Global Scientific JOURNALS

GSJ: Volume 8, Issue 9, September 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

THE EFFECT OF REFINED BIOGAS ON THE PERFORMANCE OF COMBUSTION ENGINE BASED ON LIMESTONE SEDIMENT ADSORBER

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KeyWords
biogas, $Ca(OH)_2$, performance, carbondiokasi, engine, SFCE

ABSTRACT

The purity of CH_4 produced from biogas is a very important consideration, this has an effect on the resulting calorific value. So that the CH_4 produced can be purified against CO_2. The presence of CO_2 in biogas is very undesirable, this is because the higher the CO_2 level in the biogas, the lower the calorific value of the biogas and it is very disturbing in the combustion process. This research will be conducted with CO_2 levels using $Ca(OH)_2$ media or limestone sediment. Limestone sediment are reacted with CO_2 by flowing biogas with 3 variations of flow rates, namely 5, 10 and 15 l/minute into the limestone sediment. The variable to be studied is the effect of using biogas that has been purified with various treatments on the performance of the combustion motor at engine speed of 1500, 2500, 3500 and 4500 rpm. The results showed that the most economical use of biogas was obtained from purification of variation 2, namely an average of 0,235 kg / hour. Increasing the greatest effective power obtained in variation 2 with an average increase of 20,7% of the unrefined biogas. In the variation, it was found that the average SFCE reduction against unrefined biogas was 32,3%.

INTRODUCTION

One of the alternative energies 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 in the existence of organic materials being considered as future energy in the context of realizing green technology (green technology). Biogas is a product of green technology that is currently being developed. This is because the gas produced from biological processes (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, what is used is methane gas (CH_4), because CH_4 has a calorific value / heat which can be used as fuel. Microbiological degradation of organic materials in 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 [4].

In livestock areas, livestock (horse) manure has not become an important concern of farmers. It can be seen from the large amount of unkempt dirt piling up next to the cage or just dumping it into the river. As a result, many problems arise which are caused by livestock manure such as rivers becoming shallow, destroying the view and unpleasant smells, damaging river ecosystems because river plants will grow wild, reducing oxygen levels in the water, coupled with germs carried by feces. the. During the rainy season, the dirt that is scattered next to the cage will be carried away by rainwater that flows to the lower area. As a result, the germs that are in the dirt will cause the entry of germs.

With the use of livestock (horse) manure as an alternative energy producer (biogas) by means of anaerobic degester fermentation, it can reduce the environmental impact caused by horse manure waste. In addition, biogas energy will be produced as a substitute for fuel oil, where the current energy crisis has begun to hit the world so that solutions are needed to meet the needs of fuel oil, as well as cold fertilizers that are ready to be used as plant fertilizer and no longer smell.

This 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. For example carbon dioxide (CO_2), this CO_2 level in biogas ranks second after CH4 and the percentage is approximately 40%. Where it is known that the element CO_2 is the result of combustion and if this element is present in combustion, it will interfere with the combustion process itself. Therefore, efforts are needed to reduce CO_2 levels which are expected to increase the quality of biogas.

The purity of CH_4 produced from the biogas is a very important consideration, this is because it affects the calorific value / heat produced. So that the CH_4 produced needs to be purified against other impurities. In this case the impurity that affects the heating value is CO_2, the presence of CO_2 in CH_4 gas is very undesirable, this is because the higher the CO_2 level in CH_4, the lower the heating value of CH_4 and very disturbing in the combustion process. This causes the purity of CH_4 to be low.

To reduce the CO_2 level, it can be done by passing biogas into $Ca(OH)_2$ so that the absorption process occurs. CO_2 gas immediately reacts with $Ca(OH)_2$ while CH_4 does not. By reducing the concentration of CO_2 as a result of the reaction with $Ca(OH)_2$, the ratio of the concentration of CH_4 to CO_2 is greater for the concentration of CH_4. In this study, a comparison between calcium monoxide and water was used, namely 778 grams of CaO and 250 grams of water, then the two were mixed to form 1028 grams of $Ca(OH)_2$ in the form of a paste.

CO_2 gas in biogas needs to be eliminated because it can reduce the heating value of biogas combustion. In addition, the carbon dioxide (CO_2) gas content in biogas is quite large at around 30-45% so that the heating value of biogas combustion will be reduced considerably. The heating value of pure methane gas combustion at a pressure of 1 atm and a temperature of 15,5^{o}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].

Purified biogas by using $Ca(OH)_2$ solution, biogas purification was carried out by using absorbent concentration variation, namely $Ca(OH)_2$ solution 0,1; 1,5 and 2,5 M. Gas chromatography test results showed gas after filtered is 100% of the area, whereas before refining methane gas is 82,46% of the area [2].

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 [3].

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 gascromatography test equipment. The main component contained in coconut shell ash contain 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].

Research Methods

The method used in this research is experimental method. This type of research can be used to test a new treatment or design by comparing one or more test groups with treatment and without treatment.

