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Investigation on the Effect of EGR with Diesel and Grooved Piston with Diamond Mesh Cut in an Internal Combustion Engine

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Abstract- In this present work a study about influence of the Exhaust gas recirculation (EGR) in the cylinder upon the performance and emission of a single cylinder diesel direct injection engine is presented. In order to achieve good swirl intensity in the cylinder, a grooved brass piston with 9 grooves with Diamond mesh cut configuration on the piston crown is selected. With this modification turbulence in the combustion chamber is enhanced. Also in the present work, performance of the engine is done with diesel along with 10%, 15% and 20% EGR, with 9 grooved piston (GP) with Diamond mesh cut configuration.

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I. Introduction

Regulations to reduce NOx emissions continue to become more and more stringent year after year. Since high cylinder temperatures cause NOx, it can be reduced by lowering the cylinder temperatures. Reduced cylinder temperatures can be achieved by reducing the amount of oxygen by re-circulating a part of exhaust gases back in to the cylinder, which inhibits the combustion process. In the present work, engine tests are conducted with 10%, 15% and 20% EGR along with Grooved piston with 9 grooves with Diamond mesh cut configuration *(Appendix-A),* and their effect on performance and emissions are studied.

- EGR10 :10% of exhaust gas circulation.
- EGR15 :15% of exhaust gas circulation.
- EGR20 : 20% of exhaust gas circulation.

a) Test Engine

A single cylinder air-cooled four stroke, direct injection (DI) compression ignition diesel engine is chosen for the present investigation. The detailed engine specifications are provided in *Appendix-B.* The recommended injection timing by the manufacturer is 28^0bTDC (static) and the nozzle opening pressure of 190 bar.

II. Performance Parameters

The performance parameters like brake thermal efficiency, brake specific fuel consumption and exhaust gas temperature are discussed below.

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a) Brake Thermal Efficiency

The variations of brake thermal efficiency with power output for the piston with different configurations are shown in Figure 1. The brake thermal efficiency for normal engine at 3/4 of rated load is 26%. It can be observed that the engine with EGR10, EGR15 and EGR20 give thermal efficiencies of 28.1%, 27.9 and 27.6%, respectively, at 3/4 of rated load. From Figure, it is inferred that the brake thermal efficiencies are increasing with an increase in brake power for configurations that are under consideration. It is also observed that there is a gain of 7.4% with EGR20 for normal engine.

b) Brake Specific Fuel Consumption

The variations of brake specific fuel consumption with brake power for different configurations are shown in Figure 2. The brake specific fuel consumption for normal engine at 3/4 of rated load is 0.34 kg/kW-hr. It can be observed that the engine with EGR10, EGR15 and EGR20 give brake specific fuel consumption of 0.31 kg/kW-hr, 0.32 kg/kW-hr and 0.33 kg/kW-hr respectively, at 3/4 of rated load. From Figure 4.20, it is inferred that the brake specific fuel consumption are increasing with an increase in brake power for configurations that were under consideration. It is also observed that the EGR20 has a reduction of 2.94% of fuel consumption for normal engine.

c) Exhaust Gas Temperature

The comparison of exhaust gas temperature with brake power is shown in Figure 3. The exhaust gas temperatures are higher for EGR10 compared to that of EGR20. The exhaust gas temperature for EGR20 varies from 145°C at no load to 328°C at 3/4 of rated load. For EGR 10, the exhaust gas temperature varies from 149°C at no load to 330°C at 3/4 of rated load whereas for normal engine it varies from 151°C at no load to 341°C at 3/4 of rated load. It is observed that there is a decrease of 3.8% for EGR20 at normal engine.

III. Combustion Parameters

The combustion parameters like ignition delay and peak pressure are discussed below.

a) Ignition Delay

The variation of ignition delay with brake power for different configurations is shown in Figure 4. It is inferred that ignition delay, decreases with an increase in brake power for almost all configurations. With an increase in brake power, the amount of fuel being burnt inside the cylinder is increased and subsequently the temperature of in-cylinder gases is increased. This may lead to reduced ignition delay in all configurations. However, the ignition delay for diesel fuel was lower under EGR10, EGR15 and EGR20 configurations than the normal engine. It is observed that the ignition delay of EGR10, EGR15 and EGR20 are 10.3o CA, 10.5o CA and 10.8o CA at 3/4 of rated load respectively. The reduction in the ignition delay of EGR20 is about 1.8% at 3/4 of rated load for normal engine.

b) Cylinder Peak Pressure

The variations of peak cylinder gas pressure with brake power for different configurations are given in Figure 5. It is observed that the peak pressure is increased with an increase in brake power. The peak pressures for EGR10, EGR15 and EGR20 are 57.4 bar, 57.8 bar and 58.4 bar at 3/4 of rated load respectively. There is a decrease of 2.7 % in peak pressure for normal engine.

