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Effect of Pre-Combustion and Post-Combustion Sequestration of Carbon Dioxide on Global Warming Potential

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Abstract.From the beginning of the industrial revolution time period, the exhausted gas from burning of fossil fuels and huge clearing of forest has contributed to rise in the level of carbon dioxide (CO_2) in the atmosphere. The earth surface temperature is expected to surge by 1.5degree centigrade as per the intergovernmental panel on climate change in coming decades, if greenhouse gas emissions continue at present rate in the atmosphere. Therefore, upcoming little year climate change and global warming will be challenged in the future. To decrease the growth of greenhouse gases and its consequences, the carbon capture and sequestration (CCS) techniques will we needed. Carbon capture and sequestration is best techniques among others. Present work estimates the impact of pre-and post-combustion sequestration of carbon dioxide (CO_2) on global warming potential. The Objective of study is to compare the pre-and post-combustion CO_2 capture process employing the chemical absorption technology, to estimate the CO_2 capturing efficiency of solvents at various operating condition such as weight concentration of solvents, flow rate of amine solution, height of absorber column and temperature flue gas and effect of pre-and post-combustion CO_2 sequestration on global warming potential. The absorbents used for CO_2 capture by chemical absorption are Monoethanolamine and Diethanolamine. In this work, comprehensive flow sheet model have built for each of the solvents systems, using Chemcad 6.1.3 as the modeling tool.

Key words: Carbon capture and sequestration (CCS), precombustion and postcombustion CO_2 capture, chemical absorption, monoethanolamine, diethanolamine.

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1. Introduction

Carbon dioxide (CO_2) is the main greenhouse gas among all greenhouse gases, but CO_2 is also essential gas for life, human and animal exhale it and plants sequester it [1, 2]. It exists in earth's atmosphere in comparably less concentration. But after industrial revolution started, the demand offossil fuel is increases, due to increases demand of fossil fuel; fossil fuel has lead to rapid increases in CO_2 emission [3, 4]. In atmosphere CO_2 emission is estimated in term of CO_2 concentration, from 1960 to 2018 the CO_2 emission increased from 310 to 407.06 and continuous increases at higher rate [5, 6]. To maintain the concentration of CO_2 and earth surface temperature we need to control the CO_2emission from industry such as coal based power plants because of 42% of CO_2 of total CO_2emission, come from coal based power plants. Therefore, for reduction of CO_2emission we need to capture and store the CO_2 which exhausted from fossil fuel power plants [7-9].Carbon dioxide (CO_2) capture and storage (CCS) is a technology, which through large reduction of CO_2 emission can be achieved within 10-20 years. The global CO_2 emission can be reduced by approximately 70% by 2050, with the help of CCS technology [5, 10].There are mainly three most promising carbon dioxide capture techniques are available such as pre-combustion, post-combustion and oxy-fuel combustion [3-10].There are several methods exist to capture the carbon dioxide from flue gas which exhausted from power plants. Chemical absorption is the most significant carbon dioxide capture methods in amine aqueous solution among other methods. The Monoethanolamine (MEA) aqueous solution is the most common absorbent used in the absorber- stripper CO_2 capture system.Diethanolamoine (DEA) and methyldiethanolamine (MDEA) are also mostly used absorbents after monoethanolamine [11-17]. The motive of this paper is as follows: to comparison study of two different absorbents such as (MEA and DEA) for pre and post-combustion chemical absorption techniques and comprise their carbon dioxide capturing efficiency at various condition by simulation on flow-sheet simulator ChemCad6.1.3 with applies amine model, to study the different operational condition at which carbon dioxide capturing efficiency of absorbents depends, to study the how carbon dioxide capturing efficiency of solvents increases or decreases varies with weight percentage concentration of solvents, flow rate of amine solution, absorber column height and flue gas temperature andto study the effect of precombustion and postcombustion carbon dioxide capture techniques on global warming potential of greenhouses gases.

