

## Research Paper

## Effect Methanol, Ethanol, Butanol on the Emissions Characteristics of Gasoline Engine

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## Abstract

The increasing volume of motorized vehicles leads to an increase in dependence on fossil fuels and an increase in air pollution. The problem can be reduced by utilizing renewable alcohol fuels such as methanol, ethanol, and butanol. The high number of octane and oxygen content is the main reason. Therefore, this study aims to observe the exhaust emissions of the 160 cc gasoline engine with a mixture of methanol, ethanol, and butanol. The percentage of alcohol used is 0 % to 30 % by volume. The test was carried out in 2000, 3000, and 4000 rpm. The results of the study explained that the use of methanol, ethanol, butanol in the fuel mixture was proven to reduce exhaust emissions. CO and HC emissions decreased as the percentage of alcohol in the fuel increased. The highest reduction in CO and HC emission in methanol blended fuel was 30 %, 94.55 % and 82.71 %, respectively. Meanwhile, CO<sub>2</sub> emissions increased by 34.88 % at 2000 rpm engine speed. Based on this test, the addition of methanol to fuel can reduce exhaust emissions better than ethanol and butanol.

**Keywords:** Renewable fuel; Methanol; Ethanol; Butanol

## Abstrak

Peningkatan volume kendaraan bermotor menyebabkan peningkatan ketergantungan pada bahan bakar fosil dan peningkatan polusi udara. Masalah tersebut dapat dikurangi dengan memanfaatkan bahan bakar alkohol terbarukan seperti metanol, etanol, dan butanol. Tingginya angka oktan dan kandungan oksigen menjadi alasan utama. Oleh karena itu, penelitian ini bertujuan untuk mengetahui emisi gas buang mesin bensin 160 cc dengan campuran metanol, etanol, dan butanol. Persentase alkohol yang digunakan adalah 0 % hingga 30 % berdasarkan volume. Pengujian dilakukan pada tahun 2000, 3000, dan 4000 rpm. Hasil penelitian menjelaskan bahwa penggunaan metanol, etanol, butanol pada campuran bahan bakar terbukti dapat menurunkan emisi gas buang. Emisi CO dan HC menurun karena persentase alkohol dalam bahan bakar meningkat. Penurunan emisi CO dan HC tertinggi pada bahan bakar campuran metanol masing-masing adalah 30 %, 94,55 % dan 82,71 %. Sedangkan emisi CO<sub>2</sub> meningkat 34,88 % pada putaran mesin 2000 rpm. Berdasarkan pengujian tersebut, penambahan metanol pada bahan bakar dapat menurunkan emisi gas buang lebih baik dari pada etanol dan butanol.

**Kata-kata kunci:** Bahan bakar terbarukan; Metanol; Etanol; Butanol

## 1. Introduction

Air pollution continuously increases every year. Increasing the volume of motorized vehicles is the main cause of this problem. This is endangered human health [1] and other living

things, especially during the Covid-19 pandemic. The Ministry of Environment and Forestry explained in 2019 majority of all regions in Indonesia were categorized as unhealthy and very unhealthy This was very possible due to the factor of increasing the volume of motor vehicles [2].



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According to the Central Statistics Agency (BPS), the volume of motorized vehicles in Indonesia increased by 14,63% compared to 2015. Vehicles with gasoline motorcycles became the largest contributor to the increase in vehicle volume. This is in line with actual conditions in the field that the characteristics of motorbikes that are flexible and able to adapt to the terrain cause interest to continue to increase. Also, during the Covid-19 Pandemic, the motorbike was successful in making physical distancing efforts instead of using public transportation.

The use of motorbikes has been regulated by the government through the Ministry of Environment of the Republic of Indonesia, including the resulting exhaust emissions. In the Minister of Environment Regulation number 23 of 2012, the exhaust emissions of L3 motor vehicles such as CO, HC, and NOx are not allowed to exceed the specified value threshold. Carbon Monoxide and Hydro Carbon emissions on motorbikes usually arise from incomplete engine combustion. This event usually occurs as a result of a poor quality oxidation process [3]. Poor fuel quality is also a factor in the incidence of incomplete engine combustion. Also, low heating values and octane numbers lead to increased fuel consumption and promote incomplete combustion [4]. The long duration of the ignition delay also supports the formation of CO and HC emissions [5].

