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Abstract. Indonesian people's reliance on diesel fuel is still quite strong, as seen by the rising yearly use of diesel. Because diesel is a fossil fuel that is not renewable, rising diesel usage is a concern that must be anticipated. One approach to deal with this is to switch from fossil fuels to biofuels like biodiesel. Because Indonesia is the world's largest producer of palm oil, biodiesel from palm oil is an alternative. Although biodiesel may potentially be used directly in diesel engines, there are few researches on the impacts of utilizing it and the possibility for further development. As a result, the goal of this research is to look at the combustion temperature of B100 and B20 fuels in long-term testing. Two Kubota diesel engines with 376 cc cylinder volumes are used in this investigation. Each engine will be connected to a generator that will provide 4000 W of electricity to the halogen bulbs. The two engines will run on separate fuels, with the first using B20 and the second on B100 from palm oil. The engine has a continuous rotational speed of 2200 rpm and has been running for 300 hours without stopping. The combustion temperature of the cylinder head, cylinder block, and exhaust gas pipe is measured every multiple of 4 hours. With 1.7 percent, 1.2 percent, and 2.7 percent, respectively, the B100 engine delivers lower combustion temperatures in the cylinder head, cylinder block, and pipe exhaust gas.

Keywords: Biodiesel; temperature; Diesel engine

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1. Introduction

The increasing use of alternative fuels, especially in internal combustion engines, is inseparable from two major global problems, i.e., the declining availability of crude oil and the worsening problem of exhaust emissions. Currently, public interest in the use of diesel fuel is indicated by the significantly increased consumption of diesel fuel. This increase is shown through data from the Ministry of Energy and Mineral Resources (ESDM), which shows that in 2021, diesel fuel increased by 75 million kiloliters [1]. The increase in diesel fuel consumption is a problem that must be anticipated because diesel is a fuel oil processed from crude oil, i.e., fuel made from fossils; thus, it is non-renewable fuel [2]. If diesel fuel consumption is not controlled, the presence of crude oil will decrease and dry out in 2053 [3].

Through the regulation of the Minister of Energy and Mineral Resources No. 12 of 2015, the Government of Indonesia has required the use of biodiesel fuel from palm oil or other plant sources as alternative fuels to reduce dependence on fossil fuel sources. This is done to increase energy independence and security, which thus far, Indonesia is still very dependent on fossil fuels. Biodiesel from palm oil is the choice as a substitute fuel or diesel blending material because palm oil production in Indonesia is the largest globally, with an annual production value of 51.8 thousand tons in 2019 [4].

Biodiesel fuel has the characteristics of higher viscosity, density, and oxygen content, thus allowing other impacts that can affect the performance and combustion temperature of diesel engines. According to Alloune et al., the use of biodiesel fuel from the Citrullus colocynthis plant produces a higher Specific Fuel Consumption value of 9.6% compared to diesel engines [5]. Furthermore, Tripathi & Gupta's research concludes that the higher the biodiesel content in the fuel, the lower the combustion temperature in the engine [6]. Differences in the character of palm oil cause the effect and different characters on engines that use biodiesel. However, until now, there is very little research related to the effects of using biodiesel which has the potential to be developed further. Therefore, this study aims to analyze the combustion temperature of B100 and B20 fuels operated in long-term testing.

2. Methods

This study uses two diesel engine units with the same brand and type, i.e., the Kubota RD 65 DI NB Diesel Engine, whose complete specifications are shown in Table 1. Each engine will be coupled to a Denyo electric generator type FA-5 with a peak capacity of 5 kW and efficiency of 85%, as shown in Figure 1.

Table 1. Diesel Engines Characteristics

Model	RD65DI-NB
Type	4 horizontal steps
Cylinders	1
Fill (cc)	376
Power (HP)	5.5 at 2200 rpm
Maximum Power (HP)	6.5 at 2200 rpm
Maximum Torque (kg.m)	2.36 at 1800 rpm
Combustion System	Direct Injection
Fuel Consumption (gr/HP.hr)	182
Cooling	Radiator

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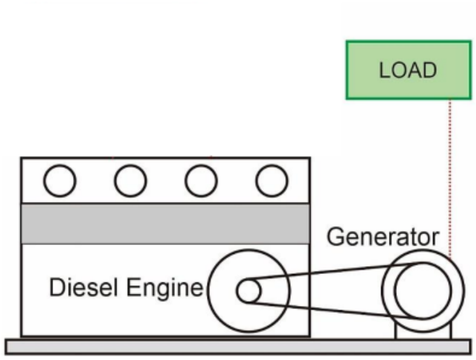

Figure 1. Schematic of research equipment.

