Removal of Carbon dioxide from flue gas by absorption in MEA solution

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Abstract :

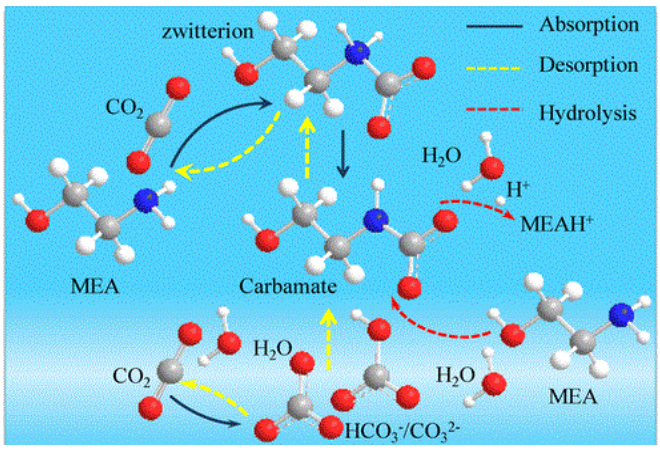
Global climate change has become a major concern today. One of the key aspects of climate stabilisation is control and reduction of carbon dioxide emitted to the atmosphere. Capture of gaseous CO_2 using amines can be one of the most promising methods for atmospheric CO_2 capture .This is done by absorbing carbon dioxide from flue gas in an aqueous solution of Monoethanolamine (MEA). The above described process has been simulated using DWSIM. The Peng-Robinson fluid property package and Nested VLE loop have been used for simulation. Absorption and stripping columns (Chemsep) were used for the absorption of CO_2 from flue gas and recovery of solvent respectively. The flue gas is effectively made free from CO_2 and it can be observed that almost 93.5% absorption is possible by adjusting the flow rates of flue gas and the MEA solvent .

Keywords – Carbondioxide , Climate stabilisation , Monoethanolamine, Absorption.

Introduction :

Global climate change due to global warming and pollution has become a major concern today. Industrial and vehicular emissions are the major sources for releasing carbondioxide into the atmosphere which is the main causative agent for global warming and is also a greenhouse gas. Control of CO_2 emission is possible by scrubbing with a suitable solvent and can prove to one of the potential methods to effectively control greenhouse gas emission.

This method involves absorption of gaseous CO_2 in amine solutions , usually mono-, di-, tri-methanolamines. It is purely based on principles mass transfer operations. The mechanism is as follows:



The advantage of this method is that CO_2 is efficiently removed by absorption and MEA solvent can be recovered by stripping and recycled. The CO_2 absorption in MEA started with the formation of carbamate according to the zwitterion mechanism, followed by the hydration of CO_2 to form HCO_3^-/CO_3^{2-}, and accompanied by the hydrolysis of carbamate. HCO_3^- ions whe heated , release CO_2 and other HCO_3^- reacted with carbamic acid ($MEAH^+$) to form carbamate which then decomposed to form MEA and CO_2.

Methodology :

For the following simulation , **Peng-Robinson equation of state**(property package) and **Nested VLE** (flash algorithm) was used .

1) Feed streams i.e flue gas and MEA solution are created with the following composition :

   Flue gas - CO_2 - 13.26 % , N_2 - 79.8% , SO_2 – 0.94% , Water vapour – 6%
   Temperature - 90 ^oC Pressure - 1.1 bar

   MEA solution - 40% by weight
   Temperature - 23 ^oC Pressure - 1.1 bar

2) The Chemsep absorption column was used with No .of stages = 12 and at a pressure of 1.1 bar.

3) The purified gas free from gaseous CO_2 exits from the top of the absorption column. Almost 93.5% of CO_2 was removed from the flue gas .

