Jurnal Polimesin
Department of Mechanical Engineering
State Polytechnic of Lhokseumawe
http://e-jurnal.pnl.ac.id/polimesin

e-ISSN	: 2549-1999	No.	: 5	Month	: October
p-ISSN	: 1693-5462	Volume	: 23	Year	: 2025

Processing dates: received on 2025-6-23, reviewed on 2025-08-22, accepted on 2025-09-14 and online availability on 2025-10-30

The effect of electromagnet variation in the fuel line on engine performance and exhaust gas emissions

Indra Swastika*, Faris Humami
Teknologi Rekayasa Otomotif, Politeknik Keselamatan Transportasi Jalan, Kota Tegal 52125, Indonesia
*Corresponding author: 21021019@taruna.pktj.ac.id

Abstract

Improving combustion efficiency and reducing exhaust emissions remain key challenges in motorcycle engine development. This study experimentally evaluates the performance of an electromagnetic device using rubber and iron core materials, applied to both carburetor-based and fuel injection 125 cc motorcycle engines. The electromagnet was installed along the fuel line to enhance fuel ionization before combustion. The tests were conducted to measure engine power, torque, and exhaust emissions under both configurations. The results show that the electromagnet with an iron core significantly improved engine performance. In the carburetor system, power increased by 0.391 HP, from 9.929 HP to 10.320 HP with the torque reached 10.042 Nm. In the injection system, power rose to 9.894 HP and torque increased by 0.449 Nm to 10.234 Nm. Emission analysis revealed notable reductions of CO levels to 3.09% and HC to 1655 ppm in the carburetor engine, while in the injection engine, CO dropped to 1.32% and HC to 356 ppm. The electromagnet has the potential to be an effective solution in improving performance and reducing emissions. By helping ionize molecules before combustion led to improving fuel-air mixing which in turn increases engine performance and reduces emissions.

Keywords:
Motorcycle, power, torque, exhaust emissions, electromagnet.

1 Introduction

Motorcycles are a preferred mode of transportation in Indonesia because they are effective and efficient, especially in congested and small road conditions. In addition, the price of motorcycles is quite affordable, so the demand for motorcycles is increasing [1]. The large number of motorcycles can have a direct impact on environmental conditions due to the increasing amount of pollution produced by motorized vehicles. In big cities, motorize vehicles make a significant contribution to air pollution, with a result about 60-70% of the total exhaust emissions generated by motorized vehicles [2].

Pollution generated by motor vehicles is created due to fuel combustion. In general, these of exhaust emissions occur due to incomplete combustion the engine's exhaust and combustion system and the release of particles due to insufficient oxygen in the combustion process [3]. Types of emissions released by motor vehicles include Carbon Monoxide (CO), Nitrogen Oxides (NO_x), Hydrocarbons (HC), Sulfur Dioxide (SO_2), lead (Pb), and Carbon Dioxide (CO_2) [4]. CO and NO_x will be in the ambient air and inhaled by humans, so which causes health problems [5].

Exhaust gas emissions need to be controlled and reduced to minimize the negative effects on humans. The combustion process in carried out by mixing fuel with air. Under certain conditions, all fuel molecules cannot combine with oxygen molecules to burn, causing some fuel molecules to escape into the atmosphere as unburned gas [6]. More complete combustion will reduce exhaust emissions produced.

By the engine [7], combustion will be more optimal if the combustion reaction rate is faster. The solution to accelerate the rate of combustion reactions by increase the surface area, increase the reaction temperature and use catalysts to accelerate the reaction rate [8]. The strong influence of the magnetic field on the fuel it causes vibrations, so that there is instability in the hydrocarbon bond chain. As a result, hydrocarbon molecules can be more reactive to oxygen so which can result in better and more efficient [9]. Strengthening of the magnetic field exposure can improve the completion of combustion process by increasing the chance of reaction between hydrocarbon molecules and oxygen [10].

The lowest fuel consumption is with a strong magnetic field of 249 gauss at 2500 rpm. Exhaust gas emissions in the form of CO, CO_2, and HC decreased after being treated with a 249 gauss magnetic field [9]. The greater the magnetic field, the higher of CO_2 content and the lower the CO content. When the fuel is passed through an electromagnetic field, the combustion energy increases [11].

The advantages of magnetic treated fuel are noteworthy since the results show that replacing an engine with magnetic conditions can be able with slight or no harmful effect. In addition, it is service-free and one-time insertions which will improve the brake thermal efficiency of the engine as well as save harmful exhaust gases [12].

2 Research methodology

2.1 Flowchart

Flowchart of research is shown in Fig. 1.

