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Article

Performance and Emission Analysis of Motorcycles Using Pertalite-Methanol Fuel Blends

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Abstract.
The increasing use of motorcycles necessitates the development of more efficient and environmentally friendly fuel alternatives. This study examines how mixing methanol with Pertalite fuel affects engine performance and exhaust emissions in carburetor motorcycles. The fuel variations tested include M0, M5, M10, M15, M20, and M25. Performance testing was conducted using a dynotest, while exhaust emissions were measured with an emission gas analyzer. The results indicate that M25 produces the highest torque and power output, particularly in the 2500–8500 rpm range. Additionally, M25 significantly reduces HC and CO emissions, with HC at 108.33 ppm vol and CO at 0.19% vol, compared to M0. The findings suggest that methanol-enhanced fuel improves combustion efficiency, enhances engine performance, and lowers emissions. Thus, methanol-Pertalite blends offer a promising alternative for improving carburetor motorcycle performance while reducing environmental impact.

Keywords: engine performance; exhaust emissions; carburetor motorcycles; Pertalite; methanol

INTRODUCTION

Motorcycles play a crucial role in modern society, particularly in Indonesia. With a growing population and increasing mobility needs, motorcycle ownership has risen significantly yearly [1]–[3]. This growth reflects the rising demand for personal transportation and highlights the importance of motorcycles in various economic sectors, such as logistics and delivery services [4], [5]. However, despite their benefits, the widespread use of motorcycles also brings consequences, particularly in fuel consumption and exhaust emissions.

In the automotive industry, fuel efficiency and environmental impact are primary concerns. Conventional fuels such as Pertalite are becoming increasingly limited as they are derived from non-renewable resources [6]. Additionally, the combustion of fossil fuels in motor vehicles generates exhaust emissions containing harmful compounds such as hydrocarbons (HC) and carbon monoxide (CO), which contribute to air pollution and health issues [6]–[8]. Therefore, innovation in alternative fuel usage is needed to create more environmentally friendly solutions while maintaining or even enhancing engine performance.

One alternative fuel currently being studied is methanol. Methanol is an alcohol compound with a higher octane rating and greater oxygen content than conventional gasoline [9]–[12]. Mixing methanol with gasoline, such as Pertalite, is expected to improve combustion efficiency, reduce exhaust emissions, and enhance engine performance in terms of power and torque [13]. Thus, this study focuses on the effects of methanol addition to Pertalite fuel on motorcycle engine performance and exhaust emissions.

Several previous studies have examined the impact of methanol and other alcohol-based additives, such as ethanol, concerning engine performance and exhaust emissions in gasoline fuel. Marwaha and Subramanian [9] found that adding methanol and ethanol significantly reduced harmful emissions, such as HC and CO, while increasing the engine's thermal efficiency. Meanwhile, research by Rifal and Sinaga [12] evaluated the effects of methanol blending with gasoline at different ratios (M15, M30, and M50) on fuel consumption and emissions in gasoline engines. The experimental results showed that methanol blends could reduce fuel consumption and lower CO and HC emissions. However, at higher methanol concentrations, CO_2 emissions increased significantly. Additionally, Agarwal et al. [14] investigated M85 fuel (85% methanol and 15% gasoline) in motorcycles. Their study revealed that M85-fueled motorcycles performed better than gasoline-powered ones, particularly in engine power, top speed, and acceleration, especially at higher speeds. However, using M85 also resulted in increased exhaust emissions.

Some aspects remain unexplored despite extensive research on methanol and ethanol blending in gasoline. Most previous studies have focused on fuel-injected vehicles, while research on carbureted motorcycle engines is still limited. Moreover, the effect of methanol blending ratios on engine performance and exhaust emissions requires further investigation, as the differences in injection and carburetor systems can affect combustion efficiency and fuel utilization [14], [15].

Therefore, this study aims to fill this research gap by conducting an experimental analysis on the impact of methanol addition to Pertalite fuel on engine performance and exhaust emissions in carburetor motorcycles. The results of this study are expected to contribute to the development of more efficient and environmentally friendly alternative fuels, while also providing new insights into optimizing motorcycle engine performance.

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METHODS

This research method follows the flowchart shown in **Figure 1**, which illustrates all stages of the process from beginning to end.

