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Performance Analysis of Diesel Engine with Exhaust Gas Recirculation

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I. INTRODUCTION

The problem of air pollution has been proven as such severe that, the legal organisations has to pressurise respective state governments to get involved in the issue. The recent example of Delhi government adapting the "Odd-Even" policy explains the intensity of the pollution. Perhaps, the entire nation will have to go with such steps to control the pollution.

In present research article focus was given to the reduction of pollution caused due to the diesel engines due to cold starting conditions. Cold starting is the condition in which input charge air has a temperature less than that of minimum required temperature leading to difficulty in starting the engine, increase at the slower cranking speed and that further reduces the compression temperature. To overcome the problem of cold starting and to reduce environmental pollution, it is necessary to develop less trouble diesel engine which can freely start even at low temperature and can emit low level of emissions to air.

Considerable amount of research has been done on the use of exhaust gas recirculation at various cetane numbers with multiple injection concepts of diesel fuel in the course of cold start of diesel engine. The difference in Indicated Mean Effective Pressure caused by the application of Exhaust Gas Recirculation increased as the injection timing is advanced. Dimethyl Ether (DME) combustion showed" nearly zero levels of soot emissions at all injection timings" and exhibited a light increase in soot emissions due to increase in EGR rate. The combustion of DME with 30% EGR produced very low NOx concentrations. The present investigation deals with the use of various blends of diesel oils along with pure diesel for operating diesel engine considering the above facts. The vital physical and combustion properties of various blends are determined and compared with that of pure diesel. Engine performance with various blends is investigated at different injection pressures, injection timing, cooling rate and various percentages of exhaust gas recirculation to study their effect. A Series of experiments are conducted for optimizing the engine performance and to minimize emissions.

II. EXPERIMENTAL TEST RIG DETAILS

The engine used in the present experimentation is Kirloskar AV-1 whose setails are shown in Table 1. Diesel is injected with a nozzle hole of size 0.15 mm, engine is coupled to a DC dynamometer. It has rated power of 3.7Kw at 1500 RPM. Kirloskar engine is one of the widely used engines in agriculture, tractors, pump sets etc. The experimentation is carried out on a single cylinder, 4-stroke, naturally aspirated, direct injection, water cooled, variable compression ratio(VCR) diesel engine. During experimentation the compression ratio is kept constant i.e., 16.09:1. Figure 1 shows the experimental test rig details.

Table 1

Type	Four- stroke, single cylinder, Compression ignition engine, with variable compression ratio.
Make	Kirloskar AV-1
Rated power	3.7 KW, 1500 RPM
Bore and stroke	80mm×110mm
Compression ratio	16.09:1, variable from 13.51 to 19.69
Cylinder capacity	553cc
Dynamometer	Electrical-AC Alternator
Orifice diameter	20 mm
Fuel	Diesel and Biodiesel
Calorimeter	Exhaust gas calorimeter
Cooling	Water cooled engine
Starting	Hand cranking and auto start also provided

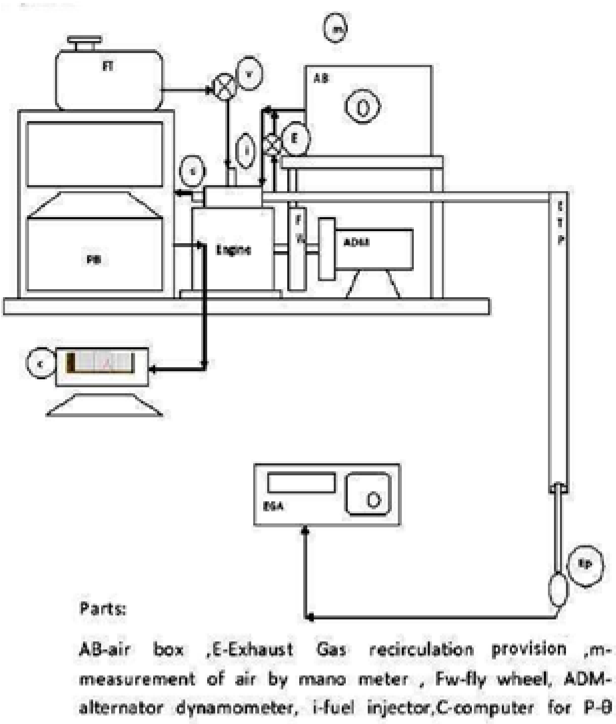

Fig.1 Experimental Test Rig

III. SIMULATION DETAILS

A computerized model of the engine is developed in FLUENT of ANSYS 14.5. The fluent model resembled all the dimensions of that of original test engine used. The simulation is carried out using "FLUENT" and these values are compared with the experimental results.

