Effect of the Magnetic Field on the Fuel Consumption of a Spark Ignition Engine

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ABSTRACT

The present work deals with the effect of the magnetic field on the performance of spark ignition engine. The engine performance was observed by examining the fuel consumption and brake specific fuel consumption for different values of octane number (68, 75, 83 and 85), to find out what sample of octane number is affected by a magnetic field significantly more than the others.

The experimental results showed that the fuel of octane number 75 exhibited a reduction in fuel consumption (L/h) up to (11.73%) and (21.48%), and brake specific fuel consumption (Bsfc) up to (11.11%) and (19.9 %), for one and two magnets respectively. Fuel of octane number 83 showed a reduction in fuel consumption (L/h) up to (0.907%) and (2.13%), and for brake specific fuel consumption (Bsfc) up to (0.96%) and (1.83%), for one and two magnets, respectively. For fuel of octane number 85, the reduction in fuel consumption (L/h) was (0.322%), and for brake specific fuel consumption (Bsfc) was (0.47%), for two magnets only.

Keywords: Magnet, magnetic field, fuel consumption, spark ignition engine.

تأثير المجال المغناطيسي على استهلاك الوقود لمحرك إشتعال بالشرر

الخلاصة

تناولت هذه الدراسة تأثير المجال المغناطيسي على اداء محرك اشتعال بالشرر عن طريق ملاحظة معدل استهلاك الوقود المكبحي النوعي لأربعة نماذج من الوقود مختلف العدد الاوكتاني وهي (68,75,83 and 85) ومعرفة أي نموذج من الوقود هو الاكثر تأثرا عند تسليط المجال المغناطيسي.

أظهرت النتائج العملية ان الوقود ذو العدد الاوكتاني 75 أظهر أستجابة لتأثير المجال المغناطيسي إذ انخفض أستهلاك الوقود بنسبة (11.37%) و (21.48%) على التوالي، وأستهلاك الوقود النوعي المكبحي بنسبة (11.11%) و (19.9%) على التوالي، بأستخدام مغناطيس وزوج من المغانط. كما أظهرت النتائج العملية ان الوقود ذو العدد الاوكتاني 83 تأثر بالمجال المغناطيسي بشكل أقل من النموذج السابق إذ انخفض أستهلاك الوقود بنسبة (0.907%) و (2.13%)، و أستهلاك الوقود النوعي المكبحي بنسبة (0.96%) و (1.83%)، بأستخدام مغناطيس واحد وزوج من المغانط على التوالي. أما بالنسبة للوقود ذو العدد الاوكتاني 85 فقد أظهرت النتائج أن تأثير المجال المغناطيسي يكون أقل من سابقيه إذ انخفض أستهلاك الوقود بنسبة (0.322%)، وأستهلاك الوقود النوعي المكبحي بنسبة (0.47%) ولم يلاحظ أي تأثير على الوقود بأستخدام مغناطيس منفرد.

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INTRODUCTION

Today's hydrocarbon fuels leave a natural deposit of carbon residue that clogs carburetor and fuel injector, leading to a reduction in efficiency and wasted fuel. Pinging, stalling, loss of horsepower and greatly decreased mileage on cars are very noticeable [1 & 2].

For many years, researchers tried to design a combustion system that has low air pollution through completely hydrocarbon combustion. Various techniques such as air-fuel mixing, ignition, temperature controlling combustion chamber and catalyst have been developed. All the previous methods are not able to completely resolve the problems yet. Low efficiency of combustion heat, unburned fuel and air pollution and soot are still problem now [3]. One of the techniques that lead to increased efficiency and reduced emission is "magnetization of the hydrocarbon fuel molecules"[4]. This is achieved by exposing the fuel to a permanent magnetic field. The concept of exposing fuel molecules to magnetic field dates back to J.D Van-der Waals and his experiments in the field in 1873 [5]. It is well known that hydrocarbon have long branched geometric chains of carbon atom, which have tendency to fold over unto themselves and on adjoining molecules due to intermolecular electromagnetic attraction existing between them [6]. Fuel molecules have tendency to interlock with other compounds temporally forming pseudo compounds, subjecting these pseudo compound to magnetic field of appropriate strength and direction tends to un-cluster the molecular grouping resulting in a reduction of fluid viscosity at the macroscopic levels, hence proper mixing, and the reduction in the delay period of combustion ensues [7]. Van der Waals applied a magnetic field to fuel molecules and found out that the viscosity of the fuel decreases with the application of the field and consequently an increase in the flow rate of the fuel. This is because all substances according to faraday are affected by a magnetic field though; in most cases, this influence may be insignificant. Fuel molecules subjected to external magnetic field, are usually excited, which in turn causes mole reorientation in order to accommodate the applied external magnetic field [8]. The above phenomenon is attributed to the fact that on the molecular level, a spinning electron subjected to precise amount of electromagnetic energy absorbs that energy and spin-flip into an aligned state [9].

