Research Inventy: International Journal of Engineering And Science
Vol.15, Issue 5 (May 2025), PP 94-100
Issn (e): 2278-4721, Issn (p):2319-6483, www.researchinventy.com

Effect of Using Racing Ignition Coil on The Exhaust Emissions of Four Strokes Single Cylinder Engine

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Abstract:*The number of transportation continues to increase from year to year, inevitably increasing the amount of exhaust emissions produced and the fuel oil crisis. Various ways to reduce emission levels in vehicles by making modifications both to the engine, air intake system to the ignition system. In this study, one way to reduce emissions is by varying the coil ignition of the engine used. The purpose of this study was to determine the effect of using standard coil and racing ignition coil with fuel variations (pertalite, pertamax and pertamax turbo) on exhaust emissions. Tests were conducted on a 2015 vario 110 FI motorcycle with a compression ratio of 9,2:1 at 1500 rpm engine speed using a gas analyzer for exhaust emissions testing. The results showed that the highest carbon monoxide (CO) exhaust emissions were obtained using a standard coil fueled by pertamax turbo at 1,92%, while the lowest CO was obtained using a pertalite-fueled racing coil at 1,08%. The highest hydrocarbon (HC) exhaust gas emissions were obtained using a standard coil fueled with pertamax turbo at 889,67 ppm, while the lowest HC was obtained using a pertalite-fueled racing ignition coil at 313,00 ppm. The highest carbon dioxide (CO2) content was obtained using a standard pertalite-fueled coil of 13,25% while the lowest CO2 was obtained using a firstx turbo-fueled racing coil of 10,78%.*

Keywords:*Ignition coil, fuel, exhaust gas emission, compression ratio.*

Date of Submission: 09-05-2025 Date of Acceptance: 22-05-2025

I. INTRODUCTION

The population of Indonesia is increasing from year to year, resulting in increasing community needs in various sectors, one of which is the transportation sector. According to data from the National Police, (2023) the number of transportation in the province of NTB reached 2,184,145 units in 2023. The high rate of transportation growth on the one hand can encourage economic growth on the other hand can have environmental impacts such as the depletion of non-renewable fossil fuels and environmental pollution (Syaief, et al., 2019). Environmental pollution as one of the causes of global warming has become an important issue throughout the world, including Indonesia. The increasing population, economic activity, and transportation are increasing environmental pollution every day (Sriyanto, 2018). Air pollution is a topic of discussion, discussion, and research throughout the world. Air pollution is the contamination of indoor and outdoor air by gases or solids that change the natural characteristics of the air (WHO, 2023).Air pollution can come from natural processes (volcanic activity, oceans, forests, etc.) and from human activities (combustion of fossil fuels, transportation, power plant emissions or emissions from other industrial processes) (Ramírez, 2012). The Ministry of Energy and Mineral Resources said that the level of emissions produced by transportation reached 60% (Nasution, 2023). Motor vehicle exhaust emissions contain various chemical compounds such as CO, HC, CO_2, and NOx. Some of the combustion gases in certain concentrations can cause death (Mara, et al., 2019).

The number of transportation that continues to increase from year to year, cannot avoid the increase in the amount of exhaust emissions produced and the fuel crisis. This should be handled with serious and continuous restriction and control efforts. One way to emphasize the reduction of exhaust emissions is the existence of government regulations regarding the obligation for motorized vehicles to carry out emission tests at least once a year in accordance with Article 206 of Government Regulation (PP) Number 22 of 2021 concerning the implementation of environmental protection and management (BPK RI, 2021).

Based on article 2 paragraph 2 of the Regulation of the Minister of Environment and Forestry Number 8 of 2023, it states that all categories of motorized vehicles and have entered a service life of more than 3 years must meet emission quality standards. In addition, article 4 paragraph 1 states that everyone who operates a motorized vehicle must attach the results of an emission test as an administrative requirement for paying motor vehicle tax, which means that the requirement to extend the vehicle tax must attach the results of an emission test. The quality standard for motorized vehicles with the category of motorcycles manufactured before 2010 has a test parameter of CO 5.5% and HC 2200 ppm with the idle test method, manufactured 2010-2016 has a test parameter of CO 4% and HC 1800 ppm, and manufactured> 2016 has a test parameter of CO 3% and HC 1000 ppm with the idle test method (PERMEN LHK, 2023). The only region that has implemented this regulation is DKI Jakarta province, because DKI Jakarta is recorded as the city with the third worst pollution level in the world (Mara, et al., 2022). However, it is possible that this regulation will be implemented nationally in the future.Various ways to reduce the level of exhaust emissions in vehicles by making modifications to the engine, air induction system, fuel system and ignition system for the combustion process (Firmansyah, et al., 2023).

