Test of Biodiesel Usage to Engine Performa on Dong Feng Diesel with Power 7 HP

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Abstract. This study aims to see the ability of Biodiesel fuel to Engine Performance on Dong Feng diesel engines with 7 kW Power. The biodiesel used was synthesized by Biodiesel using frying oil and methanol as well as limestone catalyst (CaCO3). There are 2 types of Biodiesel used, namely Biodiesel with synthetic catalysts (homogeneous) and Biodiesel with natural (heterogeneous) catalysts. The synthesis catalyst resulted in a 31.52% randement, while the natural catalyst produced a 78.79% randement.The produced biodiesel was tested on a Dong Feng diesel engine with 7 HP Power. To get a comparison of engine performance, Biodiesel fuel is used with synthetic catalysts (homogeneous), Biodiesel with natural (heterogeneous) catalysts, and Solar fuels. The results showed that the engine power produced from Biodiesel was lower than the engine power using Solar. Power from Biodiesel with synthetic catalysts (homogeneous) averages 33% lower than Power using Solar, while Biodiesel with natural catalysts (heterogeneous) is 41% lower than Solar-powered Power. Fuel Consumption, FC (g/ hour) on the engine using Solar is higher than FC engine using Biodiesel. FC from Biodiesel with synthetic (homogeneous) catalyst is an average of 7% lower than Solar, while Biodiesel with natural catalyst (heterogeneous) is 30% lower than Solar. This proves the use of Biodiesel fuel with heterogeneous catalysts is more economical than Solar fuels.Specific Fuel Consumption (SFC), also shows that SFC on a Solar fueled engine is almost equal to the SFC Biodiesel fueled engine. SFC from Biodiesel with synthesis catalyst (homogeneous) is 4% lower than Solar fuel, while Biodiesel with natural catalyst (heterogeneous) is 7% lower than Solar fuel.

Keywords: Biodiesel, Solar, catalyst, engine performance, Power, FC, SFC.

1. Introduction

Catalysts are needed to accelerate the formation of Biodiesel. Therefore, the catalyst plays a very important role in Biodiesel production [1]. Transesterification reactions with alkaline catalysts usually use alkali metals alkoxide, NaOH, KOH, and NaHCO3. The use of this catalyst has a weakness, namely the separation of catalysts from their products is relatively difficult so that it will increase production costs [2]. The remaining base catalyst can also interfere with the further processing of the produced Biodiesel [3]. For this reason, it is necessary to make heterogeneous catalysts that are easier to separate and have high catalytic effectiveness. Heterogeneous catalyst research in Biodiesel synthesis is expected to find other advantages such as more environmentally friendly and can be directly used without the need for further modification [2].

Various types of catalysts such as BaO, MgO and K2CO3 have been used for Biodiesel production and the results show that the maximum Biodiesel production obtained is 85%. Biodiesel production obtained was closely related to the base strength of the catalyst [4].

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To find heterogeneous catalysts that have good efficiency, cheap and easy to obtain, it is necessary to make an inventory of the ability of heterogeneous catalysts in producing biodiesel. One heterogeneous catalyst that is very potential to increase the amount of production and reduce the production cost of Biodiesel is CaCO3. The study of the use of natural CaCO3 will be compared with synthesis as a heterogeneous catalyst in Biodiesel production.

Biodiesel is a fuel from vegetable oil that has properties resembling petroleum diesel (Solar) and is an alternative to diesel fuel made from renewable sources. This fuel is environmentally friendly because it produces exhaust gas emissions which are far lower compared to diesel / solar, which is sulfur free. Biodiesel has a low smoke number, a higher cetane number so that it is clear burning, lubrication properties on the engine piston, and can decompose so that it does not produce toxins [5].

The chemical and physical properties of Biodiesel are almost the same as Solar so that Biodiesel can be used directly for diesel engines or mixed with Solar. Biodiesel contains oxygen, so the flash point is higher than Solar so that it is easy to burn. In addition, Biodiesel does not contain sulfur and carcinogenic benzene compounds. Therefore, Biodiesel is a cleaner and easier fuel to handle compared to Solar.

To see the ability of Biodiesel as a fuel motor fuel, the engine performance testing is performed, which can provide information about the engine's capabilities. The parameters displayed in engine performance are: 1). Torque, 2). Power, 3). Heat efficiency, 4). Specific fuel consumption.

2. Research Method

2.1 Preparing Waste Cooking Oil

Used cooking oil that is used in this study comes from used frying oil of fried chicken by street vendors in Sukajadi district, Pekanbaru. Used cooking oil that had been collected was filtered first with filter paper to remove sediment or other frying remnants [2].