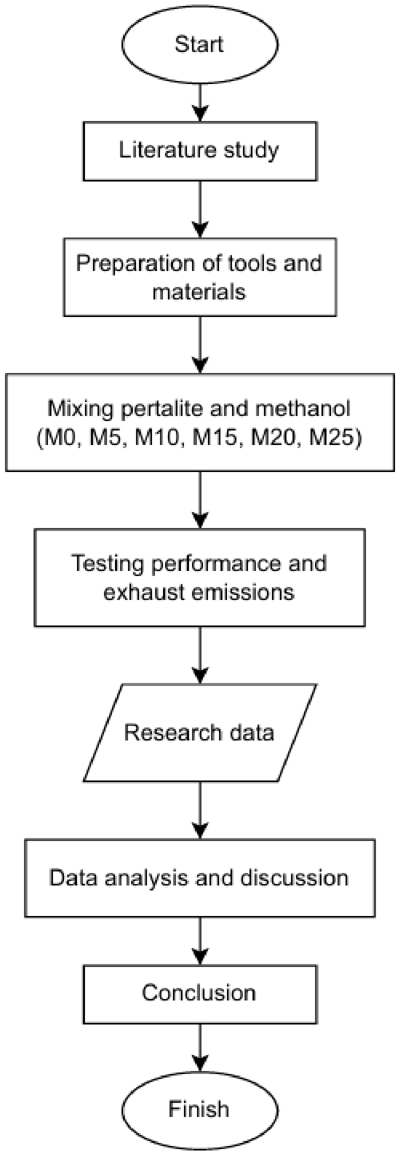

Figure 1. Research Flowchart

This study is experimental research aimed at analyzing the impact of methanol addition to Pertalite fuel on engine performance and exhaust emissions in motorcycles. The motorcycle used in this research is a carburetor-type motorcycle, with specifications detailed in **Table 1**.

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Table 1. Specifications of the Tested Motorcycle

Specification		Detail
Brand	:	Suzuki Shogun R 125
Year of manufacture	:	2007
Engine	:	4 stroke, 1 cylinder, SOHC
Engine capacity	:	124,02 cc
Bore x Stroke	:	53.5 mm x 55.2 mm
Compression ratio	:	9.5 ; 1
Cooling system	:	Air-cooled engine
Engine oil capacity	:	800 ml
Transmission system	:	4 speed (N, 1, 2, 3, 4)
Drive system	:	Chain
Ignition type	:	DC – CDI
Fuel system	:	Carburetor

This study used six types of fuel blends to observe changes in engine performance and exhaust emissions. These fuel variations include pure Pertalite and Pertalite-methanol blends with different mixing ratios, as shown in **Table 2**.

Table 2. Fuel Blend Variations

Fuel Code	Fuel Composition
M0	100% Pertalite
M5	95% Pertalite + 5% Methanol
M10	90% Pertalite + 10% Methanol
M15	85% Pertalite + 15% Methanol
M20	80% Pertalite + 20% Methanol
M25	75% Pertalite + 25% Methanol

The engine performance testing scheme is shown in **Figure 2**, illustrating the process of measuring torque and power in the motorcycle. During the testing procedure, the motorcycle is placed on a dynotest, with the rear wheel resting on the dynotest roller. When the engine is operated, the dynotest records torque and power changes at various engine speeds. The test results are displayed in real-time on a computer monitor connected to the equipment. The testing is conducted within a speed range of 2500 to 8500 rpm, with 1000 rpm intervals, ensuring accurate vehicle performance analysis.

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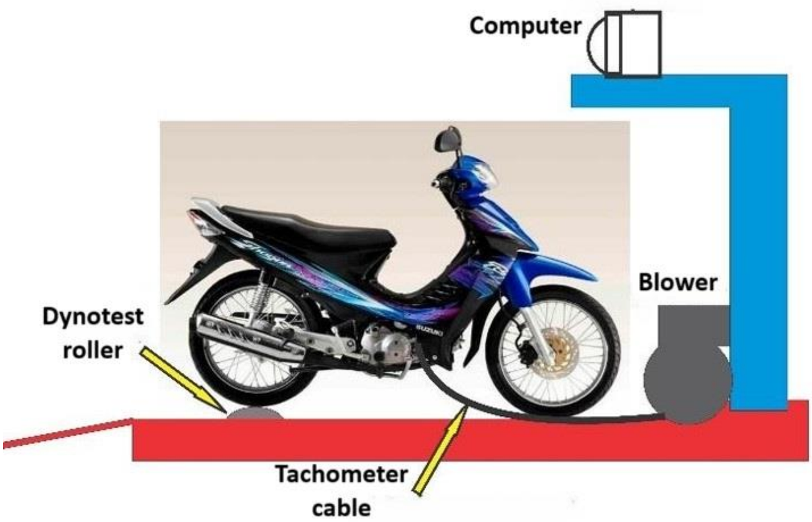

