Characteristic study of biodiesel mixtures from used oil and diesel oil

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Abstract. Biodiesel is an alternative fuel for diesel machines. Used cooking oil is blended with diesel with a certain volume ratio to improve the characteristics. The characteristics of biodiesel can not be fully used by diesel engines because it doesn’t meet the standards so that its characteristics need to be improved. As for utilizing it, it must be blended with diesel oil. The purpose of this study is to improve the physical and chemical properties of biodiesel, knowing the percentage of biodiesel volume from used cooking oil with diesel oil so that it can be known the optimal ratio of biodiesel with diesel oil which is close to diesel fuel specifications. Characteristics as variables in this paper are density, kinematic viscosity, pour point, and flash point of the specified mixture. The results show that the kinematic viscosity and density of the biodiesel-diesel mixture increase as the biodiesel mixture increases. Mixtures with higher biodiesel content have higher flash points. Mixing diesel with used cooking oil biodiesel may be of no use compared to diesel, but it can help in adjusting the viscosity, density, pour point, and flash point values according to applicable regulations.

1. Introduction
Consumption of solar oil nationally continues to increase by an average of 7% per year, estimated in 2020 solar consumption reaches 34 million kiloliters. From the consumption, about 40% are diesel imported from several countries since 2004 Indonesia became net-importer oil [1].
Vegetable oil was found to be convincing alternatives which was not only renewable but was also easy to produce [2,3]. For decades, fossil fuels have been meeting most commercial request [4]. Among these fuels, biodiesel, which is defined as a mixture of mono alkyl esters of long-chain fatty acids derived from animal fats or vegetable oils [5,6], is a sustainable fuel as a result of applicability to diesel machine without essential modifications [7,8]. Biodiesel is biodegradable, which means it hardly contains sulfur and renewable fuels. In addition, biodiesel is completely miscible with solar fuel, allowing to mix in any proportion [9,10]. For example, commercial biodiesel-diesel fuel mix containing up to 7% v/v of biodiesel (in some countries even 10% v/v) are currently used in the European, but effort is made to increase the biodiesel content to 20% [11].
The Government has mandated the use of a mixture of B20 with 20% biodiesel and 80% diesel for the transportation sector and effectively applies to the mining sector. With this mandate in force, many customers who want B20 to support this government initiative [12].
Many researchers have used a mixture of biodiesel – diesel on different automotive machines type [13]. The result concluded that the diesel engine can work well with biodiesel and its mixture without machine modification [14]. There is a significant reduction in carbon monoxide, unburned hydrocarbon, and smoke emissions on biodiesel and its mixture compared to diesel oil [15]. Such characteristics can be better understood by studying the composition and blending properties of biodiesel – diesel.

Based on previous research [16], the maximum yield data of 85% occurred in the comparison of methanol and oleic acid 6:1, 1% wt sulfate acid catalyst, with 2 hours at 65 °C. In other studies, Baharsyah et al. [17], the manufacture of biodiesel using ultrasonic waves is known to reduce reaction time up to 60 minutes. From his research acquired 95,341% yield with the use of catalyst amounted to 1,5 wt% and the comparison of alcohol and oil 6:1.

Mirrored from some previous research, through this research is expected to produce biodiesel with optimal characteristics and maximum yield of the process of blending various bait and diesel oil as well as knowing the influence of Percentage blending of the oil blending characteristics.

Based on the background can be formulated the problem of how to know a good source of used oil in the process of manufacturing biodiesel with ultrasonic waves. How to know a comparison of optimal solar and biodiesel blending in accordance with SNI solar.

2. Methods

The research was conducted in the chemical laboratory, and petroleum laboratory of PEM Akamigas Cepu, Blora-Central Java, in March – December 2019. For testing the properties analysis of biodiesel and product blending results (diesel and biodiesel) will be tested in laboratories. The material to be used in this study is used oil from palm oil, methanol, the NaOH catalyst. The tool to be used in this research is 1 series of distillation tools, 3 neck flasks, glass cooler (condenser), glass beaker, thermometer, clamp and statif, erlenmeyer, hot plate, magnetic stirrer, ultrasonic tank, picnometer, burette, and pipette.

First stage, cooking oil that will do transesterification analyzed% FFA. If the FFA rate is less than 0,5% then it will proceed next process. At this stage, the cooking oil that will do transesterification is analyzed % FFA. The second phase, a base catalyst of NaOH 1,0 wt% was dissolved in a technical methanol. The oil is inserted in the triple neck flask containing the stirrer. Afterwards put methanol into the flask. Comparative oil molar : methanol is 6:1. After that set the reaction time to run for 30 minutes and turn on the ultrasonic tank. Every time 2,5; 5; 7,5; 10; 20; and 30 minutes of sampling with a mumps pipette to be analyzed for its % FAME.

Blending between diesel and biodiesel according to B0 (0% biodiesel), B20 (20% biodiesel), B40 (40% biodiesel), B60 (60% biodiesel), B80 (80% biodiesel), and B100 (100% biodiesel).

