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The Effect of Magnet Strength and Engine Speed on Fuel Consumption and Exhaust Gas Emission for Gasoline Vehicle

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Abstract:
The study discusses the effect of magnet strength on fuel lines on fuel consumption and exhaust gas emissions. The purpose of this study was to determine the relationship of magnet strength in fuel lines to fuel consumption and exhaust gas emissions.
The research method uses pure experimental methods. using a free variable strong magnetic field (51, 102, 152, 202, and 249) gauss mounted on the fuel line and engine speed (1500 rpm, 2500 rpm, 3500 rpm, and 4500 rpm). while the dependent variable is fuel consumption (liter/hour) and exhaust gas emissions. Also, a Fourier transforms infrared (FTIR) test was performed to determine the group of fuel chemical compounds.
The results showed the highest concentration of transmittance at a wavelength of 2850 cm^{-1} - 2970 cm^{-1} amounted to 77.75% with a magnet strength of 249 gausses, when compared to standard vehicle conditions it was 33.05%. while the magnet strength of 249 gausses with 2500 rpm speed can save fuel consumption by 0.2 liters/hour. It also can reduce O exhaust gas levels by 4.16% (3500 rpm), reduce CO gas by 1.29% (2500 rpm), reduce CO_2 gas by 5.2% (1500 rpm), and reduce HC gas by 215, 66% (4500 rpm).
Key Word: *Magnet strength, engine speed, fuel consumption, exhaust gas emissions*

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I. Introduction

The growing population of the world population is driving an increase in the use of energy sources that are quite large, especially in the automotive field can be known by the number of fossil fuel vehicle transportation. This happens because of the consumptive culture of the community, resulting in air pollution [1]. The increasing number of vehicle vehicles increases the exhaust gas levels, thereby causing air pollution. There are several pollutant gases produced by vehicle vehicles, including hydrocarbon compounds (HC), carbon monoxide compounds (CO), nitrogen compounds (NOx), sulfur compounds (SOx), and lead (Pb) mixed with dust particles. Vehicle exhaust gas emissions are one of the supporting components of air pollution in the world [2], [3]. CO and CO gas are the main compounds resulting from the combustion of gasoline fuels through incomplete combustion processes, while HC compounds are emission gases that arise due to the presence of unburned fuels. Some of the negative effects of vehicle exhaust gases such as HC and CO with a large percentage cause cancer and affect death [4]–[6].

The addition of electromagnetic fields to fuels causing a reduction in fuel consumption and a reduction in the content of exhaust gas emissions that are harmful to the environment [7], [8].

The use of electromagnetic fields to improve the quality of the combustion process and reduce fuel consumption [9]. In this study an analysis of the use of electromagnetic fuel magnetization tools on the performance of a four-stroke, one-cylinder engine. Using a wire diameter of 0.35 mm with the number of copper wire coils is 3000, 4000, and 4500. The performance of the machine is analyzed at several engine speeds. The results showed that there was an increase in engine power of 12.83% and reduced fuel consumption by 10% in the number of turns of 4000 with 1500 rpm speed.

The installation of a magnetic field in the fuel channel affects the performance and emissions of the vehicle exhaust [10]. the results of his research showed an increase in engine performance and a decrease in the concentration of CO and HC exhaust gas emissions. This is due to the increase in engine performance due to the resonance of fuel particles so that the bonding of atoms in a molecule is loose and causes the molecule to become charged. The hydrocarbon chain will become stable and more reactive before the fuel enters the engine so that combustion becomes more complete and reduced CO and HC exhaust gas emissions. The highest power is obtained at 8000 rpm engine speed by installing an electromagnetic ionizer with a 99 gauss magnet strength of 8.47 KW with a torque of 10.03 Nm. While the power generated at standard engine conditions with an engine speed of 8000 rpm is only 7.58 KW with a torque of 9.01 Nm. HC exhaust gas decreases in the electromagnetic ionizer with a variation of the 99 gausses magnet strength with an average of 1358 ppm. Whereas related to CO emission reduction, it is found in electromagnetic ionizer with 99 gausses magnet strength variation with an average of 11.27%.