According to Rakopolus [6], the development of motorized vehicles such as motorbike is more directed at large capacities and collides with regulations on motor vehicle emission thresholds. Several attempts were made to control vehicle exhaust emissions, such as using alcohol as an alternative fuel [7, 8]. The use of alcohol ethanol, methanol, and butanol has been proven to reduce exhaust emissions such as CO and HC. Alcohol groups such as ethanol, methanol have properties of the octane number and concentration of oxygens which are proven to replace gasoline fuel [9]. According to Yussof [10], the use of high-quality alcohol does not need machine adjustments. The use of methanol alcohol, ethanol, and butanol results in high engine efficiency and torque [11, 12]. The concentration of alcohol in the fuel increases the oxygen content in the fuel and improves the quality of combustion, thereby reducing CO and HC emissions of

gasoline engines [13, 14, 15]. Also, the addition of alcohol reduces the ignition delay time thereby reducing the production of carbon monoxide and hydrocarbons increasing the fuel efficiency of gasoline engines [16].

Ethanol, methanol, and butanol have the properties of an octane number and a high oxygen content. These properties are believed to improve combustion quality. This is the basis of this study to determine the exhaust emissions produced by the GL 160 gasoline engine. The concentration of alcohol used is 5-30 % volume-based.

## 2. Materials and Methods

The experiment was carried out using a conventional single-cylinder GL 160 gasoline engine. The engine was set according to production standards with a cylinder capacity of 160cc, maximum power of 13.3 kW at 8500 rpm, and a maximum torque of 1.3 N.m at 6500 pm. **Table 1** are the complete parameters of the engine.

The engine is operated at 2000 (n1), 3000 (n2), and 4000 (n3) rounds using a mixture of gasoline, alcohol, methanol, ethanol, and butanol. The percentage of alcohol is 0%, 5%, 10%, 15%, 20%, 25%, and 30% of the total volume of fuel. **Table 2** are the properties of the fuel used:

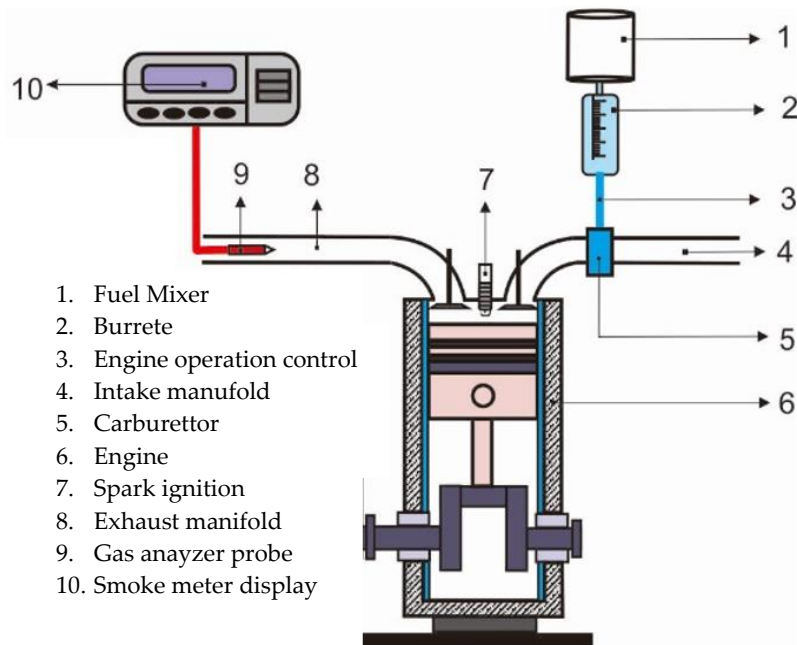
In order for the fuel to mix homogeneously, a fuel mixer is used instead of the fuel tank. The fuel from the tank is passed to the burette so that the volume can be adjusted to 100 ml per test. The fuel supply cable is manually adjusted so that the engine speed settings are easy to adjust. To get exhaust gas emission data, the engine exhaust pipe is installed with a stick gas analyzer. The concentrations of CO, HC, and CO<sub>2</sub> that are read on the display are printed and used as analysis material. To get valid data, the test was carried out 3 times. The test scheme is presented in **Figure 1**.

