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The effect of magnetic fields on exhaust emissions and fuel consumption of a 125 cc four-stroke single-cylinder engine running on ethanol-gasoline blends

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ABSTRACT: *In line with population growth, technological developments and the increase of vehicles, the need for fuel is increased. Therefore, many people try to find an alternative fuel such as ethanol as an alternative fuel. This study aims to determine the effect of magnetic field on fuel ethanol-gasoline blends on exhaust gas emissions and fuel consumption. In this study, gasoline was blended with alcohol ranging from 10% to 40% by volume (E0, E10, E20, E30 and E40) and the magnet was placed at the fuel line. Next, the exhaust gas emission levels were observed using an exhaust gas analyzer.The application of a magnetic field in the fuel line can significantly reduce CO and HC exhaust emissions as well as fuel consumption. Specifically, using E30 fuel with magnets resulted in a 15.46% decrease in CO emissions and a 44.30% decrease in HC emissions compared to E0 fuel without magnets. Additionally, fuel consumption was reduced by 48% when using E40 fuel with magnets, compared to E0 fuel without magnets.*

Keywords:*Gasoline,ethanol, exhaust emission, fuel consumption.*

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I. INTRODUCTION

The increasing number of motorcycles in Indonesia has led to a rise in exhaust emissions, which are highly dangerous for human health. Vehicles that run on gasoline and diesel fuel emit various harmful substances, including carbon monoxide (CO), hydrocarbons (HC), carbon dioxide (CO_2), sulfur oxides (SO_x), lead (Pb), and nitrogen oxides (NO_x). Additionally, the reliance on fossil fuels for these vehicles contributes to the depletion of petroleum supplies (Brimasta and Sutjahjo, 2013).

Ethanol is a high-octane fuel that can be used as an octane enhancer in gasoline (Sarjono and Putra, 2013). Because ethanol contains oxygen, it improves fuel combustion, which has the positive effect of minimizing air pollution (Mara and Nuarsa, 2024). Research by Winarno (2011) explained that adding ethanol to petrol not only enhances the performance of petrol motorbikes but also reduces emissions from motorbikes (Putra et al., 2020). The addition of ethanol leads to more complete combustion, reducing carbon monoxide (CO) emissions and increasing carbon dioxide (CO_2) emissions (Agrariksa et al., 2013).

Moreover, to improve engine performance on gasoline motorcycle using alternative fuels, it is necessary to modify several parts or systems (Mara and Nuarsa, 2024). Various methods have been employed to create tools that can save fuel and produce excellent exhaust emissions, thereby minimizing air pollution. One effective approach is to treat the fuel before it enters the combustion chamber or undergoes the combustion process. This can be achieved by applying a magnetic field (electromagnet), which utilizes a fairly simple coil (Suyatno, 2011).

II. MATERIAL AND METHODS

Research methods are the steps taken by researchers to collect information or data for analysis. This research employs both experimental methods and literature studies. The materials under investigation include gasoline and 95% ethanol, with blend variations of 0%, 10%, 20%, 30%, and 40% by volume and the present of magnetic field on fuel line. The parameters observed in this study are fuel consumption and exhaust emissions, including HC, CO, O_2, and CO_2. The schematic of the testing equipment is shown in Figure 1 below.

Figure 1. Testing equipment schematic. 1. Motorcycle, 2. Exhaust gas analyzer, 3. Digital-spring scala, 4. Fuel tank, 5. Fuel line with magnet

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III. RESULTS

Data from the research results will be analysed using appropriate equations, presented in table form, and plotted in graphs. Next, we will analyze the influence of ethanol content parameters in gasoline fuel and the effect of magnetic field on fuel line on exhaust emissions, which were observed using a gas analyzer. Table 1 below shows the exhaust gas emission data.

