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Research Article

Use of EGR in Diesel Engine for Investigating the Performance and Emission Characteristics in Diesel Engine

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Abstract

The main aim of this project is to investigate the effects of hot and cold Exhaust gas recirculation (EGR) methods on emissions and efficiency of the single cylinder, 4-stroke, direct injection diesel engine. For getting different EGR methods heat exchanger is provided. With and without Exhaust gas recirculation the performance characteristics like efficiencies, emissions were studied. In this project the different amounts of EGR like 10%, 15% and 20% of EGR is used to study the effects on the performance characteristics The recirculation of exhaust gas reduces the oxygen quantity in the combustion chamber and increases the temperature of intake charge which reduces the flame temperature and makes to lower NO_x formation. By increasing the cooled EGR rates reduces the emissions more effectively. Experimental results shows that the cold EGR is much effective than the hot and intermediate EGR for the reduction of NO_x emission. The increase in temperature of EGR gases causes to increase the combustion temperature which leads to increase in formation of NO_x.

Keywords: *diesel engine, EGR (exhaust gas recirculation), EGR percentage*

1. Introduction

Due to its high thermal efficiency and low maintenance cost compression ignition engines are widely used even though, the exhaust products of diesel engine is one of the major sources of pollution of atmosphere in the world, as per the survey for about 60% of the total pollutants were dumped into the atmosphere. UBHC, CO, NO, etc., are the major constituents of the engine exhaust pollutants and efforts are throughout the world to find effective means to control them. Thus alternative fuel for diesel and emission control is still in progress. The combustion process of Diesel engine convert the energy stored in the chemical bonds of the fuel into useful mechanical energy. This occurs in two stages. The fuel reacts chemically and releases energy in the form of heat in the first stage. The heat generated in the cylinder make the gases trapped in the cylinder will move the piston to expand, the to and fro motion of piston make the crank shaft to

In the cylinder where the heated compressed air is present and the fuel will enter, however, it will only burn when it is in a vaporized state and intimately mixed with the supply of oxygen the first small droplet of fuel enter the combustion chamber and vaporized very fast. The process of vaporization of the fuel makes the air surrounding the fuel to cool and it requires sufficient time for air to reheat sufficiently to ignite the vaporized fuel. The additional heat from combustion chamber helps to further vaporize the new fuel entering the chamber once ignition has started as long as oxygen is present in the chamber. Solid or semisolid carbonaceous matter builds up because of incomplete combustion. The compression-ignition engine exhaust gases contain Oxides of Nitrogen, carbon monoxide, organic compounds that are unburned or partially burned or partially burnt hydrocarbons, visible smoke and soot (or particulates).

The effect of exhaust gas recirculation in direct injection diesel engine Maiboom. et al. has studied. As per the experimental results at constant EGR with increasing the inlet temperature has more effects on combustion and emissions, thus sometimes giving opposite observations as traditional observations, as with increased inlet temperature the reduction of NO_x emissions occures.High EGR at constant pressure with very less NOx at low-load conditions are obtained is due to delayed combustion due to the high dilutions. This leads to increase of BSFC, CO and hydrocarbon emissions. In few operating conditions, EGR at constant AFR is a way to drastically reduce NO_x emissions without important penalty on BSFC and soot emissions. Swami Nathan et.al has investigated the chances of operating a HCCI engine with reasonably high thermal efficiencies in a wide range of BMEP's with acetylene as fuel. Based on output of engine the intake quantity of EGR and temperature of the charge have to be controlled which leads to reduce NO emissions and smoke. At high BMEP's the hot EGR leads to knocking

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tendency, but can be controlled by proper control over the temperature and quantity of re circulated exhaust gas. The experimental investigation of Walke et. al, on diesel engine performance with recirculation of exhaust gas effect and observed that with increasing rates of EGR at different torques brake thermal efficiency reduction is small. The concentration of NOx decreases with increase in EGR. Studying the effects of EGR rates on diesel engine by Goma et.al, shows that the with various EGR rates CO emissions increased. The reason may be less excess oxygen available for combustion. Rich air fuel mixture at different locations inside the combustion chamber is due to less excess oxygen. Due to high pressure and high temperatures during combustion NO in combustion chamber is reduced