IV. Emission Parameters

The emission parameters like smoke density, NOx emission hydrocarbon and carbon monoxide emission are discussed below.

a) Smoke Density

Smoke is solid soot particles suspended in exhaust gas. The comparison of smoke level with brake power is shown in Figure 6. It can be observed that smoke increases with increase in brake power. The smoke number for EGR10, EGR15 and EGR20 are 2.35 BSU, 2.38 BSU and 2.4 BSU respectively, whereas for normal engine it is 2.46 BSU. Due to the complete combustion of diesel with excess air, the smoke emissions are marginal. At 3/4 of the rated load, the smoke emissions for EGR20 are reduced by about 2.4 % for normal engine.

b) Nitrogen Oxide Emissions

The comparison of NOx emission with brake power for different configurations is shown in Figure 7. It can be observed from the figure that NOx emission increases with increase in turbulence in the cylinder because of high temperature. The NOx emissions for EGR10, EGR15 and EGR20 are 540 ppm, 520 ppm and 490 ppm respectively, whereas for normal engine it is 562 ppm. The NOx emissions are lower of 13 % for EGR20 for normal at 3/4 of rated load.

c) Hydrocarbon Emissions

The comparison of Hydrocarbon emission with brake power is shown in Figure 8. The HC emissions for EGR10, EGR15 and EGR20 are 71 ppm, 72 ppm and 74 ppm respectively, whereas for normal engine it is 78.2 ppm. The HC emissions are lower of 5.4% for EGR20 for normal at 3/4 of rated load.

d) Carbon Monoxide Emissions

The comparison of Carbon monoxide emission with brake power is shown in Figure 9. The CO emissions for EGR10, EGR15 and EGR20 are 0.155, 0.162 and 0.165 % volume respectively, whereas for normal engine it is 0.17 % volume. The CO emissions are lower of 2.9% for EGR20 for normal engine at 3/4 of rated load.

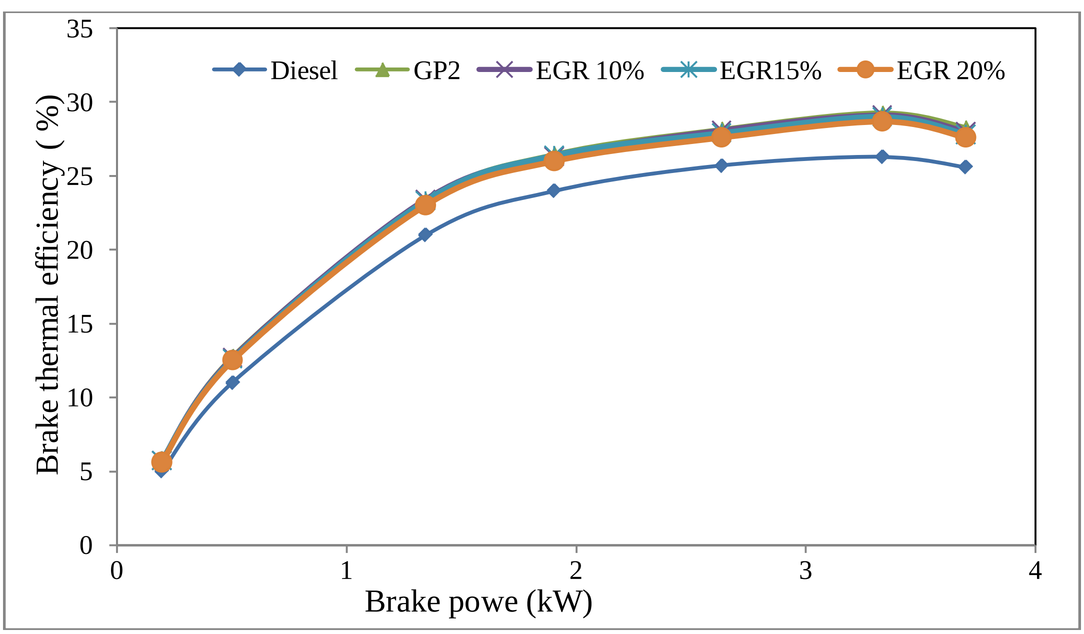

Figure 1 : Comparison of Brake thermal Efficiency with different percentages of EGR