Figure 2. Engine Performance Testing Scheme with Dynotest

Additionally, in the exhaust emission testing, as shown in **Figure 3**, various supporting equipment was used to ensure accurate measurements. The Emission Gas Analyzer plays a crucial role in analyzing the exhaust gas components produced by the engine, particularly HC and CO. A burette is used as a substitute for the fuel tank to maintain precise fuel blending control. A tachometer is employed to measure engine speed, ensuring that testing is conducted at 1500 rpm, 2000 rpm, and 2500 rpm, as required by the study. Additionally, a fan is placed in front of the motorcycle to assist the cooling system during testing, keeping the engine temperature stable for more reliable results. With this configuration, the collected data provides a more accurate assessment of the impact of methanol blending on exhaust emissions.

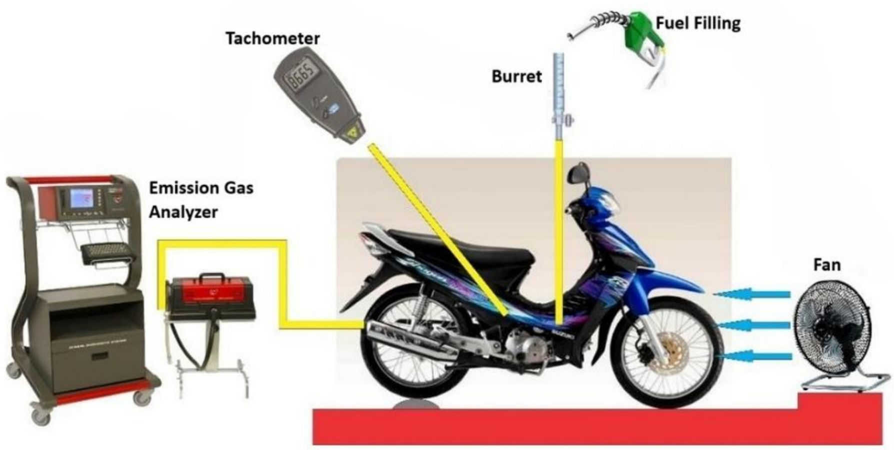

Figure 3. Exhaust Emission Testing Scheme with Emission Gas Analyzer

RESULTS AND DISCUSSION

Performance Testing

The test results for engine performance include torque and power measurements for each test parameter.

1. Torque Test

Torque is the engine's rotational force and plays a crucial role in vehicle acceleration. The higher the torque value, the better the motorcycle can deliver initial thrust. The torque test results for various fuel blend variations are shown in **Figure 4**.

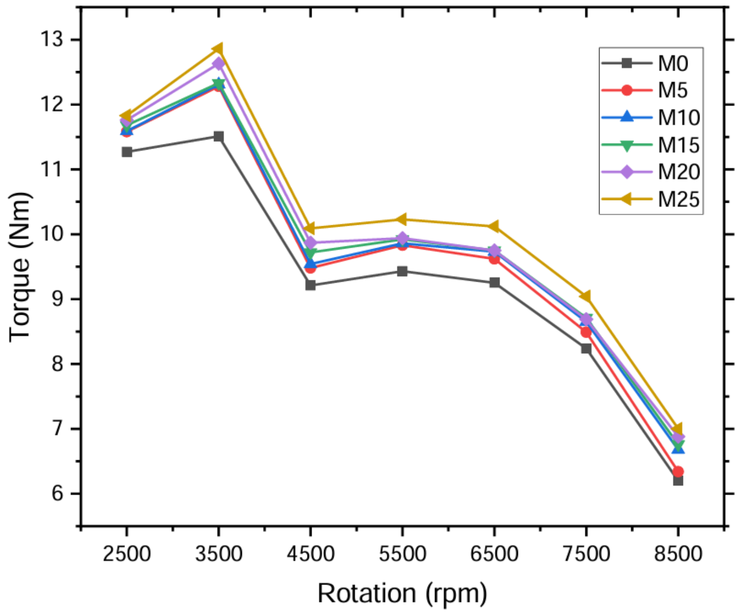

Figure 4. Torque Test Results

The torque test results show that adding methanol to Pertalite fuel generally increases torque values across various engine speeds. At 2500 rpm, M25 fuel produced the highest torque of 11.83 Nm, compared to M0, which only reached 11.27 Nm. This increasing trend continued up to 8500 rpm, where M25 still recorded the highest torque at 7 Nm, while M0 remained at 6.2 Nm. The graph also indicates that at 3500 rpm, all methanol blends showed a significant torque increase, suggesting that the engine responds better to methanol-blended fuel within this range. However, after 7500 rpm, torque values began to decline, indicating a decrease in combustion efficiency at higher speeds, although M25 continued to provide the best results compared to other blends.

