HYDROGEN SULFIDE (H₂S) GAS ABSORBSION IN BIOGAS USING FERRY OXIDE (Fe₂O₃)

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ABSTRACT

The long-term objective of this research is to obtain biogas with renewable natural gas quality and can be used as fuel for electric generators to support the availability of electricity in small island areas. The specific target to be achieved is to obtain methods / techniques to reduce impurity levels contained in biogas, especially hydrogen sulfide gas, comprehensive technology information and active ingredients to absorb hydrogen sulfide gas as materials for writing textbooks and articles for national journals. This research will be tested to reduce levels of H_2S (hydrogen sulfide) in biogas using ferric oxide (Fe_2O_3) absorbent. In this study, the variables studied were the effect of the biogas flow rate on absorbed hydrogen sulfide (H_2S) and the resulting CH_4. H_2S absorption was carried out by feeding biogas into the ferric oxide absorbent continuously at a certain biogas flow rate (1, 3, 5, 7 and 9 l / min). Then the research was continued by determining the levels of H_2S absorbed and CH_4 produced using the biogas tester set type atex directive. The increasing of the biogas flow rate that passes through the absorber tube containing Fe2O3, the smaller the H_2S gas that can be absorbed by Fe_2O_3, this is because the time to react between H_2S and Fe_2O_3 is getting smaller or less, so that the reaction that occurs is still not perfect, the biogas has left the tube. absorber. In this study, biogas with a flow rate of 1 liter / minute, obtained the best absorber ability to absorb H2S, namely H_2S lagging an average of only 14.43 ppm from 1314 ppm contained in biogas, or nearly 98.9% which can be absorbed. Meanwhile, the level of metane gas (CH_4) did not change during the purification process.

KEYWORDS: biogas, ferry oxide, hydrogen sulfide, absorbent

INTRODUCTION

The process of making biogas is the process of decomposing organic matter by including small substances in anaerobic conditions, namely conditions without oxygen (anaerobic digestion), so the equipment used requires a high air tightness. The process occurs at low temperatures up to $65^{\circ}C$, biogas can be a cheap and environmentally friendly alternative to fuel oil. Where the composition of the biogas is CH_4, CO_2, N_2, H_2, O_2, and H_2S. Methane gas or CH_4 in biogas is the main element in biogas which is a component in combustion and also has a large percentage, so that it can produce high heat. In addition to methane gas (CH_4), which is very necessary, there are other ingredients that can disturb or damage it. For example carbon dioxide (CO_2), this CO_2 level in biogas ranks second after CH_4 with a percentage of approximately 40% followed by H_2S levels with a percentage of 3%.

CO_2 gas in biogas needs to be removed because this gas can reduce the heating value of biogas combustion. In addition, the content of carbon dioxide gas (CO_2) in biogas is quite large, namely around 30-45%, so that the heating value of biogas combustion will be significantly reduced. The heating value of burning pure methane gas at a pressure of 1 atm and a temperature of $15.5^{\circ}C$ is 9100 Kcal/m^3 (12,740 Kcal/kg). While the heating value of biogas combustion is around 4,800 - 6,900 Kcal/m^3 (6,720 - 9660 Kcal/kg) [1].

The gas separation technology that has been developed is the use of membranes. In this case zeolite Mixed Matrix Membranes is used for the separation of CO_2 / CH_4. The choice of membrane as a gas separation technology is not new. Two criteria for a separation technology will be chosen if technical and economic considerations are easy [2].

[3] has carried out the process of refining and pressurized packaging of biogas and its application in the process of generating electrical energy and substituting fossil fuels. It shows that the biogas purification results are close to 100% CH_4 with an efficiency level of electricity and combustion in car engines reaching 97%. Bajracharya (2009) has carried out biogas purification and increased pressure in its storage system, showing that the heating efficiency rate has increased by up to 97%. This shows the success of biogas purification using CaO, Ca (OH)$_2$ and NH_4OH as CO_2 absorber and H_2S gas absorber.

The results of the research on horse manure utilization are very good for use as a basic material for making biogas. Horses have a special digestive system that uses microorganisms in their digestive system to digest cellulose and lignin from grass or high-fiber forages. Therefore, horse manure has a high cellulose content. Based on the results of the research, it shows that biogas with raw material of horse manure has a gas composition including methane (CH_4) 69.7%, carbon dioxide (CO_2) 25.4%, nitrogen (N_2) 2.3%, hydrogen sulfide (H_2S) 0.3% and oxygen (O_2) 0.1 % [4].