**Table 1.** Parameters of the engine

Engine capacity	: 156.6 cc
Type engine	: 4 Stroke, OHC
Bore x Stroke	: 63.5 x 49.5 mm
Compression ratio	: 9.0 : 1
Maximum power	: 13.3 kW @8500 rpm
Maximum torque	: 1.3 N.m @6500 rpm
Fuel system	: Carburetor 24"
Cooling system	: Air cooling
Clutch system	: Manual, Wet Clutch
Ignition system	: Spark NGK DP8EA-9

**Table 2.** Fuel properties

Parameters	Fuel			
	Gasoline[17]	Methanol[18]	Ethanol[19]	Butanol[20]
Octane number	90	99.28	116	98.3
Lower heating value (MJ/kg)	44.14	20	26.8	33.1
Density (kg/m <sup>3</sup> )	770	792	790	813
Oxygen content (wt.%)	-	50	21.6	34.8
Flash point (°C)	-10	11	21.1	28
Kinematic viscosity at 25 °C	0.4	0.6	1.3	2.5
Water content (wt.%)	-	0.05	0.05	0.05



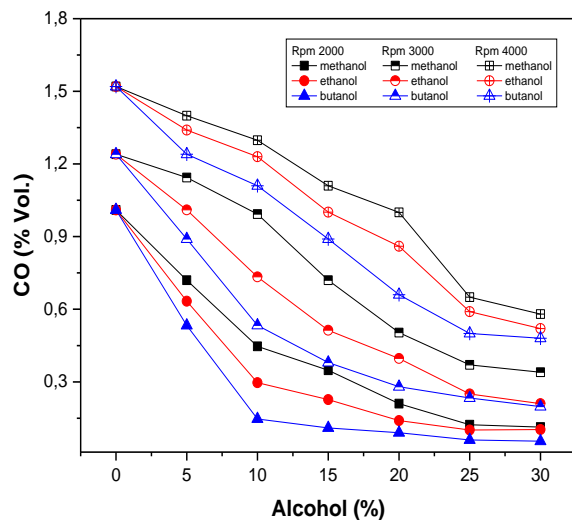
**Figure 1.** Experimental scheme

### 3. Result and Discussion

#### 3.1. Carbon monoxide (CO) emission

**Figure 2** describing the results of testing CO emissions on a GL 160 gasoline engine using a fuel mixture of gasoline methanol, ethanol, and butanol. This test was carried out at the engine speed of 2000, 3000, and 4000 rpm. The test results show that the CO emission decreased along with the increase in alcohol processing in the fuel and the increase in engine speed. Increasing the percentage of alcohol in the fuel causes a leaning effect. Effect Leaning is an increase in oxygen levels in the fuel so that the combustion process is more complete and reduces CO emissions [20, 21]. Also, the addition of alcohol to fuel increases the oxidation process which makes CO more react to become CO<sub>2</sub> so that CO emissions decrease [22]. The highest reduction in CO emission occurred in fuel with an alcohol content of methanol 30% by 94.55% at 2000 rpm engine speed. While the

lowest reduction in CO emission occurred in fuels with 5% ethanol content of 7.74% at 3000 rpm engine speed than pure gasoline.



**Figure 2.** The CO emissions of the GL 160 engine fueled by gasoline-methanol, ethanol, and butanol

### 3.2. Hydrocarbon (HC) emission

This test was carried out at the engine speed of 2000, 3000, and 4000 rpm. Figure 3 presents the test results show that HC emission decreases with increasing alcohol processing in the fuel and increasing engine speed. The addition of alcohol increases the oxygen content in the fuel which triggers the reaction of hydrogen with oxygen more than hydrogen with carbon, resulting in lower HC emissions [22]. In addition, the high oxygen content in the alcohol increased the propagation of the combustion process in the combustion chamber so that the fuel mixture burns evenly. This reduces HC emissions [23]. The highest reduction in HC emission occurred at the engine speed of 2000 rpm using a mixture of 30 % methanol as much as 82.71 %. Meanwhile, the lowest decrease occurred in the 5% methanol fuel mixture of 8.28 % compared to pure gasoline.

