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Experimental Investigation on Four Stroke Single Cylinder Diesel Engine with EGR & Magnetic Field

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Abstract:** In recent years, many efforts are being made to improve power output and emissions of internal combustion engines. The use of diesel engines have been increased day by day due to the higher thermal efficiency. But it has serious drawback of having emissions in the form of soot and NO_x emissions.To meet the stringent vehicular exhaust emissions norms worldwide, several exhaust pre-treatment, post-treatment techniques has been employed in modern engines.EGR is a prominent technique which is being used widely to reduce and control oxides of nitrogen (NO_x) emissions from diesel engines. EGR controls NO_x as it lowers oxygen concentration and flame temperature of the working fluid in the combustion chamber. However, use of EGR leads to trade off in terms soot-emissions. Higher soot generated by EGR leads to long term usage problems inside the engine such as high carbon deposits,lubricating of oil degradation and enhanced engine wear.It has been reported that magnetic field helps to improve mixture formation by increasing the atomization process of spray in the combustion chamber due to increasing rate of disintegration of the deposits as a result of reduction in surface tension and viscosity of the fuel.Ortho state of hydrogen molecule is achieved by applying a strong magnetic field along fuel line. Due to magnetic field, hydrogen of hydrocarbons changes its orientation and gets converted from para to ortho state. This hydrogen of fuel actively interlocks with oxygen and produces more complete burn in the combustion chamber. Hence magnetic field helps dispense oil particles and become finely divided the present experimental study has been carried out to investigate the effect of EGR, magnetic field and the combination of both on performance of single cylinder 4 stroke diesel engine From the values conducted in the experiment, it has been concluded that with the use of the combination of EGR at 5% and 10% and the magnetic field the engine showed best performance characteristics with brake thermal energy, BTE as 32.3% and brake specific fuel consumption, BSFC as 0.2628 kg/kwhr and exhaust gas temperature being 375^0C and 380^0C respectively.

***Keywords:** EGR, BTE, BSFC, magnetic field, Ortho Hydrogen, Para Hydrogen, Atomization, Combustion*

I. INTRODUCTION

In recent years, there are so many efforts towards the improving power output and emission of internal combustion engines per fuel, so that the products of combustion exhausted from internal combustion (IC) engines environmental friendly, and also beneficial for cost. The use of diesel engines have been increase day by day, due to their high thermal efficiency and low pollutant formation characteristics but it has a serious drawback of having a comparative larger amount of emission which is larger than that of a gasoline engine.

Magnetic field that ionized the fuel based on the principle of magnetic field mutual action with hydrocarbon molecules of fuel and oxygen molecules. There are various physical attraction forces between hydrocarbons and they form densely packed structures called pseudo compounds which can further organize into clusters. Due to the physical attraction forces between hydrocarbons, oxygen atoms cannot penetrate into their interior during air/fuel mixing process, these structures become stable. The external force by means of magnetic field helps in polarizing the hydrocarbon fuel. Due to that hydrocarbon fuel change their orientation and increase space between hydrogen. This hydrogen of fuel actively interlocks with oxygen and producing a more complete burn in the combustion chamber. It has been noted that when the fuel passes through a magnetic field, it helps in increasing the atomization process by improved mixture formation. Due to increasing the rate of disintegration of the droplets as a result of reduction in the surface tension and viscosity of the fuel.

Wagner et al. [1]. tried to achieve lower emission of NOx and soot using highly diluted intake mixture. At very high EGR rate (around 44%), PM emission decreased sharply with a continuous drop in NOx emission but this high EGR rate significantly affect the fuel economy

Sasaki et al. [2]. conducted experiments using EGR on direct injection gasoline engine and reported that an appropriate volume of EGR improves fuel economy and HC emissions. This phenomenon was presumably due to the intake temperature increase by EGR, which improved the flame propagation in the relatively lean region of the air–fuel mixture, which is non-uniformly distributed

Kusaka et al. [3]. also found that at low loads, EGR combined with intake heating can favorably reduce THC emission with improvement in thermal efficiency [16]. EGR was also used in a direct injection spark ignition engine as an effective way for improving fuel economy [17,18].

