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Optimizing the Performance of Diesel Engine With Dexlite and Biodiesel Fuels From Local Virgin Coconut Oil

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***Abstract*—The use of Biodiesel as a diesel engine fuel is being prioritized by the government to replace the increasingly thinning fuel oil and to reduce air pollution due to diesel engine exhaust gases. It is expected that in 2050 fuel oil can already be replaced with biodiesel. Biodiesel that has started to be used is biodiesel from palm oil (Elaeis Oliefiera) because the processing plant is already available and is still used as cooking oil. But for local coconuts (Cocos Nucifera) available abundantly not yet utilized maximally. Utilization of local coconut in addition to partial coconut milk is also made as cooking oil and virgin coconut oil (VCO). VCO is processed without the use of heat so that the colour is clear and durable and low viscosity. With good characteristics, VCO can be processed into one of biodiesel for diesel engine fuel. However, because to process VCO into biodiesel requires further processes to use VCO as fuel, mixing between VCO and dexlite is made to improve fuel ignition. The purpose of this study is to use dexlite fuel mixed with VCO as fuel for diesel engines and optimized with preheated heaters to reduce fuel viscosity to improve engine performance. The study was conducted by first measuring the water content in VCO to determine whether the heating process is needed or not to reduce the water content. Then VCO is mixed with dexlite with a percentage of 10%, 20%, 30%, 40% and 50%. This mixture is measured for characteristics which are then used as diesel engine fuel. The performance in question is power, fuel consumption, thermal efficiency, and exhaust emissions. Experimental results from the study show that heating fuel before using a mixture of VCO and dexlite can be compared with pure dexlite with a percentage of 30%, and if it increases to 40 and 50% engine performance begins to decrease and an increase in gas emissions caused by incomplete combustion and high viscosity.**

Keywords—optimization, engine performance, biodiesel, VCO

I. INTRODUCTION

The need for energy continues to increase along with the progress of a country, specifically in the field of transportation, the majority of energy needs are still obtained from fossil fuels (34%), and the rest from gas, biofuel, and electrical energy [1]. However, because fuel oil reserves are running low and contain high gas emissions, the use of minimal emissions and renewable energy is being intensified

Many alternative and renewable energy options are managed to meet the needs of renewable energy such as solar energy, biodiesel, wind energy and ethanol, but because the transportation sector requires equipment mobility, only energy from biodiesel that is easy to use and available is quite abundant at low prices. The Indonesian government in 2019 has used 20% biodiesel or called B20 and starting in 2020 using biodiesel B30 in diesel fuel or called bio diesel [1]. This biodiesel is processed from CPO or palm oil. As we know that Indonesia is the largest producer of palm oil in the World.

In addition to palm oil, our country is rich in biological natural resources that can be managed as alternative energy, especially biodiesel. For the East Nusa Tenggara (NTT) there are some plants that can be managed as biodiesel, including jatropha and coconut, but jatropha as a biodiesel is less successful because of its complicated and expensive processing. For local coconuts have not been used as biodiesel because most are managed for foodstuffs such as cooking oil and coconut milk, some are managed as VCO which are used as herbs and medicine. Virgin Coconut Oil (VCO) is pure coconut oil made from fresh coconut meat that is processed in low temperatures or without heating, so that the important components contained in oil are retained. VCO has advantages, namely low water content and free fatty acids, colourless (clear), aromatic fragrance, and longer shelf life [2]. Virgin Coconut Oil (VCO) also has a low viscosity, so that this oil can be used as an alternative mixture to reduce fuel dependence and pollution on diesel engines. To help reduce the viscosity of the fuel mixture so that engine performance remains optimal, heating of the fuel is carried out before use. Fuel is heated to 90°C with a fuel heater [3].

A diesel engine is a compressed ignition engine. Therefore, the fuel characteristics of a diesel engine must match compressive ignition. Characteristics of the fuel include heating value, flash point, viscosity, specific gravity and cetane number. In diesel engines an important fuel characteristic is that the cetane number must be high so that it does not easily occur knocking and has good lubricate properties [4].

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 that must be possessed by diesel engine fuels. These characteristics are like the nature of the lubricant, the heating value, the amount of cetane, the specific viscosity and gravity. One source of biodiesel that is often used is used cooking oil. With chemical treatment, 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 [5]. Apart from coconut oil, the use of other biodiesel is using mahua oil as biodiesel and mixed with pure diesel fuel and making mahua oil mixture can save fuel up to 30% and reduce exhaust emissions by up to 35% [6]. The use of VCO as a diesel mixture found that the VCO mixture in diesel fuel can increase engine power at a moderate speed, but if the engine rotates at high RPM the power will be reduced. If the VCO percentage is increased the torque and fuel consumption will decrease [7].

