Experimental Investigation of Performance and Emission Characteristics of Diesel Engine Working on diesel with Neem Biodiesel and Ethanol Blend with EGR

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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,*

1. 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].

2. 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.

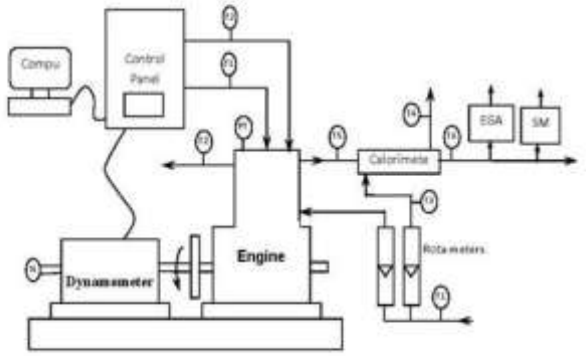

Fig -1: Experimental setup with EGR

Fig -2.1: Photograph of experimental setup

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

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

3. RESULTS AND DISSCUSSIONS

3.1 Performance characteristics:

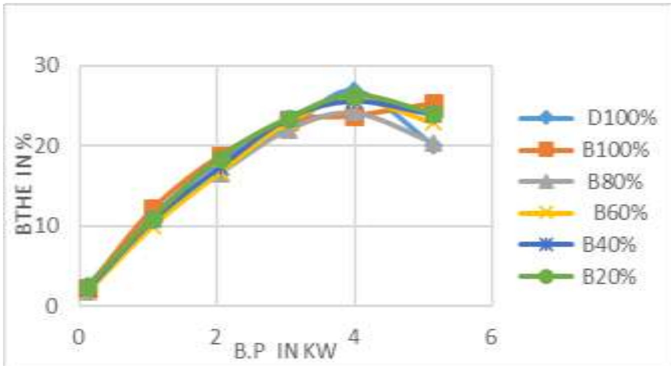

Fig -1: variation of brake thermal efficiency vs brake power for diesel and different blends.

Fig.1 shows the brake thermal efficiency of neem biodiesel and its blends with respect to the brake power. It shows that the brake thermal efficiencies of all blends are lower at almost all load levels. Among the blends B20% found to have maximum thermal efficiency of 26.32% and B40% blend is 25.6% while for diesel it is 26.9%. The decrease in brake thermal efficiency with increase in neem biodiesel concentration is due to poor atomization of the blends due to their high viscosity. The B20% and B40% blends are more close to pure diesel brake thermal efficiency.

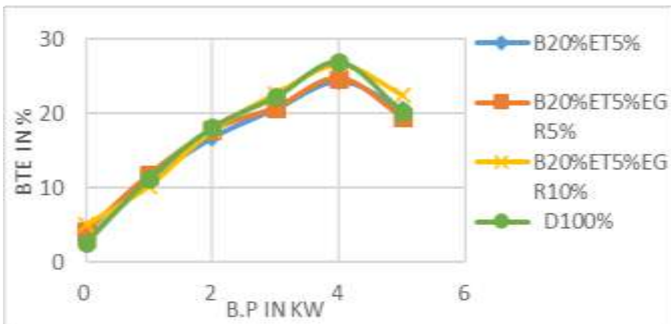

Fig -2: Variation of brake thermal efficiency with brake power for blend B20% with ethanol 5% without EGR, with EGR 5% and 10%.

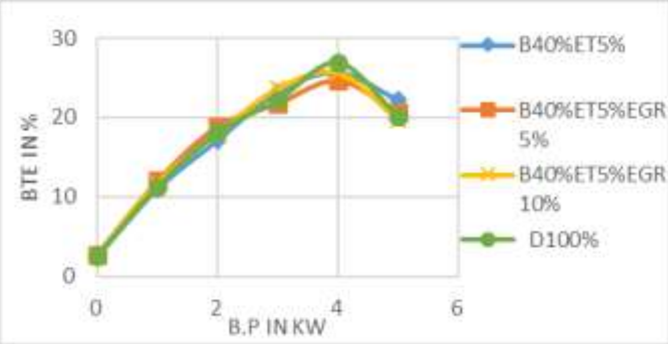

Fig -3: Variation of brake thermal efficiency with brake power for blend B40% with ethanol 5% without EGR, with EGR 5% and 10% .

Fig.2 & 3. 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.

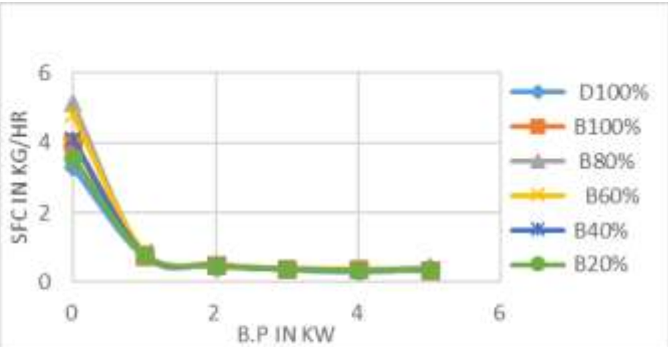

Fig -4: variation specific fuel consumption vs brake power for diesel and different blends.