Das et al. [4]. used EGR to reduce NOx emissions in hydrogen – supplemented SI engine without any undesirable combustion phenomena

Sato et al. [5].performed experiments using methanol in direct injection compression ignition engine and found that combustion performance becomes inferior under light load conditions because temperature in combustion chamber fell due to very high latent heat of methanol, thus hampering formation of combustible air–fuel mixture

Selim et al. [6]. operated the diesel engine in dual fuel mode with natural gas and found inferior performance and emissions at low loads because lean mixtures formed at low loads were hard to ignite and had slow burning characteristics. EGR was found to be and out that by establishing correct fuel burning parameters through proper magnetic means (MFC), one can assume that an internal combustion engine is getting maximum energy per liter as well as environment with lowest possible level toxic emission. MFC increases the internal energy of a fuel to cause specific changes at a molecular level which obtained easier combustion. The resultant fuel burn more completely, producing higher engine output, better fuel economy, more power & most importantly reduces the amount of HC, CO, NOx in the exhaust. & therefore control the emission at low cost. method of improving engine performance and emissions of such engines

Shweta Jain et al.[7]. Concluded that the brake thermal efficiency, indicated power are similar in both with and without Magnet Fuel Energizer but indicated power improved at lower load condition. Specific fuel consumption decreased due to the reduction of fuel consumption at higher load. There was a significant reduction in the exhaust emissions at all load condition with both neodium and ferrite but neodium gave better effect than the ferrite. The experiments results show the magnetic effect on fuel consumption reduction was up to 8% at higher load condition. The CO emissions reduced at higher load. The effect on NOx emissions reduced by 27.7%. The reduction of HC emissions was 30%. The CO2 emission reduction was 9.72% at all loads.

A. R. Attar et al. [8]. Studied the" Effect of magnetic field strength on hydrocarbon fuel viscosity and engine performance.

II. MATERIALS AND METHODOLOGY

The specifications are listed in table:1 and diesel properties intable:2.

Table 1: Engine Specifications

Make	kirloskar
Bore	80mm
No. of strokes	4
Speed	1500rpm
Length	110mm
Brake power	3.68KW
Compression ratio	16:1
Method of cooling	Water cooling

Table 2:Diesel Properties

S.No	Specification	Value
1	Density	0.916 Kg/m^3
2	Calorific value	42,500 KJ/Kg
3	Cetane number	50
4	Viscosity	0.278 poise
5	Flash point	52^0C - 95^0C

Fig1: Conventional four stroke Diesel engine

The experiment was conducted on a convectional 4-stroke single cylinder vertical,water cooled diesel engine with electrical dynamometer. The performance characteristics of the engine were as shown in table:3

Table:3 CE Readings

Exhaust gas temp.	Time taken for 10cc drop of diesel
390^0C	20sec

Fig2: Conventional diesel engine with magnetic field

Then, the performance of same engine with magnetic field by mounting 4 magnets (50mm x 25mm x 12.5mm) each of 1 Tesla strength on the fuel injector nearer to the combustion chamber wasas shown in table:4

Table:4 Reading of the Engine with Magnetic Field

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Exhaust gas temp.	Time taken for 10cc drop of diesel(fuel)
400^0C	27sec for 10cc

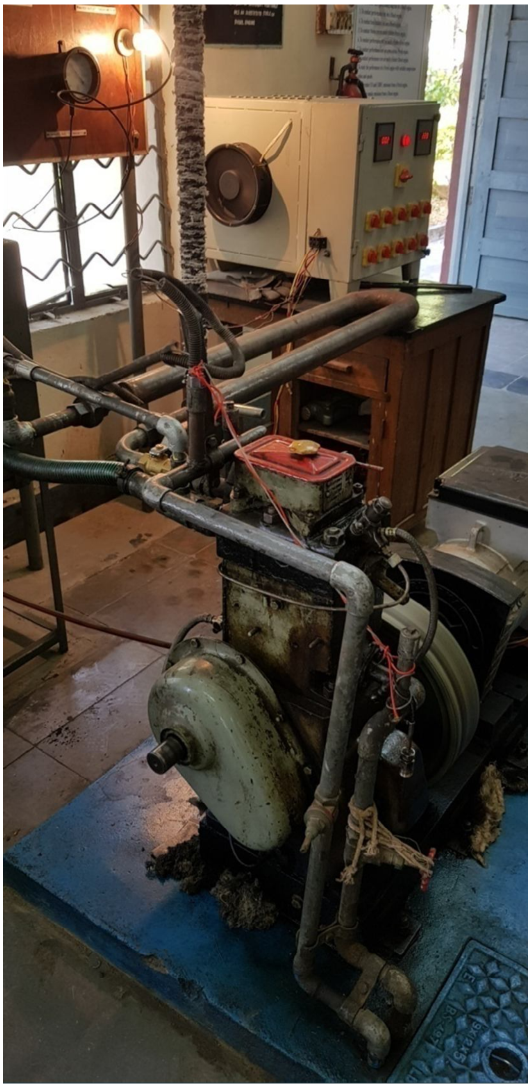


Fig 3:Diesel engine with heat exchanger

Fig4:Air compressor

The experiment was carried out on the same engine by removing the magnetic field setup and mounting a two pass counter flow double pipe heat exchanger with inner radius of 25.4mm and outer radius of 50.8mm to the engine. The heat exchanger cools the exhaust gas temperature and a certain percentage of exhaust gas(not exceeding 20%) is recirculated back into the combustion chamber.Compressed air from air compressor with the pressure of 2Kg/cm^2 cools the exhaust gas.Compressed air flows in the annular region of the heat exchanger.The performance is as shown in table:5