The CO_2 content in biogas is still quite large. This causes the efficiency of the heat produced is still low so that the quality of the biogas flame is still not optimal. Therefore, it is necessary to purify the CO_2 content in biogas, one way is to use ammonium hydroxide (NH_4OH). The purification process carried out is to create a CO_2 absorption system, where the NH_4OH solution will bind CO_2 in the biogas. This study used an experimental method with three treatments, namely the biogas rate of 1.7 m/s, 1.3 m/s, and 0.6 m/s. For data collection, it was done every 5 minutes for 20 minutes. The analysis results showed a decrease in the CO_2 content of the biogas. At a biogas rate of 1.7 m/s the CO_2 content decreased by 9.45%, at a biogas rate of 1.3 m/s decreased by 13.77%, and at a biogas rate of 0.6 m/s the CO_2 content decreased by 15, 72%. The analysis also showed a change in the molarity of the NH_4OH solution. At the biogas rate

of 1.7 m/s there was a decrease in molarity of 0.85 M, at the biogas rate of 1.3 m/s the moolarity of the NH_4OH solution decreased by 1.163 M, and 1.172 M at the biogas rate of 0.6 m/s. The absorption efficiency of CO_2 by the NH_4OH solution at the biogas rate of 1.7 m/s was higher than at the biogas rate of 1.7 m/s and 0.3 m/s. Meanwhile, the effectiveness of CO_2 absorption by NH_4OH solution at a biogas rate of 0.6 m/s is more effective than the biogas rate of 1.7 m/s and 1.3 m/s [5].

[6] The use of biogas purification technology depends on the composition of the biogas and its intended use. According to Pabby et al. (2009), the composition of the biogas depends on the source of the raw material. The biogas purification process using membranes is excellent at an operating pressure of 5–7 bar. According to Noverri (2007), the selection of a suitable method for separating CO2 from the mixture depends on several parameters, namely: CO2 concentration in the feed stream, the nature of the feed components, pressure and temperature. According to Kapdi et al. (2005), there are several methods of biogas purification (CO2 removal), including: physical absorption, chemical absorption, adsorption, membrane separation, cryogenic and chemical conversion into other compounds.

1. Research Methods

The research method that will be used to achieve the research objective is to carry out several experimental stages: the first step is to analyze the initial composition contained in the biogas to determine the initial concentration of H_2S gas and the initial concentration of CH_4 gas in the biogas. This stage will be carried out at the New and Renewable Energy Laboratory. While the second stage is to test the ability of the Fe_2O_3 absorber to bind H_2S gas in the biogas element so that it will increase the quality of the biogas, this stage is carried out in the energy conversion laboratory and the New and Renewable Energy Laboratory.

The main material needed in this study is biomass from household waste and livestock waste, then mix the biomass waste and water with a ratio of 1: 1, stirring until it dissolves. The mixture is put into a storage tank (digester). Then all the ducts and holes are closed so that no air can enter the system. Furthermore, the mixture of manure and water is left to stand for ± 3-4 weeks to form biogas. Furthermore, for the absorber, 270 g of turned iron is used and then put into the absorber tube and then exhaled with pure oxygen for 10 minutes, then the iron growler will react to ferrooxide (Fe_2O_3).

While the variables selected include: fixed variables: Biogas composition consisting of a mixture of CH_4 gases, CO_2, H_2S, H_2O and others, Operating temperature (Top): At room temperature (30°C). And for variable changes: biogas flow rate: 1 l/minute, 3 l/minute, 5 l/minute, 7 l/minute and 9 l/minute, absorber: Fe_2O_3.

The research was continued with the process of absorption of hydrogen sulfide gas contained in biogas