The ignition system consists of a battery, ignition switch, ignition coil, high-voltage cable, and spark plug. In order for the fuel mixture to burn perfectly, an ignition system mechanism is needed that is able to serve the needs of the engine at every engine speed continuously. A strong and accurate ignition system will be able to burn the fuel mixture perfectly and precisely at the time needed so as to produce optimal engine power output with efficient (economical) fuel use, and allow low exhaust emissions (Ardana, 2018). The coil is an ignition component that determines whether combustion is good or not. Exhaust emissions from motor vehicles can be caused by fuel and air that are not mixed properly, incomplete combustion of gasoline, and a damaged ignition system (Mikenda, et al., 2023). Fuel is a material that can burn and release energy. Fuel contains heat energy that can be released if oxidized or burned (Hendrawan, 2023).

Mikenda, et al., (2023) have studied "The Effect of Using Racing Coils on Exhaust Emissions and Fuel Consumption on Four-Stroke Motorcycles". This study uses an experimental method using KTC racing coils and iridium spark plugs. The engine speed variations used were 2000 rpm, 4000 rpm, and 6000 rpm for fuel consumption tests while for exhaust emission tests at idle. The results of this study produced CO emission gas of 1.25% (standard coil) and 0.50% (racing coil), HC gas of 237.6 ppm (standard coil) and 179.3 ppm (racing coil) and for fuel consumption, racing coils can reduce fuel consumption by up to 24.93% at 2000 rpm engine speed. The results of Putra & Nasir's research, (2019) on "Comparative Study of Variations in the Use of Racing Coils and Iridium Spark Plugs on Gasoline Motorcycles". The engine speed variations used were 1500 rpm, 2000 rpm, 2500 rpm, and 3000 rpm and using a Bluthander coil. The results of this study, the use of standard coils and standard spark plugs showed the highest levels of carbon monoxide and hydrocarbon exhaust emissions, namely at 1500 rpm the CO content was 2.075% and HC 646.5 ppm, at 2000 rpm the CO content was 2.95% and HC 446.5 ppm, at 2500 rpm the CO content was 4.215% and HC 528 ppm, at 3000 rpm the CO content was 4.655% and HC 763.5 ppm. Meanwhile, the use of Bluthander racing coils and iridium spark plugs, namely the highest CO and HC levels at 1500 engine speeds, the CO content is 1.83%, and HC is 856 ppm, at 2000 engine speeds the CO content is 1.655%, and HC is 284 ppm, at 2500 engine speeds the CO content is 0.715% and HC is 472 ppm, and at 3000 speeds the CO content is 0.810%, and HC is 393.5 ppm.

II. EXPERIMENTAL PROCEDURE

This study is an experimental study with a test tool scheme as shown in Figure 1. In this study using coil variations (standard coil from Honda Vario 110 and BRT racing coil) with fuel variations (Pertalite, Pertamax and Pertamax Turbo) on exhaust emissions and fuel consumption. Testing was carried out on a 2015 Vario 110 FI motorbike with a compression ratio of 9.2: 1 at 1500 rpm engine speed, using a gas analyzer for exhaust emission testing (HC, CO, and CO_2).Digital scales and stopwatches are used as fuel consumption measuring tools by weighing the initial weight and final weight of the fuel tank with a fuel consumption test time of 10 minutes.

Figure 1. Schematic of testing equipment. 1. Honda Vario 110 FI, 2. Gas analyzer, 3. Fuel tank, 4. Digital scale, 5. Ignition coil.

The primary and secondary resistance values affect the amount of voltage that can be generated by the coil. The smaller the primary resistance, and combined with large secondary resistance produces a large voltage. The function of the coil resistance is to control electric current, stabilize voltage, prevent overvoltage, regulate coil voltage. The following shows the characteristics of the two ignition coils used in this study.

Table 1 Comparison specifications of standard ignition coils and racing ignition coils.

