

The Effects of Declining Amine Contactor Tower Pressure on Rich Amine Loading: A Case Study and Simulation

¹Mohammed H. S. Zangana, ²Ribwar K. Abdulrahman, ³Khasro Salih Ali and ⁴Immanuel Sebastine

^{1&2} Chemical Engineering Department, Faculty of Engineering, Koya University, Kurdistan Region, Iraq

³North Gas Company (N.G.C.), Kirkuk, Iraq

⁴Center for process innovation, UK

Abstract— Natural gas usually contains several of non-hydrocarbon components for example, hydrogen sulphide, carbon dioxide and water vapor. Moreover, these components are undesirable and cause several technical problems for instance, corrosion and pollution. Indeed, chemical solvent gas sweetening process may be considered the most popular technology to remove acid gases from natural gas stream [1]. However, this process may face several technical problems during its operation for example, amine carry over and pressure dropping in the amine absorber. Therefore, this study aims to simulate gas-sweetening process at North Gas Company (N.G.C.) as a case study using Aspen HYSYS simulator program. The laboratory analysis has shown that the gas at the NGC possesses huge amounts of H₂S (about 2.95%) and CO₂ (about 2.54%). The simulation work has examined the effects of declining amine contactor pressure on the sweetening process performance and rich amine loading. Moreover, the simulation study has been found that when the amine contactor tower declines that will effect acid gases loading in amine solution.

Keywords— Natural gas, sour gas, contactor pressure, amine solution, sweetening simulation, Aspen Hysys, rich amine, process performance and efficiency.

Nomenclature

RMM	Relative Molecular Weight
H ₂ S	Hydrogen sulfide
CO ₂	Carbon dioxide
DEA	Diethanolamine
N.G.C.	North gas company
CR	Circulation rate

Introduction

Natural gas is considered as one of the fastest growing energy sources in the world. It can be used as heating fuel, feedstock in petrochemical plants or as motor fuel [2, 3]. Natural gas is a mixture of hydrocarbon gases with some impurities such as hydrogen sulphide, carbon dioxide and water vapour. Gases containing significant amounts of H₂S or CO₂ or both are called sour or acid gases [4]. Because of the corrosiveness of H₂S and CO₂ in the presence of water and because of the toxicity of H₂S and the lack of heating value of CO₂, these impurities must be reduced from natural gas stream (i.e. sweetened) to meet the gas pipelines specifications [5]. According to Stewart and Arnold [1], gas contracts regulation restrict H₂S content to about 4 ppm and CO₂ about 2% in natural gas stream. Different methods for natural gas sweetening have been developed over the last decades.

Absorption by alkanolamines is one of the most common natural gas sweetening processes as amine gas sweetening process has many advantages over other methods for example, continues process, the ability to regenerate the process solvent. However, any amine process has several operation conditions for instance amine contactor pressure and amine solution concentration [6]. In fact, amine contactor pressure is considered one of the most important amine process operation parameters. Moreover, the dropping of amine absorber pressure could be affected the sweetening process performance. Therefore, the raw natural gas at NGC as a case study will be examined by Aspen HYSYS V. 8.2 software. The operation pressure of amine absorber tower will be examined by changing the value of amine contactor pressure several times.

I. Amine Process at North Gas Company NGC

North Gas Company (NGC) is a state company located a few kilometers south west of the city of Kirkuk, Iraq. The company was founded in 1980 to process most of the associated gases that are produced from the northern oil fields in Iraq. The main products of the company are dry sales gas, LPG, natural gasoline and sulfur. Natural gas processing at NGC involves a number of processes to remove the non hydrocarbon impurities. The sour gas is processed in the gas sweetening unit to remove both the hydrogen sulfide (H₂S) and the carbon dioxide (CO₂). The gas sweetening unit at NGC includes two main sections: the absorption section and the regeneration section as shown in figure (1).

