# Performance and Emission Characteristics of Diesel Engine with Exhaust Gas Recirculation (EGR) on Diesel and Neem Biodiesel Blends with Ethanol as Additive

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*Abstract* - **The present investigation was to study the compression ignition (CI) engines with neem biodiesel along with ethanol and different percentage of exhaust gas recirculation (EGR) for analyzing the emission characteristics. In this experiment, the EGR percentage was varied from 0% to 20% in a four-stroke, air-cooled, single cylinder, diesel engine capable of developing 5.2 kW-rated power to study its emission characteristics, which were clearly compared with diesel fuel. From the experiment, it is observed that the increase in EGR percentage in fresh mixture which results reduction in oxides of nitrogen emissions. The maximum percentage reduction in oxides of nitrogen, when compared to pure diesel operation. By using an ethanol for reduction in emission of hydrocarbons, carbon monoxide for various EGR rate.**

*keywords* - **Biodiesel, EGR, emission.**

## I. INTRODUCTION

An enormous increase in the number of automobiles in recent years has resulted in greater demand for petroleum products. With the crude oil reserves estimated to last only for a few decades therefore efforts are made on way to do research on alternative to diesel. Depletion of crude oil would cause a major impact on the transport sector. Fossil fuels play the important and main role in development of country. Continuous supply of fuel with increasing rate should be ensured to sustain and further development of country.The main problems associated with fossil fuel like short supply, gradually increase in price, non-renewability, contamination of environment, unfavorable effect on bio systems which compiles researcher to search an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation, management, efficiency, and environmental preservation has become highly pronounced in the present context. The situation is very grave in developing countries like India which import 70% of the required fuel, spending 30% of his total foreign exchange on oil imports. In view of this, researcher found and analyses many energy sources like CNG, LNG, LPG, ethanol, methanol, hydrogen, bio-diesel and many more. Among these alternative bio fuels, India is having important scope for development of bio fuel.

India is the native place for neem trees and other parts of Asia. Neem is a tree that has importance in hole world which is for multiple uses. Besides agro forestry, it is used in pest control, toiletries, cosmetics, pharmaceuticals, plant and animal nutrition and energy generation. Neem trees are considered to be a divine tree in India because of their numerous valuable uses. Oil can be extracted from Neem seeds by either expeller or chemical solvent. Neem oil is a vegetable oil pressed from the fruits and seeds of the Neem. Neem oil and seed contains 30% of oil content. Neem Seed Biodiesel itself has 11% oxygen, which help for complete combustion of fuel. Hence CO emissions decrease with increasing biodiesel percentage in fuel [1].

## II. EXPERIMENTAL SET-UP

This project Experimental investigations were conducted on a Kirloskar make single cylinder water cooled naturally aspirated 5.2kW at 1500 rpm and at constant pressure 180 bar. Neem biodiesel and diesel were fuel considered in experimentation. Experimental setup is prepared for EGR to reduce the concentration of NOx in the exhaust gas. The experiments were conducted for pure biodiesel without EGR, 5%, 10%, and with EGR and pure diesel on normal engine. The performance, combustion and emission characteristics without EGR and with EGR using neat biodiesel are evaluated and the results compared with that of pure diesel.

The variable tests are conducted for 0, 1, 2, 3, 4, and 5 kW at a constant speed of 1500 rpm with constant injection pressure of 180 bar and EGR (Exhaust Gas Recirculation) at 5% and 10%. The performance characteristics of the engine are evaluated in terms of brake thermal efficiency (BTHE), specific fuel consumption (SFC), exhaust gas temperature (EGT) and volumetric efficiency, then emission characteristics of the engine are evaluated in terms of carbon monoxide (CO), carbon dioxide (CO2), oxide of nitrogen (NOX), and hydro carbon (HC), and combustion characteristics are evaluated in terms of pressure, crank angle, cumulative heat release rate, and net heat release rate. These characteristics are compared with the results of diesel fuel.