Methodology

The effect of the magnetic field on Iraqi gasoline fuel was used in the engine and its impact on the amount of consumption, the appropriate method is examined. We include below the description of the materials and equipment used.

Magnetic devices

Two types of Magnetic devices with intensity of (1000) Gauss are showed in Fig (1) used in this research. Both are manufactured in the U.S.A. Accepted Laboratory Tested EPA. The fuel is subjected to the lines of forces from permanent magnets mounted on fuel inlet lines. The magnet for producing the magnetic field is oriented so that its (South Pole) is located adjacent the fuel line, and its (North Pole) is located spaced apart from the fuel line. Applying a magnetic field to ionizing fuel to be fed to combustion devices, one can ensure more complete combustion, obtaining a maximization of the fuel economy, improving the fuel efficiency and reducing polluting emissions.

Figure (1). The Magnetic devices used in recent study

Engine

The experimental work was performed in the internal combustion engine laboratory of the machines and equipment engineering department – university of technology. The engine used in the experimental work is spark ignition engine (SI engine) Mercedes-Benz (200), 4-stroke, 4 cylinders. The displacement volume for this engine is 2 liters. The engine was coupled to a hydraulic dynamometer to measure the brake torque. Figure (2) shows the experimental rig of the engine.

Figure (2). S.I. engine experimental rig

Measuring parameters

The following engine parameters are measured: brake torque (using hydraulic dynamometer), air consumption (using induction air system consists of air box, orifice and the manometer), fuel consumption (using glass tube and stop watch) and engine speed (using tachometer).

Measurement of brake torque

The hydraulic dynamometer, type [isi lingegneria didattica] was used to measure the brake torque of the engine by using friction fluid. Water was used as the friction fluid.

Figure (3).Tthe hydraulic dynamometer.

Air consumption

The air supplied to the SI engine was measured by using used to measure the pressure differential between the atmosphere and pressure in the air box. See figure (4).

Fuel consumption

The glass tube was used to measure the fuel consumption of the SI engine. This glass tube has a constant volume (100) ml, and a stop watch was used to measure the fuel consumption of this volume. See figure (5).

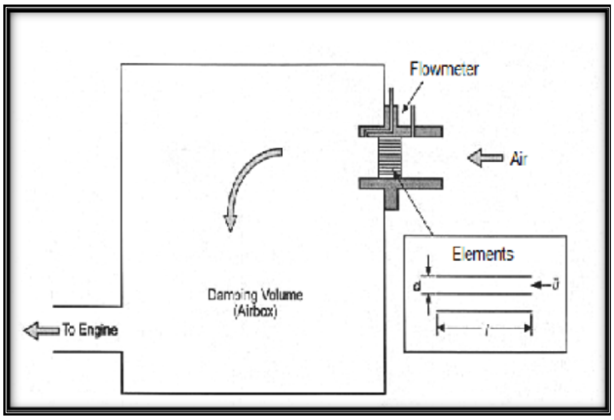

Figure (4). The air box construction [5].

