The studying of amine circulation rate effects on solvent losses from amine sweetening process

A case study and simulation

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***Abstract*— Natural gas may consider the most popular fossil fuel in the current era. In fact, natural gas possess several advantages over the other fossil fuel types for example, it has a high heating value. Moreover, natural gas exists in deep underground reservoirs under certain temperature and pressure. Therefore, it may contain several non-hydrocarbon components such as hydrogen sulphide and carbon dioxide. These undesirable components can cause several technical problems for instance, corrosion and environmental pollution. Therefore, raw sour natural gas that contents considerable amounts of H_2S and CO_2 should be sweetened to reduce or remove the acid gases from the natural gas stream. This being the case, this study is aimed to simulate an amine sweetening process that examine a given natural gas stream. Additionally, the simulation work will examine the effects of amine circulation rate on the solvent losses from the amine contractor tower. Indeed, amine losses from the sweetening process can cause several technical problems for example, environmental pollution, effects the process reboiler duty, increase the corrosion rate in the sweetening process and increase the sweetening plant operation cost. The simulation work has been achieved by ProMax simulator and the study found that the amine circulation rate could possess a relationship with the amount of emitted amine from amine contactor tower.**

Keywords- Gas sweetening, MEA, DEA, Process simulation, ProMax simulator, Process optimization, Amine losses, Energy optimization, Process efficiency.

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 [1, 2]. 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 H_2S or CO_2 or both are called sour or acid gases [3].Because of the corrosiveness of H_2S and CO_2 in the presence of water and because of the toxicity of H_2S and the lack of heating value of CO_2, these impurities must be removed from natural gas stream (i.e. sweetened) to meet the gas pipelines specifications [4]. According to Stewart and Arnold [5], gas contracts regulate H_2S content to about 4 ppm and CO_2 to about 2% in sales gas pipelines. 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. Amine sweetening processes utilize alkanolamine in solution as a chemical solvent to remove acid gases from natural gas. Several types of amine based solvents are available, such as monoethanolamine (MEA), diethanolamine (DEA), triethanolamine (TEA), methyldiethanolamine (MDEA), and diglycolamine (DGA).

1. 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 (H_2S) and the carbon dioxide (CO_2). The gas sweetening unit at NGC includes two main sections: the absorption section and the regeneration section as shown in fig. 1.

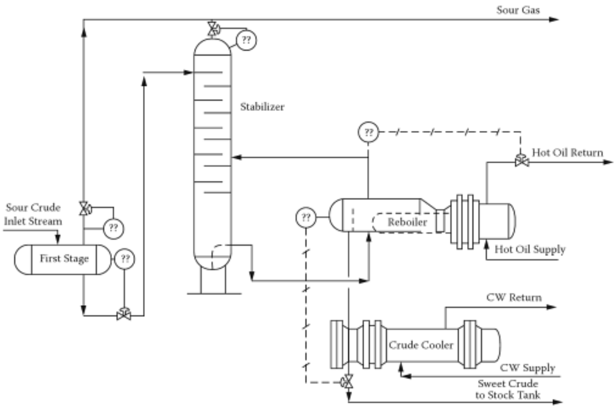

Figure 1: General flow diagram for gas sweetening process by amine solution.

In absorber section the sour gas is routed to a Knock out Drum, where any liquid 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 70ºC fed at tray NO. 19.
2- The final purification is completed in the middle section with lean DEA solution cooled down at 41ºC in the Amine trim Coolers. The middle section of the absorber is provided with 14 trays.
3- 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 44ºC and 27.6 Kg/cm^2 g and proceeds to the Dehydration unit.

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.

2. Given gas case study composition

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. In fact, ProMax simulator has a unique equipments that can estimate the water content in the sour natural.

Table 1: Given NGC raw natural gas Compositions.

Component	Mole%
H_2S	2.95
CO_2	2.54
CH_4	71.56
C_2H_6	12.83
C_3H_8	6.48
i-C_4H_{10}	0.83
n- C_4H_{10}	1.61
i-C_5H_{12}	0.51
n-C_5H_{12}	0.46
C_6+	0.23
Total	100%

Table 2: Operation conditions (NGC).

