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Comparison Emission and Fuel Consumption of Engine of 6000 Watts Electric Generator Fuelled with Biogas and Gasoline

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Abstract.
The electric generator with a capacity 6000 watts was prepared in this research to be able to be fuelled with flexible fuel. The engine in this generator was 4 strokes engine, single cylinder of 4 stroke spark ignition engine with cylinder volume of 420 cc that can be operated fully with biogas and if biogas is not available, the engine can also be run by using gasoline with an easy switch mechanism. The method developed in this research was different from the idea of dual-fuel which was the fuel was mixed. Two types of Biogas are prepared in this research, type 1 biogas was purified from H2S and H2O, and type 2 of biogas was purified from CO2, H2S, and H2O. The gasoline type that was used in this work was the pertalite with a research octane number (RON) was 90. The engine was run with no load (idle position) and with a load 250 watts and the effect on emission and fuel consumption were recorded and analyzed. The result indicates that the average fuel consumption of using biogas type 1 is about 44.24 L/Minute in idle position and increases to become 45.35 L/minute with load 250 watts. For biogas type 2 the fuel consumption is found about lower, that is 43.76 L/Minute in idling position and increase to reach 45.04 L/minute for with load 250 watts.It is noted here that by using gasoline the fuel consumption is 0,023 L/ Minutes in idle position and a little bit increase to become 0.024 L/minute for 250-watt load. The CO emission is found at 3.91 % vol. for gasoline engine in idle position and reduce a little bit to become 3.5 % vol. with load 250 watts. The emission is found excellent if biogas is used as a fuel comparing gasoline. For biogas type 1, the CO emission is found 0.06 % vol. in idle position and just a bit increase to become 0.07 % vol. if loaded at 250 watts. The best performance is found for biogas type 2 that the CO emission is found 0.04% vol. and still in this value at loading 250 watts.

1. INTRODUCTION

Over time fossil fuels such as oil, gas, coal. Sources of fossil fuels such as fuel oil, in particular, will soon run out, no later than the end of the XXI century. Experts predict that natural gas will run out in about 100 years, and coal reserves will be exhausted in 200 to 300 years. The three types of fossil fuels are categorized as energy that is not environmentally friendly because their levels of pollution are quite high. If the level of CO_2 in the air increases, this causes the temperature of the air to increase, causing some of the ice in the North Pole to melt and sea level to continue to rise which will gradually result in major flooding in cities located on the coast [1].

There are various sources of alternative energies, including biogas, which is formed through the fermentation process of organic waste materials, livestock manure, organic waste, and other materials by methanogenic bacteria in anaerobic conditions [2]. If there is no processing of waste and animal waste, methane gas that comes from decomposition will be in vain to pollute the earth's atmosphere without being utilized. Each methane gas released is equivalent to the release of 21 times carbon dioxide (CO_2) and is included in the greenhouse gas. From this point of view, it can be concluded that biogas technology is considered environmentally friendly technology if it is maximally utilized [3].

Biogas energy is familiar to developing countries. Biogas is developed through the integrated agricultural system program, which is implemented in the developing countries to improve the agricultural system in the region, but the biogas product is not utilized optimally by farmers. As environmentally friendly energy, currently biogas is only used for cooking purposes [4]. The need for electrical energy is currently the primary need for modern society. Thus, one of the uses of biogas is by using biogas as fuel to generate electricity from a generator set (genset). A generator set (genset) is a device that functions to generate electrical power. Referred to as a generator set with the meaning of a combined set of equipment from two different devices, namely the engine and generator or alternator [5].

Biogas is a gas produced through the fermentation of organic materials by anaerobic bacteria (bacteria that live in airtight conditions). These bacteria are present in all types of organic material that can be processed to produce biogas. Homogeneous organic matter (solid, liquid) such as animal dunk and urine of livestock are suitable for simple biogas systems [6]. Biogas contains methane (CH_4), carbon dioxide (CO_2), hydrogen sulphide (H_2S), ammonia (NH_3). Methane (CH_4) is a gas that is considered as a useful fuel. This gas is non-toxic, odourless, and lighter than air. Carbon dioxide (CO_2) is a gas that is colourless, odourless and heavier than air. CO_2 is a rather toxic gas. Higher CO_2 concentrations in biogas produce biogas with lower heating values. Hydrogen sulphide (H_2S) is a colourless gas. Because heavier than air (H_2S) it is dangerous in low places. At low concentrations, this gas has a special odour like rotten eggs. Ammonia (NH_3) gas emissions result from combustion (NOx). Generally, the concentration (NH_3) in biogas is low. Water vapour, although a harmless substance, will become corrosive when combined with (NH_3), (CO_2), and especially (H_2S) from biogas. The maximum water content in biogas is developed due to the temperature of the gas. When the saturated aqueous biogas leaves the digester, cooling will result in the condensation of water [7].

In this work, a generator engine that is capable of using flexible fuels / two different fuels in one engine unit was developed. The capacity of the engine is prepared to be able to provide 6000 watts of electricity. The fuels were biogas or gasoline. When the biogas fuel has not available, the engine can still be operated using its original fuel (gasoline) or vice versa. The emission, as well as fuel consumption of the engine, was be studied.

