Effect of Exhaust Gas Recirculation (EGR) on the Engine Performance

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Abstract— **The automobile industry has faced numerous challenges. One of the most compelling tasks has been the reduction of emissions and increase in the efficiency of engines. Since, the market share of diesel engine is increasing predominantly in many countries; the problem with diesel engines is to be identified. Diesel engine is widely used globally and can be found in almost every conceivable application. Diesel engines are energy efficient, but their NOx, particulate emissions and the high exhaust gas temperature present major obstacles to engine development. The aim of this work is to analyze the effect of Exhaust gas recirculation (EGR) on the engine performance and exhaust emission characteristics. The work carried out on a four stroke four cylinder Diesel engine.**

Index Terms—**NOx, EGR (exhaust gas recirculation), bsfc.**

I. INTRODUCTION

The majority of the world's energy demand is met by fossil fuels. With the rapid development of the industry and society, the requirement of fossil fuels is growing higher and higher. Facing the challenges of limited fossil fuel reserves and stringent environmental constraints, the issue of finding substitutes for fossil fuels has become a major work for researchers studying internal combustion engines. In the last two decades, the researchers and manufacturers have provided major reductions in the exhaust emission levels of the automobiles due to increasing global concern about the air pollution, but the problem has yet not been solved.

Exhaust Gas Recirculation (EGR) is a pre-treatment technique, which is being used widely to reduce and control the oxides of nitrogen (NOx) emission from diesel engines. EGR controls the NOx because it lowers oxygen concentration and flame temperature of the working fluid in the combustion chamber. However, the use of EGR leads to a trade-off in terms of soot emissions. Higher soot generated by EGR leads to long-term usage problems inside the engines such as higher carbon deposits, lubricating oil degradation and enhanced engine wear. Wagner et al. tried to achieve lower emission of NOx and soot using highly diluted intake mixture. At very high EGR rate, emission of particulate matters decreased sharply with a continuous drop in NOx emission but this high EGR rate significantly affect the fuel economy. Agarwal et al. investigated the effect of EGR on performance and emissions, carbon deposits, and wear of various parts of a diesel engine and reported that thermal efficiency is increased and brake specific fuel consumption (BSFC) is decreased at lower loads with EGR compared to without EGR but at higher loads, thermal efficiency and BSFC are almost similar.

By feeding the lower oxygen exhaust gas into the intake, diesel EGR systems lower combustion temperature, reducing emissions of NOx. This makes combustion less efficient, compromising economy and power. The normally dry intake system of a diesel engine is now subject to fouling from soot, unburned fuel and oil in the EGR bleed, which has little effect on airflow but can cause problems with components such as swirl flaps, where fitted. Diesel EGR also increases soot production, though this was masked in the US by the simultaneous introduction of diesel particulate filters.

In today's context, diesel engine has become an important power source in farming activities in rural areas where electrical energy is unavailable. Also, the market share of diesel car has increased in many countries because of its higher thermal efficiency. This trend is expected to be continued in the future. However, the problem with diesel engine is its higher emissions and exhaust gas temperature. An attempt is made to overcome this problem by injecting hydrogen peroxide into the diesel engine.

Present Work: From the Literature review, it shows that analyze the effect of EGR on the engine performance and exhaust emission characteristics. The work carried out on a four stroke four cylinder Diesel engine. There is a need to reduce the emissions and exhaust gas temperature and also to increase power. In order to reduce NOx emission EGR is extensively used. To conduct the experiments on diesel engine using neat diesel with & without EGR at different injection pressures and for various loads.

Exhaust Gas Recirculation (EGR): Exhaust Gas Recirculation is an efficient method to reduce NOx emissions from the engine. It works by re-circulating a quantity of exhaust gas back to the engine cylinders. Inter-mixing the re-circulated gas with incoming air reduces the amount of available O_2 to the combustion and lowers the peak temperature of combustion. Recirculation is usually achieved by piping a route from the exhaust manifold to the intake manifold. A control valve within the circuit regulates and times the gas flow.

