CO_2 Capture from Flue Gas by Amine Absorption; using HYSYS

A Technical and Economical Analysis

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Submitted by

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In the name of Allah, The most Gracious, most Compassionate".

Our Lord! Grant us good in this world and good in the life to come and keep us safe from the torment of the Fire. (2:201)

Dedication

Dedicated to,

My dearest family; Respected parents, wife and kids

(Abdullah, Hamna & Saad)

Contents

Abbreviations

IGCC: Integrated Gas fired Combined Cycle

ASU: Air Separation Unit

PSA: Pressure Swing Adsorption

TSA: Temperature Swing Adsorption

ESA: Electrical Swing Adsorption

MEA: Mono Ethanol Amine

DEA: Di-Ethanol Amine

MDEA: Methyl Di- Ethanol Amine

HETP: Height of Equivalent Theoretical Plate

HTU: Height of Transfer Units

PFD: Process Flow Diagram

BIP: Binary Interaction Parameters

PC: Pulverized Coal

NGCC: Natural Gas fired Combined Cycle

SOFC: Solid Oxide Fuel Cells

MMSCFD: Million Standard Cubic Feet per Day

MSCF: Metric Standard Cubic Feet

TCI: Total Capital Investment

LMTD: Log Mean Temperature Difference

PEC: Purchase Equipment Cost

FCI: Fixed Capital Investment

WCI: Working Capital Investment

GCC: Gas Capturing Cost

MJ: Mega Joule

KW: Kilo Watt

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Abstract:

Global warming due to the emission of greenhouse gases from different sources; mainly from industrial sector is a severe environmental issue in this modern world. CO_2 is the main constituent of greenhouse gases emitted from industries and playing a significant part in raising the atmospheric temperature. In developing countries emissions are expected to grow rapidly in next 15 years and surpass emissions of industrialized countries near 2018. Power plants are considered to be the major source for CO_2 emission. In addition to power plants, industrial sources like cement plants, oil refineries, iron and steel plants, ammonia & hydrogen production plants, and natural gas processing facilities are also being considered for application of CO_2 capture technologies. Active research work is being carried out and efforts are being made to establish and optimize the processes to capture CO_2 from flue gas.

Presently; amine absorption process has been reported as the most feasible and effective process for CO_2 capture at large scale. By employing this process acid gas can be recovered efficiently with required purity. Choosing the right solvent is important because, the lower temperature for solvent regeneration lowers the energy cost of CO_2 capture. In this research work amine absorption process for removal of CO_2 from flue gas emitted from coal fired plant containing about 13% CO_2 has been simulated and optimized using Amine Package in HYSYS 3.2. Optimization study has been carried out by simulating number of cases by varying pressure of solvent and feed gas. DEA as a solvent has been selected for use in comparison to MEA, since MEA is more corrosive and degradable solvent than DEA.

Economical analysis has also been carried out according to standard methods and procedures described in literature. With CO_2 removal of ≥ 90%, heat consumption is calculated to 3.57 MJ/kg CO_2 removed, close to a literature value of 4.0 MJ/kg CO_2. Calculated value of gas capturing cost is 1.60 $/MSCF or 30.70 $/ton of product. These values are well with in the range as reported in established processes for CO_2 capture and also align with the relevant literature and research work.

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Hafiz Nadeem Ijaz