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Reducing CO_2 and H_2S Gas in Biogas Using Wet Scrubber Method with $Ca(OH)_2$ Solution

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Abstract: *Biogas is one of renewable energy source containing CH_4, CO_2, H_2S and H_2O. The high amount of CO_2 and H_2S in biogas indicates the low quality of the biogas. Absorption method is an effort to enhance the quality of biogas with minimize the impurity gas in biogas. The absorbed gases are carbon dioxide (CO_2) and hydrogen sulfide (H_2S). The aim of this study is to analyze the performance of wet scrubber and the impact of treatment variants in reduction of CO_2 and H_2S. The reactor was run using batch system in pilot plan scale. $Ca(OH)_2$ used to reduce the concentration of CO_2 and H_2S . The variables were absorbent solution flowrate, packing height of column media and biogas flowrate. The study showed that the best treatment combination were absorbent solution flowrate 1.500 ml/min, packing height of column media 150 cm, and biogas flowrate 5.300 ml/min. These combination reduced CO_2 and H_2S 61,54 % and 89 % accordingly.*

Keywords: *biogas, purification, absorption, water scrubber*

1. Introduction

Biogas is one of renewable energy claimed to be environmentally friendly because it does not produce smoke. The main components of biogas are methane gas (CH_4) and carbon dioxide (CO_2), low sulfurid (H_2S), ammonia (NH_3), hydrogen (H_2) and very little nitrogen [1]. In biogas there are gases that can be harmful to the environment when released into the air such as gas CH_4, CO_2 and H_2S. Biogas has potential as a substitute for fuel oil or natural gas fuel used in generator or automotive engines, but CO_2 and H_2S in biogas can cause corrosion in machine components [2]. H_2S is a smelly and deadly gas, it is highly corrosive to many metals. High concentration of H_2S is very harmful to humans, but it can also cause corrosion in industrial equipment [3].

One of techniques of biogas purification is absorption technique using water and $Ca(OH)_2$ absorbent [4]. The absorption process is used to reduceCO_2 and H_2S gases. Absorption is the separation of a certain gas from a mixture of gases by transfer mass into a liquid soluble [4]. $Ca(OH)_2$ solution is also called lime and a moderate base. Lime solutions will react with various acids, and react with many metals in the presence of water. The solution will become turbid when contacted with CO_2 gas due to precipitation of calcium carbonate. This research was determined the performance of wet scrubber and the impact of treatment variants in reduction of CO_2 and H_2S.

2. Material and Method

This study discussed the decrease of CO_2 and H_2S gas in biogas by absorption method using wet scrubber reactor and $Ca(OH)_2$ solution. This method was choosen due to the materials are minimal cost, simple and effective in absorbing pollutant gas. All this research data would be analyzed the results and summarized into a research conclusion.

2.1. Experiment of Biogas Purification using Wet Scrubber

- Design and installation of wet scrubber. The working principle of the reactor was biogas flowed from the bottom with a predetermined flow rate, the absorbent solution flowed from the top spray with a certain flow rate, inside the reactor there was a media column with a certain height, this media is where the absorption process taken place and was composed of marbles as fluid flow resistance . Gas from the absorption process out to the outlet, at this outlet was a sampling point. The absorbent solution recirculation is performed to improve efficiency.
- Determination of variables used, that are: (1) absorbent solution flow rate with variation of debit 750 ml / min, 1.500 ml / min, and 3.000 ml / min; (2) height of packing column with variation of 50 cm, 100 cm, 150 cm; and (3) biogas flow flow rate with variation of 5.300 ml / min, 10.900 ml / min, and 16.600 ml / min.
- Measurement of CO_2 and H_2S levels before absorption and after absorption process

2.2. Analisis Data

The method of analysis used in this research was descriptive analysis. Anova statistical tests were performed to help analyze data resulting from decreases in CO_2 and H_2S. H_0 in this research was the variation of absorbent solution flow rate, variation of packing height, variation of biogas flow rate did not have an effect on amount of the efficiency of decreasing CO_2 and H_2S. H_1 in this research was the variation of absorbent solution flow rate, variation of packing height, variation of biogas flow rate effect on the amount of efficiency decrease CO_2 and H_2S.