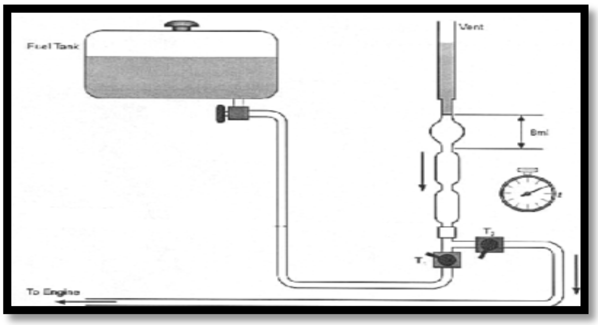

Figure (5). The measurement of Fuel Consumption of the engine [3].

Measurement of engine speed

The measuring of the engine speed of spark ignition engine was carried out by using analogue tachometer type (VDO). See figure (6).

Figure (6). Tachometer type (VDO).

Calibration

To ensure that all the data read from the measuring devices are correct, a calibration was done to all measuring devices. The calibration of each device was carried out by comparing its readings with the readings of a calibrated device at the same conditions weather load or engine speed.

Tachometer

The linear method was used to calibrate the speed measuring instrument. A measured speed by a tachometer type (VDO) setup in the the experimental rig was compared by a diagrammatic speed that was obtained from another tachometer type (gas analyzer) which can also be used for measuring the engine speed by attaching an inductive clip-on pickup to a spark plug cable. The results were compared and plotted, as shown in figure (7).

Hydraulic Dynamometer

Brake power that resulting from the hydraulic dynamometer is calibrating by compare it with the electric power that resulting from an Electric generator installed in experimental rig.

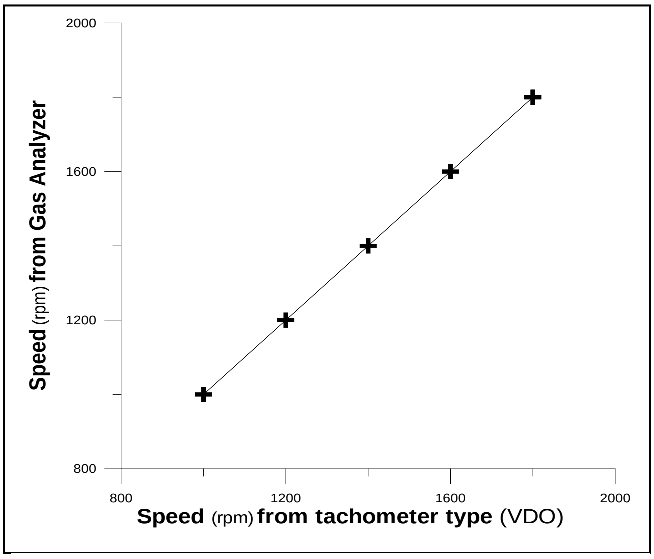

Figure (7). the tachometer calibration.

The following equations were used in calculating engine performance parameters:

The brake specific fuel consumption [10]:

$$\mathrm{Bsfc} = \frac{\dot{m}_f}{Bp} \times 3600 \quad \frac{kg}{kW.hr} \qquad \ldots (1)$$

Air Consumption($\dot{\mathbf{m}}_{\mathbf{a,act.}}$) [Device-specific equation]

$$\dot{m}_{a,act.} = \frac{5\sqrt{h_o}}{3600} \times \rho_{air} \quad (kg/Sec) \qquad ...... (2)$$

Fuel mass flow rate ($\dot{\mathbf{m}}_{\mathbf{f}}$) [10]:

$$\dot{m}_f = \frac{V_{F^*}}{time} \times \rho_F \quad (kg/sec) \qquad .... (3)$$

$^*V_F$ = volume of fuel consumption.

Experimental procedure:

The following steps were done to implement the experimental work:

1. Preparing the engine and the measurement devices to read the data for natural case and by using magnets for (1300, 1500, 1700, 1900 and 2100) rpm.

2. Measuring engine speed, brake torque, the pressure differential between the atmosphere and pressure inside the air box, and time of fuel consumed for volume of (100) ml, with and without using magnetic field.

Figure (8) represent the engine used in the implementation of the experiments with applying magnets.

Figure (8). the engine with magnets.

Result and discussion:

The experimental results were obtained by testing of the SI engine while applying magnetic field on the fuel input line.

