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The Effect of Methanol Blending with Pertalite Fuel on The Performance of a Single-Cylinder Four-Stroke Gasoline Engine

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Abstract
As petroleum-based fuel reserves continue to decline, the development of alternative fuels has become increasingly urgent. One promising approach is blending conventional gasoline with methanol, a renewable and readily available alcohol. This study aims to investigate the effects of methanol addition to Pertalite fuel on engine power, torque, and specific fuel consumption, and to determine the optimal blend ratio and engine speed for maximum engine performance. A single-cylinder, four-stroke gasoline engine was tested using a dynamometer at engine speeds ranging from 3,000 to 8,000 rpm, with methanol-Pertalite blend ratios of 0%, 5%, 10%, 15%, and 20%. The parameters measured included fuel consumption time, power, torque, and specific fuel consumption. Data were analyzed using descriptive statistics. The results showed that the 80% Pertalite–20% methanol blend yielded the best performance, with maximum power of 6.41 hp at 7,500 rpm, maximum torque of 5.76 lbf-ft at 4,500 rpm, and optimum specific fuel consumption of 5.33E+11 kg/hp-h at 7,500 rpm. It is concluded that methanol blending can significantly improve engine performance, with the 80/20 Pertalite-methanol mixture being the most effective formulation. These findings support the potential of methanol as a viable alternative fuel to reduce dependence on fossil fuels in the transportation sector.

INTRODUCTION

An internal combustion engine (ICE) is a type of engine that performs internal combustion; it is currently widely used for various purposes, including transportation (Singh et al., 2023). Almost all land vehicles utilize internal combustion engines as their primary means of propulsion (Zhou et al., 2023). Due to their significant role, the use of these engines facilitates and accelerates work processes (Liu et al., 2022). Fossil fuels supply more than ninety percent of the world's energy needs (Tian et al., 2022). If exploitation continues at current rates, it is estimated that these energy sources will be depleted within the next fifty years (Tian et al., 2022). Consequently, many developed nations have begun developing new, renewable, and environmentally friendly energy sources that are easy to produce and derived from abundant raw materials (Pandey et al., 2022). One such renewable energy source is methanol (Lan, 2022). Methanol also known as methyl alcohol or wood alcohol is a chemical compound with the formula CH3OH (Osman et al., 2022). It is the simplest form of alcohol. Under atmospheric conditions, methanol exists as a light, volatile, colorless, flammable, and toxic liquid with a distinctive odor (milder than that of ethanol). Methanol is used as an antifreeze coolant, a solvent, a fuel, and an additive for industrial ethanol (Tian et al., 2022).

This study investigates the effects of blending Pertalite fuel with methanol on engine power, torque, and specific fuel consumption.

As petroleum fuel reserves dwindle a resource upon which the vast majority of motor vehicles rely it is essential to explore better solutions to address this issue (Iliev, 2021). Consequently, investigating fuel additives or blending agents to reduce petroleum fuel consumption warrants serious consideration (Agarwal et al., 2021). Rapid technological advancements and the growing demand for operational vehicles have led to an increase in petroleum fuel consumption (Hanifuddin et al., 2023). Therefore, there is a need to develop alternative fuels to replace conventional options such as Pertalite (Pratama et al., 2022). One method of achieving this is by blending conventional fuel with an alternative fuel; methanol is a suitable candidate for use as such a blending agent (Li et al., 2019).

The study investigates the effect of adding methanol to Pertalite fuel on the power, torque, and specific fuel consumption of a gasoline engine.

According to Nofendri (2018), in an article titled "The Effect of Ethanol Addition to RON 88 and RON 92 Gasoline on Engine Performance," the research results showed a decline in gasoline engine performance (torque and power) when using ethanol blends with both RON-88 and RON-92 fuels. For ethanol/RON-88 blends, the smallest reduction occurred with the ME-10 mixture specifically, a 9% drop in torque and a 1% drop in power whereas for Pertamax (RON-92), the smallest reduction was observed with the MX-5 mixture, showing a 3% drop in torque and a 1% drop in power. Regarding Brake Specific Fuel Consumption (BSFC), improvements in fuel efficiency were observed at high engine speeds (2,000–3,000 rpm); the XE-5 blend reduced fuel consumption by 15.8%, while the XE-10 blend reduced it by 11.5%. However, most previous studies have focused on ethanol blends, while research on methanol as a blending agent for Pertalite fuel particularly its effects on power, torque, and specific fuel consumption across a wide range of engine speeds remains limited (Iliev, 2021; Martin & O'Malley, 2021; Setiawan et al., 2024; Sumarsono et al., 2025; Tamam et al., 2021). This gap provides the rationale for conducting this study.