Table -1: Specifications of the Kirloskar Diesel Engine

| ***Parameters*** | ***specifications*** |
|---|---|
| Manufacturer | Kirloskar Oil Engine Ltd., India |
| Model | TV – SR II, naturally Aspirated |

| | |
|---|---|
| Engine | Single cylinder, DI, water- cooled, four strokes |
| Bore/Stroke | 87.5 mm/110 mm |
| Compression ratio | 17.5:1 |
| Speed | 1500 r/min, constant |
| Rated Power | 5.2 kw |
| Injection pressure | 240 bar/230 BTDC |
| Type sensor | Piezo electric |
| Response time | 4 micro seconds |
| Make and model | Neptune equipment's, India, OPAX200 II/DX200P |
| Crank angle sensor | 1 – degree crank angle |

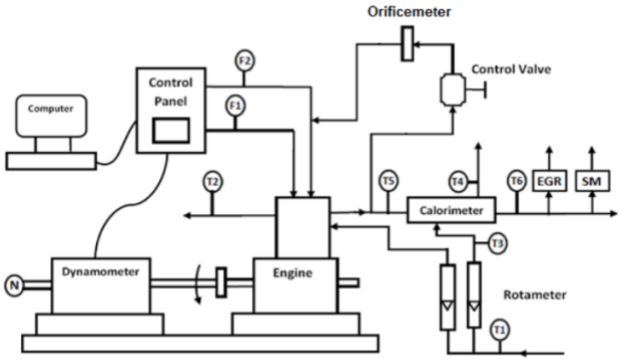


Fig -1: Experimental setup with EGR

Fig -2: Photograph of experimental setup

Table -2: Properties of Neem Biodiesel, Ethanol and Diesel

| ***Properties*** | ***Diesel*** | ***Neem*** | ***Ethanol*** |
|---|---|---|---|
| Viscosity, cSt (at 40°C) | 5.032 | 38.16 | 6.04 |
| Calorific Value, kJ/kg | 42707 | 39400 | 27800 |
| Sp. Gr. At 25°C | 0.834 | 0.919 | 0.79 |
| Density, kg/m3 | 834 | 919 | 780.8 |
| Flash point, °C | 78 | 178 | 14 |
| Fire point, °C | 85 | 195 | 26 |

## III. RESULTS AND DISSCUSSIONS

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads—the template will do that for you.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar.

***Performance characteristics:***

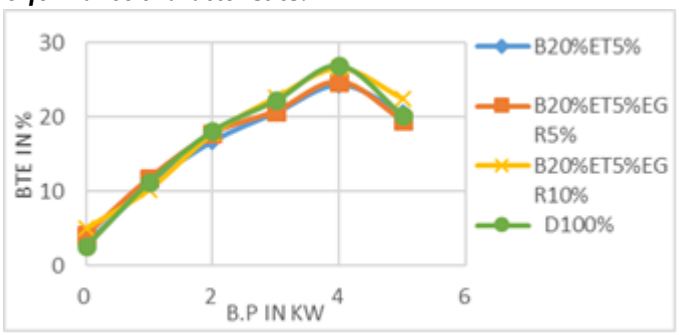


Fig.3

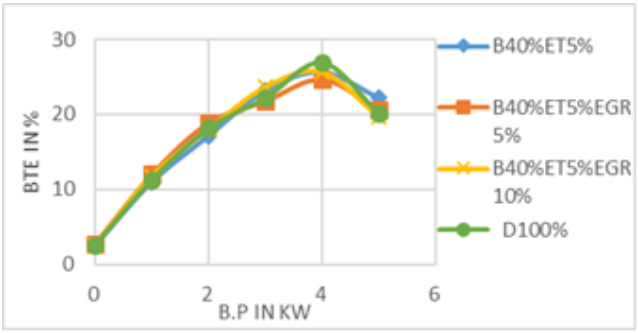


Fig.4

Fig.3 & 4. shows the comparison of brake thermal efficiency with brake power for B20% and B40% blends of neem biodiesel with ethanol 5% and EGR 5%, 10% and pure diesel. At constant pressure 180 bar, as the load on the engine increases the brake thermal efficiency because brake thermal efficiency is the function of brake power. The maximum brake thermal efficiency of