Exhaust gas recirculation reduces the concentration of oxygen in the fuel-air mixture. By replacing some of the oxygen-rich inlet air with relatively oxygen-poor exhaust gas, there is less oxygen available for the combustion reaction to proceed. Since the rate of

a reaction is always dependent to some degree on the concentration of its reactants in the pre- reaction mix, the NOx-producing reactions proceed more slowly, which means that less NOx is formed.

In addition, since there is less oxygen available, the engine must be adjusted to inject less fuel before each power stroke. Since we are now burning less fuel, there is less heat available to heat the fluids taking place in the reaction. The combustion reaction therefore occurs at lower temperature. Since the temperature is lower, and since the rate of the NOx-forming reaction is lower at lower temperatures, less NOx is formed. They are three parts such as EGR Control Valve.

The purpose of the EGR system is to precisely regulate the flow under different operating conditions. The precise amount of exhaust gas must be metered into the intake manifold and it varies significantly as the engine load changes. By integrating the fuel and load control with the EGR system, engine performance and the fuel economy can be enhanced. For this an exhaust control valve (ECV) is used to regulate the EGR flow. When EGR is required EGR valve should be turned on for the required opening. The exhaust gas being withdrawn is circulated through the water cooled Intercooler which has certain number of fins and passing pipes surrounded by water and cools the exhaust gas and brings the temperature to the room condition. The cooled exhaust gas then flow through the EGR transfer pipe to the intake manifold as shown in Fig.1.

II. EXPERIMENTAL SETUP:

1. HYDRAULIC DYNAMOMETER, 2. CONTROL VALVE 3. EGR COOLER, 4. AIR FILTER, 5. COMPRESSION IGNITION ENGINE 6. AIR CHAMBER 7. FUEL TANK 8. EGR COOLER INLET 9. EGR COOLER OUTLET 10. EXHAUST GAS OUT LET FROM SILENCER

Table.1. Engine Specification

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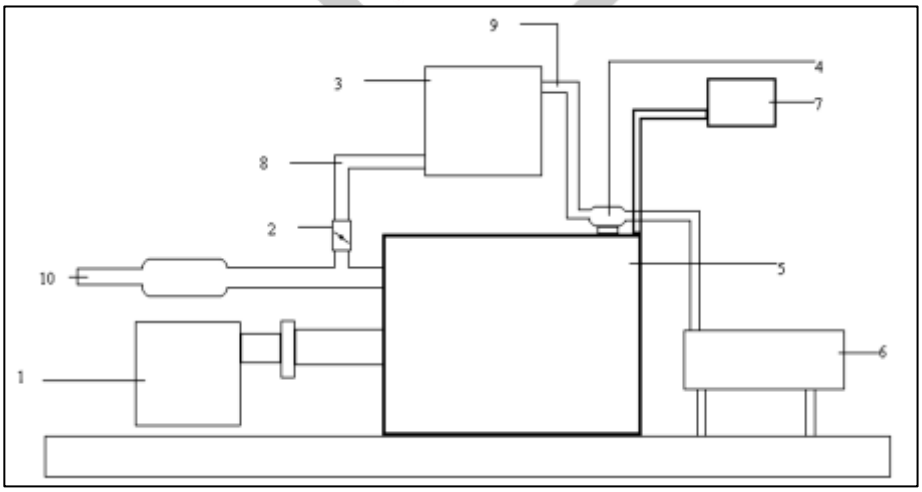
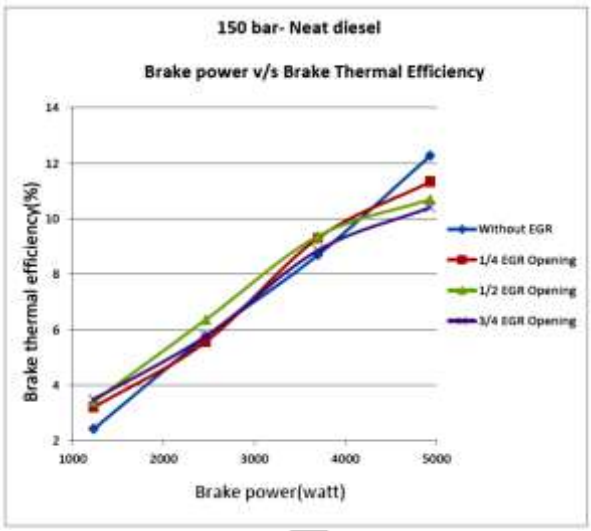
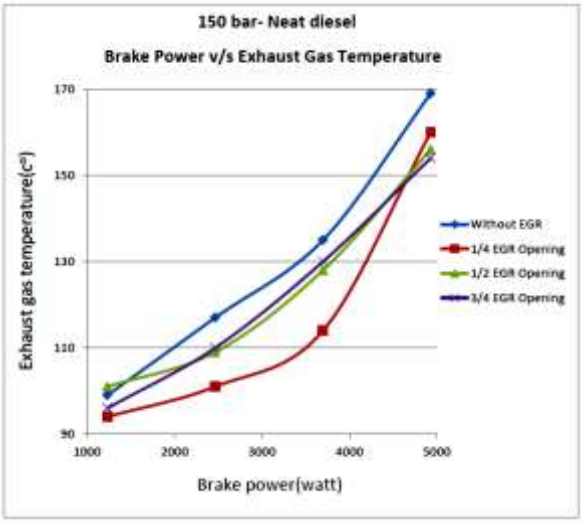
Engine Description	1.8L 68bhp 4 cylinder OHV
Engine Displacement	1817 cc
No. of Cylinders	4
Valve Configuration	OHV
Maximum Power	68 BHP @ 4800 RPM
Maximum Torque	13.7 Kgm @ 2250 RPM
Bore x Stroke	84 x 82 mm
Compression Ratio	22:1
Turbocharger	No
Supercharger	No

