JBAT 14(2) (2025) 96 – 102

Jurnal Bahan Alam Terbarukan

Accredited SINTA 3 by Ministry of Research and Technology/National Research and Innovation Agency
SK No. 10/C/C3/DT.05.00/2025
http://journal.unnes.ac.id/nju/index.php/jbat

p-ISSN 2303 0623
e-ISSN 2407 2370

Analysis on The Effect of Bio-addictive Mixtures Eugenol in Pertamax Green 95 Fuel on Engine Performance

Kuat Nursiam✉, Sonika Maulana, Wirawan Sumbodo, Rizqi Fitri Naryanto, Deni Fajar Fitriyana

DOI: https://doi.org/10.15294/jbat.v14i2.40034

Automotive Engineering Education Study Program, Semarang State University, Faculty of Engineering, UNNES Kampus Sekaran, Gunungpati, Semarang, 50229 Indonesia

Article Info

Article history:
Received
18 August 2025
Revised
1 October 2025
Accepted
16 November 2025
Published
December 2025

Keywords:
Eugenol;
Bio-additive;
Engine;
Pertamax

Abstract

Improving energy efficiency and reducing exhaust emissions from motor vehicles have become a primary focus in the transition towards green energy in the transportation sector. This study aims to analyze the effect of adding eugenol, the main compound in clove oil, to Pertamax Green fuel on engine performance, fuel consumption efficiency, and exhaust emissions in a 2018 Honda Vario 125 motorcycle. The research method is an experimental approach with variations in the fuel mixture of pure Pertamax Green (P0), Pertamax Green + 0.2% eugenol (P1), 0.5% eugenol (P2), and 1% eugenol (P3). Testing was conducted using a dynamometer to measure torque and power, a static method for fuel consumption, and a gas analyzer to analyze CO and HC emission levels. The results showed that adding eugenol generally improved engine torque and power. The P2 mixture (0.5% eugenol) produced the highest torque of 8.48 N.m at 5000 rpm and maximum power of 7.2 HP at 8000 rpm, an increase of 38% and 18%, respectively, compared to pure Pertamax Green. Fuel consumption efficiency also increased by 4.1% with the P2 mixture, while excessive eugenol (1%) decreased efficiency due to slower combustion. In terms of emissions, CO levels decreased by up to 16.7%, and HC levels reduced by up to 22.54% as the concentration of eugenol increased.

INTRODUCTION

The current environmental crisis is a daily reality, with increasing air pollution and greenhouse gas emissions threatening ecosystem sustainability and sustainable development (Irma & Gusmira, 2023). Efforts to improve energy efficiency and reduce exhaust emissions from motor vehicles are crucial issues in automotive engineering. Vehicle emissions also produce substances that are harmful to human health (Angga et al., 2024). Considering that the transportation sector is a major contributor to fossil fuel consumption and air pollution due to the high demand for mobility in Indonesia (Umah & Gusmira, 2024). Dependence on fossil fuels causes increasing carbon emissions, in addition to worsening pollution problems and its impact on the environment is increasingly massive (Pangestu & Ayuningsasi, 2024).

To address these environmental issues, Pertamina has innovated through Pertamax Green, which is a mixture of Pertamax and bioethanol. This type of fuel is superior to pure Pertamax in reducing pollution (Siregar et al., 2024). The use of bioethanol extracted in fuel is to increase the octane value of fuel (octane booster), this function is related to the improvement of vehicle engines (Susilo & Sabudin, 2018). Another function of bioethanol is as *oxygenating agent* because it contains oxygen so it can perfect combustion in the engine and has a positive impact in minimizing air pollution and can be used as *fuel extender* to save fossil fuels (Yudistirani et al., 2019).

✉ Corresponding author:
E-mail: kuatnurziam21@students.unnes.ac.id

This innovation is part of the green energy transition in the transportation sector and opens opportunities for automotive engineering students to research the impact of biofuels on engine performance, combustion efficiency, and exhaust emission reduction (Zola et al., 2023). The application of biofuels such as Pertamax Green offers further potential to improve combustion quality and reduce exhaust emissions (Abbas et al., 2024). The combustion process is crucial in determining the power output of a motorcycle (Wahyu et al., 2019). One promising approach is the addition of bio-additives, such as eugenol, which is the main compound in clove oil.

