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Effect of Used Lubricant and Biodiesel Fuel Mixture on Exhaust Emissions in Modified Diesel Engines

Pengaruh Campuran Bahan Bakar Oli Bekas dan Biosolar Terhadap Emisi Gas Buang pada Mesin Diesel Modifikasi

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Abstrak

Laboratorium Produksi Jurusan Teknik Mesin Universitas Riau telah memodifikasi mesin diesel yang digunakan sebagai genset berbahan bakar oli bekas, permasalahannya adalah emisi gas buang yang dihasilkan yaitu opasitas melebihi baku mutu yang telah di tetapkan. Tujuan penelitian ini adalah mengetahui nilai kalor dari Campuran bahan bakar oli bekas dan biosolar, mengetahui hubungan antara daya yang dihasilkan dari mesin diesel sebagai genset dengan emisi yang dihasilkan. Penelitian ini dilakukan dengan cara pengukuran langsung emisi yang dihasilkan mesin diesel dengan menggunakan alat gas *analyzer*, dengan mengoperasikan mesin diesel selama 30 menit dan pengukuran emisi setiap 5 menit sekali. Penelitian ini juga memvariasikan beban daya, yaitu pada kondisi *idle* 0 W, 1000 W, dan daya maksimum sebesar 2000 W. Nilai kalor diuji dengan menggunakan alat *bomb calorimeter*. Hasil uji emisi dari mesin diesel modifikasi merek Dongfeng Model R175 yang menggunakan campuran bahan bakar oli bekas dan biosolar sebagai bahan bakar menunjukkan emisi CO, CO_2, HC dan Opasitas yang dikeluarkan rata – rata naik dengan seiring dengan lamanya waktu operasi dari mesin diesel dan emisi tertinggi terjadi saat daya sebesar 2000 W. Tingkat tertinggi untuk emisi CO sebesar 0,0161%, untuk emisi CO2 adalah sebesar 3,53%, untuk emisi HC sebesar 28,61 ppm, dan untuk opasitas sebesar 44,85 % pada bahan bakar B30 pada saat mesin beroperasi dengan beban daya 2000W. Nilai Opasitas bahan bakar variasi tersebut telah melebihi baku mutu yang telah di tetapkan sesuai dengan Lampiran 1 PERMEN LH No 5 Tahun 2005 sebedar 40 %, namun emisi dari variasi lain masih berada di bawah baku mutu.

Kata kunci: Emisi Gas Buang, Mesin Diesel, Oli Bekas Sepeda Motor, Biosolar, Daya Beban

Abstract

The Production Laboratory of the Department of Mechanical Engineering, University of Riau has modified the diesel engine used as a used oil-fueled generator, the problem is the exhaust gas emissions produced, namely the opacity exceeds the quality standard that has been set. The purpose of this study was to determine the calorific value of a mixture of used fuel oil and biodiesel, to determine the relationship between the power generated from the diesel engine as a generator and the emissions produced. This research was conducted by direct measurement of the emissions produced by the diesel engine using a gas analyzer, by operating the diesel engine for 30 minutes and measuring emissions every 5 minutes. This study also varied the power load, namely at idle conditions of 0 W, 1000 W, and a maximum power of 2000 W. The calorific value was tested using a bomb calorimeter. The emission test results from the Dongfeng Model R175 modified diesel engine which uses a mixture of used fuel oil and biodiesel as fuel show that the CO, CO_2, HC and Opacity emissions released on average increase with the length of operating time of the diesel engine and the highest emissions occur when power of 2000 W. The highest level for CO emissions is 0.0161%, for CO_2 emissions is 3.53%, for HC emissions is 28.61 ppm, and for opacity is 44.85 % for B30 fuel when the engine is running. operates with a power load of 2000W. The Opacity value of this variation of fuel has exceeded the quality standard that has been set in accordance with Attachment 1 of PERMEN LH No. 5 of 2005 by 40%, but emissions from other variations are still below the quality standard.

Keyword: Exhaust Emissions, Diesel Engines, Used Lubricants, Biosolar, Power Load.

