JMEL 14 (2) (2025)
Journal of Mechanical Engineering Learning
https://journal.unnes.ac.id/journals/jmel
doi https://doi.org/10.15294/jmel.v14.i2.28103

The Effect of Methanol-Blended Fuel on Fuel Consumption and Exhaust Emissions of a 150 cc Gasoline Motorcycle

Mochammad Miftachul Syanusi[1*], Hadromi[2], Rizqi Fitri Naryanto[3], Ranu Iskandar[4]
[1,2,3,4]Automotive Engineering Education Study Program, Mechanical Engineering Department, Faculty of Engineering, Universitas Negeri Semarang
Building E5, Faculty of Engineering, UNNES Taman Siswa Street, Sekaran, Gunungpati, Semarang 50229, Indonesia
*Corresponding author. Email: miftahsyanusi@gmail.com

How to cite (APA Style 7th) : Syanusi, M. M., Hadromi, Naryanto, R. F., & Iskandar, R. (2025). The Effect of Methanol-Blended Fuel on Fuel Consumption and Exhaust Emissions of a 150 cc Gasoline Motorcycle. *JMEL : Journal of Mechanical Engineering Learning, 14*(2), 63–70. https://doi.org/10.15294/jmel.v14.i2.28103

ARTICLE INFO

Article History:
Received: June 19, 2025
Revised: July 6, 2026
Accepted: July 7, 2026

Keywords: Exhaust Emissions; Fuel Consumption; Gasoline Engine; Methanol-Blended Fuel; Motorcycle

Abstract

This study aims to determine the effect of methanol-blended fuel variations on fuel consumption and exhaust emissions Honda Supra X125 FI. The background of this research is the need for environmentally friendly and efficient alternative fuels to reduce air pollution from motorized vehicles. Methanol was chosen as an additive due to its high octane number and oxygen content in its structure, which can improve combustion efficiency. The tests were conducted using a Honda Supra X125 FI motorcycle with five fuel mixture variations: 0%, 5%, 10%, 15%, and 20% methanol in Shell V-Power. Data were collected using a gas aalyzer and a dynamometer to measure fuel consumption and CO and HC emission levels. The results show that methanol addition increases fuel consumption by up to 17.99% in the 20% methanol mixture due to methanol's lower calorific value compared to gasoline. However, CO emissions decreased by 23% and HC emissions by 19.26%. The 10% methanol mixture is optimal as it balances combustion efficiency and fuel consumption. The findings indicate that methanol has potential as a fuel additive for reducing emissions in gasoline motorcycles, although higher methanol concentrations may increase fuel consumption.

1. INTRODUCTION

In recent years, the increase in motorized vehicles has often been associated with economic growth and community welfare. According to AISI (2024), domestic motorcycle sales reached 4,872,496 units by September 2024, with 150 cc motorcycles are widely preferred due to fuel efficiency and maneuverability on congested roads (Zaini & Ariska, 2022). Motorized vehicles, especially motorcycles, have become the primary mode of transportation in developing countries like Indonesia. However, this increase in vehicles has led to a surge in fuel imports reaching 47.74 million tons in 2022 (BPS, 2024), as well as significant contributions to greenhouse gas emissions and air pollution (Pramudito et al., 2022; Wahyudi et al., 2024; Rahmawati, 2023). The combustion process in gasoline engines produces pollutants such as CO, NOx, and PM, especially when combustion efficiency is low (Örs et al., 2022).

Various solutions have been developed to address these challenges, ranging from efficient engine technology and emission regulations to using alternative fuels . The government has also encouraged vehicle emission testing since 2023. One promising alternative is methanol, which produces lower CO_2 emissions and has a high oxygen index (Wirawan et al., 2021; Iliev, 2021). Methanol has received significant attention in 2020-2024 research due to its ability to reduce CO, HC, and NOx emissions. The diverse sources and increasing availability of methanol make it more accessible. Even in racing, methanol has been widely used because it is environmentally friendly. Fuel quality, including viscosity and octane number (RON), significantly affects combustion efficiency and emissions (Maulana et al., 2023; Riyanto et al., 2022; Halim et al., 2022).

