Study of Amine Based CO2 Absorption From Natural Gas

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Syed Yawar Ali and Imran Nazir Unar
Department of Chemical Engineering MUET, Jamshoro

Abstract: A model of Absorption process of amine gas sweetening has been developed though Aspen Hysys to evaluate the performance of the absorption. Operating parameters like pressure, temperature, flow is directly impact on the performance of the absorption. The Performance of the absorption has been investigated through various operating parameters. Absorption Column show great performance by increasing the inlet lean Amine temperature. Likewise, operating parameters, absorbing agents obviously influence on the performance of the absorption column. Different combination of amines has been tested through simulation to evaluate the performance of the absorption. Absorption column show great performance when using different mixture of amines.

Keywords: *Temperature, Pressure, Absorption, MDEA, Simulation, Absorbing Agents*

1. Introduction

Out of other fossil fuels, natural gas is the most useable and lower combustible source of energy. It is a source of fossil fuels which are ironic in hydrocarbons. It has been recognized that natural gas is excellent fuel in 2020 – 2030[1]. At present and even in future, natural gas survives as the most substantial fossil fuel. As, it found in beneath the porous rocks so it might comprehend some contaminations in it for example hydrogen sulphide and carbon dioxide. These substances reason numerous practical difficulties. [2].

23.8% World's Energy Demand is fulfilled by Natural gas in 2010 which is about 7.4% increase from the last year i-e 2009. [13]

The rising requirements of the world for natural gas suggest refining the present practices for production, handling, energy reaping and contamination regulator. Higher Composition CO_2 and H_2S creates difficulties during refining of Raw gas. Acid gases are known to foul around forty percent in reserves [3]. Around thirteen percent of the related gas assets have H_2S over nine percent and about twenty-six percent have more than ten percent CO_2 [4]

Amount of energy required to design the gas sweetening process is guarded by value of the treated gas. Amine flow rate and Reboiler duty are the main factor that affects in amine gas sweetening process [7].

Rate base model and Equilibrium stage model are the two main methodologies usually used in the columns modeling. According to Equilibrium based model, both the liquid and vapors leave the column at each stage. On the other hand, rate-based model, examine all the properties i-e tray geometry, heat and mass transfer and concentrations. [9] Different studies had been concluded that Variations in gas purification process to improve the process productivity by enhancing absorption, heat integration. [10]

The temperature of the lean amine pumped at the top of the shower and feed gas at the bottom is used to control the reaction kinetics of the absorber column [11] The columns performance can be increase through numerous feed inlets and side draws. Absorber Intercooling is one of the best methods to improve absorber performance [12] Impurities in the raw gas i-e CO_2 & H_2S must be removed because it reacts with water to form acids & makes corrosion in pipelines [14] Ammonia has been divided into amines which are organic compounds where alkyl radical has been formed by one or more hydrogen atom. Functional group of amines is (–NH2). Absorption of CO2 has been done via two steps. [15]

2. Related Work

Real Process plants has been simulated shown in different examples. Roy in 2012 simulated the Bakhrabad gas processing plant & compared the results with the plant data. Through simulation results the real plant will be modified and the efficiency of plant has been increased. The Amine DEA has been altered from MDEA on North Caroline Plant after presenting the Simulation results [18]

3. Methodology

DEVELOPMENT OF MODEL IN ASPEN HYSYS V-11

The basic information like raw gas composition, pressure, temperature, have been taken from the daily record sheets. Two different compositions wells combine together at inlet of plant & then at inlet of absorber from the bottom. Like that Lean Amine Inlet is shower at the top of the absorber. For this learning, I develop a simulated model and evaluate the performance of absorption column.