Table 1 Exhaust gas emission data

Fuel blends	Exhaust emission without magnet				Exhaust emission with magnet			
	CO(%)	HC(ppm)	CO_2 (%)	O_2(%)	CO (%)	HC(ppm)	CO_2(%)	O_2(%)
E0	0.97	801.33	15.20	1.64	0.82	645.33	15.47	1.33
E10	0.96	636.33	15.43	1.41	0.83	610.33	15.63	1.42
E20	0.88	673.33	15.50	1.51	0.82	546.33	15.67	1.18
E30	0.89	574.00	15.67	1.41	0.82	446.33	15.77	1.18
E40	0.92	532.00	15.50	1.21	0.82	514.67	15.90	1.44

In Table 1 above, the CO exhaust gas emission data varies depending on the ethanol content in the gasoline fuel. The lowest CO emissions, at 0.88%, were observed in gasoline with 20% ethanol content, while the highest CO levels were emitted from pure gasoline (0% ethanol). Meanwhile, unburned hydrocarbon (HC) exhaust emissions tend to decrease as the ethanol content in the gasoline increases. Additionally, the presence of a magnetic field in the fuel line generally reduces exhaust emissions. Specifically, CO emissions decreased to 0.82%, and the lowest HC emissions, at 446.33 ppm, were recorded in gasoline with 30% ethanol content (E30).

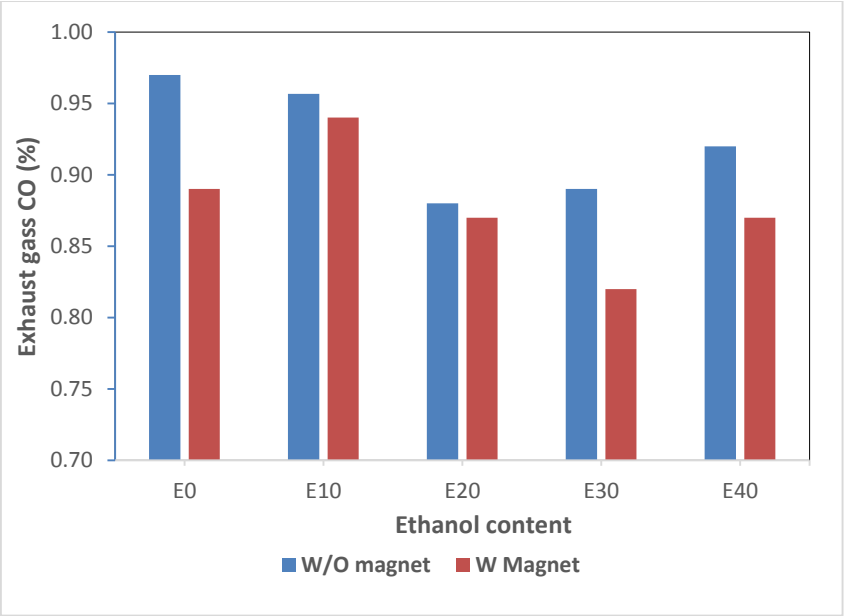

Figure 2. Exhaust gas emissions CO

In Figure 2, it can be seen that the lowest CO emissions, at 0.82%, were observed in E30 fuel using magnets. This represents a 15.46% reduction in CO emissions compared to the highest CO emissions of 0.97% when using E0 fuel (pure gasoline). Research by Suhartoyo (2021) and Nugraha (2022) explains that the oxygen contained in ethanol helps the combustion process occur more completely in the vehicle's combustion chamber, thereby reducing CO levels in exhaust emissions. Ethanol contains oxygen, and when mixed with gasoline, it increases the oxygen levels in the fuel mixture. Higher oxygen levels allow for better and more complete combustion, reducing CO emissions.

Gasoline fuel blend with ethanol can reduce carbon monoxide (CO) emissions in motor vehicles. However, if too much ethanol is used E30 and E40 tend to increase level of CO emission. Ethanol has different combustion characteristics than fossil fuels. If the ethanol mixture is too high, combustion may be less complete, producing more CO. This can reduce the quality of the fuel combustion process. Apart from that, it also allows the air and fuel ratio to become leaner or have excess air, emitting higher CO exhaust emissions.

The effect of adding magnets is explained in research (Suyatno, 2011) that the reduction in CO emission levels when using magnets is due to the hydrogen and carbon bonds in the fuel being loosened so that combustion produces low levels of CO gas due to the efficient mixture of air and fuel. With this process, combustion in the vehicle can take place more perfectly.Magnetic fields on the fuel line can affect fuel molecules, making them more likely to mix with oxygen. This increases combustion efficiency, so more fuel burns completely and produces less CO. Magnetic fields can help in improving the optimum air-fuel ratio, which is essential for better combustion. With a better A/F ratio, combustion becomes more complete, resulting in less CO emissions.

