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Experimental Study on Diesel Motor Performance Using Dimethyl Ester Mixture with Diesel

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ABSTRACT

Scarcity of fuel oil (BBM) which occurs encouraging research to develop alternative fuel sources as a substitute for diesel fuel. Based on these ideas, testing TecQuipment type.TD4A 001 diesel engine using biodiesel fuel from palm oil. In this test biodiesel derived from palm oil through the process of esterification and transesterification in ester form dimethyl. The purpose of this study was to determine the performance of the biodiesel-fueled engine dimethyl ester so it will look its effect on diesel engine performance parameters, especially reducing the content of the resulting exhaust emissions of diesel engine. This study will also provide information as a reference for the education world who wants to do research in the field of automotive in the development of biodiesel fuel and its effect on the performance of diesel engine. Biodiesel is a diesel motor fuel in the form of alkyl ester /alkyl acids - fatty acids called vegetable oil through a process of esterification. The term biodiesel is identical to the pure fuel. Biodiesel blends (Bxx is xx percent biodiesel mixed with diesel number 1-xx percent). Supposed Fuels Biodiesel (B10) containing 10% biodiesel Dimethyl Ester, 90% Diesel. Biodiesel is an alternative diesel fuel made from natural resources such as renewable, palm, castor, pecans, etc. The use of biodiesel as diesel fuel does not require modifications to the vehicle's engine. Biodiesel can be blended with diesel fuel at a certain ratio. With the use of biodiesel has the potential to reduce exhaust emissions. Using the use of biodiesel as a fuel engine will provide many advantages of the diesel engine performance.

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1. INTRODUCTION

Currently, diesel engine fuel in Indonesia, especially for four-wheeled vehicles, is dominated by diesel which is made from petroleum (Sitorus, 2014), even though the need for fuel from year to year continues to increase inversely with domestic oil production and reserves (Rukhmana & Kusuma, 2016). This is clearly seen in recent times in our country there is often a shortage of fuel oil (BBM) (Latif, 2015), even Indonesia has become a net importer of petroleum (Agus Setiono, 2014). Therefore, it is necessary to develop alternative fuel sources, especially to meet the needs of machines that consume diesel as a source of fuel (diesel engines) (Akhyar, 2010). Several efforts have been made in research and development of alternative energy sources (Kholiq, 2015), including the use of vegetable oil as a substitute for diesel fuel (Surjana, 2012). However, there are some drawbacks of vegetable oil, which when used directly (Chotimah & Hendrajito, n.d.)will produce compounds that can cause damage to the engine (Tugaswati, 2008), because it forms deposits on the injector pump. Besides, the high viscosity interferes with (Jauhari et al., 2018) the performance of the injector pump in the fuel fogging process so that the result of the injection is not in the form of a volatile mist but rather droplets of fuel that are difficult to burn (Handayani & Susilo, 2014). Therefore, commercial motor vehicle engines need to be modified if they are to use direct vegetable oil as a substitute for diesel fuel (Wibowoa & Wahyudib, n.d.). This is of course not economical, so efforts need to be made to change the characteristics of vegetable oils (Suryandari, 2016) so that it can convert vegetable oil into the form of fatty acid methyl esters (FAME: fatty acid methyl esters) which is better known as "biodiesel" (Putri Andani et al., 2018), through the process of esterification or transesterification (Mastutik, 2006). The United States and several European countries have developed and used biodiesel (Dewi, 2018) as an alternative fuel for diesel engines is widely used as raw material for soybean oil and rapesed oil (canola oil). As the world's largest palm oil producer (Latisya, 2022), Malaysia and Indonesia have also developed biodiesel products from palm oil (palm biodiesel) (Supraniningsih, 2012), although not yet done commercially (Munawaroh, 2010). Especially in Indonesia, the development of biodiesel from palm oil is considered to have good prospects where the availability of sufficient raw materials is very supportive for this development (Hambali et al., 2007). What also needs to be considered in the development of biodiesel is that the exhaust gas emissions produced must be better than diesel fuel so that biodiesel is worthy of being an alternative to diesel fuel. Based on that thought (Komariah, 2009), then the diesel motor is tested using biodiesel fuel made from dimethyl ester by making maximum use of existing laboratory equipment (Atiqi, n.d.). The purposes of this test are: To determine the effect of using a mixture of biodiesel and diesel with a composition of 7% : 93% (B-07) on the performance of a diesel engine. Benefits of testing (1) For the development of biodiesel fuel to be used in diesel engines in terms of engine performance. (2) Provide information as a reference for those who wish to conduct research in the automotive sector in the development of biodiesel fuel and its effect on the performance of diesel motors.