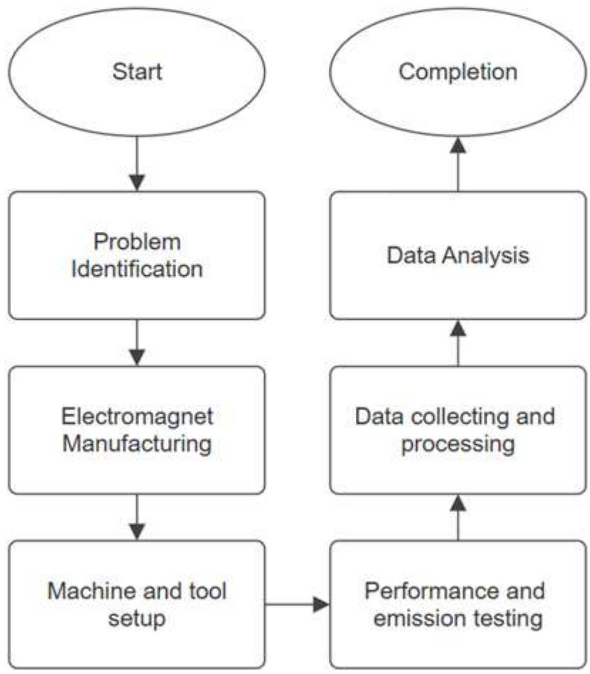


Fig. 1. Flowchart.

2.2 Engine

The research used an experimental method. Experimental research is a research method used to determine the effect of certain treatments on others under controlled conditions [13]. Experimental research is part of quantitative research with the presence of a control group. This research uses an engine with 125 cc and uses a carburetor and injection technology. The independent variables in this study are electromagnets using rubber and iron cores. The dependent variables in this study are power, torque, CO emissions, and HC emissions. The electromagnet is attached to the fuel line and will be tested for exhaust gas emissions and engine performance (Fig. 2). Detailed information about the specifications of the engine is listed in Table 1.

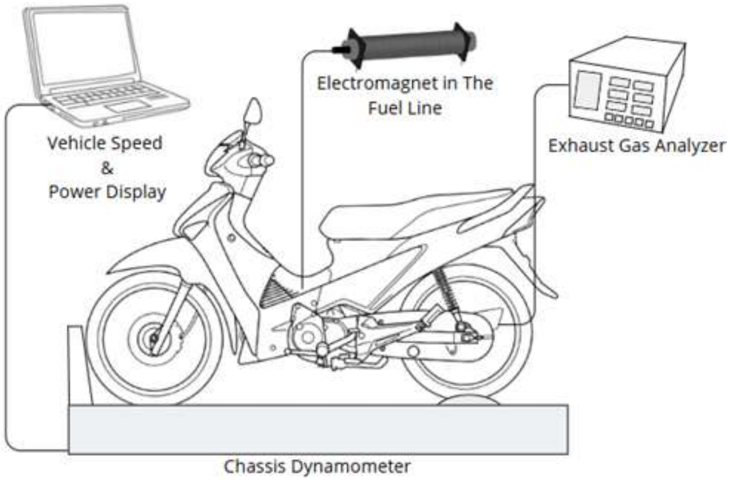


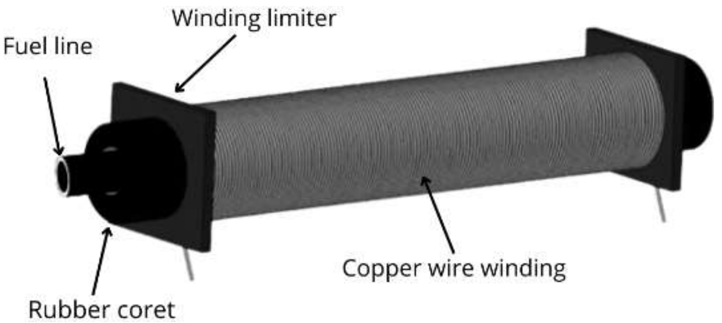
Fig 2. Experimental setup.

Table 1. Engine specifications

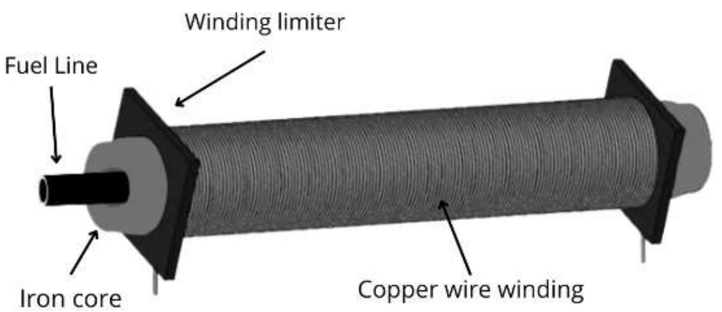
Specifications	Engine 1	Engine 2
Engine type	4-Stroke with SOHC	4-Stroke with SOHC
Bore and stroke	52.4 × 57.9 mm	52.4 × 57.9 mm
Maximum power	9.92 HP at 8.000 rpm	9.17 HP at 7.500 rpm
Maximum torque	9.30 Nm at 4.000rpm	10.10 Nm at 4.000 rpm
System fuel	Carburetor	Injection

2.3 Electromagnet preparation

The electromagnet used in this study was designed using a 0.8 mm diameter wire. The wire is wound as many as 1500 turns with a total length of 70 mm. The inner diameter of the winding structure is 110 mm, which serves as a space for the material core. The inside of the electromagnet is designed to be filled with two types of core material. The material is rubber and iron. The selection of core materials was done to evaluate the effect of different magnetic characteristics on the performance on the engine combustion system. The iron core was chosen because of its ferromagnetic properties, and rubber because of its diamagnetic properties (Fig. 3).



