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# Analysis of Combustion Temperature on Specific Fuel Consumption (SFC) of Diesel Engines Using B100 and B20 Fuel in the Long Term

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ABSTRACT

Indonesia is one of the largest palm oil-producing countries globally, with a production value of 40 million tons by 2020. Biodiesel is one of the alternative energy sources that can be processed from palm oil. Diesel engines can directly use biodiesel as a fuel. Biodiesel has distinct characteristics from diesel; thus, it will affect performance and other things on the engine. In this research, diesel engine performance tests were carried out, including specific fuel consumption (SFC), cylinder head temperature, cylinder block, and exhaust pipe, with a test time of 300 hours. This research aims to determine the effect of the cylinder head, cylinder block, and exhaust pipe temperatures on SFC using two different fuels, i.e., B100 and B20. Based on the test results, the average cylinder head, cylinder block, and exhaust pipe temperatures on the B100 engine are 136 °C, 130 °C, and 257 °C. As for the B20 engine's cylinder head, block, and exhaust pipe temperatures are 139 °C, 132 °C, and 264 °C. Engine with B100 fuel obtained SFC of 0.317 kg/kW.hour and engine with B20 fuel obtained SFC of 0.276 kg/kW.hour. In general, the combustion temperature in the cylinder head affects the increase in SFC in both engines with different fuels; the higher the combustion temperature in the cylinder head, the higher the SFC is. Engines with B100 fuel have a higher SFC value than B20 fuel, which is influenced by the higher viscosity and density values; thus, the droplets from the fuel atomization process become larger when compared to fuels with lower viscosity and density values. The graph analysis shows that the cylinder block temperature graph on the B100 and B20 fueled engines decreases between temperatures of 133-134 °C, then inflates with the increase in specific fuel consumption. The higher temperature compared to the B100 fuel engine makes the fuel undergo complete combustion when injected into the combustion chamber due to atomization or very fine droplets burning completely. The cylinder block temperature chart on the B100 and B20 fueled engines has a very significant trend difference. B100 engines tend to experience a decreasing trend in temperature along with an increase in SFC, while B20 engines tend to experience an increasing temperature trend along with an increase in SFC.

*Keywords: B100, B20, diesel engine, specific fuel consumption, temperature*

## Introduction

Palm oil has become one of Indonesia's most important crops for food, energy, and trade. There is a great effort to reduce fossil fuel dependence and new targets for introducing biodiesel blends (Khatiwada et al., 2021). Biodiesel is one of the alternative energy sources derived from vegetable oil and is included in renewable energy. Biodiesel can replace diesel fuel because of its similarities in terms of physical and chemical characteristics. Biodiesel consists of monoalkyl esters and is produced from the transesterification process of oil or fat (Ahmad, 2017).

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The diesel engine is the main driving force in the daily life of modern society. Diesel engines power most land and sea transportation, provide electric power and are used for many agricultural, construction, and industrial activities. Diesel is a strong and durable engine with lower fuel consumption than other prime mover engines (Lloyd & Cackette , 2011). A diesel engine is a combustion engine with a combustion process that occurs within the engine itself (Internal Combustion Engine). Combustion occurs because pure air is compressed in a combustion chamber (cylinder) to obtain high-pressure air and high heat and fuel atomization to cause combustion. Combustion in the form of an explosion will produce a sudden increase in heat and high pressure in the combustion chamber. This pressure pushes the piston down, which continues with the crankshaft rotating (Fuadi et al., 2020).

B20 is a fuel blend of 20% biodiesel and 80% diesel oil, striking a fine balance of material compatibility, performance, emission benefits, and cost. B20 mixtures can be used in most diesel engines without engine modification (Anderson, 2011). B100 is a fuel made from 100% pure palm oil for diesel engines/motorcycles, B100 has a specific energy content of 12.4% lower than diesel, and the average specific fuel consumption of B100 is about 14% more than solar. Approximately 11% oxygen in B100 provides complete combustion, resulting in better engine performance and less pollution (Suthisripok & Semsamran, 2018).

