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Effect of Biogas Flow Rate in Carbon Dioxide Purification Process with Pumice Adsorber

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Abstract – Biogas is an alternative energy solution that could be a replacement for fossil fuels energy cheap and environmentally friendly. The composition of biogas is CH_4, CO_2, N_2, H_2, O_2 and H_2S. CH_4 is the main element in the biogas which has a high calorific value. In addition to the indispensable CH_4 there is also a CO_2 content that actually interfere with or damage. If this element is present in biogas, it will disturb the combustion process itself. Therefore, it takes effort to reduce levels of CO_2 are expected to raise the quality of biogas. The study was conducted to reduce levels of CO_2 in the biogas using absorbent pumice sludge. The method used in this study is true experiment that is taking into account variations in the flow rate of biogas (2, 4, 6, 8 and 10 l/min) were passed through the absorbent. Next will be examined levels of CO_2 absorbed and CH_4 using gascromatography method. Results of research have shown that the greater the biogas flow rate passing through the absorbent pumice sludge then CO_2 gas levels decline with an average decrease of 14.38%, but contrary to methane gas levels rose an average of 11.79 % for each time the changes of biogas flow rate.

Keywords – Biogas, Purification, Pumice, Biogas Flow Rate, Carbon Dioxide.

I. INTRODUCTION

Along with the rapid development of industrial technology, the need for renewable energy sources becomes a very important consideration. This is due to the increasing scarcity of petroleum energy sources and the higher world crude oil prices, so that innovative research continues to be developed to find renewable energy sources. The research is not only to find new energy sources, but is able to find energy sources that are environmentally friendly.

Biogas is a cheap and environmentally friendly substitute for fuel oil. The chemical compounds contained in biogas are CH_4, CO_2, N_2, H_2, O_2, and H_2S. CH_4 in biogas is the main component in combustion and also the percentage must be large, so that it can produce high heat. In addition to methane gas (CH_4) which is very necessary, there are also other substances that interfere or damage. For example carbon dioxide (CO_2), the level of CO_2 in biogas is second only to CH_4 and the percentage is approximately 40%. Where it is known that it is uncertain CO_2 is the result of combustion and if it is not present in combustion, it will interfere with the combustion process itself. Therefore, efforts are needed to reduce CO_2 levels which are expected to improve the quality of biogas.

The purity of the CH_4 produced from the biogas is a very important consideration, this is because it affects the calorific value produced. The presence of CO_2 in biogas is very undesirable, this is because the higher the level of CO_2 in the biogas, the lower the calorific value of the biogas and it is very disturbing in the combustion process. This causes the purity of CH_4 to be low.

To reduce the CO_2 levels, it can be done by passing biogas into pumice so that the absorption process occurs. CO_2 gas reacts directly with pumice while CH_4 does not, with decreasing CO_2 concentration as a result of reaction with pumice, the ratio of CH_4 to CO_2 concentration becomes larger for CH_4 concentration.

The gas separation technology that has been developed is the use of membranes. In this case, zeolite Mixed Matrix Membranes

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are used for CO_2/CH_4 separation. The choice of membrane as a gas separation technology is not new. Two criteria of a separation technology will be chosen if technical and economic considerations are easy to do [1].

CO_2 gas in biogas needs to be removed because the gas can reduce the calorific value of biogas combustion. In addition, the content of carbon dioxide gas (CO_2) in biogas is quite large, which is around 30-45% so that the calorific value of biogas combustion will be reduced considerably. The calorific value of pure methane gas combustion at a pressure of 1 atm and a temperature of 15.5^oC is 9100 Kcal/m^3 (12,740 Kcal/kg). Meanwhile, the calorific value of biogas combustion is around 4,800 – 6,900 Kcal/m^3 [2].

One alternative energy that is currently being developed is energy derived from organic materials, this is because these organic compounds are classified as renewable energy. The existence of these organic materials is easy to obtain and their continuity is guaranteed, besides that, the most important thing is that these organic materials are environmentally friendly. This is the main factor for the existence of organic materials considered as future energy in order to realize green technology (green technology). Biogas is one of the products of green technology that is currently being developed. This is because the gas produced from the biological process (anaerobic digester) is capable of producing gases such as CH_4, CO_2, H_2S, H_2O and other gases. In this case, of course, methane gas (CH_4) is used, because CH_4 has a calorific value that can be used as fuel. Microbiological degradation of organic materials in an anaerobic environment can only be carried out by microorganisms capable of utilizing molecules other than oxygen as hydrogen acceptors. Anaerobic decomposition produces biogas consisting of methane (50 – 70 %), carbon dioxide (25 – 45%) and small amounts of hydrogen, nitrogen, hydrogen sulfide [3].

