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MAGNETIC FIELD EFFECT ON COMPRESSION IGNITION ENGINE PERFORMANCE

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ABSTRACT

Internal combustions engine significantly relies on the complete combustion of the air-fuel mixture that means fewer emissions and results with higher efficiency. This work studied fuel ionization by using a magnetic field which will make sure better combustion. The liquid fuel converts into fine particles by using fuel injector. So this work is an experimental study showed the impact of magnetic field on compression ignition engine performance. The engine speed was different from (1000 to 2500) rpm without and with using magnetic field into changed intensity which has (7000, 9000 and18000) Gauss. The magnetic field was connected to the outer surface of inlet fuel pipe in the appropriate position previously fuel injection pump. The experimental outcomes include a reduction in the fuel consumption in compression ignition engine was found up to (15.71%), brake specific fuel consumption up to (15.71%). The exhaust gas emissions presented a reduction almost by (10.25%) of CO, (7.40%) of NO_X and (29.82%) of HC, but increasing CO_2 emission by (33.04%).

Keywords: magnetic field, internal combustions engine, performance.

1. INTRODUCTION

The shortage of fuel and pollution that produce from emission from internal combustion engine induced the engine researchers and manufacturers to discover different techniques in which can be reduced the engine emissions and fuel consumption. One of these ways was ionizing the molecules of fuel to create a homogenous combination and fine droplets of fuel in injection manner via using a magnetic field.

Al-Khaledy considered the influence of using the magnetic field on pollution emission and compression ignition engine performance. The trial work was achieved by using an electrical generator (100KVA) with and without magnetic field unit for four weeks' time. The experimental outcomes display the magnetic field decreased the engine emissions and effected on engine performance [1].

Daniel studied the results of magnetic field on four-stroke diesel engine performance experimentally. The outcomes determined by the magnetic field is rising the engine efficiency and reduced engine emissions caused by improving fuel atomization [2]. Kumar examined the impact of fuel ionization on compression ignition engine effectiveness. The magnetic field has intensity 1000 gauss. The experimental consequences presented the ionization of fuel reduced the engine emissions and rose engine thermal efficiency caused by increasing the combustion efficiency [3]. Vivek[4], tested the influence of magnetic field on single cylinder four stroke compression ignition engine performance. The area of magnetic which was set up on the external surface of the fuel pipeline has the intensity of 5000 gauss. The trial outcomes demonstrate the magnetic field decreased the HC and CO but rise CO_2 and NO_X emissions. Piyush[5], examined the influence of magnetic field on single cylinder four stroke compression ignition engine performance experimentally. The magnet which set up over fuel pipe has intensity 2000 gauss. The trial consequences display the magnetic field decreases the engine fuel consumption and emissions (CO_2, CO, NO_X and HC).

Kushal[6], considered the effect of intensity for magnetic field on the single cylinder compression ignition engine effectiveness. The trial work was achieved by applying a magnetic field of changed intensity 1000G to 4000G. The highest result is found at 3000 G. The experimental outcomes display the method of the apply magnetic field on the outer surface of the fuel pipeline reduced the fuel consumption, exhaust temperature, brake specific fuel consumption and CO_2, CO, HC and NO_X emissions. Moreover, the thermal brake efficiency is more significant than before with magnetically applied to fuel pipeline. Chen [7] examined the influence of the magnetic tube on pollutant emissions from the diesel engine. The magnetic tube was set up at the fuel intake of a diesel generator at the idle condition with a constant speed of 1800 rpm, 50% and 25% loads, respectively. The fuel consumption and brake specific fuel consumption were reduced by an average of 15% and 3.5%, separately, while approximately 3.5% upgraded the thermal brake efficiency. Carbon monoxide, particulate matter, hydrocarbons and carbon dioxide emissions reduced in the range of, 5.4-11.3%, 21.9-33.3%, 29.4-64.7% and 2.68-4.18%, separately.

The current work has been focused on the effect of magnetic field on compression ignition engine performance and other properties and emissions. The engine speed was different from (1000 to 2500) rpm without and with using magnetic field into changed intensity which has (7000, 9000 and18000) Gauss. Exhaust gas analyser was used to determine the engine emissions. The Engine model was used for the first time in the current work to reveal the effect of the magnetic field on this engine according to compression ignition engine performance and emissions.

