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The effect of magnetic field on the boiler performance fueled with diesel

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Abstract— The aim of this study is to investigate the effect of a magnetized fuel on the performance of the fuel combustion in the boiler. The performance was observed by examining fuel consumption and exhaust emissions, in this experimental work we are using a diesel fuel that is subjected to a magnetic field which is placed on the fuel supply line to magnetize the fuel before admitted to the burner of the boiler. The magnetic field used in this study is coming from two permanent magnets each with (2000 Gauss).
From the experimental result show an improvement in boiler performance after the fuel subjected to a magnetic field. The fuel consumption is decreased by (3.675%). The exhaust gas emission showed a reduction nearly by (38.04%) in CO, (21.89%) in HC. An increase by (3.432%) in CO_2 and by (4.34%) in the exhaust temperature were observed.

Keywords: external combustion engine, Effect of magnetic field on fuel consumption and exhaust emission and exhaust gas temperature.

1 Introduction

The conventional boiler which runs on the combustion of diesel fuel has been around for two century. The external combustion engine has a huge role in generating steam in a power plant for its speed, high efficiency and the low cost to run [1]. The diesel combustion fuel is industry's leading prime mover, and will likely remain so for a foreseeable future. To keep using this fuel it has become imperative to improve the fuel consumption and emission characters [2].

Iraqi diesel fuel is characterized by its low cetane number (about 49) and high sulfur content [3]. Several research articles treated this dilemma from several directions as adding methanol and ethanol to diesel [3]. Other attempts like adding biodiesel fuels to diesel [4]-[5], using an alternative way to run the engine like Partially-Premixed (PPCE) [6] or adding gases like hydrogen or natural gas in dual-mode operation [7]-[8]-[9]-[10] were conducted.

Many of experimental studies presented evidence of the benefits of magnetic treatment which will enhance the fuel economy and reducing exhaust emission. Sanderson [11] showed a method and apparatus for treating liquid fuel in external combustion engine by passing it through a magnetic field before mixing it with air in the burner. Fatih & Saber [12] experiments revealed that the magnetic effect on the reduction of the fuel consumption was up to 15%, CO concentration reduction was up to 7%. The reduction of NO emission was up to 30%. The reduction of CH_4 was up to 40%. The experiment of Faris et. al. [13] comprised the using of permanent magnets with deferent intensities of (2000, 4000, 6000, 8000) Gauss, which were installed in the fuel line of two-stroke engine and study of its impact on gasoline consumption, as well as exhaust gases for comparing purpose. The result necessitated conducting some experiments without the use of magnets. The overall performance and exhaust emission tests showed a good outcome, where the rate of reduction in gasoline consumption ranged between (9-14%), and the maximum reduction value at the rate of 14% was obtained using field intensity of 6000 Gauss, as well as the field strength of 8000 Gauss. It was found that 30% and 40% decrements were the percentage of exhaust gas components (CO, HC) respectively, but CO_2 percentage increased up to 10%.

Al-Dossary [14] studied the effect of magnetic field on internal combustion engine with unleaded gasoline and found that the effect of magnetic field on CO was the most significant at most engine loads and speeds. Allawi [15] described the reduction of fuel consumption by using magnetic field, to ensure the complete combustion. This leads to higher maximum thermal efficiency and reduction of emissions by subjecting the fuel to force the magnetic flux of the magnet installed at the entrance of the of fuel manifold, leading to more efficient combustion. From the experimental results, a reduction in the fuel consumption (L/h) in compression ignition engine (C.I. engine) was obtained up to (3%), and in brake specific fuel consumption (bsfc) up to (2.877%) while the brake thermal efficiency raised by about (3%). The exhaust gas emissions showed a reduction nearly by (13.8 %) of CO, (7.8 %) of CO_2 and (10.8%) of HC. Patel et.al [16] studied the effect of magnetic field on the engine performance parameters such as specific fuel consumption; break thermal efficiency, exhausts emissions by applying the magnetic field along the fuel line immediately before fuel injector. The strong permanent magnet of strength 2000 gauss is applied to fuel line for magnetic field. The experiments are conducted at variable engine load conditions. An exhaust gas analyzer is used to measure the exhaust gas emissions such as CO, CO_2, HC and NOx. With the application of magnetic field the reduction rate in fuel consumption was about 8% at high loads, the reduction in HC and NOx were about 30% and 27.7 % respectively. The CO emission reduced with the application of magnetic field at high loads. The reduction in CO_2 emissions was about 9.72% at average of all loads by applying a magnetic field.