(a) Rubber core



(b) Iron core

Fig 3. Design of electromagnet.

An electromagnet is a combination of electricity and magnetism produced by running electricity through a wire and producing a magnet. The magnetic field lines in the solenoid (coil) are parallel to each other, which is called a homogenous magnetic field [14]. The amount of magnetic field strength generated in the solenoid can be thought of as the sum of the magnetic field generated by a circular wire [15].

2.4 Electromagnet testing

To determine the strength of the magnetic field, it is indicated by the density of magnetic lines of force [16]. In this study, magnetic field measurements were made with the gauss meter model HT 208, a measuring instrument capable of detecting and measuring magnetic field strength in gauss units with precision.

The data obtained from the gauss meter is the basis for analyzing the relationship between variations of the material core in electromagnets. Then correlated to improvements in engine performance (power and torque) and reduced exhaust gas emission (CO and HC). Magnetic field measurements are made with electromagnet cores in the form of rubber and iron. The unevenness of the arrangement of solenoid wire winding will cause the relative permeability to become even greater, causing differences between formula calculations and measuring instruments [17].

2.5 Emissions analysis

Exhaust gas emission measurements are conducted as part of the evaluation of combustion in an engine to assess the level of combustion efficiency and its impact on the environment. Exhaust gas emission measurements were carried out using a gas analyzer used is Qrotech 401 Gas Analyzer. The measurement of exhaust gas emissions is carried out to find the content of CO and HC emissions at idle conditions. Tool can detect CO emissions that can be measured, ranging from 0.00 to 9.99%. HC emissions from 0 to 9999 ppm. Measurements are made by placing the gas analyzer probe at the exhaust of engine. Then the gas content data is displayed and recorded in units % volume for CO and parts per million for HC.

These measurements determine how various different engine treatments, such as the use of rubber core electromagnets and iron core electromagnets, affect the quality of combustion.

2.6 Engine performance analysis

Engine performance of the engine with carburetor and injection technology in this study was carried out using a chassis dynamometer, which serves to measure the power output and engine directly on the wheels of the vehicle. The chassis dynamometer uses a Super Dyno 50 L. The chassis dynamometer is used to measure the power engine (Horsepower/HP) and torque (Newton meter/Nm). In the testing process, the vehicle is placed on a roller dynamometer where the drive wheels interact directly with the roller surface. Engine performance testing was conducted with engine speeds from 4.000 rpm to 9.000 rpm.

3 Results and discussion

3.1 Fuel molecules

Under normal conditions, fuel molecules tend to cluster together (Fig. 4). This clustering prevents a complete reaction between the fuel and air during combustion. As a result, incomplete combustion occurs, leaving unburned fuel remnants. These remnants are the primary source of exhaust emissions, including CO, HC, and other harmful microscopic particles. These emissions not only pollute the air but also negatively impact human health.

The effect of magnetic fields on fuel plays an important role in improving the efficiency of the combustion process in the engine. When fuel passes through a magnetic field, there is a change in molecular structure where the bonds between fuel molecules that originally tended to group together will be broken into more evenly distributed molecules (Fig. 5). This process prevents the clustering of molecules that usually inhibits the combustion reaction. With fuel molecules that have been broken down and dispersed more homogeneously, the chance of each molecule reacting directly with oxygen molecules becomes much higher during the combustion process.