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1. Introduction

The use of fossil fuels continues to increase, while the number of reserves is running low, prices are unstable tends to continue to increase) and issues that fossil fuels cause global warming and the causes of environmental damage have begun to be proven [1]. To eliminate the worst possible impact of using fossil fuels, the development of renewable energy sources is an alternative to fossil fuels. The potential of Indonesia's fossil fuels is very depleted, for example oil with reserves of 9.1 billion barrels and production of 387 million barrels/year, will only last 23 years, gas with reserves of 185.8 TSCF and production of 2.95 TSCF, will only last for 23 years. last 62 years and coal 146 years [2].

In order to overcome the depletion of fossil fuels and to reduce the effect of greenhouse gases, various technologies are being developed in many countries. Ways that can be done to reduce fuel scarcity and improve exhaust emissions include using alternative fuels and increasing thermal efficiency in power generator engines and automotive vehicles [3]. To reduce dependence on diesel, the Indonesian government stipulates regulations for the use of renewable energy sources, namely 20 percent vegetable oil to be mixed with diesel fuel, known as biodiesel or B20. Pertamina's biodiesel products must utilize 20 percent vegetable oil or biodiesel derived from palm oil [4].

Automotive workshops (cars and motorcycles) have some potential for hazardous and toxic waste (B3). Hazardous and toxic waste is a very dangerous waste, because it is corrosive, flammable, explosive, reactive, toxic, causes infection and is irritant [5]. Work activities in automotive repair shops involve many materials that contain this potential. One of them is the oil used in vehicle operation, maintenance and in the form of a repair process that will produce waste which is often called used oil. Lubricating oil waste contains a number of substances that can pollute the air, soil and water. Waste lubricating oil may contain metals, chlorine solution, and other contaminants. One liter of waste lubricating oil can destroy millions of liters of fresh water from underground water sources. If waste lubricating oil is spilled on the ground, it will affect groundwater and be harmful to the environment. This is because waste lubricating oil can cause the soil to lose nutrients [6].

Ways that can be done to reduce fuel scarcity include using alternative fuels. At the Production Technology Laboratory, Department of Mechanical Engineering, Riau University, research has been carried out that utilizes used oil as fuel by modifying a diesel motor with the trademark Dongfeng tpe R175 to be able to generate household-scale electrical energy using fuel that is utilized from used oil and carried out analysis of the resulting exhaust emissions [7].

Based on the results of previous studies, [8] the resulting Opacity (λ) exhaust gas emissions still exceed the quality standard after being compared with the Regulation of the State Minister of the Environment Number 05 of 2006 concerning Exhaust Emissions Thresholds for Old Motor Vehicles, so it is necessary to experiment with mixing used fuel oil and biodiesel. This research will determine the calorific value of a mixture of used oil and biodiesel. Then also find out the emissions released from the diesel engine exhaust by using a gas analyzer with the parameters seen are CO, CO_2, HC, and Opacity (λ) using used oil as fuel.

2. Materials and Method

2.1 Research preparation

The materials and equipment used in this study were biodiesel and used oil waste obtained from Argo Motor, an official Honda motorcycle repair shop located on Jalan H.R Soebrantas, Tampan District, Pekanbaru City, which were used as fuel for a modified diesel engine with the Dongfeng tipe R175 brand which has been modified which is used as a generator to generate electricity. The emission test tool that will be used in this research is the Gas Analyzer.

The heat test for each variation of the used fuel oil and biodiesel mixture was carried out at the Mechanical Engineering Conversion Laboratory, Riau University. Sampling of emission gases is carried out every 5 minutes for 30 minutes, which is then searched for the average value. The procedure for measuring CO, CO_2, HC, and Opacity (λ) gas emissions is carried out in accordance with SNI 09-7118.3-2005.

2.2 Research variable

The title should be clear and concise. Author's name and their affiliation as written above. The author's name is clearly written without a title.