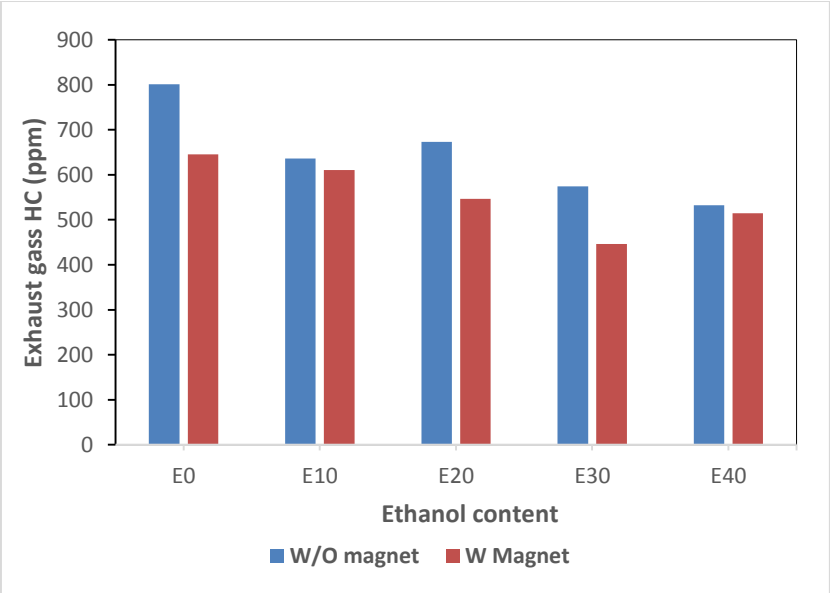

Figure 3. Exhaust gas emissions HC

From Figure 3, it can be seen that the lowest Hydrocarbon (HC) emissions are 446.33 ppm, representing a 44.30% reduction in HC emission levels when using E30 fuel with the addition of magnets to the fuel line. This is compared to the highest HC emissions of 801.33 ppm when using E0 fuel without adding a magnet to the fuel line. Research (Suhartoyo, 2021) explains that by adding ethanol to the fuel, oxygen is introduced, leading to more complete combustion and reduced HC gas emissions. This process allows combustion in the combustion chamber to occur more efficiently.

The addition of ethanol content in gasoline tends to reduce HC exhaust emissions. This is because ethanol contains oxygen, and when mixed with gasoline fuel, the oxygen level in the fuel mixture increases. Higher oxygen levels enable better and more complete combustion thereby reducing HC emissions.The effect of adding magnets is explained in research (Nugraha, 2022) that the decrease in HC emission levels when adding magnets is due to the hydrogen and carbon bonds in the fuel being loosened so that the O_2 (oxygen) element can enter the fuel compound. With this process, combustion in the combustion chamber can take place more perfectly.

