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Analysis of the mixture fuels to the performance of diesel engine

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Abstract

The demand for fuel is increasing every year that the supply comes to decrease. Biodiesel is an alternative energy for diesel fuel. It has the same characteristics as diesel fuel. It also renewable and environmentally friendly. The mixture of biodiesel and diesel fuel lessens the concentration of hydrocarbons and increases the cetane value. Therefore, combustion occurs completely. The purpose of this research is to compare the power, SFC and exhaust emission of direct injection engines with B-20 fuel to those with diesel fuel. The method to test the engine power uses ISO 1585 where the engine speed range starts from 1000-4000 rpm. The test results show that the engine has better performance when it uses mixture fuels but it is not for the engine with diesel fuel. The mixture fuels give higher power to the engine, but less emission. It is the opposite of the engine with diesel fuel, even though the difference in power is slight. It can be concluded that the mixture fuels influence the performance of direct injection engine.

***Keywords**: biodiesel; diesel engine; diesel fuel; performance*

1. INTRODUCTION

Biodiesel is an alternative fuel for diesel engine as it has the same characteristics as diesel fuel. Moreover, it can be the replacement of fossil fuels that will run out in line with the time. This fuel consists of alkyl esters of fatty acids from plant oils and animal fats through the process of esterification and transesterification or a combination of both (1). Plants used include palm oil, coconut oil, jatropha oil, and kapok (*Ceiba petranda*) seed oil, while those derived from animal fats are lard, chicken fat, beef fat, and from fish (2).

The difference between biodiesel and diesel fuel is the length of its carbon chain, wherein biodiesel has 12 to 20 carbon chains containing oxygen, while the diesel fuel has only 15 to 17 carbon chains. The biodiesel is advantageous as it is made of renewable material, high cetane number, biodegradable, and can be used on all standard engines. It functions as a lubricant and cleaning the injector and reducing carbon dioxide (CO), hydrocarbon (HC) emissions, dangerous particulates and sulfur oxides (SO_x) (3).

The actual combustion process on a diesel engine never occurs completely because the loading and rotation always vary. The amount of opacity emissions (smoke thickness) depends on injected fuels into cylinder. It is because the cylinder compresses the pure air as of the richer the mixture of fuel is, the higher the concentration of NO_x, CO, HC and smoke. Meanwhile, when the mixture is lean, the concentration of NO_x, CO, HC, and smoke is also getting smaller (4).

The research conducted by Susila I. Wayan states that the B-10 fuel produces the best engine performance at 2550 rpm compared to B-0, maximum power of 36.95 PS, lowest specific fuel consumption of 0.256 kg / (PS.hours), thermal efficiency 58.44%, smallest CO content 0.4%, and exhaust gas opacity is 58.6%. HSU meets the State

Minister of Environment Regulation No. 5 of 2006, and the modification on engine is not needed (5).

Furthermore, the results of tests conducted by Martin Djamin and Soni S. Wirawan prove that the addition of biodiesel up to 20% into diesel fuel can improve the engine performance. The highest power and torque are produced at 70 km/hr, but adding biodiesel composition decreasing engine performance. SO_2, particulate matter, CO and NO_x emissions decrease consistently with the increment of biodiesel content in the fuel mixture. However, its characteristics vary depending on the type of emission. The most significant reduction in emission levels with the use of biodiesel occurs in SO_2 and PM emissions (6).

Based on the above research it can be concluded that use of a mixture fuels, diesel fuel and biodiesel, with a certain percentage is very influential on the performance of diesel engines and the resulting emissions. This research uses B-20 biodiesel obtained from Pertamina derived from Crude Palm Oil.

2. Methods

The research is conducted with experimental laboratory research. It compares the test groups and the standards by using laboratory facilities for obtaining data. The aim is to test the performance of diesel engines and the resulting exhaust emissions based on the fuel mixture of biodiesel B-20 and diesel fuel.

