STUDYING THE EFFECT OF MAGNETIC FLUX ON DIESEL FUEL LINE ON SOME PERFORMANCE AND EMISSION OF DIESEL ENGINE

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ABSTRACT

This study aimed to investigation was carried out to evaluate the performance and product emission of four cylinder 4- stroke water cooled direct injection (DI) diesel engine fueled by permanent magnet exposed diesel fuel compared with diesel fuel (DF). Three levels of magnet field intensity were used including Diesel fuel exposer to 3000 Gauss (DG3), Diesel fuel exposer to 5000 Gauss (DG5) and Diesel fuel exposer to 9000 Gauss (DG9) fuel respectively. Permanent magnetic device was employed and installed on fuel line before interring high pressure fuel injection pump . The engine run at constant speed 1500rpm(revolution per minute) and loaded by two levels 4.5 kW and 9 kW represented as L1and L2 respectively. Results obtained showed that fuel DG5 registered an increased in thermal efficiency(TE) about 20.09% at load L1 compared with DF. Maximum reduction in brake specific fuel consumption (bsfc) about 12.12%, when using DG5 fuel at load 1 compared to DF fuel. All exhaust emission Unburned Hydrocarbon (UHC), Carbon Monoxide (CO), Carbon Dioxide (CO_2),Particular Maters (PM), and Nitrogen Oxides (NOx) are decreased when diesel fuel treated with different magnetic intensities 3000,5000 and 9000 Gauss. Compared with conventional diesel fuel. Maximum reduction in PM,HC,NO_x,CO_2,and CO about 16.56-27.08%, 3.89–64.26%, 4.79–7.91%, 4.05-5.71and 11.46-53.48% respectively. CO_2 emission was increased by 1.65-4.28 at DG5 with L1 and L2 respectively due to the operating conditions.

Key words: Internal combustion engine, Brake thermal efficiency, specific fuel consumption, Nitrogen Oxides, Greenhouse gases, energy responsible consumption

دراسة تأثير التدفق المغناطيسي على خط وقود الديزل في بعض مؤشرات الأداء وغازات العادم لمحرك الديزل

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كلية علوم الهندسة الزراعية — كلية علوم الهندسة الزراعية — وزارة العلوم والتكنلوجيا

جامعة بغداد — جامعة بغداد — دائرة البيئة والمياه

المستخلص

تم إجراء بحث تطبيقي لتقييم أداء وانبعاثات محرك ديزل رباعي الأشواط مبرد بالماء يعمل بالحقن المباشر (DI) يتم تغذيته بوقود ديزل معرض للمغناطيس الدائم ومقارنته بوقود الديزل(DF) الاعتيادي (غير الممغنط). تم استخدام ثلاثة مستويات من شدة المجال المغناطيسي وهي 3000 جاوس (DG3)و 5000 جاوس (DG5) و 9000 جاوس (DG9) على التوالي. تم استخدام جهاز مغناطيسي دائم وتركيبه على خط الوقود قبل دخوله الى مضخة حقن الوقود ذات الضغط العالي. يعمل المحرك بسرعة ثابتة 1500 دورة في الدقيقة ويتم تحميله بمستويين 4.5 كيلو واط و 9 كيلو واط يمثلان L1و L2 على التوالي. أظهرت النتائج المتحصل عليها أن الوقود DG5 سجل زيادة في الكفاءة الحرارية (TE) بحوالي 20.09٪ عند الحمل L1 مقارنة مع DF . أقصى انخفاض في الاستهلاك النوعي المكبحي (bsfc)سجل بمقدار 12.12٪ عند استخدام وقود DG5 عند الحمل L1 مقارنة معً DF . سجلت جميع مستويات انبعاثات العادم للمحرك مثل الهيدروكربونات غير المحترقة (UHC) ، أول أكسيد الكربون (CO) ، ثاني أكسيد الكربون (CO_2) ،الجسيمات الدقيقة (PM)، وأكاسيد النيتروجين (NOx) انخفاضاًعند معالجة وقود الديزل بكثافة مغناطيسية مختلفة 3000 ، 5000 و 9000 جاوس. مقارنة بوقود الديزل التقليدي. الحد الأقصى للانخفاض في PM و HC و NOx و CO_2 و CO كان بحدود 16.56–27.08٪ ، 3.89–64.26٪ ، 4.79–7.91٪ ، 4.05–5.71 و11.46–53.48٪ على التوالي.في حين سُجلت زيادة في انبعاثات ثاني أكسيد الكربون بنسبة 1.65–4.28 عند DG5 مع L1 و L2 على التوالي بسبب ظروف التشغيل.