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Table 1 Column specification data

Parameters	Flow rate of flue gas	Temperature of flue gas	Pressure of flue gas	Flow rate of amine solution	Weight concentration of absorbents	Height of absorber column	Diameter of absorber column	No. of Stages in absorber column
Data range	2095 kmol/h	273 K-333 K	1 bar	100-600 std liter/min	10%-70%	0.1-4.2 m	7.8 m	10

2. The absorption process description

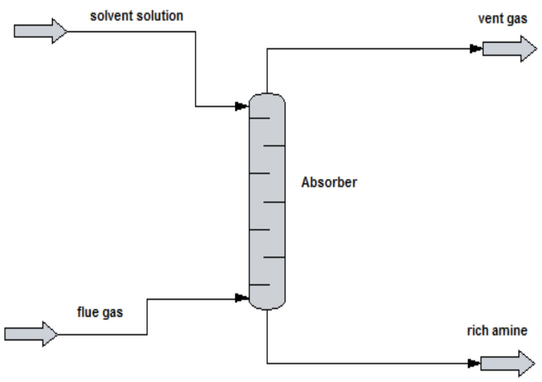

Figure 1 schematic flow diagram of amine absorption process

Figure 1 show the schematic flow diagram of amine absorption process, which include two inlet stream line such as (solvents solution and flue gas) connected with absorber column and two outlet stream product line such as (vent gas and rich amine). The solvents amine solution stream enter in the absorber column with flow rate (100-600 std liter/min) at top of the absorber column whereas flue gas stream enter in the absorber column with flow rate 2095 kmol/hr at bottom of absorber column. In pre-combustion case the composition of flue gas are; 39% CO_2, 58.2% H_2, 2.4% CO, 0.2%N_2 and 0.1% H_2S while for post-combustion case the composition of flue gas are; 10.3072% CO_2, 75% N_2, 10% H_2O and 4% O_2. When amine solution enters at top of absorber and reacts with flue gas which came from bottom of the absorber the exothermic chemical reaction begin started and carbon dioxide is absorber by solvents for both case precombustion and postcombustion carbon dioxide capture techniques. In this research work, the CO_2 capturing efficiency of MEA and DEA for both case are estimated with changes in weight concentration of (MEA & DEA), heights of absorber column, flow rate of amine solution and temperature of flue gas at specific diameter of absorber column.

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3. Results and discussion

The present study has been done to estimate the carbon dioxide capturing efficiency for two different solvents such as monoethanolamine (MEA) and diethanolamine (DEA), at different operating condition such as amine solution flow rate varies from (100 std liter/min) to (600 std liter/min), absorber column height varies from .1 to 3 meter at constant diameter of absorber column (7.8 m), flue gas temperature from (293k to 333k) and weight concentration of absorbents in amine solution from (10 wt% to 70 wt%) for pre-combustion and post-combustion process. In present work the flow rate of flue gas is taken 2095 kmol/hr for both case pre and post at 1 bar absorber column height. In present work the flow sheet model of system is made on ChemCAD 6.1.3. The result of present work is explain with the help of graph between carbon dioxide capturing efficiency on y-axis and (wt% concentration of solvents, flow rate of amine solution, height of absorber column and temperature of flue gas) on x-axis.

3.1. **Effect on CO_2 capturing efficiency of MEA varies in wt% concentration of MEA for both case precombustion and postcombustion CO_2 system at (300 std liter/min amine solution flow rate).**

