Petroleum & Coal
ISSN 1337-7027

Available online at www.vurup.sk/petroleum-coal
Petroleum & Coal 57(1) 56-59, 2015

THE EFFECT OF AMINE CONCENTRATION ON THE PERFORMANCE OF TGT ABSORBER COLUMN

Hamid Reza Mahdipoor*, Majid Kakavand

*Department of Process and Equipment Technology Development, Research Institute of Petroleum Industry, Tehran, Iran, *mahdipoor@gmail.com*

Received October 19, 2014, Accepted February 3, 2015

Abstract

Processing of sour oil and gas will usually lead to generation of large volumes of acid gases. To produce sulfur and also prevent environmental pollution, these acid gases shall be converted to sulfur in Sulfur Recovery Units (SRU). The conversion of these pollutant gases to sulfur hardly exceeds 96% causing excessive sulfur dioxide to be sent to atmosphere and hence leading to high pollution around refineries. Tail Gas Treatment (TGT) process can achieve an overall efficiency of more than 99% by eliminating certain portions of the acid gases present at the tail gas of SRU. The absorber column is the most important equipment in TGT unit. The main task of this column is selective absorption of H_2S in presence of CO_2 by means of Amine solutions. In this paper, the absorber column of a typical industrial TGT unit is simulated and then, the effect of the Amine concentration on the performance of TGT absorber will be investigated.

Keywords: Sulfur Recovery; Tail Gas Treatment; Selective Absorption.

1. Introduction

As mentioned earlier, processing of sour oil and gas can lead to generation of large volumes of acid gases which are converted to sulfur in Sulfur Recovery Units (SRU) in order to prevent environmental pollution. 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 process is [1-5],

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

In first stage, one third of the inlet hydrogen sulfide to the reaction furnace oxidizes to SO_2. The main oxidization reaction is as follows,

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

About 60% of the SO_2 resulted from reaction (2) reacts with H_2S and is then converted to elemental sulfur.

$$2H_2S + SO_2 \Leftrightarrow \tfrac{3}{2}S_2 + 2H_2O \quad (3)$$

In second stage which is catalytic, the un-reacted SO_2 and H_2S react according to relation (3) and are converted to water and elemental sulfur. The overall recovery of Claus process hardly exceeds 96% which leads to excessive sulfur dioxide sent to the atmosphere and accordingly high pollution around refineries. To increase the total recovery of sulfur and decrease the environmental pollutants, Tail Gas Treatment (TGT) unit is incorporated before incinerator of SRU. In this unit, the Clause tail gas will be processed to recover as much of its sulfur content as possible. Among several processes used for treatment of tail gases, absorption processes with amine solvent (e.g. SCOT process) is more common and have been industrialized in more places. Figure 1 shows the Schematic diagram of a typical SCOT process [6-12].

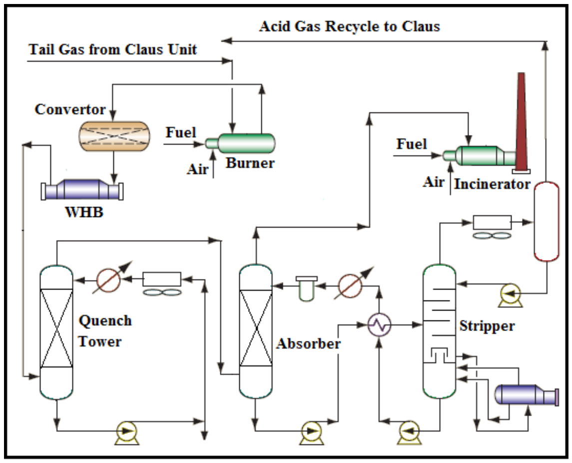

Figure1 Schematic diagram of a typical SCOT process

SCOT process was first developed by Shell to improve the efficiency of sulfur recovery unit in SRU. As illustrated in Figure 1, tail gas stream coming from Claus unit, after heating in the inline burner, enters the reduction reactor in which all its sulfur components including COS, CS_2 and SO_2 are converted to H_2S. After cooling the gas, this stream enters the amine absorber column. H_2S enriched stream (rich amine) is routed to the regenerator column (stripper). Lean amine stream from the bottom of the stripper is recycled to absorber and the gas stream with high content of H_2S from the top of the stripper is returned to the input of the Claus where it is mixed with Claus acid gas feed. The stream exiting from the top of the absorber (the off gas of SCOT process) which includes a negligible amount of H_2S is directed to incinerator where it is burned with fuel gas [11].

In next section, the absorber column of a typical industrial TGT unit is simulated to investigate the effect of Amine concentration changes on the performance of selective absorption of TGT absorber column.