The aim of this paper is to examine the effect of the magnetic field on Iraqi diesel fueled a burner of the boiler and its impact on the fuel consumption as well as emission of exhaust gases.

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2 Methodology

Fuels molecules consist of a nucleus and orbiting electrons. The charismatic movement already exists in these molecules. Therefore, they have active and negative charges. This situation tends to increase combustion fuel resistance. When fuel is passed through a magnetic field, its molecules are got realign, and the intermolecular forces are considerably reduced, and that will make them easier to interlock with oxygen; producing a complete burn in the combustion chamber. This procedure results in a better fuel consumption and reduction of hydrocarbon compounds, carbon monoxide and increases carbon dioxide emissions. The ionization of fuel also helps to dissolve the carbon build up in the fuel injectors, and combustion chambers were thereby keeping the engine in clean condition. Figs. 1 and 2 represent the effect of magnetic field on the fuel particles [17].

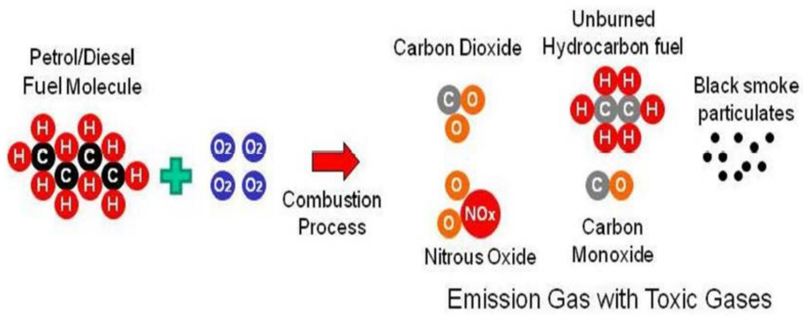

Fig. 1, incomplete combustion process without magnetic fuel

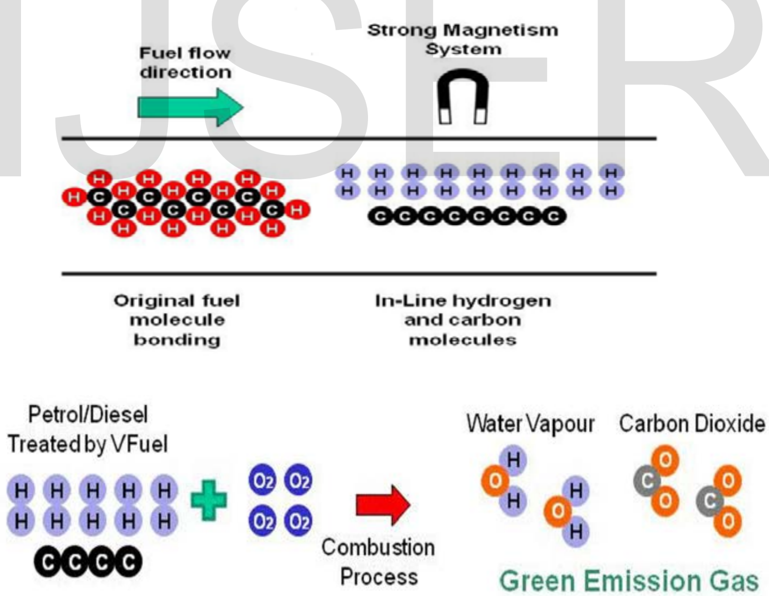

Fig. 2, schematic view of magnetic field and complete combustion

The description of the material and equipment used in the investigation are included below.

