CO_2 REMOVAL FROM NATURAL GAS USING MONOETHANOLAMINE (MEA) IN PACKED ABSORBER

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ABSTRACT

Carbon dioxide (CO_2) removal methods are of special importance because this compound is present as impurities in natural gas (NG). Packed Absorber is one of the methods that can be applied to remove level CO_2 from NG. This preliminary study aims to investigate the removal of CO_2 at high concentration level from the gaseous mixtures to elevated pressure using MEA in packed absorber. Process variables study include the CO_2 flow rate in an inlet to the absorber (20 – 60 NL/m), lean MEA temperature to the absorber (20–60 ^oC), and MEA flow rate from regen (100–140 NL/m). It was found that the CO_2 flow rate in inlet to the absorber, lean MEA temperature to the absorber, and MEA flow rate from regen effects on the efficiency of CO_2 removal, while that decreasing the CO_2 flow rate in an inlet to the absorber, and increasing MEA temperature to the absorber and MEA flow rate from regen can increase the efficiency of CO_2 removal.

Keyword: absorption, CO_2 removal, monoethanolamine, natural gas, packed absorber

1. INTRODUCTION

CO_2 removal is an essential process in the sweetening of natural gas from the underground reservoir. Natural gas generally contains a large quantity of methane along with heavier hydrocarbons such as ethane, propane, isobutene, normal butane, and a considerable amount of CO_2. CO_2 must be removed from natural gas because CO_2 is highly corrosive in the presence of moisture (water) which rapidly destroys pipelines and equipment. It also reduces the heating value of a natural gas stream and wastes pipeline capacity (Song et al., 2017; Tan, Lau, Bustam, & Shariff, 2012).

Many researches are conducted on the removal of CO_2 from natural gas, and absorption processes with chemical solvents are currently the most used technology for CO_2 separation from natural gas and post-combustion CO_2capture commercially, because they are much more efficient and cost-effective compared with other processes thus far (Lee, Pineda, Lee, & Kang, 2016). In recent years, various experimental works are carried out to further investigate the efficiency of packed column in CO_2 removal (Øi, Hansen, & Henriksen, 2017). The packed column is commonly used as a means of promoting efficient contact between gases and liquids. It could offer high mass transfer efficiency with a low-pressure drop (Oh, Binns, Cho, & Kim, 2016).

In view of this, the purpose of our study is to investigate the removal of concentration CO_2 from the mixture of CO_2-Air stream via absorption processes a function of CO_2 flow rate in an inlet to the absorber, lean MEA temperature to the absorber, and MEA flow rate from regen

2. MATERIAL AND METHODS

Materials

MEA of laboratory grade were used as solvents. A CO_2 (99.99%) pure was used as the source of the inlet gas. Raschig ring packing was used for increase contact area between CO_2 and amine solution.

Characterisation

The CO_2 concentrations in MEA solution were analyzed by titration method. CH_3COOH solution was added to the reaction flasks and its stopper. The air vent was opened on the burette and the level of water in the burette and the level in the leveling bottle was allowed to equalize. The level of the water in the burette at this point was recorded. A hypodermic syringe with 2 mL of amine solution was filled and it was inserted through the septum in the stopper of the reaction flask. Into the reaction flask was injected all 2 mL amine slowly. The reaction flask was swirled until the water level in the burette becomes constant. The leveling bottle was lowered until the water level in burette equals the level in the leveling bottle.

CO_2 liberated from the amine (mLs) = (Final burette reading – initial burette reading)-(2 mLs to allow for amine injected).

CO_2 absorption/regeneration test unit

The CO_2 absorption tests were carried out at various the CO_2 flow rate in an inlet to the absorber (20 – 60 NL/m), lean MEA temperature to the absorber (20 – 60 ºC), and lean MEA flow rate from regen (100 – 140 NL/m). The CO_2 concentration in the feed of absorber and in the flow out of absorber was recorded in the monitor. The MEA solution were feed into to the Absorber. CO_2 removal efficiency was the parameter used for describing the Absorber performance. Calculate the efficiency of CO_2 removal can use the following equation:

$$Efficiency(\%) = \left(\frac{CO_{2in} - CO_{2out}}{CO_{2in}}\right) \times 100\% \qquad (1)$$

An image of Absorber System is shown in Fig.1. The absorption column which is made of glass has a structured packing height of 1500 mm, a diameter of 100 mm and a total height of 2500 mm.

The desorption column has a packing height with P-rings of 1000 mm, a diameter of 265 mm and a total height including reboiler and condenser of 3000 mm. In the absorption column (1) air with a fraction of CO_2 is mixed counter-currently with a circulating solvent. The solvent from the absorption column (absorber) flows to a buffer tank (2) and is pumped (P01) through a heat exchanger (3) to the desorption column (desorber). The desorption column (4) is heated with steam by the reboiler and is cooled by cooling water in the condenser. The CO_2 flows from the top of the desorber, and regenerated solvent flows out of the bottom of the desorber. The regenerated solvent is heat exchanged (in 3) and is pumped back (P02) through a cooling heat exchanger (5) to the absorber (Øi et al., 2017).