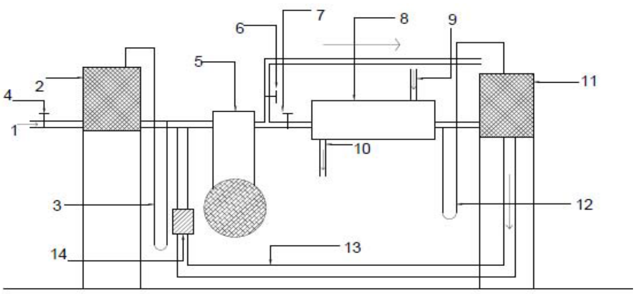
As per the experimental Investigations of Niranjan et.al, on the effects of cold EGR and hot EGR using bio-diesel as fuel and concluded that increased NOx emission is due to higher temperature of the EGR gases causes increase in temperature inside the combustion chamber, and also making the gasses of combustion chamber to stay longer periods at higher temperatures. As per the numerical investigations of Machrafi et.al, on the HCCI engine the influence of EGR, and also the effect of Co on auto ignition process. Based on this study CO can be either support or inhibit auto ignition delay. As per the investigations of Pradeep and Sharma et. al, NOx can be controlled by using hot EGR by using bio-diesel as fuel in a C.I engine. We found at full load NO emissions from bio-diesel with EGR, less than that of without EGR and it shows that the BTE was found to be comparable with and without EGR at different loads. Hitoshi Yokomura, Koji mori et.al, studied Expansion of EGR Area with Venturi EGR System. The application of EGR to IC engines achieves larger reductions in NOx emissions under a high load condition than a low-load condition for the same EGR rate. In other words, under the high-load condition, a low EGR rate produces the same NOx emission reduction effect as a high EGR rate under the low-load condition. The venturi EGR system expands the EGR-feasible range without adversely affecting fuel economy caused by an increase of pumping loss, and it is thus an effective system for turbocharged diesel engines

2. Experimentation Methodology

The test engine was performed on single cylinder, direct injection, water cooled Compression Ignition engine. The experimental setup is shown in fig.1. To the inlet manifold an orifice box was connected and the air mass flow rate was measured using the manometer connected to the orifice box. In EGR, piping system was taken from the engine exhaust pipe with control valve, and an orifice meter was used to measure the flow rate of the exhaust gases. Two valves were used to control the amount of EGR re-circulated into the inlet manifold, the first one in the inlet piping and the second one is the pipe line connecting the exhaust line and the inlet manifold. The inclined manometer is used for measuring the flow rate of re-circulated exhaust gas flows through another orifice meter before mixing with the atmospheric fresh air. By cooling the re-circulated exhaust gas the cold Exhaust gas recirculation was obtained. Parallel flow heat exchanger having cold water as fluid to transfer heat to which EGR was connected was used. The heat exchanger is connected with manometers for measuring inlet and outlet of the cold and hot fluids .For emission measurements the exhaust gas analyzer probe was inserted into the exhaust pipe. Rope brake dynamometer was connected for loading the engine and the loads are noted manually. The experimental setup are shown below

Engine Specifications

Bore in mm	85
Stroke in mm	110
Rated RPM	1500
Rated power output in kW	6.5
Loading	Rope braking
Connecting rod length	235mm
Compression ratio	18:1
Rated speed	1500rpm
Orifice diameter	0.016



1. Air inlet
2. Air inlet Orifice box
3. Air inlet manometer
4. Air inlet control valve
5. CI engine
6. Exhaust gas control valve
7. EGR control valve
8. Heat exchanger
9. Water inlet
10. Water outlet
11. Exhaust gas Orifice box
12. Exhaust gas manometer
13. EGR pipe
14. Particulate filter

