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Impact of Bioethanol and VCO Oil Additives on Power Output and Exhaust Gas Emissions in a 2-Stroke Gasoline Engine

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ABSTRACT

This research focuses on evaluating the impact of adding Virgin Coconut Oil (VCO) and bioethanol on the power output and exhaust gas emissions of a 2-stroke motorcycle engine. In 2-stroke engines, lubricating oil is crucial for mixing with the fuel and lubricating the cylinder walls to reduce friction and wear. This study aims to investigate how varying concentrations of VCO oil and bioethanol affect engine performance and emissions. VCO oil primarily contains saturated fatty acids, including about 53% lauric acid and 7% caprylic acid. The study utilized bioethanol derived from sugar cane molasses to enhance the burning point of VCO oil. Exhaust emissions are the by-products of fuel combustion released through the engine's exhaust system. Engine performance refers to its ability to convert fuel into useful power. The results indicate that the power output with 500 ml of ethanol mixed with VCO oil outperforms other mixtures, including pure VCO and lower ethanol concentrations. Additionally, higher ethanol concentrations in VCO oil lead to improved combustion efficiency and reduced exhaust gas emissions. This study demonstrates that optimizing ethanol and VCO oil ratios can enhance engine performance and reduce emissions.

Keywords: *2 Stroke Engine, VCO, Ethanol, Exhaust Gas Emissions*

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1. Introduction

A two-stroke combustion engine is an internal combustion engine which in one combustion cycle experiences two piston strokes [1]. There is something unique about the combustion of a 2-stroke motorbike, namely the addition of 2-stroke Engine lubricating oil to mix the fuel and lubricate the cylinder walls. 2-stroke Engine lubricating oil is very necessary for 2-stroke motorbikes because this oil helps lubricate the piston, cylinder walls and crankshaft to prevent wear due to friction. The oil used to lubricate will automatically be carried into the combustion chamber and burn. Therefore, the 2-stroke Engine lubricating oil is also designed to burn easily with the fuel. As a result, we will see smoke coming out of the exhaust causing the lubricating oil to decrease and producing exhaust emissions which are bad for the environment.

So far, not many have researched what liquid substances can be used as substitutes for 2-stroke Engine lubricating oil. The focus of developing research is still on alternative fuels to replace gasoline, such as the use of bioethanol as a gasoline mixture. Therefore, this research aims to determine the effectiveness of VCO oil as a substitute for 2-stroke Engine lubricating oil. Pure Coconut Oil (Virgin Coconut Oil or VCO) is a processed product native to Indonesia made from fresh coconut meat which is processed at low temperatures or without heating, so that the important contents of the oil can still be maintained [2]. The main content of VCO is around 90% saturated fatty acids and around 10% unsaturated fatty acids. VCO's saturated fatty acids are dominated by lauric acid. VCO contains ± 53% lauric acid and around 7% caprylic acid. Both are medium chain fatty acids which are usually called Medium Chain Fatty Acid (MCFA). VCO contains 92% saturated fat, 6% mono-unsaturated fat and 2% poly-unsaturated fat [3].

By its nature, VCO oil does not have a flash point, so a little fuel needs to be added to make combustion easier. Bio ethanol is the right solution because it does not come from petroleum, so mixing VCO oil and bioethanol is included in vegetable oil lubricants. Bioethanol is a colorless liquid, is biodegradable, has low toxicity and has lower emissions compared to premium oil, pertalite, or Pertamax. Bioethanol is multi-purpose because it can be mixed with gasoline at any position to provide a positive impact [4], [5], [6], [7]. Mixing 10% absolute bioethanol with gasoline (90%), often called Gasohol E-10. Gasohol is short for gasoline (gasoline) plus alcohol (bioethanol). Absolute ethanol has an octane number (ON) of 117, while premium is only 87-88. Gasohol E-10 proportionally has (ON) 92 or equivalent Pertamax. In this composition, bioethanol is known as the most environmentally friendly octane enhancer (additive) and in developed countries it has shifted the use of Tetra Ethyl Lead (TEL) and Methyl Tertiary Buthil Ether (MTBE) .