II. Theory

II.1 ELECTROMAGNETIC PRINCIPLE OF WORK ON FUELS

Hydrocarbons have a cage-like structure. That is why during the combustion process the oxidation of carbon atoms is blocked. This is caused by access to oxygen in the right amount to the interior of the molecule is blocked and oxygen with less amount will prevent complete combustion [11], [12].

Electromagnetic is a type of artificial magnet that can produce a magnetic field when a conductor (iron) that is wound by copper wire is electrified. This tool is mounted on the fuel line before entering the carburetor. With the influence of the magnetic field on the fuel causing vibrations resulting in instability in the hydrocarbon bonding chain, as a result, hydrocarbon molecules can be more reactive to oxygen. The ideal mixture of fuel and oxygen can produce better and more efficient combustion [3], [13].

The magnitude of the magnet strength in a current coil (Solenoid) is equation 1.

$$B = \mu_o.\frac{N.I}{L} \qquad 1)$$

Where: B = magnet strength (Tesla), μ_0 = Vacuum permeability ($4\pi \times 10^{-7}$ Wb / Am), N = Number of turns, I = Electric current (Amper), L = Length of solenoid.

Electromagnetic magnetization treatment, so that the hydrocarbon molecules can be polarized by exposure to magnetic energy which then raises the attraction. The magnetic attraction is the production of moments created by the movement of the outermost electrons from the hydrocarbon chain which then moves electrons to the higher main quantum conditions [14]–[17].

This situation effectively breaks down the electrons that participate in the bonding process of the fuel compound, this part then causes the bonding of the hydrocarbon molecule to be stretched so that it has more free space for the molecule to vibrate in its activity. The provision of magnetic fields in these fuels allows fast bonds in binding more oxygen. With this process, combustion in vehicle engines can take place perfectly, and reduce unburned hydrocarbon products resulting from the combustion process [18], [19].

The breakdown of the declustering of this molecule can be explained through the theory of the moment of bonding which is in a magnetic field, then it will experience a certain amount of reverse force. This force simply pushes the magnetic field to free the bonds in the magnetic field so that the carbon atom will more easily react with oxygen in the combustion process [20].

II.2 COMBUSTION PROCESS

In a gasoline vehicle, engine energy is obtained from the combustion process of a mixture of air and fuel. The combustion process of the mixture of air and fuel in the combustion chamber will produce heat and pressure. The volatility of gasoline is very necessary because gasoline that enters the cylinder must be in the form of gas to make it easy to mix with air homogeneously [21], [17]. Combustion is the reaction of oxygen and combustible materials. Complete combustion can also be assumed that all fuels burn all.

Combustion in a gasoline engine is divided into three groups, namely[22]:

1. Ignition and generate sparks (ignition and flame development). Where ignition for the mixture of fuel and air starts from the spark released from the spark plug electrodes occurs between 10-30o before TDC. About 5-10% is burned in this phase.

2. Flame propagation. When the gas mixture burns in the combustion chamber, pressure and temperature rise causing the volume to rise. At the time of the explosion the mixture of gas burned from 5% to 95%.

3. After flame propagation occurs after TDC around 15-20 ° and 90-95% the combustion process reaches the corner of the combustion chamber. About 5-10% of the gas is burned with the combustion chamber wall and the angle.

b. Equation of combustion reaction

The gasoline engines get power from the combustion of a fuel with air, gasoline fuel is converted in the gas phase in the combustion chamber. The combustion process occurs with the reaction of hydrocarbons with oxygen to water and CO_2. Equation 2 shown chemical reaction between iso-octane and oxygen are:

$$C_8H_{18} + 12.5\,(O_2+N_2) \rightarrow 8CO_2 + 9H_2O+N_2 \qquad 2)$$

Equation 2 is a reaction where gasoline fuels with air. While gasoline reacted with air will change its reaction. In the air, the nitrogen content is 78% mol, and oxygen is 21% mol. Equation 3 shows the stoichiometric combustion of gasoline and air fuels is:

$$C_8H_{18} + 12.5\,O_2 + 12.5(3.76)N_2 \rightarrow 8CO_2 + 9H_2O + 12.5(3.76)N_2 \qquad 3)$$

Mismatch of the mixture results in other products in the exhaust gases such as CO which pollutes the air.

III. Experimental Methods

To study the influence of the magnetic field and engine speed on fuel consumption and exhaust gas emissions of gasoline vehicles, this study uses an experimental method to determine fuel consumption and exhaust gas emissions of gasoline vehicles.