Fig.1 Diesel engine test rig and EGR system



III. RESULTS AND DISCUSSIONS: The investigation of diesel engine performance is done by blending diesel with diethyl ether with and without EGR is presented in this chapter. The analysis is done in the sequence of comparison of performance obtained at different concentrations of diesel fuel with diethyl ether for various EGR valve openings. The variation of brake thermal efficiency, specific fuel consumption and exhaust gas temperature at different load has been presented and discussed. The engine speed is kept at a constant speed of 1200rpm with an EGR valve opening of 1/4, 1/2, 3/4, .The results were analyzed as follows. Performance Characteristics for neat Diesel with and without exhaust gas recirculation (EGR). Performance Characteristic of neat diesel at 150 bar pressure and 180 bar pressure. The comparison of performance of diesel engine at different loadings, different valve openings and at different blending and different injection pressure are shown clearly with the graphical representation of values for different parameters like brake thermal efficiency, specific fuel consumption, exhaust gas temperature.



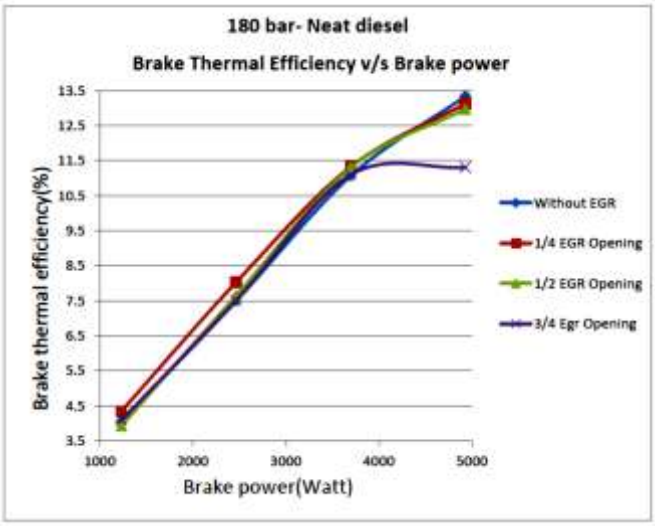


Performance characteristics of neat diesel at 150 bar pressure and 180bar pressure

Fig.a Brake thermal efficiency v/s Brake power *Fig.b Exhaust gas temperature v/s brake power*

Fig.a shows the comparison of brake thermal efficiency v/s brake power for using neat diesel. The brake thermal efficiency was measured with brake power for all the test turns with and without EGR. The efficiency has been found to decrease by recirculating exhaust gas. This happens due to burnt gas occupying the engine cylinder which thereby reduces the availability of oxygen for combustion. The maximum efficiency has been found to be 12.27% for brake power of 4931.04W ½ open EGR.