2.1 Magnetic devices

Magnetic devices (Fig. 3) which were used in this research manufactured in the USA. The fuel line is subjected to the forces from a permeate magnet mounted on the fuel inlet line. 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. The magnetic field strength was 4000 gauss. The magnetic field was applied to ionize fuel to be fed to the burner.

2.2 The Boiler

The boiler is provided with a burner type RL-70 as Fig. 4 represents. The burner has a tube of 385 mm in length, and an inner diameter of 156 mm penetrates the boiler to inject the

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tangential air and fuel inside the combustion as Fig. 5 declares. The burner has two nozzles with an orifice diameter of 0.65 mm placed in the center of the tube, which injects the fuel spray into the chamber.

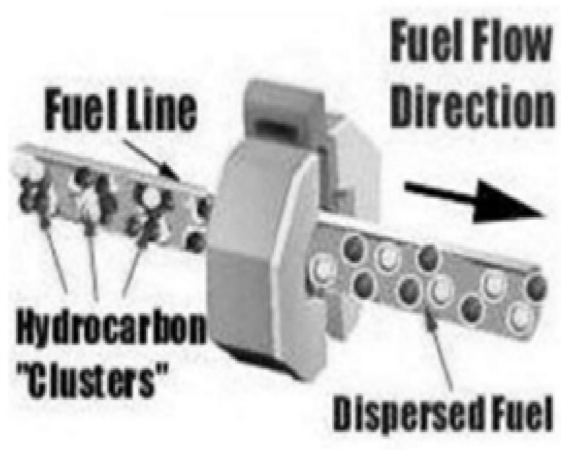

Fig. 3, the used magnet

Fig. 4, the burner

2.3 Rate of fuel consumption measurement

The rate of fuel consumption was measured by taking the initial fuel level in the observation tube and takes a measure of the level every five minutes after starting the combustion operation until the boiler is shutdown.

2.4 The rate of air consumption

The air supplied to the burner is measured by operating the burner without fuel injection (dry run), and using the air flow meter to measure the air velocity and adjusting the gate controlling the air flow. This method was used because the burner tube that penetrates the combustion chamber has a continuous area.

2.5 The exhaust gas temperature measurement

The measurement of the temperature was achieved by using a thermocouple and a digital reader. The measurement instrument was connected to the exit pipe of the exhaust manifold by a mean of the prop. Fig. 6 shows the digital reader.

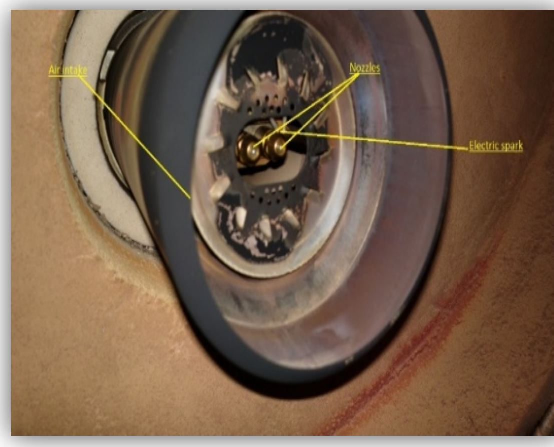

Fig. 5, the nozzles of the burner

Fig. 6, thermocouple and reader

2.6 Species consecration

The device used to measure the emission of exhaust gases is Flux 2000-4, which can detect the CO-CO_2-HC-O_2 gases. The exhaust gases are picked up by a probe from the chimney, and separated from moisture by a mean of condensate filter and goes to the measuring cell. A ray of infrared is transmitted and sent through the optical filter on the measuring element. The gases in the cell absorb the rays at different wavelengths according to their consecration. The CO_2, CO and HC are measured by their molecular composition. However, the device is equipped with a chemical sensor for the oxygen percentage. Fig. 7 represents the used appliance.