VCO oil, rich in saturated fatty acids, predominantly lauric acid (about 53%), has potential as a lubricant. However, VCO oil alone lacks a sufficient flash point for effective combustion. Therefore, bioethanol, derived from sugar cane molasses, is used to enhance the burning characteristics of VCO oil. Bioethanol is a renewable fuel alternative and, when mixed with VCO oil, could potentially improve combustion efficiency and reduce emissions.

2. Methodology of Research

The research methodology used is the experimental method. The experimental method in this research aims to determine the effect of using VCO oil mixed with bio ethanol molasses on the power and composition of exhaust emissions produced in 2-stroke petrol motorbikes. This test compares the results of 4 test variations. The first variation is testing the power and exhaust emissions of a standard 2-stroke combustion motorbike (STD), namely 100% using side oil as a fuel mixture. The second variation is to use 100% VCO as a substitute for side oil. The third variation uses a mixture of 1 liter VCO + 200 ml Ethanol (Etanol 200) as a substitute for side oil. The fourth variation uses a mixture of 1 liter VCO + 500 ml Ethanol (Etanol 500) as a substitute for side oil. The main testing tools include a dynotest to determine the output power and a gas analyzer to determine the exhaust gas emission content.

2.1. Research Variables

- Variabel Independen
  In this research, the independent variables are:
  1. Engine's rotation.
  2. Mixing of bioethanol and VCO oil.
- Variabel Dependen
  In this research, the dependent variables are: torque and exhaust emissions.

2.2. Research Instruments

A research instrument is a tool used to measure observed natural and social phenomena with the aim of producing accurate quantitative data and each instrument must have a scale. In this research, namely: The measurement instrument is an instrument for measuring the power output and exhaust emissions of a 2-stroke engine.

2.2.1 Measurement Instruments

Measuring instruments are tools used to measure exhaust gas emission levels and power. The measurement instruments used are as follows:

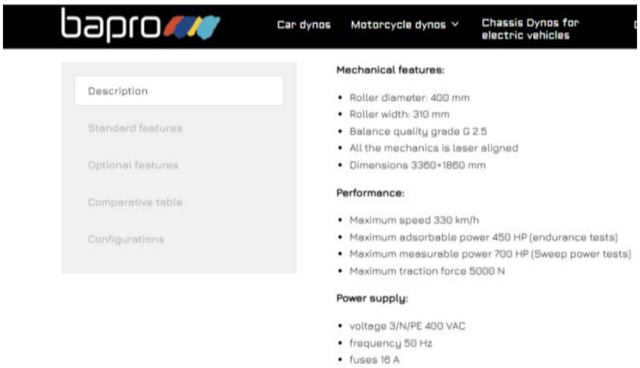
a. Exhaust gas emissions
Merk : Qrotech Exhaust Gas Analyzer (4 Gas)
Model : QRO-401
Weight : 10Kg
Spesification:
Emission Test Equipment is useful for measuring levels of Carbon Monoxide, Hydro Carbon, Carbon Dioxide, Oxygen and Air Fuel Ratio.

Figure 1. Gas Analyzer

b. Motorcycle Dynotest merk Bapro

Figure 2. Dynotest

Spesification:



3. Results and Discussion

Data collection from this combustion engine test uses a dyno test tool. Each test variable was repeated in data collection 4 times. The following table shows the average torque obtained from testing.