Fig.b. shows the Comparison of EGT (degree Celsius) v/s Brake Power. The Exhaust gas temperature was measured with brake power for all the test turns with and without EGR the Exhaust Gas Temperature is compared with brake power for all the test turns with and without EGR for 4, 8, 12 and 16 kg loads. It is found that Exhaust Gas Temperature reduces with the application of E.G.R which in turn reduces the NOx pollutant from the emission. The minimum value of EGT was found to be 151 degree Celsius for a brake power of 4931.04W with ¾ valve opening for EGR.



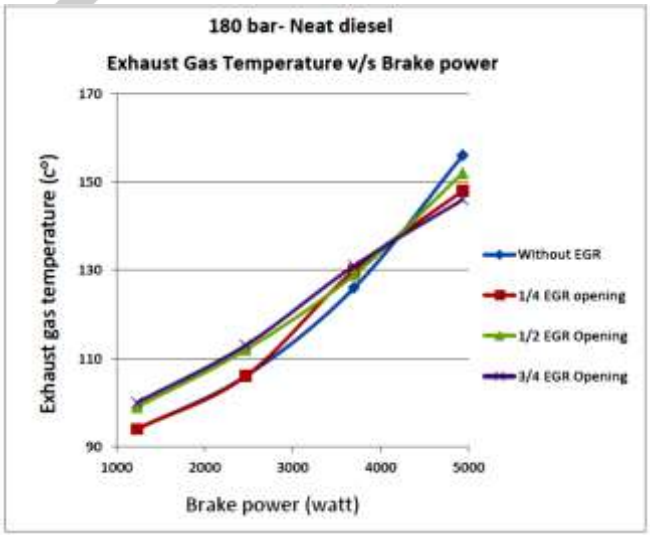


Fig.c Brake thermal efficiency v/s Brake power Fig.d Exhaust gas temperature v/s brake power

Fig. c shows the comparison of brake thermal efficiency v/s brake power for using neat diesel. The brake thermal efficiency was measured with brake power for all the test turns with and without EGR. The efficiency has been found to decrease by recirculating exhaust gas. This happens due to burnt gas occupying the engine cylinder which thereby reduces the availability of oxygen for combustion. The maximum efficiency has been found to be 13.34% for brake power of 4931.04W without EGR.

Fig d shows the Comparison of EGT (degree Celsius) v/s Brake power. The Exhaust gas temperature was measured with brake power for all the test turns with and without EGR. The Exhaust gas temperature Exhaust gas temperature is compared with brake power for all the test turns with and without EGR for 4, 8, 12 and 16 kg loads. It is found that Exhaust gas temperature reduces with the application of E.G.R which in turn reduces the NOx pollutants in the engine emission. The minimum value of EGT was found to be 146 degree Celsius for a brake power of 4931.04 W with 3/4 valve opening for EGR.
H2O2 blends.

IV. CONCLUSION: The performance study of injecting neat diesel in a compression ignition engine indicates that no major modifications are required in the existing engine. The brake thermal efficiency increase with exhaust gas recirculation for neat diesel for both pressures. At 180 bar injection pressure the engine was observed to run at smooth condition and achieved maximum performance. The maximum value of Brake Thermal efficiency is 22.75 % for neat diesel. The minimum value of Exhaust Gas Temperature is 151^{o}C for neat diesel with 3/4 EGR valve opening. The emission parameter in different load, different injection pressure, then comparison and decides the best values. By all these results we can conclude that the after treatment devices are active in reducing the engine emissions and are necessary in attaining the emission norms at 180 bar pressure.

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