A. Absorption section

In this section the sour gas is routed to a Knock out Drum, where any liquids carry-over is removed. The scrubbed raw gas is fed in the Amine Absorber, where it is contacted counter currently with a 28.55% weight concentration DEA solution for absorption of acid gasses. The absorber contains 33 ballast type trays and one accumulator tray. The gas is treated in the absorber as the following:

- 1- The bulk removal of the acid gas is performed in the bottom section of the absorber by contacting with lean DEA solution at 70°C fed at tray NO. 19.
- 2- The final purification is completed in the middle section with lean DEA solution cooled down at 41°C

in the Amine trim Coolers. The middle section of the absorber is provided with 14 trays.

- The top part of the absorber is provided with a water wash section in order to avoid any amine carry-over that could damage the gas desiccants in the next unit i.e. the dehydration unit. As the treated gas from DEA Absorber is delivered at 44°C and 27.6 Kg/cm² g and proceeds to the Dehydration unit.

B. Regeneration section

The rich amine solution from the rich amine flash drum proceeds to the Rich/Lean exchangers. The acid gases absorbed in the amine solution are stripped from the rich solution in DEA Regenerator by the steam generated in the Amine Re-boilers. The lean DEA is drawn from the bottom of the regenerator and cooled down in the Rich/Lean Exchangers and the lean amine cooler. The cooled lean amine is stored in the DEA surge tank which is sized to hold the total amine inventory. The hot acid gas/steam mixture from the overhead of the Regenerator is cooled in the Condensers, where, simultaneously, water vapor is condensed .the condensed water is separated in the reflux and pumped back to the top section of regenerator. The cooled acid gas is routed directly to the sulfur recovery unit.

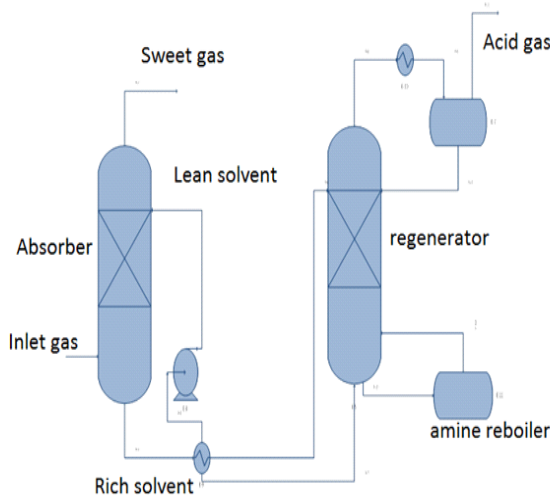


Figure 1: General flow diagram for gas sweetening process by amine solution.

II. NGC gas composition and water content calculations

The north gas company gas stream composition and operating conditions are shown in tables 1 and 2 respectively. The gas composition is based on dry basis. The water content in the natural is important to be calculated before process design or simulation. Natural gas water content can be estimated by adopting the McKetta-Wehe Chart [7]. The water content in

the raw natural gas is about 3000 kg/10⁶ std m³. Table 3 shows the natural gas composition with water content.

Table 1: Given NGC raw natural gas Compositions.

Component	Mole%
H ₂ S	2.95
CO ₂	2.54
CH ₄	71.56
C ₂ H ₆	12.83
C ₃ H ₈	6.48
i-C ₄ H ₁₀	0.83
n- C ₄ H ₁₀	1.61
i-C ₅ H ₁₂	0.51
n-C ₅ H ₁₂	0.46
C ₆₊	0.23
Total	100%

Table 2: Operation conditions (NGC).

North gas company Kirkuk	
Sample No.	Stream 1000
Sample type	Natural gas
Flow rate	6636 MMscf/hr
Pressure	27.5 bar
Temperature C ^o	42
DEA	28.55 wt%
DEA CR	800 m ³ /hr

Table 3: NGC gas compositions and quantities (wet basis).