IV. RESULTS AND DISCUSSIONS

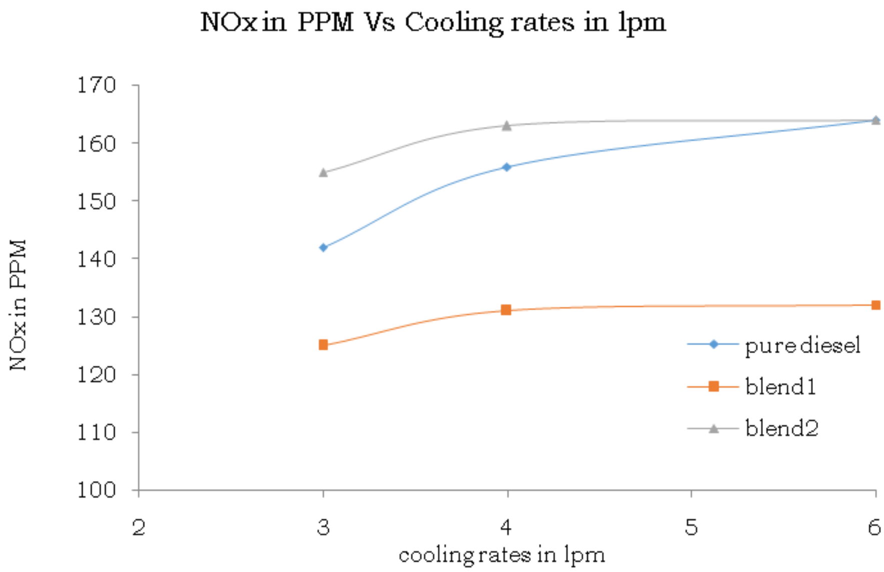

Fig.2 NO_x Vs Cooling rates

From Fig.2 it is seen that blend 1 has shown comparatively lower NO_X emissions which by trend increases along with increased cooling rate as shown in the Graph9.Blend1 at all cooling rates recorded a mean value of 44% less NOx in PPM compared to that of pure diesel & blend3.

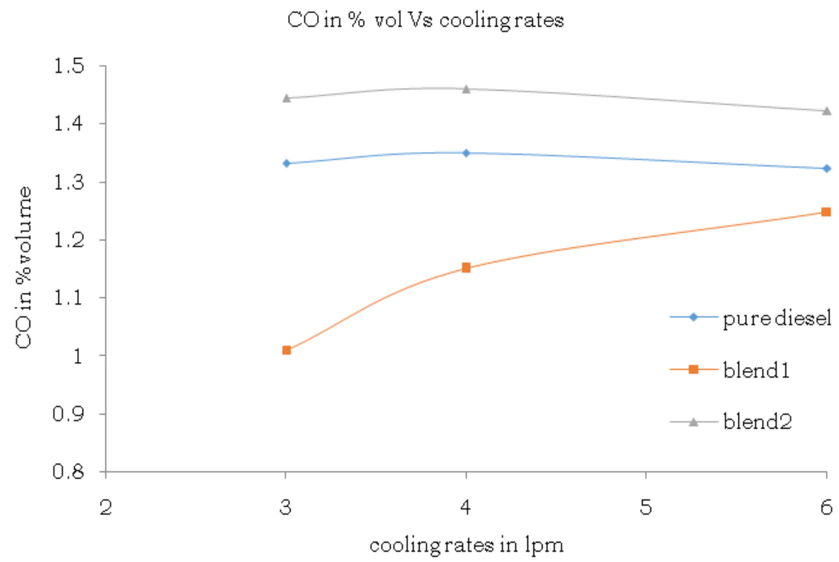

Fig.3 CO Vs Cooling rates

From From Fig.3 it is observed that blend1 has shown lowest emissions of CO when compared to that of pure diesel and blend3. At 3 lpm cooling rate the CO was 0.98% by volume and increased by 27% at 6 lpm cooling rate for blend1. For pure diesel and blend2 the increase and decrease of CO is not much different with change in the cooling rate.