In this research there are two kinds of variables being measured, namely:

- The dependent variable.

  The dependent variable is the variable that is the main concern of the researcher, by analyzing the dependent variable it is hoped that the answer or solution to the problem can be found. The dependent variables in this test are:

  1. Torque
  2. Power effective
  3. Specific effective fuel consumption (SFCE)

- Independent variables

  Independent variables are variables that affect the dependent variable. As for the independent variables in this study, namely:

  1. Biogas purification is carried out in 3 variations, namely with a biogas flow rate of 5, 10 and 15 l / min which is then passed into $Ca(OH)_2$.
  2. The engine speed used is 1500, 2500, 3500 and 4500 rpm.
  3. The fuel used is biogas that has been purified and then compared with biogas that has not been purified at the same engine speed and the biogas is injected through the intake manifold.

The main ingredients needed in this study are

- livestock manure (horse), then mix livestock manure (horse) with water with a ratio of 1: 1, stirring until dissolved. The mixture is put into a storage tank (digester).
- The absorber is used $Ca(OH)_2$ by using the above mole fraction ratio, a mixture of purifying ingredients is obtained, namely 778 grams of CaO with 250 grams of H_2O then both are mixed into $Ca(OH)_2$ as much as 1028 grams in the form of a paste.
- Conversion kit
- Fuel motor test equipment

The research was continued with the process of absorption of biogas with $Ca(OH)_2$ media or limestone deposits, then reacted with CO_2 by passing biogas with various variations in flow rates into $Ca(OH)_2$. Furthermore, testing the performance of the combustion motor is by injecting biogas into the engine through the intake manifold with the help of a conversion kit, then continued by recording the amount of braking force and fuel consumption for two minutes for various variations of engine speed, this is done for unrefined biogas. and purified biogas. The series of engine performance testing equipment (conversion kit) is as follows,

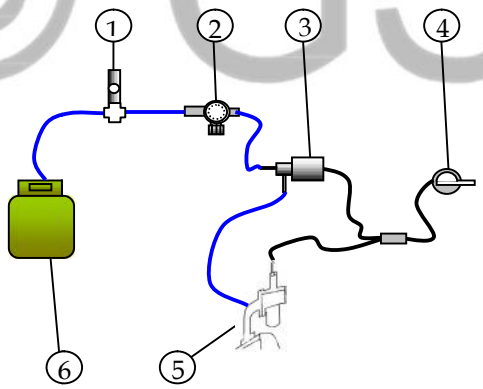

Figure 1. Conversion kit equipment. 1. flow meter, 2. valve regulator, 3. throttle valve, 4. gas regulating on the engine (gas pedal), 5. intake manifold, 6. purified biogas in the tube

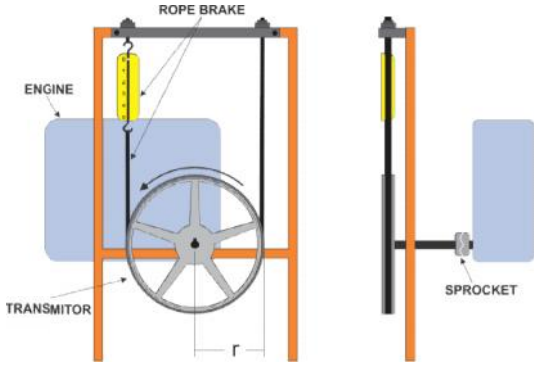

Figure 2. Installation of combustion engine testing

The specifications of the equipment used in this study are shown in table 1.

Name	Specifications
Combustion engine	100 cc
Spring balance	0 - 30 kg
Pulley radius	15 cm
Flowmeter	0 - 30 lt/min
Biogas purifier	Coconut shell ash

Table 1. Equipment and materials

Results and Discussion

Based on the research data, it shows that the level of CO_2 in the unrefined biogas is still large at 49,7% while the methane gas content is 49,5%. This causes the efficiency of the heat produced is still low so that the quality of the biogas flame is still not optimal. To reduce CO_2 levels, this is done by passing the biogas into $Ca(OH)_2$ with the biogas flow rate being varied so that the absorption process occurs. CO_2 gas immediately reacts with $Ca(OH)_2$ while CH_4 does not. By reducing the concentration of CO_2 as a result of the reaction with $Ca(OH)_2$, the ratio of the concentration of CH_4 to CO_2 is greater for the concentration of CH_4.