Table 3.1 Average results from dyno test measuring instruments

Engine's Rotation (Rpm)	Torsi (Nm)			
	VCO	STD	ETANOL 200	ETANOL 500
2500			5.1	
2750	6.27	5.02	7.37	7.34
3000	8.67	7.68	8.59	9.01
3250	9.2	8.54	9.1	9.7
3500	9.46	8.76	9.3	9.78
3515	9.46	8.76	9.3	9.79
3689	9.4	8.78	9.33	9.87
3750	9.38	8.77	9.34	9.9
3788	9.38	8.77	9.34	9.9
4000	9.37	8.74	9.27	9.86
4250	9.28	8.77	9.22	10
4416	9.35	8.74	9.28	10.05
4500	9.38	8.72	9.31	10.04
4750	9.23	8.67	9.19	9.91
5000	9.05	8.45	9.16	9.73
5250	8.76	8.25	8.86	9.42
5500	8.65	8.21	8.65	9.08
5750	8.5	8.1	8.4	8.78
6000	8.18	7.97	8.07	8.35
6250	7.84	7.61	7.74	7.92
6500	7.45	7.29	7.44	7.73
6750	7.35	6.95	7.77	7.97
7000	7.49	7.19	7.44	7.75
7250		6.95		

Next, the data is processed to obtain the power value of the combustion engine using the following equation:

$$P = T \; x \; \omega$$

$$= T \; x \; (\frac{2 \; x \; 3.14 \; x \; n}{60})$$

As an example of calculating combustion engine power using the formula above, when using VCO as a substitute for 2-stroke Engine lubricating oil at 2750 rpm as follows:

$$P = T \; x \; \omega$$

= 6.27 x (2 x 3.14 x 2750/60)
= 1.804,715 watt

= 1,8 kw

Other data are calculated in the same way and tabulated as follows:

3.2 Relationship between rotation and torque

From table 3.1 above, a graph of the relationship between motor rotation and torque is obtained as follows:

Based on the graph in Figure 3, in general it shows that the use of 100% VCO oil and a mixture of VCO+Ethanol as a replacement for side oil is able to increase the torque of the combustion engine at every variation of engine speed compared to using only side oil as the fuel mixture. The greater the volume of ethanol in the VCO oil mixture, the higher the engine torque produced. As is known, engine torque is obtained from the conversion of combustion heat energy in the combustion chamber. The greater the combustion energy in the combustion chamber will produce stronger power to move the piston so that the engine torque will also be higher. As explained in the introduction, ethanol has a much greater calorific value than gasoline. If there is no change in the fuel pump setting then gasoline fuel consumption is considered the same at the same engine speed conditions. The addition of ethanol to the fuel of course increases the calorific value of the fuel in the same cycle, so that the combustion heat energy in the combustion chamber becomes greater. Thus, Figure 3 confirms that the use of a larger volume of ethanol as a mixture of VCO oil and fuel is able to increase the torque produced at the same engine speed. It can be seen that the highest peak torque using ethanol 500 is 10.05 Nm at 4416 Rpm.

