Effect of Transesterification with Kupang Natural Zeolite on VCO Biodiesel Characteristics and Diesel Engine Performance

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Abstract: This study aims to improve the characteristics of VCO biodiesel so that when mixed with dexlite it can meet the fuel requirements of diesel engines in order to improve engine performance . The expected better characteristics of VCO biodiesel are viscosity, calorific value and density. The method used is the transesterification of biodiesel VCO using Kupang natural zeolite catalyst and methanol with a percentage of 50% catalyst and 50% VCO which is processed at a temperature of 60 ºC. Then the results of transesterification of VCO in its use are mixed with dexlite fuel with a percentage of 30% and 40%. The load used in the test was 35 kgf, and was tested at a high speed of 3000 to 4000 rpm. Diesel engine performance measured is effective power, fuel consumption, thermal efficiency and CO and HC exhaust gases. The results showed that the transesterification process with Kupang natural zeolite could improve the characteristics of VCO biodiesel by lowering the viscosity from 24 Cst to 14,5 Cst. when used as a dexlite mixture, the performance of the diesel engine produced is close to the use of pure dexlite fuel at a mixture of 30%. in the 40% mixture the exhaust emissions are reduced but the engine power is also reduced.

1 INTRODUCTION

The availability of energy is the key to the progress of human civilization because all sectors require energy to carry out their activities in order to meet the growing needs. The use of fossil energy that continues to increase as fuel in the industrial and transportation sectors as well as the agricultural sector has caused global warming and environmental pollution to become increasingly severe. Biodiesel from palm oil (CPO) is one of the alternative renewable energy options and available and environmentally friendly raw materials are the main choice to be developed, but until now its use has not been fully utilized because it still has to be mixed with fuel from diesel or the like. to maintain the characteristics of the fuel to match the standard diesel engine. In addition to palm oil, the raw material for biodiesel which is abundant and has not been used as fuel for diesel engines is local coconut which has just been used as food and medicine. Local coconut processing is carried out by heating and a natural way without heat called VCO, because without heat processing, the results are clear and have low viscosity, so they can be used as biodiese

To improve the characteristics of biodiesel so that it can be used as fuel for diesel engines, esterification and transesterification are carried out to reduce acids and fats in biodiesel materials. This process uses several choices of materials such as KoH, methanol, and zeolite as a catalyst to facilitate the improvement of characteristics. Several studies to improve the characteristics of biodiesel by esterification and transesterification have found that the use of these processes can improve the characteristics of biodiesel, especially at a decreased flash point and viscosity (Suleman, 2019) Several catalysts used in the transesterification process show that the use of zeolite can produce more acid from biodiesel materials, this occurs in palm oil and used cooking oil (Pasae, 2019)

The main problem that will be discussed in this study is whether the transesterification process with Kupang natural zeolite will improve the characteristics of biodiesel from VCO so that when used as diesel engine fuel it can increase engine power and reduce exhaust emissions. Can the percentage of VCO in dex fuel be increased by more than 30% and still produce high performance? This research really needs to be done because the need for renewable energy is very urgent to reduce air pollution due to the use of fuel.

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Transesterification and esterification are two processes that are often used to make biodiesel from vegetable oils, and are sometimes used to improve the quality of biodiesel so that it has characteristics that meet the requirements of diesel engine fuel (Aunillah, 2012). Esterification is carried out with the aim of reducing the acid content in biodiesel so that it is easy to burn, usually by heating more than 100 degrees Celsius and using KOH, CaO, H2SO4 and methanol catalysts while stirring for a few minutes and then depositing so that the acid content will dissolve to the bottom and biodiesel will be above. (Handayani, 2016). Meanwhile, the transesterification process is carried out after the esterification process is complete, the purpose of transerification is to reduce the viscosity of biodiesel by reducing the fat content in biodiesel. Transesterification was carried out by heating below 100 degrees celsius while stirring at slow speed for several hours, the catalysts used were KoH Cao and Zeolite. (Hadrah, 2018). Research shows that from several catalyst materials used for transesterification, the zeolite catalyst produces good characteristics and more biodiesel, such as lower viscosity and lower flash point or more flammability (Salim, 2016).