From Fig.4 it is inferred that blend1 has over all less HC emissions except at 6 lpm cooling rate which is only 7% more than that of diesel at 6 lpm cooling rate. Whereas, blend2 goes higher by 23% more than diesel.

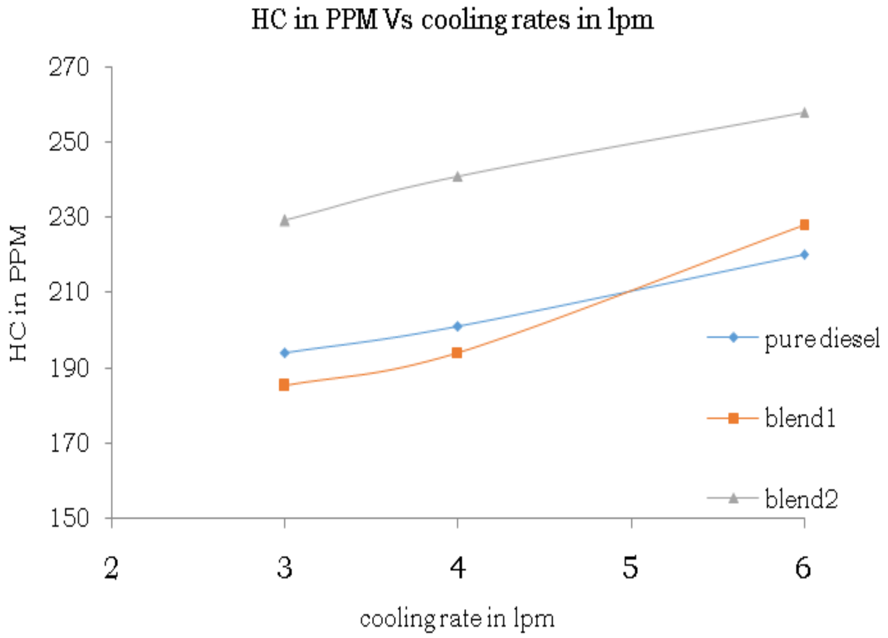

Fig.4 HC Vs Cooling rates

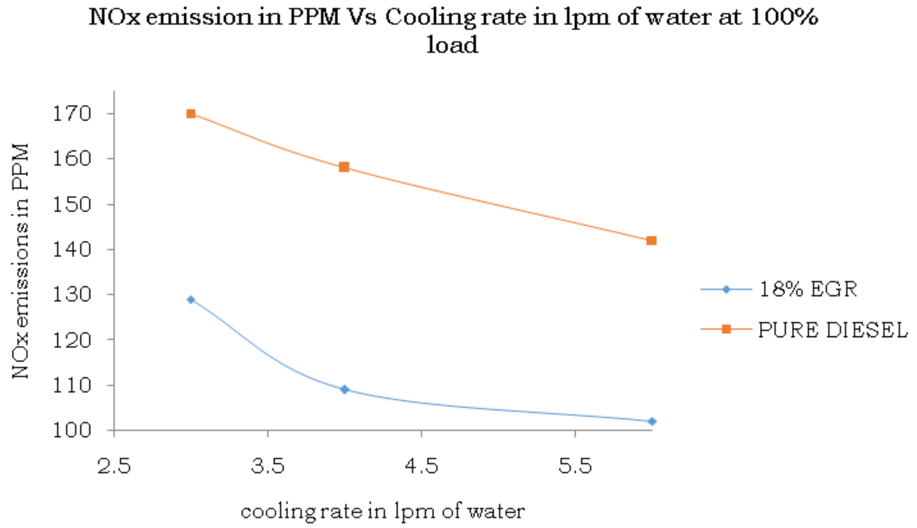

Fig.5 NO_x Vs Cooling rates at 100% load

Figure 5 shows that increasing of cooling rate decreases NOx emissions relatively at all loads. This is due to the excess cooling rates that bring down the peak temperatures and thereby decreasing NOx emissions. Induction of 18% of EGR has decreased NOx by 20% of that of pure diesel. Graph6.13 shows NOx emissions at various cooling rates, from the graph it is quite obvious that increased cooling rate decreased the peak temperatures thereby decreasing NOx by 18% and induction of 18% EGR reduced NOx to 20% of that of only diesel.

From Fig.6 it is inferred that increased cooling rates has increased the HC formation due to reduced engine temperature resulting in improper or reduced burning potency of the hydro carbons which is left as emission. Inducing of EGR into the have increased the temperature inside the combustion chamber and also complete burning of HCs which was sent out as exhaust. At part load condition decrease of Emissions was 15% to that of operated under only diesel and was 7% at peak loads.

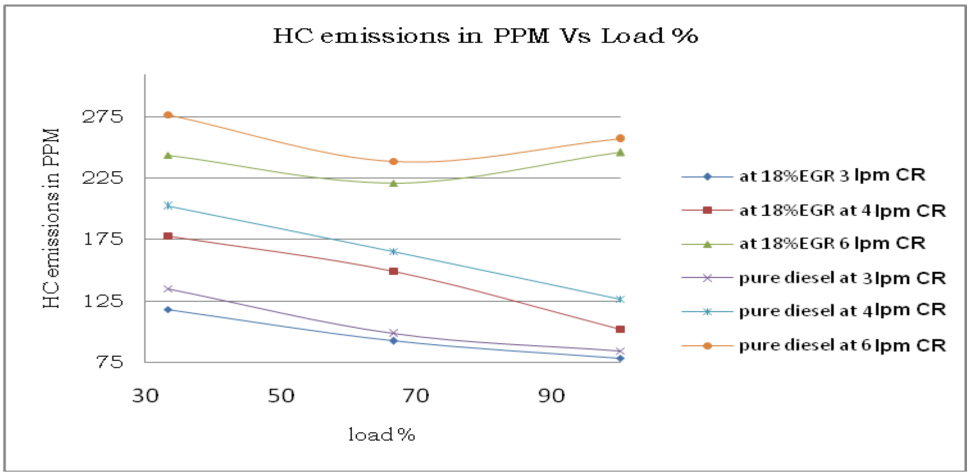

Fig.6 HC Vs % Load

IV. CONCLUSIONS

Significant conclusions are made after conducting several experiments with varying water flow rates along with Exhaust Gas Recirculation substitutions at different load conditions and observing the results.