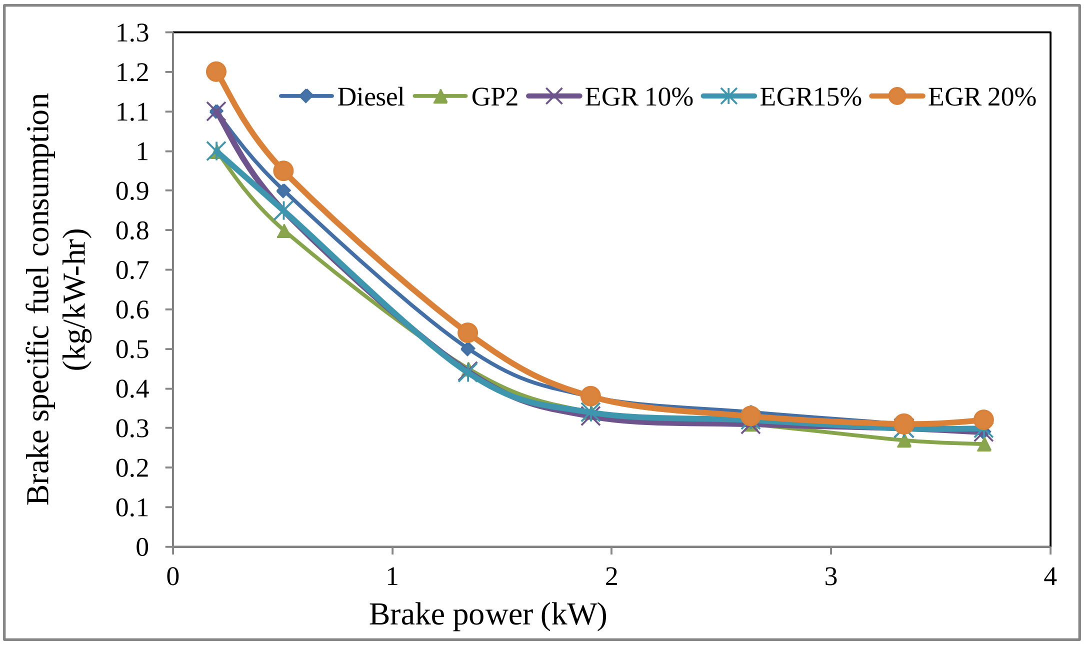

Figure 2 : Comparison of Brake specific fuel consumption with different percentages of EGR