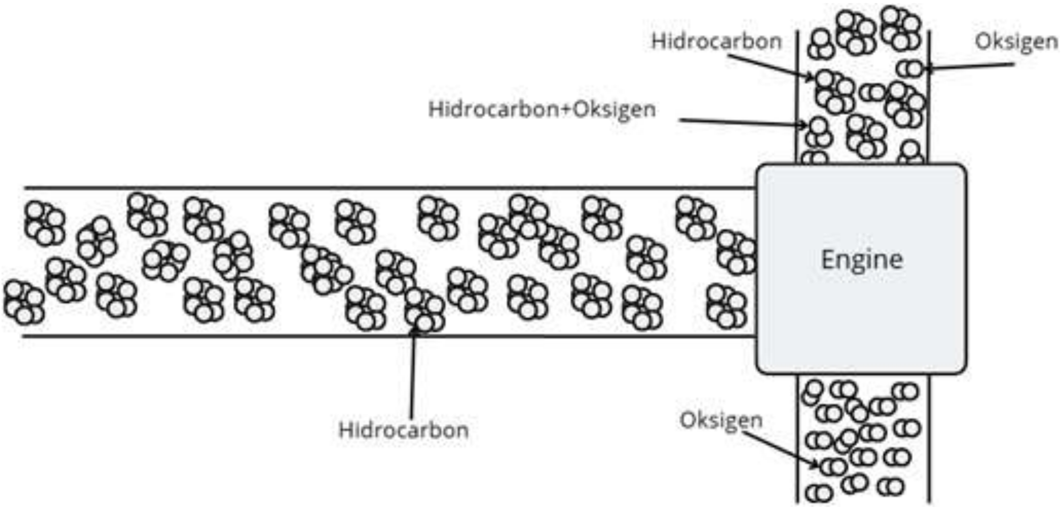


Fig 4. Fuel molecules without magnetic field.

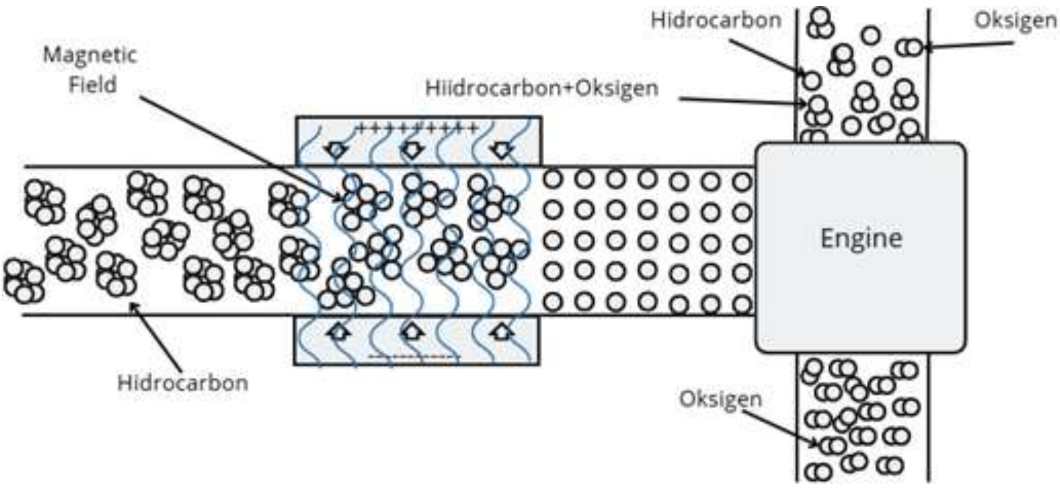


Fig 5. Fuel molecules with magnetic field.

3.2 Engine performance

Engine performance of motorcycle testing using a chassis dynamometer. Engine performance testing is carried out with a standard engine, given a rubber core electromagnet, and an iron core electromagnet.

Electromagnetic cores can improve engine performance (Fig. 6). Initial experiments demonstrated that a combustion engine without an electromagnetic produced a maximum power of 9.9 HP. When a rubber core electromagnet was introduced, the maximum power increased to 10.1 HP. This improvement shows that a rubber core electromagnet enhances engine power. The most significant gain, however, was observed with an iron core electromagnet, which boosted the engine's maximum power to 10.3 HP. Electromagnets using cores produce higher engine performance improvements when compared to rubber cores. Those insignificant changes in engine performance are likely due to low magnetic field intensity [18].

The role of electromagnetic cores in enhancing engine torque is significant (Fig. 7). Experimental data indicates that a baseline engine operating without an electromagnetic achieves a maximum torque of 9.5 Nm. The subsequent introduction of a rubber core resulted in a measured torque increase to 9.6 Nm, affirming that the electromagnet influences engine output. The most notable gain in performance was achieved with an iron core, which elevated the maximum engine torque to 10 Nm. This increase, from 9.5 Nm to 10 Nm, serves as evidence that using an iron core can substantially improve the efficiency of energy conversion within the engine. Fuel systems installed with electromagnet magnetization devices cause the molecular structure of the fuel to become smaller so that the combustion process in the combustion chamber is more perfect and can increase the power and torque of the vehicle [19].

