refineries, and chemical manufacturing units are among the largest sources of CO_2 emissions. Therefore, there is an urgent need to develop effective technologies to capture and reduce carbon emissions before they are released into the environment. Carbon capture technology has emerged as one of the most promising solutions to mitigate the impact of greenhouse gas emissions. Among the various carbon capture techniques, absorption-based carbon capture using absorption towers is widely recognized for its efficiency and reliability. This method involves separating carbon dioxide from flue gases using a liquid solvent that absorbs CO_2 through physical or chemical interaction. The absorption tower acts as the primary unit where the gas-liquid interaction takes place, enabling the removal of CO_2 from industrial exhaust gases

An absorption tower is a vertical cylindrical structure designed to facilitate maximum contact between the flue gas and the liquid solvent. The flue gas enters the tower from the bottom, while the solvent is introduced from the top. As the gas flows upward and the liquid flows downward, they come into close contact through packing materials or trays inside the tower. This counter-current flow arrangement enhances the efficiency of CO_2 absorption. The solvent, which is typically a chemical solution such as monoethanolamine (MEA), reacts with carbon dioxide and captures it effectively. The cleaned gas, with significantly reduced CO_2 content, is then released into the atmosphere.

2.1 Types of Carbon Capture

Packed Tower (Packed Bed Absorber)

Contains packing materials like Raschig rings, Pall rings, or saddles.

Provides a large surface area for gas-liquid contact.

2.2 Tray Tower Plate Column

Contains horizontal trays/plates where gas and liquid interact.

Types of trays: bubble cap, sieve, valve trays.

Gas bubbles through liquid on each tray.

2.3. Spray Tower Spray Column

Liquid solvent is sprayed as fine droplets into the gas stream.

Simple design with no internal packing or trays.

2.4 Bubble Column

Gas is introduced at the bottom and forms bubbles in liquid solvent.

No internal structures like trays or packing.

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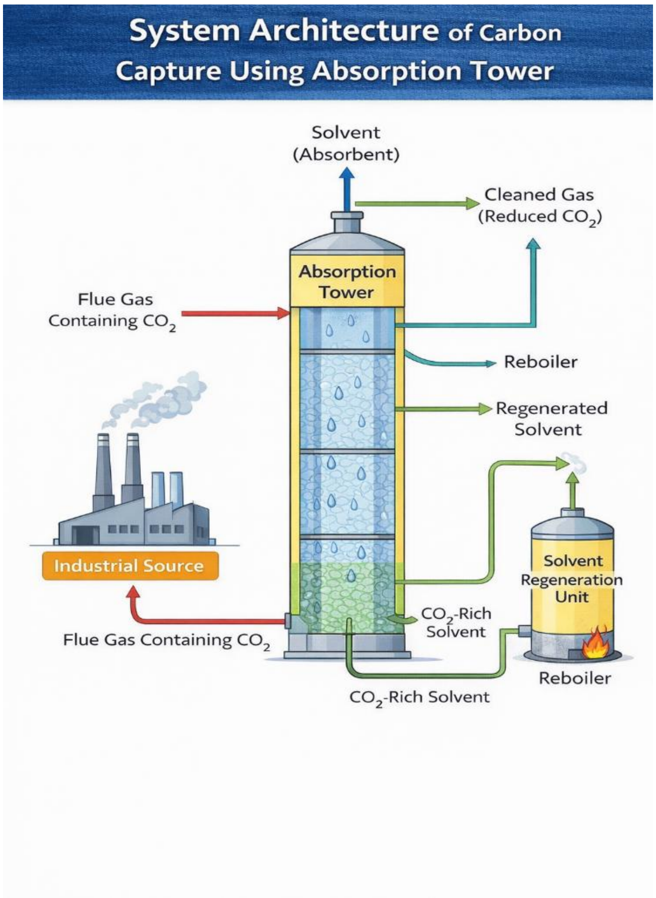
3.1 Block Diagram



4.1 Lireraturе Review

Carbon capture using absorption towers is one of the most widely researched and commercially applied technologies for reducing carbon dioxide (CO_2) emissions from industrial sources. This chapter reviews previous studies, technologies, and advancements in CO_2 capture using gas absorption processe 2.1 Rochelle, G. T. (2009) Amine Scrubbing for CO_2 Capture. This paper discusses the use of amine-based absorption systems for post-combustion CO_2 capture. The author highlighted that monoethanolamine (MEA) is highly effective for capturing CO_2 due to its fast reaction kinetics. The study also pointed out challenges such as high energy consumption during solvent regeneration and degradation of amines over time. 2.2 Aaron, D. & Tsouris, C. (2005) Separation of CO_2 from Flue Gas: A Review. This review paper analyzes various CO_2 capture technologies, including absorption, adsorption, and membrane separation. The authors found that chemical absorption using packed towers is the most mature and widely used technology. It provides high removal efficiency but requires optimization to reduce operational costs. 2.3 Kohl, A. & Nielsen, R. (1997) Gas Purification. This book explains the principles of gas absorption and purification processes. The authoemphasized the importance of packed absorpt.

3.2 Diagram Explanation

A carbon capture absorption tower is a tall column in carbon capture technology where CO2 from industrial flue gas chemically reacts with a liquid solvent (like an amine P. DR. V. V. P POLYTECHNIC, LONI 5 CARBON CAPTURE ABSORPTION TOWER solution) to remove it, with gas flowing up and solvent flowing down counter-current, resulting in purified gas exiting the top and a CO2-rich solvent exiting the bottom for regeneration in a separate stripper tower, a process crucial for reducing greenhouse gas emissions.

The working principle is based on gas–liquid absorption, where CO_2 from a gas phase is transferred into a liquid solvent.CO_2-rich gas flows upwardLiquid solvent flows downwardCO_2 gets absorbed into the liquid due to concentration difference (mass transfer).

A typical tower consists of:Column (vertical tower) – cylindrical structurePacking material / trays – increases contact area between gas and liquidGas inlet (bottom) – flue gas entersLiquid inlet (top) – solvent entersGas outlet (top) – cleaned gas exitsLiquid outlet (bottom) – CO_2-rich solvent leaves.

4.2 METHODOLOGY

The methodology adopted for this project involves a systematic approach to study, design, and analyze the performance of a carbon capture system using an absorption tower. The following steps were carried out during the project work: The methodology adopted for this project involves a systematic approach to study, design, and analyze the performance of a carbon capture system using an absorption tower. Initially, the basic concepts of gas absorption and mass transfer were studied to understand the fundamental principles involved in carbon capture. Different carbon capture technologies were reviewed, with a focus on post-combustion capture using chemical absorption. Monoethanolamine (MEA) was selected as the solvent due to its high reactivity with carbon dioxide and its widespread industrial application. Further, the design of the absorption tower was carried out by selecting a packed column and determining important parameters such as tower height, diameter, and type of packing material like Raschig rings. The system components, including the absorption column, pump, storage tank, gas inlet, and outlet, were identified and arranged to form a proper process flow. A block diagram and process flow diagram were prepared to represent the working of the system. The study also involved analyzing the absorption process under different operating conditions such as varying gas and liquid flow rates, temperature, and solvent concentration. Data was collected and tabulated, and graphs were plotted to understand the relationship between different parameters and absorption efficiency. Design calculations were performed using mass transfer equations to estimate the rate of absorption and efficiency of the system. Finally, the results were evaluated by comparing theoretical and observed values, and the performance of the absorption tower was analyzed. The entire work was documented in the form of a structured project report including diagrams, calculations, graphs, and tables.

4.3 REFERENCES .

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