EFFECTS OF VARIOUS OPERATING PARAMETERS ON THE OVERALL PERFORMANCE OF THE ABSORPTION SYSTEM VARYING PARAMETERS:

CO_2 bubbles in water at various diameters effects from the variation in pressure and Gas Flow rates has been studied in 1974.He noticed that the volume of bubbles increase with increase in gas flow rate [12] The Essential factor for absorption is selection of amine. At Operating conditions,

Corresponding author Email address*: yawerkarachi425@gmail.com*

the selected amine should have high rate of reactions & there are wide ranges of pressures, temperature and concentration which influence the absorption [16] Variation in temperature is pressure in the lean amine inlet will change the output results of the absorption. Different temperature and pressure show different results in the output

Variation of Temperature

Temperature is a key factor in CO_2 absorption process Important factors like CO_2 capture capacity and flow of lean amine directly depend on temperature of the column. To investigate the effect of absorption column Lean amine pump at following temperature.

1. 140F 2. 150F 3. 160F

Variation of Pressure

Pressure is a key factor in CO_2 absorption process Important factors like CO_2 capture capacity and corrosion rate directly depend on Pressure of the column. To investigate the effect of absorption column Lean amine pump at following temperature.

1. 1122 (LA Inlet) 2. 1124(LA Inlet)

EFFECT OF VARYING ABSORBING AGENTS ON EEFFIECIENY OF ABSORPTION COLOUMN

For achieve required sweet gas specifications, one of the most important variables is amine circulation rate. More CO2 has been picked up from raw gas if increasing solvent circulation and hence attend low concentration of CO2 at the outlet. [10] The Raw Gas Stream usually purified from acid gases through Methyl diethanolamine (MDEA). Very High Circulation rates of MDEA removed COS substantially & carbon dioxide impassive quantitatively [5]. Among all the other amines, the primary amine Monoethanolamine (MEA) is the strongest one. If other chemicals are not present MEA show stability, & at its normal boiling point it does not undergoes show deprivation. When react with H_2S & CO_2 it shows:

$$2(RNH_2) + H_2S \leftrightarrow (RNH_3)_2S$$

$$(RNH_3)_2\,S + H_2S \leftrightarrow 2(RNH_3)HS$$

$$2(RNH_2) + CO_2 \leftrightarrow RNHCOONH_3R$$

35-70% of DGA concentration can be used to make amine solution. As compare to MEA having low circulation rate at this range & showed high absorbing CO_2 by volume [8] Amine based solvents are best likely approaches to remove CO2 in Absorption column. Methyl diethanolamine (MDEA), Diglycolamine (DGA) & Monoethanolamine (MEA) are the favored absorbing agents for this purpose. [17]

For Raw Gas Sweetening, Alkanol amine are the most general and reasonable absorbents used. Multiple number of Amines used for removal of acid gases from the Natural gas. Different amines show different results in the output MDEA Amine is presently use in Gambat South Field as an absorbent. Following different mixtures of amine has been tested to examine the performance of absorption.

S.NO	ABSORBING AGENTS	CONCENTRATIONS
1	MDEA	(50% MDEA + 50% H_2O)
2	MDEA + DEA	(35% MDEA + 5% DEA +60% H_2O)
3	MDEA + DGA	(35% MDEA + 5% DGA +60% H_2O)
4	MDEA + MEA	(35% MDEA + 5% MEA +60% H_2O)