Given data	
Sample No.	Stream 1000
Sample type	Natural gas
Flow rate (MMSCFD)	334.783
Pressure (bar)	27.5
Temperature (°C)	42
DEA wt%	28.55
DEA CR (m^3/hr)	800

3. Process simulation

The current NGC amine gas sweetening plant is simulated by using ProMax simulator. The DEA is utilized as an aqueous absorbent to absorb acid gases from sour gas stream. The simulation process can be started by choosing the appropriate process package. Indeed, Amine sweetening – PR may consider the most appropriate package for this study. Figure 2 shows the property package menu. The process components for instance, methane, DEA and water can be added by using component menu that also located in simulator environment dialogue box. Figure 3 shows the components menu. The NGC sour gas stream compositions and operating conditions can be obtained from table 2. Figure 4 shows the NGC sour gas menu.

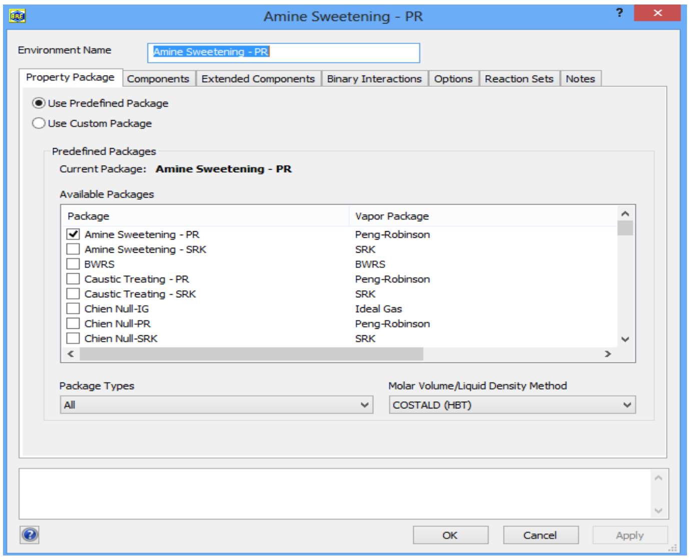

Figure 2: ProMax fluid package menu.

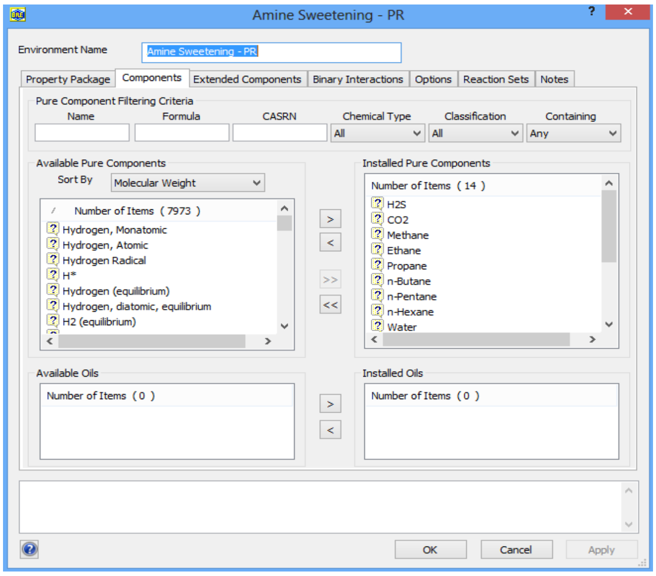

Figure 3: ProMax components menu.

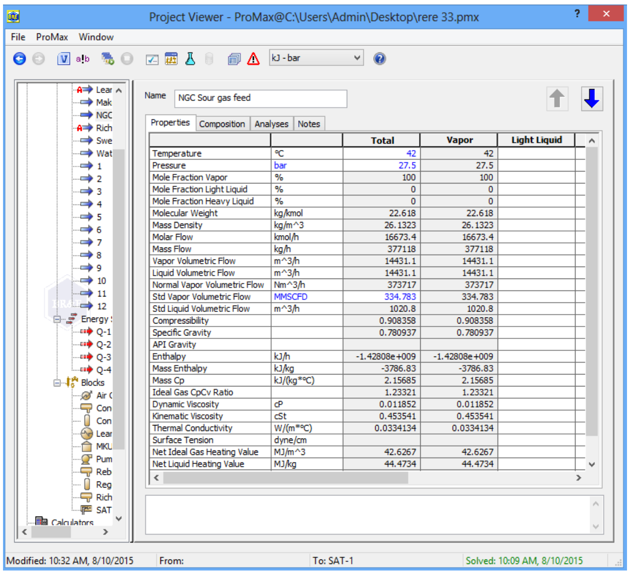

Figure 4: NGC sour gas stream composition and operating conditions.