2. EXPERIMENTAL

Mixer flexible fuels component is prepared to mix biogas fuel with air as presented in schematic in Fig. 1 theand directed the inlet of carburettor and intake manifold so that the engine can operate using biogas fuel that has been purified from carbon dioxide (CO2), hydrogen sulphide (H2S), and water vapour (H2O). Modifying the engine by increasing the compression pressure, and changing the ignition with a change in the valve gap in the engine will not be enough to make the engine operate using biogas fuel, because biogas fuel requires optimal mixing of air and pressure so that biogas can burn in the chamber of the engine. Therefore, this flexible mixer is made to make it easier for the biogas fuel to mix with air and flow the biogas into the combustion chamber with optimal pressure so that the biogas can burn in the compression step and the machine can work using biogas fuel as shown in Fig. 1.

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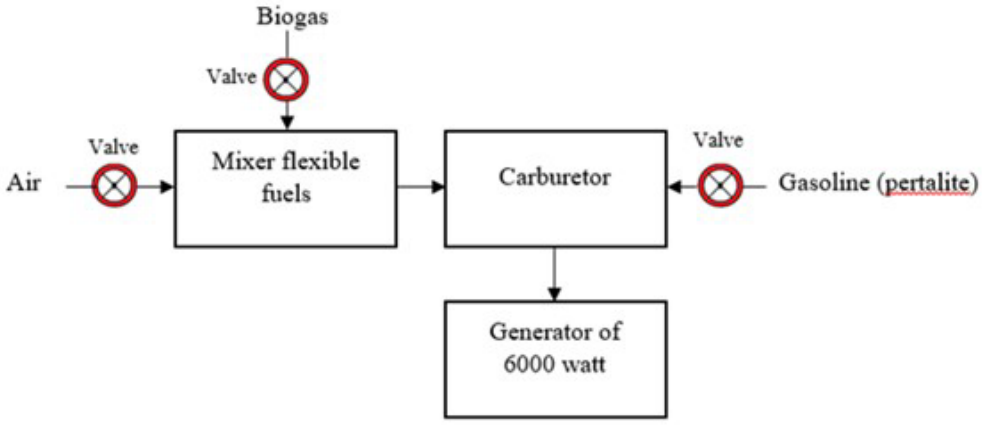

FIGURE 1. Schematic of flexible fuels mixer

Biogas was taken at the same time so that the composition of the biogas is the same. Desulfurizer is used to purify biogas from H_2S (hydrogen sulfide) impurity. CO_2 remover is used to purify biogas from CO_2 impurity. Calcium chloride is used to purify biogas from H_2O contained in biogas. The Biogas bag serves to accommodate biogas that has been purified from impurity gases, the volume meter is used to measure the volume of the biogas flow that enters the biogas storage bag with an accuracy of $0.001 m^3$.

Two types of iogas are prepared in this research, type 1 biogas was purified from H2S and H2O, and type 2 of biogas was purified from CO2, H2S, and H2O. The gasoline type that was used in this work was the pertalite with a research octane number (RON) was 90. The engine was run with no load (idle position) and with a load 250 watts and the effect on emission and fuel consumption were recorded and analysed.

A multi gas detector is a tool for measuring gas content. Carburettor and flexible fuels that serve as a mixing place for biogas or gasoline with air. The schematic of the equipment for the research is shown in Fig. 2.

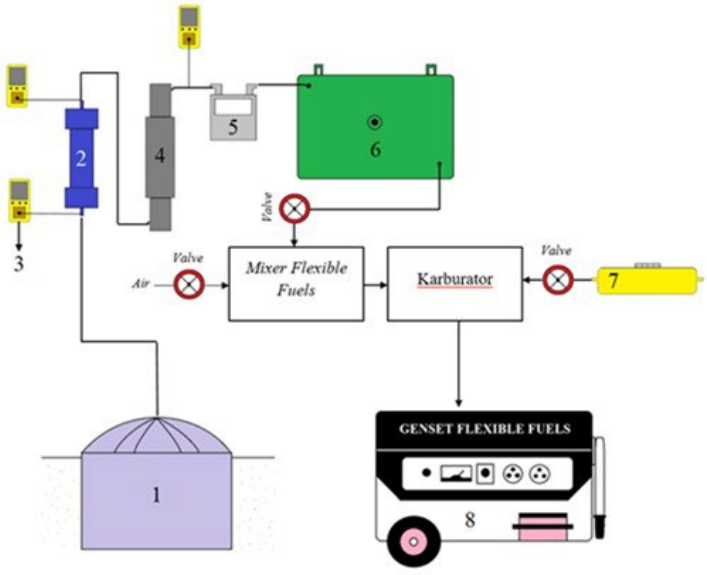

FIGURE 2. Research installation. 1. Digester, 2. Desulfurizer, 3. Multi-gas detector, 4. CO_2 remover, 5. Volume meter, 6. Biogas bag, 7. Fuel tank, 8. Electric generator

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3. RESULT AND DISCUSSION

Table 1 shows the results of the test for the consumption of each fuel. The value was taken from a 3-time sample repetition test and average value was taken. Furthermore, in Table 2, the results of the exhaust gas emissions of each fuel are shown.