In Indonesia, various fuels with different octane numbers are available in the market, significantly affecting engine performance. This research explores the effect of the methanol ratio in fuel mixtures on the consumption and emissions of 150 cc motorcycles. Using VP Racing Fuel M5, a methanol fuel with additives and Shell V-Power RON 95. This study aims to evaluate the effect of methanol-blended Shell V-Power fuel on fuel consumption, CO emissions, HC emissions, and lambda values in a 150 cc fuel-injected motorcycle.

2. RESEARCH METHODS

This study used a quantitative approach with experimental methods (true experimental design). The research object was a 2014 Honda Supra X125 FI motorcycle modified to a 150 cc engine capacity. The fuels used were Shell V-Power RON 95 mixed with methanol (VP Racing Fuel M5) in mixture ratios of 0%, 5%, 10%, 15%, and 20%. Testing was conducted at the E9 Performance Laboratory UNNES, with a test engine (dynamometer) to measure fuel consumption and engine performance, and a gas analyzer (HESBON HG-520) to measure exhaust emissions. The consumed fuel volume was measured using a burette for each fuel mixture variation. The data were then analyzed quantitatively using descriptive statistical methods to compare fuel consumption and exhaust emissions for each methanol ratio variation.

3. RESULTS AND DISCUSSION

Fuel Consumption

Table 1. Time Required to Consume 20 ml of Fuel at Different Engine Speeds

Consumption result (20 ml/s)			
Methanol Ratio	**Idle**	**2000 rpm**	**3000 rpm**
Methanol 0%	363	302.33	223
Methanol 5%	334.67	281.67	200.67
Methanol 10%	331.67	277,33	191
Methanol 15%	322.67	255.67	186
Methanol 20%	305	239.33	173.67

The above data shows the results of fuel consumption testing using 20 ml of fuel with variations in fuel mixtures at engine speeds of idle (1500 rpm), 2000 rpm, and 3000 rpm. The collected data needs to be input into the following equation formula to calculate consumption in kg/h. To convert the 20 ml/second consumption results to kg/h, the following formula is used:

$$m_f = \frac{V}{t} \times \frac{3600}{1000} \times \rho_{bb}$$

Where:

m_f : Fuel consumption (kg/h)

V : Volume of fuel used (cc)

t : Time required (seconds)

ρ_{bb} : Fuel density (kg/liter)

Table 2. Fuel Consumption

Fuel Consumption (m_f) kg/h			
Methanol Ratio	**Idle**	**2000 rpm**	**3000 rpm**
Methanol 0%	0.148	0.178	0.242
Methanol 5%	0.162	0.193	0.27
Methanol 10%	0.164	0.196	0.285
Methanol 15%	0.169	0.213	0.293
Methanol 20%	0.18	0.23	0.316

The fuel consumption of the SUPRAX125 FI motorcycle at 3000 rpm with a flow rate of 20 ml/second using Shell V-Power with various methanol blends. The fuel consumption without methanol (0%) was 0.242 kg/h. With a 5% methanol blend, consumption increased to 0.270 kg/h (an 11.57% rise), then to 0.285 kg/h at 10% methanol (a 5.56% increase from 5%). The 15% blend recorded consumption of 0.293 kg/h (a 2.81% increase from 10%), and the 20% blend reached 0.316 kg/h (a 7.85% increase from 15%), demonstrating a consistent trend of increasing consumption with higher methanol content. These results indicate that methanol blending significantly affects fuel consumption at high engine speeds, with the most substantial increase occurring at the initial 5% methanol addition. The consumption pattern suggests that while higher methanol concentrations continue to increase fuel usage, the rate of increase varies at different blend ratios.