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2. EFFECT OF MAGNETISM ON PHYSICAL PROPERTIES OF THE FUEL

Liquid or gas molecules have positive and negative electric charges. Liquid or gas atoms attracted to each other to form clusters. The magnetic field which is created by a permanent magnet or electric magnet into changed strengths effected on fuel chemical stricture and converted the random structure of liquid or gas to the organised structure as like regulated chain approximately this named ionization. The rule of the chemical composition of fuel, when put on the magnetic field of fuel, increases the capability of the fuel to respond with air and form regular combination throughout of fuel injection within the combustion chamber. The decrease in fuel surface tension as a result of magnetic field influence lower the fuel droplets size during injection process in this condition outer surface area of injected fuel, which exposes to the hot air and oxidiser, will rise this leads to better combustion efficiency. At large, the magnetic field reduced the fuel consumption, engine emissions and rose the thermal efficiency of the engine.

3. ENGINE PERFORMANCE MATHEMATICAL MODEL

The performance of engine can be simulated in the following simple model based on general heat engine thermodynamics:

1- Fuel mass flow rate.

$$\dot{m}_f = \frac{V_F}{\text{time}} \times \rho_F \quad {}^{\text{kg}}/_{\text{sec}} \qquad (1)$$

2- brake power

$$bp = \frac{2\pi * N * T_b}{60 * 1000} kW \qquad (2)$$

3- Brake specific fuel consumption

$$\text{bsfc} = \frac{\dot{m}_f}{\text{bp}} \times 3600 \quad \frac{\text{kg}}{\text{kW.hr}} \qquad (3)$$

4- Air consumption (C.I. engine)

$$\dot{m}_{\text{a,act.}} = 2.056 \times 10^{-4} \times \sqrt{\nabla P}\, \frac{\text{kg}}{\text{sec}} \qquad (4)$$

5- brake thermal efficiency

$$\eta_{bth.} = \frac{bp}{\dot{m}_f * \text{L.C.V}} \qquad (5)$$

Where;

V_F : the volume of fuel consumption.
ρ_F :the density of fuel kg/m^3.
N : rotational speed rpm.
Tb : Torque of engine N.m.
∇P : pressure differences by the manometer.

4. EXPERIMENTAL WORK

The trial work is accomplished in laboratories of the mechanical engineering department. The investigation rig is manufactured and fabricated by arm Field Company and delivered by calibrated instrumentation tools, which are required for the general study.

A. Experimental setup

The experimental trial rig, shown in the Figure-1, involves from swing dynamometer attached to the four-stroke single cylinder, compression ignition engine has a capacity of 175 cm^3, air-cooled;[Technical specification - Table-1]. A belt linked the engine and dynamometer. The dynamometer utilized for applying changing load on the engine. The modern control system can adjust the speed of the dynamometer[8]. The operation variable which can be estimated by using instrumentation tools during engine inspection is Brake torque (N. m), Engine speed (rpm), Fuel consumption, Exhaust temperature and Air consumption. The torque measuring is accomplished by using torque sensor, which connected beside the dynamometer. The speed change between the dynamometer and engine permit the dynamometer to apply the force in the two different directions on torque sensor. When using the power of torque sensor because of the difference in speed the torque sensor created an electric signal which is transmitted at later to control system to evaluate the value of torque.