Virgin coconut oil (VCO) is oil produced from local coconuts (Cocos Nucifera) that is processed without heating and chemicals so that it is not harmful to engine components and when used as a diesel mixture can increase engine performance at medium rotation [8]. The natural treatment process produces VCO that is durable, fat-free, and clear and can significantly reduce exhaust emissions [9].

The addition of a fuel heater to a diesel engine is intended to reduce fuel viscosity so that the ignition is more perfect. With fuel heating the fuel consumption is smaller and exhaust emissions are reduced [10]. Heating the fuel can be done with a spark plug heater or installation of incandescent light balloons on the part before the fuel enters the injector. Installing a heater in this section can increase torque and reduce fuel consumption [11].

Research on the use of VCO as biodiesel for a mixture of diesel as fuel for diesel engines has been carried out by several people with different methods, the results show that for a percentage below 30% it can improve diesel engine performance, such as reducing exhaust emissions and fuel consumption. Bhikuning [8] conducted research by first processing VCO using KOH and NaOH to reduce the viscosity of VCO, then mixed with diesel at a percentage of 20% VCO and 80% diesel, the results showed that the fuel mixture was able to reduce exhaust gas opacity by 20%. M. Rizal [7] conducted research by mixing VCO with diesel at a percentage of 17.5%, 20% and 22.5% using a single cylinder engine. The results showed that in a mixture of 17.5% and 20% fuel consumption decreased by 20% but the power engine and torque also decreased by 1.8%, while in the mixture of 22.5% there was an increase in fuel consumption, but the power increased by 5% and gas emissions decreased by 12%. S.S. Harsono [12] conducted a study to improve the performance of a diesel engine with a mixture of 30% VCO and 70% diesel by direct injection. The results showed that when compared to pure diesel, a mixture of 30% VCO can reduce torque and power but also reduce exhaust emissions. M. Nazir[9] conducted a study on diesel engine exhaust gas by mixing VCO with diesel in a mixture of 5%, 15%, 20%, and 25% and obtained research results that exhaust gas emissions decreased by 1.7% at medium engine speed.

Research with the fuel heating method in diesel engines was carried out by several researchers to improve the performance of diesel engines, Supriyana [3] conducted research by heating the fuel before spraying at temperatures of 55 and 65 degrees Celsius, the results showed that heating the fuel before spraying the nozzle will increase the power by 3.5% and 3.8%. Indartono conducted a study by heating the fuel before it was sprayed into the combustion chamber using heating spark plugs. The results showed that the performance of diesel engines increased by 8% and exhaust emissions decreased by 10%. Nayak [11] conducted research by heating diesel fuel and engine oil before the engine was started heating was done with a heating coil. The results showed that there was an increase in engine efficiency and power.

In this study the authors used different methods and materials to optimize the performance of a diesel engine. The fuel used is Dexlite mixed with VCO, optimization is carried out by heating the mixed fuel before it is sprayed into the combustion chamber, previous research did not heat the VCO fuel mixture with diesel but only used VCO as a diesel mixture or processing VCO with chemicals.

II. Materials and Methods

The VCO used is a product of a small business which is the result of research on local coconuts conducted by a university in Kupang, while Dexlite is taken from Pertamina products. Material characteristics were measured by tools in the laboratory of the mechanical engineering department, after remixing the characteristics of heat, viscosity and density were measured. The diesel engine is used for testing Nissan-branded and four-cylinder and four-stroke. The fuel heater used consists of a tube containing a heating element and is heated with an electric current, this tool is installed in the fuel path between the filter and injector and is equipped with a potentiometer and heat gauge, this tool can generate heat up to 90 degrees celsius or more. The use of fuel in diesel engines is done with a mixture of VCO in Dexlite at a volume of 20%, 30%, 40%, and 50%, and the measured performance is Power, Thermal, Specific Fuel Consumption and CO and HC exhaust emissions and compare with pure dexlite. Testing is carried out with a fixed load of 30 kg.

TABLE I. PHYSICAL PROPERTIES OF MATERIAL FUEL

Fuel Material	Heating Value (Calorie/gram)	Viscosity (cSt) 40°c	Density (gram/ml)
100 % Dexlite	11630.6	2.1	0.87
100 % VCO	8979.5	24.3	0.917
20% VCO	11100.4	6.48	0.88
30 % VCO	10835.17	8.5	0.89
40 % VCO	10570.16	9.98	0.889
50% VCO	10305.05	12.55	0.90

III. RESULTS AND DISCUSSION

A. Results

1) Properties of material fuel: The fuel specifications used can be shown in Table 1, showing that the dexlite heating value is 20% higher than the heating value of VCO and when mixed, the more percentage of VCO in the fuel, the heating value will decrease. in viscosity and density, it appears that VCO has a high density and viscosity, and when mixed with dexlite will increase the viscosity and density of the fuel.