III.1 Materials and Methods

In the study, Magnetization Tool Design is shown in Fig. 1, and the Design of the Magnetization geometry tool is shown in Table 1.

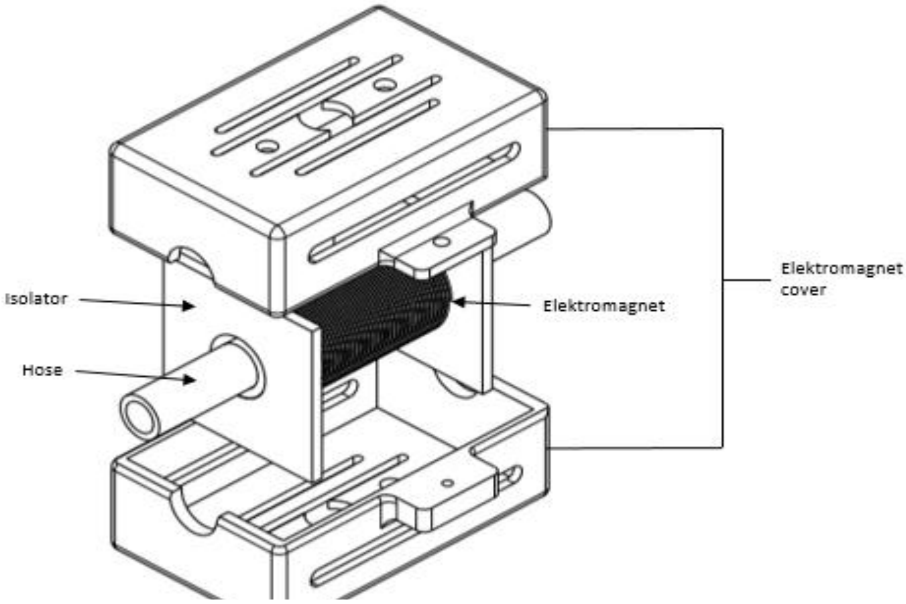

Figure 1 Magnetization Tool Design

Table 1. Magnetization Tool Geometric

Part	Dimension
Isolator	40 x 40 x 3 mm
Hose	Øin 8mm, Øout 10mm x150 mm
electromagnetic	Øin 10mm, Øout 18mm x100 mm
Electromagnetic cover	110mm x 44mm x 23mm (2x)

III.2 Experimental Setup

This research was conducted by an experimental method, testing begins with magnet strength testing and testing of fuel samples using Fourier Transform Infra-Red (FTIR). The independent variables used are variations in magnet strength (51, 102, 152, 202, and 249) gauss. Then proceed with FTIR testing to analyze the value of infrared absorption of the molecules contained in gasoline before and after magnetization. To test fuel consumption and exhaust gas emissions, each is done with variations in engine speed of 1500, 2500, 3500, and 4500 rpm. The research scheme as shown in Figure 2.

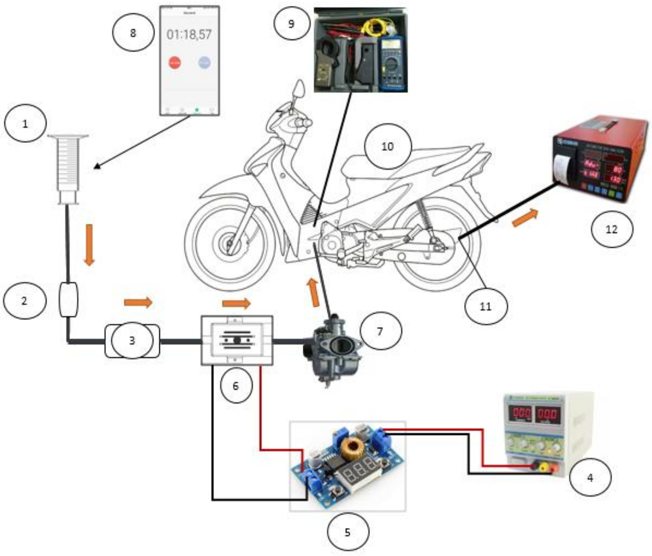

Fig. 2 Scheme of experiment setup

Where 1. Fuel tank, 2. Fuel filter, 3. Vacuum valve, 4. AC-DC voltage inverter, 5. XL4015 stepdown voltage, 6. Electromagnet, 7. Carburetor, 8. Stopwatch feature, 9. Tachometer, 10 Vehiclecycle, 11. Exhaust, 12. Gas analyzer