3. Result and Discussion

Biogas absorption process to reduce CO_2 and H_2S was used wet scrubber reactor (see in Figure 1) and $Ca(OH)_2$ solution. $Ca(OH)_2$ solution was a medium-strength base that would react greatly with various acids in the presence of water, CO_2 or called acidic charcoal acid that was able to react with $Ca(OH)_2$ solution. If there had been a process of CO_2 absorption by $Ca(OH)_2$ solution then the absorbent solution would become turbid due to precipitation of $CaCO_3$ calcium carbonate, H_2S absorption process would produce CaS deposit.

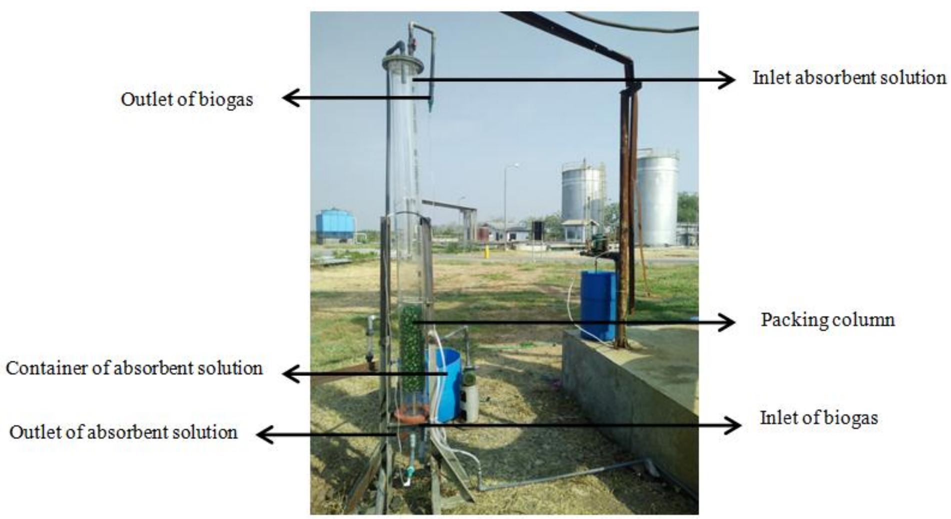

Fig 1: Wet Scrubber Reactor

Figure 2 shows the percentage of CO_2 after treatment in first 10 minutes (resirculation 1) and second 10 minutes (resirculation 2). Figure 4 shows the concentration (in ppm) of H_2S before and after treatment. The experiments of the reductionn of H2S were undertaken without resirculation because in the first treatment, the absorbent solution had been in breakthrough condition. The combination of treatments resulting in the greatest reduction efficiency in CO2 gas was at the highest absorbent flow rate rate (3,000 ml / min), highest packing media height (150 cm), and the smallest biogas (5,300 ml / min) with residence time 5.16 minutes (longest stay). The highest efficiency of CO_2 gas reduction was 61.54%.

The combination of treatments resulting in the greatest reduction efficiency in H2S gas was equal to the best combination of CO_2 gas, i.e. the highest absorbent solution (3,000 ml / min), highest packing media height (150 cm), and the smallest biogas (5,300 ml / min) with residence time 5.16 minutes (longest stay). The highest efficiency of H_2S gas decrease was 89%.