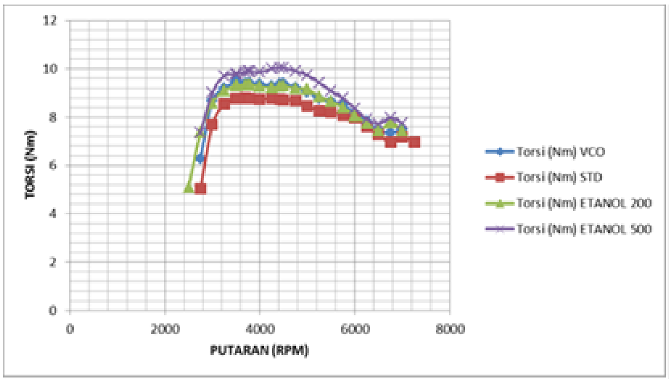


Figure 3. Graph of the Relationship Between Rotation and Torque

Table 3.2 Results of combustion engine power calculations

n (RPM)	Torsi (Nm)				Daya (watt)			
	VCO	STD	ETANOL 200	ETANOL 500	VCO	STD	ETANOL 200	ETANOL 500
2500			5.1		0.00	0.00	1.3	0.00
2750	6.27	5.02	7.37	7.34	1.8	1.4	2.1	2.1
3000	8.67	7.68	8.59	9.01	2.7	2.4	2.7	2.8
3250	9.2	8.54	9.1	9.7	3.1	2.9	3.1	3.3
3500	9.46	8.76	9.3	9.78	3.5	3.2	3.4	3.6
3515	9.46	8.76	9.3	9.79	3.5	3.2	3.4	3.6
3689	9.4	8.78	9.33	9.87	3.6	3.4	3.6	3.8
3750	9.38	8.77	9.34	9.9	3.7	3.4	3.7	3.9
3788	9.38	8.77	9.34	9.9	3.7	3.5	3.7	3.9
4000	9.37	8.74	9.27	9.86	3.9	3.7	3.9	4.1
4250	9.28	8.77	9.22	10	4.1	3.9	4.1	4.4
4416	9.35	8.74	9.28	10.05	4.3	4.0	4.3	4.6
4500	9.38	8.72	9.31	10.04	4.4	4.1	4.4	4.7
4750	9.23	8.67	9.19	9.91	4.6	4.3	4.6	4.9
5000	9.05	8.45	9.16	9.73	4.7	4.4	4.8	5.1
5250	8.76	8.25	8.86	9.42	4.8	4.5	4.9	5.2
5500	8.65	8.21	8.65	9.08	5.0	4.7	5.0	5.2
5750	8.5	8.1	8.4	8.78	5.1	4.9	5.1	5.3
6000	8.18	7.97	8.07	8.35	5.1	5.0	5.1	5.2
6250	7.84	7.61	7.74	7.92	5.1	5.0	5.1	5.2
6500	7.45	7.29	7.44	7.73	5.1	5.0	5.1	5.3
6750	7.35	6.95	7.77	7.97	5.2	4.9	5.5	5.6
7000	7.49	7.19	7.44	7.75	5.5	5.3	5.5	5.7
7250		6.95			0.00	5.3	0.00	0.00

The explanation for the decrease in torque value after passing 4500 rpm is that torque is obtained from the equation of output power divided by angular speed. This means that torque is directly proportional to power and inversely proportional to engine speed. If the increase in output power is smaller than the increase in engine speed, it is certain that the torque value will be smaller or graphically appear to be decreasing.

3.3 Relationship between rotation and power

From table 3.2 above, a graph of the relationship between motor rotation and power is obtained as follows:

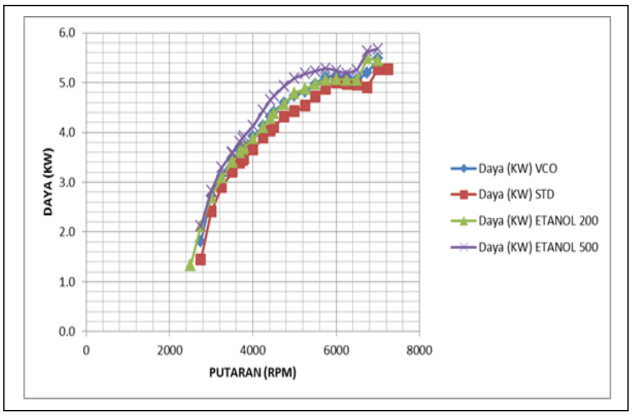


Figure 4. Graph of the relationship between rotation and power

In general, Figure 4 shows that the use of VCO oil or a mixture of VCO+Ethanol as a replacement for side oil can increase engine output power compared to using only side oil as a fuel mixture at each variation of engine speed. The power produced by Ethanol 500 is better than pure VCO, STD and Ethanol 200 oil. This happens because the larger the volume of ethanol mixed with the fuel, the greater the calorific value of the fuel and the heat energy of combustion in the combustion chamber. Ethanol 500 helps ignite the fuel, making it easier for fuel mixed with pure VCO oil to burn optimally [8].