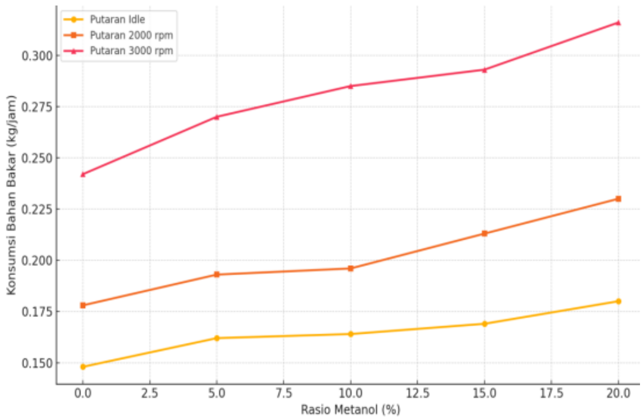

Figure 1. Effect of Engine Speed Variation and Methanol Ratio on Fuel Consumption

Figure 1 illustrates the relationship between variations in methanol blend ratios and fuel consumption at idle, 2000, and 3000 rpm, based on the average consumption of five fuel types. The test results indicate fuel consumption increases with higher methanol concentrations across all engine speeds. At idle, consumption rises from 0.148 kg/h (0% methanol) to 0.180 kg/h (20% methanol); at 2000 rpm, it increases from 0.178 kg/h to 0.230 kg/h; and at 3000 rpm, it climbs from 0.242 kg/h to 0.316 kg/h. This increase occurs because methanol has a lower calorific value than gasoline, requiring the engine to burn more fuel to produce equivalent power. Additionally, higher engine speeds elevate energy demands, further amplifying fuel consumption.

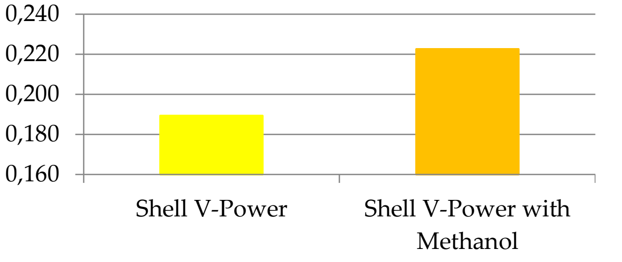

Figure 2. Average Fuel Consumption for Pure Fuel vs. Methanol-Blended Fuel

Test results show that pure fuel consumption was 0.189 kg/h, while methanol-blended consumption increased to 0.223 kg/h. This increase indicates that adding methanol to the fuel raises fuel consumption. This occurs because methanol has a lower calorific value than gasoline, requiring a larger fuel volume to achieve the same engine power output.

The fuel consumption test results on the SUPRA X125 FI motorcycle demonstrate an increase in fuel consumption corresponding with higher engine speeds and methanol blend ratios. Figures 1–5 reveal that at idle speed, a 5% methanol blend increases fuel consumption by 9.46% compared to pure fuel, with this increase continuing up to 6.51% for a 20% blend. Tests conducted on the 2014 SUPRA X125 FI motorcycle indicate that adding methanol to Shell V-Power fuel directly impacts fuel consumption, particularly at idle. Figure 1 shows that fuel consumption rises with increasing methanol ratios, with a 9.46% increase for the 5% blend compared to pure fuel. This upward trend continues for 10%, 15%, and 20% blends, showing increases of 1.23%, 3.05%, and 6.51% respectively, compared to previous variations. This suggests higher methanol concentrations lead to greater fuel consumption even at low engine speeds.

At 2000 rpm, fuel consumption shows more significant increases. Figure 2 illustrates that pure Shell V-Power consumes 0.178 kg/h, rising to 0.193 kg/h (8.43% increase) with a 5% methanol blend. The 10% blend consumes 0.196 kg/h (1.55% higher), the 15% blend consumes 0.213 kg/h (8.67% increase), and the 20% blend reaches 0.230 kg/h (7.98% increase). This indicates that higher engine loads at 2000 rpm require more fuel, and methanol addition further amplifies this demand. The upward trend continues at 3000 rpm, where higher RPMs require more fuel and air to maintain engine power and efficiency. Figure 3 demonstrates that a 5% methanol blend increases consumption by 11.57% compared to pure fuel. Subsequent blends show increases of 5.56% (10%), 2.81% (15%), and 7.85% (20%) over previous blends, confirming that methanol progressively affects fuel consumption at higher speeds.