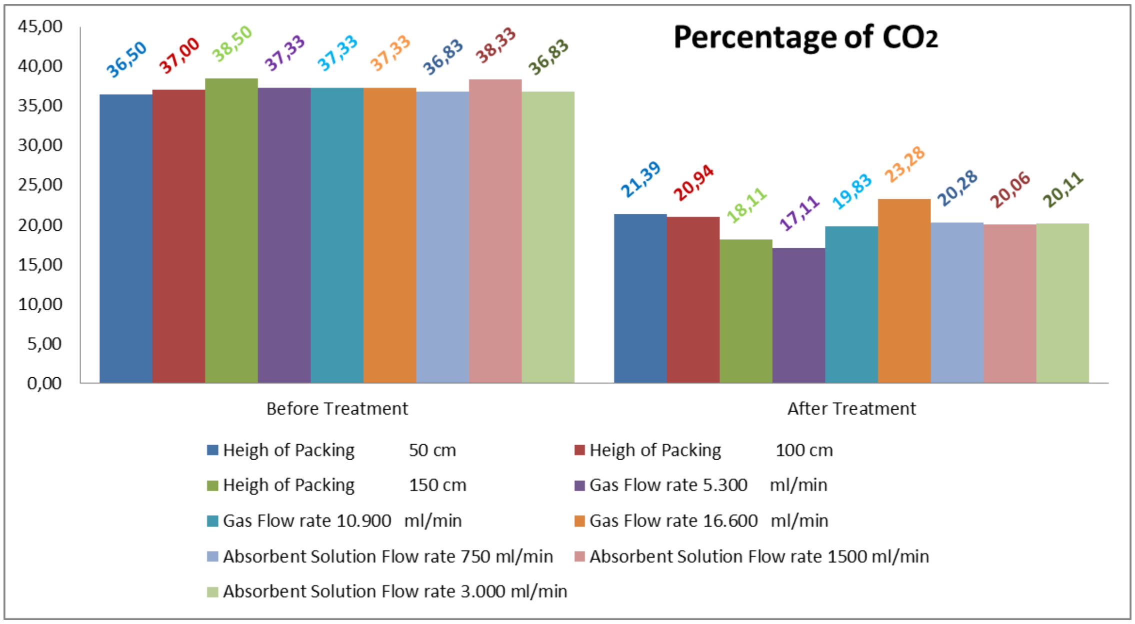

Fig. 2: The Percentage of CO_2 Before and After Treatment

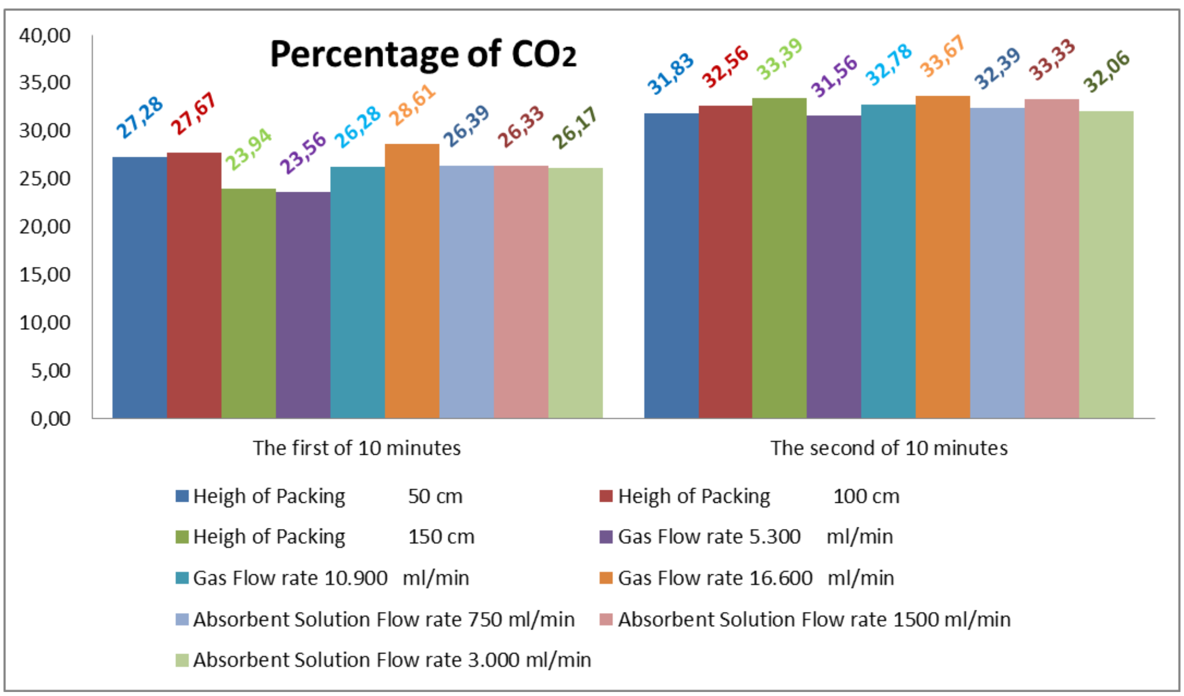

Fig. 3: The Percentage of CO_2 After treatment in First 10 Minutes (Resirculation 1) and Second 10 Minutes (Resirculation 2)