2. TGT absorber simulation test runs

In order to investigate the effect of Amine concentration on the performance of TGT absorber column, a typical industrial TGT unit is studied. The specifications of the Claus tail gas which is considered as TGT unit feed, is given in table 1. As shown in this table, the main portion of tail gas is consisting of CO_2 while the H_2S mass percent is just equal with 1%. 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 TGT absorber, there would be some problems in Claus unit such as increase of the equipment sizes, decrease of the reaction furnace temperature, etc which result in low sulfur recovery. Therefore, the ideal function of TGT absorber is selective absorption of H_2S.

Table 1 Specifications of the input tail gas to TGT unit

Property	Value
Temperature	47°C
Pressure	118 kPa
Mass Flow	75400 kg/h
Composition (mass%)	
H_2S	1
CO_2	53.7
H_2O	4.95
H_2	0.2
N_2	40.15

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 315000 kg/h and temperature of 45°C is entered from the top of the absorber column. In order to investigate the effect of MDEA presence in Amine solution on the performance of TGT absorber, Amine solution with different weight percents have been incorporated in several test runs. Figure 1 shows the changes in H_2S in the outlet sweet gas from the top of the absorber column versus the changes of MDEA mass percent in Amine solution. As illustrated in this figure, the concentration of H_2S is decreased by using more concentrated MDEA solution. Although the slop of changes in H_2S decrease for MDEA concentrations of more than 35-40%, but it is shown that concentration of below 250 ppm is sufficient in terms of environmental regulations.

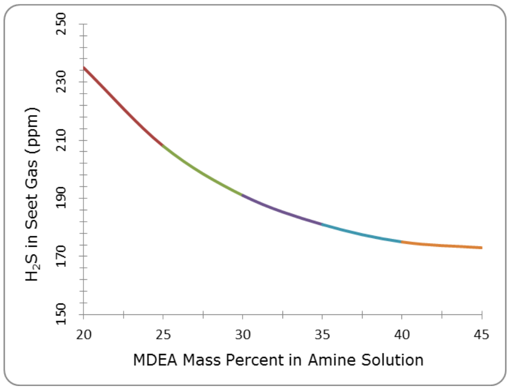

Fig.1 Changes in H_2S of sweet gas versus the MDEA mass percent

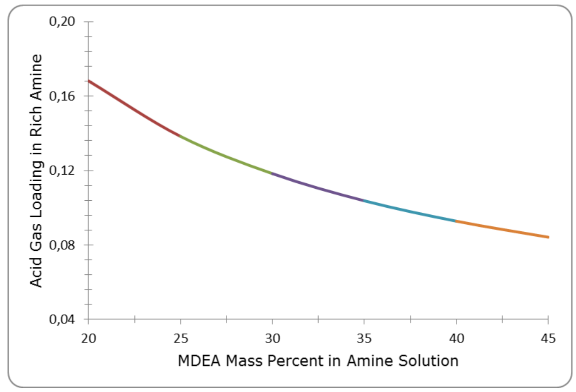

Fig.2 Changes in rich Amine acid gas loading versus MDEA mass percent

Figure 2 shows the changes in acid gas rich amine loading (moles of H_2S and CO_2 in rich Amine per moles of MDEA) versus MDEA mass percent in Amine solution. Acid gas loading is decreased by increasing the MDEA concentration. If this semi rich Amine was used in another absorber, it would be better to have less acid gas loading. However, for more MDEA concentration, more operating cost is needed.