2.3 Data Analysis and Research Results

This study aims to analyze CO, CO2, HC, and Opacity (λ) gas emissions released by diesel engines fueled with variations of used oil and biodiesel as well as identification data on the characteristics of used oil and biodiesel in the form of calorific values. The data of this research was processed using Microsoft Excel application and then compared with the Regulation of the State Minister of the Environment Number 05 of 2006 concerning the Threshold of Exhaust Gas Emissions for Old Motor Vehicles. The results of the study are in the form of a graph of the trend of increasing emissions released by diesel engines when operating. This research was conducted experimentally with variations in engine operating time with the power generated by the diesel engine and tested on the diesel engine to determine the amount of emission levels released when the diesel engine operates at each power for 30 minutes.

3. Results and Discussion

3.1. Calorific Value and Fuel Consumption

Based on the data from the calorific value test results from a mixture of used oil and biodiesel which were tested at the Mechanical Engineering Conversion Laboratory, Riau University using a bomb calorimeter as a calorific value test instrument, the data obtained in Table 1. is as follows.

Table 1. Fuel Calorific Value

Materials	Calorific Value
Bio Solar	54,453 J/kg
Used Lubricant	50,445 J/kg
90% Used Lubricant and Biosolar 10% mixture (B10)	47,725 J/kg
80% Used Lubricant and Biosolar 20% mixture (B20)	50,658 J/kg
70% Used Lubricant and Biosolar 30% mixture (B30)	59,974 J/kg

Table 1 shows the calorific value of the fuel to be used in this study, namely used oil and a mixture of biodiesel fuel used as fuel for a modified diesel engine, which aims to determine which type of fuel is better and provides more power. great on diesel engines. According to Ariani, et al (2019) explained that the calorific value contained in each unit mass of fuel [9]. The higher the calorific value of a fuel, the greater the energy contained in the fuel per unit mass. [15] explained that the calorific value of fuel determines the amount of fuel consumption per unit time. The higher the calorific value of the fuel, the less fuel it uses.

This shows that, the use of 70% used fuel oil and 30% Biosolar mixture (B30) as fuel for diesel engines produces more energy and also uses less fuel.