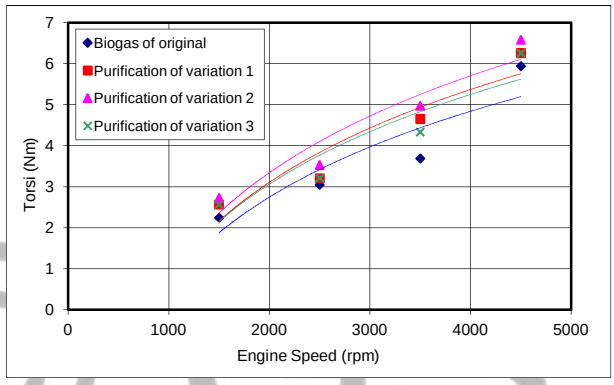

Figure 3. The relationship between engine speed and torque

Figure 3 shows that the torque generated by the engine increases with increasing engine speed. This situation arises as a consequence of the braking force used to counter the centrifugal force of the rotating engine shaft which is getting bigger along with the increasing changes in engine speed. This is followed by the increasing engine speed of a combustion motor which will have an impact on the greater braking force needed to counter the centrifugal force of a rotating engine shaft. In practice, the torque from the engine is useful for overcoming obstacles when the road vehicle is climbing, or when it speeds up the vehicle (automotive), while in the electric generator it is useful for overcoming obstacles when the power load increases.

Meanwhile, the more methane concentration in the biogas, the greater the torque produced. This situation can occur because biogas with a large concentration of methane gas has a large heating calorific value, so that the centrifugal force that occurs on the engine shaft that arises as a result of the fuel combustion process will also be large. In this study, biogas with the largest concentration of methane gas was obtained in the purification of variation 2 with a methane gas concentration of 91% followed by variation 1, the concentration of methane gas was 76,2%, then variation 3 obtained a methane gas concentration of 72% and unrefined biogas obtained a gas concentration. methane amounted to 49,53%.

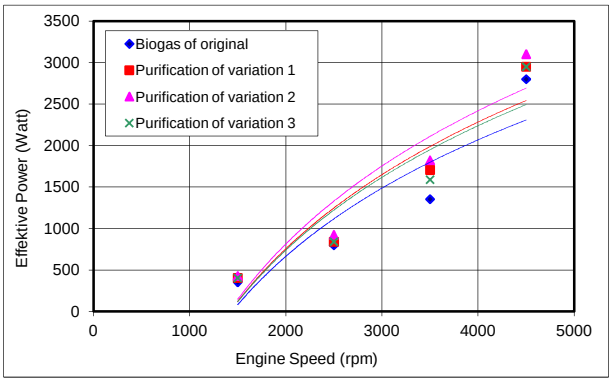

Figure 4. Relationship between engine speed and effective power

Figure 4 shows that the effective power generated by the engine increases with increasing engine speed and engine torque. Biogas with a large concentration of methane gas has a large heating calorific value, so that the centrifugal force that occurs on the engine shaft caused by the fuel combustion process will also be large. The greater the centrifugal force, the greater the torque that occurs. Meanwhile, effective power has a close relationship with torque. If the torque is multiplied by the crankshaft rotation (engine speed), the shaft power or effective power will be obtained. So that if the torque of an engine increases in size, the effective power that occurs will indirectly increase as well. In this study, biogas with purification variation 2 obtained an increase in the average effective power against unrefined biogas by 20,7%, followed by variation 1, it was obtained an increase in the average effective power of 12,8%, then variation 3 obtained an increase in the effective power by an average of 10,6%. .

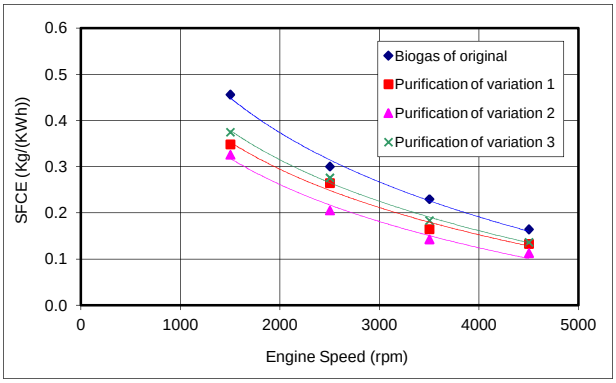

Figure 5. Relationship between engine speed and specific fuel consumption effective (SFCE)

The effective specific fuel consumption required by the engine decreases with increasing engine speed, this occurs because the higher the engine speed, the fuel consumption used per hour to produce each kW of shaft power or less effective power. Figure 5 shows that the more methane concentration in the biogas, the smaller the required SFCE. This occurs because biogas with a large concentration of methane gas has a large heating calorific value, so that the fuel consumption used per hour to produce each kW of shaft power or effective power is getting less. In this study, biogas with purification variation 2 obtained an average SFCE reduction of unrefined biogas by 32,3%, followed by variation 1, it was obtained an average SFCE reduction of 20,8%, then variation 3 obtained an average SFCE reduction of 15,8%.

Conclusion

The largest increase in effective power was obtained in biogas with purification variation 2 with an increase in the average effective power against unrefined biogas by 20,7% which was followed by variation 1, obtained an increase in the average effective power of 12,8%, then variation 3 obtained an increase in the average effective power. an average of 10,6%. In this study, biogas with purification variation 2 obtained an average SFCE reduction of unrefined biogas by 32,3%, followed by variation 1, it was obtained an average SFCE reduction of 20,8%, then variation 3 obtained an average SFCE reduction of 15,8%.

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