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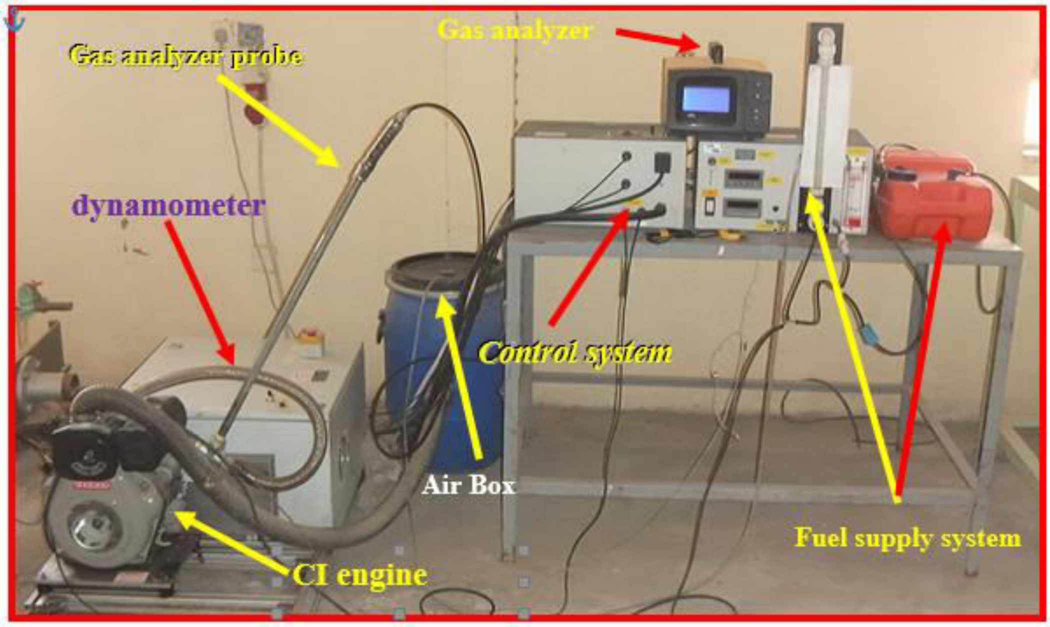

Figure-1. Combustion system test rig.

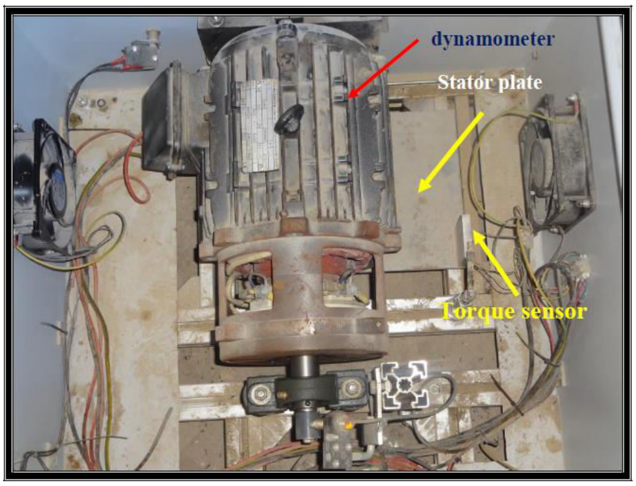

Figure-2. Torque measuring system.

The internal combustion engine test rig likewise consists of fuel measuring system which involves the graduate glass tube and stopwatch. The quantity of air consumption during engine testing can be assessed by using air box. The principle of air consumption calculation is determined by the pressure difference between atmosphere and airbox which can be considered by using a manometer. The engine speed is calculated by using speed sensor which is connected at the end of the dynamometer shaft Figure-2. The exhaust temperature of the engine can be assessed by using temperature sensor which is installed on exhaust manifold before the engine muffler. Exhaust gas analyser sort (mod 488 - Italy) was utilised to test engine emissions. The analyzer finds out the carbon dioxide, carbon monoxide, nitrogen oxide and unburned hydrocarbon.

Table-1. Main technical conditions of compression ignition engine.

Engine type	**Single cylinder, four stroke**
Engine model	95310
Ignition timing	25^0 BTDC
Displacement	118cm3
Valve per cylinder	two
Bore	60 mm
Stroke	42 mm
Compression ratio	7.5
Engine cooling type	forced air cooled
Lubrication	Forced lubrication
Engine oil capacity	0.6 L
engine rotation direction	counter clockwise (view from output shaft)

B. magnetic field intensity and position selection

The permanent magnet is used in the trial work to study the influence of fuel ionazation on compression ignition engine performance. The magnet is installed before the injection pump to ionize the fuel molecules as shown in Figure-3. The magnetic field intensity was measured by using calibrated tesla meter. The intensity was (7000, 9000, and 18000) Gauss.