Comp.	Mole %	RMM	Kmole/ hr	kg/hr	Mole% (Wet)
H ₂ S	2.95	34.076	429.3697	14631.2	2.939021
CO ₂	2.54	44.01	369.6946	16270.26	2.530547
C ₁ H ₄	71.56	16.02	10415.49	166856.2	71.29367
C ₂ H ₆	12.83	30.07	1867.394	56152.55	12.78225
C ₃ H ₈	6.48	44.09	943.1579	41583.83	6.455883
i-C ₄ H ₁₀	0.83	58.123	120.8057	7021.591	0.826911
n- C ₄ H ₁₀	1.61	58.123	234.334	13620.19	1.604008
i-C ₅ H ₁₂	0.51	72.15	74.23002	5355.696	0.508102
n-C ₅ H ₁₂	0.46	72.15	66.95257	4830.628	0.458288
C ₆₊	0.23	86.177	33.47628	2884.886	0.229144
H ₂ O		18	54.37222	978.7	0.372176
TOTAL	100		14609.28	330185.7	100

III. Steady state simulation and optimization

The current NGC amine gas sweetening plant is simulated by using Aspen HYSYS V. 8.2. The DEA is utilized as an aqueous absorbent to absorb acid gases from sour gas stream. The process simulation can be done by providing the HYSYS program by gas stream compositions from Table 3 and choosing amine fluid package as shown in figure 2.

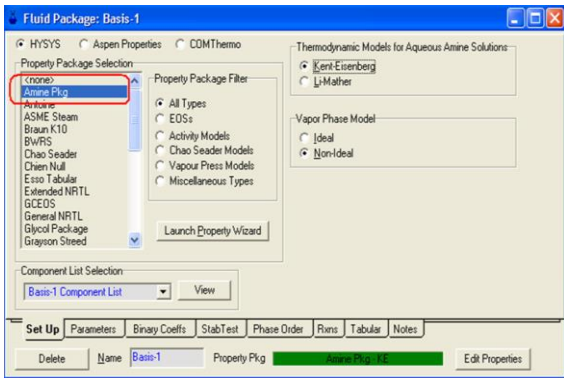


Figure 2: HYSYS fluid package menu.

The installing of inlet gas separator is quite important step [8]. Moreover, this separator is used to remove any undesirable impurities for instance, solid particulates and liquids. Amine contactor is also an important part of the sweetening plant and it also needs some specifications for example, streams temperature and pressure and Figure 3 shows the amine contactor menu. Furthermore, rich amine requires to be regenerated and that could be achieved by installing an amine regenerator after amine heat exchanger [6].

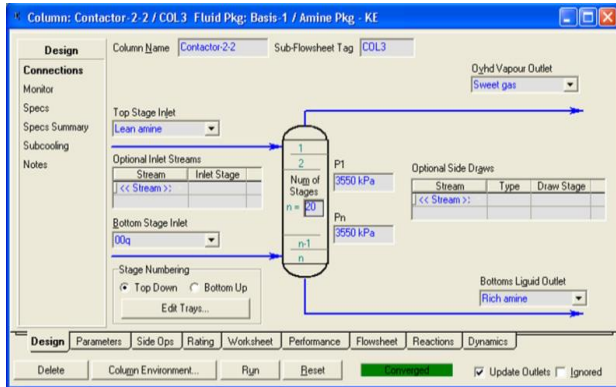


Figure 3: Amine contactor menu.

Figure 4 shows the process flow diagram of NGC gas sweetening plant. Installation of a flash tank for rich amine may be very useful to avoid any technical problems that might be caused by rich amine impurities. In addition, water make up stream should be added with a mixer to the process. Amine concentration may be built up in the process because of water losses with sweet gas [9]. The water make up stream will maintain the concentration of amine solution in the process. The simulation process is done and the process achieved high acid gas removal which will be discussed in results and discussions.