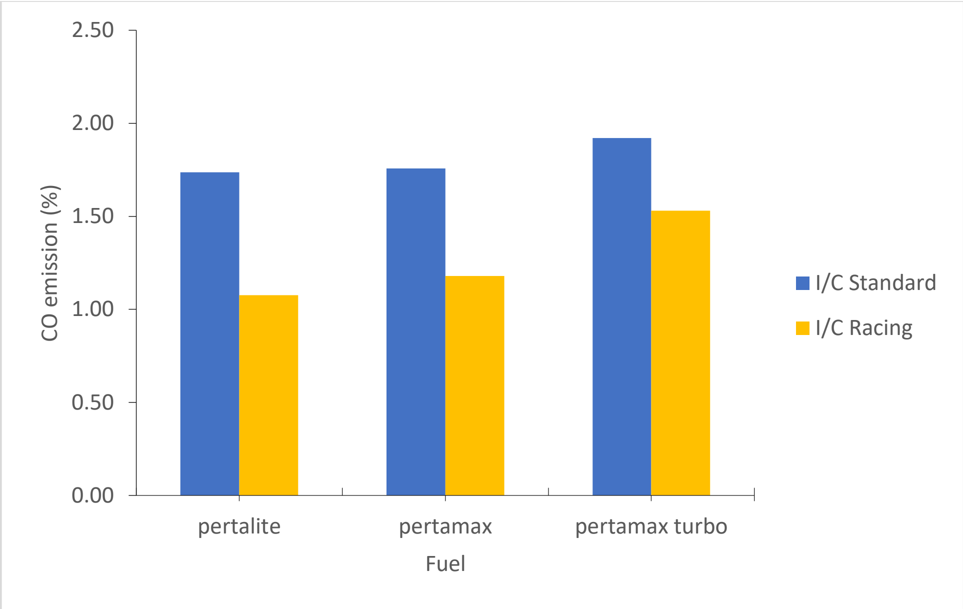
No	Description	Coil standard Vario 110 FI	Coil racing BRT
1.	Coil resistance	Primer 2,4 Ω, sekunder 9,37 KΩ	Primer 1,1 Ω, sekunder 10,02 KΩ
2.	Peak voltage	86,8 Volt	126,3 Volt

III. RESULTS AND DISCUSSIONS

From the results of the research conducted, the data obtained for the racing ignition coil specifications are different from the standard ignition coil specifications. The racing coil is capable of producing a peak voltage of 126.3 volts, while the standard coil produces a peak voltage of 86.8 volts, then a discussion is carried out on the exhaust emissions emitted by the engine.

3.1. Exhaust gas emission Carbon monoxide (CO

Figure 2. Comparison of CO exhaust emissions produced by standard coils and racing coils at 1500 rpm.



The level of CO emissions produced differs for each fuel variation, carbon monoxide produced from the combustion of pertalite fuel is lower than pertamax or pertamax turbo fuel, this is because vehicles that use fuel with an octane value that matches the compression ratio of the motor can create more optimal combustion. Supriyanto, et al., (2018) in their research using pertalite fuel produced carbon monoxide exhaust emissions of 0.14% lower than pertamax 0.24% and pertamax turbo 0.17%. In this study, using a racing coil can reduce the level of carbon monoxide exhaust emissions compared to using a standard coil because the racing coil produces a higher voltage than the standard coil, which can increase the performance of the combustion process in the combustion chamber. This is in line with the research of Mikenda, et al., (2023) which states that racing coils can reduce CO exhaust emissions by up to 60%.

The amount of CO gas emitted by a vehicle engine is influenced by the ratio between air and fuel sucked by the engine into the combustion chamber. When the mixture is rich (lack of air) CO exhaust emissions will tend to increase because the atoms from the fuel are not bound by oxygen atoms and turn into carbon monoxide. In Figure 2. above, the standard ignition coil produces CO exhaust emissions of 1.74% pertalite, 1.76% pertamax, and 1.92% pertamax turbo. While the racing ignition coil produces CO exhaust emissions of 1.08% pertalite, 1.18% pertamax, and 1.53% pertamax turbo. The highest CO content is obtained using the standard pertamax turbo fuel coil, which is 1.92%. However, this is still below the emission standard threshold set by the Regulation of the Minister of Environment and Forestry 2023, namely for two-wheeled vehicles with an idle parameter test method for CO gas of 4%.

The amount of CO gas emitted by a vehicle engine is influenced by the ratio of air to fuel sucked by the engine into the combustion chamber. When the mixture is rich (lack of air) CO exhaust emissions will tend to increase because the atoms from the fuel are not bound by oxygen atoms and turn into carbon monoxide (Syaief, et al., 2019).

3.2. Exhaust gas emission Unburn Hidrokarbon (HC)

Figure 3. Comparison of HC exhaust emissions produced by standard ignition coil and racing ignition coil at 1500 rpm.

