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REVIEW PAPER ON EXHAUST GAS RECIRCULATION

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Abstract: In diesel engines, NOx formation is a highly temperature-dependent phenomenon and takes place when the temperature in the combustion chamber exceeds 2000 K. Therefore, in order to reduce NOx emissions in the exhaust, it is necessary to keep peak combustion temperatures under control. One simple way of reducing the NOx emission of a diesel engine is by late injection of fuel into the combustion chamber. This technique is effective but increases fuel consumption by 10–15%, which necessitates the use of more effective NOx reduction techniques like exhaust gas recirculation (EGR). Re-circulating part of the exhaust gas helps in reducing NOx, but appreciable particulate emissions are observed at high loads, hence there is a trade-off between NOx and smoke emission. To get maximum benefit from this trade-off, a particulate trap may be used to reduce the amount of unburnt particulates in EGR, which in turn reduce the particulate emission also. An experimental investigation was conducted to observe the effect of exhaust gas re-circulation on the exhaust gas temperatures and exhaust opacity. The experimental setup for the proposed experiments was developed on a two-cylinder, direct injection, air-cooled, compression ignition engine. A matrix of experiments was conducted for observing the effect of different quantities of EGR on exhaust gas temperatures and opacity.

Keywords: Reducing Nox, Emission, Egr Valve, Egr Transfer Pipe, Egr Coole.

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INTRODUCTION

All internal combustion engines generate power by creating explosions using fuel and air. These explosions occur inside the engine's cylinders and push the pistons down, which turns the crankshaft. Some of the power thus produced is used to prepare the cylinders for the next explosion by forcing the exhaust gases out of the cylinder, drawing in air (or fuel-air mixture in non-diesel engines), and compressing the air or fuel-air mixture before the fuel is ignited. There are several differences between diesel engines and non-diesel engines. Non-diesel engines combine a fuel mist with air before the mixture is taken into the cylinder, while diesel engines inject fuel into the cylinder after the air is taken in and compressed. Non-diesel engines use a spark plug to ignite the fuel-air mixture, at created by compressing the air in the cylinder to ignite the fuel, which is injected into the hot air after compression. In order to create the high temperatures needed to ignite diesel fuel, diesel engines have much higher compression ratios than gasoline engines. Because diesel fuel is made of larger molecules than gasoline, burning diesel fuel produces more energy than burning the same volume of gasoline. The higher compression ratio in a diesel engine and the higher energy content of diesel fuel allow diesel engines to be more efficient than gasoline engines. For reducing vehicular emissions, baseline technologies are being used which include direct injection, turbo-charging, air-to-air inter-cooling, combustion optimization with and without swirl support, multi-valve cylinder head, advanced high pressure injection system i.e. split injection or rate shaping, electronic management system, lube oil consumption control etc. However, technologies like exhaust gas recirculation (EGR), soot traps and exhaust gas after treatment are essential to cater to the challenges posed by increasingly stringent environmental emission legislations.

II. Principal of Exhaust Gas Recirculation

In exhaust gas recirculation, some of the exhaust gas is drawn off from the exhaust system cooled and redirected back into the cylinders. Although the exhaust fills the combustion chamber, it is not involved in the combustion reaction that takes place in the cylinder due to its low oxygen content. The speed of the combustion process overall is thus reduced, with the result that the peak flame temperature in the combustion chamber is lowered. This dramatically reduces the production of nitrogen oxides.

III.LITERATURE SURVEY

The first EGR systems were crude; some were as simple as an orifice jet between the exhaust and intake tracts which admitted exhaust to the intake tract whenever the engine was running. Difficult starting, rough idling, and reduced performance and fuel economy resulted. By 1973, an EGR valve controlled by manifold vacuum opened or closed to admit exhaust to the intake tract only under certain conditions. Control systems grew more sophisticated as automakers gained experience Chrysler's "Coolant Controlled Exhaust Gas Recirculation" system of 1973 exemplified this evolution: a coolant temperature sensor blocked vacuum to the EGR valve until the engine reached normal operating temperature. This prevented drive ability problems due to unnecessary exhaust induction NOx forms under elevated temperature conditions generally not present with a cold engine. Moreover, the EGR valve was controlled, in part, by vacuum drawn from the carburetor's venturi, which allowed more precise constraint of EGR flow to only those engine load conditions under which NOx is likely to form. Later, back pressure transducers were added to the EGR valve control to further tailor EGR flow to engine load conditions. Most modern engines now need exhaust gas recirculation to meet emissions standards. However, recent innovations have led to the development of engines that do not require them.

IV. CASE STUDY

The same factors that cause diesel engines to run more efficiently than gasoline engines also cause them to run at a higher temperature. This leads to a pollution problem, the creation of nitrogen oxides (NOx). You see, fuel in any engine is burned with extra air, which helps eliminate unburned fuel from the exhaust. This air is approximately 79% nitrogen and 21% oxygen. When air is compressed inside the cylinder of the diesel engine, the temperature of the air is increased enough to ignite diesel fuel after it is ignited in the cylinder. When the diesel fuel ignites, the temperature of the air increases to more than 1500°F and the air expands pushing the piston down and rotating the crankshaft.

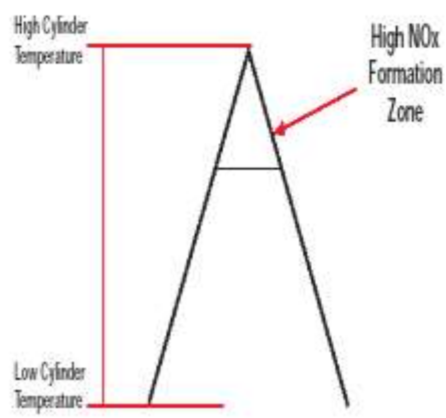

Fig. 1. Formation of Nox.