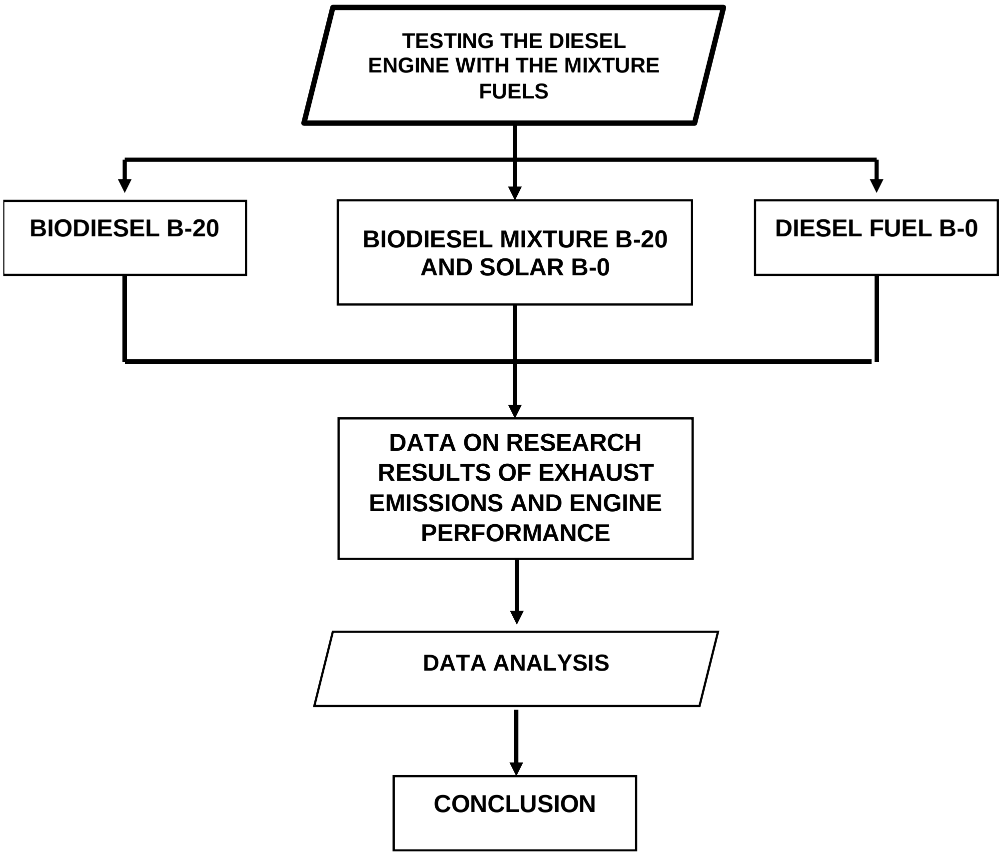

Figure 1. Research flow chart

This research used biodiesel B-20 made from Crude Palm Oil and diesel fuel B-0 obtained from Pertamina for mixture fuels. The data is obtained from the engine speed of 1500, 2000, 2500, 3000, 3000, 3500 and 4000 rpm.

The instruments used in this research are dynamometer, opacymeter, burette, stopwatch, measuring cylinder, pycnometer, digital balance, and tachometer. The testing procedure starts with measuring the density of the fuel, measuring the performance of the diesel engine (power and SFC) and the resulting exhaust emissions. The following testing procedure is explained using the image below.