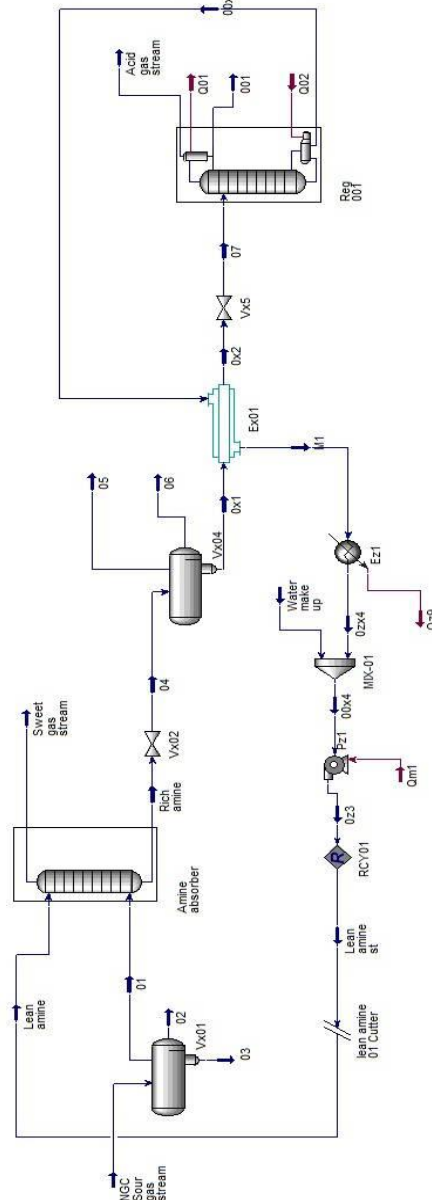


Figure 4: The Sweetening process simulation of NGC.

IV. Result and Discussion

The optimization study has studied several amine contactor operation pressures for example, 8000 Kpa, 5000Kpa and 2000 Kpa. These values have been applied in the HYSYS simulation program and the effects pressure changes have been recorded for each case. Indeed, the declining of absorber pressure could lead to decrease the capacity of contactor unit and will affect the partial pressures of the acid gases and the whole sweetening process efficiency. Rich amine loading results for several assumed operation pressures are recorded and the results can be showed in figure (5):

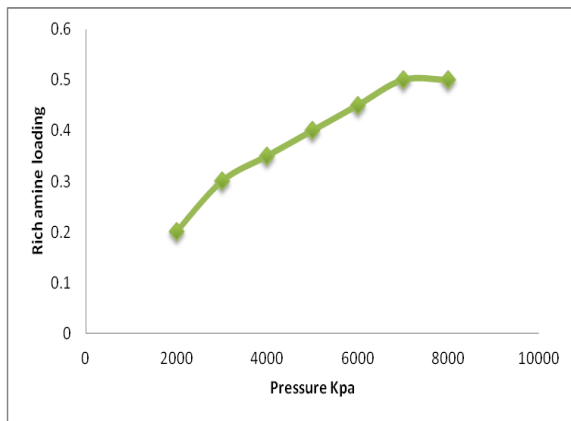


Figure 5: Effect of doping amine contactor tower on DEA sweetening unit.

Figure (5) shows the relationship between the amine contactor tower pressure and the rich amine loading of acid gases such as carbon dioxide and hydrogen sulphide. From above figure, it can be argued that the dropping of the amine contactor tower pressure will affect the whole sweetening process efficiency and performance.

V. Conclusion

In conclusion, this study is attempted to examine the effect of dropping amine contactor tower pressure on the gas sweetening performance and efficiency. Moreover, it is also simulated the gas sweetening process by Aspen HYSYS program. It can argue that the dropping of amine contactor tower pressure due

to any technical problem for example, pipeline leaks and declining the gas stream feed will be directly affected the amine gas sweetening process efficiency and performance as well. Moreover, it will also cause several technical problems for instance, it lead to increase the lean amine circulation rate, decrease rich amine acid gases lodging, increase in energy consumption by process and increase the operation cost. Therefore, the maintaining of maintenance procedure and process troubleshooting at any amine sweetening process are quite important and recommended as well.

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