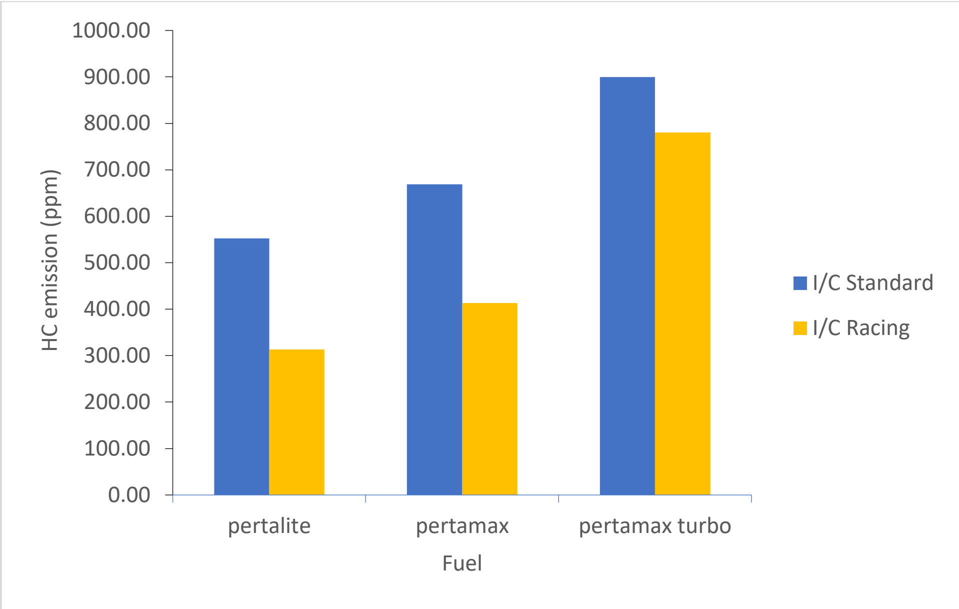


Figure 3. shows the relationship between fuel and hydrocarbon exhaust emissions in this study showing that the lowest HC exhaust gas was obtained using fuel with the lowest octane number, in line with research by Supriyanto, et al., (2018) in their study produced lower HC exhaust gas from pertalite fuel than pertamax and pertamax turbo. This is because the fuel mixture in the combustion chamber does not burn completely or fuel with a higher octane value than the engine compression value will be difficult to burn all so that it is still released in the form of hydrocarbons along with the remaining combustion gas. It can be seen in Figure 3. above that the use of a racing ignition coil can reduce HC exhaust emissions because it produces higher ignition than a standard ignition coil so that the combustion process occurs better, making more fuel mixture burned so that HC exhaust gas decreases. In addition, the lowest HC exhaust gas was obtained using a racing ignition coil with pertalite fuel, namely 313.00 ppm. Meanwhile, the highest HC exhaust gas was obtained using the standard Pertamax Turbo fuel ignition coil, which was 899.67 ppm. Referring to the Regulation of the Minister of Environment and Forestry 2023, the results of this study showed that HC exhaust gas was still below the standard emission quality standard for HC, which was 1800 ppm. This was also found in the research results of Mikenda et al., (2023) who explained in their research that racing ignition coils can reduce HC exhaust gas by 24.53% because the voltage ratio of the racing ignition coil is greater than the standard ignition coil, which makes the sparks bigger and makes combustion more optimal.

Racing ignition coils produce lower hydrocarbon (HC) exhaust emissions than standard coils because the ignition system is more efficient and produces more perfect combustion. This is because racing coils usually have a higher secondary voltage, compared to standard coils. Higher voltages produce stronger sparks, so that the fuel and air mixture burns more perfectly. With stronger sparks, fuel burns more optimally, reducing unburned fuel residue which contributes to reduced HC emissions.

3.3. Exhaust Emissions Carbon dioxide (CO2)

Figure 4. Comparison of CO2 exhaust emissions produced by standard ignition coil and racing ignition coil at engine speed 1500 rpm.

