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Performance Test of Diesel Power Generation Machine Using Biodiesel Fuel and Brown Gas

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ABSTRACT

The use of diesel fuel has an important role in reducing greenhouse gas emissions and supporting renewable energy. Biodiesel, which is similar to conventional diesel fuel, is considered a promising alternative fuel for diesel engines. I carried out tests by adding biodiesel and brown gas (HHO) to diesel fuel in a diesel power plant. I tested the mixture at 10%, 15% and 20% at loads of 100 watts, 200 watts, 300 watts, 400 watts and 500 watts. Based on this research, the author obtained test results for the highest effective power value produced when using B0_HH0 fuel of 239.05 watts and the highest torque value produced when using B0_HHO fuel of 1.79 N.m at a loading of 500 watts.

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1. INTRODUCTION

Energy plays a crucial role and is a strategic [1] factor in the development and growth of a country's economy. Its role is inseparable from people's daily activities. One form of energy that supports economic growth and public welfare is heat energy. Heat energy can be obtained from several sources, one of which is petroleum.

Dependence on fossil fuels [2] will pose future problems. The demand for oil leads to a dwindling supply of natural resources. Therefore, efforts are needed to address the issue of oil depletion. A viable solution to reducing oil use is to transition to alternative energy sources [3]. This transition can be achieved by starting the use of biodiesel.

Biodiesel [4] is an alternative fuel [5] derived from plants and is environmentally friendly [6]. One plant-based material that can be used to make biodiesel is oil obtained from plants. Indonesia has a diverse range of plants, therefore, the potential for energy independence in Indonesia is possible. However, besides plant-based materials, energy can also be obtained from waste. One such waste that can be used is used cooking oil.

Biodiesel has several advantages as an alternative fuel for diesel engines [7]. One advantage of biodiesel is that it requires no engine modifications, as its physical properties are similar to those of fossil-based diesel fuel. Diesel fuel in Indonesia is divided into several types [8]. The types available and commonly used by the public include biosolar, dexlite, and Pertamina dex. Each type of diesel fuel has different physical and chemical properties, efficiency, and exhaust emissions during combustion. Therefore, further research is needed on the types of diesel fuel currently available to provide information and ensure energy security [9].

Used cooking oil is sourced from vegetable oil, namely palm oil [10]. Processed and refined palm oil is converted into cooking oil, which is used to produce food. However, used cooking oil is currently a form of waste because it cannot be reused for food processing. Furthermore, used cooking oil, if disposed of in the environment [11], can disrupt the ecosystem . Therefore, efforts are needed to protect human health and the environment from the effects of used cooking oil.

The use of biodiesel in internal combustion engines [12] faces several challenges [13]. This is due to the physical properties of biodiesel fuel, which has a lower calorific value, higher density, and thicker

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viscosity than fossil diesel fuel. This has led to a need to mitigate the drawbacks of biodiesel use in diesel engines, which can impact engine performance. One possible approach is to add Brown's gas, commonly known as HHO. Testing of the HHO addition in diesel engines is necessary to obtain information and understand the impact of its use. This can certainly be achieved through further research.

Table 1. Biodiesel Specifications [14]

Specifications	Description
Flash Point	Minimum 52°C
Pour Point	Maximum -15°C
Kinematic Viscosity	2.4 - 3.5 mm^2/s at 40°C
Cetane Number	Minimum 51%
Water Content	Maximum 0.20%
Acid Content	Maximum 0.50 mg KOH/g
Carbon Residue	Maximum 10.00%
Glass Point	Maximum -15°C
Ash Content	Maximum 0.01%
Phosphorus Content	Maximum 0.005%
Metal Content	Maximum 25 ppm

Table 2. Biodiesel Standards (SNI 04-7182-2012) [4]

Test Type		**Standard**
Density at 40˚C	:	850 – 890 Kg/m^3
Kinematic Viscosity at 40˚C	:	2.3 – 6.0 Nm^2/s (cSt)
Cetane Number	:	51 Min
Flash Point	:	100 ˚C Min
Cloud Point	:	18 ˚C Max
90% Distillation Temperature	:	360 ˚C Max
Sulfated Ash	:	0.02 % mass Max
Sulfur Content	:	100 Mg/Kg Max
Phosphorus Content	:	10 Mg/Kg Max
Acid Number	:	0.6 Mg-KOH/g Max
Free Glycerol	:	0.02 % mass
Total Glycerol	:	0.24 % mass
Ethyl Ester Content	:	96.5 % mass Min

2. METHOD

This research was conducted using an experimental method. The experimental method aimed to determine the effects of the fuel composition used during testing to generate data on effective power, torque, and fuel consumption. The tests were conducted on a diesel engine used to generate electricity.