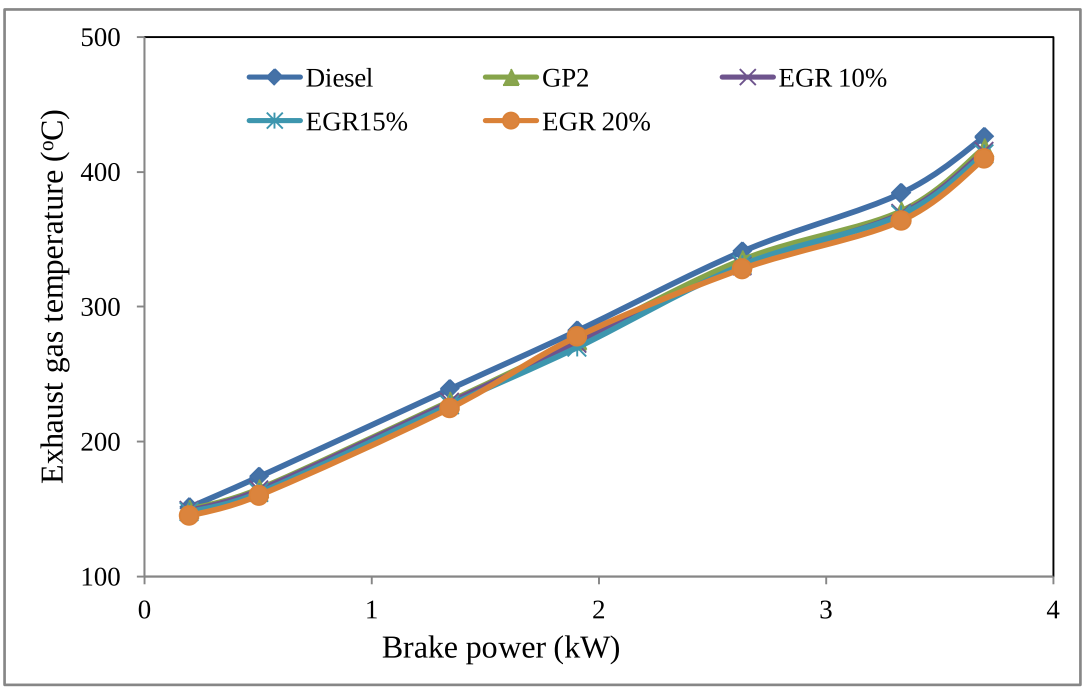

Figure 3 : Comparison of Exhaust gas temperatures with different percentages of EGR