The installing of inlet sour gas water saturator is quite important step. Indeed, the NGC sour gas stream has been analyzed in dry base. Figure 5 shows the water saturator menu. Amine contactor is also an important part of the sweetening plant and it also needs some specifications for example, streams temperature and pressure and fig. 6 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 [7]. Figure 7 shows the amine regenerator menu.

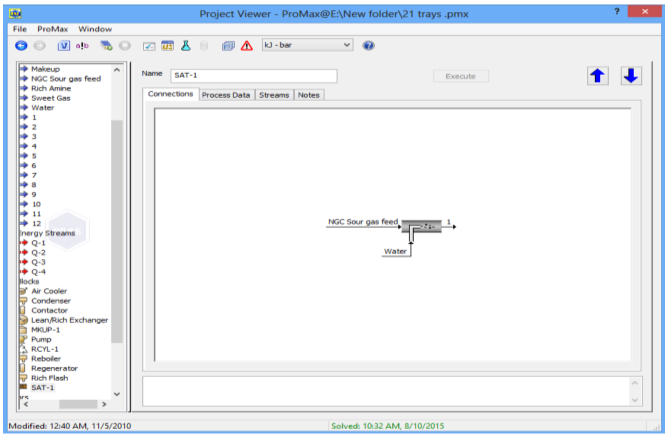

Figure 5: water saturator menu.

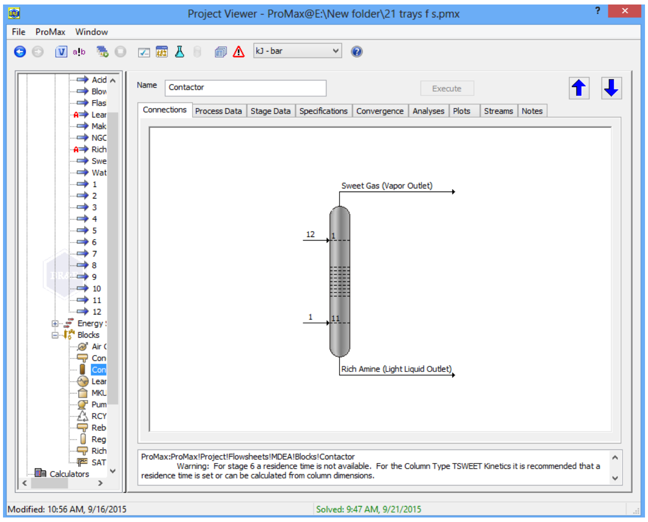

Figure 6: Amine contactor menu

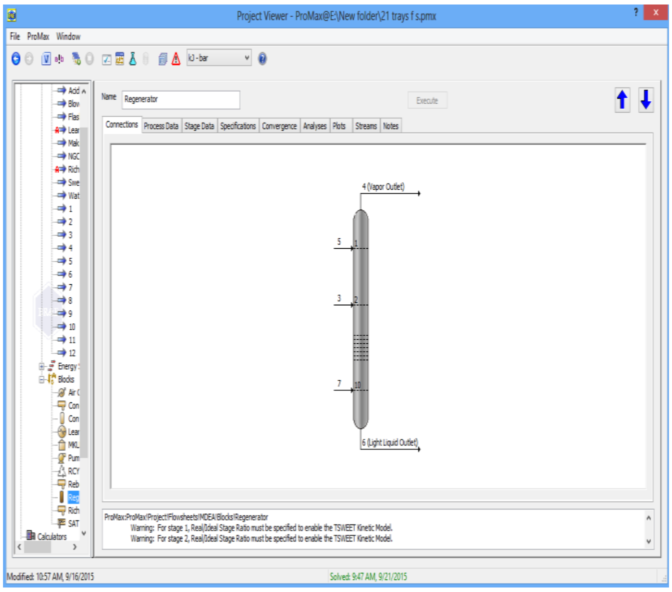

Figure 7: Amine regenerator menu.