الكلمات الافتتاحية: محرك الاحتراق الداخلي، الكفاءة الحرارية المكبحية، الاستهلاك النوعي المكبحي، اكاسيد النتروجين، الغازات الدفيئة، الاستخدام المسؤول للطاقة.

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INTRODUCTION

The main functions in fuel use, including for diesel fuel, are to reduce its consumption and reduce emissions of harmful substances into the environment. Exhaust gases contain unburned hydrocarbons (including polycyclic aromatic hydrocarbons that have a carcinogenic effect), soot particles, carbon monoxide, etc. Fuel also may contain mechanical impurities that contaminate it during storage, transportation, loading and unloading, etc., as well as capable of causing erosion, abrasive wear and engine malfunction. High fuel consumption worsens economic performance engine, increases transportation costs and, consequently, increases the cost of all work related to the operation of transport (1, 2, 5). The portion of fuel price in the cost structure of agricultural products is about 10.4% (12 ,17), so the improvement of fuel-saving technologies has a significant economic and social effect. Many theoretical and applied researches have been conducted to improve the performance indicators of internal combustion engines and enhancement the combustion of fuel to reduce fuel consumption and harmful emissions (7). numerous researchers have concluded that exposing fuel to a magnetic field changes its configuration, as a result, the bonding force between fuel molecules and their surface tension in fuel clusters decreases, i.e., it increases the internal energy of the fuel and evenly distributes them in the flow so that fuel combustion in the internal combustion engine occurs more efficient. utilizing a constant magnetic field for diesel fuel mentioned by many investigators. For example, in studies (3, 18), reported a reduction in fuel consumption by 2–20%. An increase in the thermal efficiency of the engine by 2-11% was found in (8 , 16). The results obtained by authors of (1) note that the effect of magnetic treatment revealed a reduction in fuel consumption about 12%. Interesting results were obtained in (8) when studying the magnetic treatment of mixed biodiesel fuel: other things being equal, as the proportion of biodiesel in the mixture increased from 0 to 20%, the effect of treatment increased several times. The density of exhaust gases is reduced by 12-30% (14). In numerous sources (18) note that the content of carbon monoxide in the composition of exhaust gases decreases by 4–30% and unburned hydrocarbons by 27–30%. The data on the amount of nitrogen oxides differ fundamentally. Thus, the results of study (16) prove that the content of nitrogen oxides in the composition of exhaust gases increased around 20% and there is 15%-20%reduction in fuel consumption with increasing load due to increasing combustion chamber temperature and faster air movements. Subsequently, an increase in brake thermal efficiency is noted varying between 5%-7%. There is also a decrease in brake specific fuel consumption ranging between 15%-20%., the authors of (10) reported on their researches a reduction in NO_x by up to 7.40%. The authors of (9) found the CO emissions produced by the generator are reduced by approximately21.3%. Authors (1) reported that the application of magnetic field registered a reduction in fuel consumption is about 8% at higher load, the percentage reduction in UHC and NO_x is about 30% and 27.7 % respectively. The CO emission gets reduced with the application of magnetic field at higher load. The percentage reduction in CO_2 emissions is reduced about 9.72% at average of all loads with the effect of magnetic field. (7) mounted a solenoid electromagnet on the fuel line of a single cylinder diesel engine. Brake thermal efficiency was found to increase by at least 5% and NOx emissions reduced by almost 44% in the process. Similar experimental set up and procedure was employed by. (7,8) and found an improvement in thermal efficiency of the engine up to 14% while reducing UBHC by 34%, CO and CO2 by 9% each. The scatter in the indicators of the effect of magnetic treatment is explained by the fact that approaches, terminology, methods and evaluation criteria often differ greatly, and some studies are duplicated due to insufficient awareness of the authors. A rigorous comparison of the results is difficult, since fragmentary information is given on the conditions of the experiments properties of hydrocarbon fuels at the moment of intersection of magnetic field lines during its pumping, the structure and properties of the fuel change: surface tension forces, the solubility of oxygen increases, nuclear polarization (especially hydrogen) increases, the rate constants of the chemical reaction of combustion change (burning rate increases). Under the influence of strong magnetic fields, complex fuel molecules change their structure and properties, in particular, they are partially crushed and ionized, moving in the opposite direction of the external magnetic field (10). On fig. 1 shows the passage of fuel through lines of magnetic fields intersecting between magnets. The magnetic field passing through the fuel has a density of about 6700 lines per square inch. Path length through magnetic fields (residence time and energy transfer) and travel speed depend on the model and the fuel flow rate in the system.