blends B20% and B40% with ethanol 5% without EGR the values found to be 24.38% and 25.59% respectively, at maximum load, the brake thermal efficiency of B20% and B40% with ethanol 5% with EGR 5% the values found to be 24.72% and 24.65% respectively, the brake thermal efficiency of blends B20% and B40% ethanol 5% with EGR 10% the values found to be 26.54% and 25.7% respectively against diesel of 26.9%. As comparison the blend B20% with ethanol 5% with EGR 10% value which is more near to the diesel value for higher blends may be due to the combined effect of its lower heating value, low calorific value, and increase in fuel consumption. The BTHE of neem biodiesel blends were lower than that of the diesel.

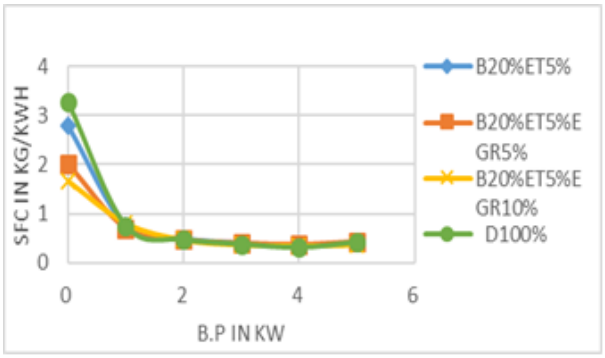


Fig.5

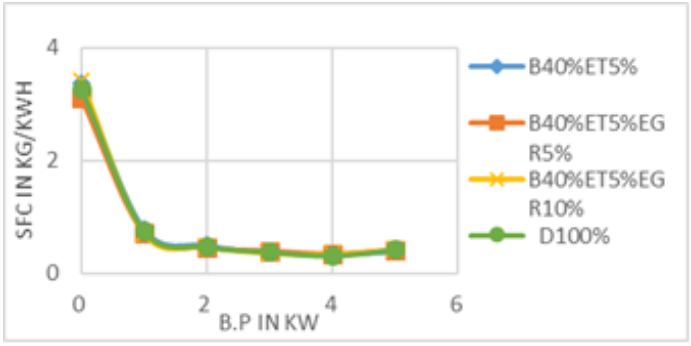


Fig.6

Fig.5 and 6. shows the comparison of specific fuel consumption with brake power for B20% and B40% blends of neem biodiesel with ethanol 5% and EGR 5%, 10% and pure diesel. Specific fuel consumption of blends B20% and B40% without EGR with ethanol 5% under full load was found to be 0.4 kg/kW-hr and 0.38kg/kW-hr respectively, the blends of B20% and B40% with 5% ethanol and with EGR 5% the specific fuel consumption found to be 0.43 kg/kW-hr and 0.41 kg/kW-hr respectively, as increase in the neem biodiesel portion the specific fuel consumption increases due to increasing the viscosity of the fuel specific consumption of B20% and B40% with 5% ethanol with EGR 10% it is found to be 0.37 kg/kW-hr and 0.43 kg/kW-hr respectively and pure diesel found to be 0.42kg/kW-hr due to its lower heating value, greater density and hence higher bulk modulus. B20% with ethanol 5% with EGR 10% has low SFC at higher load due to the fuel consumption is less compared to other blends because of its high latent heat vaporization. As compare to other blends are high fuel consumption. As compared to all the blends B20% with ethanol 5% with EGR 10% is the best blend for low fuel consumption.