Table:5 Reading of the Engine with EGR

Percentage EGR	mass flowrate of fuel	Exhaust gas temp.	Time taken for 10cc drop of diesel
5%	1.08 kg/hr	250^{0}C	28sec
10%	1.12 kg/hr	280^{0}C	27sec
15%	1.08 kg/hr	320^{0}C	28sec
20%	1.12 kg/hr	340^{0}C	27sec

Fig 5:Diesel engine with magnet and EGR

The experiment is carried out by mounting both heat exchanger and magnetic field.Performance of the engine is as shown in table:6

Table:6 Reading of the Engine with Magnetic Field and EGR

Percentage EGR	Mass flow rate of fuel	Exhaust gas temp.	Time taken for 10cc drop of fuel
5%	1.04 kg/hr	375^{0}C	29sec
10%	1.04 kg/hr	380^{0}C	29sec
15%	1.08 kg/hr	380^{0}C	28sec
20%	1.12 kg/hr	380^{0}C	27sec

III. RESULTS

At 100% load of the convectional 4-stroke single cylinder vertical diesel engine, the values of BSFC, BTE, exhaust gas temperature are shown in table:7

Table:7 Conventional Diesel Engine

BTE	BSFC	Exhaust gas temperature
18.52%	0.381Kg/Kwhr	390^{o}C

At 100% load on the convectional 4-stroke single cylinder vertical diesel engine with magnetic field, the values of BSFC, BTE, exhaust gas temperatures are as shown in table:8

Table:8 Engine with Magnetic Field

BTE	BSFC	Exhaust gas temperature

30.006%	0.2822Kg/Kwhr	400ºC

At 100% load on the engine with heat exchanger at different percentages of EGR,thevalues of BSFC, BTE, exhaust gas temperature are as shown in table:9

Table:9 Engine with EGR

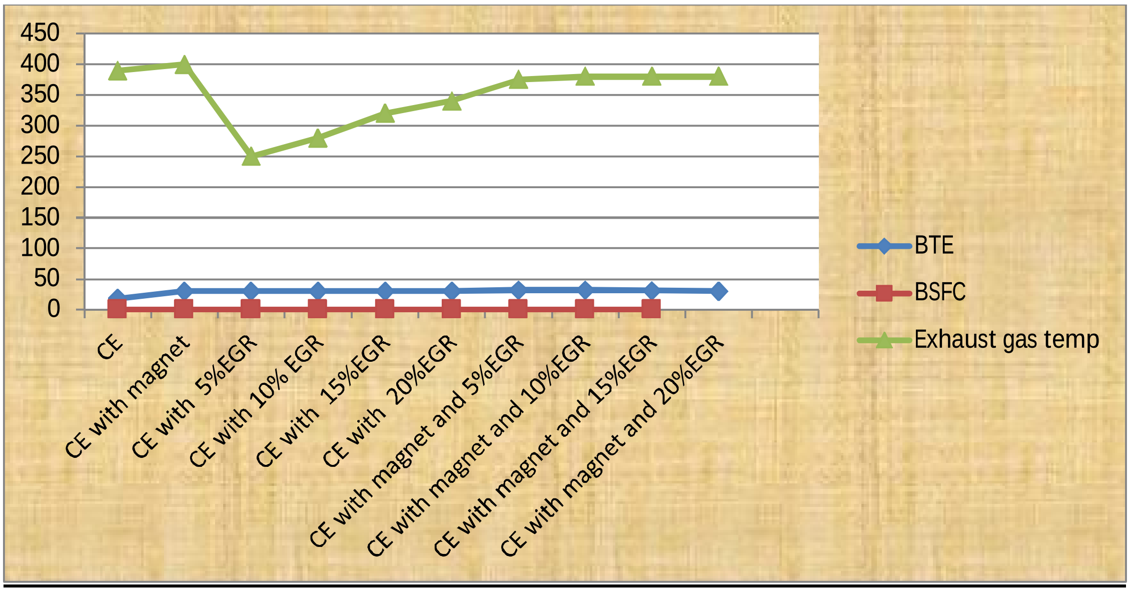
Percentage EGR	BTE	BSFC	Exhaust gas temperature
5%	30.117%	0.272Kg/Kwhr	250ºC
10%	30.006%	0.2822Kg/Kwhr	280ºC
15%	30.117%	0.272Kg/Kwhr	320ºC
20%	30.006%	0.2822Kg/Kwhr	340ºC

At 100% load on the engine with heat exchanger and magnetic field at different percentages of EGR, the values of BSFC, BTE, exhaust gas temperature are as shown in table:10

