Diesel Engine Performance with Diesel and Biodiesel Fuel from VCO on the High Load

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Abstract: This study aims to test the performance of diesel engines at high loads and speeds using biodiesel from Virgin Coconut Oil (VCO) to reduce exhaust emissions with high performance, because diesel engines are often used in heavy duty. The method used is an experimental method using biodiesel from VCO mixed with pure diesel fuel with a percentage of 30% and 40% VCO as fuel for a four-cylinder diesel engine equipped with a fuel heater and tested at high load and speed of 35 kgf load and 3000 to 4000 rpm. The experimental data were then analyzed using excel and made in the form of a graph. The results showed that at 30% the higher the engine speed, the closer the performance to the use of pure diesel and exhaust emissions showed that a mixture of VCO and pure diesel could reduce exhaust emissions of carbon monoxide (CO) and hydrocarbons (HC), while in the 40% mixture there is a decrease in exhaust emissions but lower performance. So it can be concluded that the use of VCO as biodiesel in a mixture of 30% and tested at high load and rotation produces performance that is close to the use of pure diesel and can reduce exhaust emissions of diesel engines so it is very good to use.

1 INTRODUCTION

As we know that the world is approaching a state of energy crisis because fossil energy will soon run out, therefore it is necessary to look for alternative fuel substitutes to meet the increasing energy needs due to industrial development and economic progress. In addition, the fuel used must meet the exhaust emission standards that have been set, namely fuel that does not damage the environment. Indonesia is rich in vegetable natural resources which are alternative sources of renewable and environmentally friendly energy so that when used as fuel it does not produce exhaust gases that pollute the environment and increase global warming. Biodiesel is an alternative energy that is being developed because it can be renewed and the raw materials are abundant, but in its use it cannot be fully utilized directly because it must meet diesel engine fuel standards. Biodiesel currently available is sourced from palm oil which in its use is called B 30 or a mixture of biodiesel and fuel in the percentage of 30% biodiesel and 70% fuel. In addition to palm oil, there are several sources of biodiesel energy that can be an alternative to be developed due to its abundant availability, one of which is local coconut which is currently not processed as biodiesel and is only used as food. There are two kinds of local coconut processing, namely by using heat and without heating which is called VCO. Processing without heat causes VCO to have a clear color and low viscosity so that it is close to the requirements for diesel engine fuel.

Several studies that have been carried out using VCO still have to be mixed with diesel or the like with the highest percentage still having good performance, namely 30% (Palinggi, 2020) and the efficiency is still inferior to pure diesel because the viscosity of the mixture of VCO and diesel is still higher than pure diesel. Therefore, to overcome the problem of fuel viscosity, it is necessary to heat the fuel before it is injected into the combustion chamber (Madhava, 2016). To ensure the use of biodiesel from VCO has high performance in every engine working condition, the test must be carried out at high loads and high rotations because in this condition the torque reaches its maximum state (Supriyana, 2015).

The main problem that will be discussed in this study is whether the use of biodiesel from VCO with a mixed percentage of 30% VCO 70% pure diesel and 40% VCO 60% diesel meets the fuel requirements of

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diesel engines and if supported by fuel heating before injection, has good performance. good. good and efficient at larger loads and high rotation. The goal to be achieved is to utilize VCO as a diesel mixture and then use it in engine conditions at varying loads and high rotations, as well as to determine the comparison between the use of a mixture of diesel with VCO and pure diesel. The urgency of this research is to emphasize the use of local coconut as a source of biodiesel.

Diesel engine is an engine with a compression ignition system, therefore the fuel characteristics for a diesel engine must match the compression ignition system. The characteristics of the fuel include: calorific value, flash point, viscosity, specific gravity and cetane number. In diesel engines, the important fuel characteristics are the cetane number which must be high so that it is not easy to knock and has good lubricating properties (Palinggi, 2019).

The use of biodiesel is very appropriate to reduce dependence on fossil fuels because the characteristics of biodiesel from several materials known today are close to the characteristics required for diesel engine fuel. These characteristics such as lubricating properties, calorific value, cetane number, viscosity and specific gravity. One source of biodiesel that is often used is used cooking oil or used cooking oil, with chemical treatment the used cooking oil can be cleaned so that it can be used as a diesel mixture that can reduce diesel engine exhaust emissions without reducing performance.(Elma, 2016) . One of the uses of biodiesel is using mahua oil as biodiesel and mixed with diesel and found that the mixture of mahua oil can save fuel by up to 30% and reduce exhaust emissions by 35% (Kumar, 2018). The use of VCO as a diesel mixture found that a mixture of VCO in diesel can increase engine power at medium speed, but if the engine rotates at high RPM the power will decrease. If the percentage of VCO is increased, the torque and fuel consumption will decrease (Bhikuning, 2013).