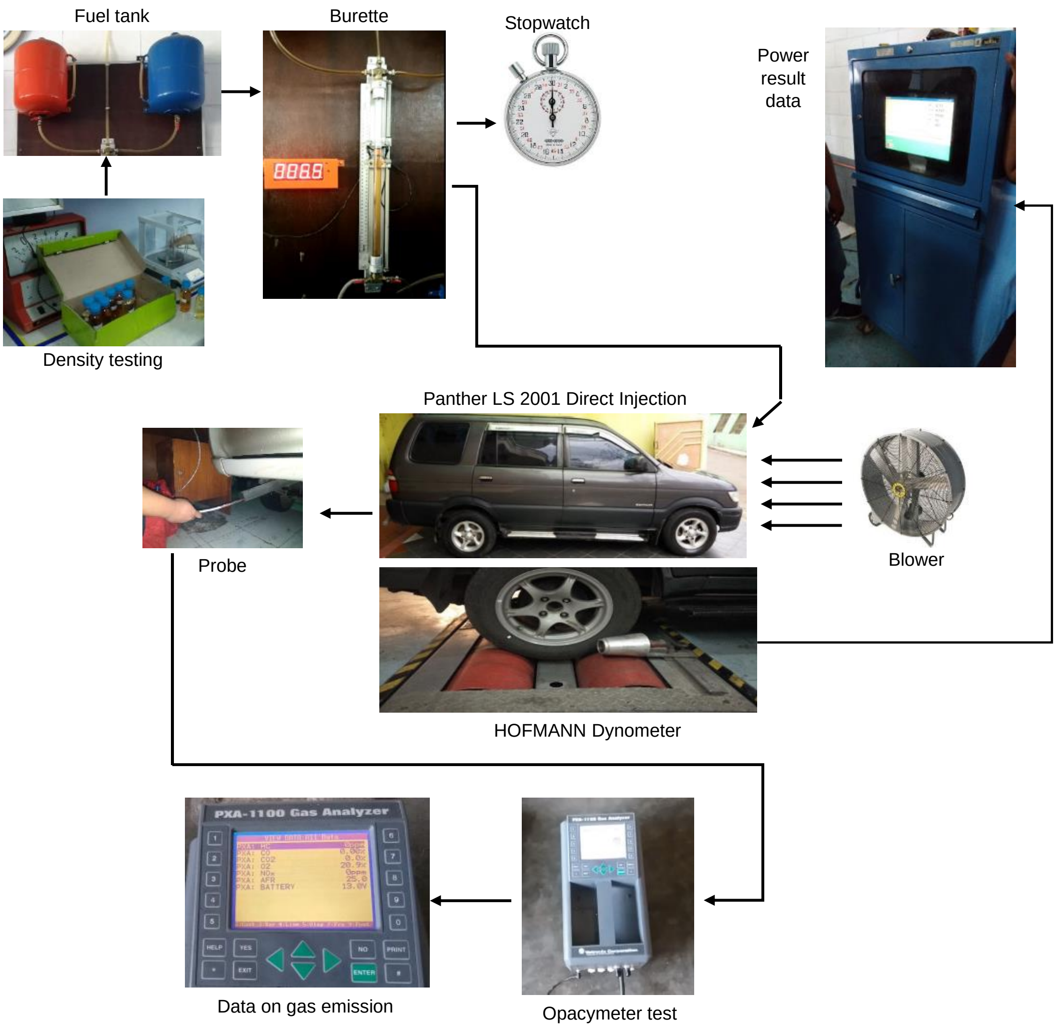

Figure 2. Research procedures

The research used a test method by changing the speed at full load (full open throttle valve) to obtain engine performance data based on ISO 1585 standards.

Data is obtained by conducting experiments to test the objects to be analyzed and recorded the required data.

Data analysis uses descriptive methods by describing or presenting systematically, factually and accurately the facts obtained during testing. The research data obtained were inputted into a table and presented in a graphic. Furthermore, it is explained in simple sentences that are easy to understand and brief to build deduction.

3. Result and Discussion

Results of the engine performance and exhaust emissions are inputted in a table and depicted into a graphic. The graphic explains the causes of increasing and decreasing engine performance and exhaust emissions as the theory stated. It leads to the determination of problem-solving to the problems.