2. RESEARCH METHOD

2.1 Data Processing Method

The data obtained from primary data and secondary data are processed into empirical formulas, then the data from the calculations are presented in tabulation and graph form (Safwan et al., 2016).

2.2 Observation and Testing Phase

In the research that will be observed are: (1) Torque (T) and power (PB) parameters.(Yang et al., 2018)(2) Parameters of specific fuel consumption (sfc). (3) Air-fuel ratio (AFR) (Rumahorbo & Hazwi, 2014) (4) Volumetric efficiency (ηv). 5. Thermal brake efficiency (Nasution et al., 2016)(ηb). (6) Parameters of flue gas composition. The test procedure can be divided into several stages, namely: (1) Testing the calorific value of the fuel. (2). Testing diesel motors with pure diesel fuel. (3) Testing diesel motors with dimethyl ester biodiesel fuel (B-07).

The Flowchart of the Testing of the Calorific Value of the Fuel Conducted in this Research can be seen in Figure 3.2

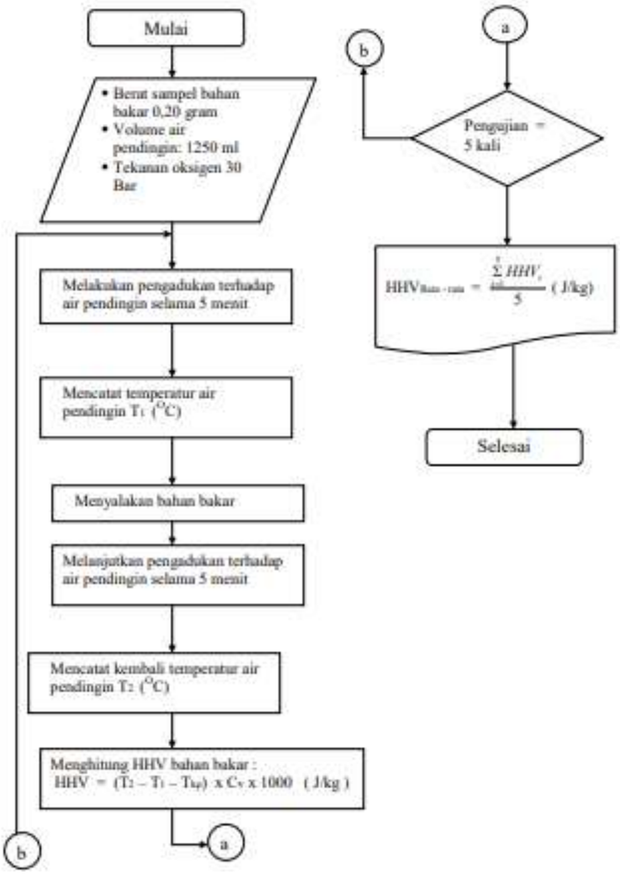

Figure 1. Flowchart of Testing Calorific Value of Fuel.