This research aims to analyze the effect of methanol blending with Pertalite fuel on the power output, torque, and specific fuel consumption of a single-cylinder four-stroke gasoline engine, as well as to determine the optimal methanol-Pertalite blend ratio and engine speed that produce the best engine performance in terms of power, torque, and fuel efficiency. The findings of this study are expected to provide both theoretical and practical benefits: theoretically, this research contributes to the body of knowledge on alternative fuels by providing empirical data on the combustion characteristics and performance implications of methanol-gasoline blends in small-scale gasoline engines across a broad engine speed range; practically, the results serve as a reference for the automotive industry and researchers in developing alternative fuel formulations that reduce fossil fuel dependence without significantly compromising engine performance, while also offering insights for vehicle owners on more economical and environmentally friendly fuel alternatives, and providing scientific evidence for policymakers to support regulations that encourage methanol adoption as part of a national strategy to achieve energy security and reduce greenhouse gas emissions from the transportation sector.

Engine Power

Power is a key parameter in determining an engine's performance. Engine power is defined as the amount of work performed by the engine over a specific period. The unit used is horsepower (hp) (Obert, E.F.). To calculate the power of a 4-stroke engine, the following formula is used: $\boldsymbol{P}$ = where: P = Engine power (hp), n = Engine speed (rpm), and T = Torque (Nm).

Engine Torque

Torque is the rotational force applied to a rotating component; a motorcycle is driven by torque from the crankshaft. Torque measures an engine's capacity to perform work or generate motion. It is a derived quantity commonly used to calculate the energy produced by an object rotating about its axis. Torque is typically expressed in Newton-meters (N.m) (M.L. Mathur & R.P. Sharma). The formula is as follows: T = F x r, where: T = Torque of the rotating object (N.m), F = Force (N), and r = Distance from the object to the center of rotation (m).

Specific Fuel Consumption

Specific Fuel Consumption (SFC) is the mass flow rate per unit of power. Calculations are performed to determine the engine's efficiency in utilizing fuel to generate power. The formula for calculating SFC is $\boldsymbol{SFC} = \dot{m}f$/P, where: SFC = Specific Fuel Consumption (kg/hp·h), $\dot{m}f$ = fuel mass flow rate (kg/h), and P = power (hp).

Pertalite Fuel

Pertalite is a new type of fuel produced by Pertamina. Based on the Decree of the Director General of Oil and Gas No. 313.K/10/DJM.T/2013 regarding the Standards and Quality of 90-Octane Gasoline Marketed Domestically (https://finance.detik.com/energi/d-2890803/pertalite-ron90-berwarna-hijau-dan-jernih), the specifications for Pertalite are as follows:

a. Research Octane Number (RON) 90.0.
b. Oxidation stability: minimum 360 minutes.
c. Sulfur content: maximum 0.05% m/m (equivalent to 500 ppm).
d. Must not contain lead.
e. No metal content (manganese and iron). Maximum oxygenate content: 2.7% m/m.
f. Distillation: 10% evaporation at a maximum of 74°C; final boiling point: maximum 215°C.
g. Residue: maximum 2.0%.
h. Sediment: 1 mg/liter.
i. Mercaptan sulfur: maximum 0.002% by mass (equivalent to 20 ppm).
j. Unwashed gum: maximum 70 mg/100 ml.
k. Washed gum: maximum 5 mg/100 ml.
l. Density at 15 degrees Celsius: minimum 715 kg/m^3, maximum 770 kg/m^3.
m. Visual appearance: clear and bright.
n. Color: green.

o. Dye content: maximum 0.13 grams/100 liters.

In addition, the government has imposed another requirement for RON 90 gasoline: any additives mixed into the fuel must be compatible with the gasoline itself meaning they must not increase engine deposits or sludge and must not contain ash-forming components. (https://finance.detik.com/energi/d-2890803/pertaliteron-90-berwarna-hijau-dan-jernih)

METHOD

In this study, the researcher conducted performance testing on a standard Honda Supra X 125 cc engine. The fuels used are Pertalite and methanol, mixed at specific ratios.