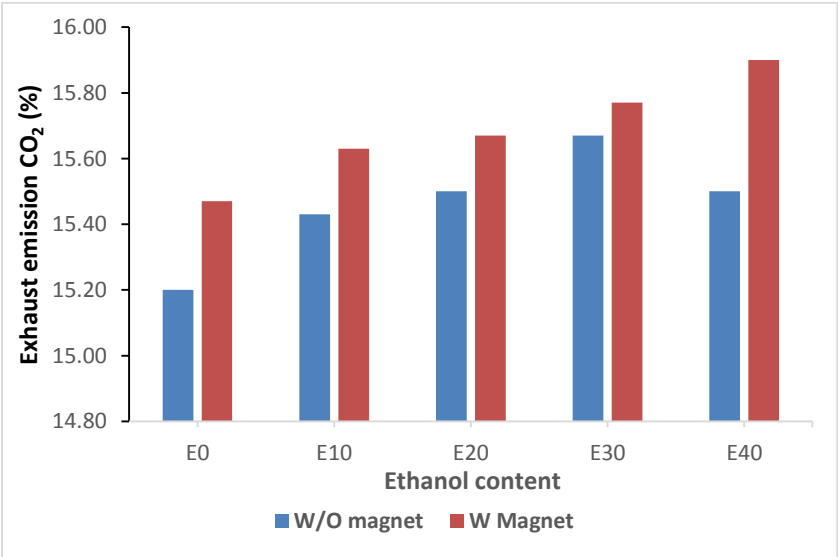

Figure 4. Exhaust gas emissions CO_2

From Figure 4, it is evident that the lowest CO_2 emissions, at 15.20%, represent a 4.40% reduction in CO_2 levels when using E0 fuel compared to the highest CO_2 emissions of 15.90% observed with E40 fuel and the addition of magnets to the fuel line. The oxygen content in ethanol plays a crucial role in the combustion

process by increasing the amount of oxygen available, which helps the fuel burn more completely, leading to higher CO_2 emissions.

The addition of a magnetic field to the fuel line shows a tendency to increase CO2 exhaust gas. This occurs because the combustion process that occurs is better in fuels affected by magnetic fields compared to fuels that are not affected by magnetic fields.Magnetic fields can affect fuel molecules, making them more likely to mix with oxygen. The better the mixing process of fuel with oxygen will increase combustion efficiency, so that more carbon in the fuel is converted into carbon dioxide (CO_2).Research by Nur and Pratiriwi(2022) explains that CO_2 content in vehicle exhaust gas is a result of complete combustion in the combustion chamber. Higher CO_2 levels indicate more complete combustion, which correlates with lower HC and CO emissions. This means that higher CO_2 levels signify less wasted fuel, as it burns more completely in the vehicle's combustion chamber.

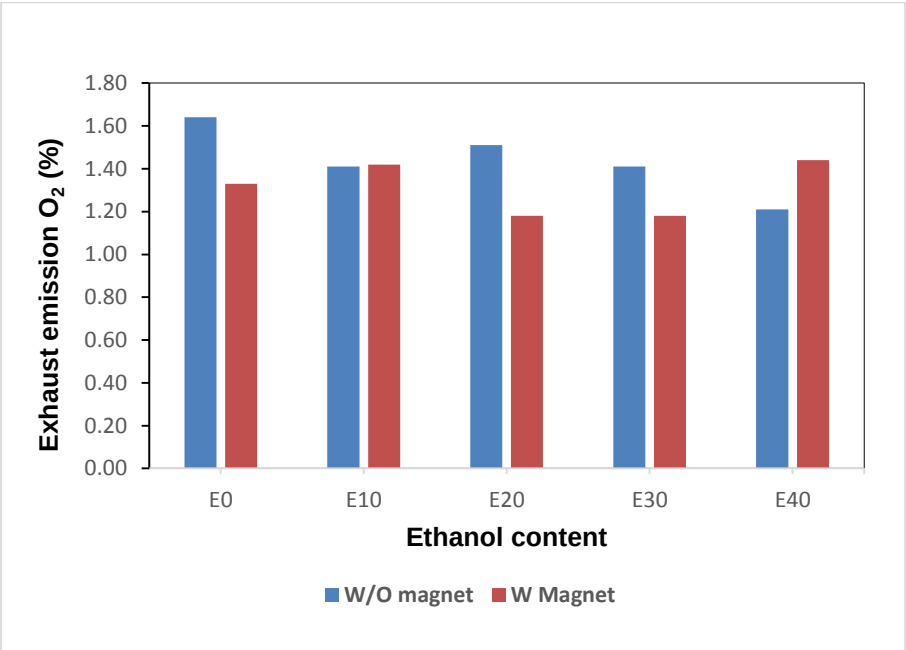

Figure 5. Exhaust gas emissions O_2

From Figure 5, showed that the lowest O_2 emission level is 1.18%, representing a 28.04% reduction in O_2 emissions when using E30 fuel with the addition of magnets to the fuel line. This is compared to the highest O_2 emissions of 1.64% when using E0 fuel without adding a magnet to the fuel line. Research by Nugraheni (2017) explains that the use of ethanol can reduce O_2 emissions because ethanol contains oxygen, which helps achieve more complete combustion in the combustion chamber. Additionally, research by Nugraha (2022) indicates that the addition of magnets can decrease O_2 emissions by weakening the attractive energy between hydrocarbon molecules, making the amount of oxygen captured during the oxidation process more ideal.Research (Nugraha, 2022)explains that the addition of magnets can cause a decrease in O_2 because magnets can weaken the attractive energy between hydrocarbon molecules, so that during the oxidation process the amount of oxygen captured by the hydrocarbon molecules is more ideal.