2.2.Preparing Catalyst CaCO3

Natural limestone (CaCO3) which was still in the form of small lumps was crushed until smooth by using mortar and pestle. After smooth, CaCO3 was sieved using a 100 mesh sieve. Then CaCO3 was calcined in the furnace at 950^{o}C for 3 hours to remove impurities and restructuring. After the calcination process was complete, the resulting CaCO3 catalyst was stored in a desiccator to keep the catalyst conditions dry, while the CaCO3 synthesis catalyst used manufacturing materials. CaCO3 was heated in an oven at 105 ° C to release water before use.

2.3. Biodiesel Synthesis

Synthesis of Biodiesel was carried out using methanolysis process between used cooking oil and methanol. Used cooking oil is transesterified with methanol using CaCO3 catalyst. The transesterification process was carried out by homogenizing 8, 25 grams of CaCO3 catalyst and 165 ml of methanol for ± 30 minutes. After homogeneous, 825 ml of cooking oil was added to the mixture while stirring and heated at 65 ° C for 2 hours. The obtained biodiesel was then filtered to separate the Biodiesel mixture with CaCO3 catalyst (natural and synthesis). After being separated, the Biodiesel was put into a separating funnel and allowed to stand for 1 night to separate Biodiesel with glycerol. The biodiesel formed in the top layer was taken and then washed with warm water (temperature ± 50^{o}C). Then Biodiesel was purified by heating at a temperature of 100^{o}C.

2.4. Engine Testing

To find out whether the Biodiesel produced was suitable for use on the engine, Biodiesel run into the Dong Feng 7 HP diesel engine for determining the best formulation was carried out. Engine performance tests included torque, rotation, power, efficiency, specific fuel usage. In order to produce high performance, modifications can be made to the engine. As a comparison, the Solar, Biodiesel and synthetic catalysts (homogeneous) and Biodiesel with natural (heterogeneous) catalysts were used in this test.

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To get the value of engine performance, measurements of rotation (RPM), load (kg), torque arm distance, fuel volume consumed (cc), and operating time (seconds) were measured. From the measurement results, Torque, Power and specific fuel usage can be calculated. The amount of power can be calculated by the formula:

$$P\ (kW) = 2.\ \pi.\ n.\ T \qquad (1)$$

Where : T = torque (Nm)

Specific fuel usage (SFC) is the use of fuel per time divided by the power produced.

$$SFC = \frac{FC}{P} \qquad (2)$$

Engine testing can also be done using Solar fuel to see the comparison of engine performance between Biodiesel fuel and Solar fuel.

3. Result and Discussion

The results of the research are shown in table 1 and 2 as follows:

Table 1. Result of Biodiesel Synthesis

NO	Oil Comparison : Methanol : Catalyst	Color	Rendement (% v oil)
1	5 : 1 : 1% $CaCO_3$ synthesis (homogeneous)	Clear Yellow	31,52
2	5 : 1 : 1% $CaCO_3$ natural (heterogeneous)	Reddish Yellow	78,79

Table 2. Characterization of Biodiesel

NO	Parameter	Unit	$CaCO_3$ synthesis	$CaCO_3$ natural	SNI-04-7182-2012
1	Biodiesel Density	(kg/m^3)	881	899	850-890
2	Amount of Water	%	< 0.05	< 0.05	Max. 0,05
3	Sediment	%	< LOD	< LOD	Max. 0,05
4	Iodine Number	mass (g-12/100 g)	59,14	63,15	Max. 115
5	Acid Number	mg-KOH/g	1,38	1,08	Max 0,8

The synthesis process of Biodiesel with used cooking oil and methanol was carried out using a comparison between oil: methanol: catalyst of 5: 1: 1% catalyst (of oil weight) and heating at 65°C for 120 minutes. The optimum time for the Biodiesel transesterification process is 120 minutes [8]. When the catalyst is used which is <1% (weight of oil) the product produced is not maximal, whereas if the catalyst is> 10%, the mixture of catalysts and reactants will become too thick, so that the results formed are also not optimal.

In table 1, it can be seen that the use of synthetic (homogeneous) CaCO3 catalyst produces Biodiesel with a 31.52% randement and clear yellow color, while the use of natural (heterogeneous) CaCO3 catalyst produces Biodiesel with a 78.79% yield and reddish yellow color.