The load variation is in the form of electrical power. The power load is 100 watts, 200 watts, 300 watts, 400 watts, and 500 watts. The engine speed during testing is idle speed. The test results are in the form of effective power, torque, mass flow rate, specific fuel consumption, and thermal efficiency. The test scheme can be seen in Figure 1.

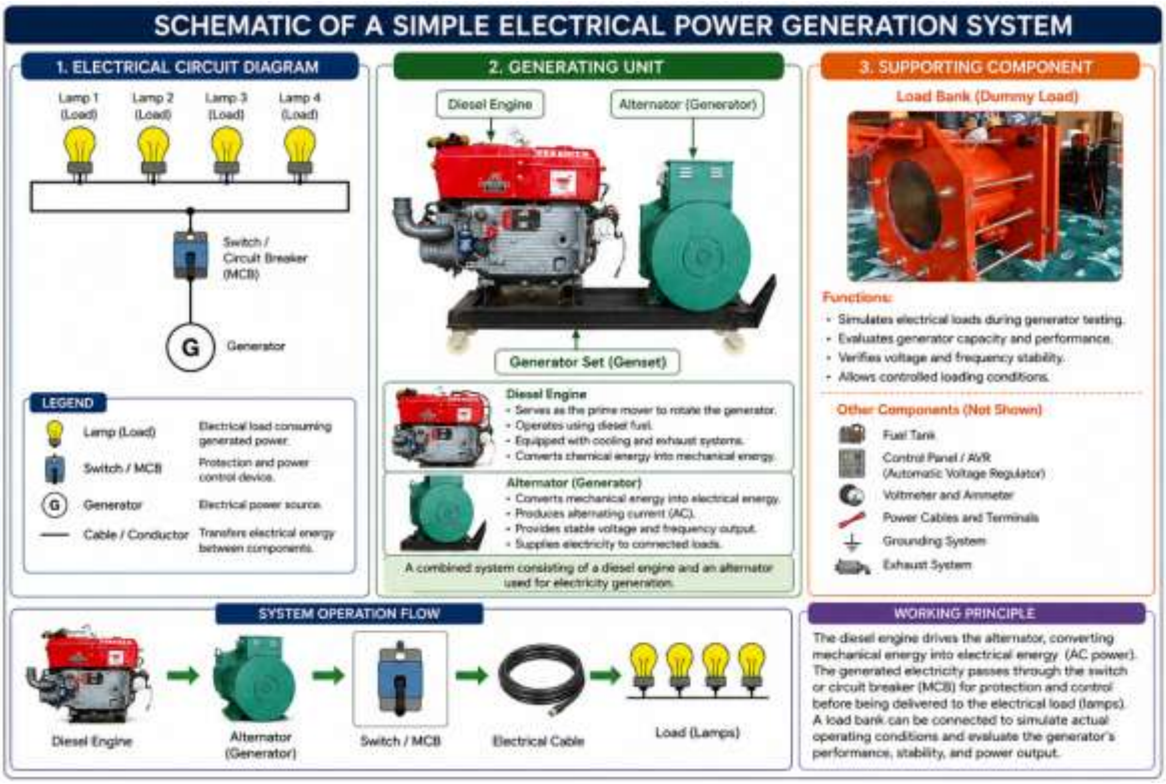

Figure 1. Testing Scheme

2.1 Research Flow Chart

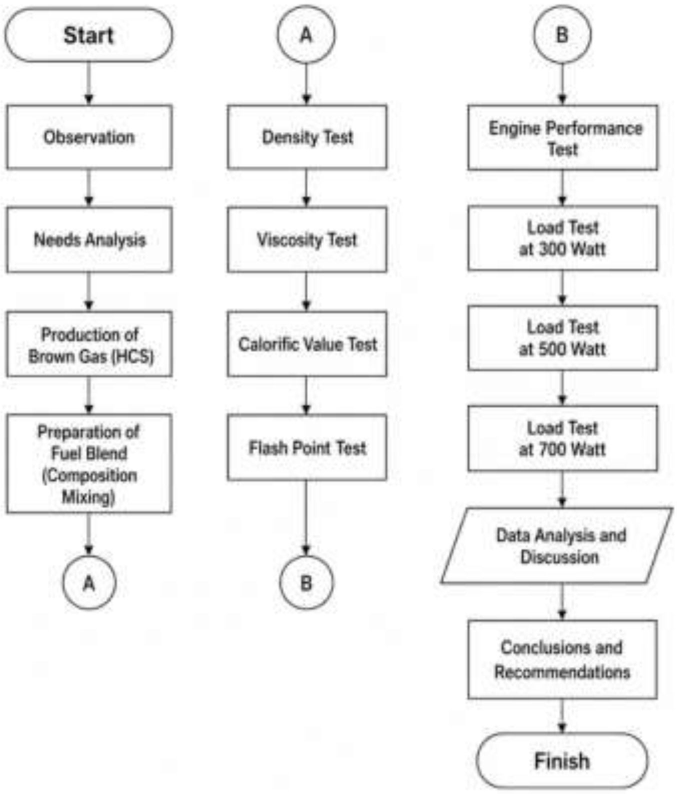

Figure 2. Flowchart

This research begins with an observation stage, which is conducted to identify existing conditions, potential problems, and opportunities for utilizing Brown Gas (HCS) as an alternative fuel source. Following the observation, a needs analysis is carried out to determine the required equipment, materials, and testing parameters necessary for the study.

The next stage involves the production of Brown Gas (HCS) through an electrolysis process designed according to the experimental requirements. Once the Brown Gas has been generated, it is blended with the base fuel during the fuel blend preparation stage, where specific fuel compositions are prepared for subsequent testing.

After the fuel blends are prepared, a series of fuel property tests are performed to evaluate their physical and chemical characteristics. These tests include a density test to determine the fuel density, a viscosity test to measure the fuel's resistance to flow, a calorific value test to assess the energy content of the fuel, and a flash point test to evaluate its ignition and safety characteristics.

Subsequently, an engine performance test is conducted using the prepared fuel blends. The engine is tested under different electrical load conditions, namely 300 W, 500 W, and 700 W. During each load test, various performance parameters such as fuel consumption, power output, engine efficiency, and operational stability are measured and recorded.

