Effect of Inlet Air Pressure and EGR Rate on the Diesel Engine Emission

Nikunj D Patel[1] Gaurav P Rathod[2] Tushar M Patel[3]
[1]Master Scholar [2]Assistant Professor [3]Associate Professor
[1,2,3]Department of Mechanical Engineering
[1,2,3]Kadi Sarva Vishwavidyalaya, Gandhinagar, Gujarat, India

Abstract—by using D.I. Engines, main pollutants contributed are NOx, Co, unburned hydrocarbons (HC) and other particulate emissions. This paper mainly focuses on reducing exhaust emission and energy saving by investigating diesel combustion with Exhaust Gas Recirculation (EGR) system. The number of experiments was conducted on a four stroke direct injection water cooled constant speed diesel engine with EGR systems. In the experiment, EGR system was made individually and also with varying inlet air pressure. In this experiment, compressor was used to pressurize the intake air. The experiments were held away to measure the emission event at different EGR rates and varying inlet air pressure of the Diesel engine. In the result, emission effect such as NOx, Co, Hc were observed. So the modified engine provides greater NOx reduction and better fuel economy without reducing useful characteristics (brake power, brake thermal efficiency etc.) of the Diesel engine.

Key words: Diesel engine, Emission, Exhaust gas recirculation, NOx

I. INTRODUCTION

In today's, Diesel engines are the most efficient in the world because of their economical fuel rate and higher force with lower maintenance cost with compare to the other engines. Diesel engines take in higher thermal efficiencies, resulting from their high compression ratio and fuel lean operation. To achieve auto-ignition the high temperatures required produced by the high compression ratio. The higher flame temperature was predominantly because local stoichiometric air–fuel ratio prevails in such heterogeneous combustion processes. There for diesel engine generates large amounts of NOx because of the higher flame temperature in the presence of abundant oxygen and nitrogen. There are many techniques available to reduce NOx. All of them EGR was a most effective technique to reduce NOx. EGR rate play an important role in determining the engine performance and emission characteristics. Thus, placing the proper EGR rate is important for the engine optimization and calibration processes, which bear on the EGR response and NOx efficiencies. The purpose of this research was to get an EGR rate strategy using experimental analysis.

II. LITERATURE REVIEW

During the combustion process of a diesel engine, there are many toxic and non- toxic gases are produced in the fumes of the engine. In the case of CO2 has the main impact on global warming. There are two most problematic exhaust gases of the diesel engine are NOx and soot particles. And small content of HC and CO or can be eliminated fairly easily with the help of oxidation catalyst. Exhaust emissions from diesel engines are usually more visible with compare to those emitted from the exhaust of petrol engines because they contain ten times more soot.

Avinash Kumar Agrawal et al at the fixed power condition as the % of EGR increase the temp. Of exhaust gas continuously decreased. Earlier it was mentioned that the most imp reason for Nox formation is extremely high temp. Further, it was found that BSFC is fairly independent of EGR [1]. Jaffar Hussain et al thermal efficiency is slightly decreased and BSFC is increased with EGR compared to without EGR. Exhaust gas temperature is decreased with EGR, but NOx emission decreases significantly. They discovered that 15% EGR rate is found to be effective to reduce NOx emission substantially without deteriorating engine performance in terms of thermal efficiency, BSFC, and discharges. EGR can be applied to diesel engine without sacrificing its efficiency and fuel economy and NOx reduction can thus be accomplished. The increase in CO, HC, and PM emissions can be cut by using exhaust after-treatment techniques, such as diesel oxidation catalysts (DOCs) and soot traps [2]. C. Beatrice et al The present paper investigates the effect of the characteristics of the "Low Pressure" EGR systems leads to an increased density of the intake charge and to a consequent increment of the in cylinder o2 trapped mass. At the same time the result reveals that the EGR flow temp. reduction permits to increase the EGR rate. As a consequence a decrement of both Nox and PM emission at the same fuel consumption was observed [3]. N. Saravanan et al EGR technically part of the exhaust gases from the engine was cooled down to 30´C and controlled by using a needle valve & admitted into the intake air. Break thermal effi. Decreased linearly with increase in the EGR flow rate [4]. Ghazikhani et al also found that volumetric effi. drop when the EGR rate is increased. The degree of reduction in NOx at higher load is more gamey. The cause of reduction in NOx using EGR is reduced concentration of oxygen [5]. P. v. walker et al In this paper they conclude that break thermal efficiency decrease with increasing EGR rates. All the same, this decrease marginally. Break specific fuel consumption increases marginally with the increasing EGR rate at high load [6]. Andrzej Bieniek et al In this present paper they conducted initial testing in stationary state an opportunity for determining the rate of NOx and PM as a result of applying advanced ECU control of the system of EGR with feedback signal from NOx sensor. As shows research results in the stationary states NOx emission could be reduced of about 30% and PMs above 10%. A possibility of reducing mostly nitrogen oxide emissions has been argued here. Analysis of transitional states shows possibilities for further EGR control algorithm optimization [7].