Supporting Equipment

The supporting equipment used includes a dynamometer, a display monitor, a dynamometer stand, an engine cooling blower, a control panel, a roller, a Honda Supra X 125 cc motorcycle, a tachometer, a stopwatch, a graduated cylinder (burette), and others.

The details regarding the supporting equipment, test materials, and measuring instruments used in the research are as follows:

Dynotest / Dynamometer

The Dynotest/Dynamometer is a device used to measure the power and torque of a motorcycle; it meets Kowa Seiki Japan specifications.

Monitor

The monitor displays the interface for the motorcycle torque and power measurement program.

Dynotest Platform

The Dynotest platform serves as the mounting base for the motorcycle during torque and power testing.

Blower

The blower functions to blow air and cool the motorcycle engine while torque and power testing is in progress.

Control Panel

The control panel serves as the interface for operating the dynotest equipment.

Roller

The roller functions to measure the motorcycle's rotational speed, power, and torque.

Test Engine

The engine used is from a Honda Supra X vehicle a single-cylinder, four-stroke gasoline engine. The engine is integrated with the testing equipment, specifically a load-applying roller connected via a sensor to the spark plug wire, allowing the computer to automatically read torque and power values at desired rotational speeds.

Tachometer

The tachometer is a device used to measure the engine's rotational speed at the output shaft. The rotational speed can be read directly on the gauge scale in revolutions per minute (rpm).

Stopwatch

The stopwatch is used to measure the time associated with fuel consumption during testing specifically, to determine the rate at which fuel is consumed during the experiment.

Burette

The burette is a device used to measure the fuel supply during testing.

Research Flowchart

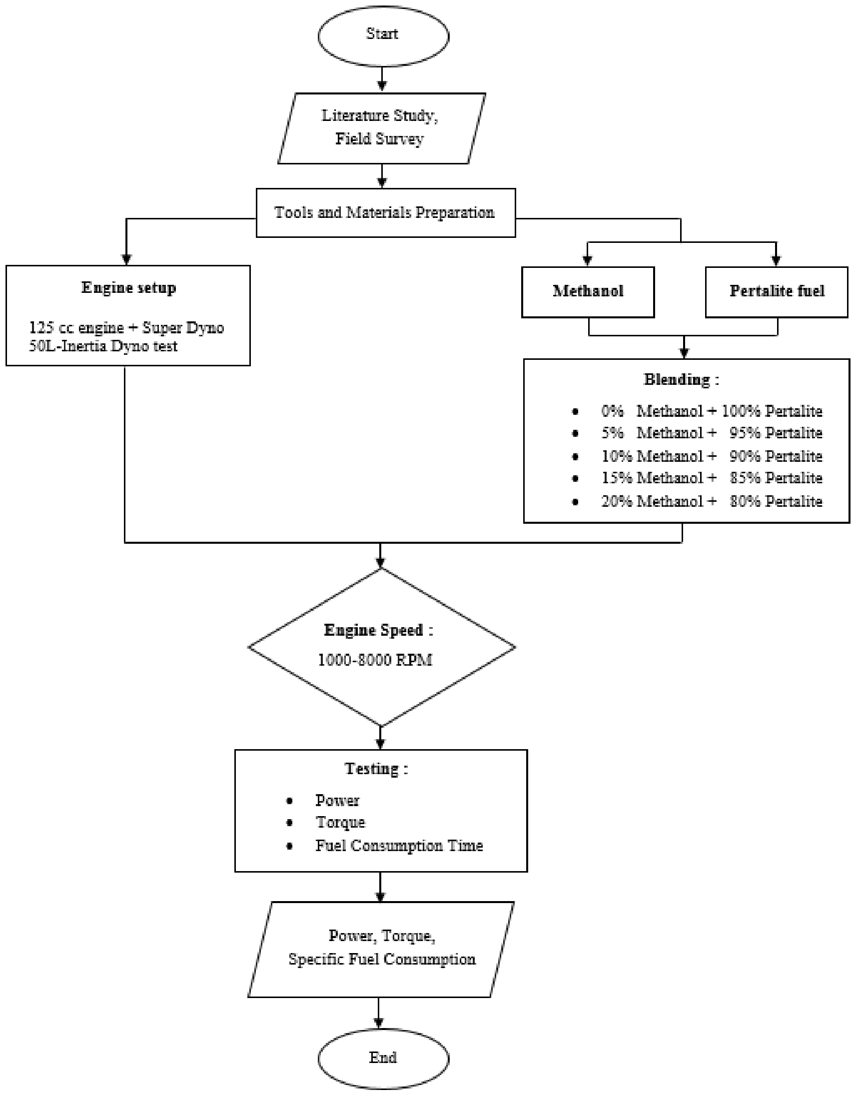

Figure 1. Research Flowchart

Source: Author's research design, 2025

RESULTS AND DISCUSSION

The test parameters observed in this study were engine speed, torque, and power, using a blend of Pertalite and methanol fuels. Meanwhile, specific fuel consumption was determined through calculation. The test and calculation data are presented in graphical form.