The process of purification and packaging of biogas pressures and their applications in the process of generating electricity and Replacing fossil fuels. The results show that biogas purification is close to 100% CH_4 with the efficiency of electricity and combustion results in car engines reaching 97%. Bajracharya (2009) has done biogas purification and increased pressure in its storage system, showing the level of heating efficiency increased to 97%. This shows the success of biogas purification by using CaO, $Ca(OH)_2$ and NH_4OH as CO_2 absorbent and H_2S gas absorber [4].

The research was conducted to reduce CO_2 levels in biogas by using coconut shell ash adsorbent. Biogas flow rate is varied with 5 variations (2, 4, 6, 8 and 10 lt/min) when passing through the adsorber, then analyzed the levels of CO_2 absorbed and CH_4 (methane) produced using the gaschromatography test equipment. The main component contained in coconut shell ash contains silica. Silica in coconut shell ash has the ability to absorb water vapor contained in biogas. The increase in CO_2 gas levels and CH_4 gas levels is more due to the reduced levels of water vapor in biogas so that the percentage of CO_2 and CH_4 volumes changes by the percentage of the volume of water vapor that can be absorbed by coconut shell ash. In the process of biogas purification with a flow rate of 10 lt / min which is passed into the coconut shell ash, the data obtained for methane gas content is 40.954% while CO_2 gas is 34.894%, this shows that an increase in methane gas levels by an average of 2.62%, while carbon dioxide gas levels also increased by an average of 3.82% [5].

II. Research Methods

The research method that will be used to achieve the research objectives is to carry out several experimental stages: The first stage is to analyze the initial composition contained in the biogas to determine the initial concentration of CO_2 gas and the initial concentration of CH_4 gas present in the biogas. The second stage is to test the ability of pumice to bind CO_2 gas in the biogas element so that it will increase the quality of biogas.

a. Research variables

In this study, the selected variables include:

Fixed variable

The composition of biogas which consists of a mixture of gases CH_4, CO_2, and others

Operating temperature (Top): At room temperature (30^oC)

Variable change

biogas flow rate : 2, 4, 6, 8 and 10 lt/min

absorber: pumice

b. Tools and materials

a. Equipment used in research: digester series, gaschromatography, PH meter, flowmeter

b. Material: Biogas is produced from biomass waste from households and livestock waste, Pumice

c. Testing procedure

The main ingredients needed in this research are biomass waste from household and livestock waste, then mix the biomass waste and water in a ratio of 1: 1, stir until dissolved. The mixture is put into a holding tank (digester). Then all the channels and holes are closed so that no air enters the system. Next, the mixture of dirt and water is allowed to stand for ± 3 – 4 weeks to form biogas.

Phase I, Analysis of biogas composition before purification

The analysis in the first stage is by using a gas cromatograph so that the composition of biogas can be known, especially the concentration of CO_2 gas and CH_4 gas concentration.

Phase II, biogas purification process from impurities

The research was continued by reducing the level of CO_2 in biogas through the process of absorption of carbon dioxide gas (CO_2) using a pumice absorber. CO_2 absorption is carried out by feeding biogas into the pumice absorber continuously with a certain flow rate (2, 4, 6, 8 and 10 lt/min). Biogas and pumice will contact each other and chemical reactions occur. Each time interval of 2 minutes, biogas after absorption is taken for analysis. The amount of CO_2 absorbed and CH_4 produced by using gaschromatography method. In this study, the variable studied was the effect of biogas flow rate on CO_2 absorbed and CH_4 produced.

d. Data analysis

This data analysis was carried out after and referring to the experimental data, by comparing the CO_2 and CH_4 content before being purified and after being purified, studying the efficiency and effectiveness of pumice in reducing CO_2 levels in biogas purification, knowing the relationship between the percentage of purified CO_2 and various flow rates of biogas.