Overall, tests across all three engine speeds (idle, 2000 rpm, and 3000 rpm) show that methanol blending increases fuel consumption rates. At idle, consumption jumps 21.62% from 0% to 20% methanol, while at 2000 rpm, the increase reaches 29.21%. Figure 4 graphically demonstrates these results, proving methanol's negative impact on fuel efficiency. On average, methanol-blended fuels consume 23.28% more than pure Shell V-Power. Higher RPMs increase consumption due to greater power demands (Setiyawan et al., 2023).

Adding VP Racing Fuel M5 to Shell V-Power 95 alters fuel characteristics, including reduced viscosity that improves air-fuel mixing. Methanol's high oxygen content, favorable hydrogen-to-carbon (H/C) ratio, and higher vaporization energy requirements (Iskandar et al., 2024; Li et al., 2019) contribute to these changes. Although methanol has a high octane rating (~102), this advantage does not necessarily benefit low-compression engines like the SUPRA X125 FI (Fahrizal & Adiwibowo, 2020). Gradual methanol blending also reduces calorific value - from 10,381.99 cal/g (5% blend) to 9,689.43 cal/g (20% blend) - while increasing density from 0.748 kg/L (pure) to 0.7634 kg/L (20% blend). Tira et al. (2023) noted that higher density correlates with lower calorific value. In conclusion, methanol blending increases fuel consumption. Pure Shell V-Power demonstrates better efficiency due to its higher calorific value and more stable combustion in low-compression engines. These findings align with research by Zhang et al. (2022) and Sarıkoç (2023), confirming that methanol blending generally increases fuel consumption rates.

Exhaust Gas Emission

Table 3. Exhaust Gas Emission Test Results

Emission Result			
Methanol Ratio	**CO (%)**	**HC (ppm)**	**Lambda (λ)**
Methanol 0%	0.83	1397	1.393
Methanol 5%	0.71	1136	1.329
Methanol 10%	0.687	1031	1.331
Methanol 15%	0.643	1138	1.552
Methanol 20%	0.516	1207	1.885

Table 3 is the average data obtained from exhaust gas emission tests using a gas analyzer. The table above shows the test results from different fuel blend variations on a Honda Supra X125 FI motorcycle regarding the resulting exhaust gas emissions of CO, HC, and lambda values.

The CO exhaust emission data show the effect of different methanol-blended fuels on the Supra X125 FI motorcycle. The results demonstrate that CO emissions decrease with increasing methanol ratios. For pure gasoline (0% methanol), emissions measured 0.83%. The 5% methanol blend yielded 0.71% (a 14.46% reduction), 10 % methanol produced 0.687% (3.24% reduction), 15% methanol resulted in 0.643% (6.4% reduction), and the 20% methanol blend achieved the lowest emissions at 0.516% (19.75% reduction compared to pure gasoline).

HC emissions (ppm) from a SUPRA X125 FI motorcycle with varying methanol fuel blends. Using pure gasoline (0% methanol), HC emissions measured 1397 ppm. The 5% methanol blend reduced emissions to 1136 ppm (an 18.71% decrease), while the 10% methanol blend further lowered emissions to 1031 ppm (a 9.26% reduction compared to the 5% blend). However, with 15% and 20% methanol blends, HC emissions increased to 1138 ppm (a 10.38%

rise) and 1207 ppm (a 6.06% rise), respectively, indicating an upward trend after the initial decline.