TABLE 1. Results of fuel consumption of test from each fuel

Fuel type	Fuel consumption (L/minutes)	
	Idle position	Loaded with 250 watt
Gasoline (pertalite)	0.023	0.024
Biogas purified H_2S, H_2O	44.24	45.35
Biogas purified H_2S, H_2O, CO_2	43.76	45.04

TABLE 2. Results of fuel consumption of test from each fuel

Fuel type	Emission			
	Idle positionn		Loaded with 250 watt	
	CO (%vol.)	HC (ppm)	CO (%vol.)	HC (ppm)
Gasoline (pertalite)	3.91	53	3.5	54.34
Biogas purified H_2S, H_2O	0.06	17.3	0.07	22
Biogas purified H_2S, H_2O, CO_2	0.04	17	0.04	15.4

For table 1 regarding the fuel consumption, it is found that the best (low) fuel consumption of the three different fuel variations is found in gasoline (pertalite) without loading with a value of 0.023 L/min, then followed by gasoline (pertalite) with a value of 0.024 L/min. Meanwhile, the highest fuel consumption results are found in biogas fuel which is purified from H_2S, H_2O with loading with a value of 45.35 L/min. This is because when the generator engine operates, it does not emit power, which causes fuel consumption better than that given the load [8]. The resulting fuel consumption is strongly influenced by the calorific value of each fuel. For biogas, the resulting calorific value is between 4800-6200 kcal / m^3, while the calorific value of pure methane gas reaches 8900 kcal / m^3, and for gasoline (pertalite) the resulting calorific value is 44260.12 kj / kg [9].

In table 2, were testing the exhaust emission produced by biogas fuel without loading is also better than biogas fuel with loading with a value of CO = 0.06% and for HC = 17.3 ppm. The same results for biogas fuel with both loading and without loading, namely having the same level of 0.04% CO, and for the HC level biogas with loading got better results, namely 15.4 ppm. And the results of exhaust gas emissions from gasoline with loading get a better CO level, namely 3.50%, while at the HC level, gasoline without loading also gets better results, namely 53 ppm.

The variation in loading of 250 watts and without loading on each fuel, shows a decrease compared to that is obtained when using a load of 250 watts to turn on the generator. That is because the generator needs to maintain its rotation speed so that the voltage on the generator can be stable. With a load of 250 watts, this generator generates 4.1% more power than without loading [10]. This causes a significant difference in the biogas fuel that has been purified by H_2S, H_2O, and biogas purified by H_2S, H_2O, and CO_2 which has the lowest heating value.

In this work, the desulfurizer is made based on a waste of iron chips [11]. For future work, other methods such as using the waste of zing from zinc-carbon battery [12] will be installed. Desulfurization is important to reduce acidity in the lubricant of the engine for acidity [13]. The biogas that is used in this work is by putting in the biogas bag which is no pressure and the intake was based on the suction of the piston. Future work will be considered to put the biogas in the compressed cylinder with activated carbon also filled inside the cylinder for adsorbed natural gas (ANG) technique [14-18]. This work uses biogas from the traditional fixed dome type of continuous digester with cow dunk as substrate. For better quality of biogas, a new improvement should be introduced for future work [19-22]. This research is

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addressed for the biogas with methane composition above 50% vol. If the methane composition in the biogas is below 50% vol., the method that is suggested should lead to our previous publication [23]. The engine in this work is designed based on 4 stroke engine [23]. Therefore, it will not work for 2 stroke engine. For 2 strokes engine, the engine design should be developed differently as can be seen in our previous publication [24].

4. CONCLUSION

Based on the results of fuel consumption and exhaust gas emission testing on biogas fuel that is purified H_2S, H_2O, biogas purified by H_2S, H_2O, and CO_2, and also gasoline (pertalite) in a 6000 watts electric generator that has been converted into flexible fuels, it can draw the following conclusions: the average fuel consumption of using biogas type 1 (purified from H2S and H2O) is about 44.24 L/Minute in idle position and increases to become 45.35 L/minute with load 250 watts. For biogas type 2 (was purified from CO2, H2S, and H2O.) the fuel consumption is found about lower, that is 43.76 L/Minute in idling position and increase to reach 45.04 L/minute for with load 250 watts. It is noted here that by using gasoline the fuel consumption is 0,023 L/ Minutes in idle position and a little bit increase to become 0.024 L/minute for 250-watt load. The CO emission is found at 3.91 % vol. for gasoline engine in idle position and reduce a little bit to become 3.5 % vol. with load 250 watts. The emission is found excellent if biogas is used as a fuel comparing gasoline. For biogas type 1, the CO emission is found 0.06 % vol. in idle position and just a bit increase to become 0.07 % vol. if loaded at 250 watts. The best performance is found for biogas type 2 that the CO emission is found 0.04% vol. and still in this value at loading 250 watts.

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