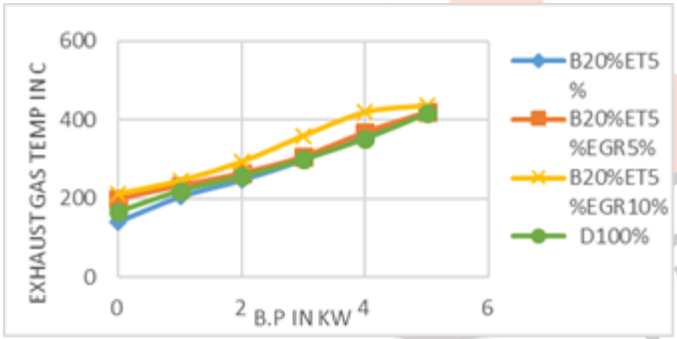


Fig.7

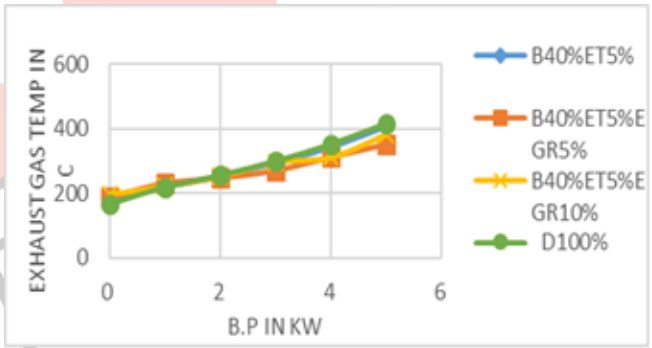


Fig.8

Fig.7 and 8 shows the comparison of exhaust gas temperature with brake power for B20% and B40% blends of neem biodiesel with ethanol 5% and EGR 5%, 10% and pure diesel. The exhaust gas temperature of B20% and B40% with ethanol 5% and without EGR at full load was 416.64 0c and 408.26 0C respectively at constant pressure 180bar and the exhaust temperature of B20% and B40% with ethanol 5% with EGR 5% at full load, it can be observed that 419.98 0C and 354.06 0C respectively. The exhaust temperature of B20% and B40% blends with ethanol 5% with EGR 10% at full load values can be found to be 435.87 0C and 383.36 0C respectively at constant pressure 180 bar, the pure diesel exhaust temperature found to be 417.68 0C. As a result of increased combustion duration, a higher exhaust gas temperature is recorded for B20% with ethanol 5% with EGR 10% blend exhaust gas temperature was higher in biodiesel compare with diesel at all load conditions. The possible reason for this temperature increased may be relatively higher availability of oxygen in biodiesel for combustion and because at full load the chemically correct ratio of air and fuel is used, because of chemically correct ratio of air and fuel, there is a generation of high heat inside the cylinder.