The following equations were used in calculating the fuel consumption of the burner [19]:

$$\text{The volume rate of fuel (m3/s)} = \frac{lenght\ (m) * width(m) * \Delta h(m)}{time}$$

The mass rate of fuel (kg/s) =the volume rate of fuel (m^3/s)* density (kg/m^3).

Fig. 7 the gas analyzer

2.7 Fuel specification

The fuel used in the experiment is prepared in the Al-Doura Refinery. This fuel made for the operations and was accompanied by a document of its properties. Table 1 is the used fuel resources.

TABLE 1
FUEL PROPERTIES

Property	Value
Fuel type	Iraqi diesel
Cetane number	58
Lower calorific value (KJ/Kg)	44844
Specific gravity (Kg/m^3)	0.8266
Flash point (^{o}C)	92
Pour point (^{o}C)	-6
Viscosity (mm^2/s at 40^{o}C)	14.3

3 Result and discussions

Two experiments were carried out to determine the impact of using the magnetic field on the fuel. The first experiment was conducted without using the magnetic field while the second one was accomplished with the magnetic field.

Fig. 8 shows the relation between the rate of fuel consumption and the time. It can be seen that the rate of fuel consumption is decreased when exposing the fuel to the magnetic field by (3.675%), as well as it reduced with time. The magnetization property improved the fuel combustion efficiency and precipitated in heating the boiler, making the fuel consumption decreases with time.

Fig. 9 represents the relation between the exhaust gas temperature and the time. It can be seen from the figure that the temperature was increased when exposing the fuel to the magnetic field by (4.34%). This result indicates a higher flame temperature produced, which in turn led to a better combustion.

