Asian Journal Science and Engineering
Open Access
Vol. 4, No. 2, December 2025
https://attractivejournal.com/index.php/ajse

The Effect of Bioethanol Blends with 92 Octane Gasoline on Engine Performance and Exhaust Emissions

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ARTICLE INFO
Received December 09, 2025
Revised December 20, 2025
Accepted December 20, 2025

Abstract

This research focuses on the use of bioethanol mixed with 92-octane gasoline as an alternative fuel to improve engine performance and reduce emissions. The main problem addressed is the lack of optimization in the bioethanol and gasoline mixture ratio, which affects combustion efficiency and engine performance. The results show that mixing bioethanol with gasoline improves the brake mean effective pressure (BMEP) and decreases specific fuel consumption (SFC) at certain engine speeds, indicating enhanced combustion efficiency. However, the mixture ratio beyond a certain percentage (30% ethanol) leads to decreased performance, showing the limits of bioethanol use in fuel blends. The distinctive feature of this study is the comprehensive evaluation of different bioethanol proportions (13%, 15%, and 17%) and their effect on engine performance, providing more specific insights into the optimal fuel mixture for various engine conditions. The results are particularly useful for the automotive industry and policymakers looking to implement bioethanol as a sustainable alternative fuel.

Keywords: Bioethanol, 92-octane gasoline, engine performance, brake mean effective pressure (BMEP), specific fuel consumption (SFC)

Published by	CV. Creative Tugu Pena
ISSN	2963-6752
Website	https://attractivejournal.com/index.php/ajse

INTRODUCTION

Currently, a relevant issue in the field of fuel technology is the use of bioethanol as an alternative fuel mixed with 92 octane fuel. Bioethanol has the potential to reduce dependence on fossil fuels and provide economic benefits by utilizing renewable resources, such as sugar cane and cassava. However, in its implementation, there are technical challenges related to the right ratio between bioethanol and gasoline to achieve efficient and environmentally friendly combustion. As explained in a study conducted by Setyadi (2016), mixing bioethanol with gasoline has significant advantages, namely increasing the octane number and producing more complete combustion, thereby reducing carbon monoxide (CO), hydrocarbon (HC), and particulate emissions.

Research conducted by Susilo and Sabudin (2021) also shows that the use of a mixture of bioethanol and Pertamax can increase engine power at mixtures of 10%, 20%, and 30%, although above 30% can cause incomplete combustion. Furthermore, this study also shows that bioethanol mixtures can affect fuel efficiency and energy consumption. For example, the use of a 20% bioethanol mixture produced the highest power of 12.92 HP at 8000 rpm, but also increased fuel consumption by 0.60 kg/kWh at 6500 rpm (Hermawan et al., 2021).

In addition, it is important to consider the appropriate mixing method between food-grade bioethanol and 92 octane fuel. Incorrect mixing methods can cause technical problems in the engine, such as damage to the fuel system. Therefore, further research is needed to determine the most efficient and safe mixing method, as well as to analyze its effect on power, torque, and fuel efficiency. The results of this study will provide a strong foundation for further development in the use of bioethanol as a sustainable, environmentally friendly fuel.

Several studies have been conducted to discuss bioethanol blends with 92 octane gasoline as an alternative fuel to reduce emissions and improve engine performance. Research by Arwin et al. (2023) shows that the use of bioethanol blends with gasoline can reduce carbon emissions and improve engine performance, depending on the type of engine used. This is in line with the findings of Jatmiko and Winangun (2019), who noted that increasing the ethanol content in fuel can improve combustion efficiency, because bioethanol has a high calorific value, which results in more complete combustion. This increase in combustion efficiency also affects engine performance, including power and torque, especially at higher engine speeds.

In addition, research by Yudistirani et al. (2019) shows that mixing Pertamax with bioethanol increases engine power and torque up to 7000 RPM, confirming the benefits of ethanol in improving engine performance. Meanwhile, Albana (2016) emphasizes that the higher octane rating of bioethanol helps accelerate the combustion process and allows for higher compression ratios, which generally improve engine efficiency.

However, the impact of higher ethanol blends on engine performance can vary. Some studies show that very high ethanol content can reduce engine performance because ethanol has a lower energy density than gasoline, which can affect engine power under certain operating conditions. Therefore, although bioethanol offers substantial benefits in terms of carbon emission reduction and energy security, it is important to consider its impact on engine performance, especially when mixed in varying proportions with gasoline.