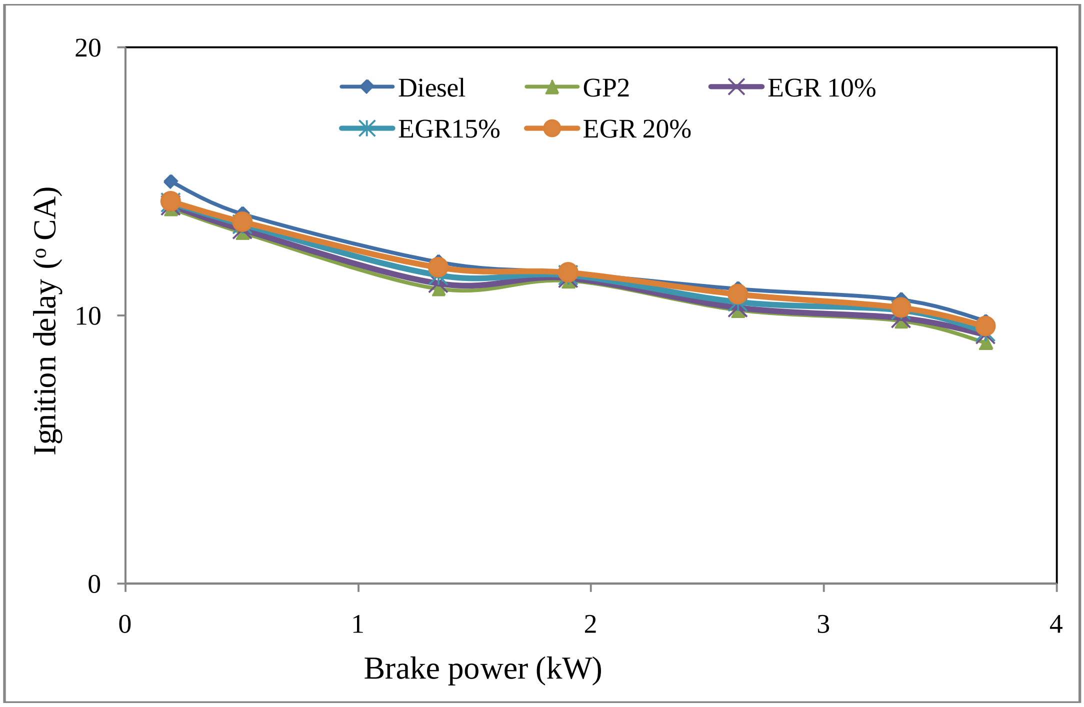

Figure 4 : Comparison of Ignition delay with different percentages of EGR

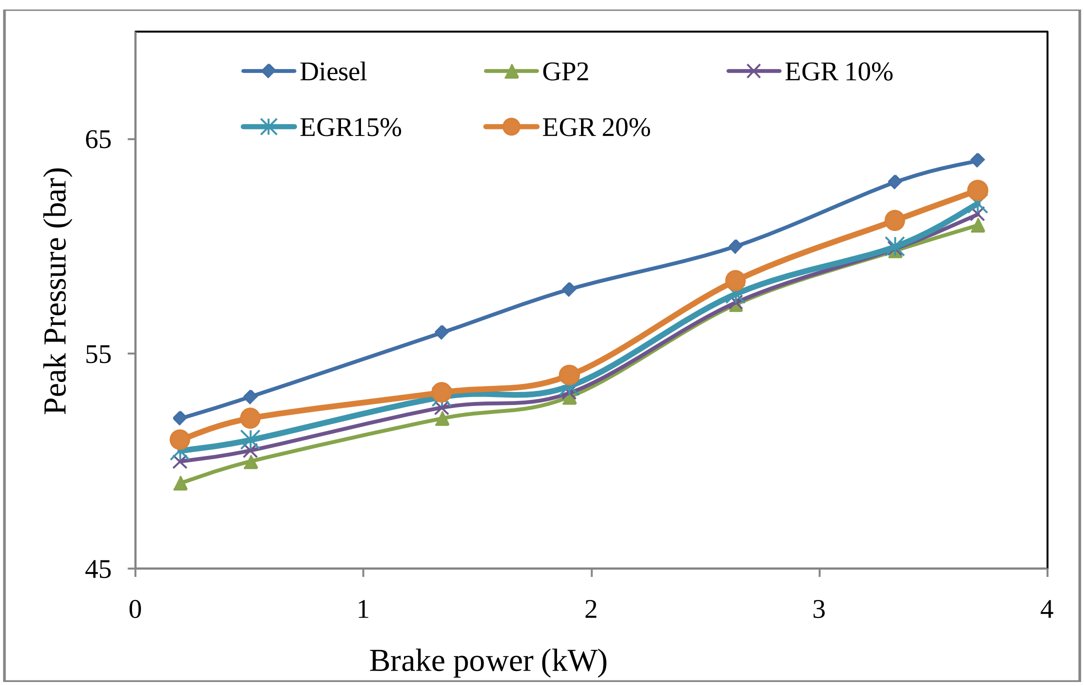

Figure 5 : Comparison of Peak pressure with different percentages of EGR

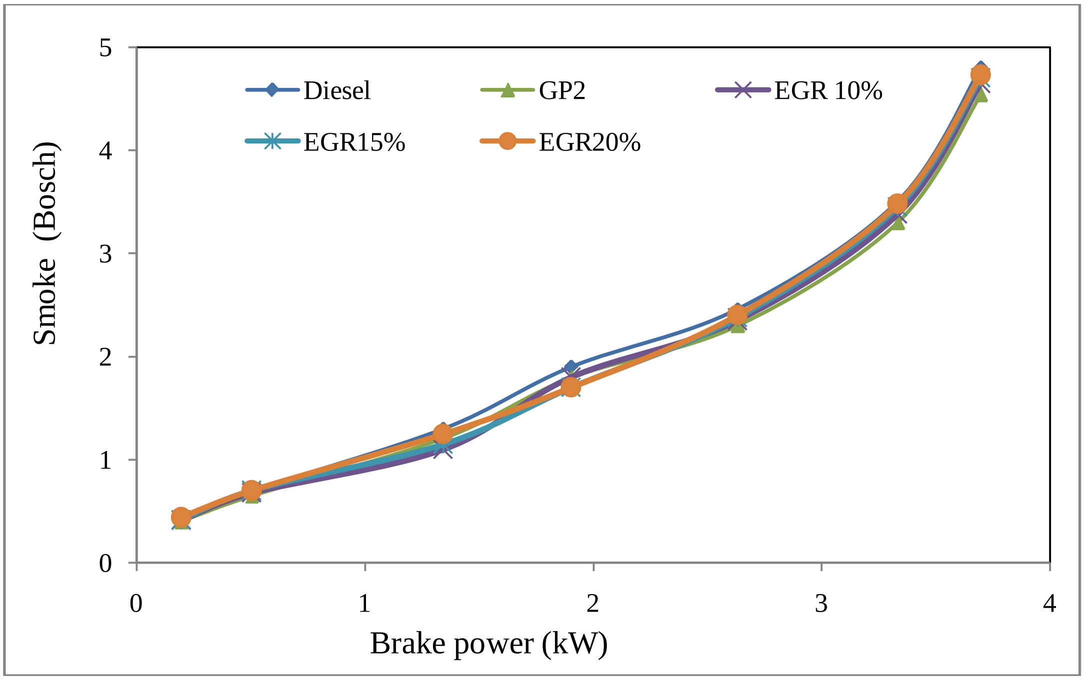

Figure 6 : Comparison of Smoke Density with different percentages of EGR

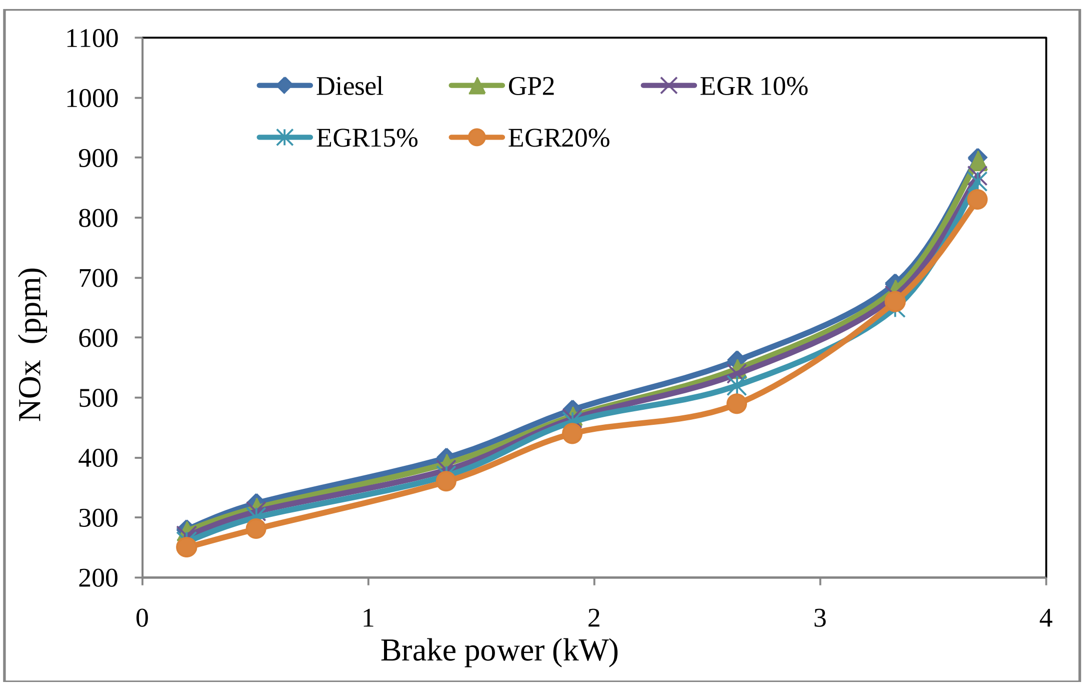

Figure 7 : Comparison of NO_x with different percentages of EGR

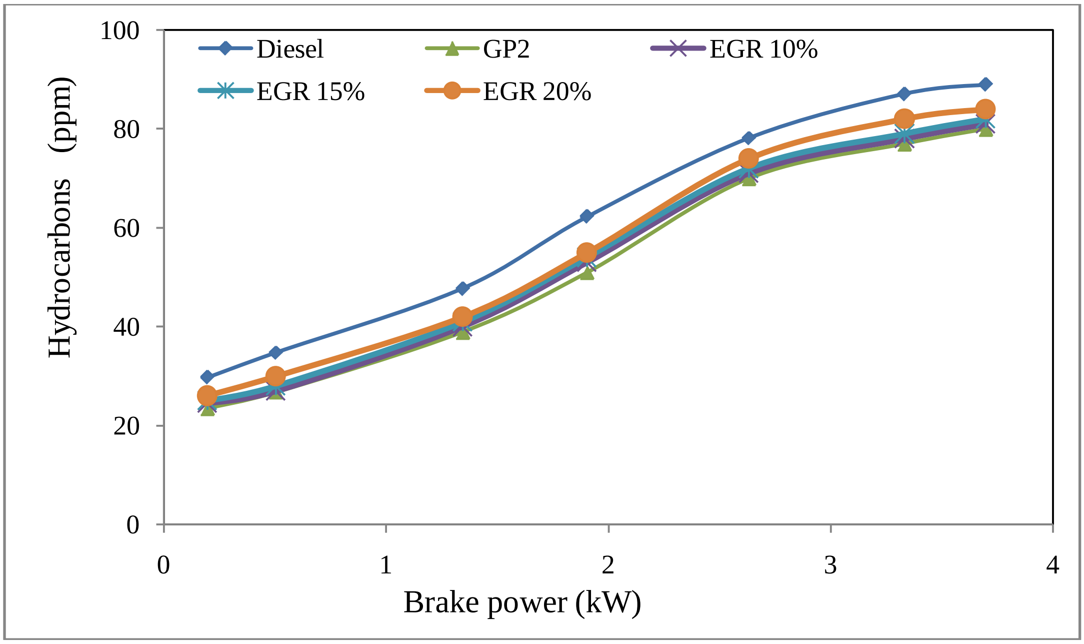

Figure 8 : Comparison of HC with different percentages of EGR

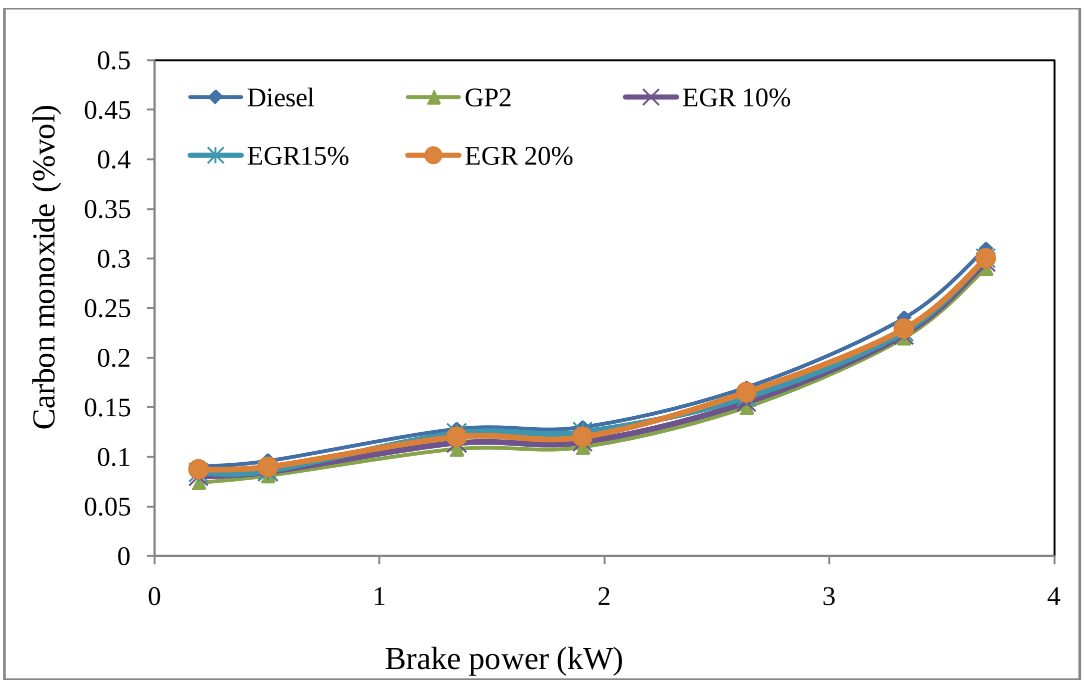

Figure 9 : Comparison of CO with different percentages of EGR