Figure 4 shows the specific fuel consumption of neem bio diesel and its blends with respect to brake power. By increasing the neem biodiesel portion blend which increases the viscosity of the fuel, which increases the specific fuel consumption due to poor atomization of fuel. However, the variations are appreciable at part load conditions for all the blends. SFC of neem was lower at full load then that of the diesel. The calorific value of neem is decreases then that of diesel with increase in biodiesel percentage in blends. From the graph it is found that the B20% blend is very close to the diesel at full load. The SFC of D100 is 0.41kg/hr and B20% is 0.38 kg/hr hence the B20% is the best blend for low fuel consumption.

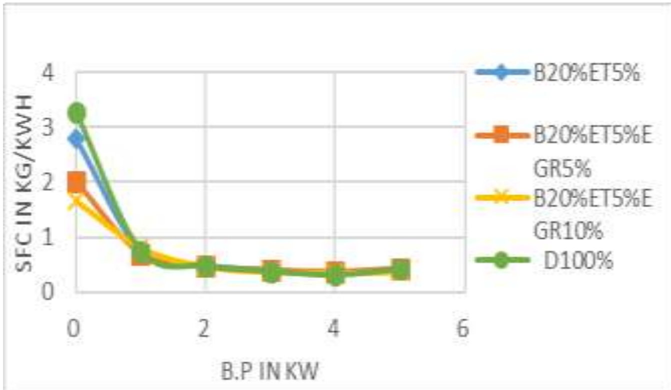

Fig -5: Variation of specific fuel consumption with brake power for blend B20% with ethanol 5% without EGR, with EGR 5% and 10% .

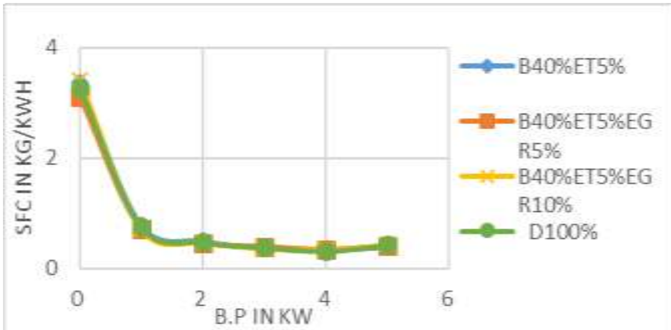

Fig -6: Variation of specific fuel consumption with brake power for blend B40% with ethanol 5% without EGR, with EGR 5% and 10%.

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.

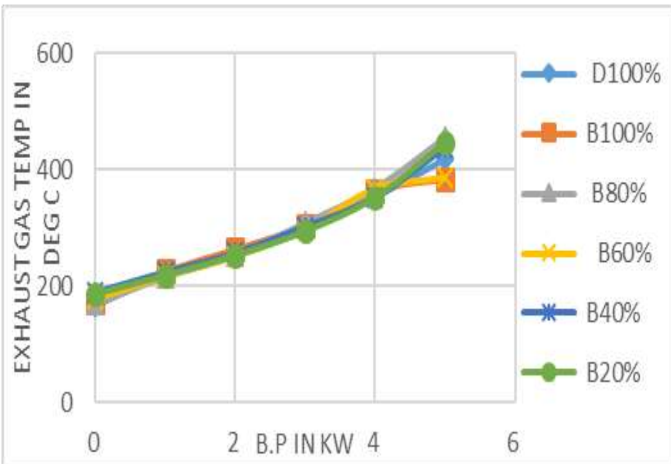

Fig -7: variation of exhaust gas temperature vs brake power for diesel and different blends.

The variation of exhaust emission temperature with brake power for diesel, and other blends of neem biodiesel are shown in figure 7, the exhaust emission temperature of all the biodiesel shows higher than the diesel as it is obtained from the graph. The exhaust gas temperature for D100% and other blends for varying loads can be observed and stated as they are slightly parallel to each other. The exhaust gas temperature of all blends and 100% diesel increase as load increases. It is observed from graph, the exhaust gas temperature is maximum at full load, this is because at full load the chemically the ratio will be correct for air and fuel which is used, due to correct ratio of air and fuel, the high heat generated inside the cylinder.

