The Phenomenon of Biodiesel Heating: Its Effect on Viscosity, Density, and Emission

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***Abstract*—biodiesel fuel is a mixture of diesel oil mixed with vegetable oil (palm). The composition of the mixture affects its properties, especially viscosity and density. The research was conducted to determine the effect of increasing temperature on these properties. By applying several experimental methods, including the ASTM D 445-95 method, the pycnometer method, and the particulate emission test method. The biodiesel test was carried out with variations in temperature of 30ºC, 40ºC, 50ºC, 60ºC, and 70ºC at room conditions of 24.0ºC temperature and 71% humidity. From the temperature variation, the viscosity is 2.23 cSt, 2.61 cSt, 3.1 cSt, 3.7 cSt, and 4.45 cSt. The results of the research prove that the increase in biodiesel temperature affects decreasing viscosity and density which has an impact on reducing particulate emissions.**

Keywords: biodiesel heating, density, emission, viscosity.

I. Introduction

Biodiesel B20 is a mixture of 20% vegetable oil and 80% diesel oil [1]. The vegetable oil in question is a product of Fatty Acid Methyl Ester (FAME), which is the raw material for biodiesel. However, research states that the fuel produced from vegetable oil has a high viscosity value [2]. High-viscosity fuels need to be preheated before being used for diesel engine operation. The fuel heating method aims to maintain the temperature of diesel fuel, which has a high viscosity potential and prevents precipitation [3] [4].

Experiments have been carried out on several types of biodiesel including jatropha, gutter, and rubber with heating methods from 10ºC - 80ºC. The experimental results show that an increase in temperature causes a decrease in the viscosity number of all types of biodiesel [5]. Increasing the temperature of biodiesel reduces the density and viscosity of jatropha oil biodiesel fuel[6].

Various studies have shown that heating of the fuel has shown a change in characteristics not only in the form of viscosity, density, and fuel surface tension but also in the water content in the fuel which is also reduced [7].

Biodiesel B20 can be used in diesel motor operations as a substitute for fossil fuels without the need for engine adjustments. Utilization of B20 biodiesel as a solution for the efficiency of fossil fuel reserves, increasing combustion and reducing environmental pollution [8].

Furthermore, a summary of several studies states that an increase in temperature can reduce the viscosity and density of the fuel which in turn affects the exhaust emissions produced by the operation of the diesel engine [9].

There are several types of biodiesel, including sunflower, canola biodiesel, and corn biodiesel with a composition of 20% have been tested and compared with pure diesel oil. The results showed that biodiesel showed higher viscosity and density than diesel fuel. Furthermore, the emission test proved a reduction in CO and an increase in CO2 and Nox [10].

Nitrogen Oxide (NO) plays a role in atmospheric chemistry, influencing the ozone cycle and the troposphere's oxidizing capacity. Nitrogen oxides at high concentrations (> 50 ppbv; ppbv = parts per billion by volume) or > 0.05 ppm cause ozone in the atmospheric boundary layer to become a toxic pollutant [11].

CO2 levels > 5,000 ppm indicate unusual or abnormal air conditions that allow other gaseous contaminants. The danger of poisoning and lack of oxygen can occur in this phase. By reducing CO2 to 3000 ppm or below 5000 ppm, you can reduce the risk of poisoning and oxygen deprivation [12].

Based on various references related to viscosity, density, and the effect on emission, further research needs to be conducted to get more accurate data and find the effect of biodiesel heating on viscosity, density, and emission.

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II. METHOD

Some of the equipment and materials used in this study include a Pycnometer, Heater, and Thermometer while the material used is B20 biodiesel fuel.

Testing the viscosity and density of B20 by heating the fuel in various ways, namely at temperatures of 30ºC, 40ºC, 50ºC, 60ºC, and 70ºC. The test is carried out with the following stages:

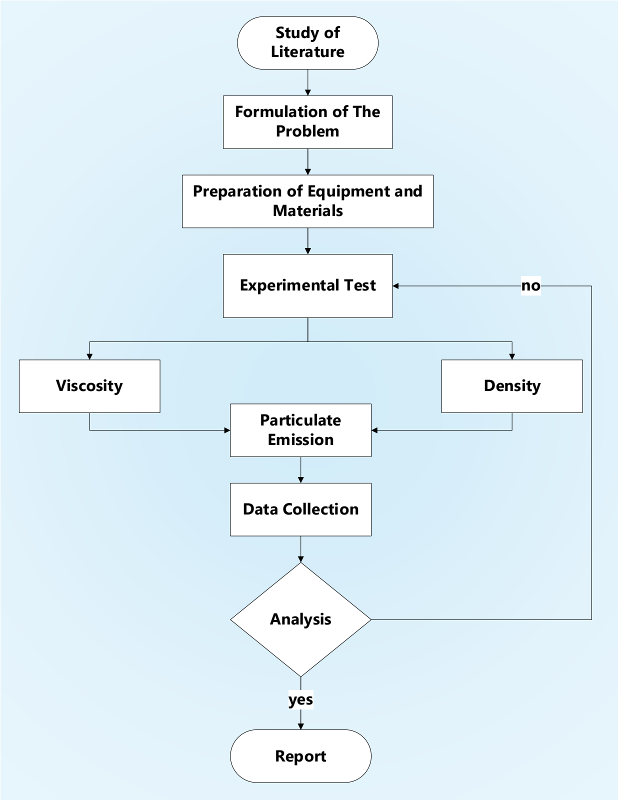

Figure. 1. Research Procedure

Based on Figure 1 shows the research procedures carried out. The study began with the identification of problems with the level of viscosity and density of B20 fuel in ship fuel.