Virgin cocnut oil (VCO) is oil produced from ordinary coconut (Cocos Nucifera) which is processed naturally without chemicals so it is safe for engine components and when used as a diesel mixture it can improve engine performance at medium speed (Bhikuning, 2013). The natural processing produces durable, low-fat and clear VCO which can significantly reduce exhaust emissions (Nazir, 2017).

The fuel heating instrument in the diesel engine aims to reduce the viscosity of the fuel so that the atomization is more perfect and fuel consumption is more efficient and exhaust emissions decrease (Indartomo, 2016). Heating spark plugs are an option that is often used to heat diesel engine fuel before it is injected, but there are also those that use incandescent lamps mounted on the fuel line (Supriyana, 2016).

2 MATERIAL AND METHOD

The research method used is a direct experimental method by observing the phenomena that occur in diesel engines which are tested at high loads using a mixture of VCO and pure diesel at a mixture of 30% and 40%.

The VCO biodiesel used is taken directly from small industries, while diesel is a product of Pertamina. The characteristics of the fuel used are as in table 1 and are the results of testing the characteristics of pure diesel and VCO as well as a mixture of VCO and pure diesel. The diesel engine used for the experiment was a Nissan brand with 4 cylinders and 4 strokes equipped with a fuel heater. The engine was tested at a maximum allowable load of 35 kgf and engine speed at 3000, 3200, 3400, 3600, 3800 and 4000 rpm. The engine was tested first using pure diesel fuel then a mixture of 30% VCO and finally a mixture of 40% VCO. The experimental data is then made in the form of tables and then graphed using excel software. The engine performance that will be analyzed is the effective power, fuel consumption, thermal efficiency and exhaust emissions of carbon dioxide and hydrocarbons.

Table 1: Physical Properties of Material fuel.

Fuel Material	Heating Value (Calori/gram)	Viskosity (cSt) 40^{o}c	Density (gram/ml)
100% Diesel fuel	10755	3.6	0.83
100 % VCO	8979.5	24.3	0.917
30 % VCO	10222,3	9,8	0.85
40 % VCO	10044,8	11,88	0.86

3 RESULT AND DISCUSSION

3.1 Resuslt and Analysis

Effective Power: Effective power can be seen in Fig. 1. which shows that the use of pure diesel produces greater power, but if the engine speed is increased, the power produced in a mixture of 30% is closer to the power produced by the use of pure diesel. at 3000 rpm rotation pure diesel produces 31.7 HP of power and a mixture of 30% 31.3 rpm, but at 4000 rpm rotation, the power produced by pure diesel is 35.9 HP and a mixture of 30% produces 35.8 HP of power, the difference is getting smaller . This happens because heating the fuel before it is injected into the combustion chamber can reduce the viscosity so that the combustion is easier. For a 40% mixture the effective power produced is lower than the 30% mixture, although if the engine speed is increased the power produced also increases

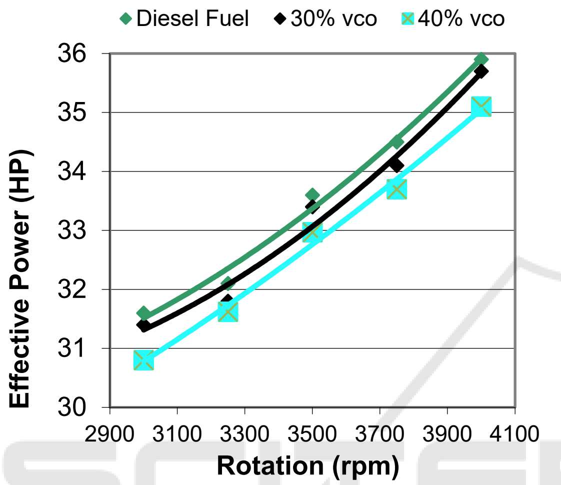

Figure 1: Effective Power of blend diesel fuel VCO and pure diesel fuel.