The experimental data obtained from the fuel property tests and engine performance tests are then processed and evaluated in the data analysis and discussion stage. This stage aims to determine the effects of Brown Gas addition on fuel characteristics and engine performance. The results are interpreted and compared to identify trends and performance improvements.

Finally, the study concludes with the conclusions and recommendations stage, where the main findings are summarized and recommendations are provided for future research and practical applications. Upon completion of these stages, the research process is considered finished.

Table 3. Fuel Composition

No.	Fuel Type			Code
	Biosolar (%)	Dexlite (%)	Biodiesel (%)	
1.	100%	0%	0%	B0
2.	100%	0%	0%	B0_HHO
3.	90%	0%	10%	B10_HHO
4.	85%	0%	15%	B15_HHO
5.	80%	0%	20%	B20_HHO

3. RESULTS AND DISCUSSION

Performance and fuel consumption tests on a diesel power plant using biodiesel and Brown's gas resulted in effective power data [15]. As observed in Figure 3, each fuel composition showed an increase. However, the resulting data differed for each fuel composition. The different effective power values can be caused by heavy loading and suboptimal combustion.

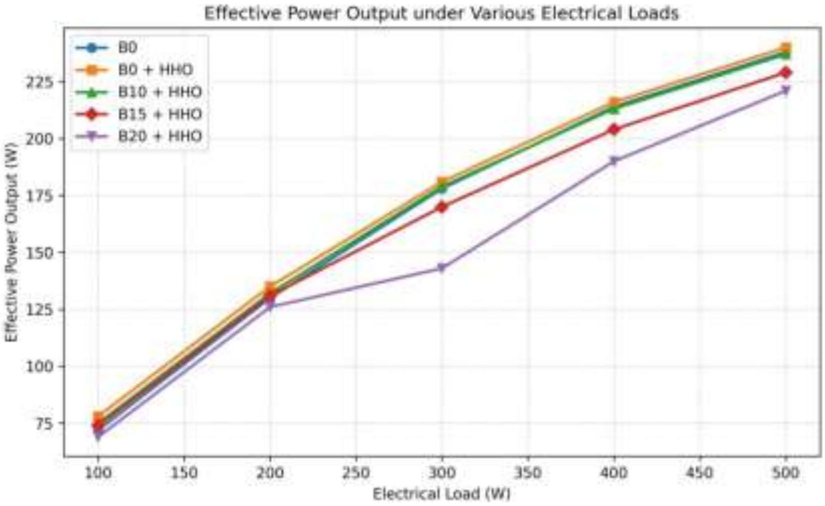

Figure 3. Effective Power Value

Tests using pure biodiesel fuel with the addition of HHO yielded high torque values [4]. In contrast, the resulting values tended to decrease with the addition of biodiesel. This is because increasing the amount of biodiesel added changes the fuel's characteristics. These characteristics include calorific value, density, viscosity, and flash point.

The addition of HHO in the test resulted in higher effective power values compared to using pure fuel. This is because the addition of HHO improves engine performance, particularly during the combustion process. Variations in effective power values can be attributed to the addition of biodiesel.