Viscosity test using ASTM D 445 method. Test procedures based on ASTM D445 include;

(1) The falling ball viscometer is cleaned with alcohol and water;
(2) the sample is introduced into the device gradually until it exceeds the starting point limit of +1 cm;
(3) insert the glass ball by tilting the tool;
(4) the instrument is tightly closed so that no sample solution drips out;
(5) the instrument is rotated 180ºC and the stopwatch is executed just as the ball moves from the starting point;
(6) the time it takes for the ball to move to the finish line.

In the test, the kinematic viscosity and dynamic viscosity are calculated using the appropriate formula [10]:

$$v_{1,2} = C.t_{1,2} \quad (1)$$

$$\eta = v \times \rho \times 10^{-3} \quad (2)$$

η = dynamic viscosity (mPa/.s)
ρ = density, kg/m^3
v = kinematic viscosity, mm^2/s
C = calibration
$t_{1,2}$ = time (second)

Density test using Pycnometer method with ASTM 53B reference standard. The test was carried out at room conditions with a temperature of 24.0ºC and a humidity of 71%.

The density measurement method uses a pycnometer by weighing an empty pycnometer, then filled with water to the limit mark to determine the volume at a certain temperature, and then filling init in the same way with the sample liquid. All determinations of density, both in water and liquid samples, in this case, lubricating oil, must be carried out at the same temperature. The volume of each liquid in the pycnometer is always the same, in this study using a pycnometer with a volume of 50 ml and a mass of 30 g. The lubricating oil sample is weighed and the result is reduced by the weight of the pycnometer so that it will get the density result.

In this study, the emission to be tested is particulate emission particulate emissions will be measured. To measure particulate emissions using equipment that is smoke/opacity meter while the standard used is SNI 19-7177.12.2005. Measurement of dust emissions was carried out using a Mitsubishi Diesel Engine Type 4D30 with a total of 4 cylinders with a load of 100%, a speed of 2200 RPM with variations in the viscosity of 4.23, 4.45, 3.75, 2.61, 2.23 cSt. Tests were also carried out on the following density variations: 0.83 g/cm3 and 0.82 g/cm3.

III. RESULTS AND DISCUSSION

Viscosity is a measurement of the resistance of a fluid that is changed either by pressure or stress. Viscosity is the viscosity of a liquid, the thicker the liquid, the higher the viscosity. The results of the B20 biodiesel viscosity test after getting heat treatment are shown in figure 2.

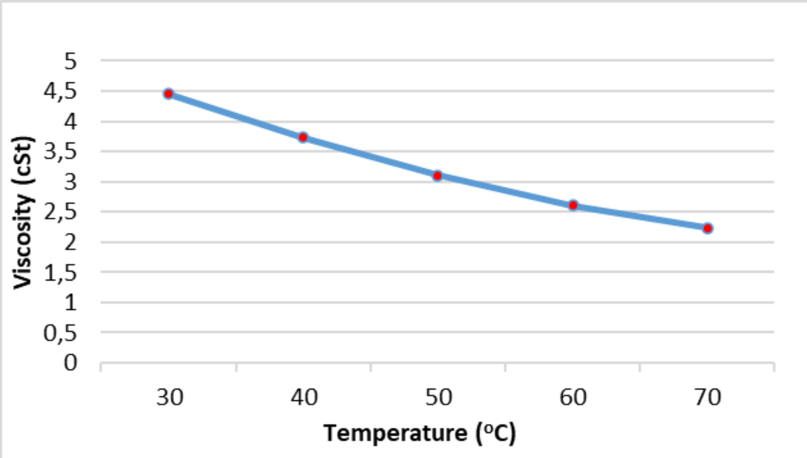

Figure. 2. Viscosity Test Results

The graph in Figure 2 explains that biodiesel B20 at a temperature of 30°C has a viscosity of 4.45 cSt, after the temperature is increased to 40°C the viscosity decreases to 3.75 cSt then at a temperature of 50°C the viscosity drops again to 3.1 cSt then at a temperature of 60°C the viscosity also decreases at 2.61 cSt until finally at temperature 70°C viscosity decreased at 2.23 cSt. The higher the temperature, the lower the viscosity of biodiesel B20. This can occur because temperature changes can result in thermal decomposition. This thermal decomposition affects changes in fluid properties.

