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THE INFLUENCE OF ACID GAS LOADING ON THE PERFORMANCE OF ACID GAS ENRICHMENT (AGE) ABSORBER COLUMN

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ABSTRACT

The Claus process is used to recover sulfur from acid gases and therefore, reduce environmental pollution. A lean acid gas feed containing a relatively low concentration of hydrogen sulfide lead to an unstable flame in reaction furnace and also deterioration of the catalyst in reactors due to incomplete combustion of hydrocarbons and soot or carbon deposition. Several alternatives are available to overcome this problem. Acid Gas Enrichment (AGE) is one of these methods using Amine solution to selective absorption of H2S and enrichment of acid gas. In this paper, the influence of acid gas loading in lean Amine on the performance of AGE absorber column is investigated. The achieved results shows this factor is a critical factor in the performance of selective absorption and therefore, more caution should be considered in the simulation of amine stripper.

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Keywords: *Sulfur Recovery, Acid Gas Enrichment, Selective Absorption.*

1. INTRODUCTION

Modified Claus is the most conventional process used for conversion of hydrogen sulfide to elemental sulfur. This process consists of a reaction furnace, a waste heat boiler (WHB) and a series of catalytic converters and condensers. The overall reaction of the Claus is [1-5],

$$2H_2S + O_2 \Rightarrow S_2 + 2H_2O \qquad (1)$$

In first stage, one third of the inlet hydrogen sulfide oxidizes to SO2 as below,

$$H_2S + \tfrac{3}{2}O_2 \Rightarrow SO_2 + H_2O \qquad (2)$$

About 60% of the SO2 resulted from reaction (2) reacts with H2S and is converted to elemental sulfur.

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$$2H_2S + SO_2 \Leftrightarrow 3/2 S_2 + 2H_2O \qquad (3)$$

The remained SO2 and H2S react according to relation (3) to produce more elemental sulfur. Although the modified Claus process has remained relatively unaltered since its introduction, further modifications to the basic process have been introduced in order to increase the plant capacity or efficiency. A Claus furnace feed containing a relatively low concentration of H2S may be incapable of producing a stable flame. Also, incomplete combustion of hydrocarbons in the feed can lead to deterioration of the catalyst in the reactors due to soot or carbon deposition. Furthermore, the amount of Carbon disulfide (CS2) which is a byproduct of reaction furnace will be decreased by increasing the furnace temperature. Therefore, the reaction furnace is better to operate at high temperature. During decades several configurations for processing of lean acid gas is presented, including oxygen enrichment of the combustion air, acid gas bypass around the furnace, fuel gas injection, acid gas preheating, acid gas enrichment, etc. [6-8].

Depending on the location of the facility and the quantity of oxygen needed, oxygen enrichment may be an expensive option or not applicable from an operational point of view. Moreover, one consequence of bypassing gas around the burner is that any hydrocarbons in the bypassed gas are not combusted, which may lead to problems in the downstream catalyst beds. Although injection of fuel gas to the reaction furnace will increase the amount of by-products such as COS and CS2 and therefore, decrease of overall sulfur recovery, it can be applied together with acid gas and/or air preheaters to achieve acceptable reaction furnace temperature [8-10].

In spite of advantages of using preheaters, Achievement of appropriate furnace temperature and overall sulfur recovery is difficult when feed stock consist of very lean acid gas. Many natural gas fields contain more CO2 than H2S. When these acid gases are removed from the natural gas to meet the sale gas specifications (normally H2S<3 ppm and CO2< 1 mole%), the resulting acid gas may contains low H2S concentrations (e.g. <20 mol%) making it unsuitable for processing in a conventional Claus unit. An AGE unit enriches the H2S content of the acid gas stream making it practical to recover sulfur in a Claus unit. Figure 1 shows the Schematic diagram of a typical AGE process [9,11,12].