Thermal Efficiency: The thermal efficiency generated by the use of a mixture of VCO and diesel at a mixture of 30% is almost the same as the use of pure diesel, in Fig. 2 it can be seen that with the maximum load, the higher the engine speed, the efficiency will increase. This happens because the viscosity of the fuel has decreased to near the viscosity of pure diesel due to heating so that it can maximize fuel atomization and better combustion. at a mixture of 40% it can be seen that the resulting efficiency is lower.

Fuel Consumption: Specific fuel consumption relates to the mass flow rate of the fuel to the power generated by the engine. In Fig. 3 it can be seen that with an increase in the percentage of VCO by 30% in fuel, the specific fuel consumption increases. This means that the use of pure diesel is more efficient than the use of biodiesel. This is caused by the calorific value of the mixture of VCO and pure diesel which is lower than the calorific value of pure diesel so that at high loads and rotations the engine flows more fuel to run the engine. in a mixture of 40% VCO it is more wasteful than the use of pure diesel and a mixture of 30%.

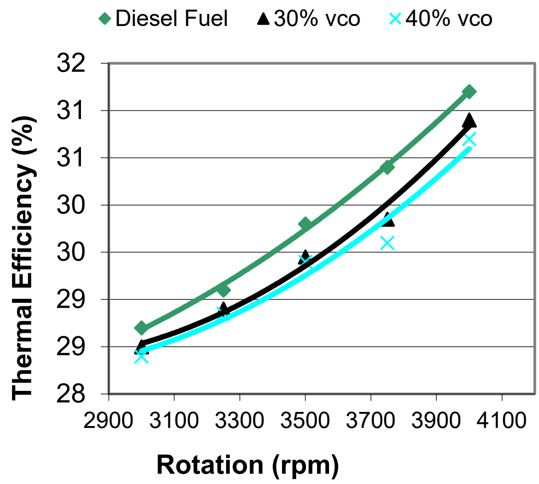

Figure 2: Thermal Efficiency of a mixture of VCO with diesel fuel and pure diesel fuel.

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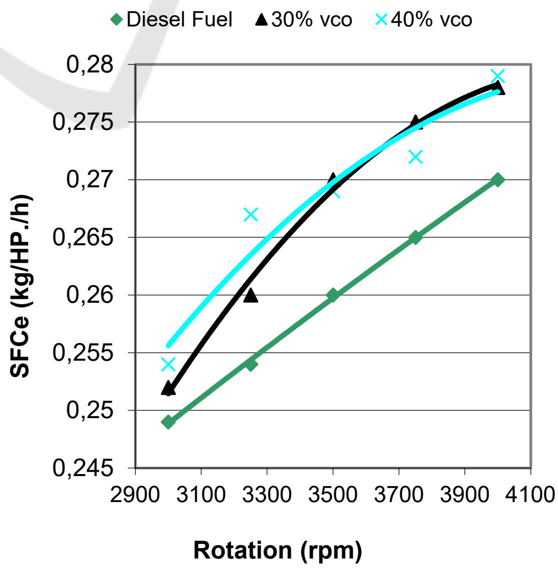

Figure 3: Specific fuel consumption of mixture VCO with pure diesel and pure diesel.

CO Exhaust Emissions: at low speed Increasing engine speed causes the amount of CO to be reduced in all types of fuel used. but if the engine operates at high speed and load, the opposite occurs, namely the higher the engine speed, the CO will increase. in Fig. 4 it can be seen that by adding VCO to the fuel, exhaust gas emissions will decrease when compared to the use of pure diesel. This happens because VCO does not contain materials that can form CO in the exhaust gas. At a mixture of 40%, exhaust emissions are almost the same as a mixture of 30% and if the engine speed is increased the exhaust emissions will also increase but the exhaust emissions of CO are less than 30% if at maximum speed, the more VCO in diesel fuel will significantly reduce exhaust emissions, so the percentage of VCO in diesel fuel needs to be increased

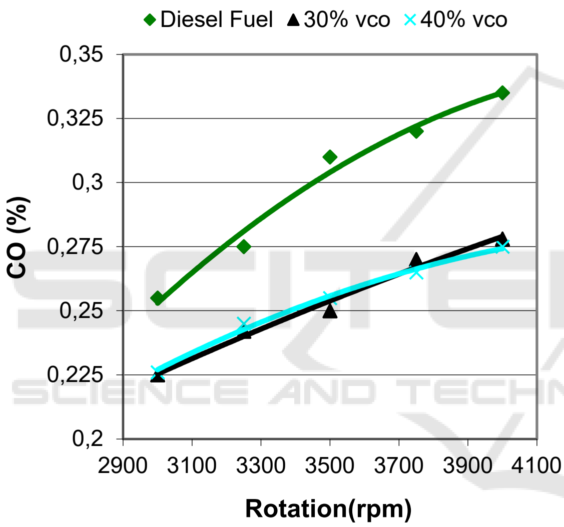

Figure 4: Percentage of CO exhaust gas of mixture VCO with pure diesel and pure diesel.