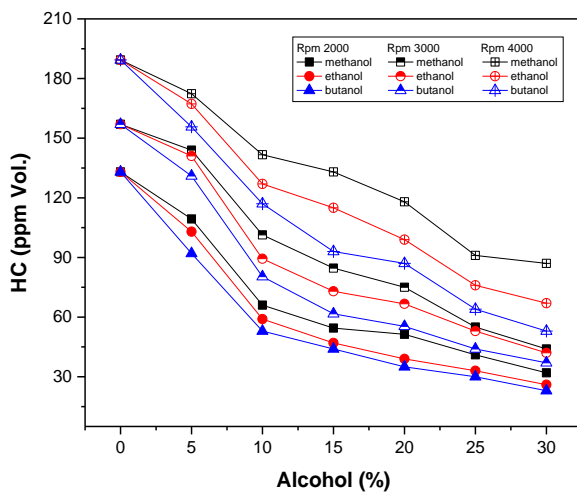


Figure 3. The HC emissions of the GL 160 engine fueled by gasoline-methanol, ethanol, and butanol

### 3.3. Carbon dioxide (CO<sub>2</sub>) emission

Figure 4 presents the CO<sub>2</sub> emissions from testing the GL 160 gasoline engine using a mixture of alcohol, methanol, ethanol, and butanol. Machine testing was carried out at the engine speed of 2000, 3000, and 4000. The test results showed that CO<sub>2</sub> emissions increased with the increase in the percentage of alcohol and engine speed. The high oxygen concentration in alcohol was linked to unburned carbon atoms during the combustion process so that the formation of CO<sub>2</sub> increases [24], [11]. In addition, alcohol has a high octane lift so that the combustion process is was more optimal and results in higher CO<sub>2</sub> emissions [25]. The highest increasing in CO<sub>2</sub> emissions

occurred in fuels with an alcohol content of 30 % methanol by 34.88 % at 2000 rpm engine speed. While the lowest increase in CO<sub>2</sub> emissions occurred in fuels with an alcohol content of 5% ethanol by 0.70 % at 4000 rpm rather than pure gasoline.

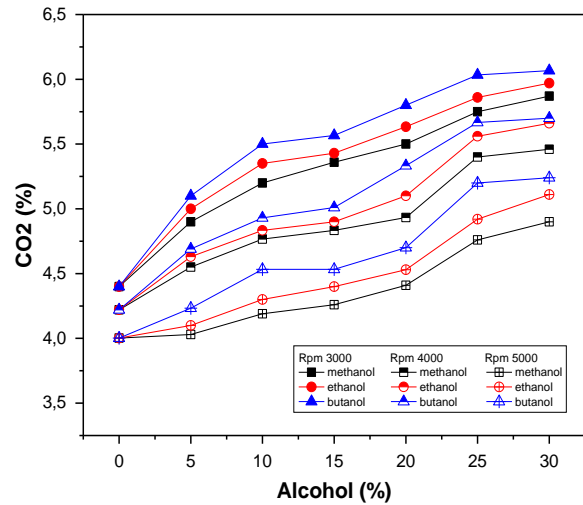


Figure 4. The CO<sub>2</sub> emissions of the GL 160 engine fueled by gasoline-methanol, ethanol, and butanol

## 4. Conclusion

The use of alcohol, methanol, ethanol, butanol in the fuel mixture shown to reduce exhaust emissions. CO and HC emissions decrease as the percentage of alcohol in the fuel increases. The highest reduction in CO and HC emission in methanol blended fuel was 30 %, respectively 94.55 % and 82.71 %. Meanwhile, CO<sub>2</sub> emissions increased by 34.88 % at 2000 rpm engine speed. Based on this test, the addition of methanol to fuel can reduce exhaust emissions better than ethanol and butanol.

## Author's Declaration

### Authors' contributions and responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation and discussion of results. The authors read and approved the final manuscript.

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### Availability of data and materials

All data are available from the authors.

### Competing interests

The authors declare no competing interest.

## Additional information

No additional information from the authors.

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