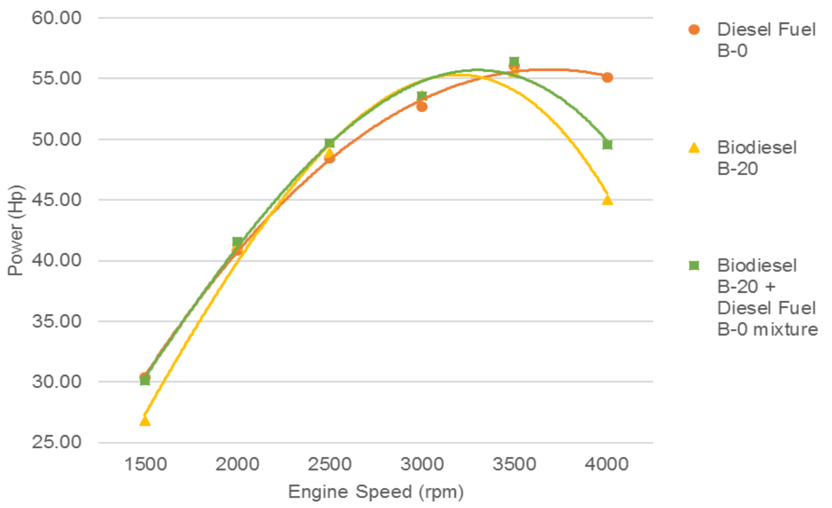

Figure 3. The correlation between engine speed and power

Based on Figure 3 above, the graph of effective power increases in each rpm level in the B-20 biodiesel mixture compared to diesel fuel B-0. It increases from 1500 rpm to 2000 rpm. This is due to the increased torque generated. The mixture of air and fuel entering the combustion chamber is almost complete and result in the increment of effective power (7).

The effective power is still increasing from 2000 rpm to 3250 rpm. It is as the result of increased engine speed that the compression pressure in the combustion chamber increases, with the increasing compression pressure the resulting power also increases (7).

The effective power graph decreases at 3250 rpm to 4000 rpm. This is caused by the high speed of torque decreases and the piston has no enough time to inhale the mixture of air and fuel, therefore, the volume of fuel consumed decreases and so the compression pressure. It leads to an incomplete combustion process. As a result, the effective power generated also decreases. (8)

The results showed that the use of mixture fuels of biodiesel and diesel fuel are able to increase the effective power produced by the Isuzu Panther LS 2001 diesel engine instead of using B-0 diesel fuel. Of all the fuels, the best or arguably the highest power is obtained by the mixture fuels of B-20 biodiesel and B-0 diesel fuel.

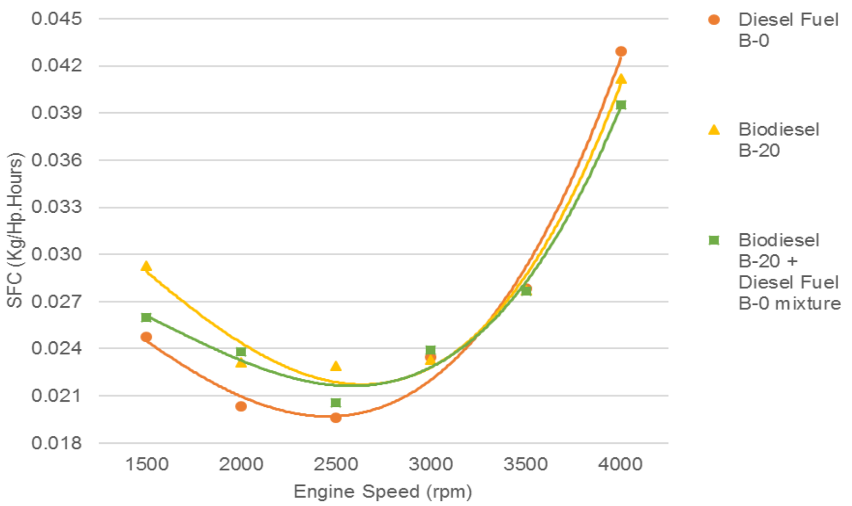

Figure 4. The correlation between engine speed and SFC

Graphic in Figure 4 shows that at low speed (1000 rpm) fuel consumption (SFC) tends to be high because at low rotation the fuel is a lot sprayed into the combustion chamber. It aims to accelerate the engine to reach operating temperature and to produce high torque during low speed. But the power produced at low rotation is small. At 2000 rpm to 3000 rpm rotation, fuel consumption (SFC) tends to be efficient because at this rotation the engine operating temperature has been reached, the mixture of fuel and air in the combustion chamber is appropriate and the power and torque produced tend to be efficient. At high rotation, fuel consumption (SFC) has increased because of the engine speed is high then the fuel requirements for the combustion process will be higher. The aim is to produce greater power (9).