3. RESULTS AND DISCUSSIONS

3.1. Fuel Calorific Value Test

The cooling water temperature data before and after ignition (T1 and T2) that have been obtained in the "Bomb Calorimeter" test are then used to calculate the heating value of the fuel (HHV) with the following equation: HHV = (T2 - T1 - Tkp) x Cv (kJ/kg) Lit.1 p 12 where: HHV = High Heating Value (High Heating Value), T1 = Cooling water temperature before ignition (0C), T2 = Cooling water temperature after ignition (0C), Cv = specific heat of bomb calorimeter (73529.6 kJ/kg 0C)
Tkp = Increase in temperature due to ignition wire (0.05 0C), Fk = Correction factor. The correction factor is obtained from the comparison between the standardized calorific value of diesel fuel 44800 kJ/kg with the average HHV of diesel that has been tested with a bomb calorimeter of 44799.67 kJ/kg, which is 0.9827. Meanwhile, for the calculation of the calorific value of biodiesel fuel dimethyl ester (B-07) which is 43235.4 kJ/kg multiplied by a correction factor (Fk) of 0.9827, it is obtained at 42487.43 kJ/kg. The cooling water temperature data before and after ignition as well as the calculation results for the calorific value in the first to fifth tests and the average calorific value using biodiesel (B-07) and pure diesel fuel, can be seen in Table 4.1 below:

Table 1. Test Results Data and Calorimeter Bomb Calculations

Bahan Bakar	No. Pengujian	T_1 (°C)	T_2 (°C)	HHV (kJ/kg)	HHV $_{rata-rata}$ (kJ/kg)
Biodiesel (B-07)	1	25,18	26	55683,3	42487,43
	2	26,19	26,31	5058,02	
	3	26,64	27,49	57806,03	
	4	27,51	28,25	49857,7	
	5	28,14	28,8	44077,09	
Solar	1	26,31	26,99	45522,24	44799,67
	2	27,06	27,72	44077,09	
	3	27,76	28,46	46967,39	
	4	28,49	29,2	47689,97	
	5	25,83	26,43	39741,64	

3.2. Diesel Motor Performance Test

The data obtained from the direct reading of the 4-stroke 4-cylinder diesel engine test equipment (TecQuipment type. TD4A 001) through the instrumentation unit and equipment used during the test include: Turns (rpm) through a tachometer. Torque (Nm) via torquemeter. Air column height (mm H2O), by reading the air flow manometer. Exhaust gas temperature (^{0}C), by reading the exhaust temperature meter. Time to spend 100 ml of fuel(s), via stopwatch reading.

3.3. Exhaust Emission Test

3.3.1. Carbon Monoxide (CO) levels in exhaust gas

Data on the results of measuring CO levels from the exhaust gases from the combustion of the two types of tests tested can be seen in Table 4.9 below

Table 2.CO Level in Exhaust Gas

BEBAN STATIS (KG)	PUTARAN (rpm)	KADAR C0 (%)	
		Biodiesel (B-07)	Solar
10	1000	0,037	0,042
	1400	0,048	0,071
	1800	0,092	0,074
	2200	0,077	0,081
	2600	0,079	0,069
	2800	0,038	0,066
15	1000	0,038	0,044
	1400	0,041	0,072
	1800	0,048	0,075
	2200	0,093	0,082
	2600	0,077	0,071
	2800	0,079	0,067

BEBAN STATIS (KG)	PUTARAN (rpm)	KADAR C0 (%)	
		Biodiesel (B-07)	Solar
20	1000	0,038	0,047
	1400	0,042	0,072
	1800	0,049	0,075
	2200	0,093	0,083
	2600	0,078	0,081
	2800	0,081	0,069
25	1000	0,042	0,048
	1400	0,036	0,064
	1800	0,078	0,087
	2200	0,071	0,099
	2600	0,068	0,099
	2800	0,058	0,100

At 10 kg loading (figure 4.26), the lowest CO content occurred when using Biodiesel (B-07) at 1000 rpm, which was 0.037 %. Meanwhile, the highest CO content occurred when using biodiesel (B-07) at 2200 rpm, which was 0.092 %. At a loading of 15 kg (figure 4.27), the lowest CO content occurred when using biodiesel (B-07) at 1000 rpm, which was 0.038 %. While the highest CO levels occur when using diesel fuel at 2200 rpm, which is 0.082%. At a loading of 20 kg (figure 4.28), the lowest CO content occurred when using biodiesel (B-07) at 1000 rpm, which was 0.038 %. Meanwhile, the highest CO levels occurred when using diesel fuel at 2200 rpm, which was 0.083 %. At a loading of 25 kg (figure 4.29), the lowest CO content occurred when using biodiesel (B-07) at 1000 rpm, which was 0.042%. While the highest CO levels occur when using diesel fuel at 2800 rpm, which is 0.10%. Comparison of CO levels contained in the flue gas of each test can be seen in the following figure:

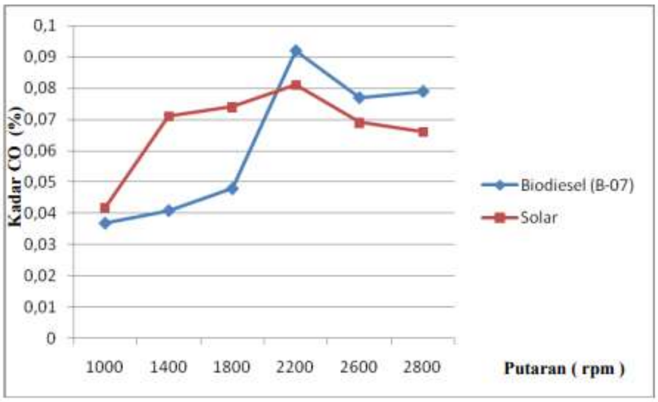

Figure 2. Graph of CO Levels Vs Rounds For 10 Kg . Loads

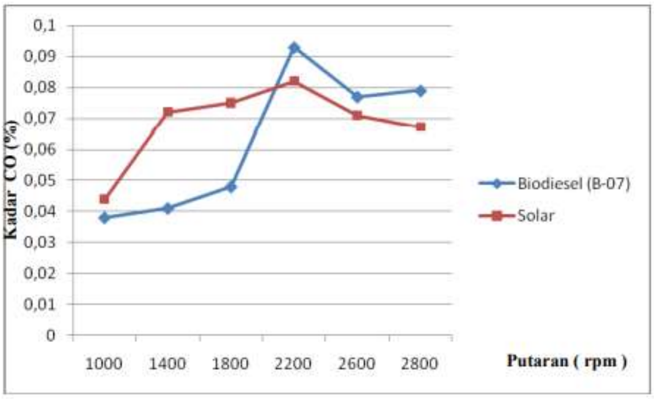

Figure 3. Graph of CO Levels Vs Rounds For 15 Kg . Loads

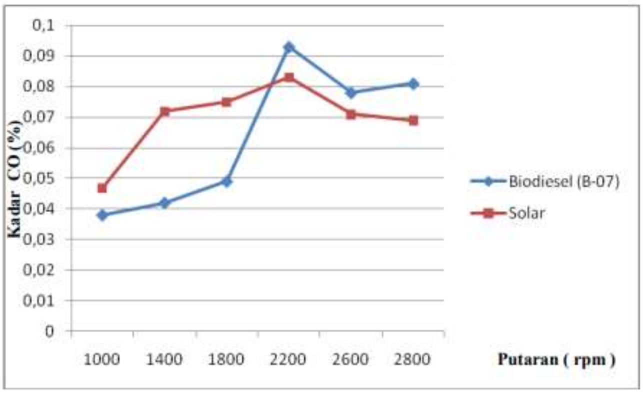

Figure 4. Graph of CO Levels Vs Rounds For 20 Kg Loads.

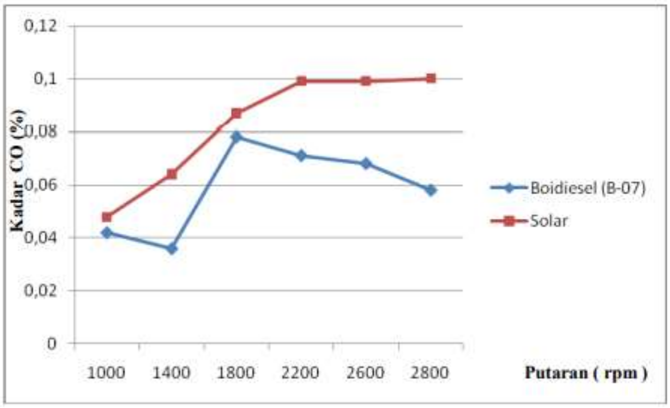

Figure 5. Graph of CO Level Vs Rotation For 25 Kg . Load

CO arises due to less than optimal combustion process so that the fuel does not burn due to lack of oxygen. This occurs when the fuel mixture is richer than the stoichiometric mixture, and occurs at low load and maximum output during acceleration. From Figures 4.26, 4.27, 4.28 and 4.29 it can be seen that the percentage of CO content from the combustion of biodiesel (B-07) is smaller than that of diesel fuel, because the combustion is not optimal due to lack of oxygen in the combustion process. Therefore, the presence of oxygen in biodiesel (B-07) will add to the local mixture of fuel air so that combustion takes place better.