with a ferric oxide absorber. H_2S absorption is carried out by feeding biogas into the ferric oxide absorbent continuously at a certain flow rate (1, 3, 5, 7 and 9 l / min), meanwhile the biogas is flowed to the bottom of the column. Gas and ferric oxide will contact each other and a chemical reaction occurs. Each time interval of 2 minutes, the biogas after absorption is taken for analysis. The amount of H_2S absorbed was analyzed using the atex directive method. In this study, the variables studied were the effect of the biogas flow rate on the H_2S absorbed and the resulting CH_4. The series of biogas purification testing tools are as follows,
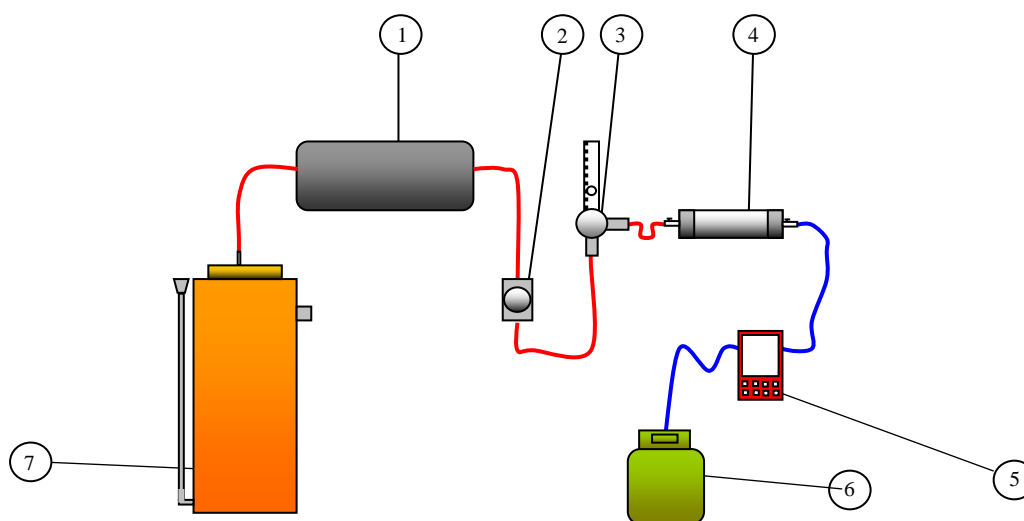

Figure 1: A series of test equipment. 1. A place to collect biogas, 2. Vacuum pump, 3. Flowmeter, 4. Absorber, 5. Biogas tester (type. ATEX Directive 94/9/EC), 6. Purified biogas tube, 7. Digester

2. Results and Discussion

Biogas content in general is methane gas, carbon dioxide gas, hydrogen sulfide and other gases in small amounts. To determine the level of gas contained in the biogas, a biogas tester is used. Hydrogen sulfide contained in biogas is relatively small but is very detrimental because it can cause corrosion, foul odor and is poisonous. The content of hydrogen sulfide in biogas can be reduced by chemical absorption using ferric oxide (Fe_2O_3) absorbent. Biogas that passes through the absorbent will experience absorption of hydrogen sulfide through a chemical reaction that occurs between hydrogen sulfide and ferric oxide (Fe_2O_3) to form Fe_2S_3. This results in a reduced level of hydrogen sulfide in the biogas. The biogas produced will be used as fuel which is no longer corrosive. The content of hydrogen sulfide contained in biogas before purification and after purification can be seen in figure 2.

In Figure 2. It can be seen that with the increasing rate of biogas flow through the absorber tube, the H2S gas that can be absorbed by Fe2O3 is getting smaller. This situation occurs because the time to react between H2S and Fe2O3 is getting less, the reaction that occurs between H2S and Fe2O3 is still not perfect, the biogas has left the absorber tube. In this study, biogas with a flow rate of 1 liter / minute, obtained the best absorber ability to absorb H2S, namely H2S lagging an average of only 14.43 ppm from 1314 ppm contained in biogas, or nearly 98.9% which can be absorbed. Meanwhile, the absorber as a function of time in terms of the length of time it uses an absorber in biogas purification is shown in Figure 3.
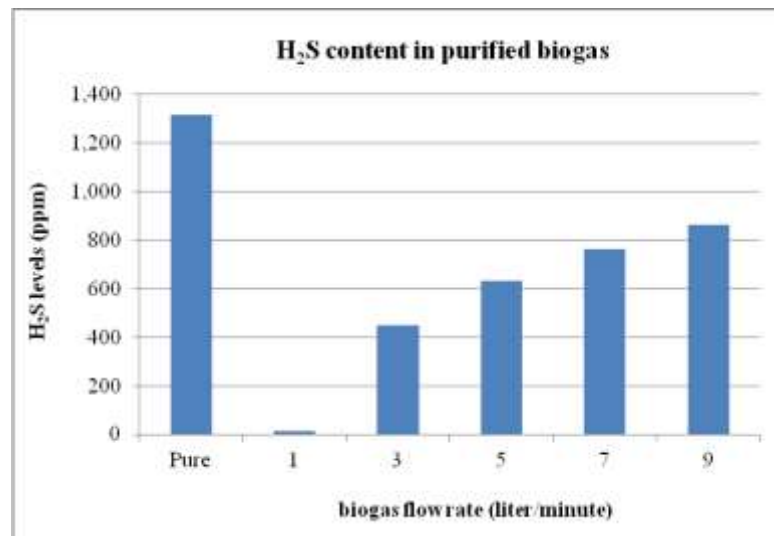