Fig.1. Fuel flow through magnetic flux lines.

The target of this study is to evaluate the effect of permanent magnetic field on fuels used in diesel engine and by testing the effect of magnetized fuel on performance indicators and exhaust gas emissions and comparing it with the use of conventional diesel fuel.

MATERIALS AND METHODS

Experimental Setup and instrumentation

Experimental tests were carried out on a 4-cylinder 4-stroke DI diesel engine. Table 1 shows the technical specifications of test engine. Figure 2 is shown schematic diagram of experimental engine test bench. The engine is coupled directly to AC generator type STC-24 kW for engine output brake power measurement. A sharp edged orifice mounted in one side of the air box to measure the air flow rate. Temperature measurements in exhaust gas were done using thermocouple probes of type K. Fuel flow measurements. was made using one burette with stopcock and two way valves. Exhaust gas analyzer type (AIRREX, HG-540) and (OPABOK AUTOPOWER) smoke meter were used for smoke and exhaust emissions measurements. The experimental work was carried out by two engine loads variation from 4.5 kW to 9kW at constant speed of 1500 rpm.

Table 1. Specification of engine test.

	Detail of specification
Model	J2 2701
Make	KIA
Type	4- stroke,DI,Water cooled Diesel Engine
No. of cylinders	4
Bore	95 mm
Rated speed	1800 rpm
Stroke length	95 mm
Combustion	Specification
Nominal output	80 HP@ 4000 rpm
Max,Torque	16.8 N.m@2400rpm

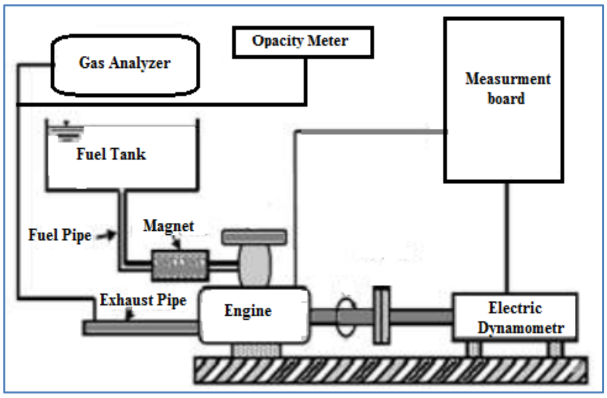

Fig.2. Schematic Diagram of a diesel test bench.

Fuel

Four types of fuel were examined in this experiment included, PD fuel considered as a control and three types of magnetized fuel DG3, DG5 and DG9. Fuel were magnetized by a permanent magnetic device putting on the line of fuel before entering injection pump. fig3. (CRD) statistical experiment was used, and choosing the least significant difference L.S.D with a probability of 0.05 and the results were analyzed in Gen-Stat Release 12.1 programs.

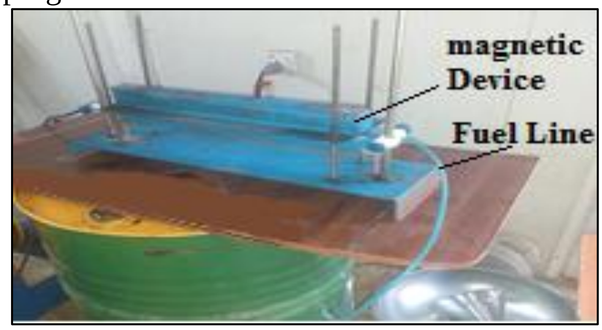

Fig.3. Permeant magnetic device

Results obtained from the experiment were recorded under the chosen experimental conditions, such as fuel consumption, brake power and exhaust gases for each type of fuel, and they were repeated three times to obtain the required accuracy. The equations were used to calculate the performance of engine indicators suggested by (3, 9, 10) .

RESULTS AND DISCUSSION

Effect of magnate fuel on BTE .