The lambda values of a SUPRA X125 FI motorcycle with different methanol fuel blends. Using pure gasoline (0% methanol), the lambda value was 1.393, indicating a lean mixture. The 5% methanol blend reduced the lambda value to 1.329 (a 4.6% decrease), while the 10% methanol blend slightly increased to 1.331 (0.15% higher than the 5% blend). At higher methanol concentrations, significant increases were observed: the 15% blend reached 1.552 (16.63% increase) and the 20% blend jumped to 1.885 (21.45% increase). These results demonstrate that higher methanol percentages cause progressively leaner mixtures, which may affect combustion efficiency and exhaust emissions. The most dramatic changes occurred between 15-20% methanol blends, suggesting a threshold concentration where methanol's oxygen content begins to substantially alter the air-fuel ratio characteristics in this fuel-injected motorcycle engine.

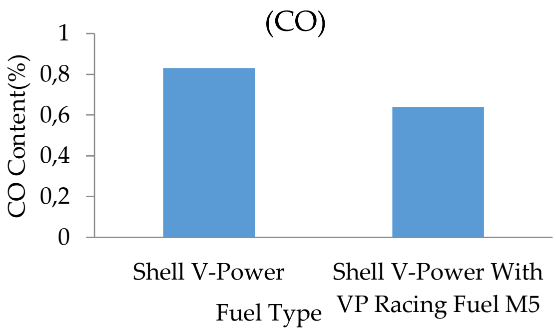

Figure 3. Average of Pure Fuel vs. Methanol-Blended Fuel on CO Emissions

Based on the average results of CO exhaust emissions (%) from using pure Shell V-Power fuel without a methanol blend and Shell V-Power with a methanol blend, as shown in the figure above, the pure Shell V-Power fuel produced an average CO emission value of 0.83%. In comparison, the Shell V-Power fuel with methanol blend showed an average CO emission value of 0.639%. This indicates that the Shell V-Power fuel with methanol blend produces 23% lower CO emissions than the pure Shell V-Power fuel. Methanol's oxygen content (48.13% according to VP Racing Fuels M5 specifications) improves combustion efficiency, reducing CO while increasing CO_2 (Royyan et al., 2025; Sahaja & Pudukarapu, 2019).

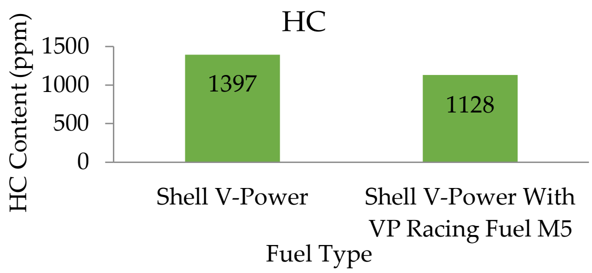

Figure 4. Average of Pure Fuel vs. Methanol-Blended Fuel on HC Emissions

HC levels decreased from 1397 ppm (pure fuel) to 1136 ppm (5% methanol) and 1031 ppm (10% methanol). However, at higher concentrations (15% and 20% methanol), HC levels rise to 1138 ppm and 1207 ppm, respectively. This increase occurs due to excessively lean combustion caused by methanol's high oxygen content and octane rating. While oxygen in methanol initially improves combustion and reduces HC (Nidhi & Subramanian, 2019; Martin & O'Malley, 2021), at higher concentrations, methanol's high latent heat of vaporization cools the combustion chamber, creating lean conditions that increase HC emissions (Sinkala et al., 2024; Li et al., 2019).

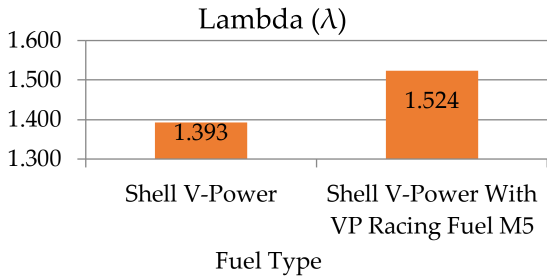

Figure 5. Average of Pure Fuel vs. Methanol-Blended Fuel on Lambda (λ) Values

The lambda value decreased from 1.393 at 0% methanol to 1.329 at 5% methanol, remained nearly constant at 10%, and then increased sharply at 15% and 20% methanol, then slightly to 1.331 (10%), before jumping significantly to 1.552 (15%) and 1.885 (20%).