Clove oil (*Eugenia caryophyllata Tumb*.) is obtained through steam distillation of clove flowers or leaves (Bangngalino et al., 2022). The eugenol contained in this essential oil plays a crucial role in increasing the oxygen content in fuel, which can help improve combustion quality (Hadi et al., 2021). The high oxygen content in eugenol can significantly reduce exhaust emissions produced by vehicles (Kadarohman et al., 2010).

The above review is the basis for research related to the effect of adding eugenol bio-additives. on Pertamax Green on motor vehicle performance. A series of fuel mixture tests were applied to a 125 cc motorcycle to further analyze and obtain a comprehensive understanding of the impact of using Pertamax Green with eugenol concentration on vehicle performance including torque, power, and fuel consumption. In addition, exhaust emission testing was also conducted as a reference to obtain a better understanding of the impact of using a mixture of Pertamax Green and eugenol on its contribution to the development of more environmentally friendly fuels in the future.

MATERIALS AND METHOD

In this study, the research method was applied with an Experimental and quantitative approach, which was chosen because it has systematic, measurable, and objective characteristics in analyzing the relationship between variables. Because quantitative research methods are designed and commonly used in population-based research or certain samples (Sugiono, 2013). The study was conducted to analyze the effect of the use of Pertamax Green fuel concentrated with clove extract (Eugenol) on vehicle performance which includes torque and power parameters, fuel consumption efficiency, and exhaust emissions consisting of Carbon Monoxide (CO) and Hydrocarbon (HC) on the 2018 Honda Vario 125 vehicle. The specifications of this vehicle or fixed variables in the research being conducted can be seen in Table 1.

Table 1. 2018 Honda Vario 125 Specifications

Type	**Specification**
Engine Type	4-stroke, SOHC, eSP
Engine Capacity	124,8 cc
Diameter x Step	52.4 x 57,9 mm
Maximum Power	8.2 kW (11.1 PS) at 8,500 rpm
Maximum Torque	10.8 Nm (1.1 kgf.m) at 5,000 rpm
Fuel Supply System	PGM-FI (*Programmed Fuel Injection*)
System Starter	Electricity
Clutch System	*Automatic Centrifugal Clutch Dry Type*
Ignition System	*Full transistorized*
Battery Type	MF 12V-5 Ah
Lubricating Oil Capacity	0.8 liters at periodic replacement

This research was conducted through a series of systematic procedural stages, starting with the process of preparing the fuel variations that would be used in the test. The fuel used consisted of pure Pertamax Green RON 95 and Pertamax Green RON 95 that had been mixed with eugenol additives at various concentrations, the comparison of this trial was with a ratio of 1 ml to 1000 ml (or 1:1000). The variation in eugenol levels was designed to identify the effect of differences in the composition of the mixture when applied to vehicles through a series of tests that would be carried out. The variation in fuel concentration used can be reviewed in Table 2.

Table 2. Fuel variations

Mixture	**Pertamax Green (%)**	**Eugenol (%)**
P0	100	0
P1	99.8	0.2
P2	99.5	0.5
P3	99	1

After the fuel variation preparation process was complete, the next step was to conduct a series of tests on the vehicle's performance and emissions

characteristics. Torque and power tests were conducted using a dynamometer (*dyno test*), which functions to record and display torque and power data in graphical form. The dynamometer has the ability to measure power output, torque, and vehicle efficiency under appropriate loading conditions. Data collection was carried out in stages over an engine speed range of 2,000 to 9,000 RPM to obtain a comprehensive picture of engine performance under various operating conditions.

Next, fuel consumption tests were conducted to assess the energy efficiency of each fuel mixture used. Fuel consumption tests are essential for evaluating a vehicle's engine fuel efficiency and are a key measurement parameter in engine testing research (Xu, 2022). This test was conducted using a static method, namely when the engine reaches operating temperature (± 80°C) and operates at idle speed (± 1600 RPM) without external loading. The observed parameter was the time required for the engine to consume a fuel volume of 10 ml, which was measured using a measuring instrument, namely a burette. This can be seen in Figure 1 the motorbike testing using Vario 125 2018.

Figure 1. 2018 Vario 125cc motorcycle testing. (1) 2018 Honda Vario 125cc motorcycle (2) blower (3) measuring tank (burette) (4) display monitor dyno test (5) gas analyzer (6) chassis dynamometer (7) stopwatch (8) tachometer digital.