Exhaust Gas Emissions of HC: HC are hydrocarbons and are one of the dominant residual fuel residues in the fuel so that the increase in engine speed causes HC to also increase, in Fig. 5 when viewed on each fuel, pure diesel fuel causes the highest HC, while the lowest HC is in the 30% VCO Mix. This is caused by the presence of a fuel heating device installed in the engine which lowers the viscosity of the fuel before use so that the atomization becomes better which causes better fuel combustion. in the 40% mixture there is still more HC because the increase in VCO in the fuel causes the viscosity to increase.

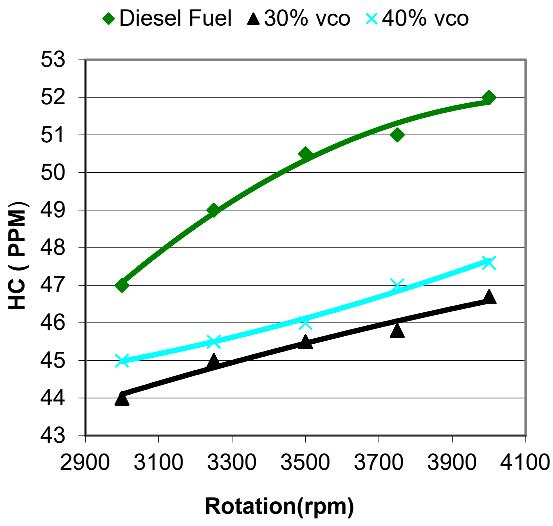

Figure 5: The amount of HC in exhaust gas from mixture of VCO with pure diesel and pure diesel.

3.2 Discussion

The use of VCO as bio-diesel with a percentage of 30% and 40% is quite good judging from the results of research conducted, although it is not the same as the use of pure diesel. By adding VCO to pure diesel, it is certain to increase the viscosity because the viscosity of VCO is higher than pure diesel. Likewise with the calorific value of the fuel mixture, because the calorific value of diesel is higher than VCO, when the two fuel materials are mixed, the calorific value will be reduced. The fuel heater installed in the test engine is quite helpful in reducing the viscosity because heat can reduce the viscosity of the fuel. The graph in Figure 1 shows that if the engine speed is increased, the effective power increases for each fuel consumption, the ratio between the use of pure diesel and a mixture of 30% increases in balanced power even though the use of pure diesel is still better but the difference is small. In Figure 2 the efficiency produced at a mixture of 30 and 40% is quite high and close to the use of pure diesel, meaning that heating the fuel before injection reduces the viscosity so that the fuel bar atomization is better. Similarly, for specific fuel consumption the use of pure diesel is more efficient but the use of VCO biodiesel to generate power but the use of 30% VCO is quite economical and close to the use of pure diesel, this can be seen in Figure 3. In Figures 4 and 5 the use of VCO as biodiesel is quite profitable. because it can reduce exhaust emissions, this is indeed the purpose of using biodiesel, although if the engine speed is increased the exhaust emissions also increase this is due to the amount of fuel used due to high rotation and high load. In previous studies, due to low revs and light loads, the emission reduction was only slightly, but if the rotation and load were high, it significantly reduced CO and HC exhaust emissions.

4 CONCLUSIONS

In this study, VCO biodiesel was used as a diesel mixture without further processing, but the fuel heater was installed on the test machine before spraying. Then it can be concluded as follows:

- Biodiesel from VCO is very good as a mixture of diesel fuel for diesel engines that work at high loads, because if the rotation is increased, the power and efficiency of the engine also increase.
- The addition of VCO to pure diesel can significantly reduce CO and HC exhaust emissions because with the presence of VCO that does not contain hydrocarbons, the exhaust gas will be cleaner.
- The use of VCO as biodiesel needs to be supported and increased because the raw materials are abundantly available, but the most important thing is to find a way to increase the percentage of VCO in diesel fuel without reducing engine performance.

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