Figure 5 illustrates this upward trend in lambda values, driven by ECU re-mapping to accommodate increased engine capacity (Fatra et al., 2020) and methanol's oxygen content (Sarikoç, 2020). Higher lambda values correlate with increased fuel consumption, as lean combustion prompts the ECU to inject more fuel (Nnamdi & Prince, 2024). Since methanol has a lower calorific value, maintaining engine performance requires an additional fuel supply. This phenomenon also explains the reduction in CO and HC emissions (Iskandar et al., 2020; Sanjaya & Syarifudin, 2020).

4. CONCLUSION

The results showed that adding methanol to the Shell V-Power fuel mixture on the SUPRA X125 FI motorcycle caused a significant increase in fuel consumption across all engine speeds (idle, 2000 rpm, and 3000 rpm). The addition of methanol to Shell V-Power fuel affected both fuel consumption and exhaust emissions in the 150 cc Supra X125 FI motorcycle. Increasing the methanol ratio raised fuel consumption at idle, 2000 rpm, and 3000 rpm because methanol has a lower calorific value than gasoline. In terms of emissions, methanol blending reduced CO emissions across the tested mixtures, while HC emissions decreased at 5% and 10% methanol but increased again at 15% and 20% due to lean combustion conditions and the high latent heat of vaporization of methanol. The lambda values also increased at higher methanol ratios, indicating a leaner air–fuel mixture. Overall, the 10% methanol blend provides the most balanced result between emission reduction and fuel consumption, while higher methanol concentrations are less favorable for fuel efficiency.

5. DECLARATION/STATEMENT

5.1. Acknowledgment

The authors would like to thank the E9 Performance Laboratory, Universitas Negeri Semarang, for providing facilities and technical support during the experiment. The authors used a generative AI tool only for language editing and grammar improvement without influencing the scientific content, data analysis, or conclusions of this article. No generative AI tool was used in preparing this manuscript.

5.2. Author Contributions

The first author contributed to conceptualization, experimental testing, data collection, data analysis, and manuscript drafting. The second author contributed to research supervision and methodology review. The third author contributed to data interpretation and manuscript revision. The fourth author contributed to validation, academic guidance, and final manuscript review. All authors read and approved the final version of the manuscript.

5.3. Conflict of Interest

The authors declare that there is no conflict of interest related to the research, authorship, or publication of this article.

6. REFERENCES

AISI. (2024). *Statistik Penjualan Sepeda Motor Domestik*. https://www.aisi.or.id/statistic/

Fahrizal, M. A., & Adiwibowo, P. H. (2020). Analisis Pengaruh Campuran Bahan Bakar Metanol Dengan Pertalite Terhadap Unjuk Kerja Mesin Sepeda Motor Yamaha Nmax Tahun 2020. *Jurnal Teknik Mesin Unnesa*, *12*(03), 69–76.

Fatra, F., Mahendra, S., & Setiawan, I. (2020). Analisis re-mapping ECU terhadap performa mesin sepeda motor injeksi 4 tak 150cc The effect of standard ECU re-mapping variations using pertamax fuel on the performance of a 150cc 4 stroke injection motorcycle. *Jurnal Taman Vokasi*, *11*(1), 41–49. http://dx.doi.org/10.30738/jtv.v11i1.14499

Halim, R. G., Riza, A., & Darmawan, S. (2022). Pengaruh Nilai Oktan Terhadap Unjuk Kerja Mesin Dan Kajian Analisis Pembakaran Akibat Delay Combustion Pada Mesin Otto Satu Silinder. *Jurnal Cahaya Mandalika*, 223–230.

