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Achievement Analysis of One Cylinder Diesel Engine Using Virgin Coconut Oil Biodiesel

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Abstract. Coconut biodiesel is one of the alternative fuels as a substitute for diesel fuel because it can be produced from renewable energy sources, such as virgin coconut oil (VCO). VCO is one of the most potential ingredients as biodiesel feedstock because of its high oil content. Biodiesel from virgin coconut oil in this study produced a transesterification reaction process using CaO catalyst. This study aims to compare the performance of diesel engines "Dong Feng R-175" using biosolar (B5) and virgin coconut oil biodiesel. This study shows that pure coconut oil biodiesel can be used directly in "Dong Feng R-175" diesel engines. The maximum torque of virgin coconut oil biodiesel is 9.81 Nm at 1200 RPM, and the maximum power produced is 1.33 kW at 1700 RPM with specific fuel consumption (SFC) 0.24 kg / kWh. On average, the thermal efficiency of diesel engines "Dong Feng R-175" using virgin coconut oil biodiesel increased by 33.08% compared to using biodiesel B5.

Keywords: virgin coconut oil biodiesel, diesel engine, engine performance, virgin coconut oil, alternative fuel

1. Introduction

One form of renewable energy is biodiesel which is a substitute fuel for diesel (diesel oil) in diesel engines. Biodiesel can be made from vegetable oils obtained from plants such as palm oil, jatropha, coconut oil, soybeans, sunflowers, and seeds. Biodiesel is known as an environmentally friendly fuel because it is renewable and produces relatively cleaner exhaust emissions compared to conventional diesel fuels, namely diesel oil. In addition, biodiesel is known to be environmentally friendly because the exhaust gases produced from combustion that is released into the atmosphere will be reabsorbed by plants for photosynthesis[1,11-12]. Biodiesel will reduce exhaust emissions without sacrificing performance and engine efficiency. The biggest obstacle to biodiesel applications is that the price is still expensive. This can be seen from the cost of biodiesel production which is still 15.4% higher than the cost of producing petrodiesel. Biodiesel can be made from various biomass containing oil. Coconut is one of the potential biomass to be developed into biodiesel feedstock, because the oil contained is quite large, which is 30-35% of the weight of wet coconut fruit. In addition, the spread of coconuts in Indonesia is broad so that they are easily available[2]. Indonesia produced 3.25 million tons of coconut fruit in 2010 and is the largest coconut producer in the world, which is 31.15% of the total world coconut production[3].



There have been several studies on biodiesel that have been done before, including the manufacture of biodiesel from coconut oil with methanol as solvents and reactants using extractor transesterifiers by Oky Satria Nugraha and Taharuddin (2015) Department of Chemical Engineering, Faculty of Engineering, University Lampung [4]. Meanwhile, Suryanto Buyung in 2011 has conducted research that studies the effect of engine performance on exhaust gas emissions as a mixture of diesel fuel on the performance of diesel engines, where the greater the fuel consumption increases, the oxygen level decreases, carbon dioxide levels rise, oxide levels nitrogen also decreases, carbon monoxide levels rise.[5]

In 2014, Adly Havendri conducted research on the comparison of performance and exhaust emissions of diesel engines using a mixture of diesel fuel with biodiesel CPO, castor oil and coconut oil in the Energy Conversion Laboratory[6], Department of Mechanical Engineering, Faculty of Engineering, Andalas University, Padang. Meanwhile, research on the increase in solar temperature used in Isuzu type 4 JA diesel engines at 850 rpm to 2500 rpm turns has also been investigated, the results show there is an increase in engine power, a decrease in specific fuel consumption and an increase in the thermal efficiency of diesel engines[7].

In its application to combustion motors, mixing biodiesel with conventional fuels (diesel) is a practical way, quite cheap and has a positive impact on exhaust emissions (particulates). In general, a mixture of diesel oil and biodiesel also provides better engine performance than using pure biodiesel. Conversely, the use of pure biodiesel always creates problems such as difficulties in start-up, blockages in filters and other problems in the fuel line[8].