Appendix-A

Specifications of Diesel Engine

Appendix-B

Engine Parameters	Specifications
Make	Kirloskar
Type	Single Cylinder, DI Vertical
Type of Cooling	Water
Rated Horse Power(kW)	3.68
Rated Speed (R.P.M)	1500
Compression Ratio	16.5:1
Bore (mm)	80
Stroke (mm)	110
Swept Volume (cm^3)	553
Injection Timing	28° b TDC

V. Conclusions

The following conclusions are drawn based on the effect of EGR in the cylinder and the results are compared to normal engine at 3/4 of the rated load.

- The brake thermal efficiency is increased by about 7.4%.
- The improvement in brake specific fuel consumption is about 2.9%.
- The exhaust gas temperature is lower and it is 3.8% less than normal engine.
- The reduction in the ignition delay is about 1.82%.
- The peak cylinder pressure is decreased by about 2.7%.
- The smoke emission in the engine is reduced by about 2.4%
- The maximum reduction in NOx emissions are about 13%.
- The maximum reduction in HC emissions are about 5.4%.
- The carbon monoxide emissions are found to be reduced by about 2.9%.

From the investigation, it is evident that in the single cylinder D.I diesel engine, the combination of karanja bio-diesel with EGR20 and piston with nine grooves give better performance and reduced emissions.

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