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A review about effect of exhaust gas recirculation on the exhaust emission from diesel engine

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Abstract— **Internal combustion engines, being the major power source in the transportation sector as well as in individual transport, play an important role in the man-made emissions. In present, developed technologies are used to reduce the fuel consumption and exhaust emission of a diesel engine. Fuel consumption in a CI engine is reduced to a considerable amount, but the emission of NOx is a critical issue. This paper tries to present a review about the effect of EGR system on a CI engine, as well as in DF engine. A way to reduce the nitrogen oxide emissions of a diesel engine is the use of exhaust gas recirculation, EGR. Here, a part of the exhaust gases is rerouted into the combustion chamber. This leads to a lower peak combustion temperature which in turn reduces the formation of NOX. EGR system is effectively reduce the NOx emission from an engine, by reducing the amount of available oxygen and reduces the flame temperature in the combustion chamber.**

Keywords— **EGR system, NOx, Diesel engine, Emissions**

I. INTRODUCTION

All internal combustion engines generate power by creating explosions using fuel and air. These explosions occur inside the engine cylinder, the next explosion forcing the exhaust gases out of the cylinder. The need to control the emissions from automobiles gave rise to the computerization of the automobile [1]. Now a days, the stringent emission legislation are compelling the engine designer to reduce the exhaust emission by the use of developed technologies and manufacture an engine such that having low fuel consumption and very low COx and HC emission at high temperature but it has a considerable amount of NOx emission at high temperature and it also emits the particulate matter (PM) with the smog. Therefore it is desirable to reduce the NOx emission from the engine. To reduce the exhaust emission and to control effectively the NOx emission, EGR system is used. The recirculated exhaust gases have been proven to be an efficient method to reduce the NOx emission [3]. In addition, mixing of exhaust gases with intake air increases specific heat of intake mixture, which results in the reduction of flame temperature. Thus combination of lower oxygen quantity in the intake air and reduced flame temperature reduces rate of NOx formation reactions [2, 3].

II. EXHAUST GAS RECIRCULATION

In diesel engine, emission of CO and HC can be reduced by increasing flame temperature, but the NOx formation is increased at high temperature in the combustion chamber. To reduce the NOx emission EGR system is used. NOx is formed in high concentrations whenever combustion temperature exceed about 25000 F. In this recirculation system a portion of an engine's exhaust gases are recirculated back into the engine cylinders. In diesel engines exhaust gas replaces some of the excess oxygen in the combustion chamber. In EGR system exhaust gases are recirculated and mixed with intake air to the combustion. Exhaust gases are displaced the fresh air and reduce the oxygen concentration and also reduces the A/F ratio. Re-circulated exhaust gas displaces fresh air entering the combustion chamber with carbon dioxide and water vapor present in engine exhaust. As a consequence of this air displacement, lower amount of oxygen in the intake mixture is available for combustion. Reduced oxygen available for combustion lowers the effective air–fuel ratio. Thus result in lower flame temperature during combustion process. Due to this reduction of ignition temperature, the NOx emission is reduced to a considerable level. The engines using EGR emit lower quantity of exhaust gases compared to non-EGR engines because part of the exhaust gas is re-circulated [4]. Jaffar Hussain et al [6] have been carried out an experiment to investigate the effect of EGR on performance and emissions in a three cylinders, air cooled and constant speed direct injection diesel engine. They mainly focus on different EGR rate. They were measured the emission of hydrocarbons (HC), NOx, carbon monoxide (CO), exhaust gas temperature, and smoke opacity and also calculated the performance parameter such as thermal efficiency and brake specific fuel consumption (BSFC). They concluded that 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 observed 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 emissions. EGR can be applied to diesel engine without sacrificing its efficiency and fuel economy and NOx reduction can thus be achieved. The increase in CO, HC, and PM emissions can be reduced by using exhaust after-treatment techniques, such as diesel oxidation catalysts (DOCs) and soot traps [7] and its impact on reducing NOx emissions from bio diesel fuel combustion. Diesel engines are very popular power plant used all over the world, mostly in rural areas..Diesel engine has high emission pollutants such as CO, CO2, HC and NOx etc. to reduce this pollutant emission mainly NOx from diesel engine, EGR system is used along with CI engine. Diesel engines are used for bulk movement of goods, powering equipment, and to generate electricity more economically than any other device in this size range. In most of the global car markets, record diesel car sales have been observed in recent years [5].