2) Effective power: Effective power can be seen in Figure 1 showing that the use of pure dexlite produces more power, but the 20% and 30% VCO mixture approaches the pure dexlite energy. in a mixture of 40% and 50%, the effective power will drop significantly because it is influenced by high viscosity and low heating value of fuel.

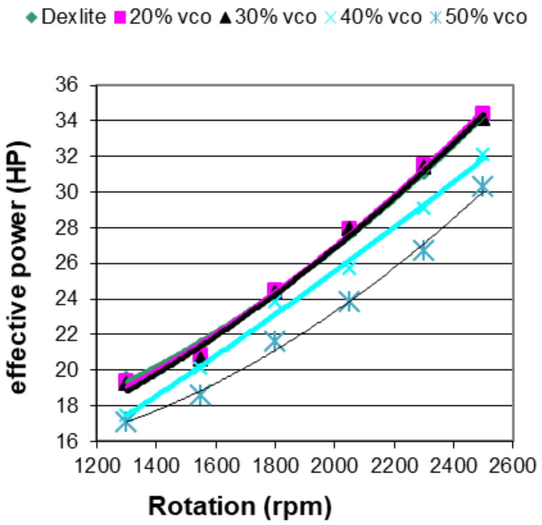

Fig. 1. Effective Power of a mixture of VCO with dexlite and dexlite.

3) Thermal efficiency: The efficiency of an engine is related to the use of energy that enters the combustion chamber into useful energy turning the engine. Figure 2 shows that the mixture of 20% and 30% VCO in dexlite approaches the efficiency of pure dexlite, as engine speed increases, efficiency also increases. in a mixture of 40% and 50% engine efficiency decreases due to the use of fuel with low heating value and high viscosity.

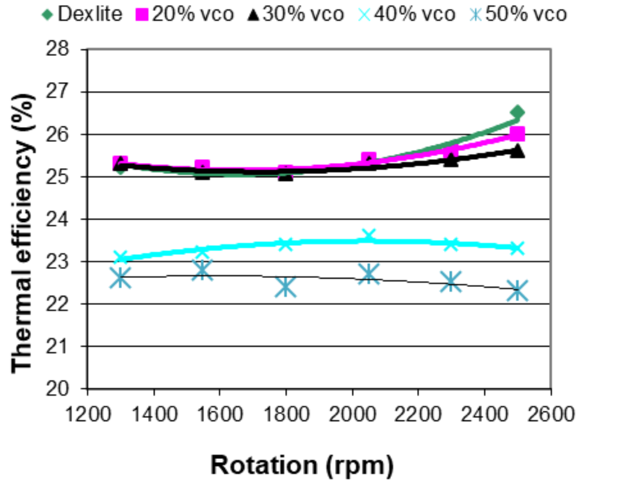

Fig. 2. Comparison thermal effeciency of a mixture of VCO with dexlite and pure dexlite.

4) Fuel consumption: Specific fuel consumption is related to the mass flow rate of the fuel to the power generated by the engine. In Figure 3 we can see that with the increase in the percentage of VCO in the fuel, the specific fuel consumption increases but in the mixture of 20% and 30%, it is approaching the use of pure dexlite because the viscosity of the fuel decreases due to heating the fuel before it is sprayed into the combustion chamber, in the mixture 40 % and 50% of wasteful fuel consumption because high fuel viscosity and heating do not significantly reduce viscosity.

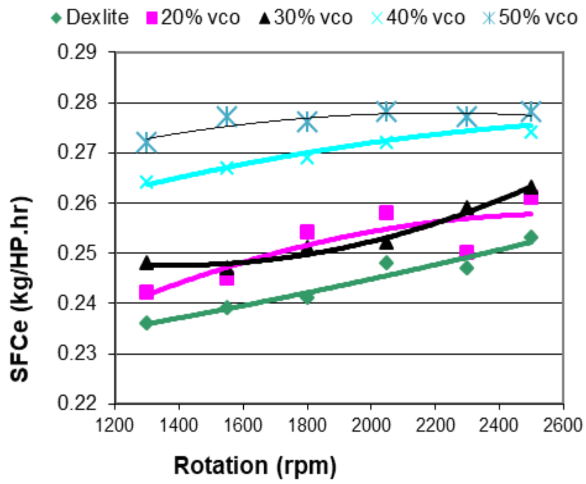

Fig. 3. Spesific fuel consumtion of mixture VCO with dexlite and pure dexlite.

*5) Exhaust emission **CO**:* Increased engine speed causes the amount of CO will be reduced in all types of fuel used. It can be seen in Figure 4 that the percentage of CO in dexlite fuel is higher than in the mixture of 20% and 30%, this is because combustion at this percentage is still good and the presence of VCO and heating before spraying reduces CO emissions. At a mixture percentage of 40% VCO and 50% the percentage of CO rises due to incomplete combustion caused by high fuel viscosity and fuel heating cannot reduce fuel viscosity.