At low engine speed (1500-2500) rpm the use of solar B-0 has a more efficient specific fuel consumption (SFC) value of 0.01961 kg/ hp.hours compared to all variations of the fuel mixture. Whereas bio solar B-20 has a more wasteful specific fuel consumption value (SFC) which is 0.02288 Kg/hp.hour compared to all variations of the fuel mixture. This is because the viscosity value of diesel fuel B-0 is lower compared to all variations of the fuel mixture so that the extraction process is more evenly distributed, the fuel flow rate is faster and the fuel can burn completely. In this case, the temperature factor has not had a significant effect on the viscosity value of each fuel because at low rpm the engine working temperature is also low. At high speed (3000-4000) rpm the viscosity value of each fuel decreases significantly because it is affected by high temperatures so that the ignition process tends to be evenly distributed on each fuel and the fuel can burn completely (10). Therefore at high rpm, the efficiency of specific fuel consumption (SFC) is not only influenced by viscosity but is also influenced by the cetane number and power efficiency produced at each variation of fuel (11). So that at high rpm the bio solar mixture of B-20 and solar B-0 has a more efficient specific fuel consumption (SFC) value of 0.040 kg / hp.hour. While diesel B-0 has a more extravagant value of specific fuel consumption (SFC) which is 0.043 Kg / Hp.

The results showed that the use of B-20 biodiesel blends with diesel fuel can improve the efficiency of fuel consumption produced by the Isuzu Panther LS 2001 diesel engine. Of all fuels, the most efficient or the lowest possible specific fuel consumption produced at solar B-0 at 2500 rpm.

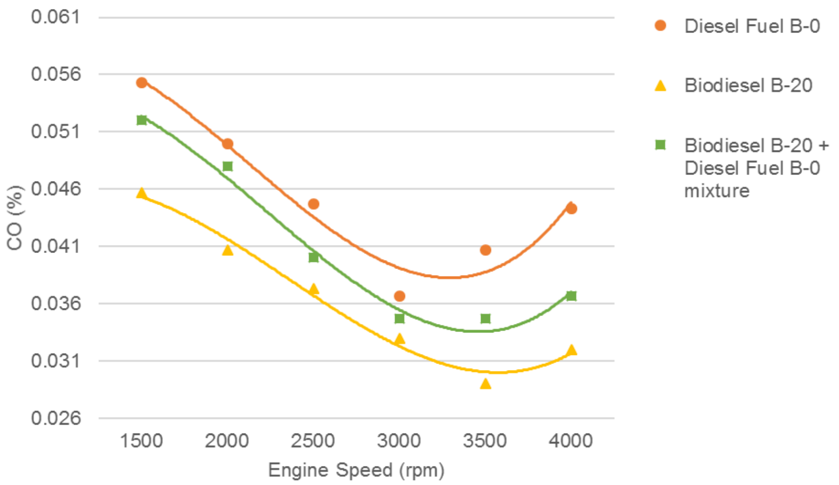

Figure 5. Relationship between engine speed and CO

Figure 5 shows that the CO emission graph tends to decrease in various rpm levels in the B-20 biodiesel mixture compared to the B-0 diesel fuel. At low cycles, the CO emission tends to be high because the ratio of air to fuel is inappropriate because when a rich mixture is formed when the concentration of CO emissions is higher. Conversely, if the mixture is smaller, the concentration of CO emissions will also be smaller (12).

The results of this research indicate that the lowest CO emissions are owned by biodiesel fuel B-20, which is 0.029% at 3500 rpm engine speed. While the highest CO emissions are owned by diesel fuel B-0 which is 0.055% at 1500 rpm engine speed. This is due to biodiesel fuel B-20 having a cetane number > 50 so that shortening ignition delay and combustion is better than diesel fuel B-0 which has a cetane number 48 (13). The sulfur content in biodiesel fuel B-20 is lower than diesel fuel B-0. Besides that, in the biodiesel fuel, B-20 has a higher oxygen content, resulting in a better oxidation process and more perfect combustion and more environmentally friendly (14).