This torque improvement demonstrates that methanol addition enhances combustion efficiency, allowing for more optimal energy conversion from fuel combustion. This effect is due to methanol's higher octane rating, which prevents premature detonation and optimizes combustion inside the cylinder chamber. The higher oxygen content in methanol-blended fuel also promotes more complete combustion, contributing to increased torque. With a higher octane rating, methanol-based fuel blends enable more stable combustion, producing greater engine power than pure Pertalite fuel. These findings align with studies by Agarwal et al. [14] and Fatkhurrozak et al. [16], which also concluded that methanol blending significantly increases engine torque.

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2. Power Test

Power represents the engine's ability to perform work over time and is a key factor in determining a vehicle's maximum speed. The higher the power output, the greater the motorcycle's ability to achieve higher speeds. The power test results can be seen in **Figure 5**.

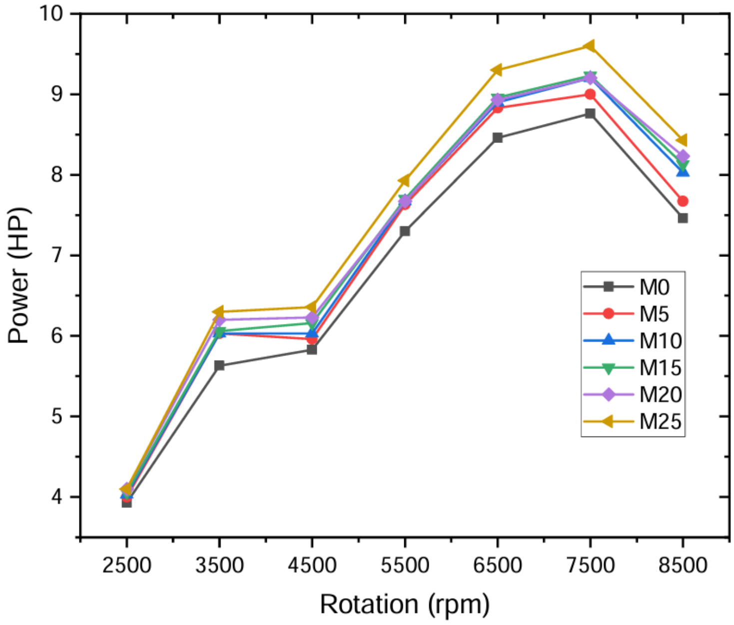

Figure 5. Power Test Results

The power test results show that adding methanol to Pertalite fuel enhances engine power output across the entire engine speed range. At 2500 rpm, M25 fuel produced the highest power at 4.1 HP, compared to M0, which only reached 3.93 HP. This increasing trend continued until 7500 rpm, where M25 recorded the highest power output of 9.6 HP, while M0 only reached 8.76 HP. The peak power was observed at 7500 rpm, indicating that combustion efficiency was at its maximum at this speed. Beyond 7500 rpm, power output started to decrease for all fuel variations. However, M25 maintained the highest power at 8500 rpm, reaching 8.43 HP, compared to M0, which produced only 7.46 HP. These results suggest that methanol positively impacts increasing engine power, particularly at medium to high engine speeds, which contributes to better overall vehicle performance.

The increase in engine power indicates that methanol improves thermal efficiency, allowing the heat energy generated from combustion to be converted into mechanical power more effectively. Methanol has a higher octane rating, which helps reduce knocking and enables more complete combustion, especially at higher engine speeds. As Shenghua et al. [17] explained, higher oxygen content in methanol-blended fuel increases laminar flame speed, leading to faster and more efficient combustion. As a result, more energy is converted into mechanical work, improving overall power output. Furthermore, high-octane fuels like methanol allow the engine to operate more efficiently at higher

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compression pressures, further supporting a significant increase in power output.