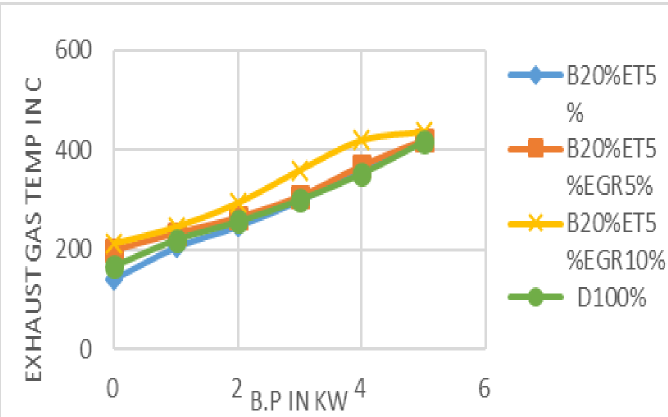

Fig -8: Variation of exhaust gas temperature with brake power for blend B20% with ethanol 5% without EGR, with EGR 5% and 10%.

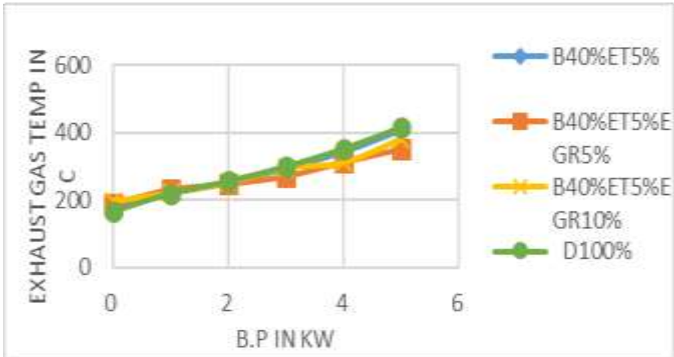

Fig -9: Variation of exhaust gas temperature with brake power for blend B40% with ethanol 5% without EGR, with EGR 5% and 10%.

Fig.8 and 9 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.

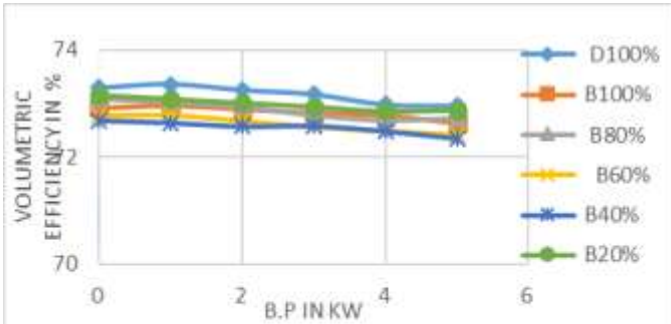

Fig -10: variation of volumetric efficiency vs brake power for diesel and different blends.

From the graph it is found that the diesel has higher volumetric efficiency compare to biodiesel blends and we can conclude that the volumetric efficiency is maximum at lower load. So volumetric efficiency is the just a measure of how good the engine is at sucking in air and anything which reduces the flow of air into the engine will lower the volumetric

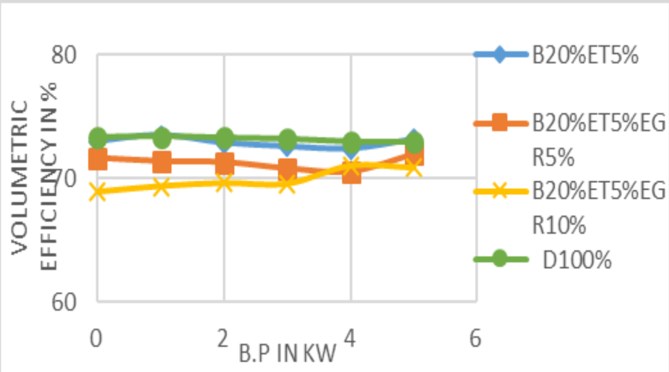

Fig -11: Variation of volumetric efficiency with brake power for blend B20% with ethanol 5% without EGR, with EGR 5% and 10% .

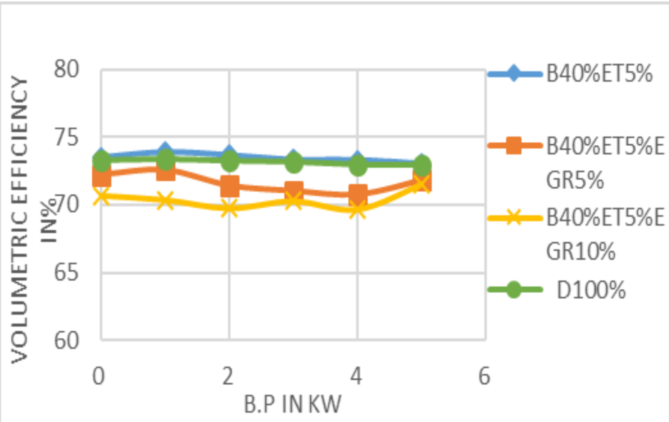

Fig -12: Variation of volumetric efficiency with brake power for blend B40% with ethanol 5% without EGR, with EGR 5% and 10% .