The properties analysis is intended to know the physic and chemical properties of diesel that have been blending with biodiesel. Type of testing or properties according to the specifications issued by general directorate of oil and gas include density, kinematic viscosity, acid figures, pour point, and flash point.

3. Results and discussion

Referring to SK Dirjen Migas No. 3675 K/24/DJM/2006 and SK Dirjen Migas No. 978. K/10/DJM. S/2013. Minister regulation of energy and mineral resources, No. 32 year 2008 on the provision, utilization, and commerce of biofuels.

| Characteristics               | Unit   | Min limitation | Max limitation | Test method (ASTM) |
|-------------------------------|--------|----------------|----------------|--------------------|
| Cetane Number                 |        | 48             | -              | D613               |
| Cetane Index                  |        | 45             | -              | D4737              |
| Density @15°C                  | kg/m³  | 815            | 860            | D1298/ D4052       |
| Viscosity @40°C                | mm²/sec| 2              | 4,5            | D445               |
| Distillation 90%/Vol. Vapour   | °C     | -              | 370            | D486               |
| Flash Point                   | °C     | 52             | -              | D93                |
| Pour Point                    | °C     | -              | 18             | D97                |
| Copper Strip Corrosion         | Minute | -              | Class 1        | D130               |
3.1. The Effect of biodiesel percentage against density 15°C
Fuel density affects the consumption. The more dense fuel density of its consumption will be less. Biodiesel from used palm oil is slightly denser than diesel. Blending biodiesel from used palm oil with diesel oil will reduce its density to a certain extent. The higher the biodiesel content, the higher the mixture density as shown in figure 1.

The equation that can predict the density value from B0 to B100 is $y = 0.0003x + 0.8495$ with $R^2$ is 0.9797.

Based on the government-issued specification, the density B0 until B40 entered the solar/biosolar range. While the density B60 until B100 has not entered the allowable range.

![Figure 1. Variation of density with varying biodiesel percentage.](image)

3.2. The effect of biodiesel percentage against kinematic viscosity
Higher fuel viscosity has poor atomization characteristics, and a narrow burst angle. Fuel with poor viscosity, resulting in excessive wear, and poor lubrication. So, the fuel is desirable to have the optimal value of kinematic viscosity. The kinematic viscosity included in the biodiesel standard is ranged between 1.9-6.0 mm²/s according to ASTM D6571. It can be noted that the pure viscosity of biodiesel (B100) is almost doubling the viscosity of diesel (B0). However, the pure kinematic viscosity of biodiesel can be reduced to the desired value by mixing it with diesel in certain proportions.

With the increasing percentage of biodiesel, the viscosity of samples is found increased as shown in the figure 2. The relationship between the kinematics viscosity mixture and the percentage of biodiesel (x) mixed is $v = 0.0111x + 3.4781$ with coefficient of determination ($R^2$) = 0.9864.

Based on the government-issued specifications, the kinematic viscosity of B0 to B80 is entered the solar/biosolar range. While kinematic viscosity B100 not yet entered the allowable range.

![Figure 2. Comparison between biodiesel percentage and kinematic viscosity.](image)
3.3. Effects of biodiesel percentage against flash points

Pure Biodiesel (B100) found to have a flash point of 148 °C, this does not meet the biodiesel criteria according to ASTM D93 because its maximum limit is 130°C. Add the diesel oil to biodiesel, lowering the flash point in a certain boundary using ASTM D93. The flash point increased at a percentage increase in biodiesel in the diesel oil. The flash point changes with the percentage of biodiesel (x) are shown in the figure 3. The equation describing the flash point relationship and the percentage of biodiesel (x) is $y = 0.002x^3 - 0.017x^2 + 0.8881x + 62.668$, with $R^2 = 0.9941$. Based on the government-issued specification, the B100 flash point is included in the solar/biosolar range.

![Figure 3. The flash point relationship and the percentage of biodiesel.](image1)

3.4. Blending effect against pour point

Pure biodiesel (B100) found to have a pour point of 10 °C, it still meets the biodiesel criteria according to ASTM D97 because its maximum limit is 18°C.

Add the diesel oil to biodiesel, lowering the pour point value to a certain limit using ASTM D97. The pour point increases at the increased percentage of biodiesel in the diesel oil. The flash point changes with the percentage of biodiesel (x) are shown in the figure 4.

The equation describing the pour point relationship and the percentage of biodiesel (x) is $y = -1E-5x^3 + 0.0025x^2 - 0.0351x - 0.7857$, with $R^2 = 0.9796$. Based on the government-issued specification, the pour point B0 until B100 is entered solar/biosolar range.

![Figure 4. Variation of pour point with biodiesel percentage.](image2)
4. Conclusions
Density $B_0$ to $B_{40}$ in solar/biosolar range, while the density $B_{60}$ until $B_{100}$ has not entered the allowable range. Kinematic viscosity $B_0$ to $B_{80}$ in solar/biosolar range, while kinematic viscosity $B_{100}$ not yet entered in the allowable range. Cetane index $B_0$ to $B_{100}$ enter the solar/biosolar range. The flash point $B_0$ until $B_{100}$ entered the solar/biosolar range. Pour point $B_0$ until $B_{100}$ entered the solar/biosolar range.

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