The diesel engine ignition system is compression ignition, therefore the fuel used must meet several characteristics suitable for compression ignition so that biodiesel must first be treated so that it can be used as diesel engine fuel. Biodiesel produced from the transesterification process has characteristics that must be measured to determine whether the biodiesel meets the requirements as diesel engine fuel, such as viscosity, calorific value, flash point, cetane number, lubricating properties, and specific gravity. Diesel engines require fuel with a high cetane number to avoid knocking in the combustion chamber (Palinggi, 2020).

Biodiesel is one of the main options to replace fuel for diesel engines because raw materials are abundant and have long been managed for food. Biodiesel from palm oil has begun to be developed in bulk because its characteristics are close to those of fuel and lower exhaust emissions because the combustion products do not contain carbon. (Elma, 2016). VCO as biodiesel has not been widely used and is only limited to laboratory research with results showing that VCO can be mixed with fuel with a percentage of up to 30% producing power that is almost the same as pure fuel and low exhaust emissions (Rizal, 2015).

Virgin cocnut oil (VCO) is oil produced from local coconut (Cocos Nucifera) which is processed without heating and chemicals so it is not harmful to engine components and when used as a diesel mixture it can increase engine performance at medium speed. (Nazir, 2017) . The natural processing produces VCO that is durable, fat-free and clear and can significantly reduce exhaust emissions. Previous research found a problem with VCO biodiesel, namely the viscosity is still high even though it has been mixed with fuel, so it needs further treatment such as transesterification to reduce viscosity. (Bhikuning, 2013)

2 MATERIAL AND METHOD

The research method used is an experimental method by transesterifying VCO biodiesel using a Kupang natural zeolite catalyst and methanol with a ratio of 50% VCO and 50% catalyst processed at a temperature of 60 degrees Celsius. The transesterified biodiesel is then mixed with dexlite type diesel engine fuel. The VCO biodiesel used is taken directly from small industries, while the dexlite is a product of Pertamina. The diesel engine used for the experiment is 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 dexlite fuel then a mixture of 30% VCO and finally a mixture of 40% VCO. The results of the study were then made in tabular form and then graphed using excel software. engine performance to be analyzed is the power consumption of fuel, effective power, thermal efficiency and exhaust emissions of carbon dioxide and hydrocarbons.

3 RESULT AND DISCUSSION

3.1 Result and Analysis

Table 1: Physical Properties of Material fuel.

Fuel Material	**Heating Value (Calori/gram)**	**Viskosity (cSt) 40°c**	**Density (gram/ml)**
100% Dexlite	11245	3.6	0.83
100 % VCO	9579.5	14,5	0.917
30 % VCO	10745,8	6,87	0.85
40 % VCO	10578,8	7,96	0.86

Table 1 shows the results of testing the characteristics of VCO biodiesel that has been processed by transesterification, there is an improvement in the characteristics of the heating value and viscosity before transesterification, the calorific value of VCO is 8979.5 cal/gram and the viscosity is 24.3 cSt to 9579.5 cal/gram and 14, 5 cSt.

Effective Power

If we look at Figure 1, the use of pure dexlite produces greater power, but as the engine speed increases, the power generated at a mixture of 30% VCO approaches the power produced by the use of pure dexlite. at 3000 rpm the pure dexlite produces 32.6 HP of power and a mixture of 30% 31.9 HP, but at 4000 rpm the power produced by pure dexlite is 36.9 HP and a mixture of 30% produces 36.3 HP of power. This happened because the VCO viscosity was getting smaller after the transesterification process, and the fuel heater installed added to the improvement in the quality of the VCO and dexlite mixture. For a 40% mixture the power produced is lower than the 30% mixture, but if the engine speed is increased the power produced also increases

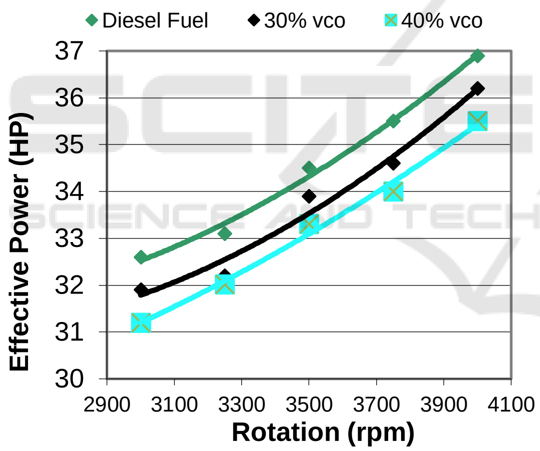

Figure. 1: Effective Power of blend diesel fuel VCO and pure dexlite.