Effect of magnetic field on fuel consumption (L/h):

Figures (9) and (10) show that the fuel consumption was increased when the octane number was decreased and when the engine speed was increased, respectively.

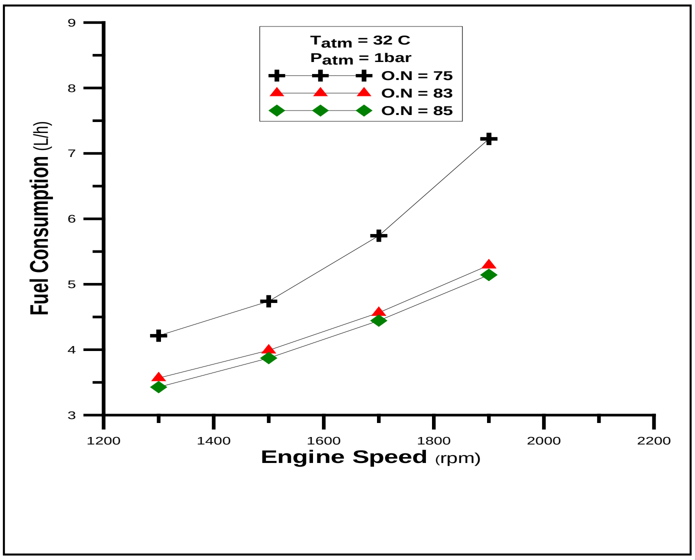

Figure (9). Fuel consumption (L/h) as a function of engine speed for three samples of fuel without magnet.

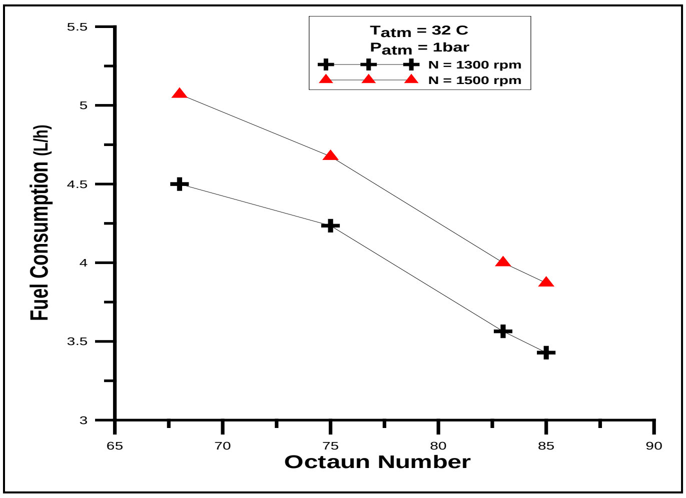

Figure (10). Fuel consumption (L/h) as a function of octane number for engine speeds (1300) and (1500) rpm without magnet.

Increasing engine speed requires more fuel causing higher fuel consumption, while the reduction in gasoline octane number means reducing the lighter hydrocarbon molecules which has high resistance to knock, and in the same time it burned completely. Higher hydrocarbon molecules with longer ranches need more heat to be cracked and evaporated and more time to mix with air. All these factors cause that some of the fuel will not burn, and as a result, a reduction engine performance and increment in fuel combustion will be achieved.

Figure (11) represents the amount of fuel consumed (L/h) with the engine speeds for the engine used fuel of octane number 75, with magnetic field and without it.

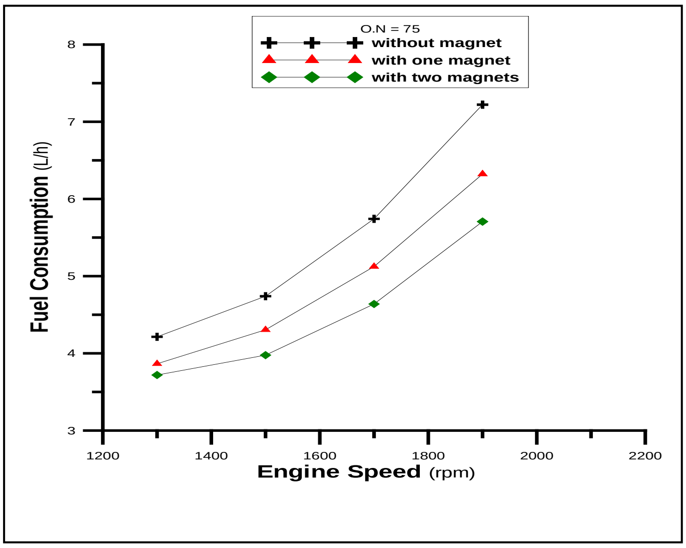

Figure (11). Fuel consumption (L/h) as a function of engine speed for fuel has octane number of 75, with and without magnetic field.