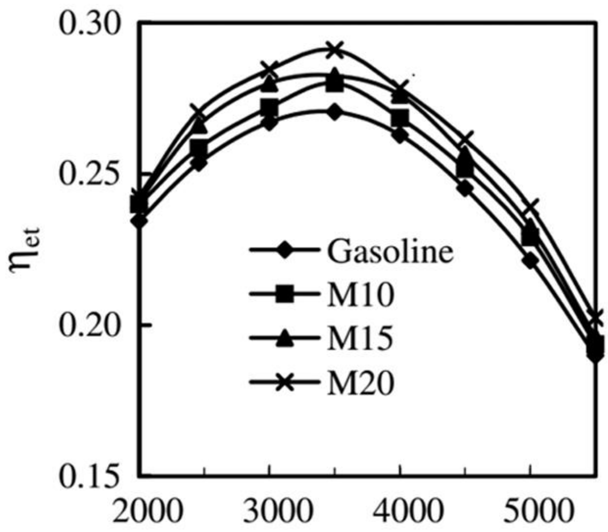

Figure 6. Effect of Methanol Addition on Thermal Efficiency [17]

Exhaust Emission Testing

The exhaust emission test results include measurements of hydrocarbon (HC) and carbon monoxide (CO) concentrations for each test parameter.

1. Hydrocarbon (HC)

Hydrocarbon (HC) is a compound produced from incomplete fuel combustion and contributes to air pollution. A high HC concentration indicates much unburned fuel, particularly in overly rich or lean fuel mixtures. The HC test results in this study are shown in **Figure 7**.

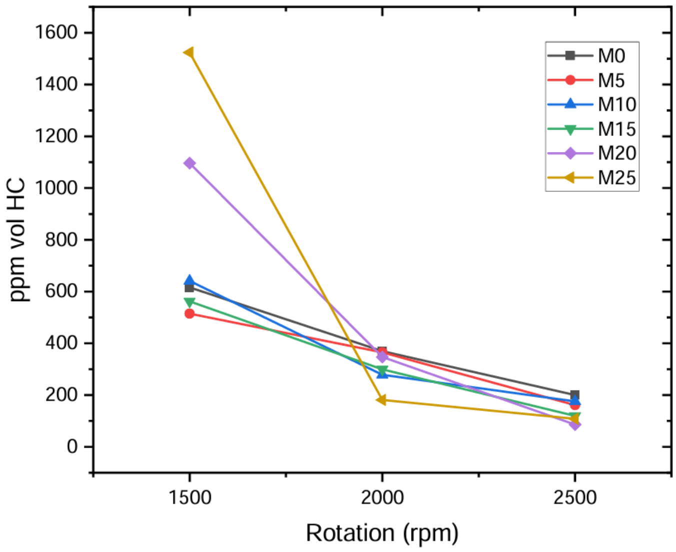

Figure 7. Hydrocarbon (HC) Test Results

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Based on the HC test results, it is observed that HC concentrations decrease as engine speed increases across all fuel variations. At 1500 rpm, M0, M5, M10, and M15 have relatively lower HC concentrations than M20 and M25, which record the highest values at 1096.67 ppm vol and 1524 ppm vol, respectively. The higher HC emissions in M20 and M25 are due to the leaner fuel mixture caused by higher oxygen content in methanol, leading to misfiring due to slower flame propagation, causing some fuel to remain unburned. However, as engine speed increases, HC emissions decrease significantly. At 2000 rpm, HC emissions in M25 drop to 181 ppm vol, while in M20, it decreases to 347.34 ppm vol, indicating that higher combustion temperatures and improved combustion stability at higher engine speeds contribute to lower HC emissions.

At 2500 rpm, M20 records the lowest HC emissions at 85.67 ppm vol, followed by M25 at 108.34 ppm vol. These results suggest that at higher engine speeds, combustion becomes more efficient, reducing the amount of unburned hydrocarbons. The higher HC emissions at lower speeds (e.g., 1500 rpm) occur because the fuel mixture is still rich, preventing complete combustion and producing excess HC emissions. Additionally, Dogan et al. [18] state that higher engine speeds improve fuel-air mixture homogeneity, enhancing combustion efficiency. This aligns with the observed decrease in HC emissions as engine speed increases, suggesting that methanol addition to Pertalite fuel can effectively lower HC emissions, especially at higher RPMs.