Fig.11 and 12 shows the comparison of volumetric 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, the Volumetric efficiency of blends B20% and B40% without EGR with ethanol 5% under full load was found to be 73.13% and 73.06% respectively, the blends of B20% and B40% with 5% ethanol and with EGR 5% the volumetric efficiency found to be 73.09% and 71.82% respectively, as we can say from the graphs volumetric efficiency is maximum at lower load volumetric efficiency of B20% and B40% with 5% ethanol with EGR 10% it is found to be 70.85% and 71.51% respectively and pure diesel found to be 73.26% due to its lower heating value, greater density and hence higher bulk modulus. B20% with ethanol 5% without EGR has high volumetric efficiency at higher load.

3.2 Emission characteristics:

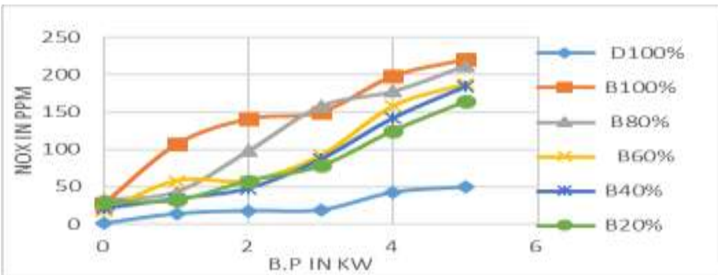

Fig -13: variation of oxides of nitrogen vs brake power for diesel and different blends.

NOx is formed by a combination of nitrogen and oxygen from the air under heat and pressure. More heat and pressure give you more NOx. The main reason for higher NOx production is the temperature and duration of the combustion flame due to a burning of mixed fuel and air. Due to increase in applied load on the engine, emission of NOx rate increases. At maximum load, diesel emits 50ppm, B20% and B40% emits 164ppm and 184ppm. To minimize the NOx emitting rate further, EGR technique is used. EGR is an engine conditioning technique to control NOx which works by re-circulating a portion of an engine's exhaust gas back to the cylinders of engines. This tends to decrease the amount of excess oxygen during combustion period. This gives better result in a reduction of NOx rate to a minimal level.

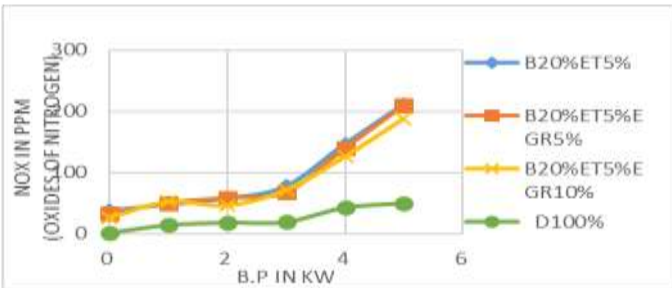

Fig -14: Variation of emission of oxides of nitrogen with brake power for blend B20% with ethanol 5% without EGR, with EGR 5% and 10%.

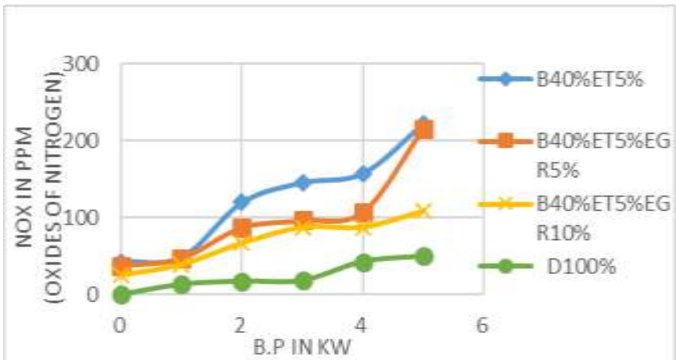

Fig -15: Variation emission of oxides of nitrogen with brake power for blend B40% with ethanol 5% without EGR, with EGR 5% and 10% .

Fig.14 and 15 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.

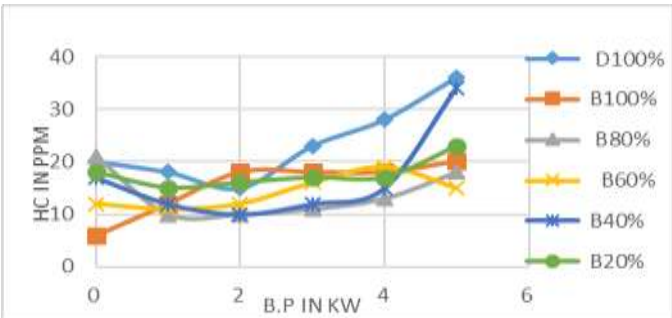

Fig -16: variation of emission of unburnt hydrocarbon vs brake power for diesel and different blends.