Although many studies have examined the use of bioethanol blends with 92 octane gasoline, there are still several gaps that need to be addressed in the development of this alternative fuel technology. Most previous studies, such as those conducted by Yudistirani et al. (2019) and Susilo & Sabudin (2021), have only focused on the effect of bioethanol blends with gasoline on engine power and torque at certain blend ratios, without optimizing the ideal volume ratio for various engine conditions. Research by Hermawan et al. (2021) also shows that the use of bioethanol blends of more than 30% can cause incomplete combustion, but further research on the long-term impact and engine efficiency at higher blends has not been widely conducted. In addition, most studies have not considered the influence of other variables such as fuel temperature, more varied engine speeds, or additional components in the engine that can affect the test results.

Another research gap is the lack of discussion on more efficient and safer blending methods, especially in the application of food-grade bioethanol with 92 octane gasoline, as well as universally applicable testing standards to ensure the sustainability and safety of bioethanol use in various types of vehicles. Therefore, this study aims to fill this gap by conducting an in-depth examination of the optimal volume ratio for bioethanol and 92 octane gasoline blends in various types of engines, as well as developing more precise and safer blending methods, taking into account external factors that affect overall engine performance.

The purpose of this study is to examine the effect of bioethanol blended with 92 octane gasoline on engine performance, exhaust emissions, and fuel consumption in vehicle engines. This study also aims to determine the optimal volume ratio between bioethanol and 92 octane gasoline, as well as to evaluate its impact on combustion efficiency and emission reduction.

Research Methods

This research method uses laboratory experiments with tests on a 4-stroke single-cylinder engine using 92 octane fuel and food-grade bioethanol. The material used in this study is a mixture of 92 octane fuel and food-grade bioethanol with 95% ethanol purity. The fuel specifications involved comparing bioethanol mixtures with gasoline at volumes of 13%, 15%, and 17% to observe their effect on engine performance.

The research variables included fuel temperature, bioethanol blend in gasoline, and engine speed controlled within a range of 3000-9000 rpm at 1000 rpm intervals. The dependent variables measured were torque, brake mean effective pressure (bmep), and specific fuel consumption (SFC). This study used a data collection method in the form of recording changes in power, torque, and fuel consumption during testing. The data collection process was carried out in three replicates to obtain accurate results.

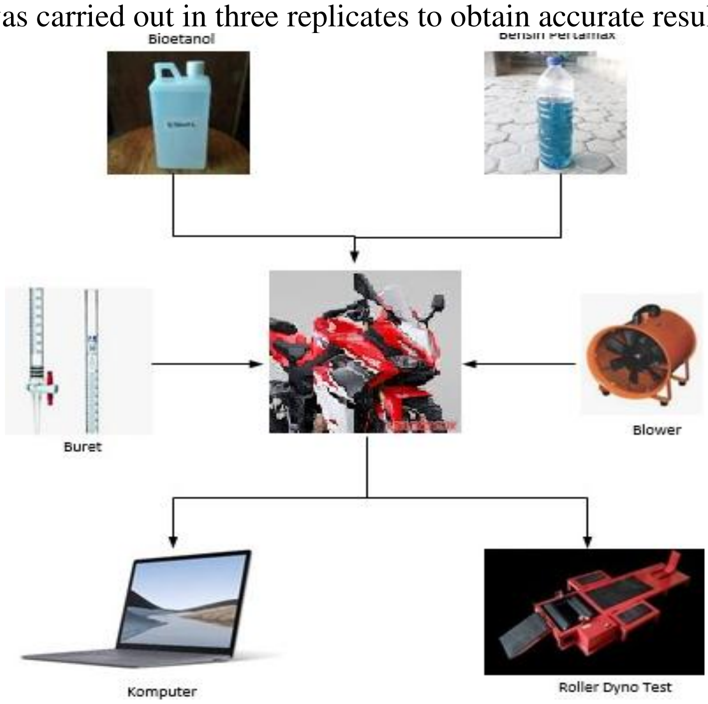

Figure 1. Experimental setup

Figure 1 shows bioethanol and premium gasoline being mixed using a burette to measure the exact amount of fuel. The motorcycle was tested using a roller dynamometer to measure power and torque at various engine speeds. A blower was used to keep the engine temperature stable during testing. The data obtained from the roller dynamometer was analyzed using a computer to evaluate engine performance, fuel efficiency, and the impact of the bioethanol mixture on engine performance.

RESULTS AND DISCUSSION

Based on the research results, a graph was obtained as shown in Figure 2.