2. Carbon Monoxide (CO)

Carbon monoxide (CO) is a toxic gas produced from incomplete fuel combustion, particularly when the air-fuel ratio is too rich. CO forms when there is insufficient oxygen in the combustion chamber to fully convert carbon into carbon dioxide (CO_2), resulting in partial oxidation. High CO concentrations in exhaust emissions indicate low combustion efficiency and pose environmental and health risks. Therefore, reducing CO emissions is crucial to developing cleaner and more efficient fuels. The CO test results in this study are shown in **Figure 8**.

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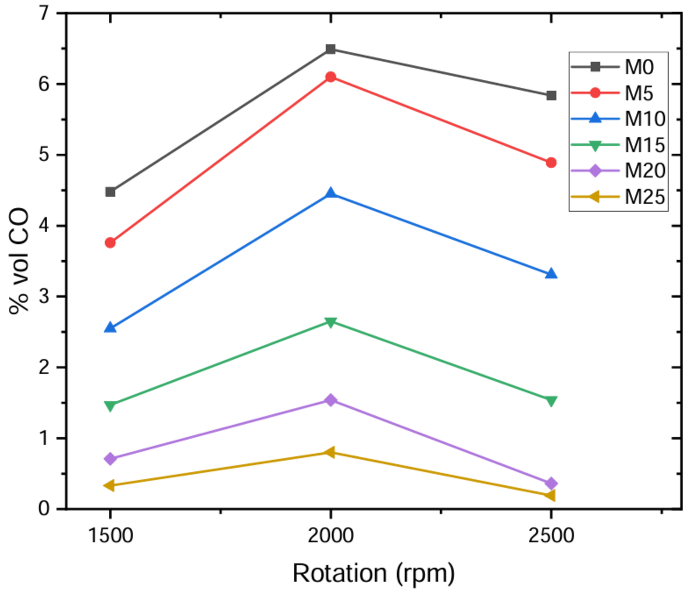

Figure 8. Carbon Monoxide (CO) Test Results

Based on the CO test results, it is observed that higher methanol content in the fuel blend leads to lower CO emissions. M25 fuel recorded the lowest CO concentration, while M0 produced the highest CO emissions across all engine speeds. At 1500 rpm, M0 recorded the highest CO emissions at 4.48% vol, whereas M25 had the lowest at 0.33% vol. This reduction indicates that methanol, as an oxygenated fuel, improves combustion efficiency, allowing less incomplete carbon oxidation into CO. Methanol enhances the combustion reaction with higher oxygen content, leading to more carbon being fully oxidized into CO_2 rather than CO. The study by Rifal and Sinaga [12] also confirmed that methanol addition reduces CO emissions but increases CO_2 emissions due to more complete combustion.

At 2000 rpm, CO emissions temporarily increased before decreasing at 2500 rpm. M0 still recorded the highest CO emissions at 6.49% vol, whereas M25 only produced 0.8% vol. The increase in CO at 2000 rpm is due to a richer air-fuel mixture across all fuel variations, leading to more incomplete combustion and higher CO formation. However, as engine speed reached 2500 rpm, CO emissions decreased, as the air-fuel mixture became leaner, leading to more complete combustion.

These findings align with the study by Jayanti et al. [19], which states that higher oxygen content in the fuel blend helps reduce CO emissions, as more carbon reacts with oxygen to form CO_2 instead of CO. Thus, the addition of methanol to Pertalite fuel proves to be effective in lowering CO emissions, especially in M20 and M25 blends, which produced the lowest CO emissions among all fuel variations.

CONCLUSION

This study demonstrates that adding methanol to Pertalite fuel enhances engine performance and reduces exhaust emissions in carburetor motorcycles. The M25 fuel blend (25% methanol + 75% Pertalite) produced the highest torque and power output compared to pure Pertalite (M0), particularly within the 2500 to 8500 rpm range. This improvement is due to methanol's higher octane rating, which helps reduce premature detonation, and its higher oxygen content, which increases combustion efficiency. Therefore, methanol can be utilized as a fuel additive to boost engine power in carburetor motorcycles.

Additionally, HC and CO emissions decreased as methanol concentration in the fuel increased. M25 recorded the lowest exhaust emissions, with CO at only 0.19% vol and HC at 108.33 ppm vol at 2500 rpm, compared to M0, which had CO at 5.84% vol and HC at 200 ppm vol. This indicates that methanol, as an oxygenated fuel, enables more complete combustion, reducing pollutant emissions. Therefore, blending methanol with Pertalite is proven effective in improving carburetor motorcycle performance while lowering exhaust emissions, making it a more environmentally friendly fuel alternative.

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