Based on the background of the above problems, researchers felt the need to conduct research on the achievement of the performance of a single cylinder diesel engine using virgin coconut oil biodiesel fuel. The objective to be achieved in this study is to obtain data that can compare the performance of a single cylinder diesel engine with pure coconut oil biodiesel fuel with a single cylinder diesel engine with B5 biodiesel fuel.

2. Research Methodology

2.1 Tools and Materials

The equipment used in this study included a prony brake dynamometer unit that had been made and installed on the testing machine. The prony brake dynamometer used in this study can be seen in Figure 1. In addition, several other research tools, namely magnetic tachometer are used to measure engine speed. Stopwatch is used as a time gauge, to find out how long the machine is turned on. 100 ml measuring cup used to measure the volume of fuel used in this study.

Based on the background of the above problems, researchers felt the need to conduct research on the achievement of the performance of a single cylinder diesel engine using virgin coconut oil biodiesel fuel. The objective to be achieved in this study is to obtain data that can compare the performance of a single cylinder diesel engine with virgin coconut oil biodiesel fuel with a single cylinder diesel engine with B5 biodiesel fuel.

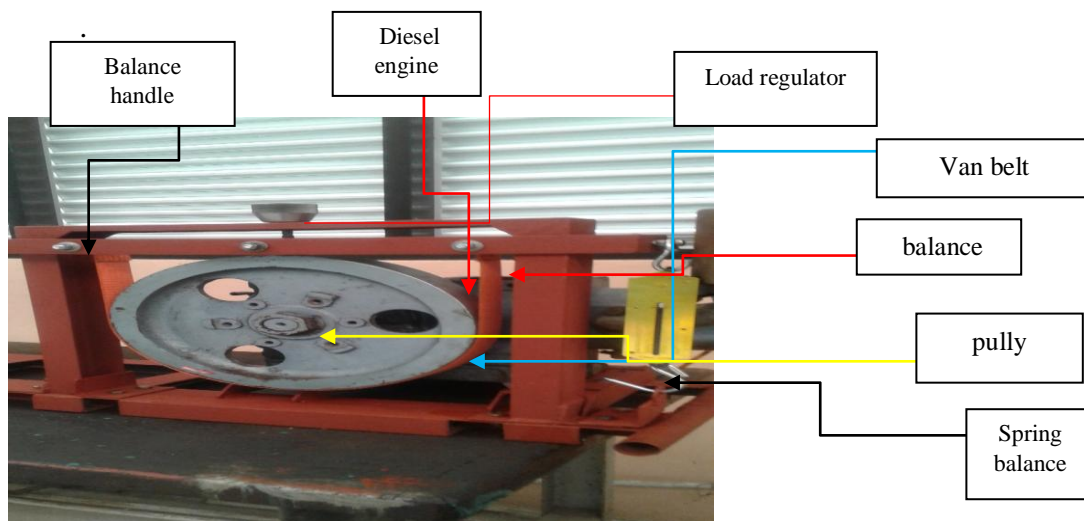


Figure 1. Prony Brake Dynamometer

The research object used as the testing material is a four-cylinder one-cylinder diesel motor can be seen in Figure 2. The specifications of the diesel engine used are a horizontal one cylinder diesel engine 7 HP "Dong feng R-175" brand with a gravity and circulation water cooling system. The research materials used in this study include biosolar B5, and pure coconut oil biodiesel as a result of the transesterification reaction process using CaO catalyst.



Figure 2. Diesel engine brand "Dong feng R-175 A"

2.2 Research Methods

In this study, the main parameters of the fuel motor performance that are studied include torque, power, rotation and fuel efficiency. By measuring and analyzing the relation of these four parameters, the achievement of a combustion motor can be known more really[9]. Engine performance testing is carried out by turning on a diesel engine at 1500 rpm, then holding for ± 15 minutes to get the normal working temperature of the engine. After the machine is operating normally, data retrieval begins. Data retrieval is done by looking at the measuring instrument and recording on the recording sheet that has been prepared.