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. Different characteristics of palm oil generate different effects and characteristics on biodiesel engines. However, until now, very few researches related to the effects of using biodiesel have the potential to be further developed (Saputro et al., 2022). Therefore, this research aims to analyze the combustion temperature on specific fuel consumption (SFC) using B100 and B20 fuels, which are operated in long-term testing.

**Material and Methods**

This study uses an experimental method with two diesel engines with the exact specifications and two different fuels. The fuel used is B100 and B20 fuel, with a total testing time of 300 hours of operation. The measurement of fuel consumption per unit of time using a burette, the measurement of fuel consumption using a manual technique with a 20 ml capacity burette, and time measurement of the time the engine spent 20 ml of fuel using a stopwatch. Meanwhile, the cylinder head, block, and exhaust pipe temperatures were measured using a digital infrared thermometer carried out every 4 hours of operation.

The fuel used in this research is B100 and B20 fuel. B100 is pure biodiesel fuel from Crude Palm Oil (CPO), while B20 is a fuel mixture consisting of 20% palm oil biodiesel and 80% fossil diesel fuel. Table 1 shows the physical and chemical properties of B100 and B20 fuels (Saputro et al., 2020).

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 |

*To be continued…*

| | | | | | |
|---|---|---|---|---|---|
| 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 |

## Results and Discussion

### *Cylinder head*

Testing of the combustion temperature on the cylinder head component against SFC can be seen in the graph in Figure 1. Based on the analysis results, the average cylinder head temperature value for the B100 engine was 136 °C, and the average cylinder head temperature for the B20 engine was 138 °C. The average value of SFC on the B100 engine was 0.317 kg/kW. hour while the average value of the SFC on the B20 engine was 0.276 kg/kW.hour. Based on the graphic analysis, it can be seen that the cylinder head temperature chart on the B100 and B20 engines decreases between 135-140 °C, then inflates with the increase in specific fuel consumption. In general, the combustion temperature in the cylinder head affects the increase in SFC in both engines with different fuels; the higher the combustion temperature in the cylinder head, the higher the SFC is. Engines with B100 fuel have a higher SFC value than B20 fuel, which is influenced by the higher viscosity and density values; thus, the droplets from the fuel atomization process become larger when compared to fuels with lower viscosity and density values. The formation of larger droplets makes the mixture of fuel and air not homogeneous; therefore, the combustion process becomes imperfect and causes a decrease in engine performance and an increase in fuel consumption.