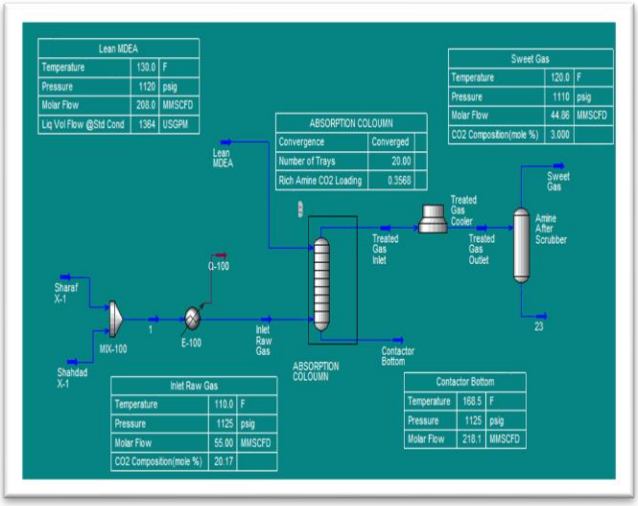
4. Results and Discussion

1	Case-1	At GS GPF-II Current Parameters
2	Case-2	(At 140F LA Temperature)
3	Case-3	(At 150F LA Temperature)
4	Case-4	(At 160F LA Temperature)
5	Case-5	(At 1124 LA Pressure)
7	Case-6	(At 1122 LA Pressure)
9	Case-7	MDEA + MEA
10	Case-8	MDEA + DEA
11	Case-9	MDEA + DGA

Results of Case-1

In this work this model is used as the base model. Current operating parameters of Gambat South Gas Processing Facility has been displayed in this model. Generally, amine circulation rate has been maintained around 1364 USGPM at 55MMSCFD gas at the inlet of Amine Contactor. CO2 has been achieved below 3 mol% as required for sale gas specification at this flow of MDEA. Simulation result & Table 4.1 shows the process parameters.

Parameter	Typical value
Gas Inlet flow rate [MMSCFD]	55
Gas outlet flow rate [MMSCFD]	44.86
CO_2 in gas inlet stream [Avg. Mole%]	20.17
CO_2 in outlet stream [Avg. Mole%]	3.0
Amine circulation rate [GPM]	1364
Absorber column Top/bottom pressure [Psig]	1120/1125
Absorber column Top/bottom Temperature [°F]	130.5/168.5
Number of trays in Amine contactor	20
CO_2 loading [Mole fraction]	0.3568
Lean Amine temperature °F	130

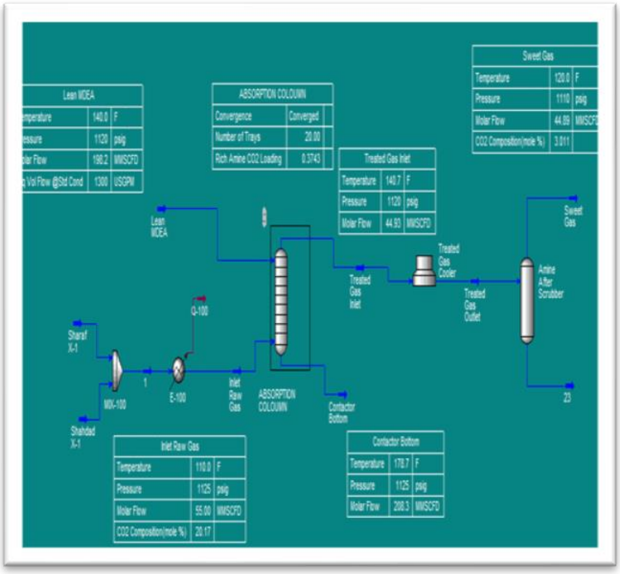


Simulation of Absorption column has been performed by input all the parameters which are actually the current parameters of Gambat South Gas Processing Facility i-e 55mmscfd of Raw Gas which includes 20.17% of CO2.Inlet amine flow at the top is 1364 USGPM. Results Showed that CO2 loading in absorption column is 0.356 and outlet CO2 is 3%. Amine contactor contains 20 Trays & top to bottom pressure and temperature is 1120/1125 and 130/169 respectively.

Results of Case-2

In this model some variations with respect to temperature has been performed. Lean Amine temperature has been variating from 1300F to 1400F to investigate the result. CO2 has been achieved 3 mol% as required for sale gas specification & flow of MDEA has been reduced from 1364 USGPM to 1300 USGPM.