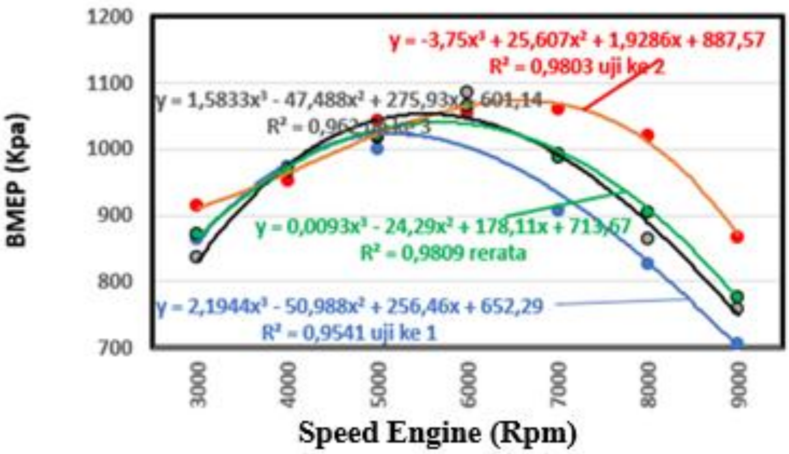

Figure 2 Calculated BMEP octane 92

Figure 2 shows that the mixture of bioethanol with 92 octane gasoline significantly affects engine performance. Based on the curve produced, BMEP increases with increasing engine speed until it reaches a peak at around 6000-7000 rpm, after which it begins to decline. The R^2 value for each test curve (between 0.9541 and 0.9809) indicates a very high correlation between the model and the experimental data. This indicates that selecting the right fuel mixture can optimize combustion efficiency and engine power at a certain rpm range, but there are limitations to engine performance at higher mixtures.

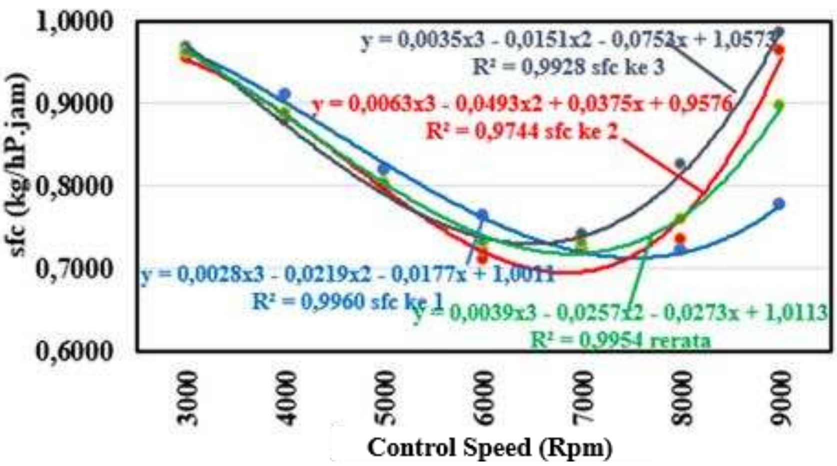

Figure 3 Calculated results for octane 92 SFC

Figure 3 shows the results of specific fuel consumption (SFC) testing for 92 octane fuel, indicating an inverse relationship between SFC and engine speed. Based on the graph, SFC decreases at low speeds until it reaches its lowest point at around 6000-7000 rpm, after which it begins to increase. Each test curve (tests 1, 2, 3, and average) shows a consistent pattern, with high R^2 values, namely 0.9928 in test 3, 0.9744 in test 2, 0.9960 in test 1, and 0.9954 in the average calculation. This indicates that at certain engine speeds, the 92 octane fuel mixture achieves the best fuel consumption efficiency. The decrease in SFC at certain speeds indicates more efficient fuel use, suggesting that optimizing the fuel mixture can improve engine efficiency at medium to high speeds.

This identifies that the initial fuel requirement is very high because the engine is still cold, so the combustion process requires a lot of fuel. The fire is still not burning completely, so the heat cannot burn the fuel completely. In addition, it also overcomes high friction and inertia. Furthermore, up to a certain point, this condition increases because combustion is complete. In addition, the combustion frequency increases, which means that as the engine speed increases, the number of work cycles (intake, compression, combustion, exhaust) per minute also increases. This condition results in greater fuel injection.

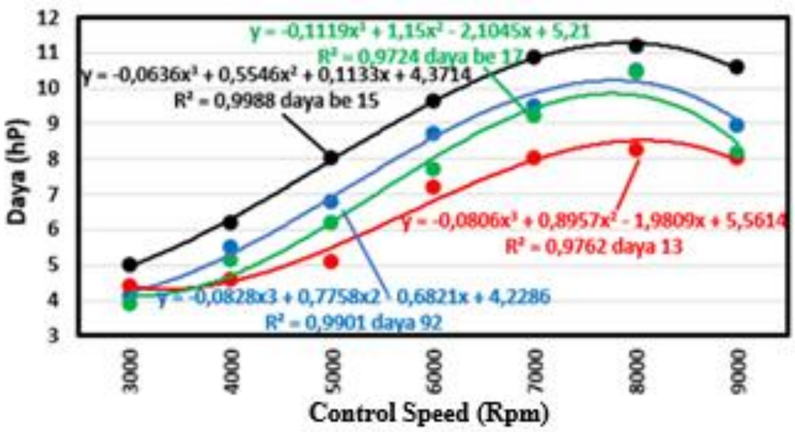

Figure 4 shows a comparison of engine power between 92-octane fuel and bioethanol at various engine speeds (rpm).