III. EGR SYSTEM

In an EGR system some of the exhaust gases is re-circulated into the combustion chambers. This can be achieved either internally with the proper valve timing, or externally with some kind of piping. By mixing the exhaust gases with the intake air, the oxygen concentration of the cylinder charge is turned down. EGR is to hold combustion chamber temperature cool down although practically. The lower combustion temperature directly reduces the NOx formation, as the NOx formation rate is extremely temperature dependent. It also reduced the thermal efficiency of the engine. Probably the most uncomplicated and practical method of reducing maximum flame temperature is to dilute the air-fuel mixture with non-reacting parasite gas. EGR rate is defined as follows [8]:

$$EGR\ [\%] = \frac{\dot{m}\ exhaust,intake}{\dot{m}\ exhaust,intake + \dot{m}\ air,intake} \times 100 \qquad (3.1)$$

IV. EXPERIMENTAL SETUP

The experiments were conducted on a single-cylinder, 4-Stroke, water-cooled diesel engine of 5 HP rated power[8]. The engine is coupled to a rope brake dynamometer through a load cell. A five exhaust gas analyzer was used for measuring NO, CO2, HC and CO. The exhaust gas analyzer determined the emissions of NO, CO2, HC and CO by means of electrochemical sensors. The experimental setup is shown in below Figure [8]

Fig.1: Experimental Setup

The setup enables study of engine performance. Show below technical specification of this engine.

Item	Specification
Engine	Single cylinder diesel engine
Cooling	Water cooled
Bore × Stroke	80 mm × 110 mm
Compression ration	16 : 1
Maximum Power	5 hp or 3.7 kW
Rated speed	1500 rpm
Capacity	553 CC

Table 1: Technical Specifications [8]

V. METHODOLOGY

In this experiment, diesel engine connected with the rope brake dynamometer. By using a dynamometer, varies the load on the engine and gas analyzer is utilized to quantify the emission from exhaust gas. The readings are taken at taken at varying the load (2,4,6,8), inlet air pressure(-ve pressure, Atm. pressure, +ve pressure) and EGR rate (10%, 20%, 30%). In this experiment, a two stage reciprocating air compressor was used to (+ve pressure) inlet air.

Perform this experiment, the first experiment was carried out with a conventional diesel engine at atmospheric inlet air pressure. For experiment three different EGR rates 10%, 20% and 30% respectively were selected. Then after the experiment was carried out for varying inlet air pressure with same different EGR rates and observed the effect of engine emission. The three ranges of inlet air pressure (-ve pressure, Atm. pressure, +ve pressure) were selected. The data for HC, NOx, CO, CO2 and fuel consumption were recorded.