3.3.2. Nitrogen Oxide (N0x) Content in Exhaust Gas

Data on the measurement results of NOx levels from the exhaust gases from the combustion of the three types of tests tested can be seen in Table 4.10 below:

Table 3. Nox Level in Exhaust Gas

BEBAN STATIS (KG)	PUTARAN (rpm)	KADAR NO_X (ppm)	
		Biodiesel (B-07)	Solar
10	1000	5	5,8
	1400	4,7	5
	1800	3,5	4,1
	2200	3,3	3,9
	2600	3,2	3,4
	2800	2	2,2
15	1000	5	5,4
	1400	4,5	4,9
	1800	3,2	3,8
	2200	3,1	3,6
	2600	3	3,3
	2800	2	2,1
	1000	4,8	5
20	1400	3,6	4,7
	1800	2,7	3,4
	2200	2,3	3
	2600	2	2,8
	2800	1,5	2
25	1000	4,8	5
	1400	3,4	4,7
	1800	2,5	3,1
	2200	2,2	2,9
	2600	2	2,6
	2800	1,5	1,8

At 10 kg loading (figure 4.30), the lowest NOx level occurred when using diesel fuel at 2800 rpm, which was 2.2 ppm. While the highest levels of NOx occurred when using biodiesel (B-07) at 1000 rpm, rpm, which was 5 ppm. At 15 kg loading (figure 4.31), the lowest NOx level occurred when using diesel fuel at 2800 rpm, which was 2.1 ppm. While the highest levels of NOx occurred when using biodiesel (B-07) at 1000 rpm, rpm, which was 5 ppm. At 20 kg loading (figure 4.32), the lowest NOx level occurred when using diesel fuel at 2800 rpm, which was 2 ppm. While the highest levels of NOx occurred when using biodiesel (B-07) at 1000 rpm, rpm, which was 5 ppm. At a loading of 25 kg (figure 4.33), the lowest NOx levels occurred when using Solar at 2800 rpm, namely 1.8 ppm and ppm. Meanwhile, the highest NOx levels occurred when using biodiesel (B-07) at 1000 rpm, which was 4.8 ppm. NOx is formed due to the high combustion temperature of the air fuel in the cylinder. The higher the combustion temperature, the higher the levels of NOx formed. The comparison of the levels of NOx contained in the exhaust gases of each test can be seen in the following figure:

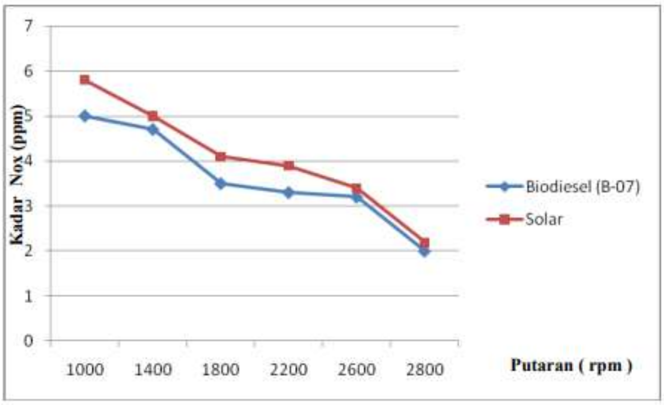

Figure 6. Graph of Nox Content Vs Round For 10 Kg Load.