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Figure-3. Shows the position of magnetic field on the outer surface of the fuel pipeline.

C. Experimental procedure

The experimental work should follow this process to complete trials:

a) The instrumentation and the engine were set to standby mode. The magnet is connected to the outer surface of the fuel pipeline and takes the results of the emissions with and without magnetic field existence at different intensity.

b) Determining brake torque, engine speed, the pressure differential between the atmospheric pressure inside the air box, timing of fuel consumtion for the volume of (100) ml and exhaust temperature all this work would be with and without using a magnetic field.

RESULTS AND DISCUSSIONS

The results acquired from the experimental work are presented to reveal the effect of using the magnetic field on compression ignition engine performance. The primary operating variables estimated to be affected by using the magnetic field on spark ignition are break power, specific fuel consumption, engine emission, and magnetic field intensity.

To sum up, the major results are presented through the following concluded remarks:

- The magnetic field decreased the brake specific fuel and fuel consumption. The brake specific fuel consumption and fuel consumption drop increasing with the rising intensity of magnetic field. The maximum decrease in fuel consumption when using magnetic field has intensity(7000,9000,18000) Gauss, are (7.14 %, 13.63 %, 15.71%) respectively as shown in Figures (4) and (5). This trend attributed to that the magnetic field induced diesel surface tension and formed a homogeneous mixture

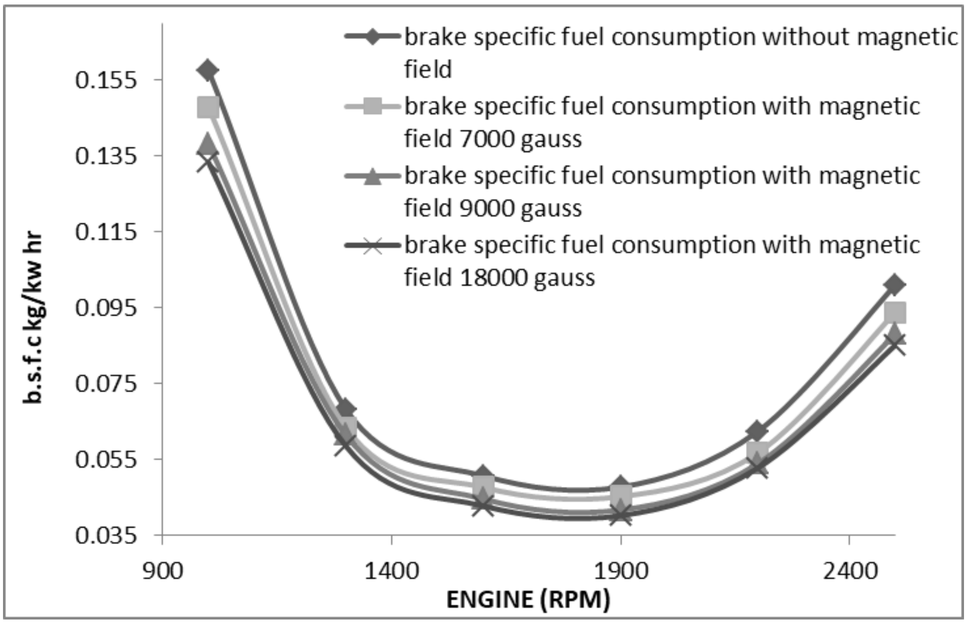

Figure-4. The relation between engine speed and brake specific fuel consumption (bsfc).

