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Water Scrubbing for Removal of CO_2 (Carbon Dioxide) and H_2S (Hydrogen Sulfide) in Biogas from Manure

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Abstract

Purifying biogas from CO_2 (carbon dioxide) and H_2S (hydrogen sulfide) needs to be done to improve the quality of the biogas in the fuel. The presence of H_2S in biogas can cause corrosive to the equipment, in addition to this, H_2S is also dangerous for human and animal health. CO_2 contained in Biogas is also an impurity that can cause corrosive beside H_2S so the contained in biogas is also an impurity that can cause corrosive, so the purification process needs to be done in order to qualify biogas as natural gas which environmentally friendly and safe for health. The basic ingredient of biogas purification using water scrubbers base ingredients are water, which flowed pressurized biogas purification column from the bottom, of the column in order to reduce CO_2 and H_2S gases. The result of purification by using this method was that the levels of H_2S in biogas reduced by 32.8 % while the CO_2 content decreased by 21.2 %. It can be concluded that the H_2S gas more soluble in the water compared with CO_2, as H_2S gas has higher efficiency removal from CO_2.

Keywords: biogas; carbon dioxide; hydrogen sulfide, waters scrubber.

1. Introduction

Eliminate acid gas impurities such as CO_2 (carbon dioxide) and H_2S (hydrogen sulfide) from biogas is very important prior to usage as fuel. The presence of CO_2 in the biogas can reduce the heat, while H_2S is a gas that is highly toxic and corrosive to the equipment [1]. Therefore, to full fill the quality standards of environmentally friendly fuels both these acid gases must be removed

There are two stages of biogas purification, namely using physical absorption, and chemical scrubber water method. Water scrubber method uses liquid base material to remove pollutant [2]. Biogas quality is determined by the presentation of CO_2 (carbon dioxide) and H_2S (hydrogen sulfide), because the higher the lower the percentage of CO_2 and H_2S in the biogas combustion quality. Therefore substrate suitable for use as biogas production is cow dung, because the content is not so high H_2S [3].

Water scrubbers packed in the form of a high tower. It is intended to lengthen the contact between water and the gases, so greater reduction of acid gas within the water occurs. The working principle of water scrubber is that the biogas from the reactor is flowed into the purification column whose stream is the opposite to the flow of water. The water that has interacted with the acid gas flowed down the column with continuous circulation until the water changes. In this stage the water is saturated and the water needs to be regenerated in order to avoid problems in the

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operation of the gas purification [4].

Several water scrubber methods have been carried by Lien, et al. [4] in this kinds of research which is to design a water desulfurization scrubber equipment to reduce hydrogen sulfide from biogas. Biogas pressure which flows through the aeration plate will generate many small biogas bubbles. The bubbles will interact with water, leading to adsorption desulfurization. Various water level and flow rate of biogas is tested to detect the content of hydrogen sulfide in the biogas after passing through a water scrubber. Data collecting method is by using variations of water levels : 50 cm, 60 cm and 70 cm high; water flow rates of 50 L min^{-1}, 100 L min^{-1} and 140 L min^{-1}, and time of 30 sec and 90 sec. From results obtained we find that the best reduction of H_2S gas is best with 78 % efficiency value is by water speed of 50 L / min and 70 cm high water for 30 sec [4].

From the results above, this research is purposed to designing a biogas purification of water scrubbers to reduce hydrogen sulfide and carbon dioxide in the biogas. With pressurized biogas method is introduced from the bottom of the purification column tray through the trap, while the water streamed from above through a nozzle. The nozzle here serves as a place for water to flow from the pipe while the trap shaped like a sieve tray as a point of contact of water and biogas.

2. Methodology

This biogas purification experiment was conducted created from dung cow in Nongkojajar Pasuruan. The biogas was made through anaerobic process from cow manure and water, with mass ratio of water and cow manure 1:1 inside a biogas reactor. The biogas is used as a source of light energy and fuel for cooking. Biogas generated from the anaerobic process is qualified as an environmentally friendly fuel by designing purifiers.

Purification column of biogas has a diameter of 6 dim and column height of 1.5 m, at top of it is the nozzle which is used as a circulating water from the water tank located at the bottom of the purification column. In addition to nozzle the tower equipped with a tray shaped like a sieve trap, where interaction between water with biogas derived from the bottom of the column occurred. Here is the schematic tool scrubber water purification.