Figure 1: Schematic Diagram of Experimental setup

3. Results and Discussion

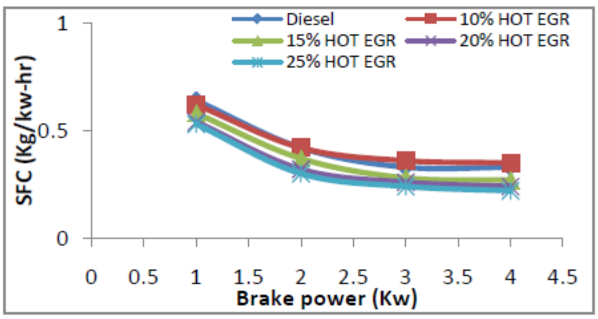


Figure 2: BP Vs SFC for various Hot EGR Ratios

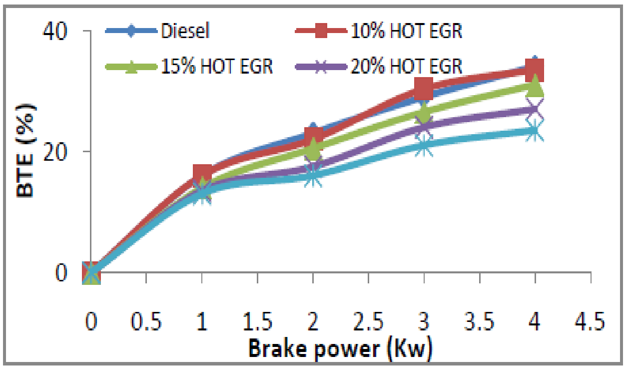


Figure 3: BP Vs BTE for various Hot EGR Ratios

The tests are conducted at the rated speed of 1500 rpm at different loads. Based on the experimental data the graphs were drawn. These graphs show the variation of specific fuel consumption, mechanical efficiency, Brake Thermal efficiency, Indicated power, BMEP and IMEP with respect to Brake power for various percentages and methods of EGR.

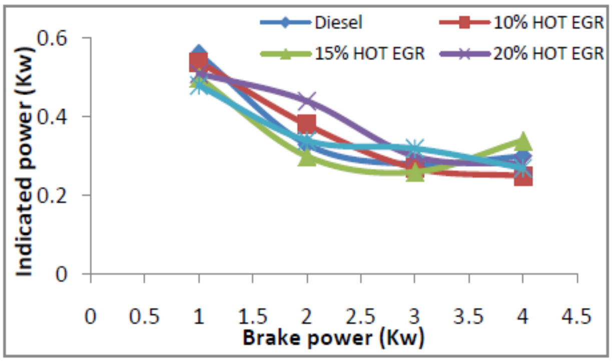


Figure 4: BP Vs IP for Various Cold EGR Ratios

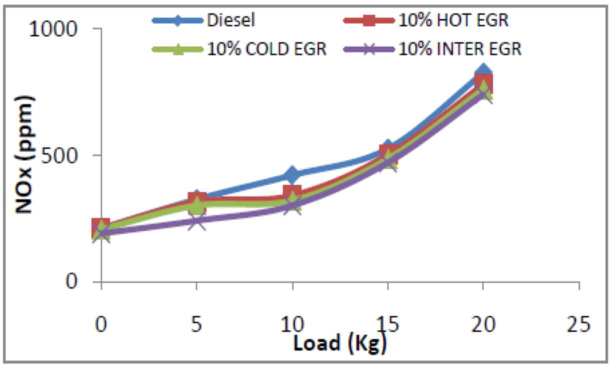


Figure 5: Load Vs NOx for 10% EGR

Specific fuel consumption is found to be more at all loads with and without EGR.

Brake thermal efficiency with 10% EGR was comparable without EGR at all loads. Indicated thermal efficiency with cold EGR is found to be better as compared with hot and intermediate EGR but it relatively low without EGR.

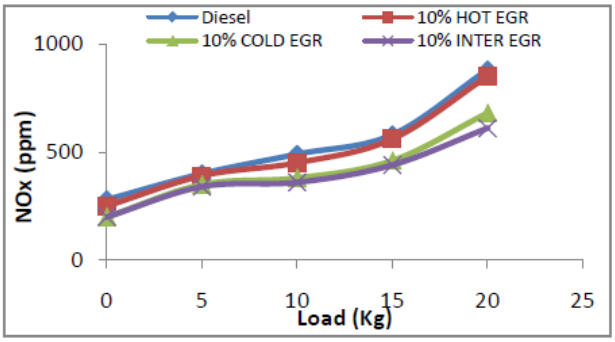


Figure 6: LOAD Vs NOx for 15% EGR

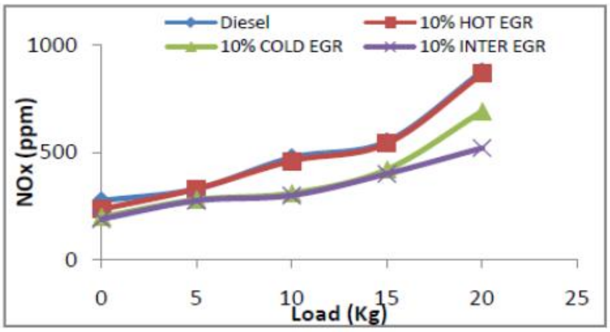


Figure 7: LOAD Vs NOx for 20% EGR

NOx emission from hot EGR is comparatively higher than without EGR. Cold EGR of higher rates shows much effective in reducing NOx emission.CO2 emission at 10% cold EGR percentages is very high than that of higher EGR rates.CO emissions with EGR was increased in part loads and decreases with higher loads as compared without EGR