Figure 16 shows the variation of HC emissions against brake power variations. The exhaust of unburnt hydrocarbon is due to a incomplete combustion of carbon compounds in blends. The HC emission value decreases with increase in biodiesel proportion in the fuel blends as in the graph it is observed that the 100% diesel at full load and part load condition the HC emission is more as compare to the other blends. High percentage of oxygen content and cetane number leads to less amount of HC. B80% and B60% the HC emission is less than that of the diesel.

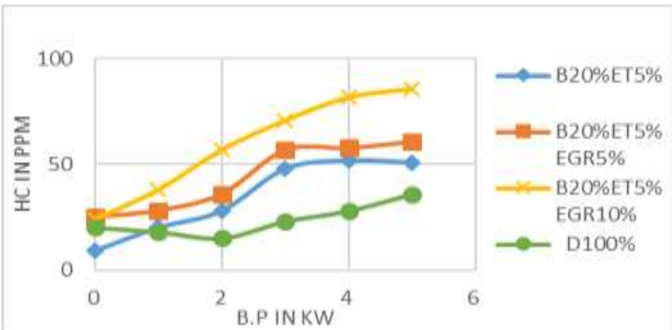

Fig -17: Variation emission of unburnt hydrocarbon with brake power for blend B20% with ethanol 5% without EGR, with EGR 5% and 10% .

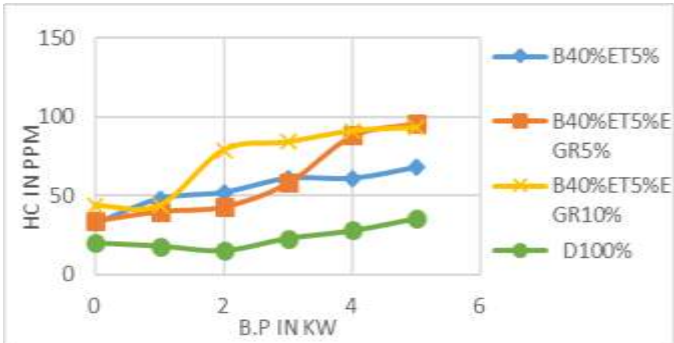

Fig -18: Variation emission of unburnt hydrocarbon with brake power for blend B40% with ethanol 5% without EGR, with EGR 5% and 10%.

Figure 17 and 18 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.

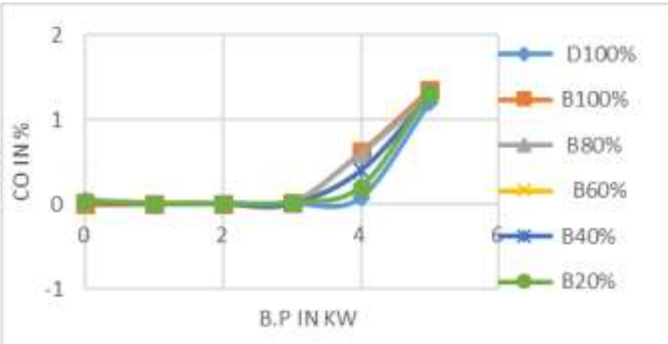

Fig -19: variation of emission of carbon monoxide vs brake power for diesel and different blends.

Fig. 19 shows variation of carbon monoxide with load for different blends, the CO emission increases with increasing the load. From the graph we can say that 100 % of biodiesel the CO emission is more as compare to other blends this is because of high viscosity and poor atomization tendency of neem biodiesel which leads poor combustion and higher carbon monoxide emission.CO emission increase as air-fuel ratio becomes greater than stoichiometric value. As compare to the biodiesel blends diesel emits more CO under all loading conditions. Biodiesel which as O2 itself which helps for complete combustion. B20% shows less emission of carbon monoxide.

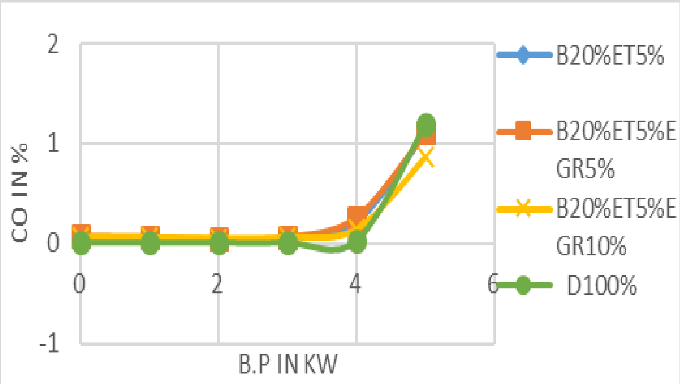

Fig -20: Variation emission of carbon monoxide with brake power for blend B20% with ethanol 5% without EGR, with EGR 5% and 10%.