***Emission characteristics:***

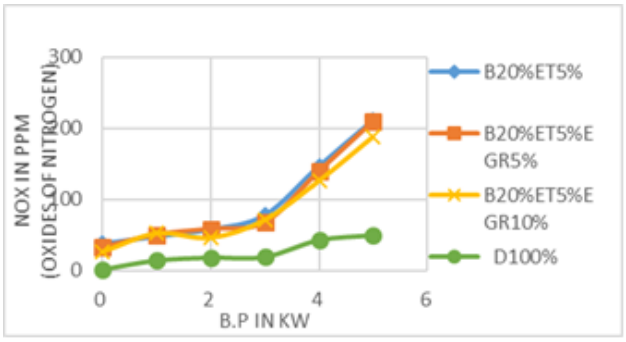


Fig.9

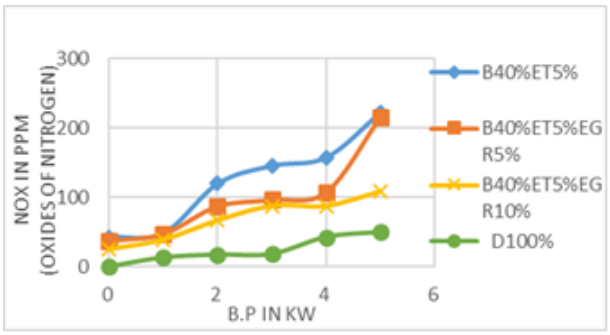


Fig.10

Fig.9 and 10 shows comparison of NOx with brake power for B20% and B40% blends of neem biodiesel with ethanol 5% and EGR 5%, 10% and pure diesel. At constant pressure 180 bar. It is observed that the NOx emissions increased with increase in load and increase in nozzle opening pressures. The NOx emissions for the blends B20% and B40% with ethanol 5% without EGR at full load the values found to be 212 ppm and 223 ppm respectively. The blends B20% and B40% with ethanol 5% with EGR 5% at full load the values found to be 209 ppm and 216 ppm respectively. The blends of B20% and B40% with ethanol 5% with EGR 10% at full load the values found to be 109 ppm and 188 ppm respectively. The pure diesel found to be 50 ppm at full load. The increase in NOx emission may be due to more oxygen present in the biodiesel, resulting in increased peak combustion temperature. It is observed that the lower NOx emissions are109 ppm at a blend of B20% with ethanol 5% with EGR 10%, with increase in EGR the NOx level was reduced. Also reductions in brake thermal efficiency were observed.

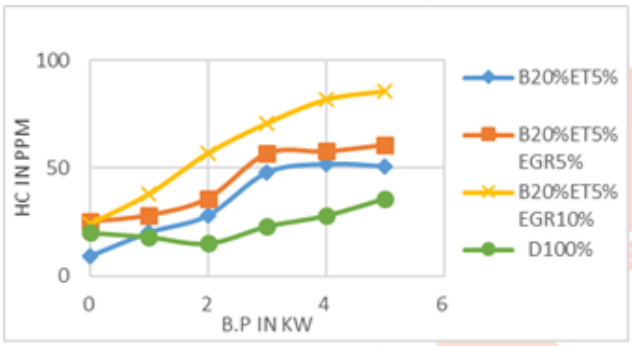


Fig.11

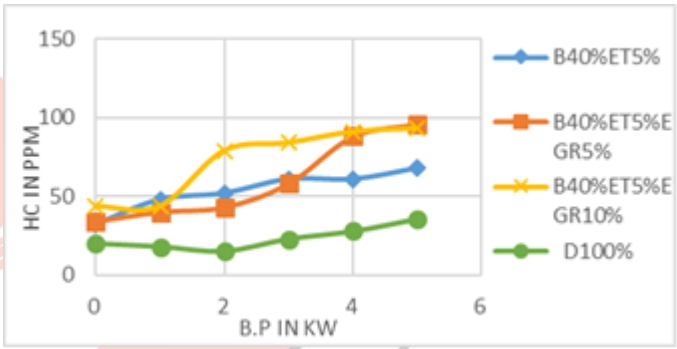


Fig.12

Figure 11 and 12 shows comparison of Unburnt hydrocarbon with brake power for B20% and B40% blends of neem biodiesel with ethanol 5% and EGR 5%, 10% and pure diesel. The emissions of unburnt hydrocarbon for biodiesel are high as compared to the diesel in both the graphs. At higher load and 180 bar injection pressure. The blends B20% and B40% with ethanol 5% without EGR the values found to be 51ppm and 68 ppm respectively, the blends B20% and B40% with ethanol 5% with EGR 5% the values found to be 61ppm and 92ppm. The blends B20% and B40% with ethanol 5% with EGR 10% the values found to be 86 ppm and 96 ppm. The EGR widely used to reduce and control the oxides of nitrogen emission by lowering the oxygen concentration and flame temperature of working fluid in the combustion chamber this leads more emission of unburnt hydrocarbon to decrease a emission of unburnt hydrocarbon the 5% ethanol alcohol is used, which reduces some amount of unburnt hydrocarbon, as we can observed from the graphs the B20% with ethanol 5% without EGR emits less emission of hydrocarbons at higher load.