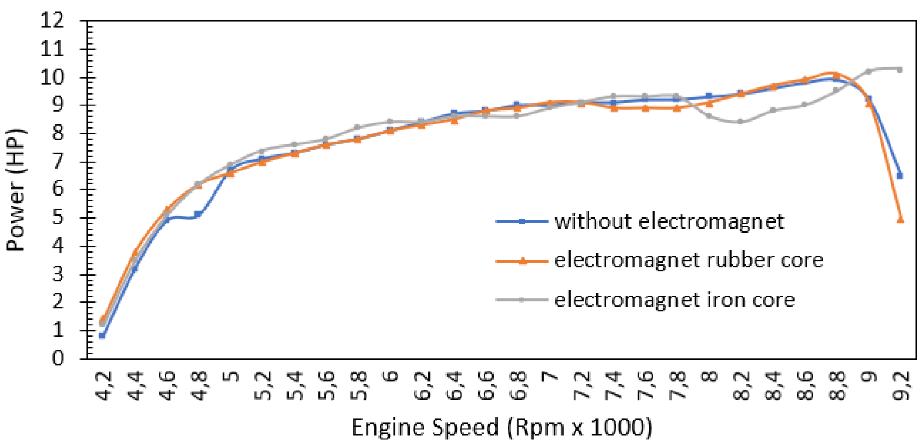


Fig 6. Power of the carburetor engine.

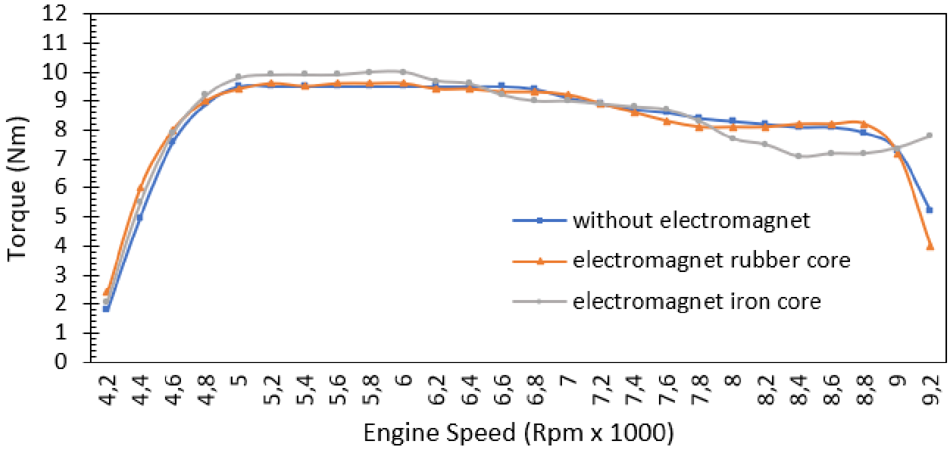


Fig 7. Torque of the carburetor engine.

Without electromagnets, engines with injection technology can produce a maximum power of only 9.3 HP (Fig. 8). After installing rubber-core electromagnets, engine performance improved, raising the maximum power to 9.5 HP. The use of iron-core electromagnets led to an even greater increase, achieving a maximum power of 9.9 HP. This demonstrates that the type of core material in electromagnets significantly affects the optimization of the combustion process, enhancing energy conversion efficiency and generating more power than standard conditions without electromagnets. Iron-core electromagnets provide more substantial performance improvements compared to rubber-core electro-magnets because they create field strength when compared to rubber-core electromagnets. The iron core produces a stronger magnetic field [20]. A larger magnetic field magnetizes the fuel more effectively, resulting in more complete combustion [21].

The use of electromagnetic cores has been shown to significantly improve engine performance (Fig. 9). Under initial conditions, an engine without an electromagnetic device produced a maximum torque of 9.5 Nm. After installing a rubber-core electromagnet, the maximum torque increased to 10 Nm. Further enhancement was achieved with an iron-core electromagnet, resulting in the highest maximum torque of 10.3 Nm. This demonstrates that the type of core material directly influences the engine's torque-producing capacity. Scientifically, this effect can be attributed to the magnetic field's impact on the physicochemical properties of the fuel, which promotes better atomization and creates a more efficient air-fuel mixture. Improved combustion efficiency leads to greater energy conversion and, ultimately, higher torque output compared to engines in standard conditions. The quality of combustion affects both engine performance and exhaust emissions [22].

The application of magnetic fields in fuel lines for engines using carburetors and injection technology offers additional benefits. These benefits include an increased combustion rate and overall improved engine performance. The magnetic field in the fuel line can increase the combustion rate and improve the engine performance [23].

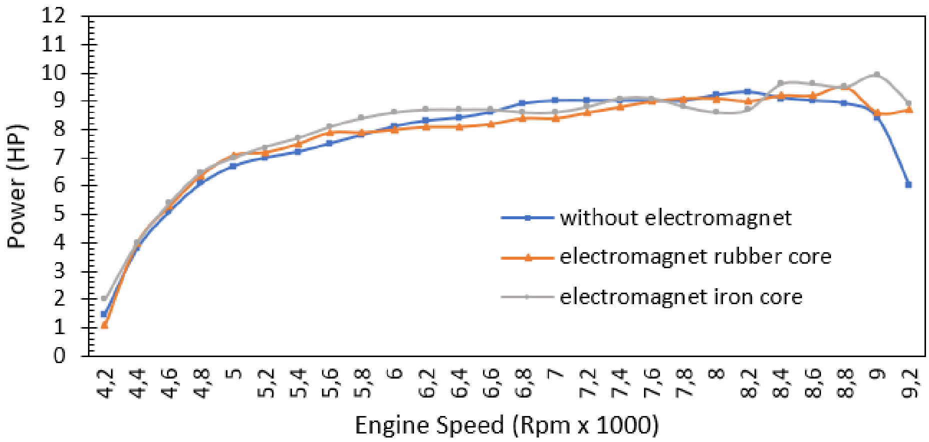


Fig 8. Power of the injection engine.