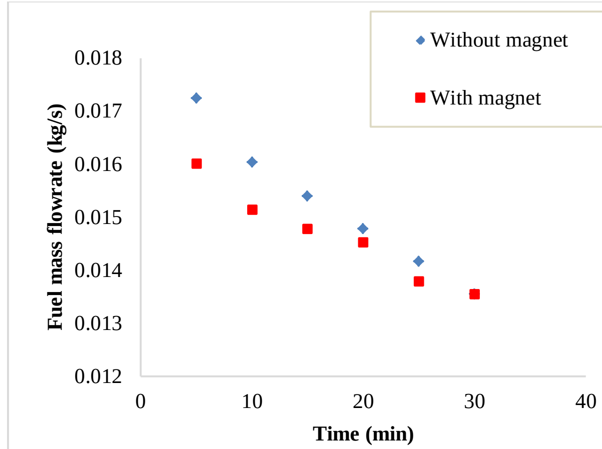

Fig. 8, the relation between the fuel consumption and the time

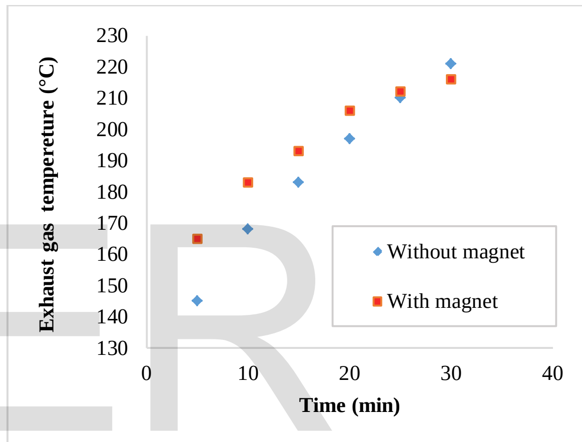

Fig. 9 the relation between the exhaust gas temperatures and the time

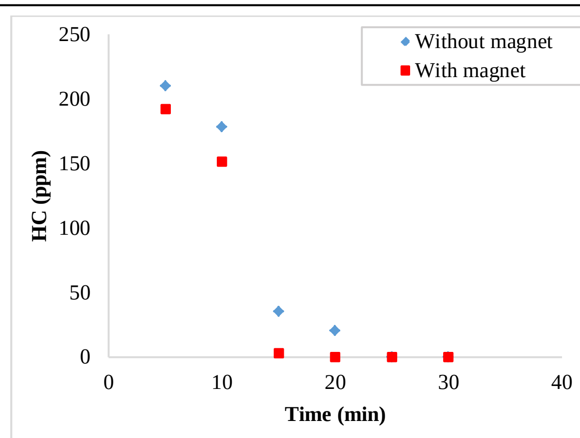

Fig. 10 shows the relation between the exhaust gas emission (HC) and the time

Figs 10 and 11 reveal the relation between the HC and CO concentrations in the exhaust gas emission respectively, and the time. The figures clarify that the HC emission is decreased by (21.89%) while the CO levels were reduced by (38.04%).

The effect of the magnetic field was tangible and the same line with what was indicated by many researchers as References [12]-[13]-[14].

Fig. 12 shows the relation between the CO_2 concentrations in exhaust gas emission and the boiler's operation time. CO2 increased by (4.4705%) when exposing the fuel to the magnetic field, and this indicates the tendency of the combustion toward the idle combustion.

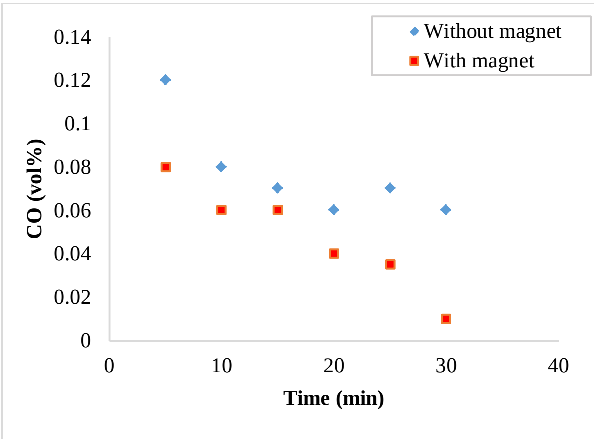

Fig. 11 the relation between the exhaust gas emission (CO) and the time

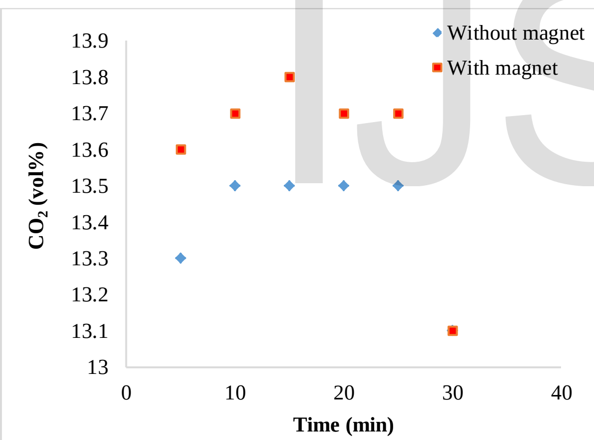

Fig. 12 the relation between the exhaust gas emission (CO_2) and the time

4 Conclusions

In this research work diesel, fuel was exposed to a magnetic field before entering a boiler combustion chamber. The practical results reveal:

1. An increase in the exhaust gas temperature and that indicate a higher flame temperature, as well as a better combustion.

2. A decrease in fuel consumption of 3.675% compared to using regular diesel

3. HC and CO exhaust gas emissions were reduced when the magnetic field was used with 21.89 and 38.84 respectively. CO_2 concentrations increased by 4.47% when diesel fuel was exposed to the magnetic field.

The tests results indicate an improvement in fuel combustion of the fuel resulted in lower fuel consumption and CO and HC concentrations and Higher CO_2.

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