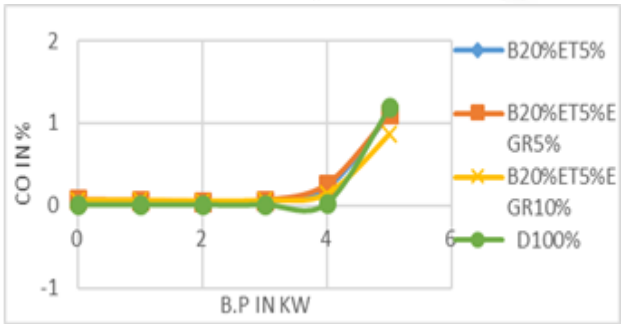


Fig.13

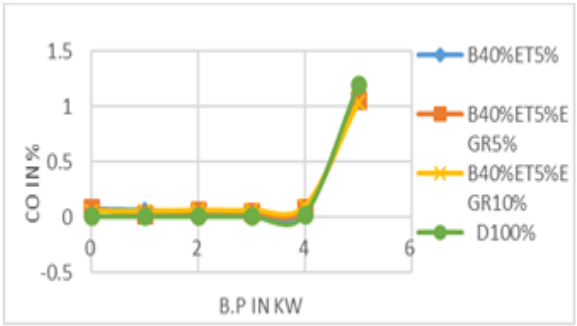


Fig.14

Fig.13 and 14 shows the comparison of CO emission with brake power for B20% and B40% blends of neem biodiesel with ethanol 5% and EGR 5%, 10% and pure diesel. The CO emissions with ethanol 5% without EGR were obtained from neem biodiesel and its blends B20% and B40% at full load the CO emission is 1.11% and 1.10% respectively in 180 bar injection pressure and CO emission of B20% and B40% with ethanol 5% with EGR 5% is 1.12% and 1.06% respectively, the CO emission of B20% and B40% blends with ethanol 5% with EGR 10% the emission found to be 0.87% and 1.03% and pure diesel CO emission found to be 1.2% , as comparison with diesel the B20% with ethanol 5% with EGR 10% shows less CO emission . This is due to using of ethanol alcohol which reduces the carbon monoxide percentage.

## IV. CONCLUSION

The conclusion of this experiment is as follows.

The biodiesel produced from neem oil by transesterification process reduces the viscosity of biodiesel found to be higher than that of diesel and the calorific value of biodiesel is lower than that of the diesel.

The maximum brake thermal efficiency is obtained in the case of engine with EGR setup. The efficiency of biodiesel is lower than that of diesel fuel. However, the efficiency of the engine with EGR setup the biodiesel fuel is well within the expected limits. SFC is low for the 180 bar pressure with EGR because of its high latent heat vaporization. the blend B20% with ethanol 5% with EGR 10% is the best blend for low fuel consumption.

The CO and HC emission is lower for Neem biodiesel without EGR than that of normal diesel engine for entire load of operation. The increase in EGR increases the CO and HC emissions.

The NOx emission increases with increase in load and reaches maximum and then decreases. NOx emission is almost all comparable with diesel except a narrow band of part load. By increasing the EGR there is a considerable reduction in the NOx formation. NOx emission with 5%, 10% is respectively lower.

It is concluded that neem biodiesel B20% with ethanol 5% with 10% EGR at 180 bar pressure can be used as, alternate fuel for DI diesel engine without any major modification.

The above study clearly reveals the possibility of using the biodiesel in DI diesel engine with EGR. The combustion, performance and emission characteristics shows the suitability of neem biodiesel in engine with EGR.

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