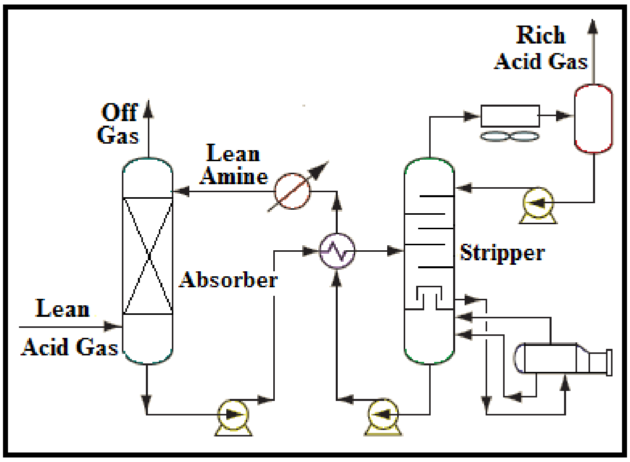

Fig.1. Schematic diagram of a typical Acid Gas Enrichment configuration [10]

As illustrated in Figure 1, lean acid gas stream coming from Amine sweetening unit, enters the bottom of the amine absorber column. Rich Amine is routed to the regenerator column (stripper) in which the absorbed acid gases is stripped from Amine solution and then routed to Claus unit as rich acid gas. Lean amine which contains negligible amounts of H_2S and CO_2 is then recycled to the AGE absorber from the bottom of the stripper. The AGE absorber off gas which includes a negligible amount of H_2S is directed to incinerator where it is burned with fuel gas. In the next section, the absorber column of a typical industrial AGE unit is simulated to investigate the effect of lean Amine acid gas loading on the performance of selective absorption of AGE absorber column.

2. AGE absorber simulation results

In order to investigate the effect of lean Amine acid gas loading on the performance of AGE absorber column, a typical industrial AGE unit is simulated. The specifications of a lean acid gas which is considered as Claus unit feed, is given in table 1. As shown in this table, the major portion of lean acid gas is consisting of CO_2 while the H_2S mass percent is equal with 30% which is not an appropriate value as Claus feedstock.

Table.1. Specifications of the input lean acid gas to AGE process

Property	Value
Temperature	60 °C
Pressure	1.8 bar
mole Flow	15000 kmole/h
Composition (mole%)	
H_2S	20
CO_2	70
H_2O	10

As described before, the rich Amine is routed to regenerator column, where in the absorbed acid gases (i.e. CO_2 and H_2S) are striped and returned to Clause unit. If high concentration of CO_2 was absorbed by AGE absorber, there would be some problems in Claus unit such as increase of the equipment size, decrease of the reaction furnace temperature, etc which result in low sulfur recovery. Therefore, the ideal function of AGE absorber is selective absorption of H_2S.

Among conventional Amine solutions, N-methyl-diethanolamine (MDEA) and Diisopropanolamine (DIPA) can be used for selective absorption of H_2S. In this study MDEA has been selected as the Amine solution as it is more commercial. MDEA solution with flow rate of 15000 kmole/h and temperature of 45 °C is entered from the top of the absorber column. The mole fraction of MDEA and water is equal with 0.06 and 0.94, respectively. In order to investigate the effect of acid gas concentration in lean Amine solution on the performance of AGE absorber, Amine solution with different acid gas loadings have been considered in several simulation cases.

At the first step, the effect of CO_2 concentration in lean Amine solution on the remained H_2S in the AGE off-gas (the top of the absorber column) was investigated. In this case study, the mole fraction of H_2S in lean Amine is supposed to be equal with zero. The achieved results show that the concentration of CO_2 has individually negligible effect on the mole fraction of H_2S in the AGE off-gas, as well absorption of H_2S. However, it seems that the remained CO_2 in lean amine will slightly decrease enrichment of H_2S. At the next step, this study was performed for lean Amine H_2S loading, i.e. the change of H_2S in the AGE off-gas with H_2S concentration of lean Amine solution was investigated. The mole fraction of CO_2 in lean Amine is supposed to be equal with zero, 500 ppm and 1000 ppm, respectively. As illustrated in this figure, the concentration of H_2S in AGE off-gas is increased by increasing the H_2S content of lean Amine. Moreover, the effect of CO_2 presence is more notable at higher ranges of H_2S concentration in lean Amine. However, CO_2 has not a considerable effect on the concentration of H_2S in the AGE off-gas yet. According to figure 2, for the assumed circulation rate of Amine solution, maximum H_2S content in the lean Amine solution must be below 500 ppm to ensure that the remained H_2S in the AGE off-gas is an appropriate value.