Iliev, S. (2021). A comparison of ethanol, methanol, and butanol blending with gasoline and its effect on engine performance and emissions using engine simulation. *Processes*, *9*(8). https://doi.org/10.3390/pr9081322

Iskandar, R., Arlinwibowo, J., Setiadi, R., Mujaki, A., Naryanto, R. F., Setiyawan, A., & Musyono, A. D. N. I. (2024). Impact of biodiesel blends on specific fuel consumption: A meta-analysis. *IOP Conference Series: Earth and Environmental Science*, *1381*. Retrieved from https://iopscience.iop.org/article/10.1088/1755-1315/1381/1/012033/meta

Iskandar, R., Sukoco, Sutiman, Arifin, Z., Adkha, N. F., & Rohman, J. N. (2020). The quality of vehicle exhaust gas emission in Sleman, Indonesia in 2019. *Journal of Physics: Conference Series*, *1456*(1), 012030. Retrieved from https://iopscience.iop.org/article/10.1088/1742-6596/1456/1/012030/meta

Li, X., Zhen, X., Wang, Y., Liu, D., & Tian, Z. (2019). The knock study of high compression ratio SI engine fueled with methanol in combination with different EGR rates. *Fuel*, *257*(July), 116098. https://doi.org/10.1016/j.fuel.2019.116098

Martin, A., & O'Malley, J. (2021). *Kompatibilitas pencampuran bahan bakar A20 pada mesin berbahan bakar bensin di Indonesia*.

Maulana, S., Syahid, D. N., Widjanarko, D., & Setiyawan, A. (2023). Pengaruh Pemanasan Awal (Pre-Heater) Bahan Bakar Terhadap Performa Mesin Diesel Dengan Pemanas Kontrol Otomatis Di Laboratorium Pengujian Performa Mesin Jurusan Teknik Mesin FT UNNES. *Journal Of Mechanical Engineering Learning*, *12*(1), 1–10.

Nidhi, & Subramanian, K. A. (2019). Experimental investigation on effects of oxygen enriched air on performance, combustion and emission characteristics of a methanol fuelled spark ignition engine. *Applied Thermal Engineering*, *147*, 501–508. https://doi.org/10.1016/j.applthermaleng.2018.10.066

Nnamdi, A., & Prince, E. (2024). *Catalyst System and Oxygen Sensor Performance in Automobile Exhaust Emissions on Injection Engine*. *November*. https://doi.org/10.56201/ijemt.v10.no9.2024.pg19.29

ÖRS, İ., GÜLCAN, H. E., KUL, B. S., YELBEY, S., & CİNİVİZ, M. (2022). Evaluation of the Effects of Methanol and Ethanol Additions on Performance and Emissions in a Spark Plug Ignition Engine Fueled with Gasoline. *International Journal of Automotive Science and Technology*, *6*(2), 156–164. https://doi.org/10.30939/ijastech..1081731

Pramudito, Y., Maymuchar, M., Wibowo, C. S., Anggarani, R., Warahadi, D., Fathurrahman, N. A., & Aisyah, L. (2022). Kinerja Mesin Spark Ignition (SI) Berbahan Bakar Campuran Bensin-Metanol (M-20) Dan Bensin-Etanol (E-20) Pada Variasi Nilai Oktan. *Lembaran publikasi minyak dan gas bumi*, *56*(2), 89–98. https://doi.org/10.29017/lpmgb.56.2.1173

Rahmawati, S., & Pratama, I. N. (2023). Pengaruh Penggunaan Transportasi BerkelanjutanTerhadap Kualitas Udara Dan KesejahteraanMasyarakat. *Journal of Enviromental Policy and Technology*, *1*(2), 90–99.