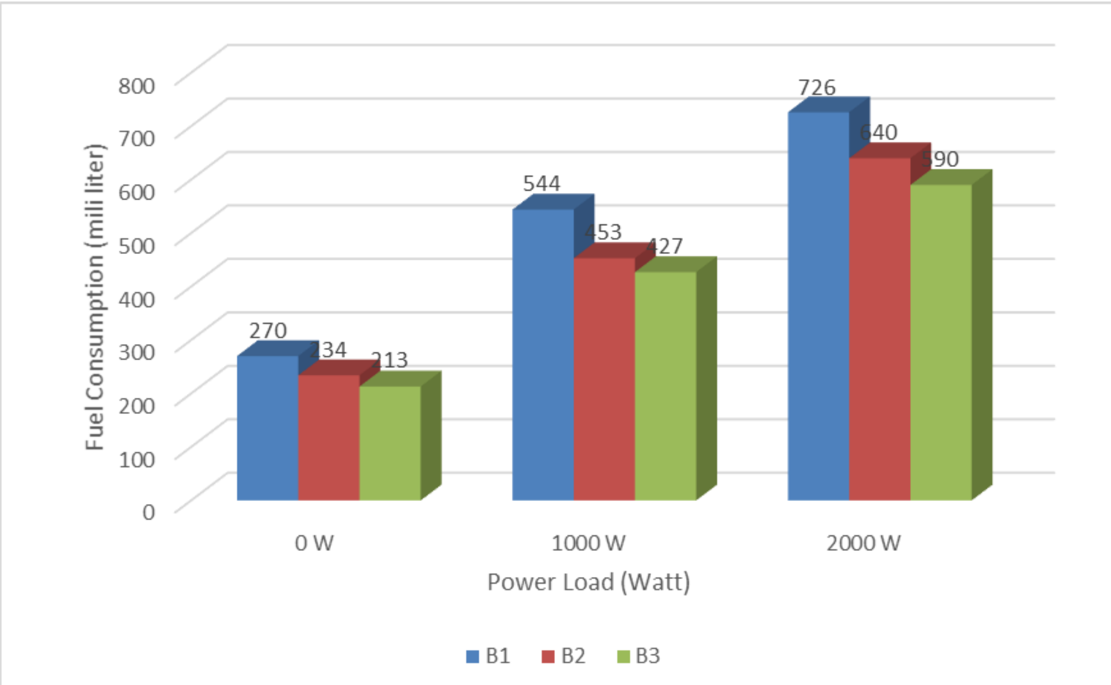

Figure 1. Fuel Consumption

In Figure 1. it can be seen that fuel consumption continues to increase along with the addition of the power load on the diesel engine. When the engine is operated in idle condition or operated without a power load (0 watts), fuel used is 213 ml at the percentage of B30 fuel while the highest fuel usage is 726 ml at the percentage of B10 fuel with a power load of 2000 W. Measurement of the amount of fuel consumption used. Measured using a measuring cup used as a fuel tank. Replacement of the fuel tank using a measuring cup aims to facilitate the measurement of fuel consumption used. This is due to the difference in the calorific value in each percentage, where the higher the calorific value of a fuel, the higher the engine performance and the lower fuel consumption [11].

3.2. CO emissions

CO exhaust emissions released when the diesel engine is operated for 30 minutes using 90% fuel Used oil and a mixture of 10% biodiesel (B10), 80% used oil and a mixture of 20% biodiesel (B20) and 70% used oil and a mixture of biodiesel 30 % (B30) can be seen in the picture

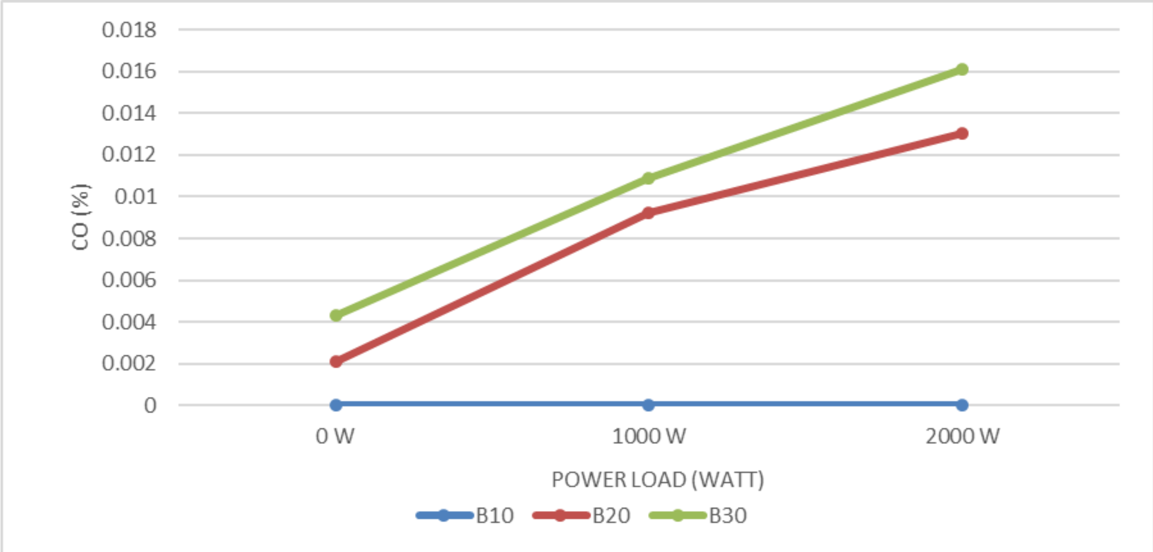

Figure 2. Graph of CO Value

From Figure 2 it can be seen, CO when the engine is operated without power is very low with a range of 0,05% to 0.1%. The value of CO concentration at the beginning of engine operation continues to increase along with providing power to the diesel engine according to the research variables that have been determined. The more power load is added to the diesel engine, the higher the concentration of CO gas emissions. This can be proven by looking at the graph.