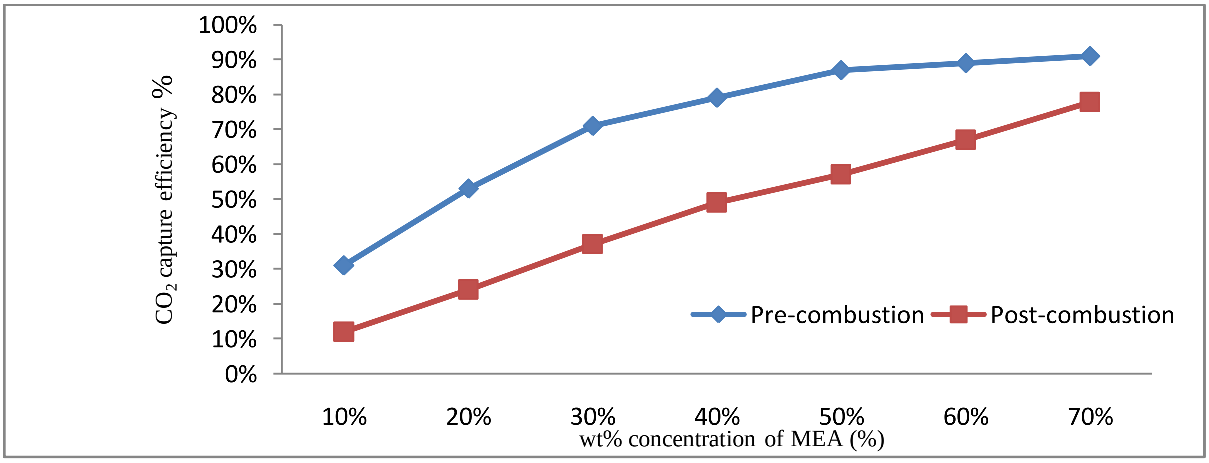

Figure 2 Comparison of CO_2 capturing efficiency of MEA for both caseprecombustion and postcombustion

From figure 2 it can say that the CO_2 capturing efficiency of MEA is continuously increase with varies in wt% concentration of MEA in aqueous amine solution for both cases, due to more concentration of MEA in aqueous amine solution, more MEA molecule react with molecule of CO_2, therefore the more molecule of CO_2 is absorb in MEA solution. From above figure it can see that the CO_2 capturing efficiency of MEA in pre-combustion case is more than post-combustion case, due to the different CO_2 composition in flue gas.

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3.2. Effect on CO_2 capturing efficiency of DEA varies in wt% concentration of DEA for both case precombustion and postcombustion CO_2 system at (300 std liter/min amine solution flow rate).

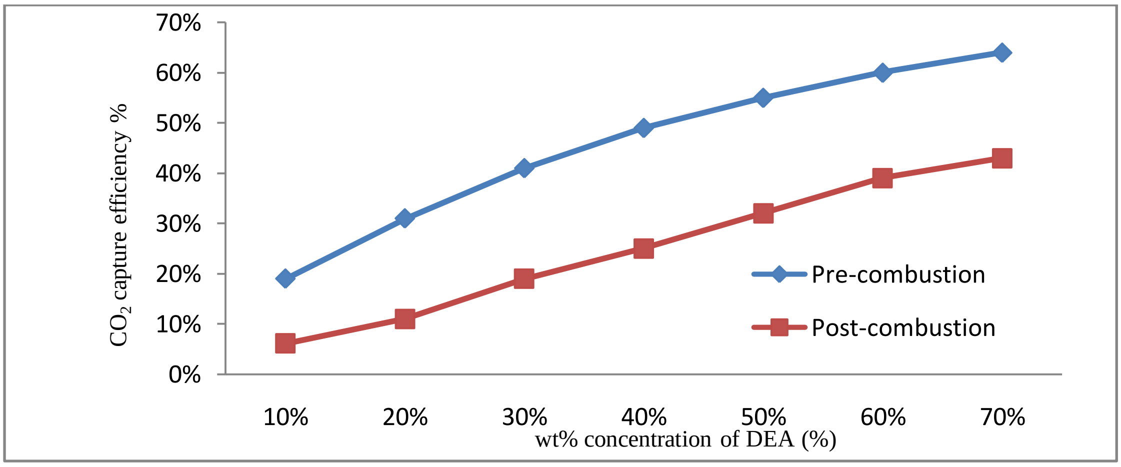

Figure 3 Comparison of CO_2 capturing efficiency of DEA for both case precombustion and postcombustion system

From figure 3 it can say that the CO_2 capturing efficiency of DEA is continuously increase with varies in wt% concentration of DEA in aqueous amine solution for both cases, due to more concentration of DEA in aqueous amine solution, more DEA molecule react with molecule of CO_2, therefore the more molecule of CO_2 is absorb in DEA solution. From above figure it can see that the CO_2 capturing efficiency of DEA in pre-combustion case is more than post-combustion case, due to the different CO_2 composition in flue gas.