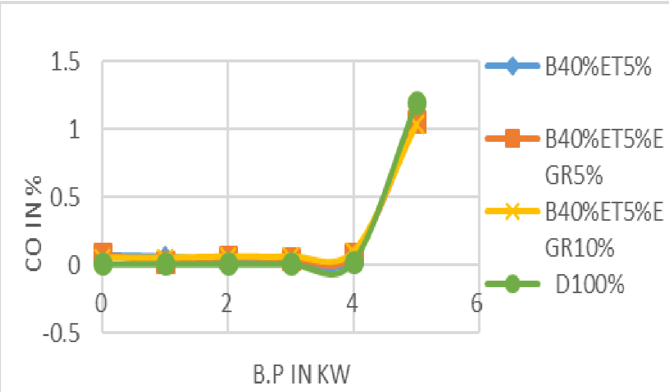

Fig -21: Variation emission of carbon monoxide with brake power for blend B40% with ethanol 5% without EGR, with EGR 5% and 10%.

Fig.20 and 21 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.

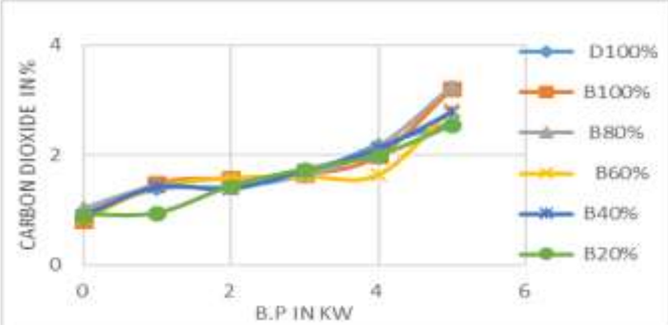

Fig -22: variation of emission of carbon dioxide vs brake power for diesel and different blends.

Fig. 22 shows the variation of carbon dioxide with brake power different blends of neem biodiesel and diesel. CO2 emission increases with increase in load, at full load CO2 emission is more B20% gives lower emission as compare to the diesel The CO2 emission for diesel is higher than that of the all the blends. This is due to a complete combustion of fuel. The B20 blend gives lower emission with respect to other blends.

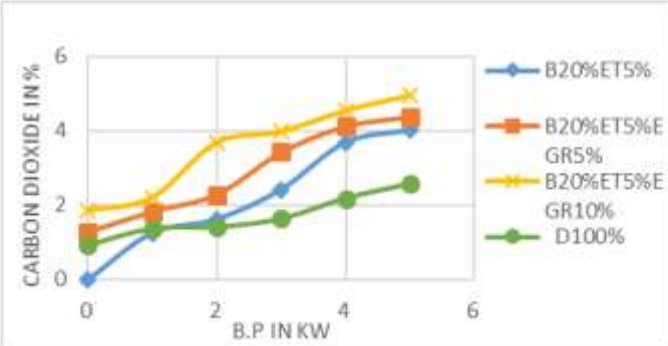

Fig -23: Variation emission of carbon dioxide with brake power for blend B20% with ethanol 5% without EGR, with EGR 5% and 10%.

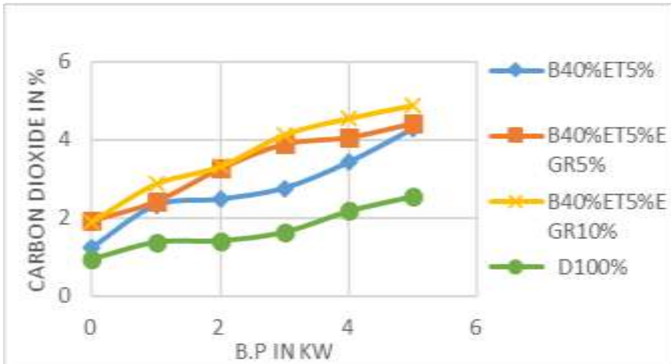

Fig -24: Variation emission of carbon dioxide with brake power for blend B40% with ethanol 5% without EGR, with EGR 5% and 10%.

Fig.14 and 15 shows the comparison of CO2 emission 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. The CO2 emission of blends B20% and B40% with ethanol 5% without EGR, at full load the values found to be 4.01% and 4.27% respectively. The CO2 emission of blends B20% and B40% with ethanol 5% with EGR 5%, at full load the emission value found to be 4.38% and 4.42% respectively. The CO2 emission of blends B20% and B40% with ethanol 5% with EGR 10%, at full load the emission value found to be 4.95% and 4.87% respectively. The CO2 emission of diesel found to be 2.56%. at full load. As compared to biodiesel the diesel emits less CO2 emission. In this biodiesel blends B20% without EGR shows less emission. The CO2 emission increases with EGR this is due to oxygen deficiency.