Riyanto, L., Suwignyo, J., & Mahendra, S. (2022). Pengaruh Variasi Injector Dengan Bahan Bakar Terhadap Performa Mesin Dan Emisi Gas Buang Yamaha Soul Gt 2014. *Journal of Vocational Education and Automotive Technology*, *4*(2), 77. https://doi.org/10.31331/joveat.v4i2.2403

Royyan, M. A. D., Margianto, & Raharjo, A. (2025). Pengaruh penambahan metanol pada gasoline ron 95 terhadap emisi gas buang motor bakar 4-langkah. Undergraduate Thesis. https://repository.unisma.ac.id/handle/123456789/11556?show=full

Sahaja, K., & Pudukarapu, L. (2019). *Effect Of The Use Of Methanol, Toluene And Nitromethane Mixtures As Fuel Additives In A Gasoline Engine On Engine Performance And Exhaust Emissions*. *6*(6), 1–4.

Sanjaya, F. L., & Syarifudin, S. (2020). Konsumsi Bahan Bakar Dan Emisi Gas Buang Mesin Motor 100 cc Berbahan Bakar Premium Dan Metanol. *Nozzle : Journal Mechanical Engineering*, *9*(2), 38–40. https://doi.org/10.30591/nozzle.v9i2.2261

Sarikoç, S. (2020). Impact of various lambda values on engine performance, combustion and emissions of a SI engine fueled with methanol-gasoline blends at full engine load. *International Journal of Automotive Engineering and Technologies*, *9*(4), 178–189. https://doi.org/10.18245/ijaet.735553

Sarıkoç, S. (2023). Environmental and enviro-economic effect analysis of hydrogen-methanol-gasoline addition into an SI engine. *Fuel*, *344*(March), 128124. https://doi.org/10.1016/j.fuel.2023.128124

Setiyawan, A., Fitriyana, D. F., Bahatmaka, A., Firmansyah, H. N., Darsono, F. B., Aryadi, W., Kriswanto, Roziqin, A., & Naryanto, R. F. (2023). Diesel Engine Performance using Pertamina Dex and Biodiesel (B30) on RPM and Fuel Consumption. *IOP Conference Series: Earth and Environmental Science*, *1203*(1). https://doi.org/10.1088/1755-1315/1203/1/012010

Sinkala, H., Özarslan, S., & Benarous, A. (2024). Effect of Excess Air Ratio on Emissions, Performance and Efficiency of Gasoline Fueled Engines: A Review. *Energy, Environment & Storage*, *4*(2), 32–45. https://doi.org/10.52924/pupx2065

Tira, H. S., Mirmanto, Iwanuddin, Salman, & Sudirman. (2023). Analysis of the Calorific Value and Specific Gravity of Breadfruit Peel Bioalcohol (Artocarpus Altilis) as an Alternative Fuel at Various Distillation Temperatures. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5163–5169. https://doi.org/10.29303/jppipa.v9i7.2878

Wahyudi, K., Makai, K., & Sukmono, Y. (2024). *Implementasi Stasiun Pengisian Kendaraan Listrik Umum (SPKLU) Sebagai Infrastruktur Penunjang Electrical Vehicle dalam Mendukung Net Zero Emission*. *2*(2), 38–46.

Wirawan, T. S., Putra, A. E. E., & Aziz, N. (2021). Gasoline Engine Performance, Emissions, Vibration and Noise with Methanol-Gasoline Fuel Blends. *IOP Conference Series: Earth and Environmental Science*, *927*(1). https://doi.org/10.1088/1755-1315/927/1/012027

Zaini, A. K., & Ariska, I. (2022). Motorcycle Behavior and Traffic Safety (Case of Ujung Batu District, Rokan Hulu Regency) Riau Province. *Asian Journal of Mechatronics and Electrical Engineering*, *1*(1), 13–24.

Zhang, Z., Wen, M., Cui, Y., Ming, Z., Wang, T., Zhang, C., Ampah, J. D., Jin, C., Huang, H., & Liu, H. (2022). Effects of Methanol Application on Carbon Emissions and Pollutant Emissions Using a Passenger Vehicle. *Processes, 10*(3), 10.3390/pr10030525

.