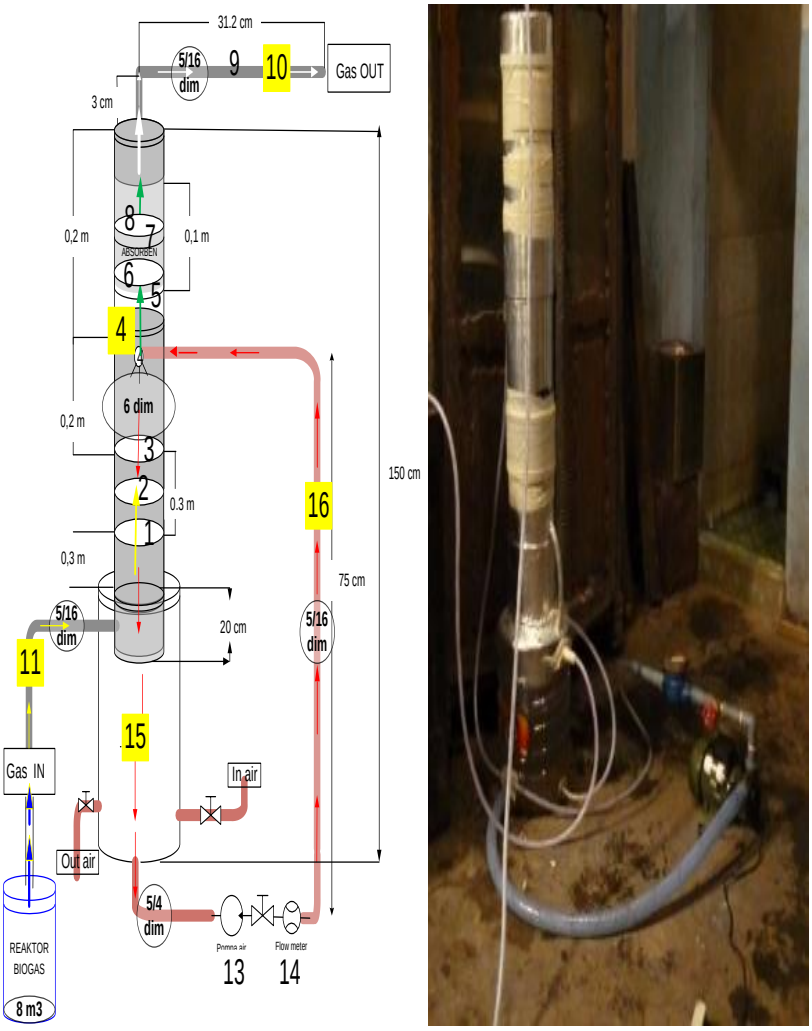

Fig 1. Water scrubber.

Diagram information of the water scrubber.

1	Tray trap	9	Out biogas
2	Tray trap	10	Termokopel
3	Tray trap	11	Input biogas
4	Nozzle	12	Termokopel
5	Tray trap	13	Water pump
6	Screen	14	Flow meter
7	Tray trap	15	Cistern
8	Screen	16	Pipe flow water

The water scrubbers is equipped with a nozzle from with the water comes after flow through the pipe, while the trays serve as a place of interaction between trapped biogas with water so that the longer the contact happened, more acid gas will be reduced.

Fig 2. nozzle and tray trap.

3. Results and discussion

The result of the elimination efficiency levels of CO_2 and H_2S in the biogas from the experiment can be seen in Figure 1, where the efficiency levels of H_2S gas removal was 32.8 % compared to the levels of carbon dioxide which has 21.2 % efficiency. This is due to that the H_2S gas has a high solubility in water than the carbon dioxide. solubility of H_2S in the liquid phase is higher than CO_2 at the same pressure and temperature, in accordance with the experimental data. The H_2S has a dipole moment closer to the water, which is why its molecule more soluble. CO_2 is not the dipole moment but has a quadrupole [5].

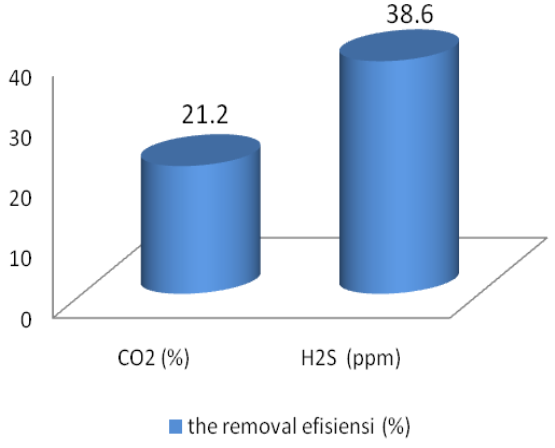

Fig. 3. Removal efficiency gas H_2S and CO_2.