Generally the higher the temperature, the more efficient is the engine

1. Good Performance

2. Good Economy

Some of the oxygen is used to burn the fuel, but the extra is supposed to just pass through the engine unreached. The nitrogen, since it does not participate in the combustion reaction, also passes unchanged through the engine. When the peak temperatures are high enough for long periods of time, the nitrogen and oxygen in the air combines to form new compounds, primarily NO and NO2. These are normally collectively referred to as “NOx”.

V. PROBLEMS OF NOX

Nitrogen oxides are one of the main pollutants emitted by vehicle engines. Once they enter into the atmosphere, they are spread over a large area by the wind. When it rains, water then combines with the nitrogen oxides to form acid rain. This has been known to damage buildings and have an adverse effect on ecological systems. Too much NOx in the atmosphere also contributes to the production of Smog. When the sunrays hit these pollutants Smog is formed. NOx also causes breathing illness to the human lungs.

VI. HOW CAN NOX BE REDUCED?

Since higher cylinder temperatures cause NOx, NOx can be reduced by lowering cylinder temperatures. Charge air coolers are already commonly used for this reason.

Reduced cylinder temperatures can be achieved in three ways.

1. Enriching the air fuel (A/F) mixture.

2. Lowering the compression ratio and retarding ignition system.

3. Reducing the amount of oxygen in the cylinder.

Enriching the air fuel (a/f) mixture to reduce combustion temperatures. However, this increases hc and carbon monoxide (co) emissions. Also lowering the compression ratio and retarded ignition timing make the combustion process start at a less than the optimum point and reduces the efficiency of combustion.

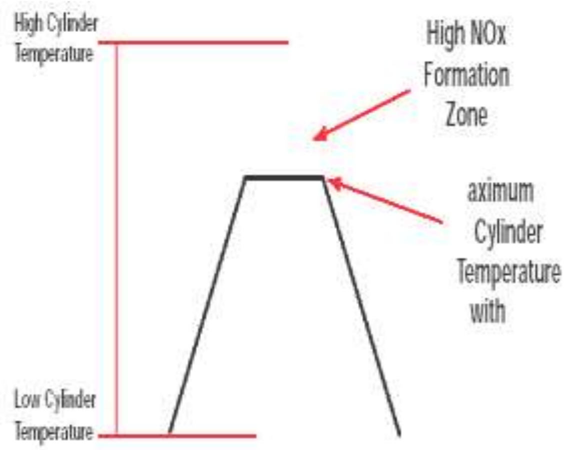

Fig2.Nox Reduction By Lowering The Temperature.

These techniques lowers the cylinder temperature, reducing NOx, but it also reduces fuel economy and performance, and creates excess soot, which results in more frequent oil changes. So, the best way is to limit the amount of Oxygen in the cylinder. Reduced oxygen results in lower cylinder temperatures. This is done by circulating some exhaust gas and mixing it into the engine inlet air. This process is known as Exhaust Gas Recirculation.

VII. BASIC PARTS OF EGR

There are 3 basic parts of EGR

1. EGR Valve

2. EGR Cooler

3. EGR Transfer Pipe

When EGR is required engine electronic controls open the EGR valve. The exhaust gas then flows through the pipe to the cooler. The exhaust gases are cooled by water from the truck cooling system. The cooled exhaust gas then flow through the EGR transfer pipe to the intake manifold.

When EGR is required, the engine's electronic controls open the EGR valve.

The exhaust gases flow through this pipe to the EGR cooler.

The exhaust gases are cooled by water from the truck cooling system.

The cooled exhaust gases then flow through the EGR transfer pipe into the intake manifold.

ADVANTAGES OF EGR

1) Reduced NOx

2) Potential reduction of throttling losses on spark ignition engines at part load

3) Improved engine life through reduced cylinder temperatures (particularly exhaust valve life)

DISADVANTAGES OF EGR

1) Since EGR reduces the available oxygen in the cylinder, the production of particulates (fuel which has only partially combusted) is increased when EGR is applied. This has traditionally been a problem with diesel engines, where the trade-off between NOx and particulates is a familiar one to calibrators.

2) The deliberate reduction of the oxygen available in the cylinder will reduce the peak power available from the engine. For this reason the EGR is usually shut off when full power is demanded, so the EGR approach to controlling NOx fails in this situation

3) The recalculated gas is normally introduced into the intake system before the intakes divide in a multi-cylinder engine. Despite this, perfect mixing of the gas is impossible to achieve at all engine speeds / loads and particularly during transient operation. For example poor EGR distribution cylinder-to-cylinder may result in one cylinder receiving too much EGR, causing high particulate emissions, while another cylinder receives too little, resulting in high NOx emissions from that cylinder.

CONCLUSION

Thus, as seen that using Exhaust Gas Recirculation Technique in engines, the emissions are very much controlled due to lesser amounts of NOx entering the atmosphere. Thus the emission levels to be maintained are attained by the engines. As seen, Exhaust Gas Recirculation is a very simple method. It has proven to be very useful and it is being modified further to attain better standards. This method is very reliable in terms of fuel consumption and highly reliable. Thus EGR is the most effective method for reducing the nitrous oxide emissions from the engine exhaust. Many of the four wheeler manufacturers used this technique like Ford Company, Benz Motor set to improve the engine performance and reduce the amount of pollutants in the exhaust of the engine.

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