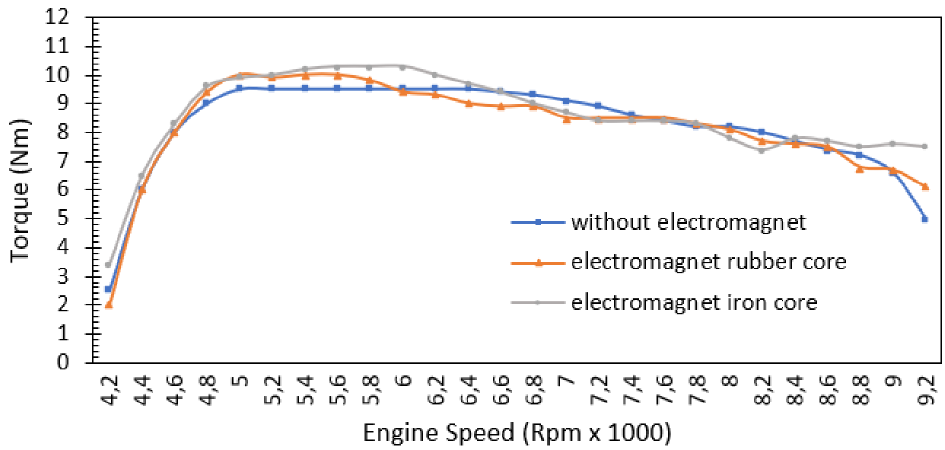


Fig 9. Torque of the injection engine.

To validate the use of electromagnets, statistical tests were conducted. The results of a one-way ANOVA test on engine power and torque indicated a significant effect, as shown by a p-value (Sig) less than 0.05, leading to the rejection of the null hypothesis (H_0). Therefore, it is concluded that there is a significant difference in the power and torque of the engine when comparing those without electromagnets, with rubber-core electromagnets, and with iron-core electromagnets.

3.3 Exhaust gas emission

Exhaust gas emissions were measured using a gas analyzer while the engine was idling. The tests were conducted with the engine in standard condition, using both a rubber core electromagnet and an iron core electromagnet. The experimental evaluation of these categories contributes to environmental regulation [24]. The results of the exhaust gas emission tests are presented in Table 2.

Table 2. Experimental results of exhaust gas emissions

Engine	Variations	Threshold		Results	
		CO (%)	HC (ppm)	CO (%)	HC (ppm)
Carburetor	Standard	5.5	2200	3.43	1851
	Rubber core electromagnet			3.31	1806
	Iron core electromagnet			3.09	1655
Injection	Standard	3	1000	1.73	570
	Rubber core electromagnet			1.63	552
	Iron core electromagnet			1.32	356

Exhaust gas emissions from engines using carburetor and injection technologies are currently below the limits set by emission regulations. However, efforts to further reduce these emissions continue, especially to support environmental conservation and combat air pollution. One effective innovation is the use of electromagnets in the fuel line, which promotes more complete combustion in the engine.

Tests were conducted on exhaust gas emissions in both carburetor and injection engines to assess how variations of electromagnets can reduce emissions during combustion. The primary parameters analyzed were CO and HC levels, which are key indicators of combustion efficiency and air pollution in gasoline engines. HC represent unburned fuel remaining in the engine.

In a carburetor engine without electromagnetism, CO emissions measured 3.43%. After applying an electromagnet with a rubber core, CO levels decreased to 3.31%. This reduction indicates that the magnetic field influences the fuel, leading to more complete combustion. A more significant decrease was observed with an electromagnet featuring an iron core, which resulted in CO emissions of 3.09%. This iron core electromagnet demonstrated the greatest reduction among the three conditions tested, reinforcing the idea that iron core electromagnets are more effective in decreasing emissions and improving combustion quality.

In addition to CO emissions, HC content also decreased with the variation of electromagnetic treatment. The carburetor engine under standard conditions produces HC emissions of 1851 ppm. When using a rubber core electromagnet, HC emissions decrease to 1806 ppm. The most decrease occurred in the use of iron core electromagnets, where HC emissions were recorded at 1655 ppm.

In standard conditions without electromagnet treatment, the CO emissions produced by the injection engine were recorded at 1.73%. When the engine was treated with a rubber core electromagnet, there was a relatively small decrease which shows that the magnetic field produced can affect the combustion process. A greater decrease in emissions was seen when using an iron core electromagnet. In this condition, CO emissions decrease more than the rubber core electromagnet to reach 1.32%. This decrease is the highest compared to the other conditions. An electromagnet with an iron core has a higher effectiveness in influencing the combustion process.