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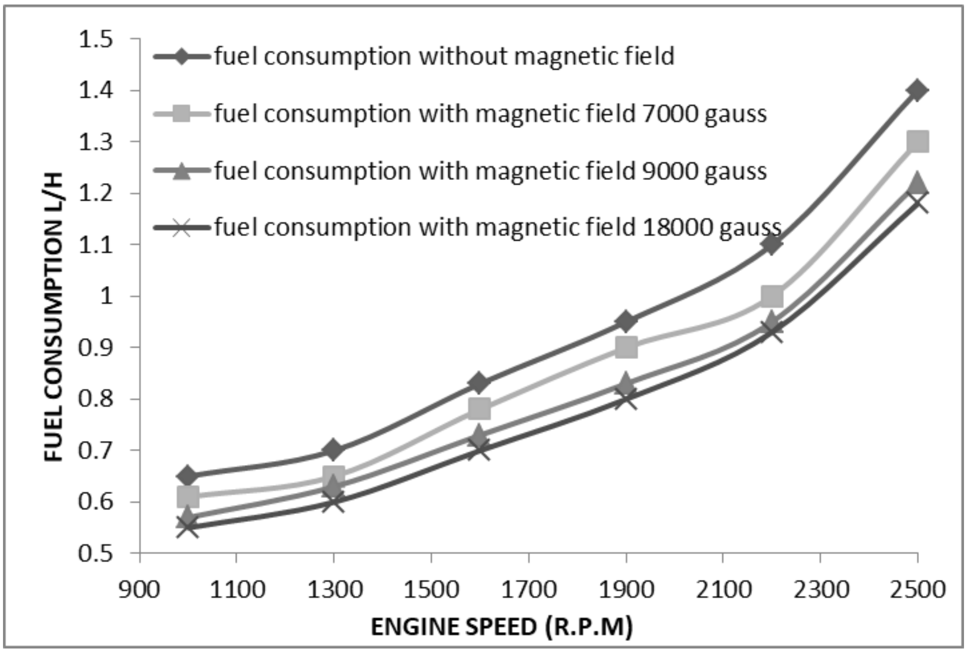

Figure-5. The correlation between engine speed and fuel consumption (L/h) engine.

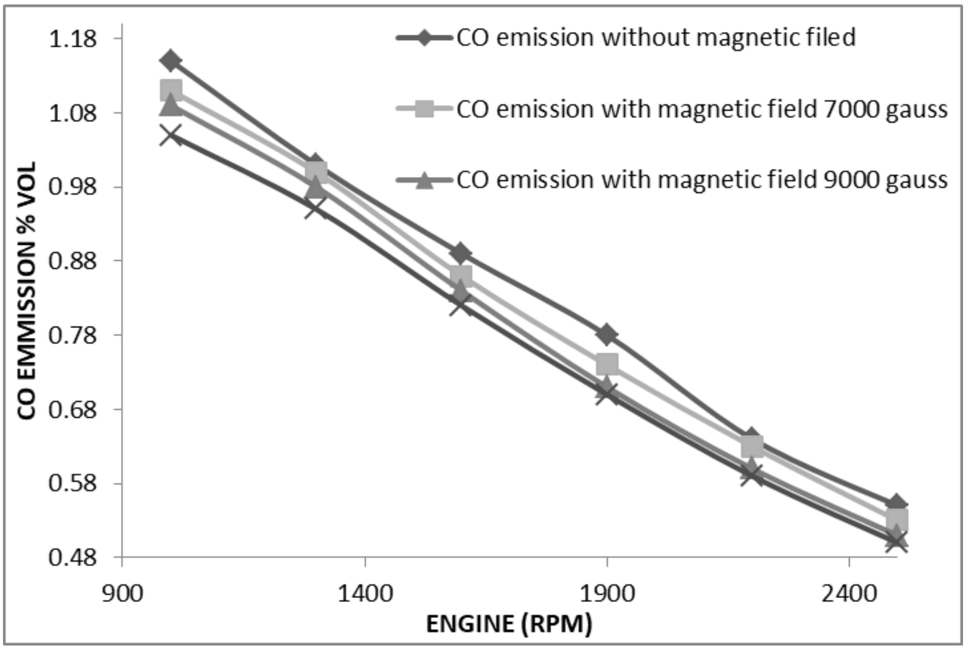

Figure-6. The relationship between engine speed and (CO) emission with and without magnetic field effect.

- The magnetic field reduced engine emissions. The maximum lessening in emissions of (CO, HC and NOX) are (10.25%,29.82%,7.4%) respectively when using magnetic field has the intensity of 18000 gauss as shown in Figures (6,7 and 8).