The independent variables in this test are engine speed, and load. Meanwhile, the dependent variable in this test is torque and fuel consumption. Fuel consumption is calculated based on the difference in the reading of the fuel level in the measuring cup, which is attached to the fuel tank, per unit time. Measurement and recording of fuel consumption in each variation are carried out three

times, then the three values are averaged. The variation of diesel engine rotation speed tested on this measurement is 2500 rpm, 2200 rpm, 1700 rpm, 1500 rpm, and 1200 rpm.

From the results of testing on the machine and after completion of data collection in the form of engine speed and time, then inputting and calculating data into the formula has been determined to get the power value on the machine, then displayed in tables and tables to graph the relationship between parameters machine work and engine performance. In this study, some input and output parameters are specified as in Table 1, so the results of the study are expected as expected.

Table 1. Input Parameters and Experimental Output

<i>Input Parameters</i>		<i>Output Parameters</i>	
Constant	Various	Measured	Calculated
-A Set Of One Cylinder Diesel Engine 353cc	- Engine Speed 1200rpm 1500rpm 1700rpm 2200rpm	-Fuel Volume (ml)Per Minute -Torsion	-Torsi (Nm) -Bhp (T.W) -Sfc -Thermal
-Operating Time Of Each Experiment Variation 1 Minute At a Stable Condition	-Market Bio Fuel(B5) -Virgin coconut oil	-Engine Speed When Burdened (w)rpm	

From the average value of the engine, rotation is used to calculate the power generated by the engine in each variation of load and rotation, and calculate the efficiency of fuel consumption. As for calculating engine torque, engine power, bhp, and fuel efficiency, equation (1) through equation (4) is used.[10]

$$T = m \cdot g \cdot l \dots\dots\dots (1)$$

Where: T = torque (Nm),
 m = mass (kg),
 g = gravitational force constant 9.81 (m / s²),
 l = distance = 0.3m.

$$P = T \cdot \omega = f \cdot r \cdot (\pi \cdot n) / 30 \dots\dots\dots (2)$$

Where: T = torque (Nm),
 f = force (N),
 n = diesel engine rotation (rpm)
 r = moment arm distance (m).

$$\text{specific fuel consumption: } sfc = mbb / bhp \dots\dots\dots (3)$$

Where: sfc = specific fuel consumption (kg / kW.hour)

mbb = fuel usage per unit time (kg / hour)

bhp = effective engine shaft (kW)

$$\eta_{th} = bhp / (bbb \times Q) \times 100\% \dots\dots\dots (4)$$

Where: η_{th} = thermal efficiency

mbb = fuel usage per unit time (kg / hour)

bhp = effective engine shaft (kW)

Q = the heating value of the fuel used (J / kg)

3. Results And Discussion

3.1. Machine Performance Test Data

There is a difference in performance produced by the "Dong Feng R175-A" one-cylinder diesel engine between using biodiesel B5 fuel and VCO biodiesel. This can be seen in Table 2 and Table 3, where the engine performance uses B5 fuel, the maximum torque that can be achieved is 12.26 Nm at 1200 rpm. While the engine performance using VCO biodiesel fuel is only able to produce maximum torque of 9.81 Nm at 1200 rpm.

Table 2. "Dong Feng R175-A" One Cylinder Diesel Engine Performance Test Data with B5 Biosolar fuel

Fuel	RPM	Burner (kg)	Torsi (Nm)	BHP (kW)	KBB (liter/h)	Sfc (kg/kW.h)	Hth (%)
B5	2500	2.04	6.01	1.57	0.77	0.42	24.47
	2200	2.40	7.05	1.62	0.74	0.39	26.26
	1700	3.14	9.24	1.64	0.48	0.25	41.27
	1500	3.62	10.64	1.67	0.36	0.19	55.03
	1200	4.17	12.26	1.54	0.31	0.17	59.90

The engine power produced using B5 fuel is 1.67 kW at 1500 rpm. This condition is different from the application of VCO biodiesel fuel which is capable of producing engine power of 1.33 kW at 1700 rpm.