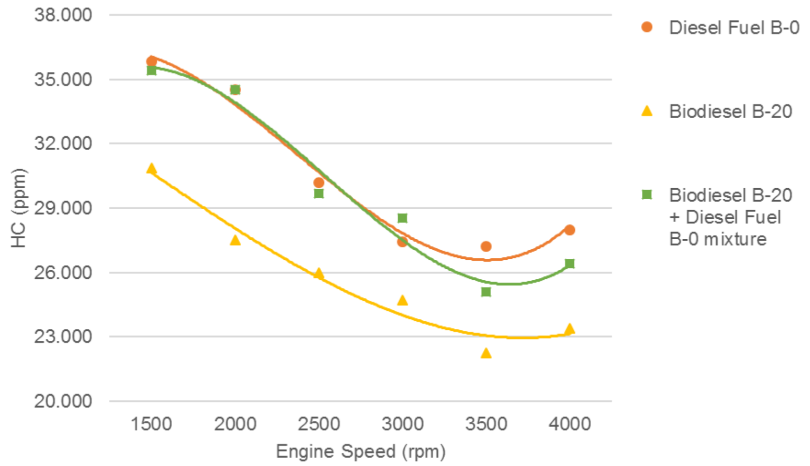

Figure 6. Relationship between engine speed and HC

On figure 6, the HC emission graph tends to decrease in various rpm levels in the B-20 biodiesel mixture compared to the B-0 diesel fuel oil. At low rotation, HC emissions tend to be high because the ratio of air to fuel is not appropriate because when a rich mixture is formed the concentration of HC emissions is higher. Conversely, if the mixture is smaller, the concentration of HC emissions will also be smaller. Besides the long ignition delay, the injector spray volume is uneven, the compression pressure and injector opening are low so that the ignition process is not right, the combustion chamber wall is low and dirty air filters can cause increased HC emissions (12).

The results of this research indicate that the lowest HC emissions are owned by biodiesel fuel B-20, which is 22.27 ppm at 3500 rpm engine speed. While the highest HC emissions are owned by diesel fuel B-0 which is 35,83 ppm at 1500 rpm engine speed. This is due to biodiesel fuel B-20 having a cetane number > 50 so that shortening ignition delay and combustion is better than diesel fuel B-0 which has a cetane number 48 (13). In Biodiesel fuel B-20 there is 20% biodiesel fuel consisting of vegetable fatty acid methyl esters and no hydrocarbon compounds so that when mixed with petroleum diesel it will reduce the hydrocarbon compounds in it (15). Also in the B-20 biodiesel fuel has a higher oxygen content to produce a better oxidation process and more complete combustion (14).