Fig. 8 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.

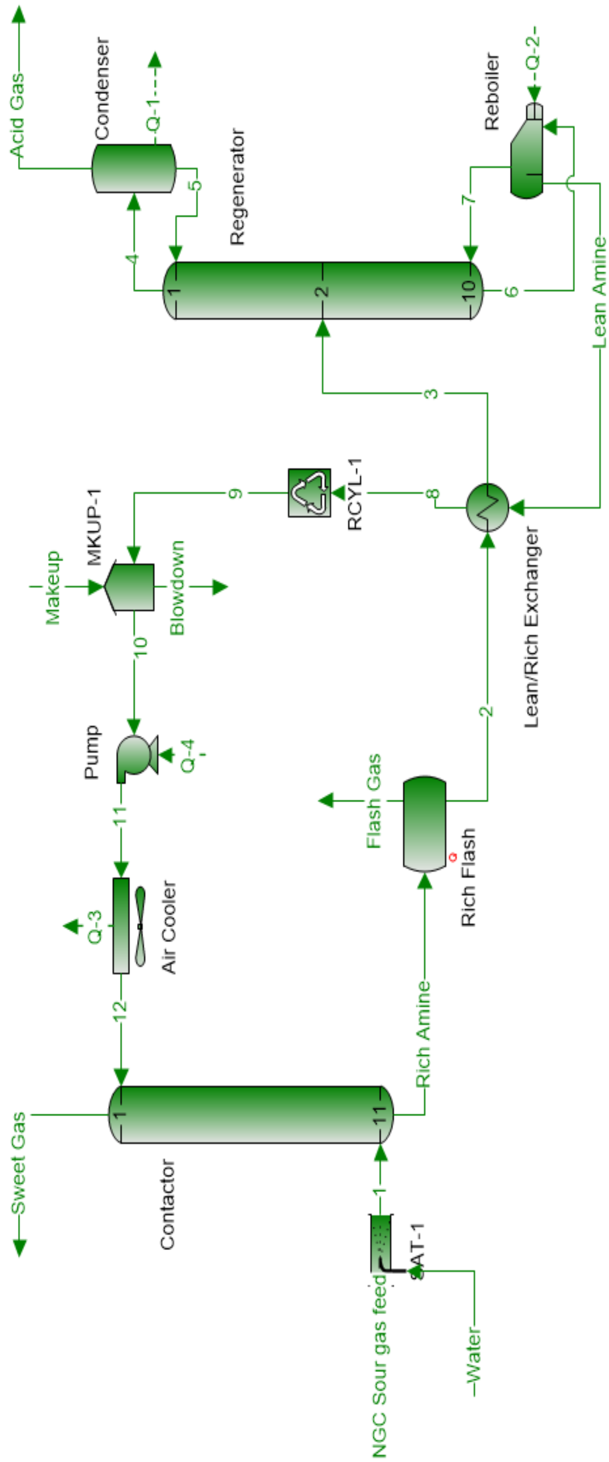

Figure 8: The Sweetening process simulation of NGC.