IV. RESULT AND DISCUSSION

IV.1 FTIR OF GASOLINE

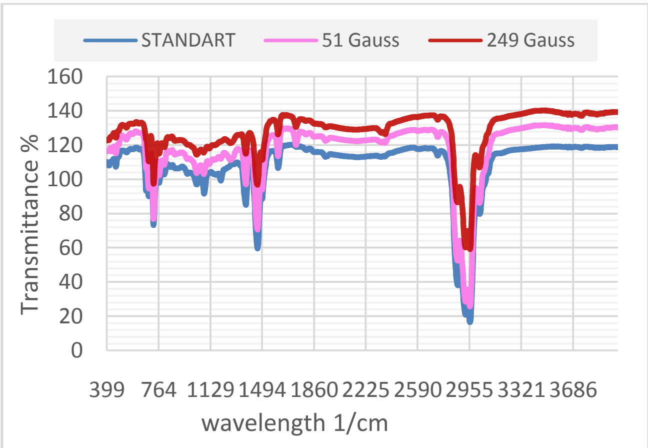

Figure 3 FTIR of Gasoline

Figure 3 shows that there is a change in the percentage of infrared radiation absorbance values for fuel compounds, this is indicated by the greater magnitude of the magnetic field used, the greater the infrared radiation absorbed by the molecule. increased absorption of C-H is characterized by the emergence of strong bands below 3000 cm $^{-1}$ with alkane compound groups in waves of 2850 cm $^{-1}$ - 2970 cm $^{-1}$.

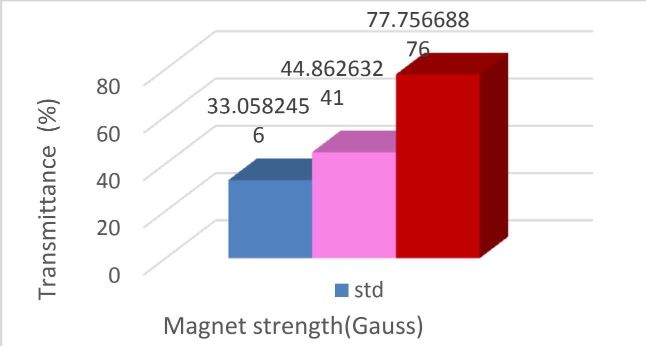

Figure 4 Percentage of CH Molecular Absorption
(Wavelength 2850 cm^{-1} - 2970 cm^{-1})

In figure 4 in detail, it shows the percentage of absorption value (transmittance) of CH molecules of gasoline at wavelengths of 2850 cm^{-1} - 2970 cm^{-1}, when averaged, the highest percentage of absorption values is in the given variation of the magnetic strength of 249 gauss which is equal to 77.75% than the standard condition the absorption value is 33.05%. This proves that giving greater magnet strength can more effectively weaken the energy of molecular bonds by stretching the bonds of hydrocarbon molecules which tend to cluster so that fuels that are bonded to their hydrocarbon molecules have more free space to vibrate their activities. In this condition when given infrared spectroscopy, the infrared radiation that is exposed will detect these vibrations and then convert them into a change in the percentage of the transmittance is increasing.

