3rd International Conference Eco-Innovation in Science, Engineering, and Technology
Volume 2022
http://dx.doi.org/10.11594/nstp.2022.2754

NST Proceedings
OPEN ACCESS

Conference Paper

Analysis of Combustion Temperature on Specific Fuel Consumption (SFC) of Diesel Engines Using B30 Fuel in the Long Term Performance

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ABSTRACT

The world's energy keeps continuing to increase, meanwhile, the fossil energy used creates emissions problems and long-term dependence. Therefore, it is necessary to diversify energy to new and renewable energy. Especially to replace fossil energy whose availability is reducing. One alternative energy that has the potential to continue to be developed is biodiesel. Indonesia is currently one of the largest palm oil-producing countries in the world with a total production of 40 million tons by 2020. Biodiesel can be used directly without having to modify the combustion chamber of a diesel engine. However, the use of biodiesel, especially B30 (30% biodiesel + 70% diesel mixture) which is currently used in Indonesia, must receive special attention for the effects if applied to diesel engines in the long term. Therefore, the purpose of this study is to analyze the use of B30 on the performance of the diesel engine produced with a test time of 200 hours of operation. This study uses an experimental method, with a loading using a 4000 Watt halogen lamp. Engine rotational speed is kept constant at 2200 RPM and measurement of fuel consumption per unit time using a burette. Fuel consumption was measured using a manual technique with a 20 ml capacity burette, while the time the engine spent fuel was measured using a stopwatch. Based on the test results, the average power and torque values produced by the B30 engine are 4.45 kW and 12.54 N.m. Meanwhile, the value of specific fuel consumption and average thermal efficiency produced is 0.28 kg/kW.hour and 29.43%. Performance changes in diesel engines can be influenced by several factors including the calorific value of the fuel and the viscosity value of the B30 fuel used.

Keywords: B30, diesel engine, specific fuel consumption, performance

Introduction

The Government of Indonesia has recently 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 with the aim that Indonesia has energy security and is not dependent on increasing imports of fuel. B30 is a fuel mixture with a composition of 30% biodiesel and 70% diesel which is currently the main fuel substitute for diesel in Indonesia. The choice of biodiesel is because Indonesia is the country with the largest palm oil producer in the world with a total production of 51.8 thousand tons in 2019. The implementation of B30 as a fuel for diesel engines must receive special attention, especially the effects it will have when applied to diesel engines in the long term.

Several important parameters that can affect the performance of a diesel engine include the characteristics of the value of viscosity, density, calorific value, and oxygen content. According to Bari and Hossain (2019), the use of biodiesel fuel from palm oil resulted in lower torque and

How to cite:
Saputro & Saputro. (2022). Analysis of combustion temperature on Specific Fuel Consumption (SFC) of diesel engines using B30 fuel in the long term performance. *3rd International Conference Eco-Innovation in Science, Engineering, and Technology*. NST Proceedings. pages 362-366. doi: 10.11594/ nstp.2022.2754

thermal efficiency values of 5.3% and 1%, respectively, and resulted in a higher specific fuel consumption (SFC) of 10% compared to diesel engines. Alloune et al. (2018) also in their research explain that the use of biodiesel fuel from the *Citrullus colocynthis* plant produces a higher specific fuel consumption (SFC) value of 9.6% compared to diesel engines. Tripathi and Gupta (2018) concluded in their research that a higher content of biodiesel in the fuel will result in an increase in SFC and lead to a decrease in engine performance.

The direct use of biodiesel can be used as fuel for diesel engines without having to modify the engine combustion chamber. Therefore, this study aims to directly test the use of B30 fuel directly on the performance of the diesel engine produced with a test time of 200 operating hours.

Material and Methods

This study used a diesel engine with a cylinder volume of 376 cc. The lubricant used is Pertamina Meditran SX Bio SAE 15W-40. The engine is connected to an electric generator with a capacity of 5 kW to turn on a 4000 W halogen lamp which functions as the engine loading. The selection of a 4000 W load is carried out with the consideration that the generator has an efficiency of 80%. Each halogen lamp used requires 1000 W of power so the halogen lamps are arranged in parallel so that the total load used is 4000 W. The test was carried out for 200 hours, with a constant engine speed of 2200 rpm. The description of the test setup can be seen in Figure 1. Meanwhile, the B30 fuel used is obtained from the Pertamina Fuel Filling Station, where the specifications for the fuel can be seen in Table 1.