3.3. Effect on CO_2 capturing efficiency of MEA varies in flow rate of amine solution from (100-600 std liter/min) for both cases precombustion and postcombustion CO_2 system at (30 wt%concentration of MEA)

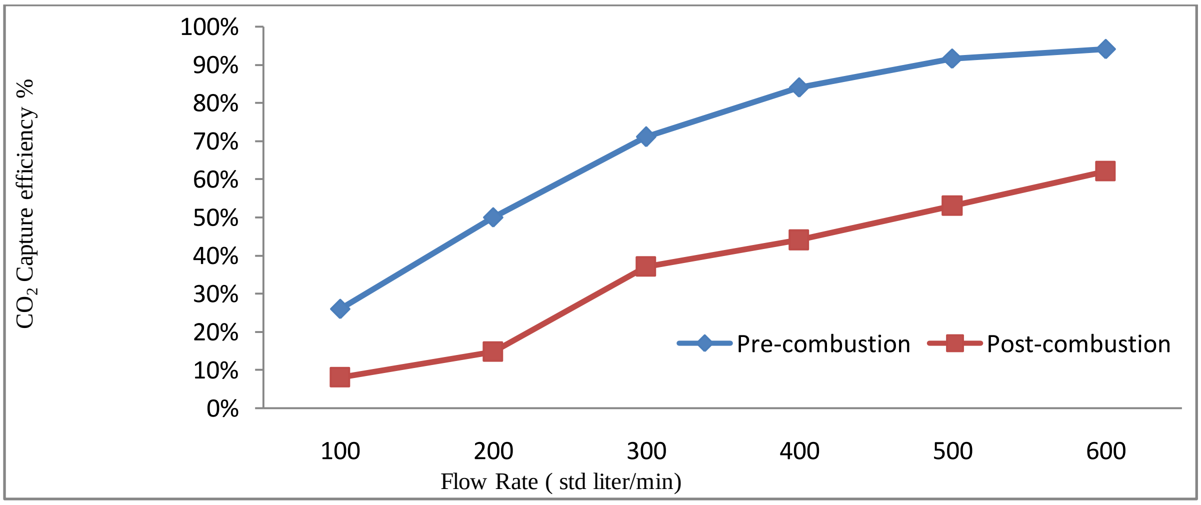

Figure 4 Comparison of CO_2 capturing efficiency of MEA for both case precombustion and postcombustion system

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Figure 4 show the carbon dioxide capturing efficiency of MEA is continuously increases with increases in flow rate of amine solution in absorber column for both cases, because of chemical reaction rate between CO_2 and MEA solution is increase, due to fast rate of chemical reaction between CO_2 molecule and MEA molecule, more CO_2 is absorb in MEA solution. From figure 4 it can say that the CO_2 capturing efficiency of MEA in pre-combustion case is more than post-combustion system.

3.4. Effect on CO_2 capturing efficiency of DEA varies in flow rate of amine solution from (100-600 std liter/min) for both cases precombustion and postcombustion CO_2 system at (30 wt%concentration of DEA)