It can be seen from the figure that adding magnetic field reduced fuel consumption highly. The reduction in fuel combustion was 11.73 and 21.48% for adding on magnet and two respectively.

Figure (12) depicts the amount of fuel consumed (L/h) with the engine speeds for the engine used fuel of octane number 83, with magnetic field and without it. It can be seen from the figure that adding magnetic field to fuel line has limited effect on fuel consumption reduction. The reduction in fuel combustion was 0.907 and 2.13%, for adding on magnet and two respectively.

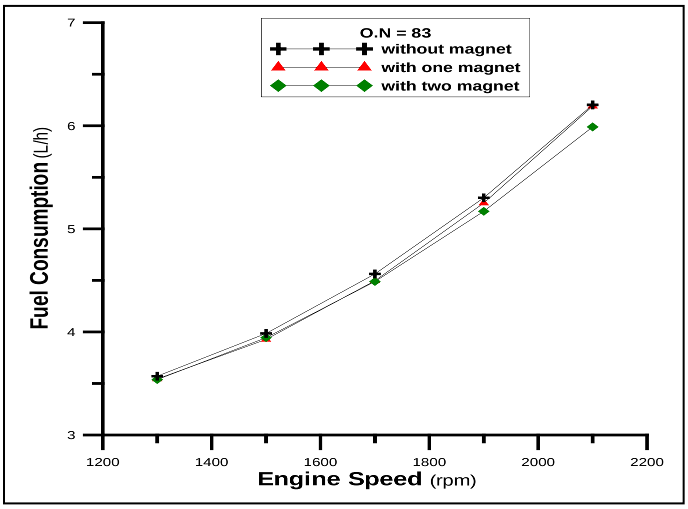

Figure (12). Fuel consumption (L/h) as a function of engine speed for fuel has octane number of 83, with and without magnetic field.

Figure (13), represents the amount of fuel consumed (L/h) with the engine speeds for the engine used fuel of octane number 85, with magnetic field and without it.

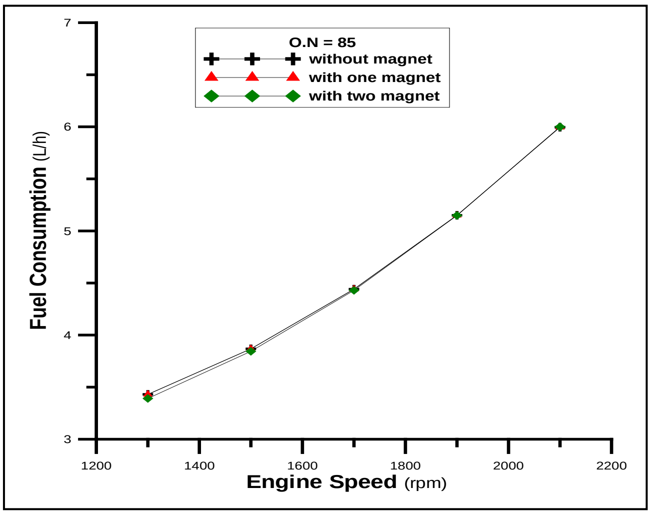

Figure (13). Fuel consumption (L/h) as a function of engine speed for fuel has octane number of 85, with and without magnetic field.

The effect of adding magnetic field is very limited in this case. The reduction in fuel combustion was 0.322%, for adding two magnets while adding one magnet didn't reveal any reduction in fuel consumption.