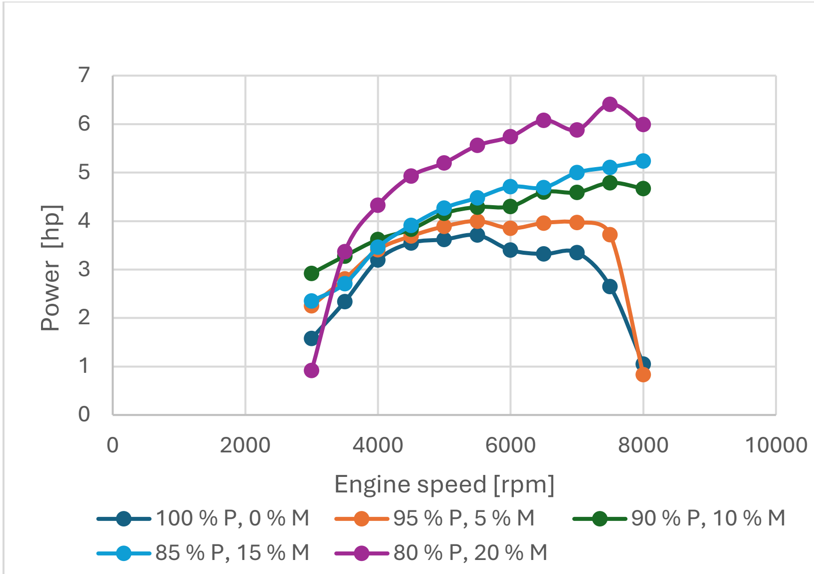

Figure 2. Relationship between effective power and engine speed

Source: Test results from dynamometer measurement, 2025

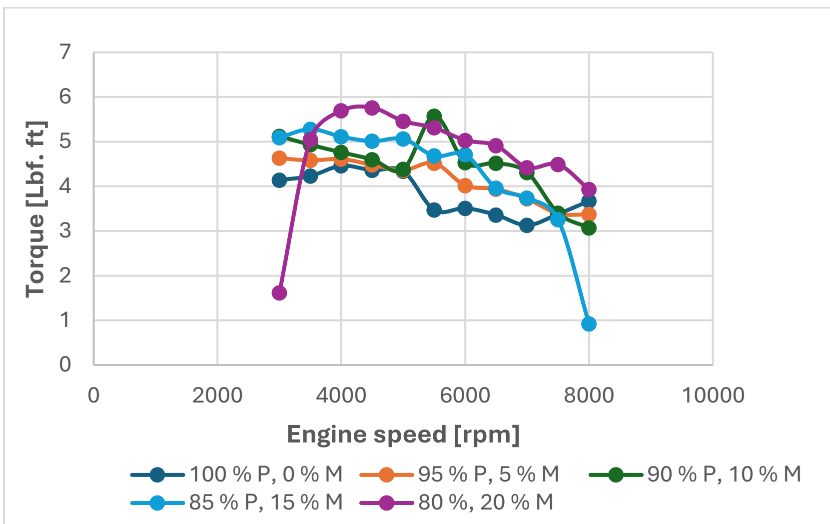

Figure 3. Relationship between torque and engine speed

Source: Test results from dynamometer measurement, 2025

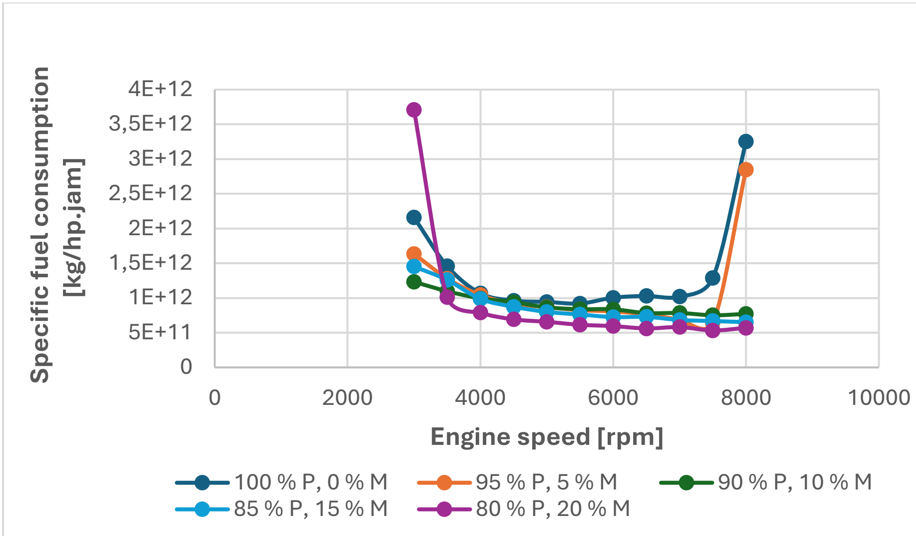

Figure 4. Relationship between specific fuel consumption and engine speed
Source: Calculated from test data, 2025

Figures 2, 3, and 4 illustrate the relationships between effective power and engine speed, torque and engine speed, and specific fuel consumption and engine speed; these graphs depict the performance of a single-cylinder engine.

According to the reference test standards, the point at which effective power reaches its optimum coincides with the optimization of specific fuel consumption meaning the most efficient fuel usage occurs at that specific engine speed [Matur, M.L. and Sharma, R.P.].

Based on the test data, using a fuel supply of 100% Pertalite, the maximum power generated was 3.71 hp at an engine speed of 5,500 rpm, with a specific fuel consumption of 9.20396E+11 kg/hp·h.

Test results using a fuel blend of 80% Pertalite and 20% methanol demonstrated the most optimal (efficient) specific fuel consumption of 5.3271E+11 kg/hp·h, an optimal power output of 6.41 hp at 7,500 rpm, and an optimal torque of 5.76 lbf·ft at 4,500 rpm when compared to 100% Pertalite and other blend compositions. This highlights the phenomenon where the propagation of the ignition spark through the charge is only possible within specific limits dictated by the mixture ratio.

Test data across the 3,000 to 8,000 rpm engine speed range showed Air-Fuel (A/F) ratios between 13.8 and 15.75; this falls within the practical operating range for carbureted engines (9–21) approaching complete combustion and remains within the flammability limits for hydrocarbons (A/F of 7–30) [Matur, M.L. and Sharma, R.P.].