The combustion temperature was measured every 4 hours of operation using additional equipment such as a thermogun for 300 hours of testing. This test aims to determine the combustion temperature of the cylinder head, cylinder block, and exhaust gas pipe during a specific test time and compare it with different fuels. The fuel used for the two engines in this study was B100 obtained from the palm oil processing process of PT Pelita Agung Agrindustri in Dumai – Riau. Meanwhile, B20 was obtained from the Pertamina Refueling Station. The comparison of the two fuel specifications can be seen in Table 2. The lubricant used by both machines is identical, i.e., Pertamina Mediteran SX Bio SAE 15W-40 produced by PT Pertamina Lubricant. Details of the test conditions of this study are shown in Table 3.

Table 2. Fuel specification standards.

No	Test Parameters	Test Method	Unit	B100 Test Result	B20 Test Result
1	Density at 40 °C	ASTM D 1298-12b	kg m^{-3}	862.4	-
2	Density at 15 °C	-	kg m^{-3}	-	845.7
3	Kinematic viscosity at 40 °C	ASTM D 445-06	mm^2/s	4.53	2.92
4	Cetane numbers	ASTM D6980-12	Min : 51	61	56.7
5	Flash point	ASTM D 93-02	°C	177	65
6	Distillation temperature 90%	ASTM D 1160-06	°C	350	344
7	Color	ASTM D 1500	Colour ASTM	1	1.1
8	Methyl ester levels	Calculation	% (mm^{-1})	98.24	-
9	FAME content	-	% v/v	-	20
10	Water content	ASTM D 6304	ppm	267	159.63

Table 3. Experimental conditions.

Parameters	B100 fuel engine	B20 fuel engine
Fuel	B100	B20
Engine rotation	2200 rpm	
Lubricant	Pertamina Mediteran SX Bio SAE 15W-40	
Cooler	Prestone	
Load	4 kW	

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3. Results and Discussion

The results of the combustion temperature test on the cylinder head are shown in graphical form as in Figure 2. Based on the analysis results, it is found that the B100 engine produces a combustion temperature of the cylinder head, which is 1.7% lower than the B20 engine. The B100 engine has an average combustion temperature of 136 ˚C, while the B20 engine has an average combustion temperature of 138 ˚C.

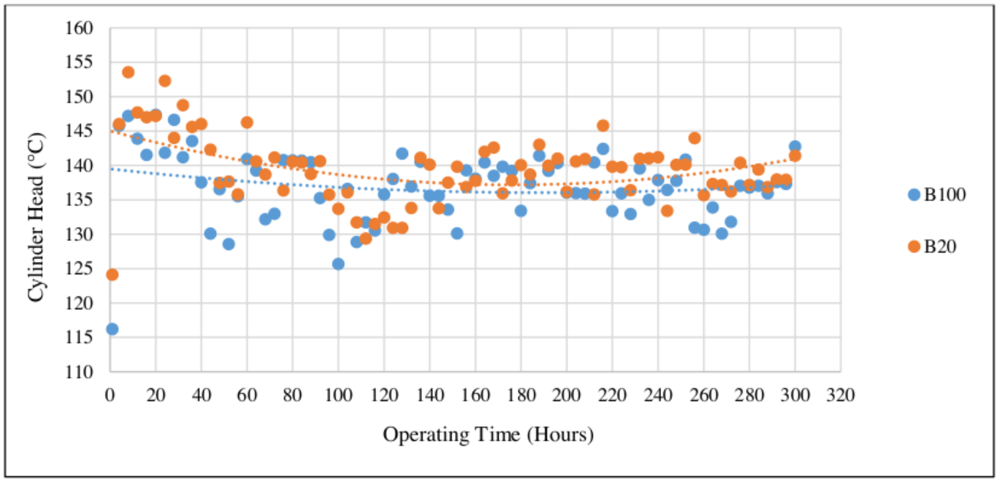

Figure 2. Graph of cylinder head temperature against time.