III. Results and Discussion

Based on the research data, it is shown that the level of CO_2 in biogas that has not been purified is still large, which is around 43.69% while the level of methane gas is around 39.95%. In fact CO_2 gas is a gas resulting from the combustion process so it must be purified. The results showed that the higher the flow rate of biogas, the methane content increased by an average of 11.79% (figure 1), while the carbon dioxide gas content decreased by 14.38% (figure 2). The increase in methane gas levels in various variations indicates that pumice is able to absorb carbon dioxide gas, while the effect of biogas flow rate is the greater the biogas flow rate, the ability of carbon dioxide to react with pumice is shorter in time so that only a small portion of carbon dioxide gas can be absorbed by pumice.

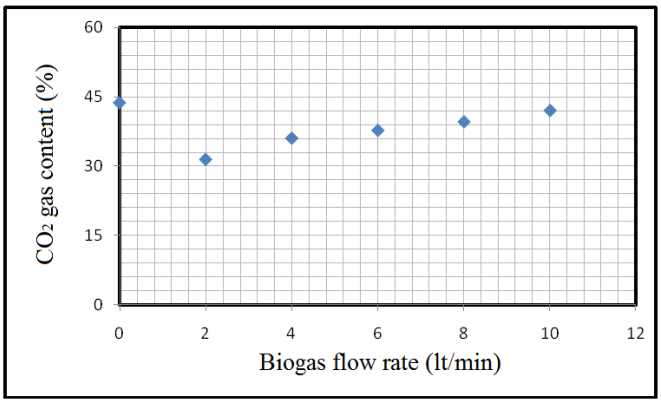

Fig 1: The relationship between biogas flow rate and CO_2 gas content

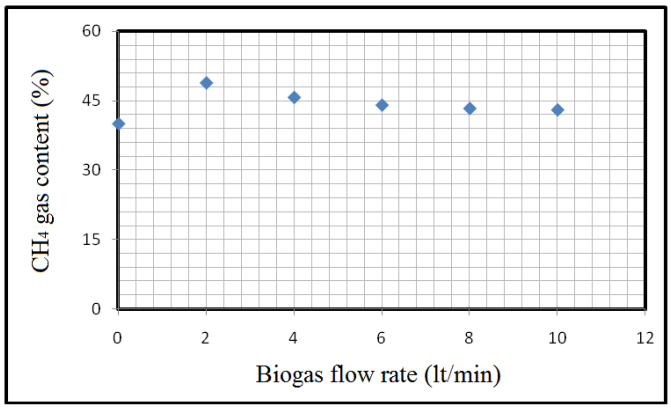

Fig 2: The relationship between biogas flow rate and CH_4 gas content

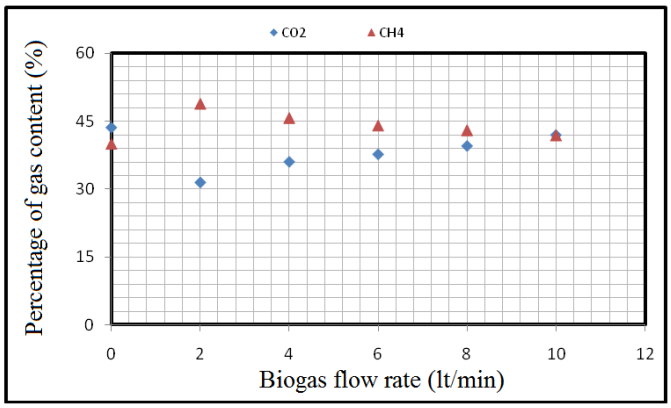

Fig 3: The relationship between biogas flow rate and the percentage of gas content

At a biogas flow rate of 2 lt/min, it shows the greatest increase in methane gas content, which is 22.25%, while carbon dioxide gas content decreases by 27.83%. The increase in methane gas levels is due to a decrease in carbon dioxide gas levels, so that it has an impact on increasing methane gas levels even though methane gas does not react with pumice. The reduced concentration of CO_2 as a result of the reaction with pumice will have an effect on the ratio of the concentration of CH_4 to CO_2 to be greater for the concentration of CH_4 (figure 3).

IV. Conclusion

The conclusion that can be drawn from the results of this study is that pumice can be considered less good at absorbing carbon dioxide, it can be seen that the carbon dioxide level is still quite high at 31.54% even though the flow rate of biogas that passes through it is at the lowest flow rate of 2 liters/minute. followed by methane gas content ranging from 48.84%.

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