- Increasing of water flow rate decreases NO_x emissions approximately at maximum load conditions. This is due to the excess water flow rate which reduces the peak temperatures and thereby decreasing NO_x emissions. At 18% Exhaust Gas Recirculation decreased NOx by 20% of that of pure diesel., it is quite obvious that at higher flow rates of water the peak temperatures decreases and it leads to decrease in NO_x by 20% .

- Increased water flow rates has increased the formation of HC due to decrease in engine temperature leads to improper or reduced burning potency of the hydro carbons(HCs) which is left as emission. Inducing of EGR into the engine cylinder increases the temperature inside the combustion chamber and also complete burning of Hydro Carbons which is sent out as engine exhaust. At part load conditions decrease of Emissions by 15% to that of operated under only diesel by 7% at peak load conditions.
- Formation of Carbon monoxide due to the carbon particles which are not totally oxidized .Usage of EGR decreases oxygen percentage which is require while burning in the combustion chamber there by reducing the oxidation of carbon flakes and increases the formation of CO. But the increase in CO emissions due to induction of EGR is not so considerable and is not more than 4% of that of condition when engine is operated with pure diesel.
- Induction of EGR obviously reduces the intake of oxygen and hence dominant to reduction in outcome of unused oxygen. The increase in the water flow rate of the engine anyhow decreased the CO_2 emissions by 20% but increase in 19% to that of operation of engine without EGR.

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