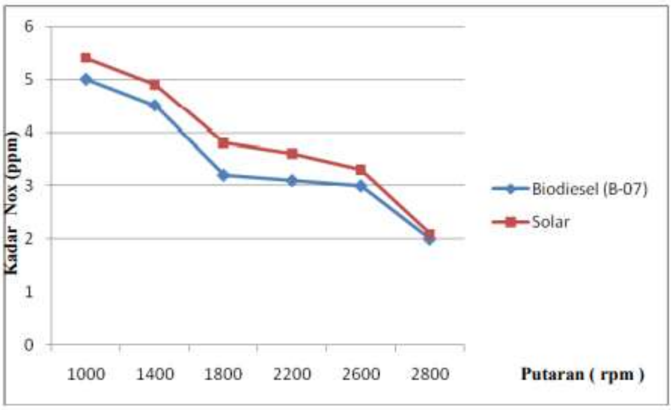

Figure 7. Graph of Nox Levels Vs Rounds For 15 Kg Loads.

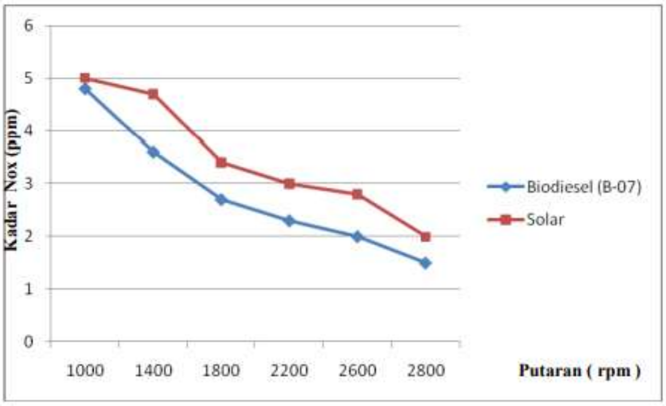

Figure 8. Graph of Nox Content Vs Round For 20 Kg . Load

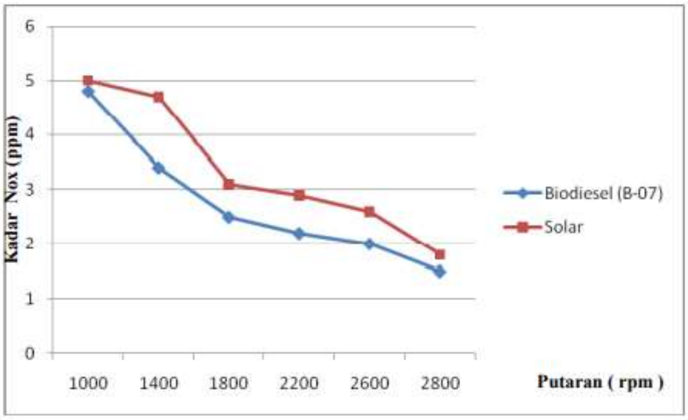

Figure 9. Graph of Nox Content Vs Round For 25 Kg . Load

By using biodiesel (B-07), the combustion temperature of the fuel in the cylinder will be lower. Suitable for use on four-wheeled diesel motorized vehicles because it is environmentally friendly.

4. CONCLUSION

The conclusions that can be drawn from this test are: (1) The use of biodiesel fuel (B-07) on the performance of a diesel motor at low speed has smaller torque and power. Due to the small torque and power at low speed, the diesel motor is less powerful. (2) Consumption of biodiesel specific fuel (B-07) is lower than using diesel fuel. Thus, using biodiesel fuel (B-07) is more efficient than using diesel fuel. (3) In exhaust emissions, the use of biodiesel fuel (B-07) is lower than that of diesel fuel. This proves that biodiesel is friendly to the environment and reduces air pollution.

Suggestions in this study are: (1) To support the smoothness and accuracy of the test results, it is better to check and calibrate the instrumentation and measuring instruments every time the test will be carried out. (2) To improve the results of testing this fuel with dimethyl ester, it is better to vary the load a lot and the % of the fuel must also be varied so that later useful results can be obtained and dimethyl ester biodiesel fuel can be used in the community. (3) To get the results of the exhaust gas emission tool where the data listed on the auto gas analyzer tool changes, it is necessary to re-calibrate for 5 minutes and clean the gas fittings so that the sensor performance is more effective.

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