This behaviour of engine emissions reduction because of that the magnetic field ionized fuel molecules so that microstructure of fuel molecules will convert from cluster shape to straight chain shape in this situation the homogenous mixture will be shaped during the injection process. Furthermore, the magnetic field decreased the fuel surface tension due to fuel molecules ionization in this condition.

The acceptable droplets of fuel will produce during injection process this will raise the outer surface area which exposes to the heat and oxidiser. Therefore, the combustion efficiency will rise, and pollution emission from IC engine will be reduced.

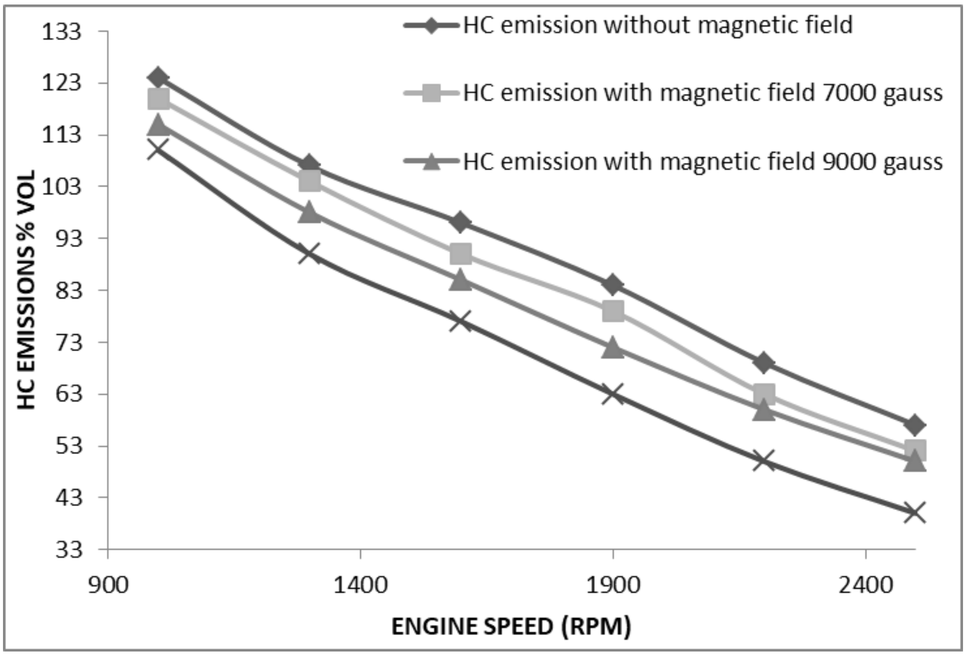

Figure-7. The relation between engine speed and (HC) emission with and without magnetic field effect.