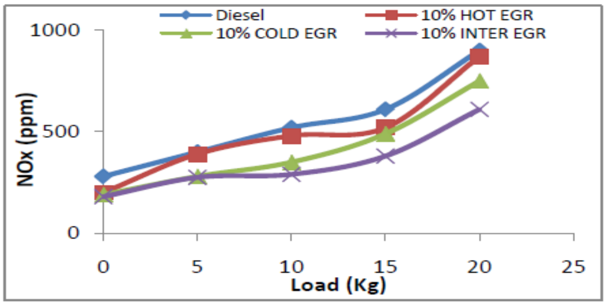


Figure 8: LOAD Vs NOx for 25% EGR

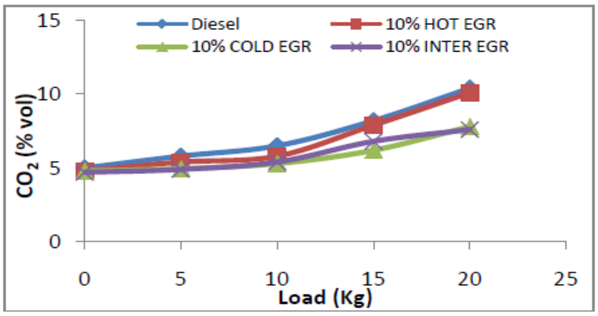


Figure 9: LOAD Vs CO_2 for 10% EGR

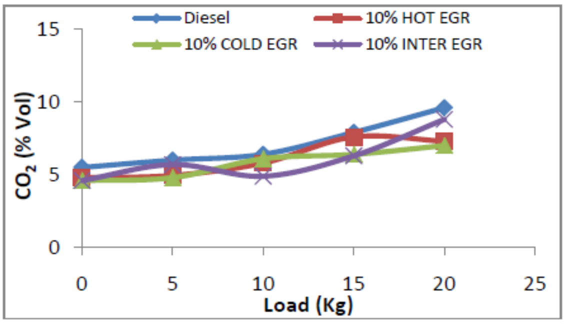


Figure 10 : LOAD Vs CO_2 for 15% EGR

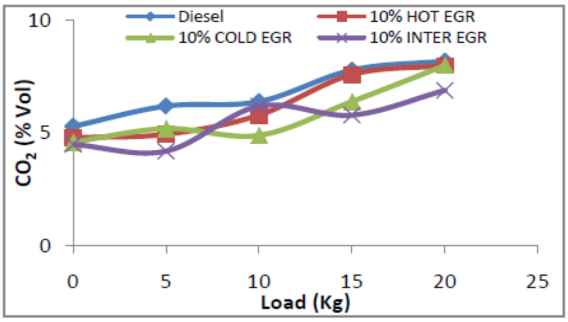


Figure 12: LOAD Vs CO_2 for 20% EGR

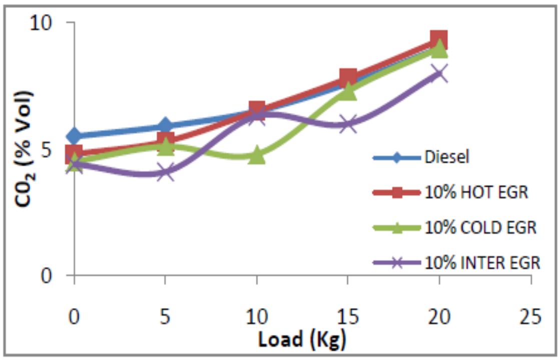


Figure 13: LOAD Vs CO_2 for 25% EGR

4. Conclusions

As per the experimental results we conclude that the NOx is reduced due to exhaust gas recirculation and how ever the Efficiency is slightly decreased.

At higher loads NOx is decreasing and at partial loads NOx is increasing. The relation between NOx formation and other gases are diverging with load conditions.

The cold EGR is much effective than hot EGR as per the results. 15-25% of cold EGR reduces the formation of NOx very well as per the results the experiments on EGR with techniques like variable geometry turbocharger, alternative fuels for improving the performance in future scope

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