3.1. Density

Both of the biodiesel produced meet the SNI Biodiesel for density parameters, which are 850-890 kg/m3. The mass of Biodiesel produced is 881 (CaCO3 synthesis) and 899 kg / m3 (natural CaCO3). Biodiesel that has a density greater than the provisions, an imperfect reaction will occur in the conversion of used cooking oil. Biodiesel with a quality like this cannot be used for diesel engines because it will increase engine wear, emissions, and cause damage to the engine [11].

3.2. Acid Number

Both of the biodiesel synthesized from the heterogeneous catalyst CaCO3 meet SNI 04-7182-2012 for acid number parameters (max 0.8 mg-KOH / g). Biodiesel acid value using synthesis CaCO3 is 1.38 mg-KOH / g,

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while Biodiesel with natural CaCO3 catalyst is lower at 1.08 mg-KOH / g. High acidity is an indicator of Biodiesel which still contains free fatty acids [11].

3.3. Water and sediment content

Based on the results of testing the water and sediment content, the Biodiesel sample from CaCO3 catalyst did not show any water or sediment content. This shows that when the heterogeneous catalyst separation process is used completely separately, and when the process of purifying the water remaining from the previous washing process has also completely evaporated, sediments contained in Biodiesel can clog and damage the engine [6].

Because the absence of sediment content in the Biodiesel sample shows that a perfect separation process does not leave the CaCO3 catalyst. Thus the Biodiesel produced can be applied to diesel engines.

3.4. Iodine number

The iodine number is a parameter used to show the number of double bonds in the fatty acid composing Biodiesel. Biodiesel with high iodine content (> 115) will result in a tendency to be polymerized and form deposits in the engine during the combustion process [12].

In the iodine number test, the biodiesel synthesized using CaCO3 synthesis and natural CaCO3 catalysts were 59.14 and 63.15 g-12/100 g, respectively. The iodine number meets the quality requirements of SNI 04-7182-2012. Thus, the Biodiesel is expected to be used as a substitute fuel for Solar.

3.5. Engine Performance

Dong Feng diesel engine specifications used are a maximum power of 7 HP and a maximum rotation of 2600 rpm. In the first test, solar fuel was used, and then Biodiesel fuel with synthesis catalyst, as well as Biodiesel with natural catalyst.

The results of data collection from this test are as in table 3, table 4 and table 5

Table 3 Engine Testing Data with Solar Fuels

No.	Rotation (RPM)	Load (kg)	Arm distance (m)	Fuel Volume (cc)	time (second)
1	1520	3.6	0.35	14	30
2	1660	4.1	0.35	17	36
3	1870	4.6	0.35	20	45
4	1960	4.8	0.35	15	36
5	2030	5.1	0.35	19	45
6	2250	5.3	0.35	20	38
7	2310	5.4	0.35	20	32
8	2370	5.5	0.35	17	26
9	2460	5.8	0.35	14	19
10	2510	5.9	0.35	20	25
11	2550	5.7	0.35	21	22

Table 4 Machine Testing Data with Synthesis Catalyst Biodiesel Fuel

No.	Rotation (RPM)	Load (kg)	Arm distance (m)	Fuel Volume (cc)	time (second)
1	1500	2.8	0.35	9	20
2	1620	2.8	0.35	8	19.5
3	1700	3	0.35	8	22.3
4	1750	3.2	0.35	7	20.6
5	1800	3.7	0.35	6	17.4
6	1850	4	0.35	6	16.2

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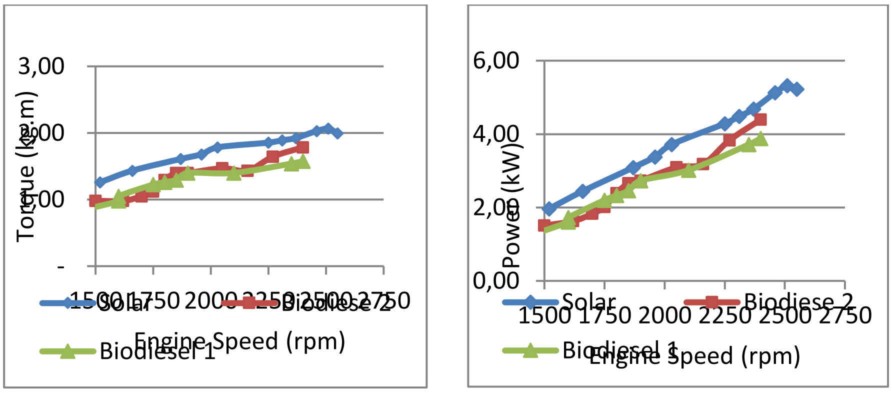
7	1900	4	0.35	6	18
8	2050	4.2	0.35	5	13.4
9	2160	4.1	0.35	6	16.06
10	2270	4.7	0.35	8	17.2
11	2400	5.1	0.35	10	18.4