Table 3. "Dong Feng R175-A" One Cylinder Diesel Engine Performance Test Data with VCO Biodiesel fuel

Fuel	RPM	Burner (kg)	Torsi (Nm)	BHP (kW)	KBB (liter/h)	Sfc (kg/kW.h)	Hth (%)
B5	2500	1.53	4.51	1.18	0.61	0.44	29.58
	2200	1.87	5.49	1.26	0.58	0.39	33.50
	1700	2.53	7.46	1.33	0.37	0.24	55.26
	1500	2.87	8.44	1.32	0.26	0.17	77.24

1200	3.33	9.81	1.23	0.24	0.16	79.81
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3.2 The Effect of Fuel on Engine Performance

The use of fuel will affect the performance of the engine produced. This is in line with what is shown in Figure 3 and Figure 4. There is a difference in the maximum torque value that can be achieved by the engine of 2.45 Nm, between the use of biodiesel B5 fuel with VCO biodiesel. Where the use of biodiesel B5 fuel is superior to the use of VCO biodiesel fuel. Where the use of biodiesel B5 fuel is superior to the use of VCO biodiesel fuel.

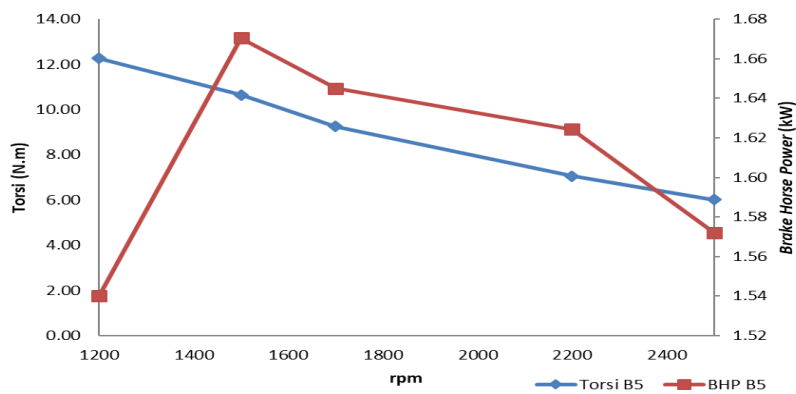


Figure 3. Graph of "Dong Feng R175-A" One Cylinder Diesel Engine Performance fueled by Biosolar B5

Judging from the engine power produced, the use of biodiesel B5 fuel is superior to the use of VCO biodiesel fuel. In addition, the engine power characteristics that use biosolar B5 are capable of producing maximum power with a lower engine speed compared to the use of VCO biodiesel fuel.

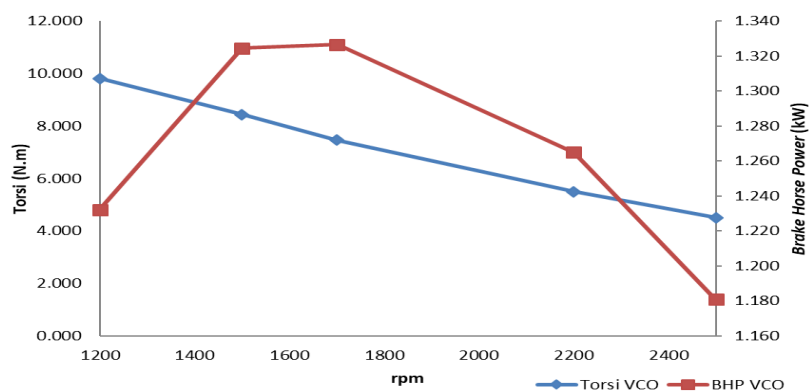


Figure 4. Graph of "Dong Feng R175-A" One Cylinder Diesel Engine Performance with VCO Biodiesel fuel

In Figure 4 above shows that the engine power of VCO biodiesel fuel is stable enough at an engine speed of 1500 rpm to 1700 rpm. Unlike the application of biosolar B5, the power produced tends to be stable at an engine speed of 1700 rpm to 2200 rpm. This is consistent with the profile of the BHP B5 chart in Figure 3.