Parameter	Typical value
Gas Inlet flow rate [MMSCFD]	55
Gas outlet flow rate [MMSCFD]	44.89
CO_2 in gas inlet stream [Avg. Mole%]	20.17
CO_2 in outlet stream [Avg. Mole%]	3.01
Amine circulation rate [GPM]	1300
Absorber column Top/bottom pressure [Psig]	1120/1125
Absorber column Top/bottom Temperature [°F]	141.5/178.7
Number of trays in Amine contactor	20
CO_2 loading [Mole fraction]	0.3743
Lean Amine temperature °F	140

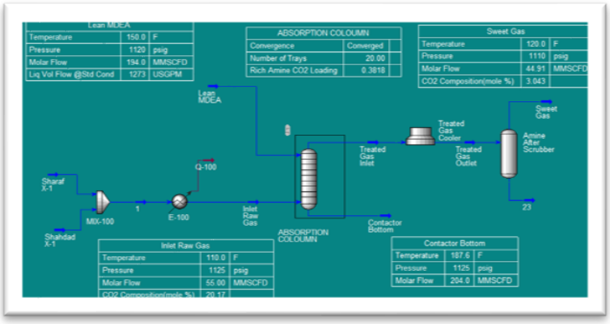


Results of Case-3

In this model some variations with respect to temperature has been performed. Lean Amine temperature has been variating from 1300F to 1500F to investigate the result. CO2 has been achieved 3 mol% as required for sale gas specification & flow of MDEA has been reduced from 1364 USGPM to 1273 USGPM.

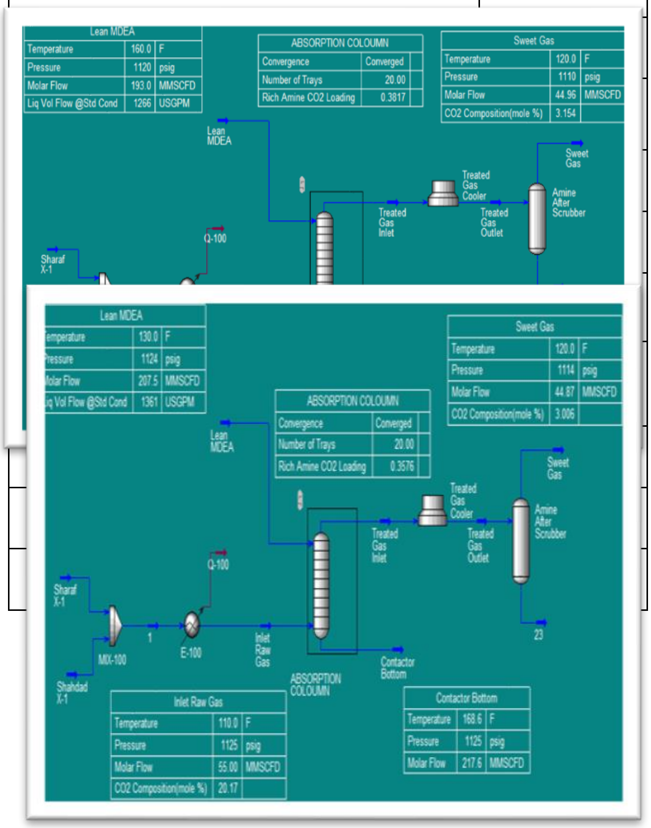
Parameter	Typical value
Gas Inlet flow rate [MMSCFD]	55
Gas outlet flow rate [MMSCFD]	44.91
CO_2 in gas inlet stream [Avg. Mole%]	20.17
CO_2 in outlet stream [Avg. Mole%]	3.043
Amine circulation rate [GPM]	1273
Absorber column Top/bottom pressure [Psig]	1120/1125
Absorber column Top/bottom Temperature [°F]	151.5/187.6
Number of trays in Amine contactor	20
CO_2 loading [Mole fraction]	0.3818
Lean Amine temperature °F	150

Results of Case-4



In this model some variations with respect to temperature has been performed. Lean Amine temperature has been variating from 1300F to 1600F to investigate the result. CO2 has been achieved 3 mol% as required for sale gas specification & flow of MDEA has been reduced from 1364 USGPM to 1266 USGPM.