Carbon Monoxide is the result of incomplete combustion in a combustion chamber in the engine and is harmful to health. Measured in percentage (%). The ideal result is 0,5 – 3% [12]. So it can be concluded, the tolerance limit for CO from engine combustion is below 3%. If viewed from the graph, the CO level of the diesel engine which is operated without power load is given a maximum power load of 2000 W. The highest CO concentration is 0,0161% using B20 fuel. This emission value is very far below the tolerance limit of 3%.

3.3. CO_2 Emissions

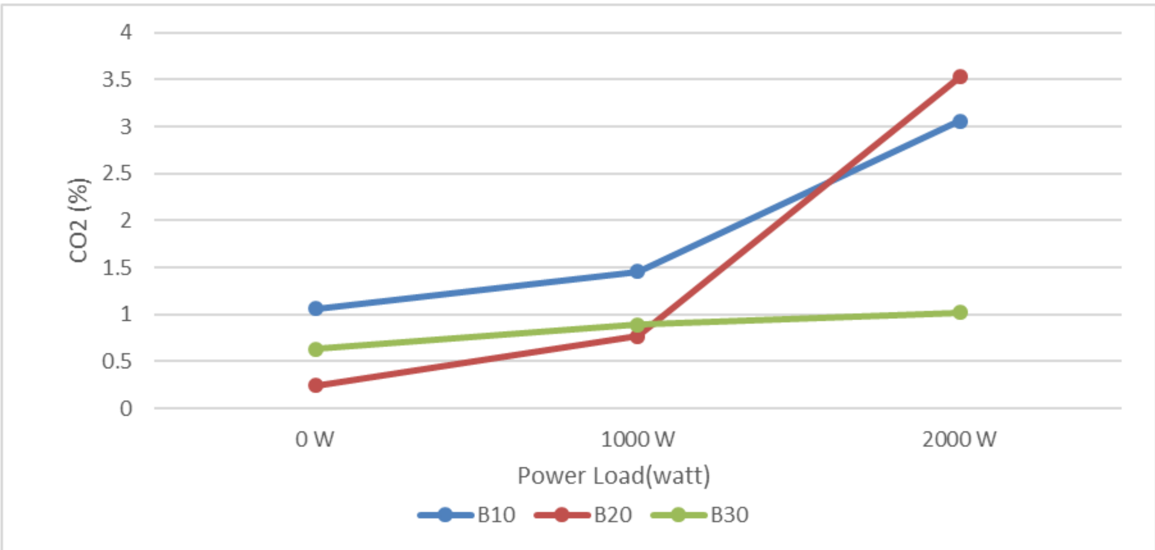

Figure 3. Graph of CO_2 Value

In the Figure 3 it can be seen, the level of CO_2 emission concentration increases along with the added power load on the diesel engine. This means that it shows that as the engine is turned on, the CO_2 combustion shows the results of combustion in the engine. The ideal number should be above 12%. The higher the value, the better the combustion that occurs (max 16%). This means that more and more energy is burned. If CO_2 is below 12% there are several factors that must be adjusted, such as an inappropriate fuel-air mixture or a dirty combustion chamber [13]. The highest CO_2 is 3.53% on 80% fuel used Oil and 20% Biodiesel mixture (B20) with a power load of 2000 W. A concentration value below the ideal value of 12% indicates combustion in the combustion chamber between air and fuel using the mixture of used oil and biodiesel in the diesel engine combustion chamber is still not perfect.

In research conducted by Saputro, et al. (2022) said that the more routine maintenance of the machine, the higher the value of carbon dioxide produced [14]. CO is a by-product of burning fossil fuels with stoichiometric air, the more routinely the vehicle is serviced, the higher the value of carbon dioxide emissions produced because by doing regular engine maintenance, the engine will always be in a top performance position, resulting in perfect combustion.