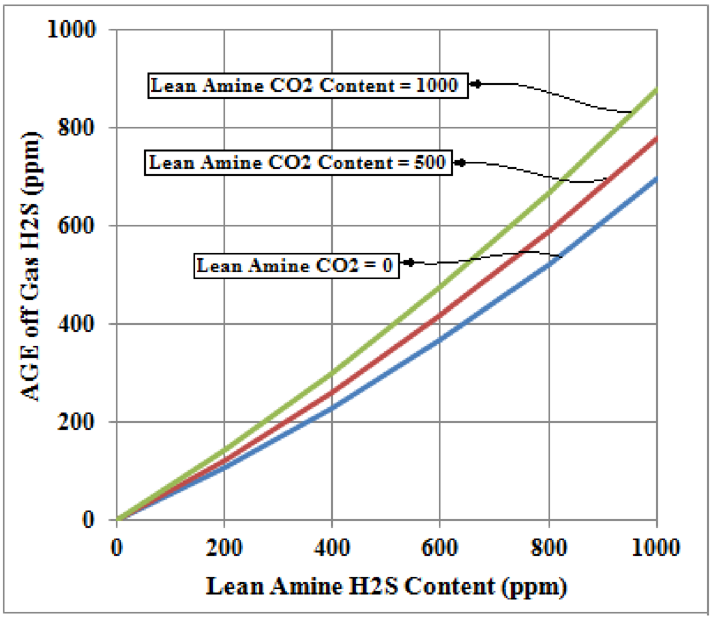

Fig.2.The changes in the H_2S in AGE off gas versus the lean Amine H_2S Concentration.

Figure 3 shows the changes in acid gas content exited from the bottom of the regenerator (stripper) column (H_2S and CO_2 in lean Amine) versus consumed low pressure steam for the Reboiler of stripper column. As is illustrated in this figure, remained CO_2 in the lean Amine is almost constant and equal with 200 ppm. Regarding to the results achieved in the previous paragraph, a steam flow rate equal with about 60 tones/h seems is appropriate in this case study.

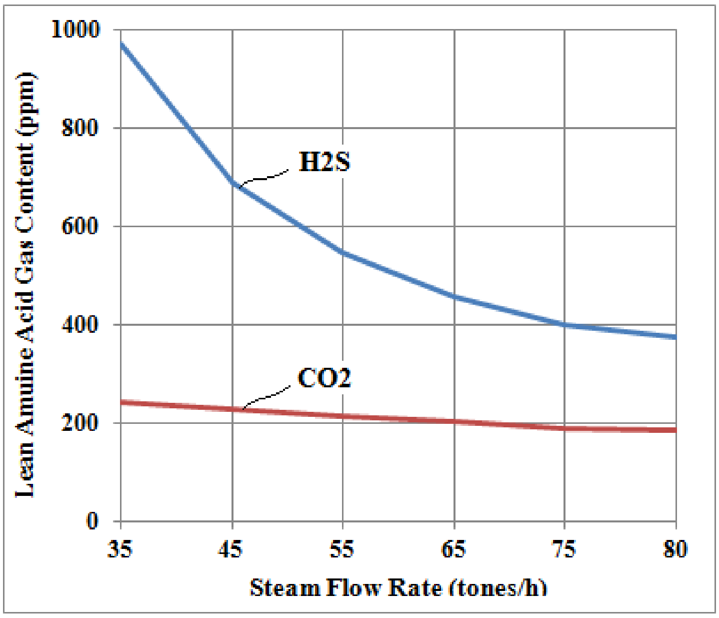

Fig.3. Changes in lean Amine acid gas loading versus MDEA mass percent.