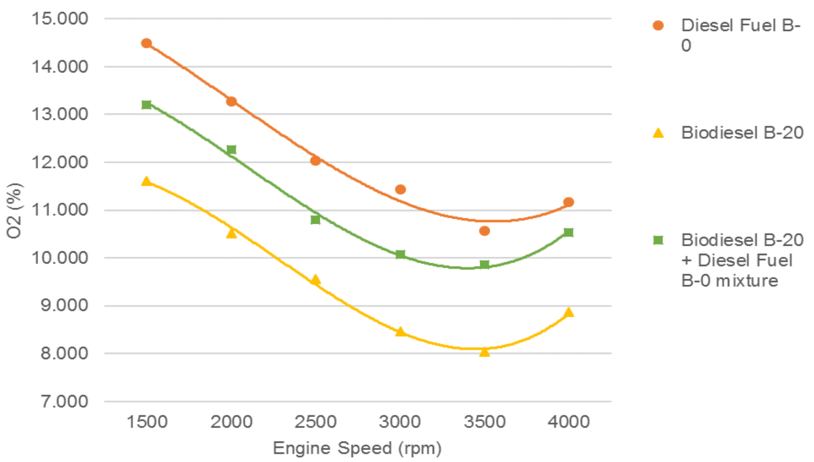

Figure 7. Relationship between engine speed and O_2 emissions

The O_2 emission graph on figure 7 tends to decrease in various rpm levels in the B-20 biodiesel mixture compared to the B-0 diesel fuel oil. At low rotation, O_2 emissions tend to be high because the combustion process is incomplete so that a lot of oxygen cannot react with the fuel and comes out with vehicle exhaust emissions. The reason oxygen cannot react is late fuel injection time, fuel ratio tends to be rich, engine working temperature has not been reached and the injector spray volume is uneven. Conversely, at high rotations, O_2 emissions tend to be small because the combustion is gradually approaching stoichiometry due to engine temperatures that have been reached and the right fuel injection (12).

The results of this research indicate that the lowest O_2 exhaust emissions are owned by biodiesel fuel B-20, which is 8.003% at 3500 rpm engine speed. While the highest O_2 emissions are owned by diesel fuel B-0 which is 14.5% at 1500 rpm engine speed. This is due to biodiesel fuel B-20 having a cetane number > 50 so that shortening ignition delay and combustion is better than diesel fuel B-0 which has a cetane number 48 (13). The sulfur content in biodiesel fuel B-20 is lower. then diesel fuel B-0. Also in the B-20 biodiesel fuel has a higher oxygen content to produce a better oxidation process and more complete combustion (14).

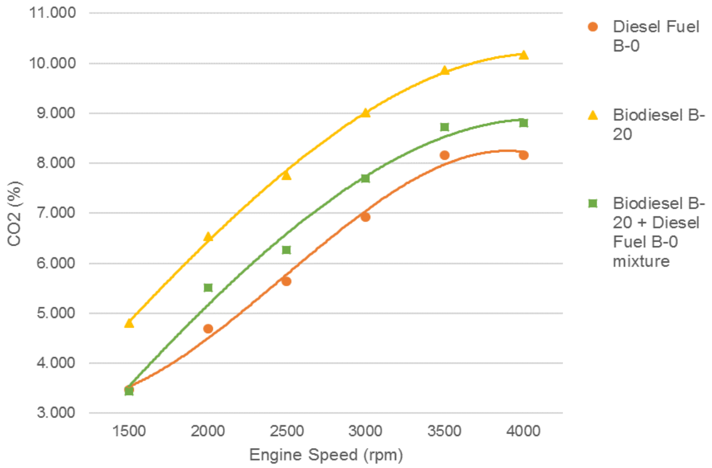

Figure 8. Relationship between engine speed and CO_2 emissions

The CO_2 emission graph tends to decrease in various rpm levels in the B-20 biodiesel mixture compared to the B-0 diesel fuel. It is depicted on Figure 8. At low cycles, the CO_2 emission tends to be small because the ratio of air to fuel is inappropriate because when a rich mixture is formed then the concentration of CO_2 emissions is getting smaller because the combustion process lacks oxygen. Conversely, if the mixture is smaller (stochiometry), the concentration of CO_2 emissions will also increase (12).

The results of this research indicate that the lowest CO_2 emissions are owned by biodiesel fuel B-20, which is 10.1667% at 4000 rpm engine speed. While the lowest CO_2 emissions are owned by diesel fuel B-0 which is 3.667% at 1500 rpm engine speed. This is due to biodiesel fuel B-20 having a cetane number > 50 so that shortening ignition delay and combustion is better than diesel fuel B-0 which has a cetane number 48 (13). The sulfur content in biodiesel fuel B-20 is lower than diesel fuel B-0. Besides that, in the biodiesel fuel B-20 has a higher oxygen content, resulting in a better oxidation process and more complete combustion (14).

4. Conclusion

The test results prove that the use of a mixture of biodiesel fuel B-20 and diesel fuel B-0 can improve engine performance. Highest power and the most efficient specific fuel consumption produced at 4000 rpm engine speed. Whereas HC, CO, and O_2 emissions decreased and CO_2 emissions increased consistently with the use of biodiesel B-20 in the fuel mixture. However, its characteristics vary depending on the type of emission. The most significant reduction in exhaust gas emissions by using a biodiesel B-20 mixture occurred in HC and CO emissions.

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