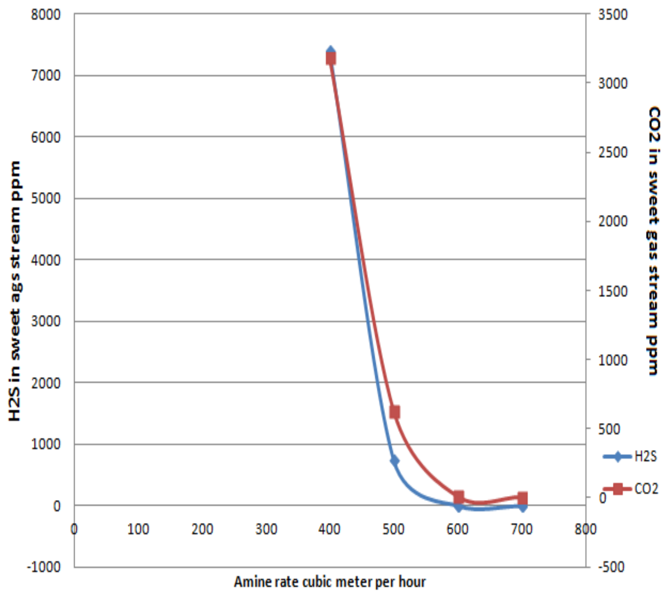

Figure 9: The relationship between 28.55 DEA rate and acid gas PPM in sweet gas stream.

Figure 9 shows the relationship between 28.55 DEA rate and acid gas PPM in sweet gas stream. Indeed, the NGC currently is utilized 800 m^3/ hr of DEA to reduce the acid gases content in natural gas stream and it success in reducing H_2S content to less than 1 ppm. However, the using of MDEA and its blends may achieve more acceptable results at low amine circulation rate.

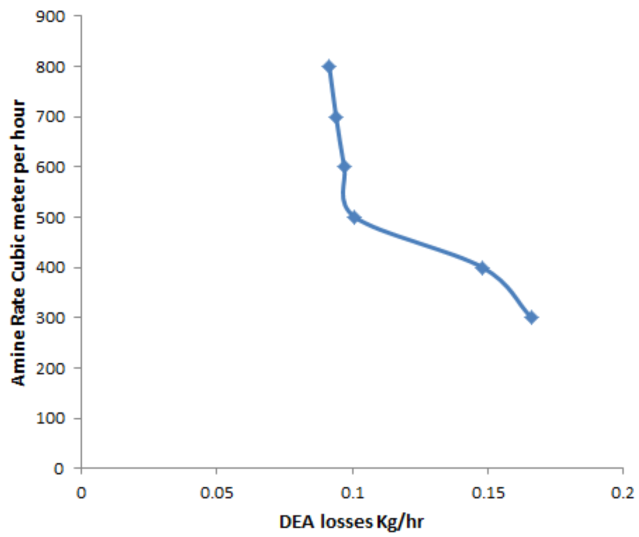

Figure 10: shows the relationship between DEA rate and DEA loses.

Figure 10 shows the relationship between DEA circulation rate and DEA losses from amine contactor tower.

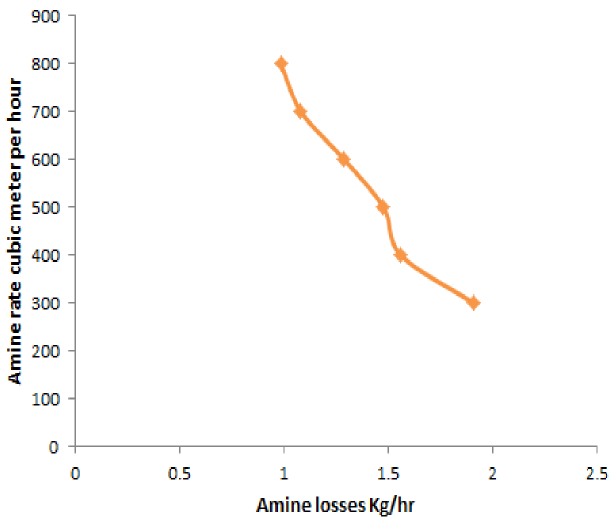

Figure 11: Shows the relationship between MDEA circulation rate and amine losses.

Figure 11 shows the relationship between MDEA circulation rate and amine losses form amine contactor tower. From previous results it seems the amine losses from amine contactor tower are reduced by increasing amine circulation rate.

4. Conclusions

In conclusion, this study is attempted to Kirkuk NGC sweetening plant. Moreover, DEA losses from the amine contactor tower are much lower than in MEA and MDEA system. That due to DEA has relatively low vapor pressure compared with MEA and MDEA for example, DEA vapor pressure is approximately 1/30 MEA vapor pressure. Thus, it is not recommended to use MEA because it has relatively high vapor pressure compared with other amines. It also recommends that to achieve more optimization studies to find out the optimal amine for this process.

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