Thermal efficiency

The thermal efficiency produced by the use of a mixture of VCO and dexlite at a mixture of 30% is still lower than the use of pure dexlite, but if the engine speed is increased, the 30% VCO mixture is closer to the efficiency produced by pure dexlite. In Figure 2 it can be seen that the transesterification process in VCO can improve the characteristics so as to increase engine efficiency. This happens because the viscosity of the fuel has decreased to near the viscosity of pure dexlite and as a result of the addition of a heating device so as to maximize fuel atomization and better combustion. in the 40% mixture, it can be seen that the resulting efficiency is still lower than the 30% mixture.

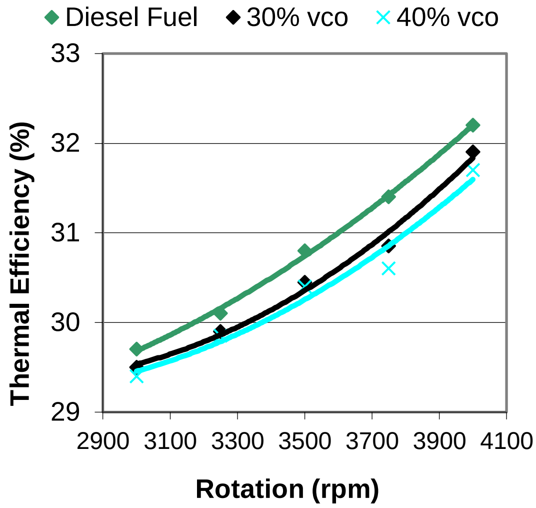

Figure. 2: Thermal Effeciency of a mixture of VCO with diesel fuel and pure dexlite.

Fuel Consumption: Specific fuel consumption is the mass flow rate of the fuel compared to the power generated by the engine. In Figure 3 it can be seen that with a VCO percentage of 30% in the fuel, the specific fuel consumption is higher than pure dexlite. shows that the use of pure diesel is more efficient than the use of biodiesel. This is due to the calorific value of a mixture of 30% VCO with dexlite is lower than the calorific value of pure dexlite. This causes the load and high engine speed to flow more fuel to run the engine. For a mixture of 40% VCO it is more wasteful than the use of pure diesel and a mixture of 30%

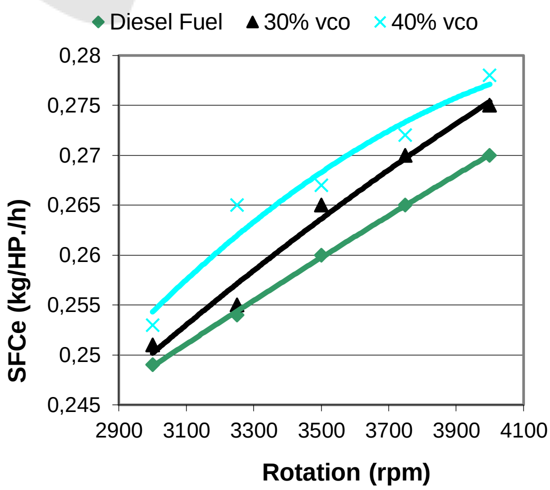

Figure. 3: Spesific fuel consumtion of mixture VCO with pure dexlite and pure dexlite.

Exhaust gas emissions of HC: HC are hydrocarbons and are one of the dominant combustion residues, so that an increase in engine speed causes HC to also increase, in Figure 4 when viewed on each fuel, pure dexlite fuel produces the highest HC, while the lowest HC is at 30% VCO Mix. This is because the characteristics of the VCO have been improved by the transesterification process and the presence of a fuel heater installed in the engine to reduce the viscosity of the fuel before use so that atomization becomes better which causes better fuel combustion. for a 40% mixture there is still more HC because the increase in VCO in the fuel causes the viscosity to increase.