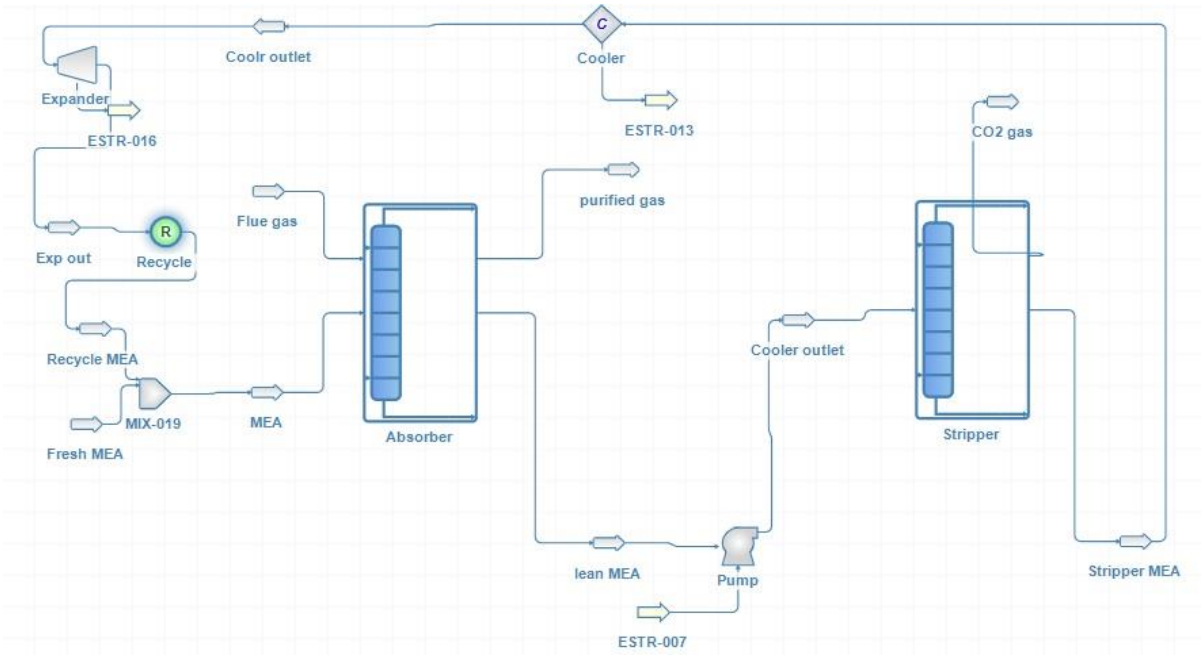
   % Absorption = (outlet / inlet) x 100

   % Absorption = (8.32457 / 8.91047) x 100 = 93.42459 %

4) The lean MEA solution from the bottom of the absorption column was sent at a pressure of 2 bar using a pump into the stripping column for recovery.

5) The stripper is operated at 2 bar with no.of stages = 6 . The stripped MEA solution exits the stripper at a temperature of 124.9 ^oC and 2 bar.

6) This stream is then cooled to 25 ^oC and brought to a pressure of 1.1 bar and recycled through a recycle block to the mixer where it is mixed with the fresh MEA feed and sent into the absorption column. [1]



Results :

The stream conditions for all the inlets and outlets are mentioned in the following table :

Results									
Object	purified gas	lean MEA	Stripper MEA	Recycle MEA	MEA	Fresh MEA	Flue gas	CO2 gas	
Temperature	23.5297	19.6078	124.997	25.0059	23.2001	30	90	122.79	C
Pressure	1.1	1.1	2	1.1	1.1	1.1	1.1	2	bar
Mass Flow	43.033	3523.56	2174.32	2174.32	3521.59	1356.5	45	1349.24	kg/h
Mass Flow (Vapor Phase) / Carbon dioxide	8.32457	0	9.0853E-12	0	0	0	8.91047	0.585904	kg/h
Mass Flow (Liquid Phase 1) / Carbon dioxide	0	0.585904	3.89651E-10	3.98737E-10	2.89012E-17	0	0	0	kg/h
Mass Flow (Liquid Phase 1) / Monoethanolamine	0	1459.46	1315.11	1315.12	1459.5	143.087	0	0	kg/h

Conclusion :

The process of removal of carbondioxide from industrial flue gases using absorption in MEA solution was simulated using DWSIM open source chemical process simulator. An absorber was used to remove CO_2 from flue gas and a stripping column was used to recover the MEA solution and then recycle and reuse for further absorption. The results obtained were very accurate and close to reality. Almost 93.5% absorption of gaseous CO_2 in MEA solution was achieved .

Refernces :

[1] H. M. Kvamsdal, J. P. Jakobsen, and K. A. Hoff, “Dynamic modeling and simulation of a CO2 absorber column for post-combustion CO2 capture,” *Chem. Eng. Process.*, p. 10, 2009.