3.4. HC emissions

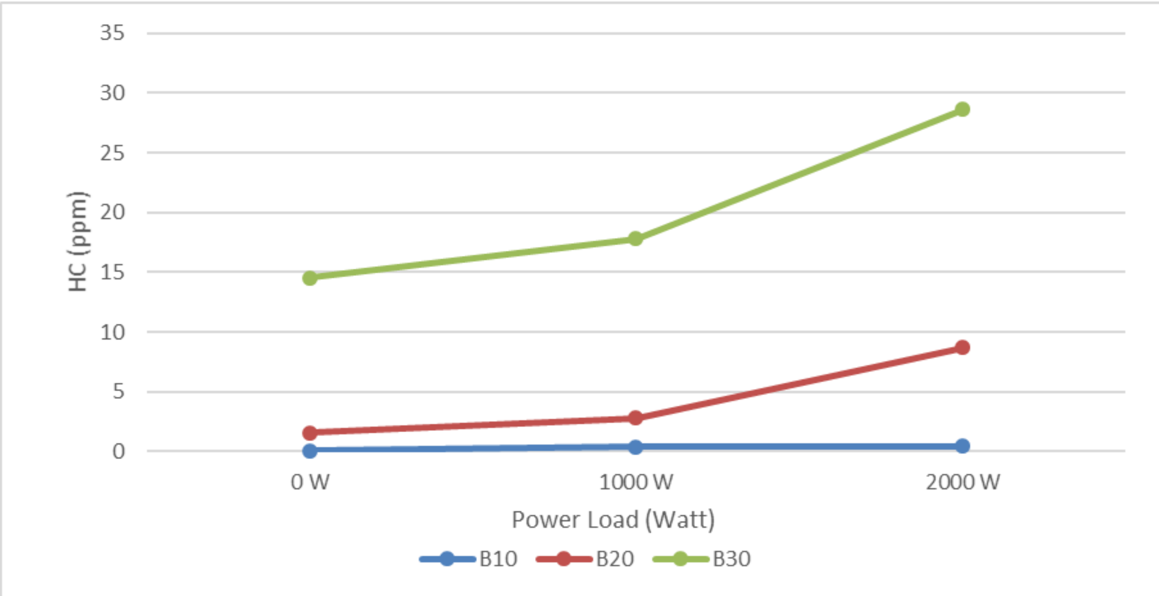

Figure 4. Graph of HC Value

The figure 4 shows a graph of the level of HC exhaust emissions released from a static diesel engine, the highest concentration of HC is 28.61 ppm which is released when a static diesel engine operates when powered by 2000 W. While the lowest emission value is 0.071 ppm when idle.

According to [15], there are several main causes of the emergence of hydrocarbons (HC), namely the walls of the combustion chamber which have low temperatures resulting in hydrocarbons (HC) around the walls not being burned. Misfiring (ignition failure) occurs when the motor is accelerated or decelerated. The existence of overlapping intake valves (both valves are open together) so that HC functions as a gas flushing/cleaning Ignition delay is a factor that drives an increase in HC emissions. In addition to disturbing health, excessive HC emission also causes the phenomenon of photochemical smog (fog). Since HC is part of the unburned fuel, higher HC emissions mean less motor power and increased fuel consumption.

3.5. Opacity emissions

Figure 5 shows a graph of the level of opacity released from a static diesel engine that uses 90% used oil and a 10% biodiesel mixture (B10) as fuel. The highest Opacity concentration is 44.85 % which is released when the static diesel engine operates when powered by 2000 W. While the lowest emission value is 12.84% when the static diesel engine operates without power (0 W).