The next stage was exhaust emissions testing, which focuses on measuring the concentrations of carbon monoxide (CO) and hydrocarbons (HC) using a gas analyzer. This is because the oxygen content in the eugenol additive has the potential to significantly impact these two emission components.

RESULTS AND DISCUSSION

A series of tests were conducted to analyze the effect of adding eugenol to Pertamax Green fuel on vehicle performance, which includes torque, power, as well as fuel consumption and emission levels emitted by the 2018 Honda Vario 125 motorcycle. The fuel variations used in the test consisted of pure Pertamax Green (P0), Pertamax Green with the addition of eugenol of 0.2% (P1), Pertamax Green with the addition of eugenol of 0.5% (P2), and Pertamax Green with the addition of eugenol of 1% (P3). Can be reviewed in Figure 2, which is the variation of fuel used in the tests conducted.

Figure 2. Variations in fuel used.

Torque and Power Testing

Torque and power testing was carried out using*dyno test*. Data taken during testing starts from engine speed of 2000 RPM to 9000 RPM. The graph of the results of the torque test on the vehicle can be seen in Figure 3.

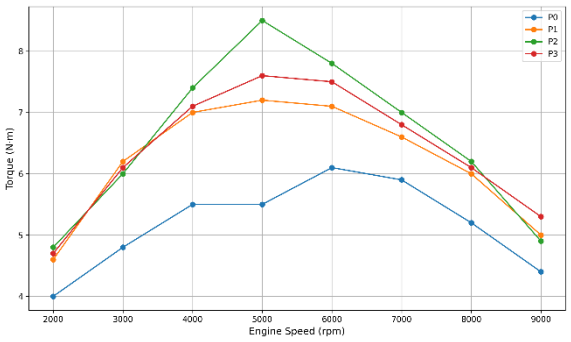

Figure 3. Test results of fuel variations on torque values at each rotation.

The test results show an increase in torque on the Honda Vario 125 engine with the addition of eugenol to Pertamax Green 95. The graph is the average result of 3 (three) tests of each fuel mixture

variation. Based on the data, the addition of eugenol generally increases the torque value compared to pure Pertamax Green 95, especially in the 3000–6000 RPM range. This is due to the oxygen content in eugenol which improves the combustion process, so that the piston thrust increases.

From Figure 4 it can be seen that the optimal torque value is achieved in the P2 mixture of 8.48 N.m at an engine speed of 5000 rpm, which indicates that the composition produces the most efficient combustion and maximum vehicle torque. In the P2 mixture or the addition of 0.2% eugenol, the most significant increase in torque is 38% when compared to P0 or Pertamax Green Murni. Then, there is a 23% increase in torque in the P1 mixture when compared to the use of P0. In addition, in the P3 mixture the increase in torque is also not too significant when compared to P0, which is only 23.1%, even decreasing compared to the use of the P2 mixture. This occurs due to combustion that is too fast (*pre-ignition*).

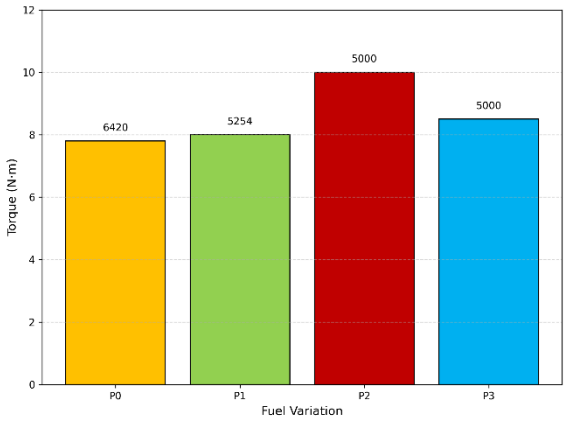

Figure 4. Maximum torque value when using various fuels.

The highest torque value in the test achieved on the P0 mixture is 7.81N.m at 6420 engine speed, then at P1 the torque value is 7.84 at 5254 engine speed and the highest torque value occurs at P3 at 9.85 at 5000 engine speed. At P3 the torque value drops by 8.17 at 5000 engine speed. After the torque test is carried out, then continue with a power test with the test result graph can be seen in Figure 5.

Using pure Pertamax Green, it only produces a peak power of 6.0 hp at 5,000 rpm. Power testing showed a similar pattern to torque, indicating that adding eugenol to pure Pertamax Green increases engine power.