3.3 Combustion Characteristics

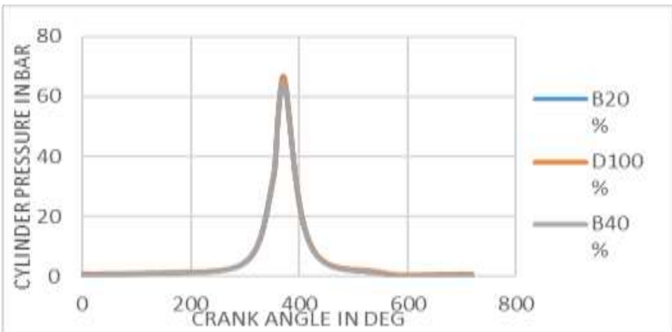

Fig -25: variation of cylinder pressure vs crank angle for diesel and different blends.

Fig. 25 indicates the cylinder pressure variation with crank angle, at full load cylinder pressure the diesel and biodiesel B20 and B40. Peak pressure of D100 found to be 67.05 bar and B20 and B40 found to be 65.32 bar at a crank angle of 371.This is due to a good mixture formation for biodiesel blends at higher loads the temperatures also high. From the test results we observed that the peak pressure variations are less hence the properties such as calorific value, viscosity and density are brought closer to diesel after transesterification of vegetable oil, no major variation in pressure are found.

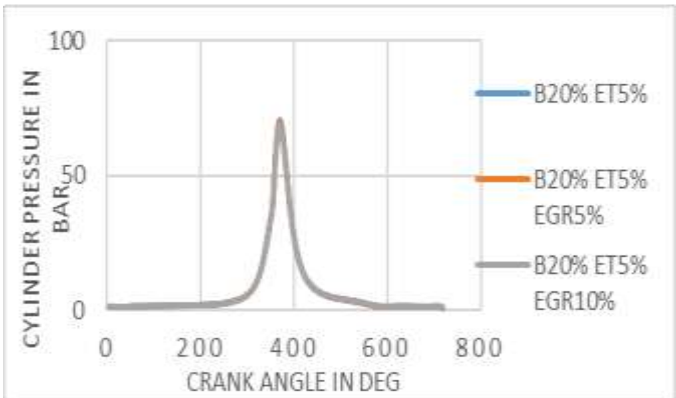

Fig -26: Variation of cylinder pressure with crank angle for blend B20% with ethanol 5% without EGR, with EGR 5% and 10%.

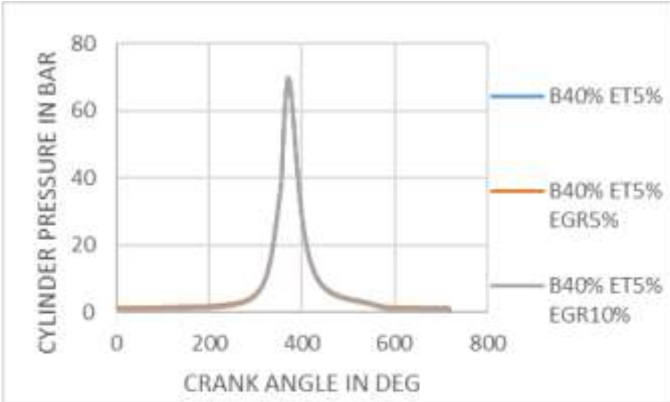

Fig -27: Variation of cylinder pressure with crank angle for blend B40% with ethanol 5% without EGR, with EGR 5% and 10%.

The variation of cylinder pressure with respect to crank angle for neem biodiesel blends of B20% and B40% at constant pressure 180 bar is shown in figures 26 and 27. From the figures it is observed that the peak pressures variation is less because the properties such as calorific value, viscosity, and density are brought closer to diesel. Cylinder pressure of blends B20% and B40% with ethanol 5% without EGR at full load. Peak pressure was found to be 70.94 bar and 69.35 bar respectively. Cylinder pressure of blends B20% and B40% with ethanol 5% with EGR 5% the values found to be 70.31 bar and 69.43 bar respectively. Cylinder pressure of blends B20% and B40% with ethanol 5% with EGR 10% at full load the values found to be 68.94 bar and 69.88 bar respectively. The diesel cylinder pressure at full load found to be 67.05 bar. The cylinder pressure of blend B20% with ethanol 5% without EGR value found to be high, this is due to good mixture formation for bio-diesel at higher loads where temperatures are high, EGR serves as a heat absorbing agent, which reduces the cylinder charge temperature in the combustion chamber during the combustion process.

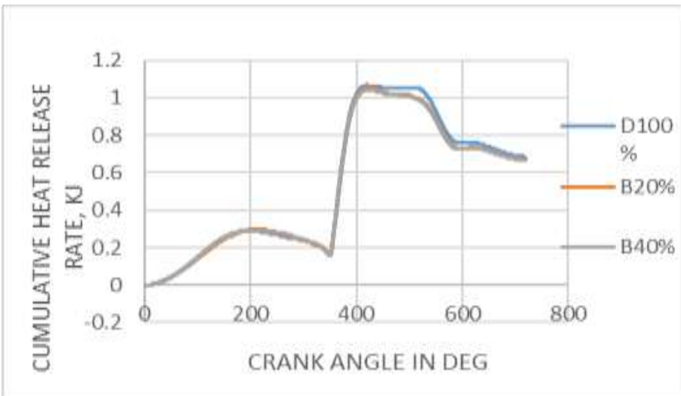

Fig -28: variation of cumulative heat release rate vs crank angle for diesel and different blends.