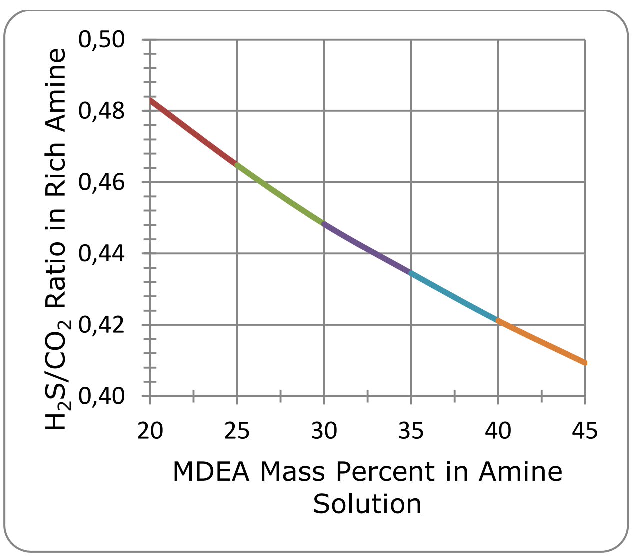

Fig. 3 Changes in rich Amine H_2S/CO_2 ratio versus MDEA mass percent

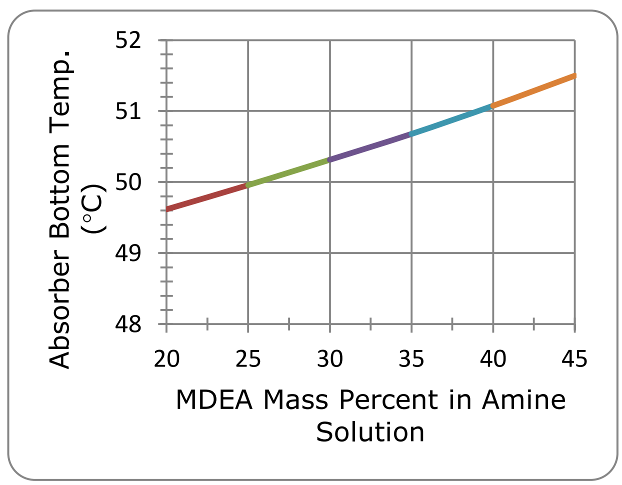

Fig. 4 Changes in acid gas versus MDEA mass percent

As mentioned before, in addition to ppm of H_2S in the sweet gas, the ratio between H_2S and CO_2 is an important parameter to evaluate performance of TGT absorber column. The changes in H_2S/CO_2 ratio with MDEA concentration is depicted in figure 3. As shown in this figure, H_2S/CO_2 ratio is decreased with increase of MDEA concentration. Therefore, using lower MDEA concentration is more appropriate in terms of selective absorption of H_2S. Furthermore, the changes in rich amine temperature exiting from the bottom of the absorber column against changes in MDEA concentration is illustrated in figure 4.

As shown in figure 1, increase of the MDEA concentration will decrease H_2S in sweet gas indicating occurrence of more reaction between H_2S and MDEA. Since this reaction is exothermic, the temperature of Amine is increased at the bottom of the column (see figure 4). Moreover, increase of Amine temperature will decrease the absorption of H_2S rather than CO_2. Therefore, H_2S/CO_2 ratio is decreased with increase of the MDEA mass percent (see figure 3).

3. Conclusions

The conversion of acid gases to elemental sulfur hardly exceeds 96% in the conventional Claus units which leads to excessive sulfur dioxide sent to the atmosphere and hence high pollution around refineries. Tail Gas Treatment unit can achieve overall efficiencies of more than 99% by eliminating the remained sulfur in the Claus tail gas. The absorber column is the most important equipment in the TGT unit. In this paper, selective absorption of H_2S by means of MDEA solution in a typical industrial TGT unit was studied. For this purpose, the absorber was simulated and then, the effect of Amine concentration on the performance of TGT absorber was illustrated. The results show that a range between 30 to 35 wt% could be considered as optimum MDEA concentration in terms of maximizing H_2S/CO_2 ratio as well minimizing the volume of H_2S remained in the sweet gas.

References

[1] Monnery, W. D., Hawboldt, K. A., Pollock, A. E., Svrcek, W. Y., Ammonia Pyrolysis and Oxidation in the Claus Furnace, Ind. Eng. Chem. Res., 40, pp. 144-151, 2001.

[2] Hawboldt, K. A., Monnery, W. D., Svrcek, W. Y., A Study on the Effect of Quench Design on the Quality of Experimental Data, Ind. Eng. Chem. Res., Vol. 38, pp. 2260-2263, 1999.

[3] Hawboldt, K. A., Monnery, W. D., Svrcek, W. Y., New Experimental Data and Kinetic Rate Expression for H2S Cracking and Re-Association, Chem. Eng. Sci., Vol. 55, pp. 957-966, 1999.

[4] Mahdipoor, H. R., Ganji, H., Minabi, A., Zareie Abyane, M., Different options for reheating of the Claus Hydrolyzing Reactor, Pet. & Coal 56(2) 200-205, 2014.

[5] Clark, P. D., Dowling, N. I., Huang, M., Chemistry of the Claus Front-End Reaction Furnace. Hydrocarbon Reactions and the Formation and Destruction of CS_2, Proceedings of the Brimstone Sulfur Recovery Symposium, Vail, pp. 23-26, 1997.

[6] Mahdipoor, H. R., Khorsand, K., Hayati, R., Javaherizadeh, H., Effect of Reaction Furnace and Converter Temperatures on Performance of Sulfur Recovery Units (SRUs), JPSR, Vol. 1, Issue 1, PP. 1-3, 2012.

[7] Nasato, L. V., Karan, K., Mehrotra, A. K., Behie, L. A., "Modeling Reaction Quench Times in the Waste Heat Boiler of a Claus Plant", IEC, Res., Vol. 33, pp. 7-13, 1994.

[8] Elsner, M. P., Menge, M., Müller, C., W. Agar, D., The Claus process: teaching an old dog new tricks, Catalysis Today 79 (2003) 487-494.

[9] Anonymous, Gas Processors Suppliers Association (GPSA), Engineering Data Book, GPSA Tulsa, Chapter 22, 1987.

[10] Sames, J., Sulfur recovery process fundamental, Technical paper, Sulfur experts Inc.

[11] The effective parameters at choosing an appropriate tail gas treatment process, CTAIJ 7(3) 82-86, 2012.

[12] Slavens, A., La mar, J., Enhanced sulphur recovery from lean acid gases, GAS, 2011.