Figure 5 shows that the most significant increase occurred in P2, which produced 7.2 HP at 8000 rpm, an increase of 18% compared to P0, which only produced 6.1 HP at maximum power. This indicates a more optimal combustion efficiency in the mixture. The P1 mixture also produced 6.9 HP, an increase of 13.1% compared to the maximum power produced by P0. Then, when using the P3 mixture, there was a 9% increase in power compared to the maximum torque of the P0 mixture. However, in the P3 mixture, the power produced tended to decrease compared to P2, indicating that the addition of excess additives caused less efficient combustion due to a non-ideal air-fuel mixture ratio.

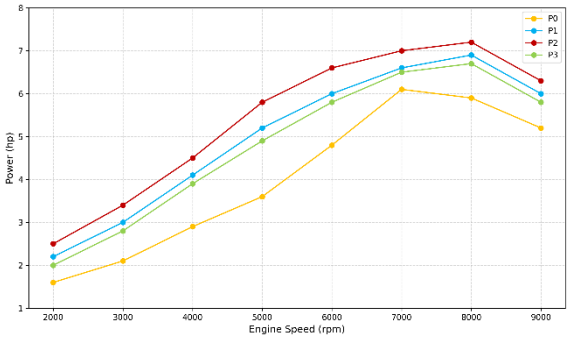

Figure 5. Test results of fuel variations on power values at each engine speed.

Thus, the addition of 0.5% eugenol has proven to be the most optimal in significantly increasing engine torque and power by increasing oxygen levels in the fuel without sacrificing combustion efficiency in the engine.

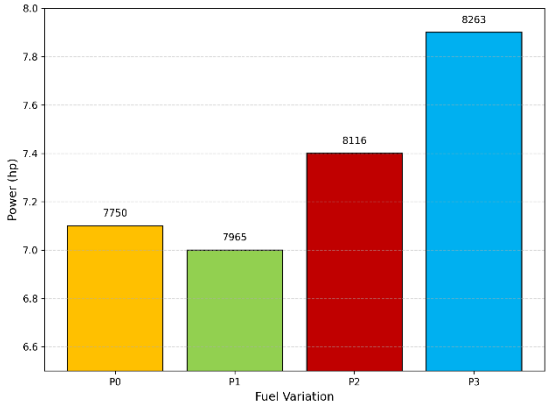

Figure 6. Maximum power value when using various fuels.

Figure 6 shows that the maximum power value achieved in the P0 mixture is 7.1 Hp at 7750

engine speed, then at P1 the torque value is 7.1 at 7965 engine speed. At P2 the power value is 7.3 at 8116 engine speed. and the highest power value occurs at P3 at 7.9 at 8263 engine speed.

Fuel Consumption Testing

Fuel consumption testing is carried out when the vehicle is at operating temperature and the vehicle is idling (1600 rpm) or the test is carried out statically. The formula for fuel consumption is shown in Eq. (1).

$$\text{Consumption} = \frac{10\ ml}{Average\ Time} \quad (1)$$

This equation calculates the average fuel flow rate or average fuel consumption in milliliters per unit of time. The results of the fuel consumption test can be seen in Figure 7.

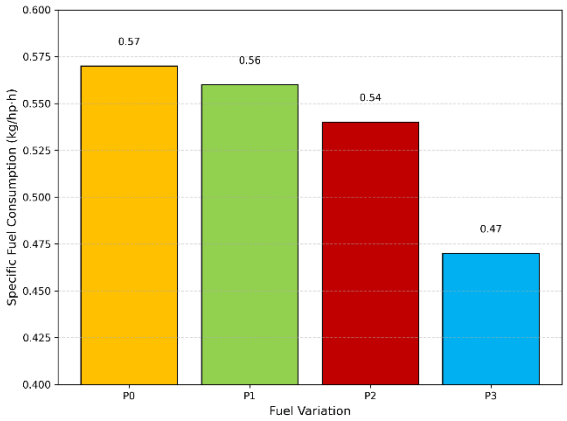

Figure 7. Fuel consumption test value.

Based on three tests, the average fuel consumption time for pure Pertamax Green (P0) is 0.57. There is an increase in fuel consumption time in the P1 mixture if averaged to 0.56 or increased by 1.4% compared to the use of P0. Then, there was an increase in fuel consumption time in the P2 mixture, namely if averaged at 0.54 or an increase of 4.1% compared to the use of P0. Meanwhile, there was a significant increase in fuel consumption time in the P3 mixture, which averaged 0.47 seconds, or an increase of 20.6% compared to P0.