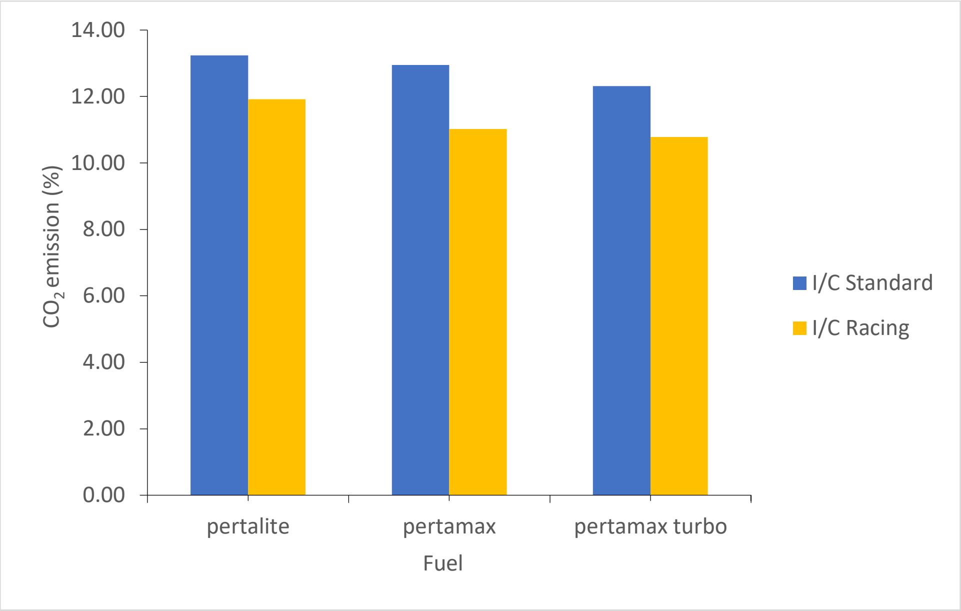


Figure 4. shows the relationship between fuel and CO_2 content showing changes in CO_2 emission levels in the use of racing ignition coil and standard ignition coil with fuel variations. Racing ignition coil has lower CO_2 than standard coils, this can happen because the combustion of racing coils produces larger sparks for more even combustion and has a higher 02 content than standard coils. This study is in line with Ardana, (2018) racing coils produce lower CO_2 than standard coils. Carbon dioxide will be inversely proportional to HC and CO exhaust emissions, which means that the higher the CO_2 content, the lower the HC and CO emissions formed, this condition shows that less fuel is wasted. In this study, the CO_2 content using standard coils with pertalite fuel was 13.23%, pertamax was 12.95%, and pertamax turbo was 12.32%. While the CO_2 content using racing coils with pertalite fuel was 11.91%, pertamax was 11.03%, and pertamax turbo was 10.78%.

Racing ignition coils have a higher secondary voltage, which produces a stronger and more stable spark. A stronger spark allows for more complete fuel combustion, reducing the amount of unburned carbon that can contribute to the formation of CO_2 exhaust emissions. With more complete combustion, more carbon in the fuel reacts directly with oxygen to form CO_2 in optimal amounts, without producing excess carbon monoxide (CO). Standard ignition coils often produce less efficient combustion, resulting in more CO that then reacts further to form CO_2, increasing total carbon emissions. With an improved ignition system, racing ignition coils not only improve engine performance but also contribute to overall carbon emission reductions.

Although the octane number of pertalite fuel is lower, its chemical properties and combustion efficiency cause higher CO_2 production compared to higher octane fuels such as pertamax and pertamax turbo. In addition, pertamax and pertamax turbo fuels contain cleaning additives and combustion efficiency enhancers, which help optimize chemical reactions in the combustion chamber. With cleaner combustion, the amount of CO_2 produced is lower compared to pertalite.

IV. CONCLUSION

From the discussion on the effect of standard ignition coil and racing ignition coil with fuel variation on exhaust emissions and fuel consumption using Honda Vario 110 FI 2015, it can be concluded that the use of standard ignition coil and racing ignition coil with fuel variation affects the exhaust emissions produced. The lowest CO exhaust emissions were obtained in the use of racing ignition coil pertalite fuel with a value of 1.08%. The highest CO exhaust emissions were in the standard coil with a value of 1.92% pertamax turbo fuel. Likewise, the lowest HC exhaust emissions were obtained in the use of racing ignition coil with pertalite fuel with a value of 313.00 ppm. And the highest CO2 exhaust emissions were in the standard ignition coil with a value of 13.23% pertalite fuel, while the lowest CO2 exhaust emissions were in the racing ignition coil pertamax turbo fuel with a value of 10.78%.

Conflict of interest
There is no conflict to disclose.

ACKNOWLEDGEMENT
The author would like to thank the Department of Mechanical Engineering, Faculty of Engineering, University of Mataram for the support of the facilities provided. Thanks are also expressed to colleagues who have contributed to the completion of this paper.

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