For all above cases, the effect of the magnetic field is clear in the fuel of lower octane number. The decrement in the octane number is directly proportional to the fuel viscosity ddecreasing. The magnetic field affected the molecular grouping resulting in a reduction of fluid viscosity at the macroscopic levels, ionization and realignment of fuel molecule or hydrocarbon chain, the fuel is now actively interlocked with oxygen, hence proper mixing and combustion occurs in (I. C. E) resulting in a better fuel economy.

Effect of magnetic field on brake specific fuel consumption (Bsfc)

Figure (14) shows that the brake specific fuel consumption decreased when the octane number and the engine speed was increased.

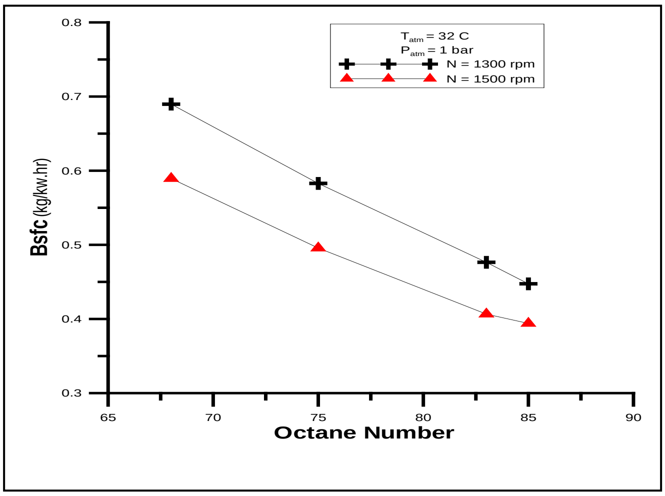

Figure (14). Brake specific fuel consumption (Bsfc) as a function of octane number.

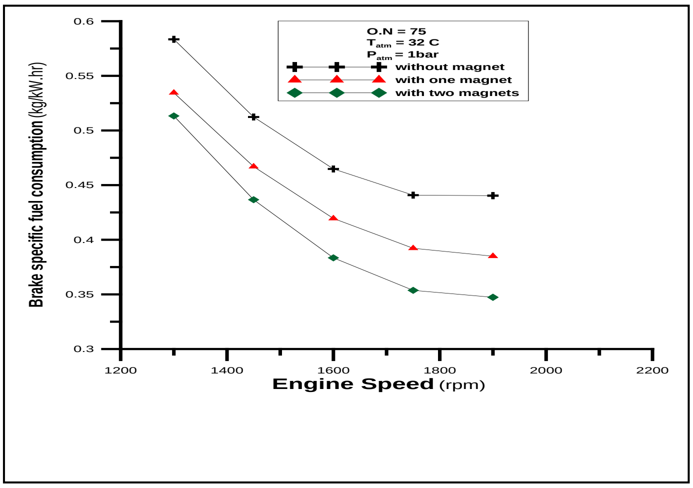

Figure (15). Brake specific fuel consumption (Bsfc) as a function of engine speed using octane number of 75, with and without magnetic field.

Octane number can be increased by increasing short hydrocarbon chains in the fuel. These hydrocarbons mix with air better than long chains and make the fuel viscosity lower enhancing the combustion and reducing Bsfc.

Figure (15) shows the relation between brake specific fuel consumption (Bsfc) and engine speed with and without using magnetic field for the engine, when using the fuel octane number of 75. The effect of adding magnetic field is clear in reducing Bsfc. Increasing magnetic field intensity by subjecting two magnets on fuel line reduced Bsfc by 19.9% while subjecting one magnet reduced Bsfc by 11.11%.