VI. RESULTS AND DISCUSSION (EMISSION ANALYSIS)

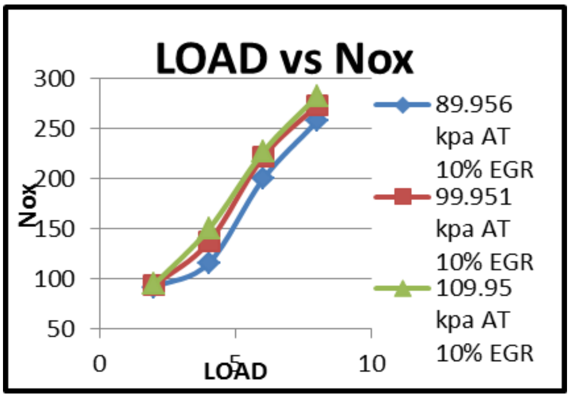

Fig. 2: Graph of LOAD Vs Nox At 10% EGR

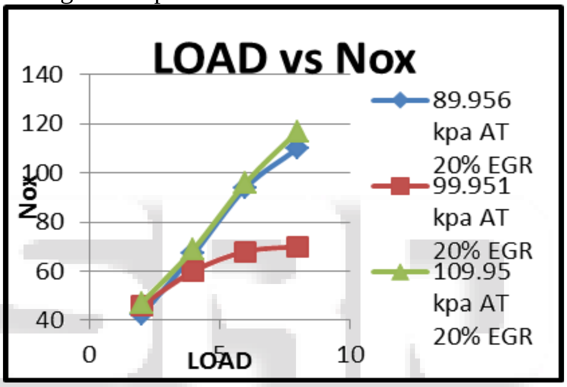

Fig. 3: Graph of LOAD Vs Nox At 20% EGR

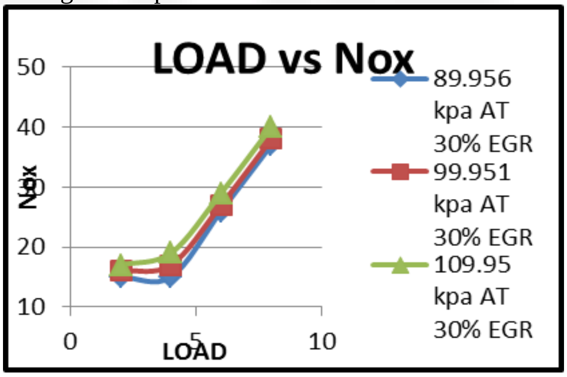

Fig. 4: graph of LOAD vs NOx at 30% EGR

Shown above fig. (2,3,4) Represents comparison of NOx for EGR with inlet air pressure for the load (2,4,6,8,) condition. When the EGR rate increases and also increases inlet air pressure increasing than The discharge air decreases. It was found from the experiment that NOx is decreasing with increasing in an EGR rate because temperature available for combustion is reduced. Only by increasing inlet air pressure with EGR system, NOx is increased because by supplying pressurized inlet air.

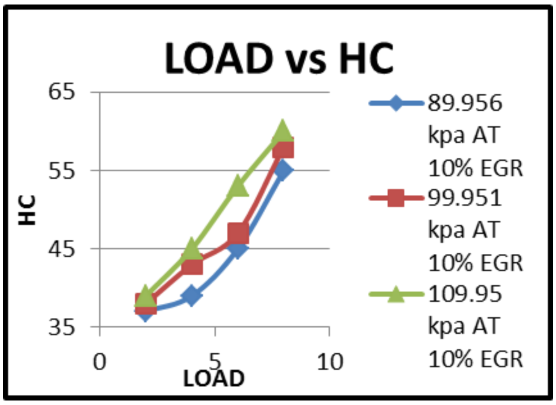

Fig. 5: Graph of LOAD Vs HC At 10% EGR

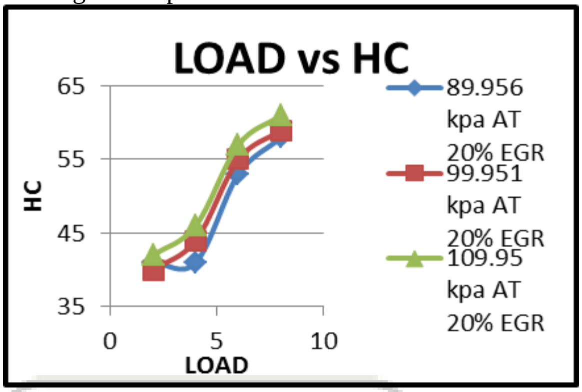

Fig. 6: Graph of LOAD Vs HC At 20% EGR

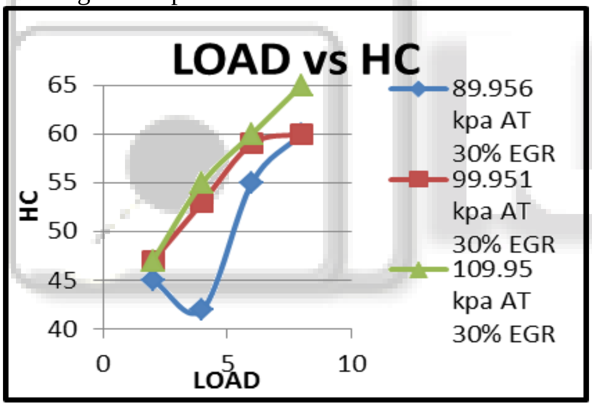

Fig. 7: Graph of LOAD Vs HC At 30% EGR

HC for different load condition are presented in Fig. (5,6,7). The general trend of the NOx emissions is inversely related to the HC, CO and CO2 emissions. HC is increased with increasing rates of EGR and decreasing with inlet air pressure. It may be possible, the possible reason may be decrease in combustion temperature or exhaust gas temperature.

VII. CONCLUSIONS

An experiment was developed to measure the effect of increasing inlet air pressure and EGR rate on engine emission like NOx, HC, CO2 and CO. From the result following conclusion has been gained.

- NOx decreases and HC increases by increasing EGR rate.
- It was a more beneficial way to reduce NOx emission than the individual EGR system because Nox is reduced as the combustion temperature decreases.

VIII. ACKNOWLEDGMENT

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