In addition to the reduction of CO emissions, the use of the electromagnet also has a positive impact on reducing hydrocarbon (HC) emissions. The injection engine without electromagnet treatment produced HC emissions of 570 ppm. The application of a rubber core electromagnet on the fuel line reduced the HC to 552 ppm. The highest reduction was again achieved by the iron core electromagnet, where HC emissions were recorded at 356 ppm.

Overall, the results show that the application of an electromagnet on the fuel line, particularly with an iron core, not only contributes to increased engine power and torque but also can reduce exhaust emissions. This makes electromagnet a potential solution in supporting energy efficiency and environmental impact reduction in gasoline fuel engines with carburetor and injection systems.

The Iron core electromagnet produced the highest reduction in exhaust gas emissions for both carburetor and injection engines. This decrease indicates more complete combustion, which is enhanced by the larger magnetic field [11]. Research by [25] shows that smoke density is lowest when a magnetic field is applied, while it is highest without a magnet. Additionally, applying a magnetic field to the fuel line can reduce exhaust gas emissions in four-stroke single-cylinder engines [26]. Using magnetic fields in the fuel lines of carburetor and injection engines not only lowers emissions but also improves fuel efficiency. Thus, magnetic fields have the potential to enhance the combustion process [21].

4 Conclusions

This study demonstrates that installing electromagnets in the fuel line of both carbureted and fuel-injected engines enhances combustion efficiency, thereby improving performance and reducing exhaust emissions. Particularly, the iron core electromagnet increases power in carbureted engines by 0.391 HP and torque by 0.407 Nm. In fuel-injected engines, it raises power by 0.402 HP and torque by 0.449 Nm. Additionally, the iron core electromagnet reduces CO emissions by 0.34% and HC emissions by 196 ppm in carburate engines. For fuel-injected engines, CO emissions decrease by 0.41% and HC emissions by 214 ppm. This research establishes that iron core electromagnets are more effective for optimizing combustion, as evidenced by the improvements in engine performance and significant reductions in emissions. Thus, iron core electromagnets hold promise as a tool for achieving more complete combustion in both carburate and fuel-injected engines.

References

[1] A. M. P. Acuviarta, Permana, “Analisis Faktor Yang Mempengaruhi Permintaan Sepeda Motor di Kota-Kota Besar Jawa Barat,” Jurnal Riset Ilmu Ekonomi, vol.2, no. 3, 2023, doi: https://doi.org/10.23969/jrie.v2i3.41

[2] M. K. Sukma, F. A. Senoaji, K. A. Restu, “Analisis Upaya Penegakan Hukum Terhadap Krisis Lingkungan Atas Implkasi Pencemaran Udara Akibat Asap Kendaraan Bermotor di Daerah Khusus Jakarta (DKJ),” Jurnal Kajian Ilmu Sosial, Politik dan Hukum, vol.1, no. 3, 2023.

[3] Amir, B. S. Waluyo, Y. K. Effendi, “Analisa Pengaruh Emisi Gas Buang Terhadap Pemakaian Turbo Cyclone Pada Sepeda Motor Maatic 110 CC Berbahan Bakar Pertamax,” Jurnal Teknik Mesin Universitas Muhammadiyah Tangerang, vol. 5, no. 2, 2021.

[4] L. N. Asri, K. E. Sari, C. Meidiana, “EMisi co kendaraan bermotor pada ruas jalan dengan Tingkat pelayanan rendah di Kota Malang” Planning for Urban Region and Environment, vol. 11, no. 1, 2022.

[5] S. Machmud, U. B. Surono, T. Hasanudin, “Analisis Pengaruh Tahun Perakitan Terhadap Emisi Gas Buang Kendaraan Bermotor,” Jurnal Mesin Nusantara, vol. 4, no. 1, Juni, 2021.

[6] L. P. Oommen, K. G. N, “A Study on Effect of Magnetic Field on the Properties and Combustion of Hydrocarbon Fuels” www.tjprc.org SCOPUS Indexed Journal editor@tjprc.org.www.tjprc.org, 2019.

[7] K. Chaware, “Review on Effect of Magnetism by Varying Intensity on Performance and Emission of Single Cylinder Four Stroke Diesel Engine,” International Journal of Engineering Research and General Science, vol.3, no.1, 2015.

[8] I. W. Redhana, I. N. Suardana, I. N. Selamat, L. M. Merrta, “Pengaruh Praktikum Kimia Hijau Pada Sikap Siswa Terhadap Kimia,” EDUSAINS, vol. 12, no. 2, 2020.

[9] A. Nugraha, S. Orhani, “The Effect of Strong Magnetic Field and Engine Rotation on Fuel Consumption and Exhaust Gas Emissions for Gasoline Engines,” Asian Journal Science and Engineering, vol. 1, no. 1, June, 2022.