Figure 4 shows the results of performance and fuel consumption tests on a diesel power plant using biodiesel with Brown's gas produced. The highest torque values were obtained when using pure biodiesel fuel. Furthermore, the lowest torque values were obtained using fuel with 20% biodiesel added.

The addition of HHO Can Cause Differences in Torque Values. As observed in Figure 4, pure biodiesel fuel with the addition of HHO produces higher performance values compared to pure biodiesel fuel without the addition of HHO. The addition of HHO optimizes combustion in the combustion chamber, resulting in higher performance values.

Adding 10%, 15%, and 20% biodiesel to the fuel results in lower torque at each load increase compared to pure biodiesel fuel. This is because the high mass density makes combustion inefficient.

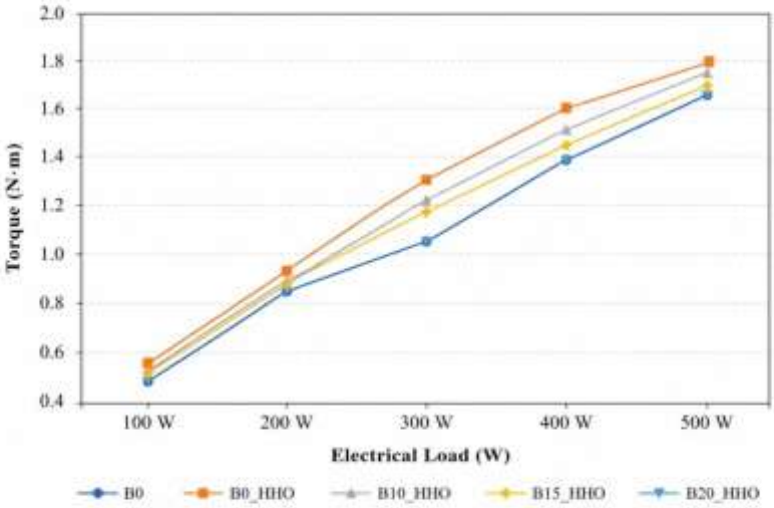

Figure 4. Torque Value

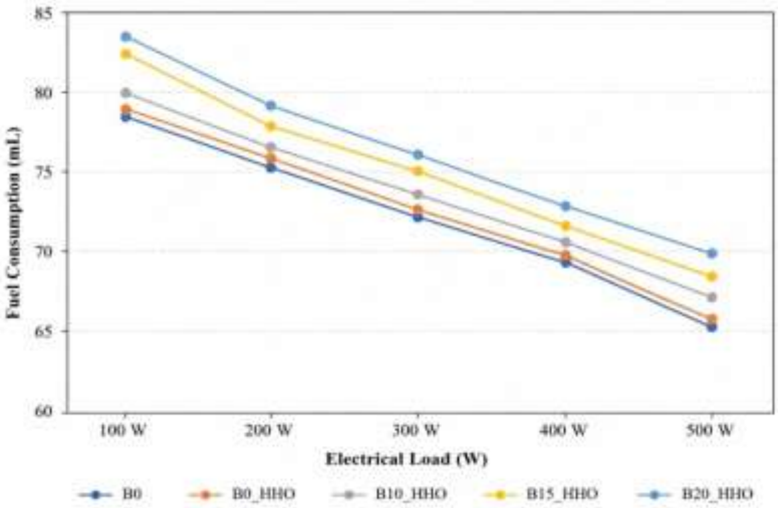

Figure 5. Fuel Consumption

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Performance and fuel consumption [16] tests on a diesel power plant using biodiesel and Brown's gas resulted in fuel consumption data. Figure 5 shows the longest fuel consumption at the beginning of the test. The fuel composition with the longest consumption [17] time was obtained when using biodiesel fuel mixed with biodiesel. The greater the biodiesel mixture, the longer the consumption time. This is in contrast to using pure fuel, which has a faster consumption time. Several factors contribute to the long fuel consumption time, including fuel characteristics. The greater the biodiesel addition, the higher the density. High density in the engine makes the fuel difficult to decompose.

4. CONCLUSION

Based on the test curves for biodiesel fuel, pure biodiesel with added HHO exhibited stable performance at 300 watts, 500 watts, and 700 watts. Meanwhile, biodiesel with 10%, 15%, and 20% biodiesel content experienced a decrease in output. It can be concluded that increasing biodiesel addition can decrease engine performance.

In the torque test, the highest value was achieved when using pure biodiesel with added HHO. The resulting data showed a steady increase at loads of 300 watts, 500 watts, and 700 watts. This is due to the low density and viscosity of pure biodiesel fuel, and the addition of HHO allows for optimal combustion. Fuel consumption testing was conducted to determine how long the fuel would last during the test. The longest consumption time was achieved when using the biodiesel blend at a load of 100 watts.

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