Figure 4 shows that engine power increases as engine speed increases. For 92 octane fuel (blue curve), power increases steadily with an R^2 value of 0.9901, indicating an excellent fit of the model to the experimental data. The maximum power is recorded at around 8000 rpm. Meanwhile, for food-grade bioethanol (green and red curves), the power also increases with engine speed, but the maximum power recorded is lower than that of 92 octane, despite having R^2 values of 0.9724 for power 12 and 0.9762 for power 13, respectively. The decrease in power in this bioethanol mixture may be due to differences in combustion characteristics between bioethanol and gasoline, where bioethanol has lower energy per liter. Nevertheless, the use of bioethanol still provides advantages in terms of emission reduction and fuel sustainability, even though it slightly reduces engine power at high speeds.

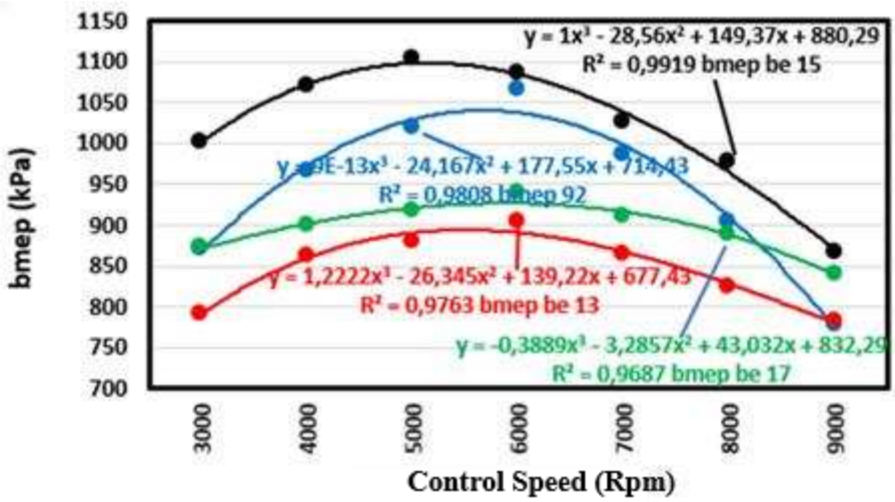

Figure 5 Comparison of Brake Mean Effective Pressure (BMEP) between 92 octane fuel and bioethanol at various engine speeds (rpm).

Figure 5 shows the relationship between BMEP and engine speed for fuel mixtures, with curves representing experiments on 15%, 13%, and 17% bioethanol mixtures, as well as 92 octane fuel. Based on Figure 5, it can be seen that BMEP increases with increasing engine speed until it reaches a maximum point at around 6000-7000 rpm, after which it begins to decline. For 92 octane fuel (blue curve), BMEP reaches its peak value with an R^2 value of 0.9808, indicating an excellent fit between the model and the experimental data. Meanwhile, in the food-grade bioethanol mixture, the R^2 value in the 15% test (black curve) was 0.9919, indicating excellent fit and a more significant increase in BMEP compared to other tests.

However, in the 17% bioethanol mixture (green curve) and 13% mixture (red curve), there was a decrease in BMEP after reaching its peak, indicating efficiency limitations in higher mixtures. The R^2 value for the 17% bioethanol mixture is 0.9687, and for the 13% mixture it is 0.9763, which still shows good fit despite the decrease in BMEP at high engine speeds.

These results show that bioethanol blends with 92 octane gasoline can increase BMEP, but only at certain blend levels. The decrease in BMEP at higher blends indicates that there is an optimal limit for bioethanol use that must be considered in order for the engine to continue to operate efficiently.

CONCLUSION

1. This study shows that blending bioethanol with 92-octane gasoline can improve combustion efficiency and engine performance, especially at a 15% bioethanol blend, which results in increased engine power and torque. However, at a 17% bioethanol blend, engine performance decreases, indicating an optimal limit for bioethanol use in fuel blends.
2. The decrease in power in high bioethanol mixtures is due to the low energy per liter of bioethanol compared to gasoline, although there are still benefits in reducing CO and HC emissions. This shows the potential of bioethanol as an environmentally friendly alternative fuel.

3. This study provides an important basis for the development of alternative fuels, but further research is needed to test the long-term effects and other variables, such as fuel temperature, on engine performance in optimal bioethanol and gasoline blends.

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