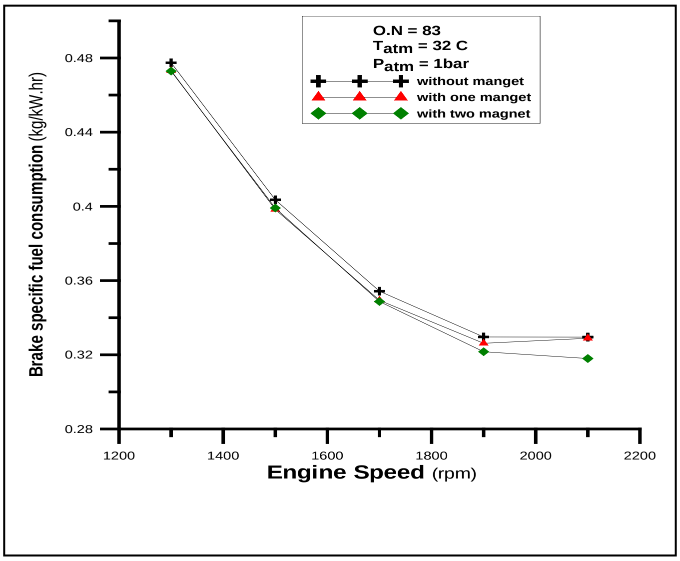

Figure (16). Brake specific fuel consumption (Bsfc) as a function of engine speed using octane number of 83, for with and without magnetic field.

Also, Figure (16), reveals the relation between brake specific fuel consumption (Bsfc) and engine speed with and without using magnetic field for the engine when using the fuel octane number of 83. It can be seen from the figure that the effect of magnetic field was reduced compared with fuel has octane number of 75. Basically, increasing octane number depends on reducing fuel viscosity by increasing hydrocarbons with shorter chains. When the fuel has higher octane number that means it already achieved these parameters, and the magnetic field will add limited reduction in fuel Bsfc

Figure (17) reveals the relation between brake specific fuel consumption (Bsfc) and engine speed with and without using magnetic field for the engine when using the fuel with octane number of 85.

The results conducted in this figure insure the previous explanation for the reduced effect of magnetic field on Bsfc of gasoline with higher octane number. In this case operating the engine with fuel has octane number of 85 demonstrated no response for adding on magnet to the fuel pipe line. Adding two magnets resulted in very little reduction of about 0.47%. The magnetic field effect appears at low engine speeds while at high engine speeds it has no effect. Increasing engine speeds means higher fuel flow rate that reduced the time needed by the magnetic field to affect the fuel viscosity.

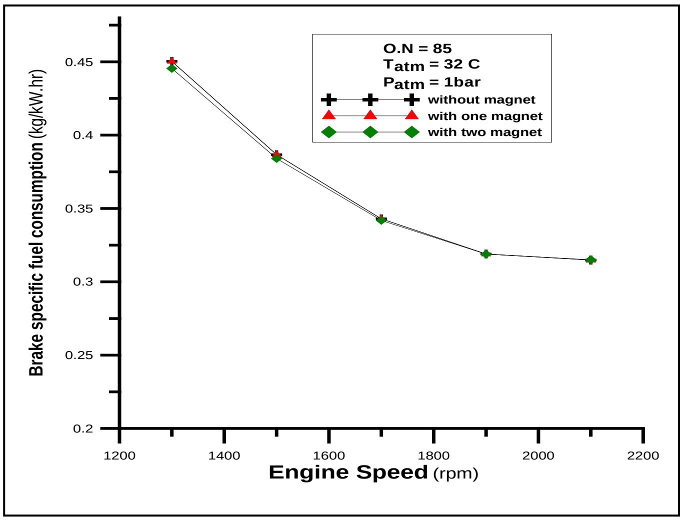

Figure (17). Brake specific fuel consumption (Bsfc) as a function of engine speed using octane number of 85, with and without magnetic field.

CONCLUSION

1.Fuel of octane number 75, Showed disorder in the performance of the engine when the engine is running with speeds higher than 1900. Because the higher speed resulting in fluctuation of the engine speed.

2.Fuel of octane number 75, showed a response to the effect of the magnetic field more than the fuels of octane number 83 and 85. This means that the magnetic field affects the fuel with lower octane number.

3.Bsfc of the engine improved with the increasing of the octane number, and this is clear in this work.

4.Adding magnets to engine fuel lines on reducing fuel viscosity which is depended on fuel composition weather low carbon hydrocarbons (that means C_1, C_2, C_3 and so on or high carbon with long chains hydrocarbons).

5.As Iraqi gasoline is low octane number fuel it is recommended to use this procedure in gasoline automotives.

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