Figure 2. The composition of purified H_2S levels against variations in the biogas flow rate
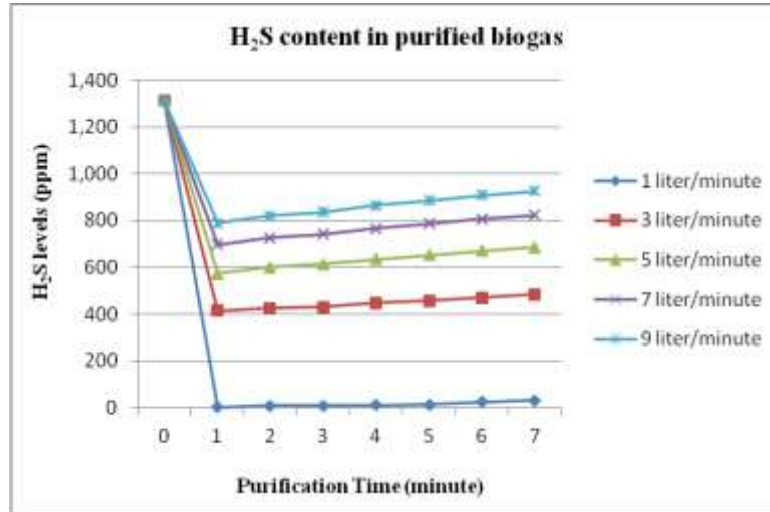
Figure 3. The composition of H_2S levels against purification time with variations in the biogas flow rate

Figure 3 shows that the longer it takes to purify biogas, the absorber's ability to absorb H_2S will decrease. This situation is more due to the saturation of Fe_2O_3, so that between Fe_2O_3 and H_2S no longer reacts, therefore the H_2S levels that can be absorbed by the absorber are decreasing, meaning that the H_2S levels in the biogas are getting bigger. This situation applies to all variations in the biogas flow rate. Meanwhile, metane gas (CH_4) levels did not change during the purification process, as shown in Figure 4.
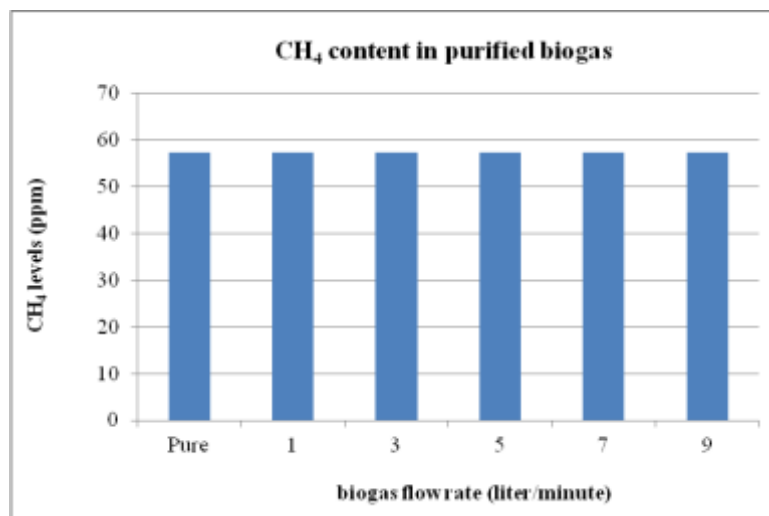

Figure 4. The composition of purified CH_4 levels against variations in the biogas flow rate

Figure 4 shows that during the purification process using an Fe_2O_3 absorber, that metane gas does not react with ferrous oxide so that the metane gas content tends not to change during the refining process. The amount of metane gas both before purification and after refining was constant.

3. CONCLUSION

The greater the rate of biogas flow through the absorbent tube, the smaller the percentage reduction in hydrogen sulfide that occurs. The longer the time runs, the ability of the absorbent tube will decrease in absorbing hydrogen sulfide contained in the biogas.

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