The increase in fuel consumption time indicates that the addition of eugenol reduces fuel consumption, meaning the fuel burns more slowly and is used more efficiently by the engine. However, at high concentrations such as in the P3 mixture, combustion becomes too slow, resulting in a decrease in engine power potential. Therefore, the addition of eugenol up to 0.2% and 0.5% to Pertamax Green still has a positive effect on combustion efficiency, while an excess addition of 1% is feared to reduce performance due to the combustion speed being too low.

Exhaust Gas Emission Testing

Exhaust gas testing was conducted to measure the exhaust levels produced by vehicles when varying Pertamax Green fuel mixtures with eugenol concentrations were applied. This testing was conducted using a gas analyzer, and the exhaust emissions measured focused on CO and HC levels. The CO levels produced by the varying fuel mixtures can be seen in Figure 8.

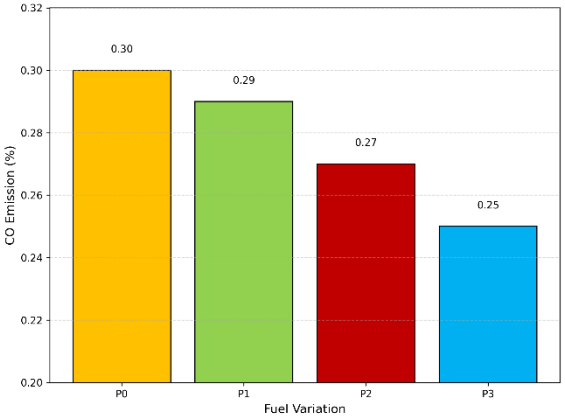

Figure 8. CO level test value.

The results of testing the levels of carbon monoxide (CO) gas emissions produced by the engine showed a decrease along with the increase in the concentration of eugenol in the fuel. The average CO level in pure Pertamax Green (P0) was 0.30%, while in P1 it decreased to 0.29% or a decrease of 3.3%. Then, in P2 or decreased by 10% with a CO level of 0.27% from the comparison P0. Also, in P3 a very significant decrease in CO levels to 0.25% with a percentage decrease of 16.7%. This decrease in CO levels indicates that the addition of eugenol improves the quality of the combustion process because the oxygen content in the chemical structure of eugenol helps the carbon oxidation process more perfectly, so that the formation of CO (Carbon Monoxide) can be suppressed. Thus, it can be concluded that the addition of eugenol is effective in reducing CO emission levels. Then, the HC (Hydrocarbon) levels produced by exhaust gas emissions when using Pertamax Green variations with eugenol concentrations can be seen in Figure 9.

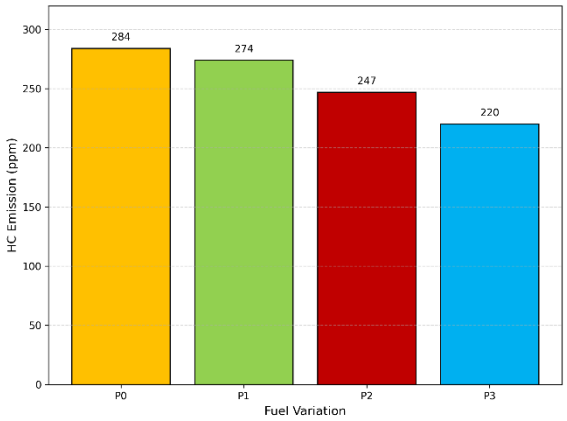

Figure 9. HC content test value.

It can be seen from Figure 9 that the HC level increases along with the increase in eugenol levels in the fuel. The average value of HC levels for P0 is 284 ppm, while for P1 it decreases to 274 ppm down 3.52%, P2 decreases more significantly to an average of 247 ppm down 13.03% compared to P0, and P3 decreases drastically with an average of 220 ppm down 22.54%. This decrease in HC levels shows that the addition of eugenol helps increase combustion efficiency because the oxygen content in the eugenol molecular structure improves the fuel oxidation process in the combustion chamber.