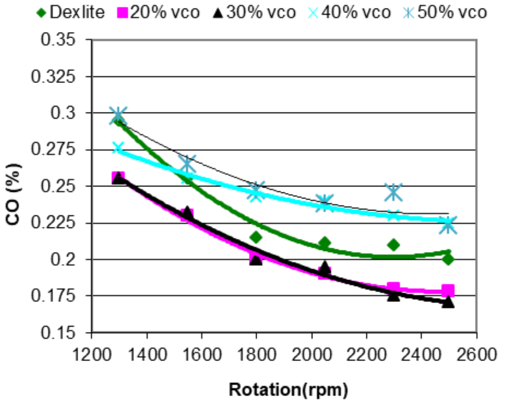

Fig. 4. Percentage of CO exhaust gas of mixture VCO with dexlite and pure dexlite.

6) Exhaust emission HC: HC exhaust emissions are shown in Figure 5. HC is hydrocarbons in the fuel so that the increase in engine speed causes HC to increase, if seen in each fuel, dexlite causes the highest HC, while the lowest HC is in the 30% VCO mixture This is caused by heating the fuel before use which causes the viscosity to decrease and the percentage of VCO in the fuel to reduce the hydrocarbons from the fuel because the VCO does not contain hydrocarbons. In the mixture of 40% and 50% HC is high enough to approach dexlite due to high fuel viscosity which causes incomplete combustion.

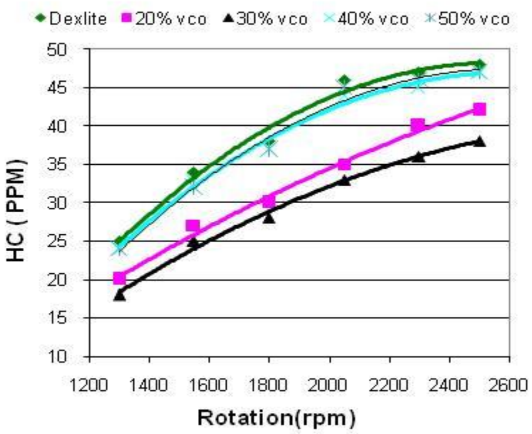

Fig. 5. The amount of HC in exhaust gas from mixture of VCO with dexlite and pure dexlite.

B. Discussion

From the table of the results of testing the physical properties of the fuel it can be seen that the addition of VCO to dexlite affects the properties of dexlite. Because the calorific value and viscosity are different, the more the percentage of VCO in dexlite, the calorific value will decrease, and the viscosity increases. Because this cannot be avoided, to reduce the increase in viscosity, the fuel mixture needs to be heated before entering the combustion chamber.

The use of a mixture of dexlite and VCO as fuel for diesel engines with a percentage of 20% and 30% VCO indicates power and fuel consumption which tends to be the same as the use of pure dexlite at low rotation of 1300 rpm to medium rotation of 2500 rpm, this is because the calorific value and viscosity of the fuel mixture used is not much different from pure dexlite by heating the fuel first which can decreases the viscosity, while the exhaust emission decreases because the percentage of dexlite decreases due to the presence of VCO in the fuel. In a mixture of 40% and 50% VCO, there is a decrease in engine performance which shows a 2 to 4 HP drop in power, this is because the heating of the fuel does not significantly reduce the viscosity of the fuel and there is a decrease in heating value because the amount of VCO in the mixture increases. In a mixture of 40% and 50% VCO, exhaust emissions increase due to decreased engine power and incomplete combustion due to high viscosity

IV. Conclusion

In this study, the use of VCO as a dexlite mixture without further processing but with the addition of a fuel heater before spraying can be concluded as follows:

- There are differences in the characteristics between dexlite and VCO, namely the calorific value of dexlite is higher, and the viscosity is low so that the percentage of VCO in dexlite affects the characteristics of the fuel.
- The mixture between dexlite and VCO can increase the viscosity of the fuel, but with the addition of heating the mixture up to a percentage of up to 30% gives high performance, namely increased effective power, decreased fuel consumption and high thermal efficiency. but if the percentage of VCO in dexlite is increased to 40% and 50% it will cause engine performance to decrease.
- The addition of VCO to dexlite can reduce CO exhaust emissions by a percentage of 30% but if the percentage of VCO is increased, the CO will increase, likewise in the exhaust gas of HC VCO can reduce HC in a mixture of 20% and 30% and if it is increased then HC will also increase.
- Because coconut in Indonesia is abundant, VCO can be processed into an alternative biodiesel but in its use, it needs treatment to reduce its viscosity, so the next research is expected to examine more deeply the use of VCO as biodiesel and test it in maximum load and rotation.

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