The experimental results show that there was an improvement on engine performance and a reduction in exhaust gas emission when exposed fuel line on magnetic fields. fig. 4 shows that there was an increase in values of BTE for all magnetic fuel for different loads compared with conventional diesel fuel that not magnetized. One can observe from this figure that DG5 tend to produce higher value of BTE at high load (load2) while DP fuel registered the lowest. This results was also observed in a similar study by the authors (10). To explain the effect of a constant magnetic field on diesel fuel, is that there is practically a single point of view on fuel magnetic treatment reduces the density, viscosity, surface tension and increases the degree of dispersion of diesel fuel. For example, the authors of (5) observed a decrease in fuel density after magnetic treatment from 826.44 to 824.67 kg/m^3, and the heat of combustion increased from 42,223.52 to 42,408.55 kJ/kg which contribute to enhance the combustion efficiency and consequently increase the brake thermal efficiency.

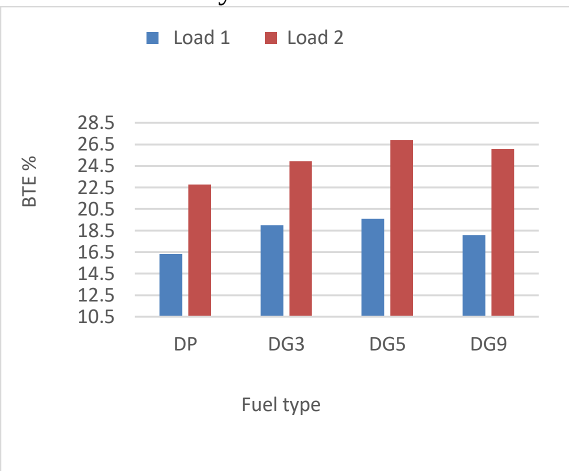

Fig. 4. BTE variation with fuels under different loads

Effect of magnate fuel on bsfc.

The experimental results show that the fuel consumption of engine was less when the engine with magnet than that without fuel magnet at higher load. Always less amount of fuel was consumed with the fuel with magnetic field. The fuel type vs bsfc shown in fig.5 , the maximum reduction in bsfc is about 12.12 % pointed by magnetic fuel DG5 compared to DP fuel. Results gained by(13,14) produced similar result for both bsfc and fuel consumption at 50% loading condition in their work. bsfc is decreased significantly by 11%, while put variation in engine load from 25% to 50%..This results underlies the method of processing the fuel coming through the hose. Here, the magnets destroy the clumps of molecules in the fuel, which move from a state of rest to a state of excitation, a magnetic resonance occurs, this attracts additional oxygen, the fuel is ionized, and as a result reduced the consumption of fuel per unite power.

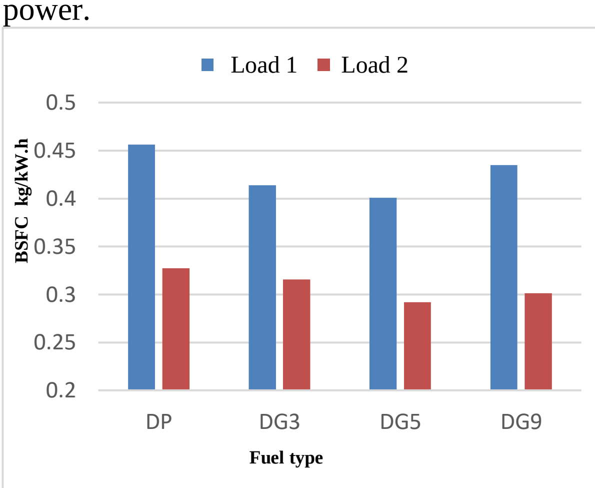

Fig. 5. BSFC variation with fuels under different loads

Effect of magnate fuel on exhaust gas emissions.

The comparison between exhaust gas emissions prediction have done at two levels of load and constant engine speed conditions for conventional diesel fuel and diesel fuel treated by three levels of magnetic intensities are tabulated in Table 2.and table 3.

Table 2. Emission levels at load L1 with different magnetic field.

Magnetic field (Gaus)	CO %	UHC ppm	CO_2 (%)	PM m^{-1}	NOx ppm
0	0.053	56.8	10.84	0.026	579.8
3000	0.030	50.7	10.22	0.02	552
5000	0.030	20.7	11.30	0.02	545.3
9000	0,029	20.3	10.40	0.02	548

Thus it is clear (from the Table 2) that the results obtained from the experiment effect of magnetic field in the fuel line is used to reduce emission, especially CO is more in engine exhaust due to incomplete combustion. The magnetic strength is taking care of significant decrease in the pollutant formation, diesel was treated with 9000 Gauss magnetic intensity condition gives a better result in CO emission is 0.029% which is reduced by 45.2 % at load 1, and the when diesel fuel treated with 3000 Gauss registered a maximum reduction about 53.3% at load 2 condition when compared with conventional diesel fuel.