Table 1. The removal efficiency of H_2S and CO_2 content for biogas.

Water scrubber time (min)	15	
Type of gas	CO_2 (%)	H_2S (mg L^{-1})
Concentration before the purified	15	18.4
Concentration after the purified	11.8	11.3
The removal efficiency (%)	21.2	38.6

The correlation of CO_2 concentration with time, before and after purification can be seen in Figure 4, where CO_2 levels prior to urification is 15 %, was steady within 15 minutes, while reduction of CO_2 gas from the first minute until the third minute of a very significant decline. This is because the biogas has not fully filled the purification column space so that the gas is detected so small. While in the fourth minute, of water started to interact with CO_2 therefore reduction started to 4^{th} in minutes to four minutes till the eleventh, although the amount is too small. Meanwhile in twelfth to fifteenth minutes the CO_2 reduction rise, this is because the interaction of water and CO_2 did not happen anymore so that the CO_2 levels did not change.

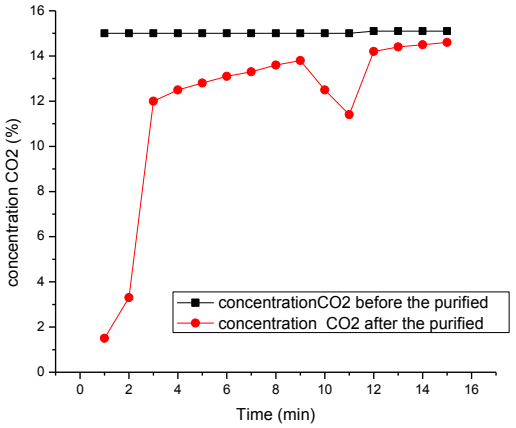

Fig. 4. Concentration of CO_2 gas before and after purified.

H_2S gas concentration when measured in the first up to fourth minute have not decreased as shown in Figure 5. It is caused by the interaction of the gas and the water has not happened yet. In the fifth minute up to fifteen decreased levels of H_2S decreased very significantly up to 93 % of the H_2S gas concentration before purification from the result, it can be concluded that the H_2S gas is very soluble in water. H_2S is more soluble in water because its dipole higher compared to CO_2, and H_2S dipole moment closer moments with water, so the water bond with H_2S greater. Dipole is an attractive force between polar molecules with polar molecules negative positive [5].

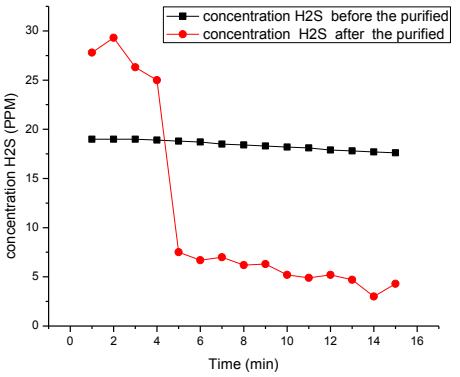

Fig. 5. Concentration of H_2S gas before and after purified.

Based on the chart above that the second image biogas purification tool that has been designed with water-based materials can reduce CO_2 (carbon dioxide) in the biogas of 11.8 mg L^{-1} of the initial content of the biogas at 15 mg L^{-1} for 15 minutes. So it can be stated that the solubility of CO_2 in water is not so great that it requires a catalyst that is able to bind CO_2 is more effective when mixed with water. While the reducing H_2S gas using water absorbent could reduce 38.6 % of the acid gas, so it can be stated that H_2S is more soluble in water than CO_2. Biogas purification tool is able to reduce acid gas in a short amount of time is 15 min, and purification tools can be developed to reduce the size of the diameter, height and purification tool for the performance and reducing the absorption of gases in the more effective and also vacuum on this important tool that no gas leak.

4. Conclusion

Biogas purification from acid gasses CO_2 and H_2S using water scrubber reduced more H_2S than CO_2, because H_2S dissolves better than CO_2 in water. As for purification tool that has been designed is capable of reducing CO_2 and H2S in the biogas in a very short period of 15 min. Absorption performance is not so great because of the vacuum in the tool is not so large that there is a great likelihood that gas out.

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