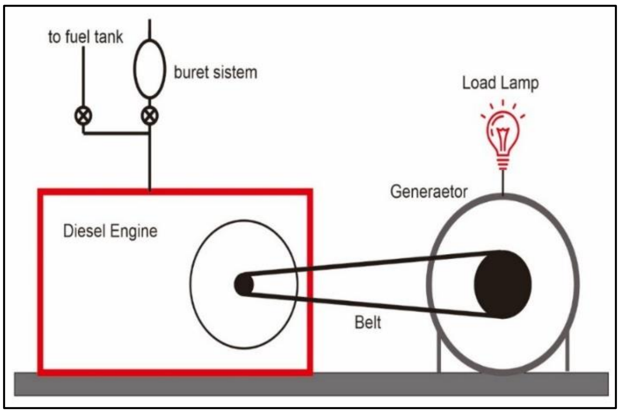

Figure 1. Experiment setup

Table 1. Fuel specification standards

No	Test Parameters	Test Method	Unit	B30 Test Result
1	Density at 40 °C	ASTM D 1298-12b	kg m^{-3}	-
2	Density at 15 °C	-	kg m^{-3}	845.7
3	Kinematic viscosity at 40 °C	ASTM D 445-06	mm^2/s	2.92
4	Cetane numbers	ASTM D6980-12	Min : 51	56.7
5	Flash point	ASTM D 93-02	°C	65
6	Distillation temperature 90%	ASTM D 1160-06	°C	344
7	Color	ASTM D 1500	Colour ASTM	1.1
8	Methyl ester levels	Calculation	% (mm^{-1})	-
9	FAME content	-	% v/v	20
10	Water content	ASTM D 6304	ppm	159.63

Results and Discussion

Power and torque

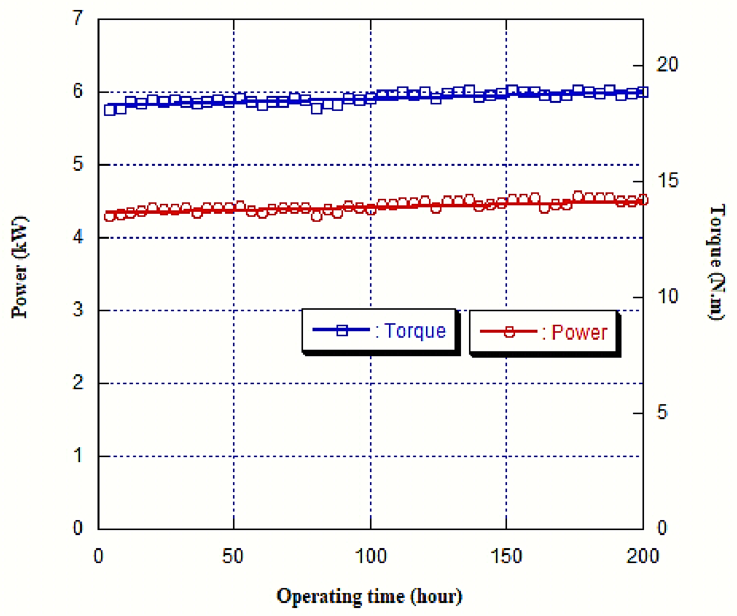

Figure 2. The relation between engine power and torque against operating time

After testing for 200 hours of operation, current and voltage data were obtained for both types of fuel and then the engine shaft power analysis was carried out. Based on the results of the analysis, the average power value produced by the B30 engine is 4.45 kW. Based on Figure 2, it can be seen that the engine power of B30 fuel tends to increase slightly with increasing operating time. This is because the combustion temperature has increased and the resulting power is higher. However, after a certain operating time, the power is relatively constant and there is a decrease in the resulting power due to the formation of deposits on engine components, wear and tear, and a decrease in the quality of the lubricant used. In addition, the average power value can be affected by the heating value and the viscosity value of the fuel. Engines with fuels that have a lower heating value and a higher viscosity value make the fuel atomization conditions worse and affect the air and fuel mixing process during the combustion process (Kegl et al., 2013). Generally, fuels with higher biodiesel content have lower heating values (Ali et al., 2016). B100 fuel has a calorific value of 39.9 MJ/kg (Borhanipour et al., 2014) and B30 fuel has a calorific value of 43.828 MJ/kg (Liaquat et al., 2013). Mofijur et al., (2014) conducted a study on the power produced by a mixture of B5 and B10 fuel from palm oil with diesel fuel as a comparison. Based on the results of his research, the power produced by the B0 fuel engine is higher than the B5 and B10 fuel engines and the power produced by the B5 fuel engine is higher than the B10 fuel engine.