Table 5 Data Testing Machines with Natural Catalyst Biodiesel Fuels

No.	Rotation (RPM)	Load (kg)	Arm distance (m)	Fuel Volume (cc)	time (second)
1	1450	2.5	0.35	10	24.76
2	1480	2.5	0.35	6	15.03
3	1600	2.8	0.35	8	26.91
4	1600	3	0.35	6	20.2
5	1750	3.5	0.35	5	14
6	1800	3.6	0.35	5	13.5
7	1850	3.7	0.35	6	20.2
8	1900	4	0.35	4	13.16
9	2100	4	0.35	5	16.06
10	2350	4.4	0.35	8	17
11	2400	4.5	0.35	10	18

Test data from Tables 3, 4 and 5 are processed using equations (1) and (2) to obtain torque, power, fuel consumption per hour, and specific fuel usage. The results can be seen in the graph in Figures 1, 2, 3 and 4.



(a) (b)

Figure 1. (a) Graph of Engine Speed Relationship with Torque, (b) Graph of Engine Speed Relationship with Power

Based on the graph in Figure 1 (a) it is seen that the torque on a Biodiesel fueled engine is lower than the torque of a diesel fueled engine. Whereas in Figure 1 (b) it can be seen that the power of a Biodiesel fueled engine is lower than the power of a diesel fueled engine. The average difference in Power between Biodiesel 1 and Biodiesel 2 with Solar is 41% and 33%.

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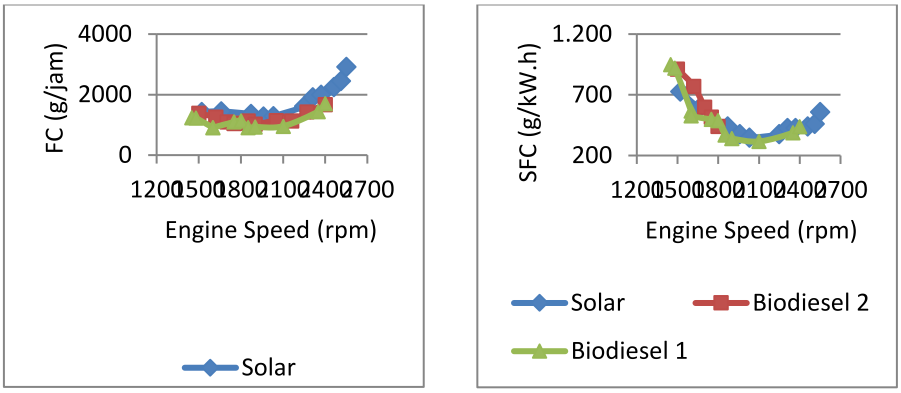

(a) (b)

Figure 2. (a) Graph of Engine Speed Relationship with Hourly Fuel Consumption (FC), (b) Graph of Engine Speed Relationship with Specific Fuel Consumption (SFC)

In Figure 2 (a) it can be seen that the fuel consumption (FC, g/hour) on a diesel fueled engine is higher than the fuel consumption of a Biodiesel fueled engine. This means that the use of Biodiesel fuel is more efficient than Solar fuel. The average difference in fuel consumption between Biodiesel 1 and Biodiesel 2 with Solar is 7% and 30%. Specific fuel use (SFC) is the ratio of fuel usage per hour to the power produced. In Figure 2 (b) it can be seen that the specific fuel consumption (SFC) on a diesel fueled engine is almost equal to the fuel consumption of a Biodiesel fueled engine. The average difference in specific fuel consumption between Biodiesel 1 and Biodiesel 2 with Solar is 4% and 7%. This means that the use of Biodiesel fuel is more efficient than diesel fuel, but the power produced by diesel fuel is higher than Biodiesel fuel

4. Conclusion

Randemen Biodiesel which uses natural CaCO3 catalyst is higher which is 78.79% compared to CaCO3 synthesis which is 31.52%. However, qualitatively, the biodiesel produced from both catalysts meets the requirements of SNI 04-7182-2012. Heterogeneous catalysts (CaCO3) have the potential to produce economical and environmentally friendly biodiesel. Biodiesel can be used as a fuel for Diesel Engines. Torque and power generated from Biodiesel fuel is lower than Solar fuel, but the consumption of Biodiesel fuel is smaller than Solar fuel. This means that Biodiesel fuel is more efficient than Solar fuel

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