IV.2 Effect Magnet strength and Engine Speed Against Fuel Consumption

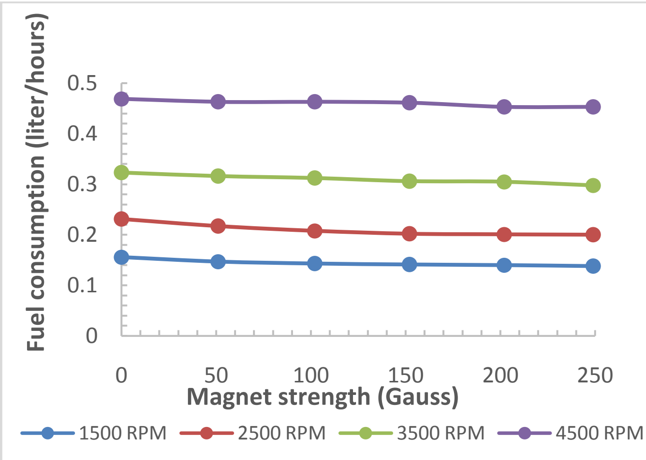

Figure 5 Effect Magnet strength and Engine Speed Against Fuel Consumption

Figure 5 shows that the higher the engine speed, the more fuel is used. The fuel consumption experienced the highest saving occurred at 2500 rpm with a strong magnetic field of 249 gauss which is equal to 0.2 liters/hour compared to standard conditions of 0.231 liters/hour. This is because at 2500 rpm speed the fuel flow rate is not too slow or not too fast, giving greater magnet strength can be more effective to stretch the bonds of hydrocarbon molecules that tend to cluster (cluster), so that the fuel molecules are magnetized effectively.

IV.3 EFFECTS OF MAGNET STRENGTH AND ENGINE SPEED AGAINST GAS EMISSION O2

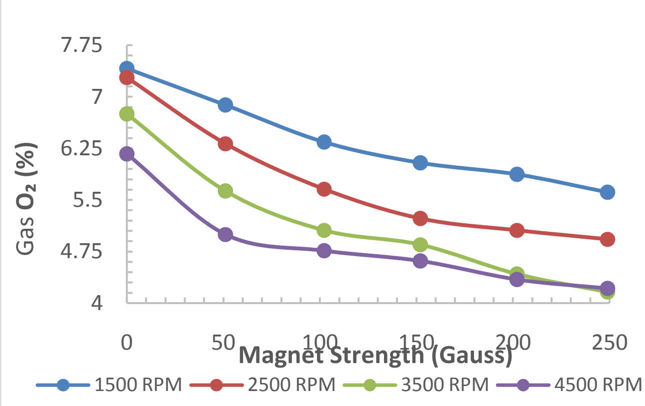

Figure 6 Effects of Magnet strength and Engine Speed Variations on O_2 Flue Gas

Figure 6 shows that there was a significant reduction in O_2 exhaust gas emissions. The higher the engine speed, the O_2 exhaust emission content will decrease in value, but the lowest O_2 exhaust gas content occurs around the engine 3500 rpm with variations in the magnet strength of 249 gausses where O_2 content of 4.16% compared to the standard conditions of 6.75% and the highest O_2 exhaust gas level is at 1500 rpm with a variation of the 249 gausses magnet strength of 5.61%, much lower than the standard conditions of 7.41%. The decrease in the O_2 exhaust gas at each engine speed is caused by the influence of the magnetic field which weakens the energy of attraction between hydrocarbon molecules so that during the oxidation process the amount of oxygen (O_2) captured in the hydrocarbon molecule is more ideal. This is why a decrease in O_2 gas levels indicates better engine combustion compared to standard conditions.

IV.4 EFFECTS OF MAGNET STRENGTH AND ENGINE SPEED AGAINST GAS EMISSION CO

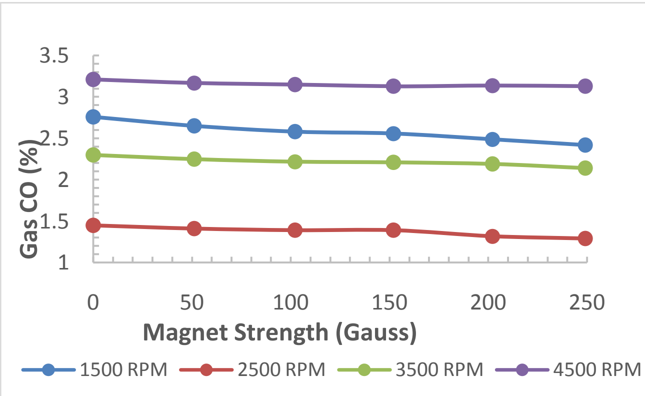

Figure 7 Effect of Magnet strength Strength and Speed of the Engine Against Exhaust Gas CO