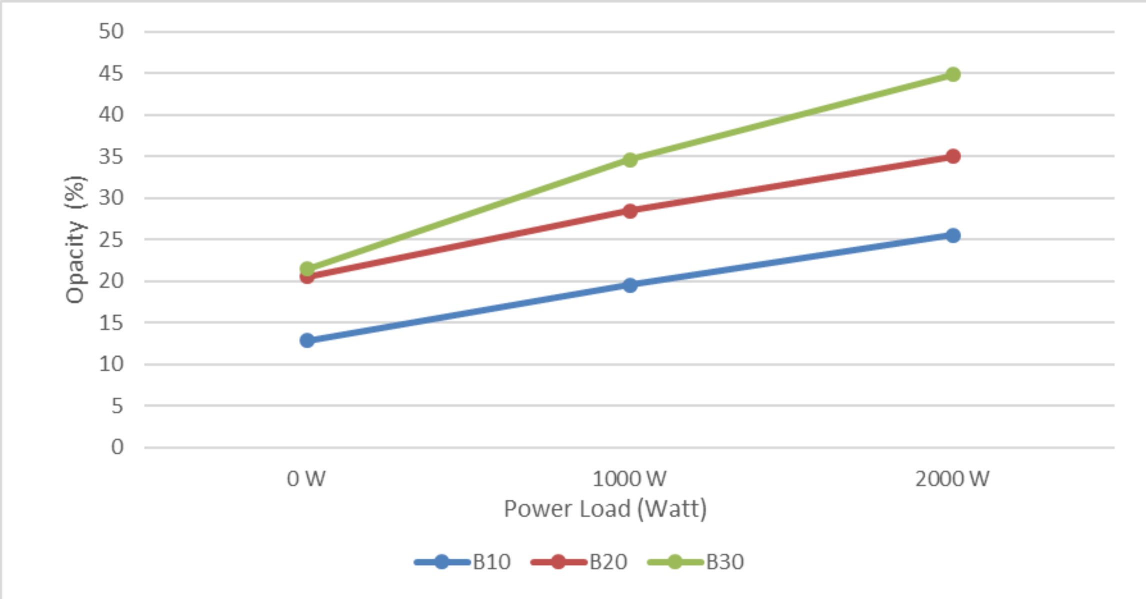

Figure 5. Graph of Opacity Value

The high opacity value is influenced by incomplete combustion where the mixture of fuel with air is not right or the combustion chamber is dirty which is characterized by the level of CO2 emissions released by a static diesel engine that does not reach the ideal value of 12%-16%. The graph of opacity when the machine is operating when given a power load the opacity level tends to increase. This is also caused by a dirty engine combustion chamber, resulting in incomplete combustion and the engine running a little stuttering and emitting quite thick smoke from the exhaust hole. Another cause of the opacity level that goes up and down is the age of the machine and the lack of maintenance on the machine. Maintenance that has less impact on the engine room and cylinder becomes dirty, so that the effectiveness of combustion in the engine is not optimal, causing quite thick smoke [16].

In the Regulation of the State Minister of the Environment Number 5 of 2006 concerning the Threshold of Exhaust Gas Emissions for Motorized Vehicles, the old vehicle with a diesel engine with a weight below 3.5 tons and the year of manufacture above 2010, the opacity quality standard is 40%. The static diesel engine used as a generator with a mixture of used oil and biodiesel, achieved the highest opacity level of 44.85 % using 70% used oil and 30% biodiesel mixture (B30) when the engine was operating with a power load of 2000 W. This means, the level of opacity produced by the diesel engine on this fuel variation has exceeded the predetermined quality standard, while in other variations it is still below the quality standard.

4. Conclusion

Based on the results of the measurements and analysis carried out, the following conclusions were obtained from the calorific value test of 90% used oil and 10% biodiesel, the calorific value was 47.725 kJ/kg, 80% used oil and 20% biodiesel was 50.658 kJ/kg and 70% oil used and 30% biodiesel of 59,974 kJ/kg. The emission test results from the Dongfeng Model R175 diesel engine which uses a mixture of used fuel oil and biodiesel as fuel show that the CO, CO2, HC and Opacity emissions released on average increase with the length of operating time of the diesel engine and occur when the power is equal to 2000 W. The highest level of CO emission is 0.0161%. The highest level of CO2 emissions is 3.53%. The highest level of HC emission is 28.61 ppm. The highest level of opacity is 44.85 % on B30 fuel when the engine is operating with a power load of 2000W. The Opacity value of this variation of fuel has exceeded the quality standard that has been set in accordance with Attachment 1 of PERMEN LH No. 5 of 2005 by 40%, but emissions from other variations are still below the quality standard.

5. Acknowledgments

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