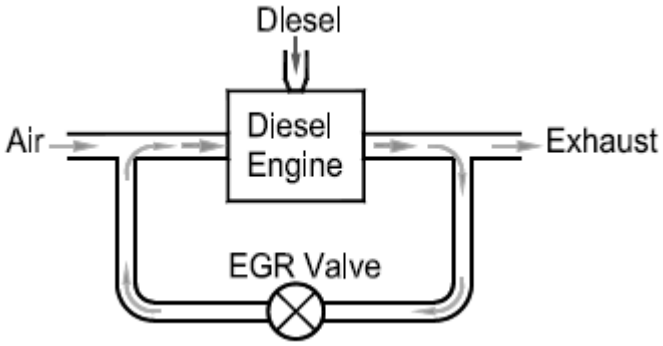

Figure 1 Exhaust Gas Recirculation

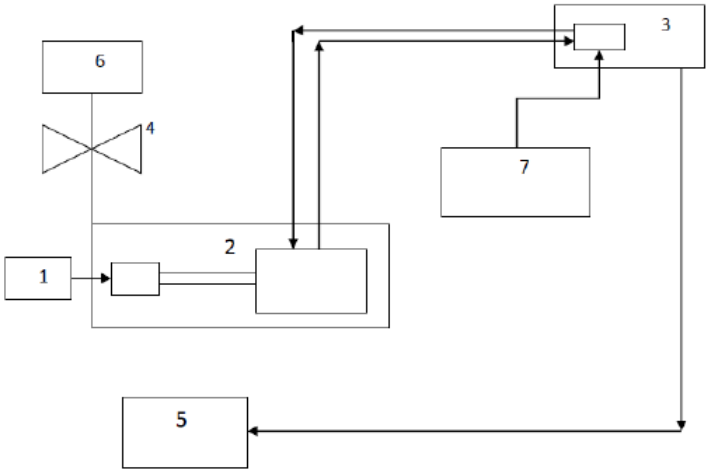

Figure 2 Line Diagram of EGR(Exhaust Gas Recirculation) Setup

1 Electrical loading, 2 Single cylinder 4-stroke diesel engine & Alternator, 3 Exhaust gas Recirculation System, 4 Control valve, 5 Gas Analyzer& Smoke meter, 6 Fuel Tank, 7 Air drum

III. RESULTS AND DISCUSSION

Reviews show that there is a considerable improvement in engine performance and emissions.

A. Oxides of Nitrogen (Nox)

Wagner et al. 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 [10]. Das et al. used EGR to reduce NOx emissions in hydrogen – supplemented SI engine without any undesirable combustion phenomena [9]. When EGR is applied, NOx emission is decreased with increase in the EGR rates. The reason behind this is, reduced oxygen concentration because of dilution of intake charge and decreased flame temperature. The EGR rate cannot be raised beyond the limit as thermal efficiency will decrease in a high rate.[7]

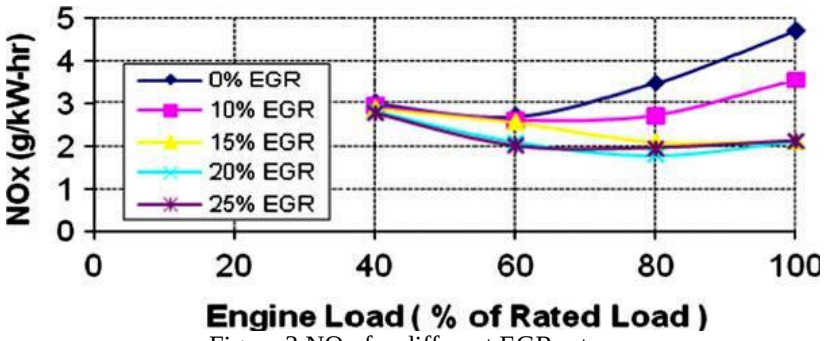

Figure 3 NOx for different EGR rates.