CONCLUSION

The use of eugenol extracted in Pertamax Green 95 fuel showed a positive impact on the performance of the 2018 Honda Vario 125 engine. The addition of eugenol to Pertamax Green generally increased engine torque and power compared to pure fuel (P0). The most optimal increase occurred in the P2 mixture (0.5%), which produced the highest torque of 8.48 N.m at 5000 RPM and maximum power of 7.2 HP, but at a higher eugenol concentration P3 (1%), performance decreased due to the non-ideal air-fuel mixture ratio. Furthermore, the addition of eugenol was shown to improve fuel efficiency. Average fuel consumption increased by 4.1% in P2 and 20.6% in P3, indicating more efficient combustion and reduced fuel consumption. However, in the 1% eugenol mixture (P3), combustion was too slow, thus underutilizing energy efficiency. In addition, emission test results show that the addition of eugenol reduces CO levels by up to 16.7% and HC by up to 22.4% compared to pure fuel. Overall, the addition of eugenol of 0.5% (P2) is the most ideal composition because it provides a significant increase in engine torque and power performance, better fuel consumption efficiency, and a significant reduction in exhaust gas emissions without causing negative effects on the combustion process.

REFERENCES

Abbas, A., Ady Saputra, A., Pahruzi, R., Kamal, M. 2024. Performance of the Turbocharged Engine Toyota Raize using Pertamax 92 and Pertamax Green 95. Jurnal Material dan Pross Manufaktur. 8(2): 120–126.

Angga, Roziqin, A., Rohman, A. K., Fatimah, S. 2024. Efektifitas Temperatur Aktivasi Arang Berbahan Tempurung Kelapa terhadap Kualitas Emisi Gas Buang Kendaraan. J-Protection: Journal of Scientific Studies and Mechanical Engineering Technology. 9(1): 66-71.

Bangngalino, H., Sukasri, A., Fathadillah, M. A., Suparman. 2022. Isolation of Eugenol from Steam Distilled Clove Oil. National Seminar on Research & Community Service. 190–195.

Hadi, I. M., Sintali, I. S., Dandakouta, H., Tokan, A. 2021. Performance Characteristics of Clove Oil, Eugenol and Eugenyl Acetate as Bio-Additives in a Single Cylinder Diesel Engine. Saudi Journal of Engineering and Technology. 6(8): 2415–6264.

Irma, M. F., Gusmira, E. 2023. Evaluation of Environmental Policy on Greenhouse Gas Emissions in Indonesia. Collaborative Journal of Science and Applied Sciences. 2(1): 12–18.

Kadarohman, A., Hernani, Khoerunisa, F., Astuti, R. M. 2010. A potential study on clove oil, eugenol and eugenyl acetate as diesel fuel bio-additives and their performance on one cylinder engine. Transport. 25(1): 66–76.

Pangestu, R. C. K., Ayuningsasi, A. A. K. 2024. The Effect of Energy Consumption in the Industrial, Household, and Transportation Sectors on Carbon Emissions in Indonesia. Initiative: Journal of Economics, Accounting and Management. 3(4): 297–311.

Umah, R., Gusmira, E. 2024. The Impact of Air Pollution on Public Health in Urban Areas.Profit: Journal of Management, Business and Accounting. 3(3): 103–112.

Siregar, J. J., Rahman, M. F., Baharrudin, R. 2024. Pertamax Quality Improvement with Ethanol on Octane Number, Density and Water Content. Proceeding International Conference on Religion, Science and Education. 3: 691–697.

Sugiono. 2013. Qualitative, and R&D Research Methods (19th ed.). Alphabet.

Susilo, S. H., Sabudin, A. M. 2018. The Effect of Bioethanol – Pertamax 92 Mixture on Otto Engine Performance. Journal of Energy and Manufacturing Technology. 1(2): 21–26.

Wahyu, M. A., Mufarida, N. A., Kosjoko, K. 2019. The Effect of Ethanol Addition Percentage to Pertalite Fuel on Power and Torque in 125 Cc Automatic Motorcycle Engines. J-Protection. 3(2): 15-28.

Xu, D. 2022. Test and Measurement Data Analysis of Fuel Consumption Measurement and Control System of Floating Ball Engine. Journal of Physics: Conference Series. 2264(1): 012026.

Yudistirani, S., Yudistirani, S. A., Mahmud, K. H., Ummay, F. A., Ramadhan, A. I. 2019. Analisa braket motor. Technology Journal. 11(1): 85–90.

Zola, G., Nugraheni, S. D., Rosiana, A. A., Pambudy, D. A., Agustanta, N. 2023. Electric vehicle innovation as an effort to improve environmental sustainability and encourage green economic growth in Indonesia. Resource and Environmental Economics. 11(3): 159–170.