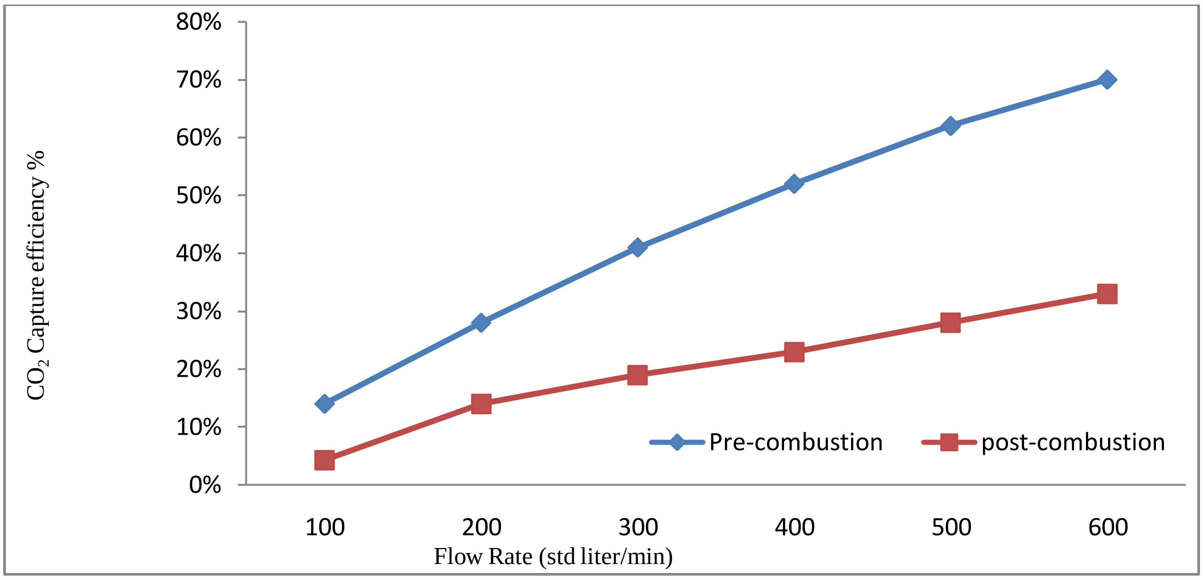

Figure 5 Comparison of CO_2 capturing efficiency of DEA for both case precombustion and postcombustion system

From figure 5 it can say that the carbon dioxide capturing efficiency of DEA is continuously increases with increases in flow rate of amine solution in absorber column for both cases, because of chemical reaction rate between CO_2 and DEA solution is increase, due to fast rate of chemical reaction between CO_2 molecule and DEA molecule, more CO_2 is absorb in DEA solution. From figure 5 it can say that the CO_2 capturing efficiency of DEA in pre-combustion case is more than post-combustion case.

3.5 Effect on CO_2 capturing efficiency of MEA varies in height of absorber column from (0.2m- 2m) at 30 wt% concentration of MEA, 300 std liter/min flow rate of amine solution for both cases

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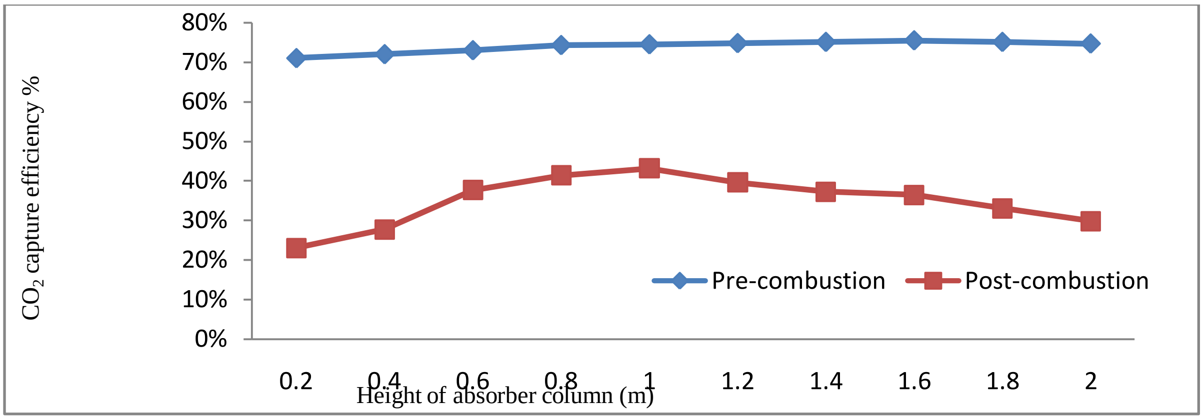

Figure 6 comparison of CO_2capturing efficiency of MEA for both case precombustion and postcombustion system

Figure 6shows the CO_2 capturing efficiency of MEA is first increases up to 1.6m (pre-combustion case) after that CO_2 capturing efficiency decreases, because of slow chemical reaction rate between CO_2 and MEA molecules, due to slow chemical reaction between CO_2 and MEA molecule, the CO_2 capturing efficiency of MEA is decreases after certain height of absorber column. In case of post-combustion system the CO_2 capturing efficiency of MEA is increases up to 1m height after that it goes to decreases. From figure 6 it can see that the CO_2 capturing efficiency of MEA in pre-combustion case is more than post-combustion case.