In this work, measurements of CO_2 removal efficiency and heat consumption were measured as a function of gas flow, gas concentration, and liquid flow. Absorption and regeneration experiments using about 30 wt-% monoethanolamine (MEA) as the solvent have been performed with the desorber part including the reboiler and the condenser in operation. In the first experiment series the wt-% MEA was 30 %, but due to evaporation of water, the concentration of MEA increased gradually. The rig has been operated under stable conditions with the absorption of CO_2, desorption at approximately 1.8 bar, steam heating to 120℃ and amine recirculation. After a change in operating conditions, the rig spends in order of magnitude 15 minutes for stabilization of the continuously measured parameters. Parameters which have been varied in the experiments in this work are the CO_2 flow rate in an inlet to the absorber, lean MEA temperature to the absorber, and MEA flow rate from regen.

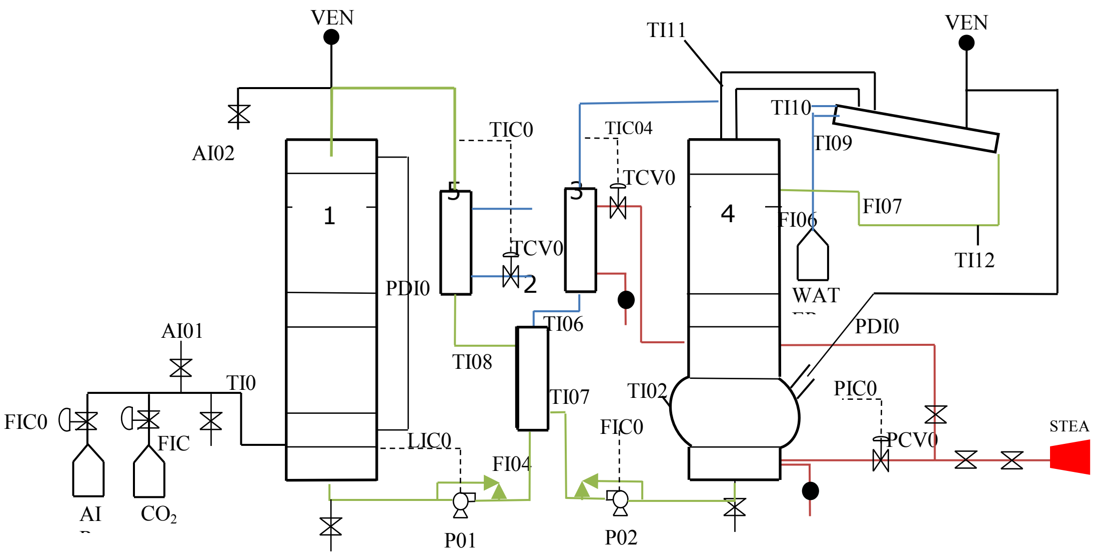

Fig. 1. The Packed Absorber and Desorber

RESULTS

Effect of CO_2 flow rate in an inlet to the absorber on the efficiency of CO_2 removal

The effect of CO_2 flow rate in an inlet to the absorber on the efficiency of CO_2 removal is shown in Fig.2. In this experiment, it is conducted in various CO_2 flow rate in an inlet to the absorber (20, 30, 40, 50, 60 NL/m). Airflow in an inlet to the absorber, MEA flow rate from regen, and lean MEA temperature to the absorber where kept constant at 224.3 NL/m, 100 NL/m, and 30 ^oC. The efficiency of CO_2 could be calculated using Eq. (1).

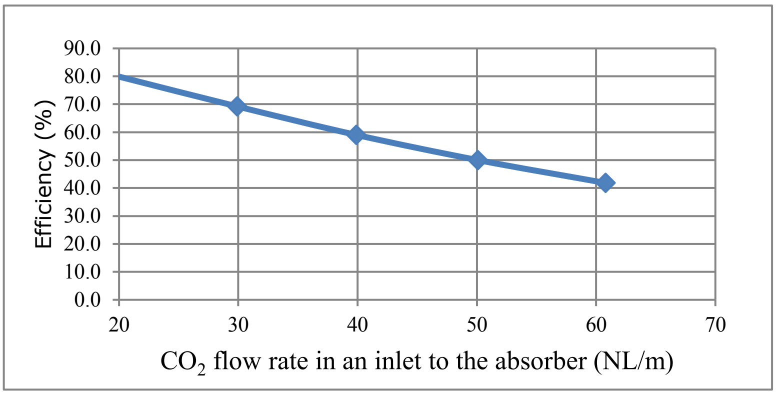

Fig. 2. Effect of CO_2 flow rate in an inlet to the absorber on the efficiency of CO_2 removal

It was observed that the efficiency of CO_2 removal is significantly effected by CO_2 flow rate in an inlet to the absorber. Decreasing CO_2 flow rate in an inlet to the absorber can increase the efficiency of CO_2 removal. This case caused to decreased CO_2 flow rate in an inlet to the absorber can obviously increase the contact area of the two phases.