Meanwhile, after testing for 200 hours of operation, engine speed data (RPM) was obtained and then torque analysis was carried out. Based on the calculation results, the average torque value produced by the B30 engine is 12.54 N.m. Based on Figure 2, it can be seen that the torque of the B30 engine tends to increase slightly with increasing operating time. The formed trend has similarities with the power trend. This is because torque is a function that is directly proportional to engine power. According to Ozsezen et al., (2009) in addition to the combustion temperature, the calorific value of the fuel is also a factor in the engine torque produced.

Specific fuel consumption and thermal efficiency

After testing for 200 hours of operation, data was obtained for the time required by the engine to spend 20 ml of B30 fuel. Based on the results of the analysis, the average SFC value produced by the B30 engine is 0.28 kg/kW.hour. The SFC calculation is based on the specific gravity of the fuel, which is 845.7 kg/m^3 (Table 1). Based on Figure 3, it can be seen that the SFC of the B30 engine tends to decrease with increasing operating time. This is because as the operating time increases, the average combustion temperature in the cylinder block increases to 134° C, so that in producing a certain power, less fuel is injected.

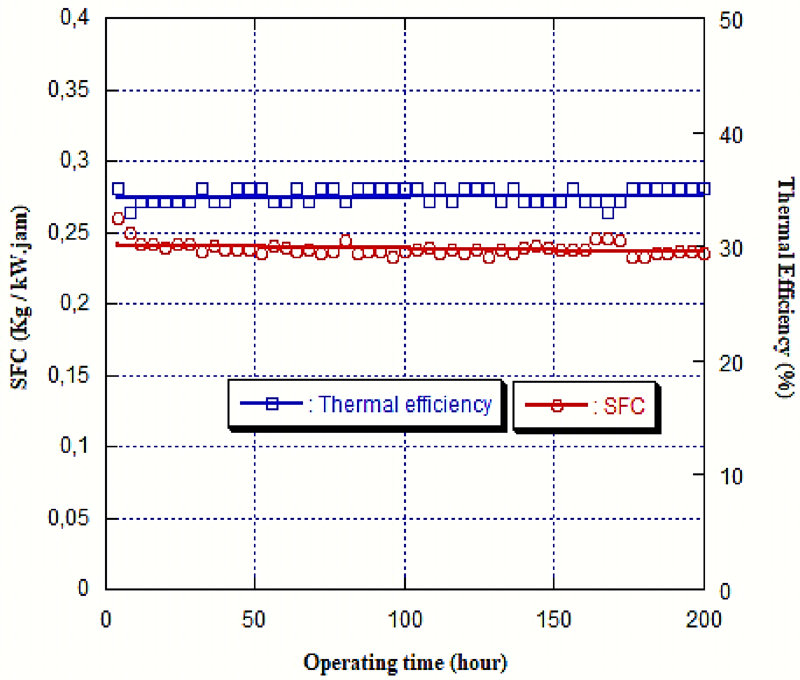

Figure 3. The relation of SFC and thermal efficiency against operating time

The calculation of thermal efficiency is based on the assumption of the calorific value of both fuels. B30 fuel has a calorific value of 43,828 MJ/kg (Liaquat et al., 2013). Based on the test results of 200 hours of operation, the average value of thermal efficiency produced by the B30 engine is 29.43%. The low thermal efficiency value indicates the conversion process of chemical energy into mechanical energy of the machine is slightly worse. Based on Figure 3, it can be seen that the thermal efficiency of the B30 engine tends to increase with increasing operating time. This is because the thermal efficiency function is directly proportional to the power and inversely proportional to the amount of fuel injected into the combustion chamber. So that if the power increases and the amount of fuel injected decreases, the thermal efficiency of the engine will increase and vice versa.

Conclusion

Based on the research results, B30 can be used directly as a diesel engine fuel without having to modify the engine combustion chamber. The use of B30 fuel produces an average power and torque value of 4.45 kW and 12.54 N.m. Meanwhile, the value of specific fuel consumption and average thermal efficiency produced is 0.28 kg/kW.hour and 29.43%. The power and torque values can be affected by the heating value and the viscosity value of the fuel. Engines with fuels that have a lower calorific value and a higher viscosity value make the fuel atomization conditions worse so it will affect the resulting performance.

Acknowledgment

The author would like to thank the LPPM of the University of Pembangunan Nasional "Veteran" Jawa Timur for the support of the facilities provided. The author would also like to thank the Directorate General of Diktiristek, for the financial assistance through the Basic Higher Education Research (PDUPT) scheme so that this research can run well.

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