3.6 Effect on CO_2 capturing efficiency of DEA varies in height of absorber column from (0.2m- 2m) at 30 wt% concentration of DEA, 300 std liter/min flow rate of amine solution for both cases

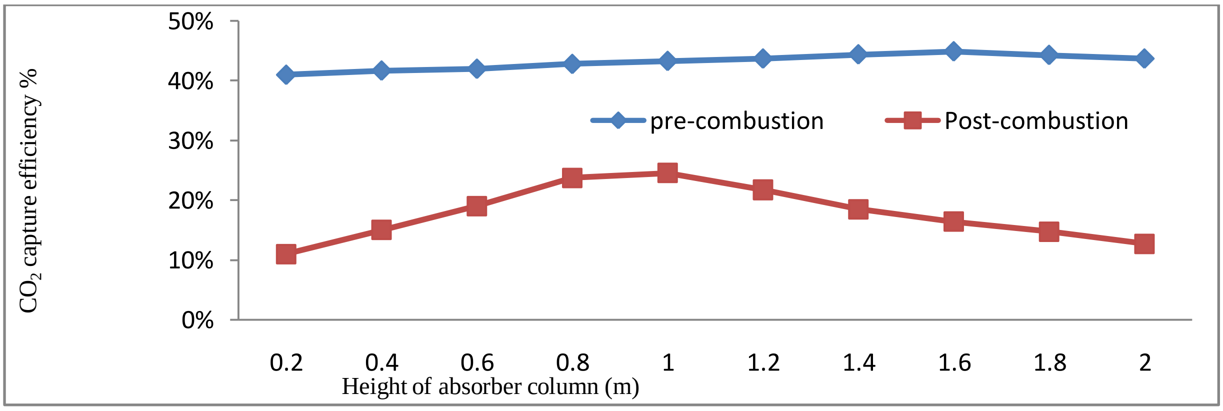

Figure 7 comparison of CO_2 capturing efficiency of DEA for both case precombustion and postcombustion system

Figure 7 shows the CO_2 capturing efficiency of DEA is first increases up to 1.6m (pre-combustion case) after that CO_2 capturing efficiency decreases, because of slow chemical reaction rate between CO_2 and DEA molecules, due to slow chemical reaction between CO_2 and DEA molecule, the CO_2 capturing efficiency of DEA is decreases after certain height of absorber column. In case of post-combustion system the CO_2 capturing efficiency of DEA is

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increases up to 1m height after that it goes to decreases. From figure 7 it can see that the CO_2 capturing efficiency of DEA in pre-combustion case is more than post-combustion case.

3.7 Effect on CO_2 capturing efficiency of MEA varies in temperature of flue gas from (293k-333k) at 200 std liter/min (flow rate of amine solution) and 70 wt% concentration of MEA for both case