Figure 7 shows that the standard conditions (without magnetization) of CO exhaust gas emissions increased at 4500 rpm engine speed with CO levels of 3.21% and the lowest CO levels occurred at 2500 rpm engine speed of 1.45%. With the treatment of magnet strength in the fuel flow, the resulting CO exhaust gas levels have decreased significantly, but the lowest CO exhaust gas levels occur at 2500 rpm engine speed using a 249 gauss magnet strength of 1.29% and exhaust gas levels The highest CO is at 4500 rpm engine speed using 249 gausses magnet strength of 3.13%. This can be explained by giving variations in the strength of the magnetic field 249 gausses around the 2500 rpm engine which tends to have a mass flow rate of fuel not so fast or slow so that the magnetization process is more optimal and causes the fuel molecules to be more likely to polarize electrons in the constituent hydrocarbon constituents. to be more organized, so that resonance occurs which results in conditions of bonding attraction between unstable hydrocarbon molecules and stretching bonds. As a result of the stretching of molecular bonds resulted in the formation of an optimal distance between the bonds of hydrocarbon molecules to be able to bind the oxygen atom (O_2) ideally when the oxidation process takes place. With better atomization of fuel and air during the combustion process, the CO gas content produced tends to decrease due to efficient combustion in the engine combustion chamber. So the use of strong magnetic fields can improve the quality of combustion.

IV.5 Effects of Magnet strength and Engine Speed Against Gas Emission CO2

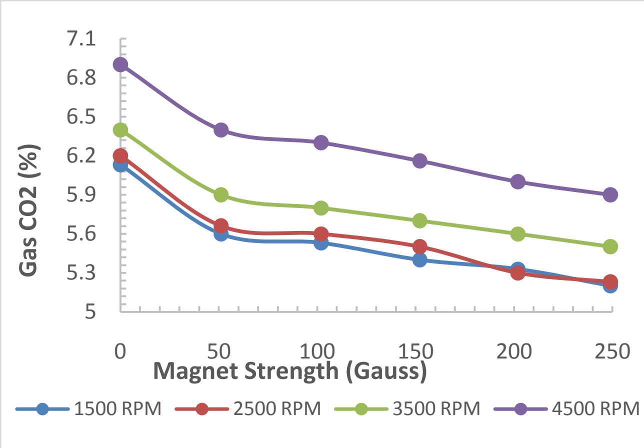

Figure 8 Effects of Magnet strength and Engine Speed Variations on exhaust Gas emission CO_2

Figure 8 shows the relationship between engine speed and carbon dioxide (CO_2) exhaust gas emissions. In standard conditions, the 1500 rpm engine speed has the lowest CO_2 exhaust gas content of 6.13% and the highest at 4500 rpm engine speed of 6.9%. The use of field strength variations makes the resulting exhaust CO levels gradually decrease, with the lowest CO_2 gas levels in the use of 249 gauss magnet strength s at 1500 rpm at 5.2% and the highest CO_2 exhaust levels at 4500 rpm at 5.9%, if averaged the strength of the 249 gauss field gives a reduction in the percentage of CO gas flue gas levels worth 14.84% from standard conditions (without magnetization). The use of greater magnetic energy causes hydrocarbon bonds to decrease in attractive forces so that when the oxidation process of the fuel will bind more oxygen elements (O_2) and the resulting combustion output is more perfect than the standard conditions.

IV.6 Effects of Magnet strength and Engine Speed Against Gas Emission HC

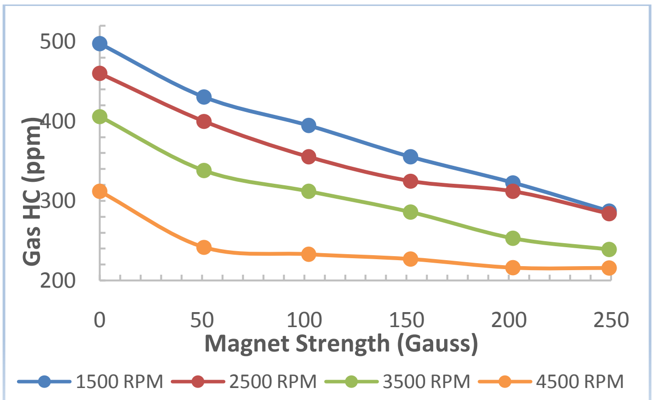

Figure 9 Effects of Magnet strength and Engine Speed on exhaust Gas emission HC.