Moreover, figure 4 shows the change of H_2S in the AGE off-gas with flow rate of lean Amine solution. According to this figure, after flow of 14300 kmole/h, the H_2S in the AGE off-gas has a constant value. On the other hand, increasing the amine flow rate will increase the CO2 absorption and hence, the H2S/CO2 ratio in rich amine and H2S enrichment will be decreased (see figure 5). In fact, the flow rate of lean Amine should be increased until the concentration of H_2S in the AGE off-gas has a constant value.

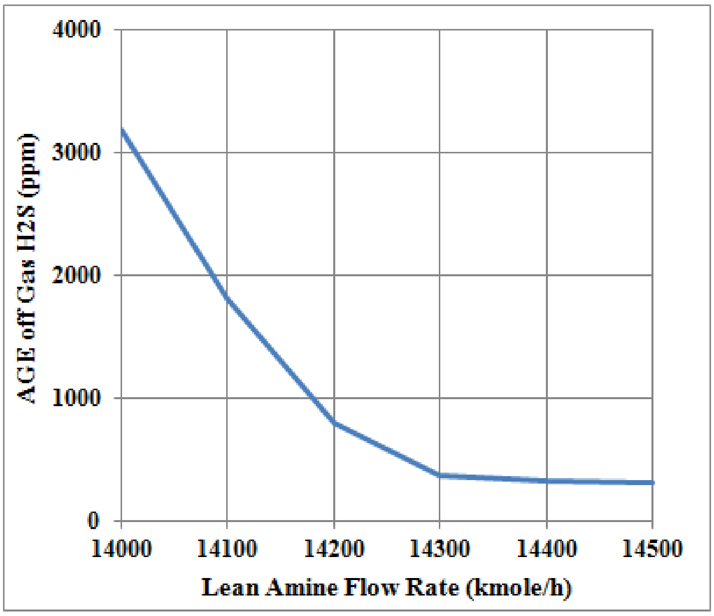

Fig.4. The change of H2S in the AGE off-gas vs. flow rate of lean amine.

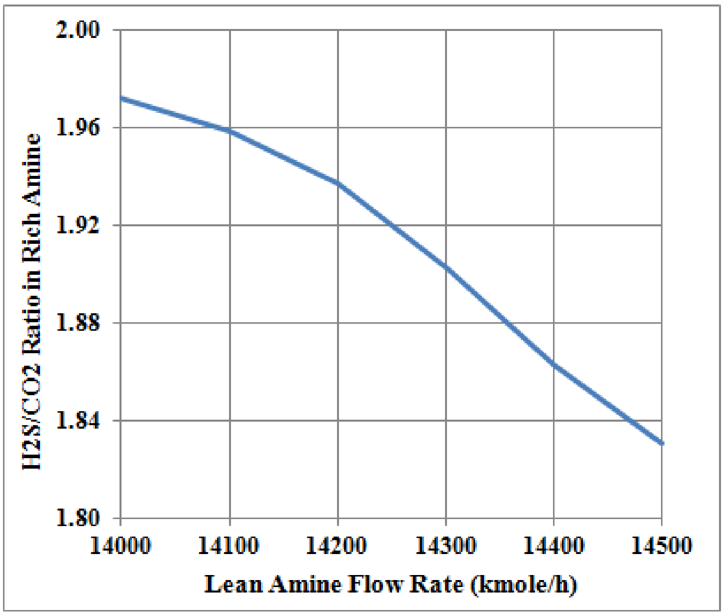

Fig.5. The change of H_2S/CO_2 ratio in lean amine vs. flow rate of lean amine**.**

3. CONCLUSION

The Claus process is used to recover sulfur from acid gases, as well as reduce environmental pollution. A lean acid gas feed containing a relatively low concentration of hydrogen sulfide lead to several operational problems. Several alternatives are available to overcome this problem. Acid Gas Enrichment process is applied to enrich acid gas using selective absorption of H_2S. In this paper, a typical AGE absorber was simulated. The achieved results showed that the effect of H_2S concentration in lean amine on the performance of AGE absorber column is more important than CO_2 concentration. The flow rate of low pressure steam for the reboiler of stripper column should be increased until remained H_2S in the lean solution decreased less than 500 ppm. Moreover, the flow rate of lean Amine should be increased until the concentration of H_2S in the AGE off-gas has a constant value.

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