Table::10 Engine with Magnetic Field and EGR

Percentage EGR	BTE	BSFC	Exhaust gas temperature
5%	32.31%	0.2628Kg/Kwhr	375ºC
10%	32.31%	0.2628Kg/Kwhr	380ºC
15%	31.17%	0.272Kg/Kwhr	380ºC
20%	30.006%	0.2822Kg/Kwhr	380ºC

IV. CONCLUSION



Graph:1

It can be concluded that the engine performance improved due to the effect of magnetic field and also due to EGR.
Better performance was shown due to the combined effect of magnetic field and at 5% and 10% EGR with Brake Thermal Efficiency (BTE) to be 32.31% and Brake specific fuel consumption (BSFC) to be 0.2628 kgs/kwhr and exhaust gas temperature to be 380ºC.

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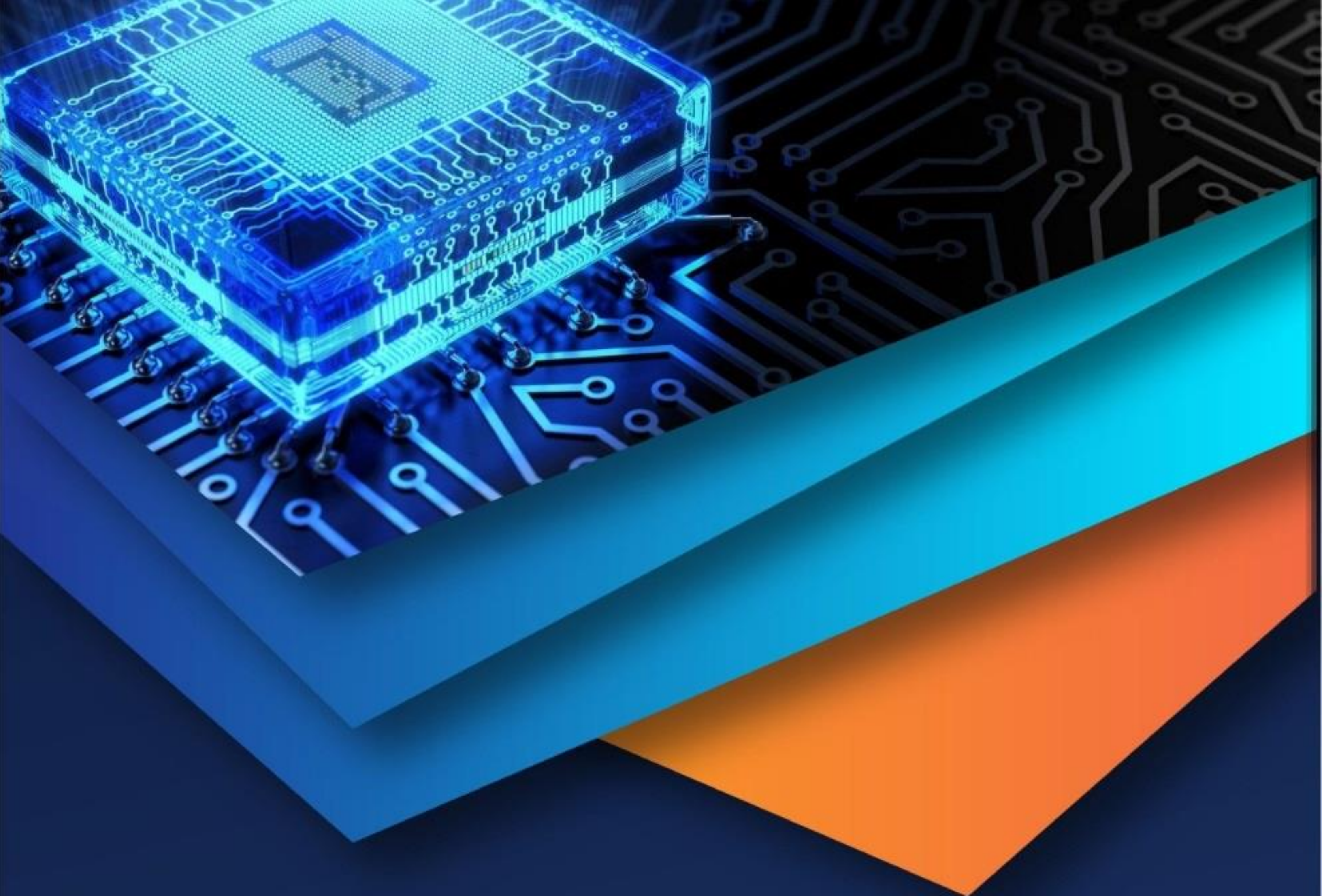
Future Scope

Research work can be carried out by analyzing the emissions and find whether BS1V emission standards can be achieved by the combination of EGR and magnetic field.



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