Figure 9 shows the relationship between engine speed and hydrocarbon (HC) exhaust gas emissions. It can be explained that the higher the engine speed, the HC flue gas level decreases, but at the highest standard condition, the HC flue gas is in the 1500 rpm engine speed of 497.33 ppm and gradually decreases at 4500 rpm engine speed with the HC content of 312 ppm. If the concentration of HC in high flue gas indicates incomplete combustion, which homogeneity of the fuel with oxygen affects the flame point when burning (burning). When given the influence of strong magnetic field variations there is a significant decrease in each engine speed. And the highest HC exhaust gas content is 287 ppm at 1500 rpm engine speed using 249 gausses magnet strength, which continues to 4500 rpm speed at 215.66 ppm.

At 4500 rpm engine speed, the effect of magnet strength variations on the fuel decreases, this is because the fuel flow rate is getting faster and the length of time of magnetized fuel is relatively shorter. When averaged the magnitude of the decrease in HC flue gas levels from standard conditions with a variation of the 249 gausses magnet strength is 38.14%, indicating that the combustion process is getting better, moreover hydrocarbon molecules that capture magnetic field energy so that the ability to pull it becomes weak and when oxidation process has free space for oxygen to react with each other to bind.

V. CONCLUSION

From the results of the research that has been done, the following conclusions can be drawn:

1. Giving the variation of magnet strength on the fuel lines of gasoline engines provides a significant influence to reduce fuel consumption. The fuel consumption experienced the highest savings that occurred at 2500 rpm with a 249 gauss magnet strength of 0.2 liters/hour compared to standard conditions of 0.231 liters/hour. The higher the magnet strength variation used, the more efficient fuel consumption.

2. With the influence of magnet strength variations on the fuel lines of gasoline engines, the levels of O_2 , CO, CO_2 , and HC exhaust emission significantly improved. The best improvement in exhaust gas levels is by using variations of the 249 gausses magnet strength. the lowest O_2 flue gas content occurred at 3500 rpm engine speed with variations of the magnetic field 249 gauss O content of 4.16% and the highest O_2 exhaust gas content was at 1500 rpm engine speed with 249 gausses magnet strength variation of 5.61% much decreased compared to the standard conditions of 7.41%. For CO gas levels the lowest levels occurred at 2500 rpm engine speed using variations of the 249 gausses magnet strength of 1.29% and the highest CO exhaust gas content at 4500 rpm engine speed variations of the 249 gausses magnet strength of 3.13%. Then for the exhaust gas CO_2 levels decreased with the lowest levels in the magnetic field variation of 249 gausses around the 1500 rpm engine speed of 5.2% and the highest exhaust CO_2 gas content occurred at 4500 rpm engine speed of 5.9%. Then the highest HC exhaust gas level is 287 ppm at 1500 rpm engine speed using 249 gausses magnet strength, continues to 4500 rpm speed of 249 gausses magnet strength variation at 215.66 ppm.

References

[1] F. Perera, “Pollution from fossil-fuel combustion is the leading environmental threat to global pediatric health and equity: Solutions exist,” Int. J. Environ. Res. Public Health, vol. 15, no. 1, 2018, doi: 10.3390/ijerph15010016.

[2] K. Gwilliam, M. Kojima, and T. Johnson, “Reducing Air Pollution from Urban Transport,” World Bank, p. 194, 2004.

[3] L. Jie, “Environmental Effects of Vehicle Exhausts, Global and Local Effects – A Comparison between Gasoline and Diesel,” p. 32, 2011.

[4] R. Prasad and V. R. Bella, “A review on diesel soot emission, its effect and control,” Bull. Chem. React. Eng. & Catal., vol. 5, no. 2, pp. 69–86, 2010, doi: 10.9767/bcrec.5.2.794.69-86.

[5] I. A. Reşitoılu, K. Altinişik, and A. Keskin, “The pollutant emissions from diesel-engine vehicles and exhaust aftertreatment systems,” Clean Technol. Environ. Policy, vol. 17, no. 1, pp. 15–27, 2015, doi: 10.1007/s10098-014-0793-9.

[6] J. Wang et al., “Vehicle emission and atmospheric pollution in China: problems, progress, and prospects,” PeerJ, vol. 7, p. e6932, 2019, doi: 10.7717/peerj.6932.