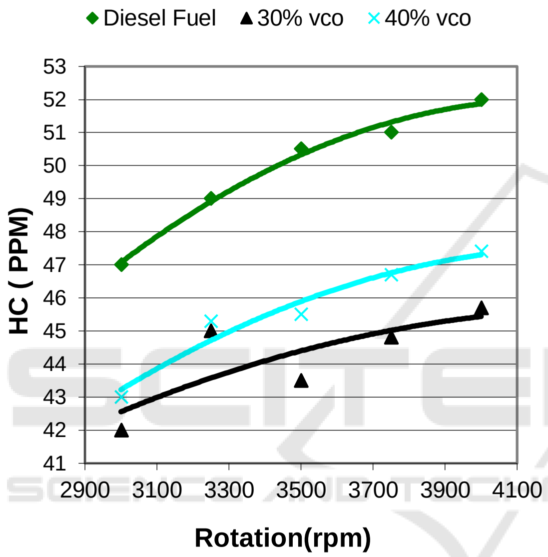

Figure. 4: The amount of HC in exhaust gas from mixture of VCO with pure dexlite and pure dexlite.

CO exhaust emissions: if the engine operates at low speed, the CO produced is also low, the opposite is true, namely the higher the engine speed, the greater the CO. in Figure 5 it can be seen that by adding transesterified VCO to dexlite fuel, exhaust gas emissions will be reduced when compared to the use of pure dexlite. 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 CO exhaust emissions are less than 30% if the maximum speed is increasing. VCO in diesel will reduce exhaust emissions significantly, so the percentage of VCO in diesel needs to be increased

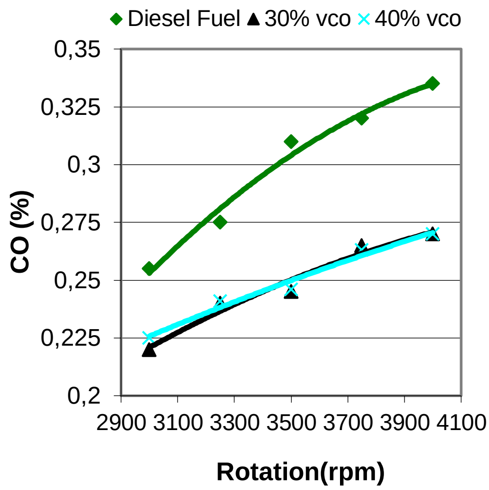

Figure. 5: Percentage of CO exhaust gas of mixture VCO with pure dexlite and pure dexlite.

3.2 Discussion

The transesterification process in VCO biodiesel can improve characteristics, especially on viscosity and calorific value, so that when used as a dexlite mixture, the resulting performance is close to the performance of pure dexlite use. the transesterification process is able to reduce saturated fat in VCO so that the viscosity decreases and increases the calorific value. on the use of transesterified VCO with a mixture of 30% VCO and 70% dexlite, the power generated is still lower than pure dexlite but if the rotation is increased then the power is closer to the use of pure dexlite as shown in Figure 1. 30% mixture is close to the efficiency of pure dexlite and for 40% mixture the resulting efficiency is lower. For fuel consumption in Figure 2, the use of pure dexlite is more efficient because of its high calorific value, while the 30% mixture requires more fuel to produce large power. very good results are produced from exhaust gas emissions of HC and CO, where the use of VCO as a dexlite mixture can reduce levels of HC and CO significantly because VCO does not contain materials that can produce carbon.

4 CONCLUSIONS

After doing research and testing, it can be concluded as follows:

1. The transesterification process with Kupang natural zeolite catalyst and methanol can improve the characteristics of VCO biodiesel, namely reducing viscosity and increasing calorific value

2. The use of transesterified VCO as a dexlite mixture produces performance that is close to the performance of using pure dexlite

3. The resulting cleaner exhaust emissions, namely hydrocarbons and carbon monoxide, decreased significantly.

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