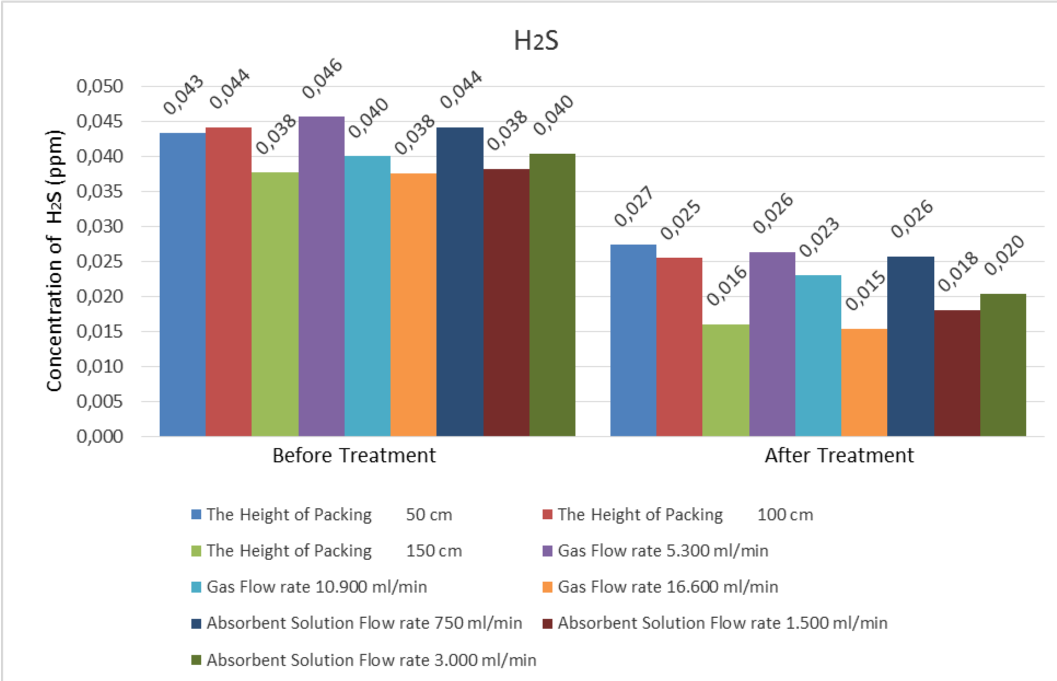

Fig. 4: The Concentration of H_2S in Before and After Treatment

The absorption process could occur because the absorbent solution was an alkali and absorbent $Ca(OH)_2$ solution which would be bonded in the absorption process i.e. CO_2 and H_2S were acidic, resulting in a reaction between absorbents and the absorbat. $Ca(OH)_2$ absorbent solution had a certain capacity in absorption, in absorbent breakthrough state was no longer able to absorb the absorbent. This may be indicated by the pH condition of the absorbent solution, at breakthrough conditions the pH of the solution turned to acid. The more acidic pH of the absorbent solution the absorbing ability would decrease, indicating absorbent saturation.

Biogas residence time in the column packing affected the absorption process. The calculation of residence time was obtained from the column packing volume divided by the biogas flow rate entering the reactor. There were 3 variations of absorbent solution flow rate, 3 variations of column packing media height and 3 variations of biogas flow rate entering the reactor, so there were 9 variants of residence time in this experiment. The residence time and the decrease of H_2S gas has linier correlation, the longer the residence time the higher the efficiency of the H2S gas decrease. This happened because the longer time to stay then the absorption process could run optimally.

4. Conclusion

The conclusion of this study are:

- The most effective absorbent solution flow rate in lowering CO_2 and H_2S was 1.5000 ml / min. The flow rate of a solution that was too large caused the absorbent solution to rapidly drop into the outlet of the absorbent solution so the contact time was shorter and the absorption process was less than optimal. If the flow rate of the solution was too small, the absorbent requirement would be less so the absorption process was less than optimal.
- The height of the column packing resulting in the greatest CO_2 and H_2S reduction gas efficiency occurring at the highest altitude of 150 cm. This was occured because with the high packing column then the volume used for absorption was also greater, so the contact time between absorbent and absorbat was longer and absorption process occured optimally.
- Biogas flow flow rate which produced the greatest CO_2 and H_2S gas reduction efficiency occured at the smallest flow rate of 5,300 ml / min. This occured because with a small flow, the biogas flowed more slowly and held longer in the packing column so that the contact time of biogas with longer absorbent, so absorption process occurs more optimally.

5. Acknowladgements

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