[10] N. A. Wibowo, S. M. Utami, C. A. Riyanto, A. Setiawan, “Impact of Magnetic Field Strengthening on Combustion Performance of Low-Octane Fuel in Two-Stroke Engine,” Jurnal Pendidikan Fisika Indonesia, vol. 16, no. 1, 2020.

[11] T. H. Nufus, A. Ulfiana, I. Nuriskasari, E. Ridwan, S. Lestari, “Efek Medan Elektromagnet Pada Mesin Bensin Terhadap Emisi Gas Buang Dan Energi Pembakaran,” Jurnal Teknologi Terapan, vol. 7, no.1, 2021.

[12] A. R. Kumar, G. J. Raju, “Experimental Investigation on Magnetic Conditioning of Diesel to enhance the performance and Emissions of the Diesel Engine,” IOP Conference Series: Materials Science and Engineering, vol.1057, no. 1, 2021, doi: https://doi.org/10.1088/1757-899X/1057/1/012043

[13] Sugiyono, “Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kulalitatif, dan R&D”, Bandung: Alfabeta, 2010.

[14] M. Hamdhani, B. Sudarmanta, “Studi Eksperirmental Variasi Kuat Medan Magnet Induksi Pada Aliran Bahan Bakar Terhadap Unjuk Kerja Mesin SINJAI 650 cc (studi Kasus: Mapping Sumber Tegangan Induksi Magnet),” Jurnal Teknik ITS, vol. 5, no.2, 2016

[15] I. Prastyaningrum, N. Imansari, “Medan Elektromagnetik,” UNIPMA Press, 2023.

[16] A. F. Bahalwan, D. Darmawan, A. Suhendi,”Optimasi Parameter Koil Untuk Meningkatkan Kuat Medan Magnet Pada Sumber Medan Magnet Berbasis Solenoida,” e-Proceeding of zEngineering, vol. 6, no. 2, 2019.

[17] N. L. Navira, “Pengaruh Pemberian Medan Magnet Pada Air Untuk Pertumbuhan Kangkung (Ipomoea Reptans) Hidroponik,” Doctoral dissertation, Universitas Islam Negeri Maulana Malik Ibrahim, 2021.

[18] A. A. A. Rehim, A. A. A. Attia,”Does magnetic Fuel Treatment Affect Engine’s Performance?,”SAE Technical Papers, 2014.

[19] I. P. B. Artayasa, K. R. Dantes, “Pengaruh Diameter Kawat Tembaga Pada Sistem Bahan Bakar Terhadap Performansi Motor Bensin 4 Langkah,” Jurnal Pendidikan Teknik Mesin Undiksha, vol. 9, no. 2, 2021.

[20] Salomo, Erwin, U. Malik, M. Ginting, “Analisa Pengaruh Inti Koil Terhadap Medan Magnetik dan Muatan Pada Kapasitor Dalam Rangkaian Seri LC,” Jurnal Ilmiah Edu Research, vol. 6, no. 1, 2017.

[21] I. M. Mara, I. M. Nuarsa, I. B. Alit, I. G. B. Susana, “Pemanfaatan Medan Magnet Pada Saluran Bahan Bakar Sepeda Motor Untuk Penghematan Konsumsi Bahan Bakar Dan Penurunan Emisi Gas Buang,” Dinamika Teknik Mesin, vol. 12, no.1, 2022.

[22] Rosid, “Analisa Proses Pembakaran Pada Motor Bensin 113,5 cc Dengan Simulasi ANSYS,” Jurnal Teknologi, vol. 8, no.2, Juli, 2016.

[23] O. Öztürk, M. Taştan, “A Review of Magnetic Field Assisted Combustion,” International Journal of Energy Studies, vol. 9, no. 1, 2024, doi: https://doi.org/10.58559/ijes.1412125

[24] Men-LHK, “Peraturan Menteri Lingkungan Hidup dan Kehutanan Nomor 8 Tahun 2023 tentang Penerapan Baku Mutu Emisi Kendaraan Bermotor Kategori M, Kategori N, Kategori O, dan Kategori L” Indonesia, July 2023. https://peraturan.bpk.go.id/Details/262504/permen-lhk-no-8-tahun-2023

[25] B. Maruli, T. Pakpahan, H. Iskandar, R. Manullang, “Pengaruh Kuat Medan Magnet Pada Saluran Bahan Bakar Terhadap Performansi Gasoline Engine High Technology,” Jurnal Ilmiah Teknik Mesin ITM, vol. 5, no. 2, 2019.

[26] D. R. Mane, V. S. Sawant, “A Comparative Study Of Effect Of Magnetic Field on Exhaust Emission in Internal Combustion Engine,” IOSR Journal of Applied Physics, vol. 7, no.6, 2015, doi: https://doi.org/10.9790/4861-07623840