The results of the combustion temperature test on the cylinder block are shown in graphical form in Figure 3. Based on the analysis results, it is found that the B100 engine produces a combustion temperature of 1.2% lower in the cylinder block compared to the B20 engine. The B100 engine has an average combustion temperature of 130 ˚C, while the B20 engine has an average combustion temperature of 132 ˚C**.**

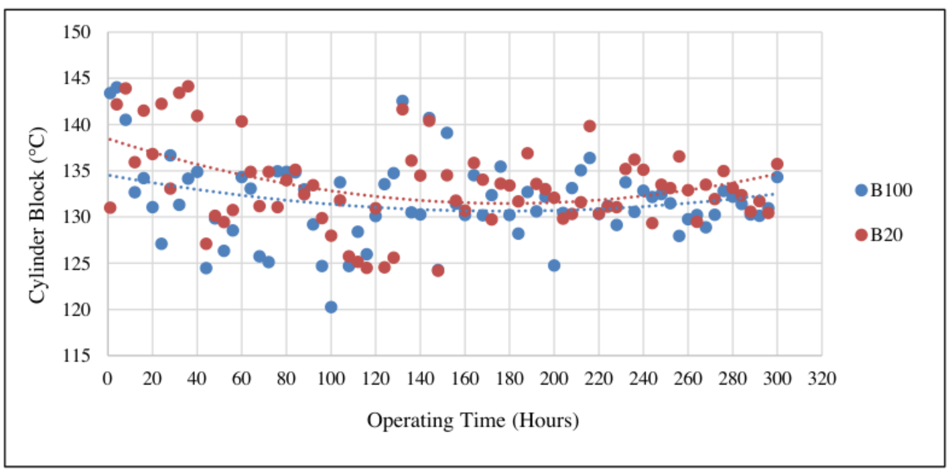

Figure 3. Graph of cylinder block temperature against time.

After testing for 300 hours of operation, the testing results of the combustion temperature on the exhaust gas pipe are shown in a graph in Figure 4. Based on the analysis results, it was found that the B100 engine produces a lower combustion temperature in the exhaust gas pipe by 2.7% compared to the B20 engine. The B100 engine has an average combustion temperature of 258 ˚C, while the B20 engine has 265 ˚C.

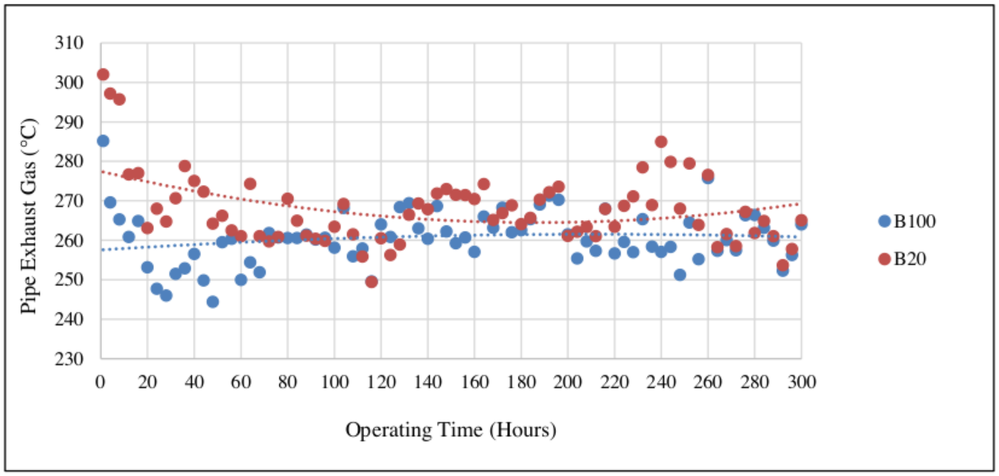

Figure 4. Graph of pipe exhaust gas temperature against time.

The lower combustion temperature values for the cylinder head, cylinder block, and exhaust gas pipe for B100 engines are caused by B100 fuel having a lower heating value and a higher viscosity value than B20. According to Kegl et al., a higher viscosity value worsens the fuel atomization conditions and affects the air and fuel mixing process during the combustion process [7]. In addition, the higher viscosity and density values of B100 fuel will reduce the rate of mixing of fuel and air. B100 fuel has a heating value of 39.9 MJ/kg [8], and B20 fuel has a heating value of 43.828 MJ/kg [9]. Meanwhile, the viscosity value of B100 fuel is 4.53 mm^2/s, and the viscosity value of B20 fuel is 2.92 mm^2/s (according to Table 2). The lower temperature in the B100 fuel engine makes the B100 fuel combustion not reach the flammability limit point, resulting in lower power and low energy content.

4. Conclusion

Based on the research that has been done, it can be concluded that generally, the use of B100 fuel will result in lower combustion temperatures whether, in the cylinder head, cylinder block, and exhaust gas pipe, each is 1.7%; 1.2%; and 2.7% respectively. The low combustion temperature in the B100 engine is influenced by the B100 fuel having a lower calorific value and a higher viscosity value than B20. Therefore, the lower temperature in the B100 fuel engine makes the B100 fuel combustion not reach the flammability limit point and produces lower power and low energy content.

5. Acknowledgment

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