Parameter	Typical value
Gas Inlet flow rate [MMSCFD]	55



Results of Case-5

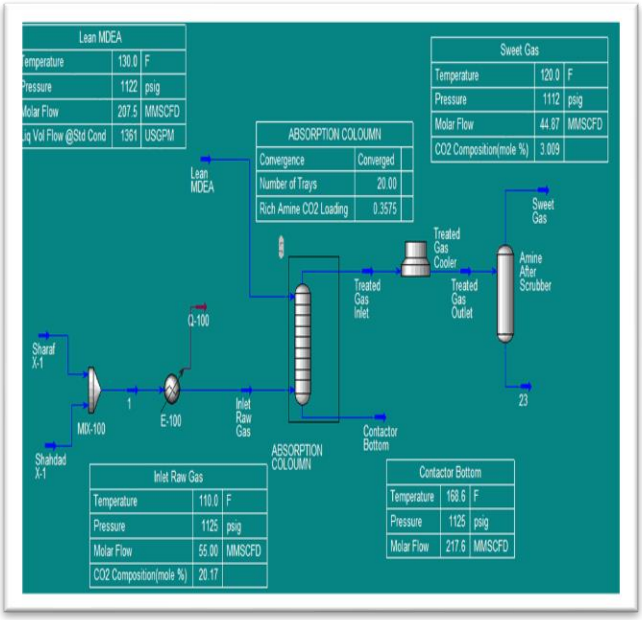
In this model some variations with respect to pressure has been performed. Lean Amine pressure has been variating from 1125 psi to 1124 psi also amine contactor pressure variated to investigate the result. CO2 has been achieved 3 mol% as required for sale gas specification & flow of MDEA has been reduced from 1364 USGPM to 1361 USGPM.

Parameter	Typical value
Gas Inlet flow rate [MMSCFD]	55
Gas outlet flow rate [MMSCFD]	44.87
CO_2 in gas inlet stream [Avg. Mole%]	20.17
CO_2 in outlet stream [Avg. Mole%]	3.0
Amine circulation rate [GPM]	1361
Absorber column Top/bottom pressure [Psig]	1124/ 1125
Absorber column Top/bottom Temperature [°F]	130.5/ 168.5
Number of trays in Amine contactor	20
CO_2 loading [Mole fraction]	0.3576
Lean Amine temperature °F	130

Results of Case-6

In this model some variations with respect to pressure has been performed. Lean Amine pressure has been variating from 1125 psi to 1123 psi also amine contactor pressure variated to investigate the result. CO2 has been achieved 3 mol% as required for sale gas specification & flow of MDEA has been reduced from 1364 USGPM to 1361 USGPM

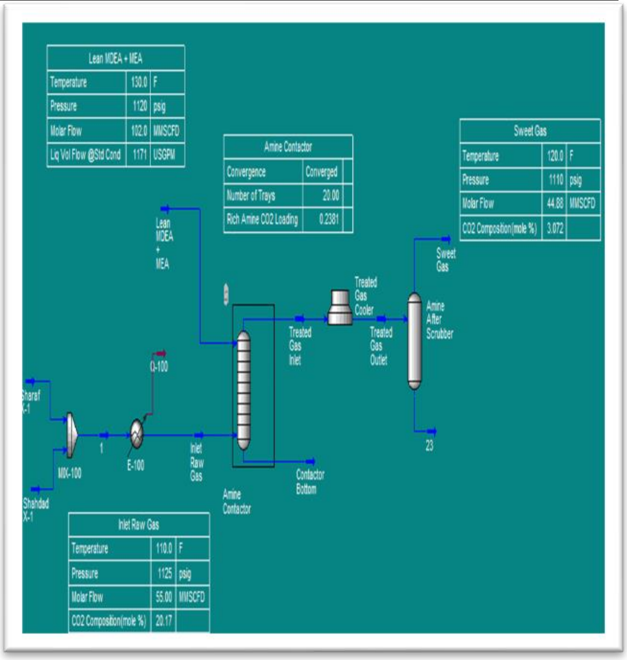
Parameter	Typical value
Gas Inlet flow rate [MMSCFD]	55
Gas outlet flow rate [MMSCFD]	44.87
CO_2 in gas inlet stream [Avg. Mole%]	20.17
CO_2 in outlet stream [Avg. Mole%]	3.0
Amine circulation rate [GPM]	1361
Absorber column Top/bottom pressure [Psig]	1122/1125
Absorber column Top/bottom Temperature [°F]	130.5/168.6
Number of trays in Amine contactor	20
CO_2 loading [Mole fraction]	0.3575
Lean Amine temperature °F	130