The optimization of power, torque, and specific fuel consumption is closely linked to the air-fuel (A/F) ratio. Test data indicate that optimal power and specific fuel consumption were achieved at an A/F ratio of 14.77, whereas optimal torque was achieved at an A/F ratio of 14.33. The measurements show that the A/F ratio did not reach the extremes of the "lean" or "rich" mixture ranges, where the heat released by the spark would be insufficient to initiate combustion in the surrounding unburnt mixture.

CONCLUSION

Based on performance results obtained at wide-open throttle using various fuel mixtures specifically 100% Pertalite and blends of Pertalite and methanol (95%/5%, 90%/10%, 85%/15%, and 80%/20%) the optimum performance was achieved with the 80% Pertalite and 20% methanol blend. The maximum torque produced was 5.76 lbf-ft at an engine speed of 4,500 rpm, the maximum power produced was 6.41 hp at 7,500 rpm, and the optimum specific fuel consumption (SFC) was 5.3271E+11 kg/hp-h at 7,500 rpm. Based on these findings, several suggestions are proposed. For further research, it is recommended to investigate the long-term effects of methanol blends on engine durability, including corrosion and wear on engine components such as fuel lines, injectors, and valves, as well as to analyze exhaust emissions (CO, HC, and NOx) to evaluate the environmental impact of methanol-blended fuels. Additionally, future studies could explore higher methanol blend ratios or the addition of co-solvents to improve blend stability and address phase separation issues. For vehicle owners and the general public, it is advisable to consider methanol-blended fuels as an economical alternative, provided that proper engine adjustments (such as carburetor re-tuning or ECU recalibration) are made to optimize air-fuel ratio and ignition timing for maximum performance and fuel efficiency. For policymakers and the automotive industry, it is recommended to support the development of methanol production and distribution infrastructure, establish clear standards for methanol-blended fuels, and promote public awareness campaigns to encourage the adoption of this alternative fuel as part of a national strategy for energy diversification and emission reduction.

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