Effect of lean MEA temperature to the absorber on the efficiency of CO_2 removal

To determine the effect of lean MEA temperature to the absorber toward the efficiency of CO_2 removal, in this experiment it was conducted various lean MEA temperature to the absorber (20, 30, 40, 50, 60 ^oC) by keeping the condition of airflow in an inlet to the absorber, CO_2 flow rate an in inlet to the absorber and MEA flow rate from regen was constant at 224.3 NL/m, 20 NL/m, and 100 NL/m. The effect of lean MEA temperature to the absorber on the efficiency of CO_2 removal is shown in Fig. 3.

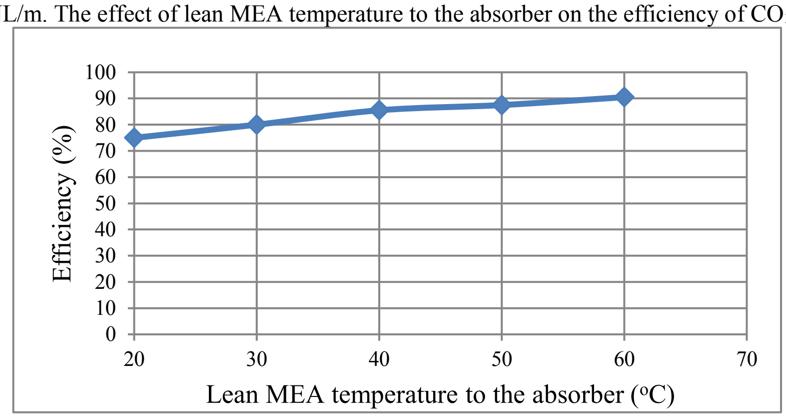

Fig. 3. Effect of lean MEA temperature to the absorber on the efficiency of CO_2 removal

The figures show that the effect of an increase of lean MEA temperature to the absorber has little effect on the efficiency of CO_2 removal. This illustrates that the increase of lean MEA temperature to the absorber cannot obviously increase the contact area of the two phases.

Effect of MEA flow rate from regen on the efficiency of CO_2 removal

The effect of increasing MEA flow rate from regen to absorber conducted by keeping constant airflow in an inlet to the absorber, CO_2 flow rate in an inlet to the absorber, and lean MEA temperature to the absorber at 224.3 NL/m, 20 NL/m, and 40 ºC is shown in Fig. 4. From Fig. 4, it is found that the efficiency of CO_2 removal is getting higher along with bigger MEA flow rate from regen. This case caused to increase the MEA flow rate from regen can obviously increase the contact area of the two phases.

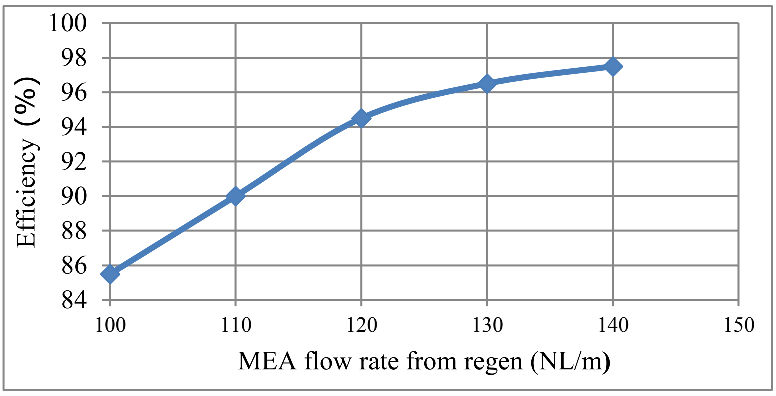

Fig. 4. Effect of MEA flow rate from regen on the efficiency of CO_2 removal

CONCLUSION

The following conclusions from the present study can be drawn:
CO_2 flow rate in an inlet to the absorber, lean MEA temperature to the absorber, and MEA flow rate from regen effects on the efficiency of CO_2 removal, while that decreasing the CO_2 flow rate in an inlet to the absorber, and increasing MEA temperature to the absorber and MEA flow rate from regen can increase the efficiency of CO_2 removal.
Further studies are required to determine the limits of changing the variables.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support for this work by Ministry of Research Technology and Higher Education, Indonesia in Retooling Program.

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