Results of Case-9

In this model some variations with respect to absorbing agent has been performed. MDEA with mixture of MEA has been used with same pressure & temperature as in base model to investigate the results. CO_2 has been achieved 3 mol% as required for sale gas specification & flow of MDEA has been reduced from 1364 USGPM to 1171 USGPM.

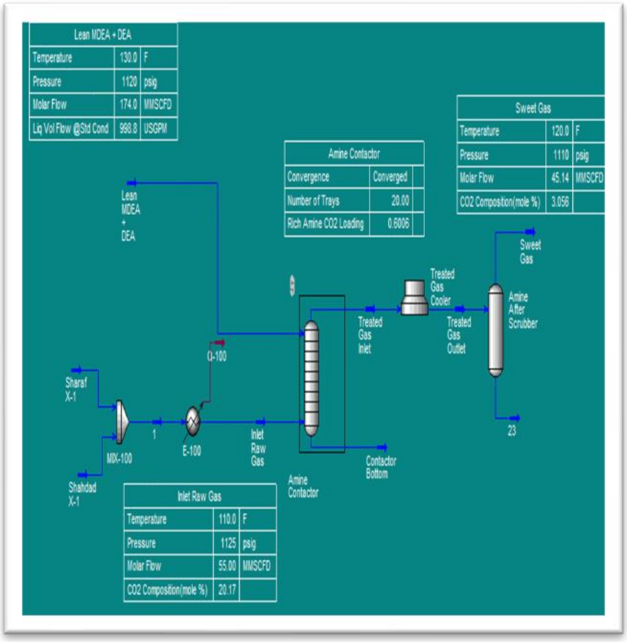
Parameter	Typical value
Gas Inlet flow rate [MMSCFD]	55
Gas outlet flow rate [MMSCFD]	44.88
CO_2 in gas inlet stream [Avg. Mole%]	20.17
CO_2 in outlet stream [Avg. Mole%]	3.0
Amine circulation rate [GPM]	1171
Absorber column Top/bottom pressure [Psig]	1120/1125
Absorber column Top/bottom Temperature [°F]	130.5/168.6
Number of trays in Amine contactor	20
CO_2 loading [Mole fraction]	0.2381
Lean Amine temperature °F	130



Results of Case-10

In this model some variations with respect to absorbing agent has been performed. MDEA with mixture of DEA has been used with same pressure & temperature as in base model to investigate the results. CO_2 has been achieved 3 mol% as required for sale gas specification & flow of MDEA has been reduced from 1364 USGPM to 998.8 USGPM.