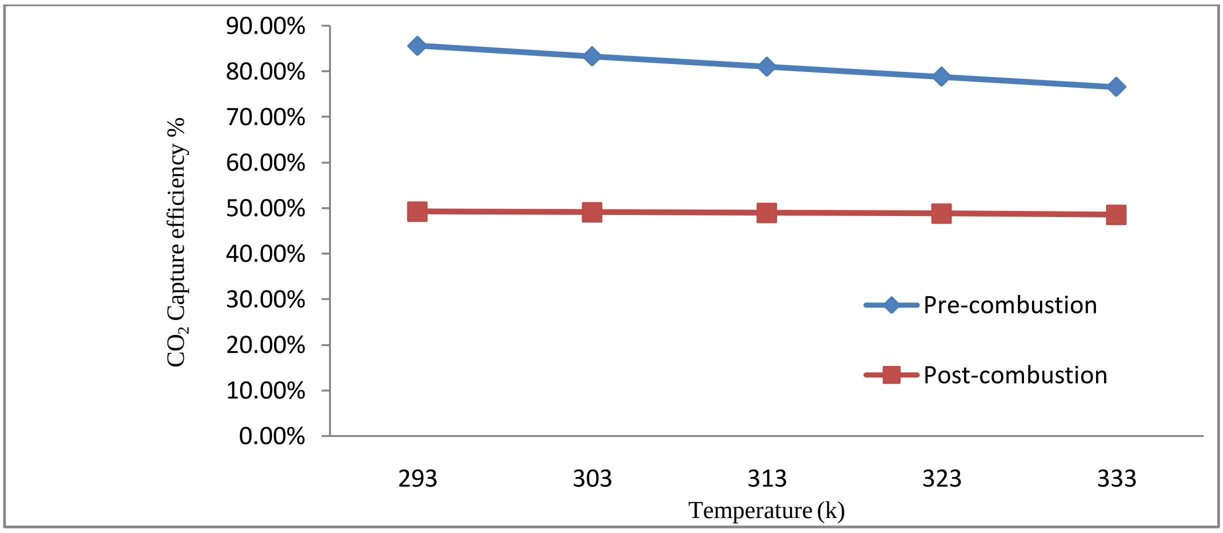

Figure 8 Comparison of CO_2 capturing efficiency of MEA for both cases

Figure 8 shows the CO_2 capturing efficiency of MEA is continuously decreases with increases in temperature of flue gas from 293k – 333k; because of more heat is produce when temperature of flue gas is increases. The produced heat increases the pressure of absorber column, due to more pressure is created inside the absorber column the chemical reaction become slow, because of slow chemical reaction rate the MEA molecules absorb less molecules of CO_2, therefore the CO_2 capturing efficiency of MEA is continuously decreases whenever temperature of flue gas increases. From figure 8 it can say that the CO_2 capturing efficiency of MEA in pre-combustion case is more than post-combustion case.

3.8 Effect on CO_2 capturing efficiency of DEA varies in temperature of flue gas from (293k-333k) at 200 std liter/min (flow rate of amine solution) and 70 wt% concentration of DEA for both case

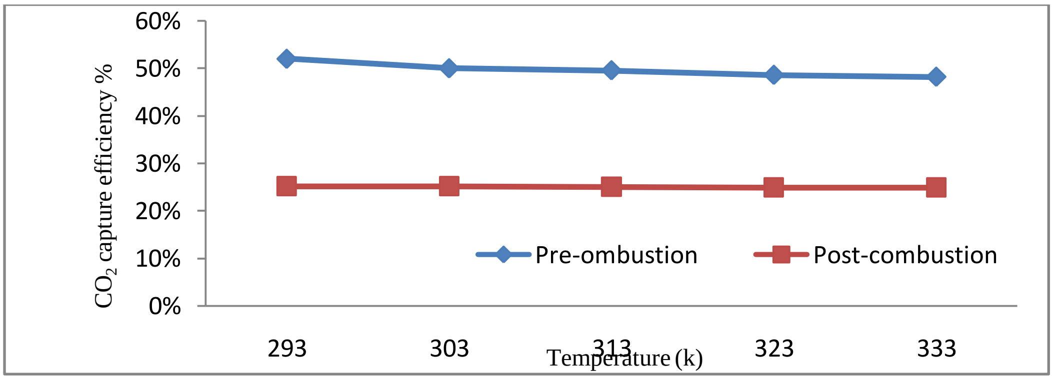

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Figure 9 Comparison of CO_2 capturing efficiency of DEA for both cases

Figure 9 shows the CO_2 capturing efficiency of DEA is continuously decreases with increases in temperature of flue gas from 293k – 333k; because of more heat is produce when temperature of flue gas is increases. The produced heat increases the pressure of absorber column, due to more pressure is created inside the absorber column the chemical reaction become slow, because of slow chemical reaction rate the DEA molecules absorb less molecules of CO_2, therefore the CO_2 capturing efficiency of DEA is continuously decreases whenever temperature of flue gas increases. From figure 9 it can say that the CO_2 capturing efficiency of DEA in pre-combustion case is more than post-combustion case.

Conclusion

In this work a comparative analysis was made between MEA and DEA for precombustion and postcombustion CO_2 capture system by chemical absorption methods simulated on ChemCad 6.1.3 flow-sheet simulator. The operational parameters which affect the CO_2 capturing efficiency of MEA and DEA was studied without recycling the amine solution and wash- water in absorber column. The CO_2 capturing efficiency of MEA is more than DEA in both cases. The carbon dioxide capturing efficiency of solvents in pre-combustion case is more than post-combustion CO_2 capture system. The precombustion and postcombustion CO_2 capture system has major role to maintain the CO_2 emission because of in both case the 90% CO_2capturing efficiency of solvents is achieved due to high CO_2 capturing efficiency, the less CO_2emission is enter in the atmosphere. As we know that the global warming potential of greenhouse gas is depended on equivalent mass of CO_2. Therefore the global warming potential can be maintain to implement the precombustion and postcombustion CO_2 capture technology in new and old existing power plants.

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