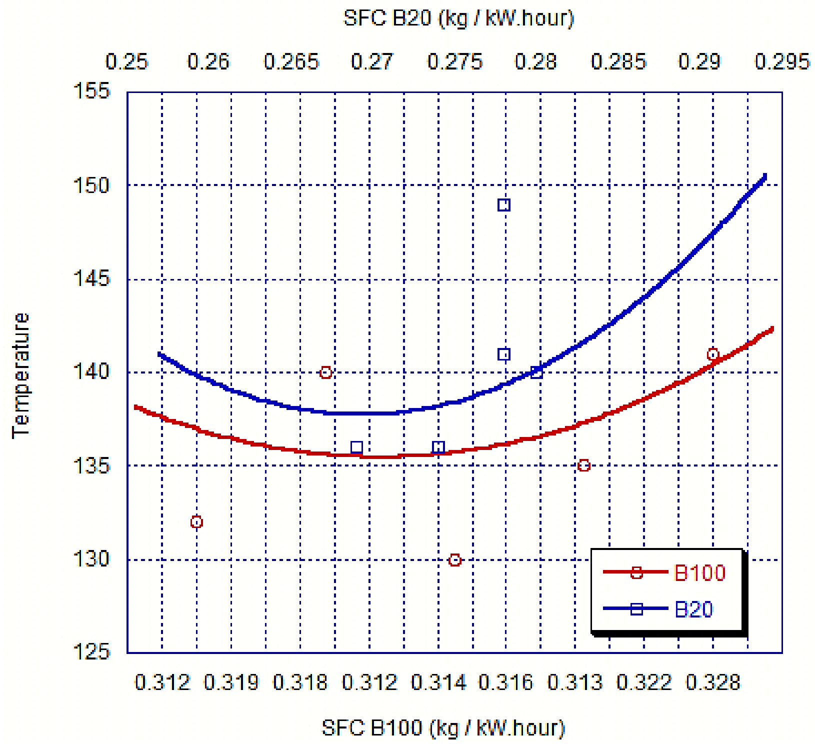


Figure 1. Graph of correlation between cylinder head temperature toward SFC

### *Cylinder block*

Testing of the combustion temperature of the cylinder block component against the SFC can be seen in the graph in Figure 2. Based on the analysis results, the average cylinder block temperature for a B100 engine was 131 °C, and the average cylinder block temperature for a B20 engine was 133 °C. The average value of the SFC on the B100 engine was 0.317 kg/kW. hour while the average value of the SFC on the B20 engine was 0.276 kg/kW.hour. The graph analysis shows that the cylinder block temperature graph on the B100 and B20 fueled engines decreases between temperatures of 133-134 °C, then inflates with the increase in specific fuel consumption. The higher temperature compared to the B100 fuel engine makes the fuel undergo complete combustion when injected into the combustion chamber due to atomization or very fine droplets burning completely. Meanwhile, based on Table 1, the acid content in B100 fuel which is higher by 20%, will cause several problems such as the formation of deposits and higher wear. This problem causes the oxygen content in the combustion process to be lower because it is absorbed by deposits that have absorption characteristics meanwhile acid wears out engine components; thus, the compression on the B100 engine will be lower and cause a decrease in combustion temperature when compared to the B20 fuel engine.