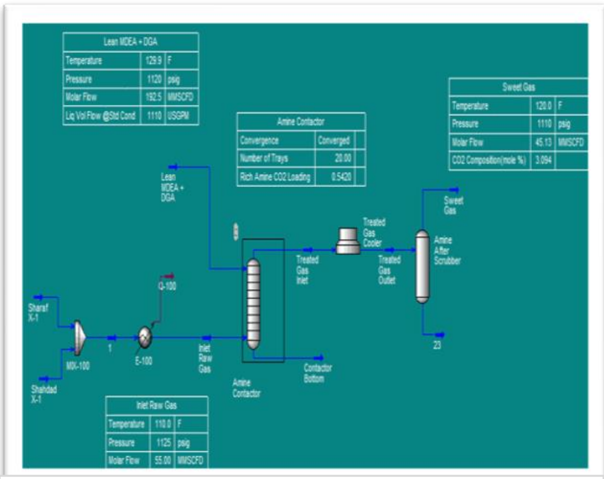
Parameter	Typical value
Gas Inlet flow rate [MMSCFD]	55
Gas outlet flow rate [MMSCFD]	45.14
CO_2 in gas inlet stream [Avg. Mole%]	20.17
CO_2 in outlet stream [Avg. Mole%]	3.0
Amine circulation rate [GPM]	998.8
Absorber column Top/bottom pressure [Psig]	1120/1125
Absorber column Top/bottom Temperature [°F]	130.5/168.6
Number of trays in Amine contactor	20
CO_2 loading [Mole fraction]	0.6006
Lean Amine temperature °F	130

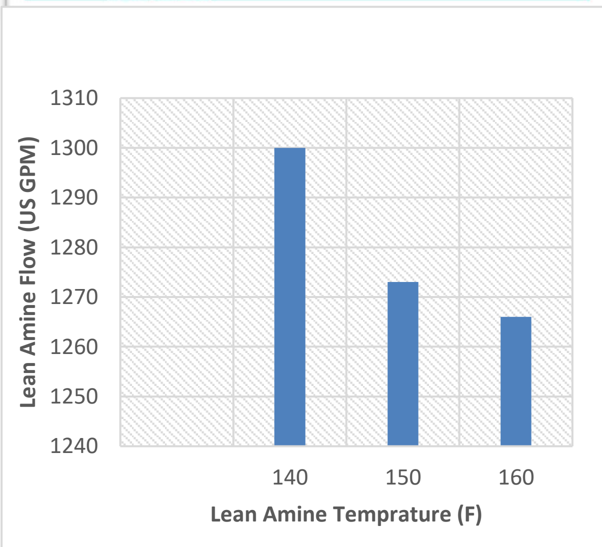


Results of Case-11

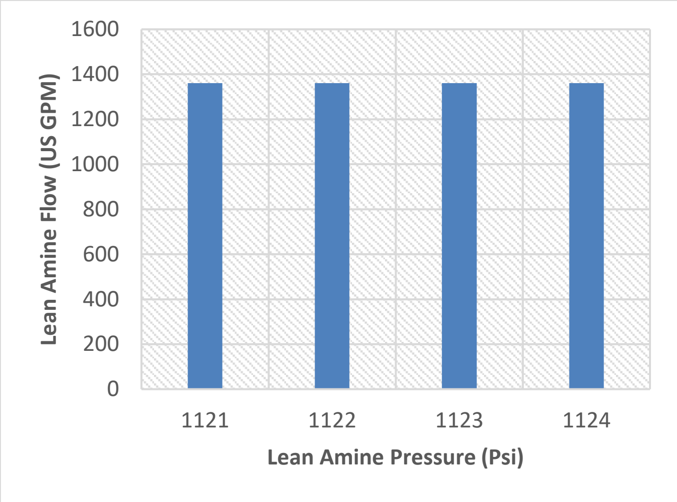
In this model some variations with respect to absorbing agent has been performed. MDEA with mixture of DGA has been used with same pressure & temperature as in base model to investigate the results. CO_2 has been achieved 3 mol% as required for sale gas specification & flow of MDEA has been reduced from 1364 USGPM to 1110 USGPM.