Density or density measures the mass of each unit volume of an object. The higher the density of an object, the greater the mass of each volume. The average density of each object is the total mass divided by the total volume. An object that has a higher density will have a lower volume than an object with the same mass that has a lower density. After being heated biodiesel B20 experienced a decrease in density or density.

The graph of the decrease in density or density can be seen in Figure 3.

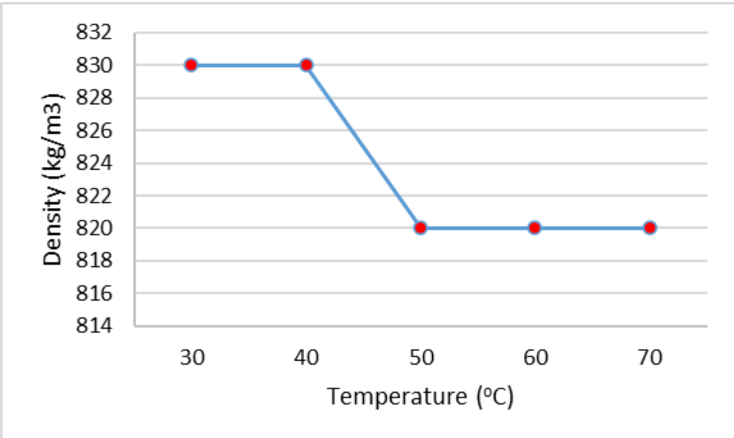

Figure. 3. Density Test Results

Figure 3 describes the decrease in the density of biodiesel after heating. At temperatures of 30°C and 40°C the viscosity of biodiesel B20 was 0.83 g/cm^3 while at 50°C, 60°C, and 70°C the density decreased to 0.82 g/cm^3. It can be concluded that an increase in temperature has an impact on decreasing density. This is due to the increase in temperature, there is a reduction in the density of the substance in this case biodiesel.

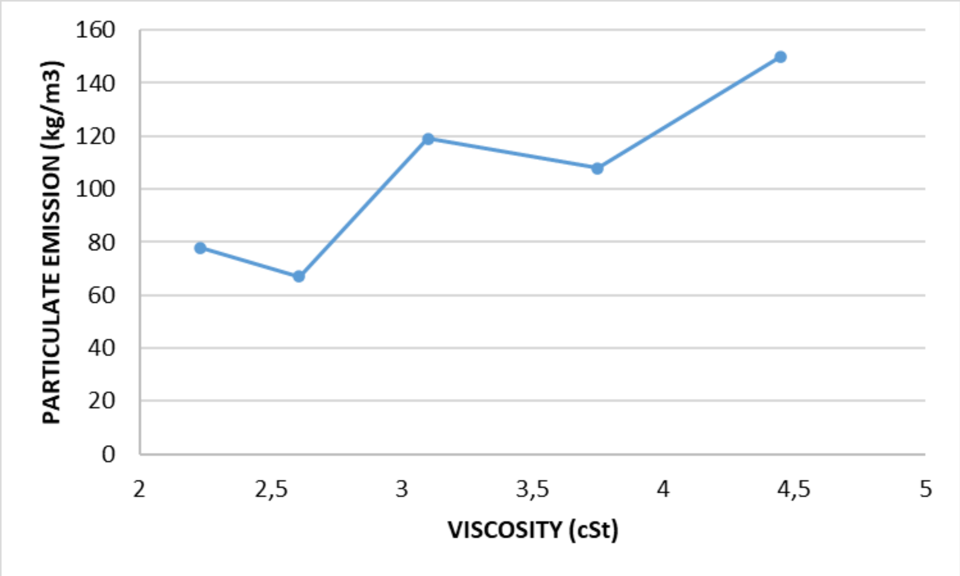

Figure. 4. Viscosity VS Particulate Emission

The graph in Figure 4 shows that in biodiesel B20 at a viscosity of 2.23 cSt the emission level is 78 kg/m3, at 2.61 cSt the emission level decreases to 67 kg/m3, but at 3.1 it increases again to 119 kg/m3, but at 3.7 cSt it decreases at 108 kg/m3 and finally at a viscosity of 4.45 cSt, the emission levels rise to 150 kg/m3. From this condition, it can be concluded that there is a tendency to increase the content of particulate emissions with increasing biodiesel viscosity. Although not the increase is not linear.

IV. Conclusion

From the three experiments conducted, namely viscosity, density, and surface tension on biodiesel B20 which was given heat treatment with temperature variations of 30^{o}C, 40^{o}C, 50^{o}C, 60^{o}C, and 70^{o}C, the results showed that the increase in temperature was directly proportional to the decrease in viscosity, density, and surface tension.

These conditions will provide various advantages in the fuel combustion process, especially in diesel engine combustion. Whereas with low viscosity, density and surface tension the fuel will be more flammable and more complete.

Furthermore, the impact of more complete combustion will improve the performance of the engine itself and reduce exhaust emissions from combustion.

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