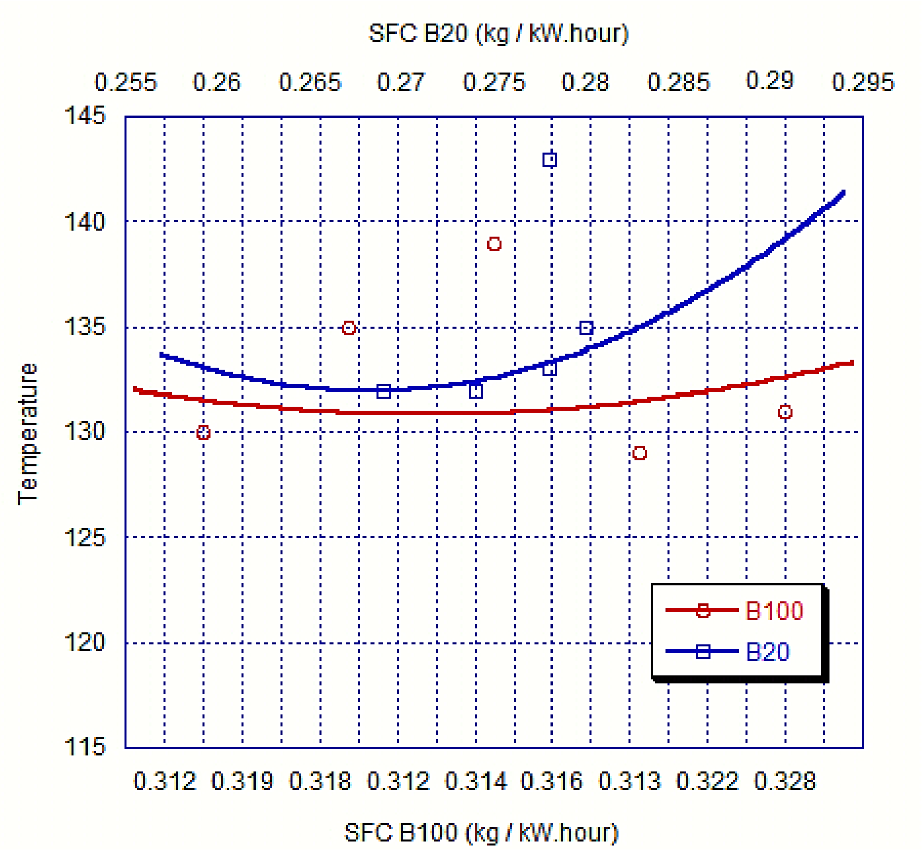


Figure 2. Graph of correlation of cylinder block temperature toward SFC

***Exhaust pipe***

The testing results of the combustion temperature on the exhaust pipe component against SFC can be seen in the graph in Figure 2. Based on the analysis results, the average value of the exhaust pipe temperature for the B100 engine was 260 °C, and the average cylinder block temperature for the B20 engine was 267 °C. The average value of the SFC on the B100 engine was 0.317 kg/kW. hour while the average value of the SFC on the B20 engine was 0.276 kg/kW.hour. The graphic analysis shows that the cylinder block temperature chart on the B100 and B20 fueled engines has a very significant trend difference.

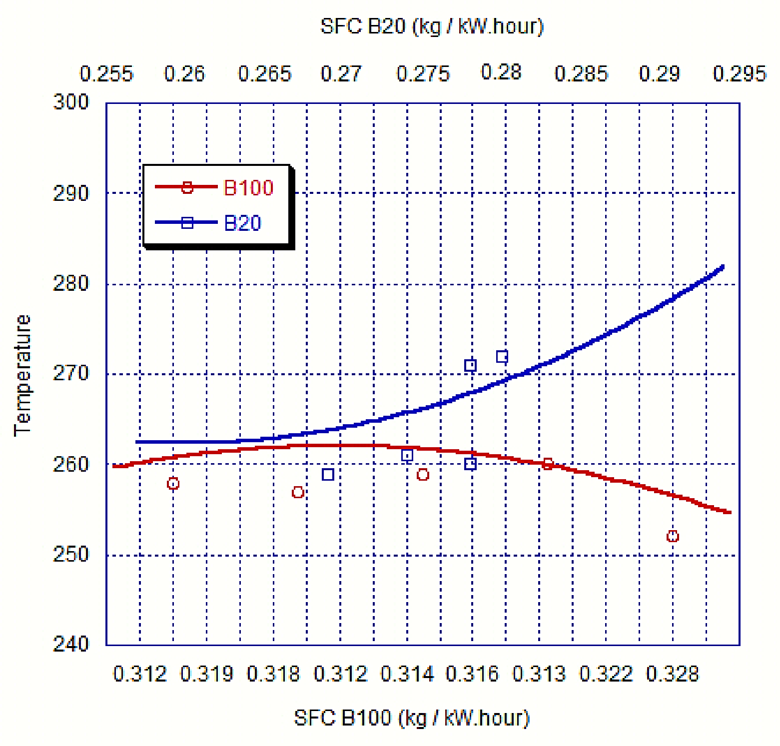


Figure 3. Graph of correlation between exhaust pipe temperature and SFC.

B100 engines tend to experience a decreasing trend in temperature along with an increase in SFC, while B20 engines tend to experience an increasing temperature trend along with an increase in SFC. This shows that there is a faster heat transfer to the environment in the B100 engine.

## Conclusion

Based on the research, it can be concluded that the use of B100 fuel will generally increase specific fuel consumption, which is higher than B20 fuel. The average specific fuel consumption on the B100 engine was 0.317 kg/kW. hour while on the B20 engine was 0.276 kg/kW.hour. The average combustion temperature of B100 in the cylinder head, cylinder block, and exhaust pipe was 136 oC, 131 oC, and 260 oC. Meanwhile, the average combustion temperature of B20 in the cylinder head, cylinder block, and exhaust pipe was 138 oC, 133 oC, and 267 oC. The higher viscosity and density values influenced the low combustion temperature in the B100 engine; thus, the droplets from the fuel atomization process became larger. The formation of larger droplets makes the mixing of fuel and air inhomogeneous; therefore, the combustion process becomes imperfect and increases the amount of fuel consumption.

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