Parameter	Typical value
Gas Inlet flow rate [MMSCFD]	55
Gas outlet flow rate [MMSCFD]	45.13
CO_2 in gas inlet stream [Avg. Mole%]	20.17
CO_2 in outlet stream [Avg. Mole%]	3.0
Amine circulation rate [GPM]	1110
Absorber column Top/bottom pressure [Psig]	1120/1125
Absorber column Top/bottom Temperature [°F]	130.5/168.6
Number of trays in Amine contactor	20
CO_2 loading [Mole fraction]	0.5420
Lean Amine temperature °F	130

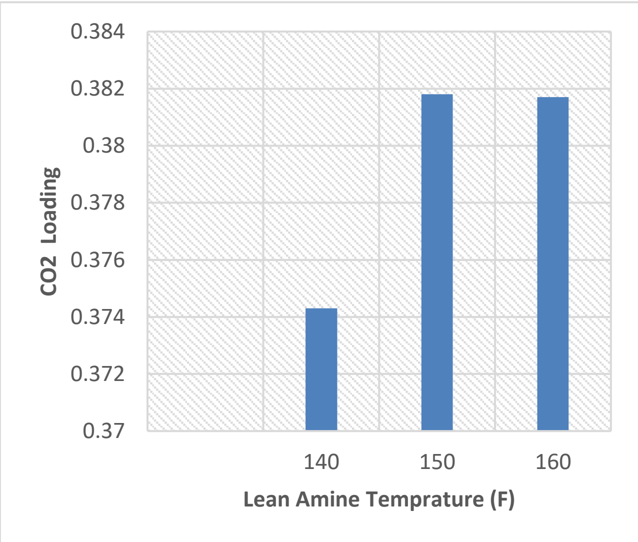


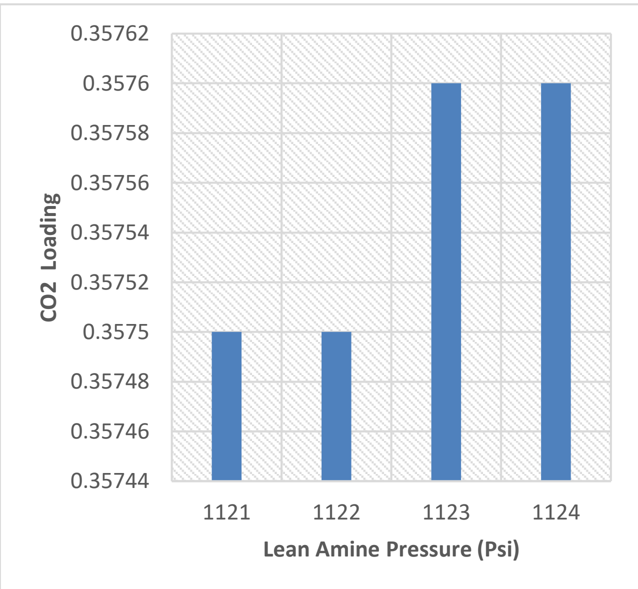


FFECTS OF OPERATING PARAMETERS VARIATIONS

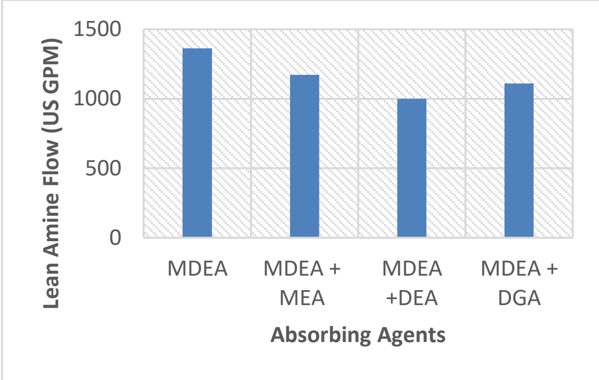


ACID GAS LOADING





EFFECTS OF DIFFERENT SOLVENTS



5. Conclusion

In this paper we study increase the efficiency of the absorption column by varying the inlet parameters and the effect of carbon dioxide loading also investigated by introducing different amines. After successfully accomplishing the first milestone, next phase is to vary the inlet temperature and pressure of the absorption column and their effect on carbon dioxide loading is observed. For attaining the optimum efficiency, it is recommended to decrease the differential between the Lean Amine & Inlet Raw Gas temperature which increase the efficiency of the column and better specification of sweet gas in the outlet

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