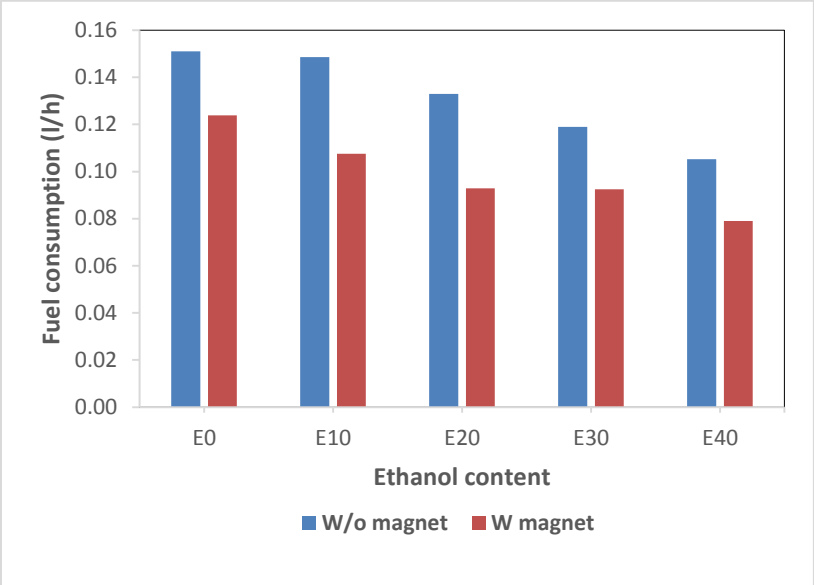

Figure 6. Fuel consumption

From Figure 6, it is evident that the lowest fuel consumption was 0.08 L/hour, representing a 48% reduction in fuel consumption when using E40 fuel with the addition of magnets to the fuel line. This is compared to the highest fuel consumption of 0.15 L/hour observed with E0 fuel without the addition of magnets. According to Rifal (2018), ethanol contains a higher oxygen content, specifically 34.78%. This increased oxygen content facilitates more complete combustion within the combustion chamber, allowing a smaller quantity of fuel to generate sufficient power to drive the motor mechanism. Additionally, Ilman (2017) found that the application of magnets reduces fuel consumption by making the fuel more reactive. The magnetic field influences the fuel molecules, enhancing their ability to bind with oxygen and thus burn more efficiently. The magnetization process alters the molecular structure of the fuel, breaking it into smaller bonds, which promotes easier and more complete combustion. Consequently, this process enables the engine to consume less fuel while maintaining the same power output.

The addition of magnets has an effect on reducing fuel consumption because the magnetic field can cause the fuel to be affected or become more reactive to bind oxygen so that it is more flammable (12). This is because the size of the fuel molecule structure changes into a smaller bond due to magnetization. This smaller molecule size will directly result in an easier combustion process in the combustion chamber. In other words, the magnetization process in the fuel will make combustion more perfect so that the engine consumes less fuel to produce the same power.

IV. DISCUSSION AND CONCLUSION

Based on the results of the research that has been carried out, several conclusions can be drawn as follows.

The magnetic field in the fuel line can reduce CO and HC exhaust emissions and can reduce fuel consumption. The lowest CO emissions occurred in E30 fuel using magnets of 15.46% decrease in CO emissions compared to the highest CO emissions of 0.97% when using E0 fuel without adding magnets to the fuel line. The lowest Hydrocarbon or HC emissions were 446.33 ppm or there was a decrease in HC emissions of 44.30% using E30 fuel with the addition of magnets to the fuel line compared to the highest HC emissions of 801.33 ppm when using E0 fuel without adding magnets to the fuel line. The lowest fuel consumption was 0.08 L/hour or there was a decrease of 48% in E40 fuel with the addition of magnets to the fuel line compared to the highest fuel consumption of 0.15 L/hour when using E0 fuel without adding magnets.

Conflict of interest

There is no conflict to disclose.

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