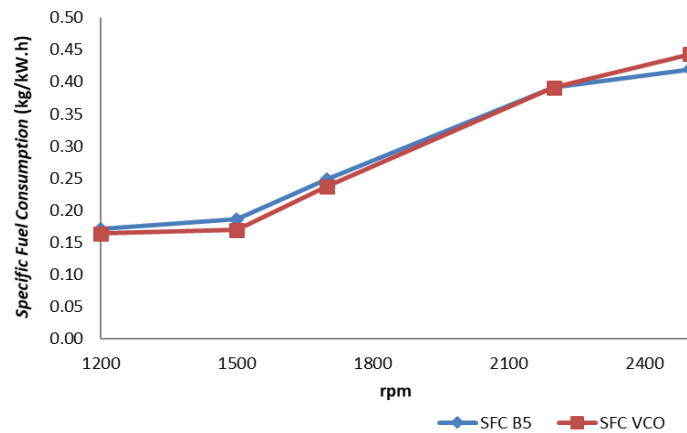


Figure 5. Comparative Graph of the use of B5 and VCO Fuels to the sfc produced "Dong Feng R175-A" One Cylinder Diesel Engine

In Figure 5 shows that the amount of fuel used by the engine for a certain time unit on the two fuels used does not have a significant difference. At engine speed below 2200 rpm, the use of VCO biodiesel fuel is better than the use of B5 biodiesel fuel. However, at engine speeds above 2200 rpm, the use of biosolar B5 fuel is superior to the use of VCO biodiesel fuel.

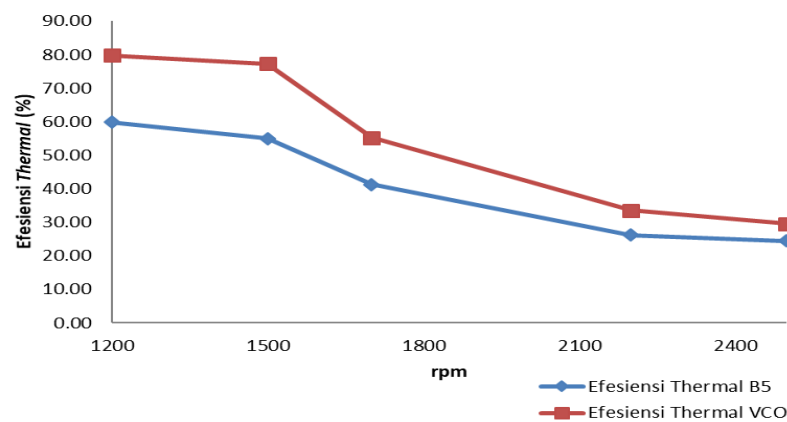


Figure 6. Comparison Graph of the use of B5 and VCO Fuels to Thermal Efficiency generated by the "Dong Feng R175-A" One Cylinder Diesel Engine

From the comparison of the value of thermal efficiency shown in Figure 6, in general, the application of VCO biodiesel on the machine is higher than the application of biodiesel B5. In all variations of engine rotation, the thermal efficiency of the use of VCO biodiesel fuel on a single cylinder diesel engine is the best.

4. Conclusions and Suggestions

4.1 Conclusion

From this study, it can be concluded that pure coconut oil biodiesel (VCO) can be used directly in a "Dong Feng R-175" diesel engine. The maximum torque of VCO biodiesel is 9.81 Nm at 1200 RPM, and the maximum power produced is 1.33 kW at 1700 RPM with specific fuel consumption (SFC) 0.24 kg / kWh. On average, the thermal efficiency of the "Dong Feng R-175" diesel engine using VCO biodiesel increased by 33.08% compared to using biosolar B5.

4.2 Suggestion

Further research is needed regarding the effect of VCO biodiesel application on 4-cylinder diesel engines or other types of diesel engines.

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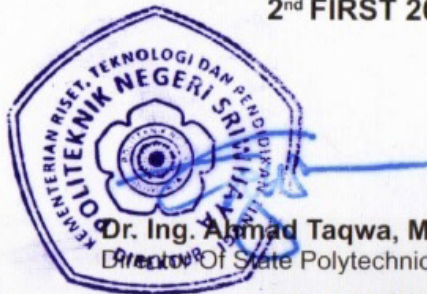
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