Table 2. Emission levels at load L2 with different magnetic field.

Magnetic field (Gauss)	CO (%)	UHC ppm	CO_2 (%)	PM m^{-1}	NOx ppm
0	0.060	59	16.34	0.096	814.5
3000	0.028	56.7	15.60	0.07	757.3
5000	0.053	59.3	16.61	0.08	759.7
9000	0.050	51.0	15.61	0.1	750

Results showed in tables (1) and (2) for UHC emission at load L1 and L2 condition is noted for diesel engine with and without magnetic field.UHC was emitted due to incomplete combustion of fuel and causes of line fault or storage tank ,so minor escape through leak and evaporation. A maximum reduction in UHC concentration was about 64.2% when fuel line treated magnet flux 9000 Gauss at load (1) condition compared with diesel fuel. The amount of HC emissions is found to be from 56.8 ppm to 59 ppm for diesel under normal conditions with load (1) and (2) respectively, when magnetic field is introduced in fuel line corresponding UHC values are approximately decreased. The variation of CO_2 emission with respect to different engine loads is critical and affected by magnetic field. The CO_2 emissions are directly proportional to the quantity of fuel consumed by the engine and it is increased under all operating conditions (4). At load (2) and magnetic flux 5000 Gauss condition it was reached maximum 16.6%. The mechanism of NOx formation demands higher cylinder temperature, at no load and part loads condition, the NOx emission was less due to low consumption of fuel and slightly reduced in cylinder temperature [10-17]. From tables (1) and (2) it is getting a reduction in NO_x when magnetic field increased. At load L2 due to higher combustion temperature, the amount of NOx emissions are 814.5 ppm for diesel without magnetic field and 750 ppm with magnetic field 9000 Gauss with a reduction about 7.9%, while a reduction in NOx emission is about 5.9% registered in DG5 compared with normal diesel fuel with load L1 conditions. Particulate matters (PM) are formed due to incomplete combustion of fuel in combustion chamber and presents of impurities in fuel, as results that shows in table (1) a constant reduction 2.3% noted in DG3, DG5, and DG9 respectively compared with PD fuel, while at load (2) a reduction in NO_x pointed about 2.7% and1.6% for DG3 and DG5 respectively compared with diesel fuel that not treated with magnetic field.

CONCLUSIONS

In the present study, the effect of magnetic diesel fuel on engine performance and emission was investigated and compared with diesel fuel not treated with magnet the tested engine was run at constant speed (1500rpm) and loaded with two levels 4.5 kW and 9kW at. the results obtained from the study showed that

- Rising in brake thermal efficiency when diesel fuel exposure to magnetic field about 9.57%,18.23% and 14.58% respectively when using DG3,DG5and DG9 at load L2 .the maximum increasing about 20.09% with using DG5 fuel at load L1 compared with normal diesel.
- Reducing in bsfc when using different magnetic levels DG3,DG5and DG9 about 3.57%,10.81% and 7.94% respectively at load L2 .The maximum reduction 12.12% with DG5 at load L1 compared with diesel fuel.
- Maximum reduction in PM ,UHC,NO_x,CO_2,and CO about 16.56-27.08%, 3.89–64.26%, 4.79–7.91%, 4.05-5.71and

11.46-53.48% respectively. CO_2 emission is increased by 1.65-4.28 at DG5 with load 1and load L2 respectively due to the operating conditions. Finding ways to reduce costs in agricultural production is the cornerstone of sustainable development goals (2,4,6,11,15)

Recommendations

According to the results experiment, we can say that all of the above will lead to a decrease Reducing carbon deposits and soot will reduce the time required during maintenance to clean the piston rings, piston head, cover and cylinder liner from soot,. Reduced fuel consumption will result in reduce the cost of fuels and lubricants and to reducing the cost of transportation. In the future, an impact study magnetic field on the properties of different types of hydrocarbon fuel engine with magnets of different powers, as well as checking the possibility of replacing permanent magnets with an electromagnet and treatment of fuel with a pulsed magnetic field with specified parameters.

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