Empirically, engine output power is a function and is directly proportional to the torque value and engine rotation. So if torque and rotation increase, the output power will certainly also increase. Even if the torque decreases but the rotation increases, the value is greater than the rate of decrease in torque, it still causes the output power to increase.

3.4 Exhaust gas analysis

The exhaust gas data discussed in this research is only CO2 levels. The CO2 content in the flue gas shows the perfection of the chemical combustion reaction between the fuel and air in the combustion chamber. The higher the CO2 level in the exhaust gas, the more fuel will burn completely. Below is a table of exhaust gas test results.

Table 3.3 Exhaust Gas Testing

EXHAUST GAS CO2 CONTENT			
VCO & ethanol mixture (vco:etanol)	rpm 4000	rpm 5000	rpm6000
1:00	1.5	1.9	2
1:200 ml	1.8	2	2.1
1:500 ml	2.2	2.3	2.7
oli standart	1.8	2	2.1

After the researchers finished getting the exhaust gas emission test results, they then compiled them into a line diagram to make it easier to find out the differences in CO2 levels at each specified RPM. Below is a graph shown.

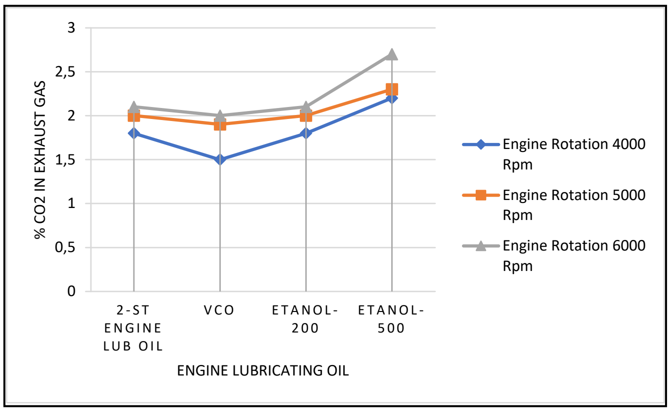


Figure 5. Line diagram of CO2 levels

Empirically, the chemical formula for ethanol is C2H5OH. This means that the ethanol molecule is composed of carbon (C), hydrogen (H) and oxygen (O) atoms. As is known, apart from sulfur (S), C and H are the main constituents of fuel. O is an oxidizing agent that is needed by S, C and H atoms for combustion to occur. Therefore, adding ethanol to fuel will not only increase the calorific value of combustion, but will also perfect the chemical combustion reaction process because of the oxygen content in ethanol [9].

Based on the graph in Figure 5, it shows that the CO2 content (%) in exhaust gas emissions is the largest in the Ethanol-500 test as side oil. The lowest CO2 levels (%) in exhaust emissions were found in tests that only used VCO as side oil. So in testing CO2 levels (%) where the greater the volume of ethanol as a VCO mixture, the greater the CO2 levels (%) produced. This is because ethanol contains oxygen atoms. The larger volume of ethanol mixed causes an increase in the amount of oxygen in the chemical combustion reaction. This makes the combustion more complete so that the CO2 levels (%) produced are greater. As for the use of Ethanol-200, the addition of an ethanol volume of 200 ml as a VCO mixture has not had an impact on increasing CO2 levels (%) in the exhaust gas. The CO2 content value (%) is still the same as the exhaust gas emissions from standard combustion using side oil [10].

4. Conclusion

1. The use of ethanol-500 as a substitute for side oil produces the greatest engine power compared to pure VCO, STD and Ethanol-200 oil because the larger the volume of ethanol will increase the calorific value of the fuel and the combustion heat energy in the combustion chamber.
2. The use of ethanol-500 as a substitute for side oil produces the highest CO2 levels in the exhaust gas compared to other oils. This shows that ethanol-500 is able to produce a better and more perfect combustion reaction.

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