Oxides of nitrogen (NOx) are formed when temperature in the combustion chamber get too hot. or hotter, the nitrogen and oxygen in the combustion chamber can chemically combine to form nitrous oxides, which, when combined with hydrocarbons (HCs) and the presence of sunlight, produces an ugly haze in our skies known commonly as smog [11].

B. Hydrocarbons (HC)

Figure 4 shows variation of the HC with load for the different EGR rates for the CI engine. The HC emission is increases with % EGR increases. But as the load is increases it becomes decreases. [8]

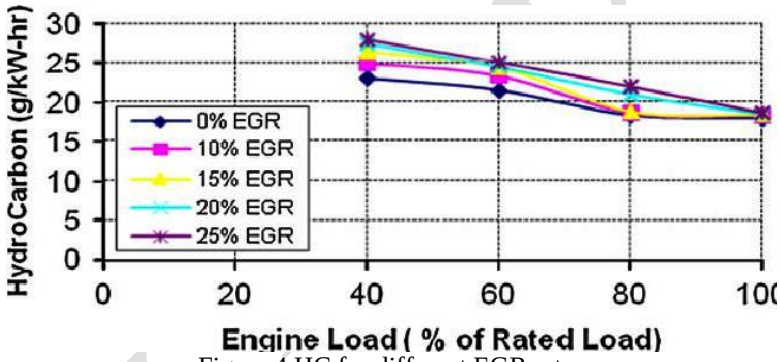

Figure 4 HC for different EGR rates

C. Carbon monoxide

The presence of CO in the exhaust gas of an engine is a representation of the chemical energy of the fuel which is not fully utilized. Generally, the CO emission is affected by the fuel type, combustion chamber design and atomization rate, engine load and engine speed. It is observed from the above figures that the CO emission decreases with the increase in load upto certain load and increases later.[10]

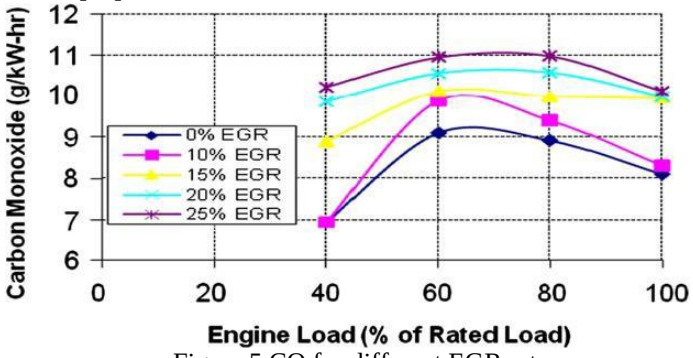

Figure 5 CO for different EGR rates

Diesel engines are widely used all over the world, but the diesel exhaust contains HC, CO, CO2, NOx and PM. It is concluded that, EGR system is an effective system used to reduce these exhaust emission as compared to other smog control device. In diesel engines, formation of NOx is occurred at high temperature in combustion chamber. To reduce the NOx formation, exhaust gases are re-circulate and mixed with intake fresh air, because of this oxygen available for combustion is reduced in the combustion chamber, thus reduces the flame temperature and NOx formation. The CO emission is reduced throughout the engine operation with EGR gases in comparison to dual fuel mode of operation [6]. This paper work concluded that, the EGR system reduces the NOx emission to a considerable level and the engines using EGR emit lower quantity of exhaust gases compared to non-EGR engines because part of the exhaust gas is re-circulated [8].

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