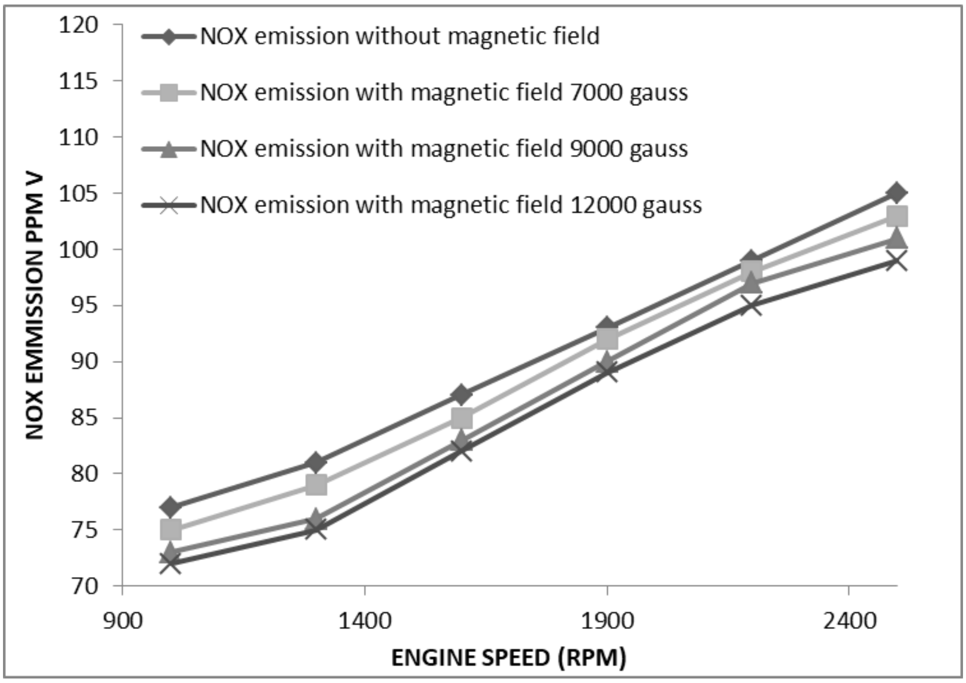

Figure-8. The relationship between engine speed and NO_X emission with and without magnetic field effect.

- Using magnetic field improved percent of (CO_2) where this emission was lower without using magnetic field by about (37.20%), respectively. As shown in Figure-9, the carbon monoxide emissions are increasing using magnetic field because of the magnetic field ionized fuel and produce a homogeneous mixture which gives good combustion efficiency throughout of the combustion progression.

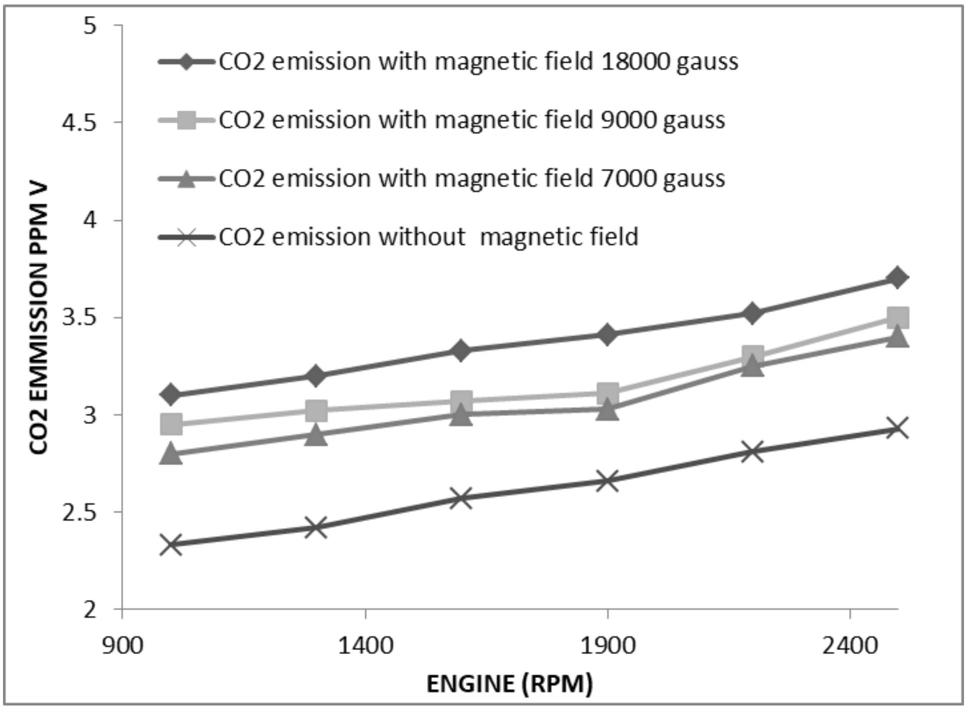

Figure-9. The relation between engine speed and (CO_2) emissions with and without magnetic field effect.

6. CONCLUSIONS

The outcome of using the magnetic field on compression ignition engine performance, for a variety of engine speed and magnetic field intensity can be concluded as below:

a) Magnetic field reducing fuel and specific fuel consumption.

b) Using magnetic field increasing the engine thermal efficiency due to rise combustion efficiency within the combustion chamber.

c) CO, HC and NO_X emissions reduced by using a magnetic field.

d) Using magnetic field increased CO2 emissions as a result of improving the combustion efficiency.

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