[7] F. A. El Fatih and G. M. Saber, “Effect of fuel magnetism on engine performance and emissions,” Aust. J. Basic Appl. Sci., vol. 4, no. 12, pp. 6354–6358, 2010.

[8] T. H. Nufus et al., “Study of Diesel Engine Performance on the Electromagnetic Effect of Biodiesel (Waste Cooking Oil),” J. Phys. Conf. Ser., vol. 1364, no. 1, 2019, doi: 10.1088/1742-6596/1364/1/012075.

[9] A. S. Faris et al., “Effects of magnetic field on fuel consumption and exhaust gas emissions in two-stroke engine,” Energy Procedia, vol. 18, pp. 327–338, 2012, doi: 10.1016/j.egypro.2012.05.044.

[10] P. G, N. MK, S. JV, R. Vasupalli, and P. Lade, “Effect of Magnetic Field on the Emissions of Single Cylinder Four Stroke Petrol Engine,” Adv. Automob. Eng., vol. 06, no. 04, pp. 4–7, 2017, doi: 10.4172/2167-7670.1000175.

[11] G. Mutschke, K. Tschulik, T. Weier, M. Uhlemann, A. Bund, and J. Fröhlich, “On the action of magnetic gradient forces in micro-structured copper deposition,” Electrochim. Acta, vol. 55, no. 28, pp. 9060–9066, 2010, doi: 10.1016/j.electacta.2010.08.046.

[12] M. Ünaldi, A. Kahraman, and M. Taşyürek, “Effects of Gasoline Exposed to Magnetic Field to the Exhaust gas emissions,” Int. J. Electr. Energy, vol. 3, no. 4, pp. 239–242, 2015, doi: 10.18178/ijoee.3.4.239-242.

[13] World Bank Group and ESMAP, “The Energy Subsidy Reform Assessment Framework (ESRAF). Good Practice Note 8, Local Environmental Externalities due to Energy Value Subsidies: A Focus on Air Pollution and Health,” 2017.

[14] M. K. Nasir, R. Md Noor, M. A. Kalam, and B. M. Masum, “Reduction of fuel consumption and exhaust pollutant using intelligent transport systems,” Sci. World J., vol. 2014, 2014, doi: 10.1155/2014/836375.

[15] R. Santilli and A. Aringazin, “Structure and Combustion of Magnegases,” pp. 0–32, 2001.

[16] G. Kalghatgi, “Development of Fuel/Engine Systems—The Way Forward to Sustainable Transport,” Engineering, vol. 5, no. 3, pp. 510–518, 2019, doi: 10.1016/j.eng.2019.01.009.

[17] J. Bacha et al., “Diesel Fuels Technical Review,” Chevron Glob. Mark., pp. 1–116, 2007, doi: 10.1063/1.3575169.

[18] M. Raza, L. Chen, F. Leach, and S. Ding, “A Review of particulate number (PN) emissions from gasoline direct injection (gdi) engines and their control techniques,” Energies, vol. 11, no. 6, 2018, doi: 10.3390/en11061417.

[19] H. M. Engineering, W. K. Cheng, and D. Hardt, “Control Strategy for Hydrocarbon Emissions in Turbocharged Direct Injection Spark Ignition Engines During Cold-Start,” 2013.

[20] P. G. Kristensen, B. Karll, A. B. Bendtsen, P. Glarborg, and K. Dam-Johansen, “Exhaust oxidation of unburned hydrocarbons from lean-burn natural gas engines,” Combust. Sci. Technol., vol. 157, no. 1–6, pp. 263–292, 2000, doi: 10.1080/00102200008947319.

[21] S. Verhelst, J. W. Turner, L. Sileghem, and J. Vancoillie, “Methanol as a fuel for internal combustion engines,” Prog. Energy Combust. Sci., vol. 70, no. January, pp. 43–88, 2019, doi: 10.1016/j.pecs.2018.10.001.

[22] G. Kalghatgi and B. Johansson, “Gasoline compression ignition approach to efficient, clean and affordable future engines,” Proc. Inst. Mech. Eng. Part D J. Automob. Eng., vol. 232, no. 1, pp. 118–138, 2018, doi: 10.1177/0954407017694275.

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