Fig.28 shows that the variation of cumulative heat release rate with crank angle. The neem biodiesel blends are similar to diesel. Maximum net heat release rate of blends B20% and B40% is 1.05 kj and 1.04kj, against 1.06 kj of diesel for diesel engine. The diesel value is higher than that of all diesel blends.

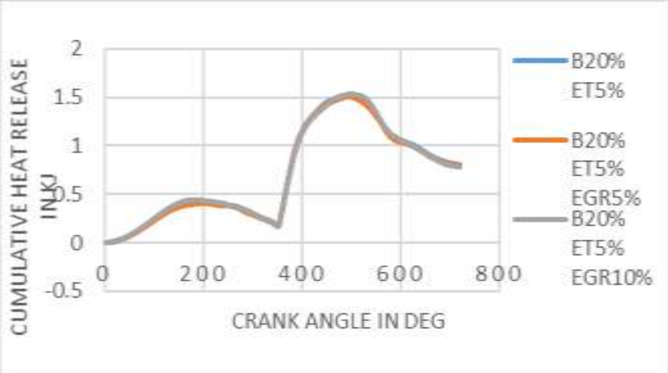

Fig -29: Variation of cumulative heat release rate with crank angle for blend B20% with ethanol 5% without EGR, with EGR 5% and 10%.

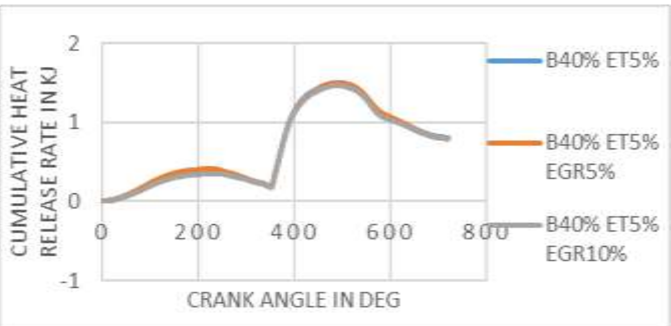

Fig -30: Variation of cumulative heat release rate with crank angle for blend B40% with ethanol 5% without EGR, with EGR 5% and 10%.

The variation of Cumulative Heat Release Rate with respect to crank angle for diesel and different blends B20% and B40% neem biodiesel at constant pressure of 180 bar is as shown in figures 29 and 30, At full load condition without EGR cumulative heat release rate of 20% and 40% blends with 5% ethanol values found to be 1.54 kj and 1.49 kj respectively. The blends B20% and B40% with ethanol 5% with EGR 5% the values found to be 1.51 kj and 1.5 kj respectively. The blends B20% and B40% with ethanol 5% with EGR 10% the values found to be 1.53 kj and 1.46 kj respectively. The pure diesel value found to be 1.06 kj. It was observed from the graph that there is an increase in the ignition delay for the blends. It is observed that the cumulative heat release rate curves of the diesel, neem biodiesel and their blends shows similar patterns. From figure Peak cumulative heat release rate was found to be 1.54 kJ for without EGR B20% with 5% ethanol .This is because of EGR which absorb the heat, this reduces the cylinder charge temperature in the combustion chamber during the combustion process.

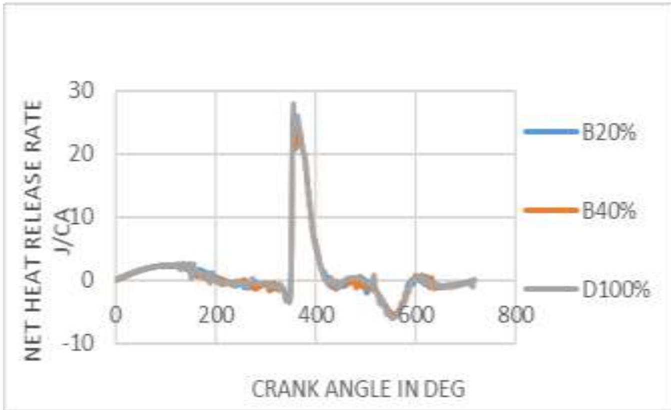

Fig -31: variation of net heat release rate vs crank angle for diesel and different blends.

Fig.31 shows that the variation of net heat release rate of blends B20% and B40%, pure diesel with crank angle. The net heat release rate for B20% and B40% is 25.1 j/deg CA and 26.42 j/deg CA.the diesel value found to be 28 j/deg CA. The peak heat release rates of neem biodiesel and their blends are lower than that of diesel.

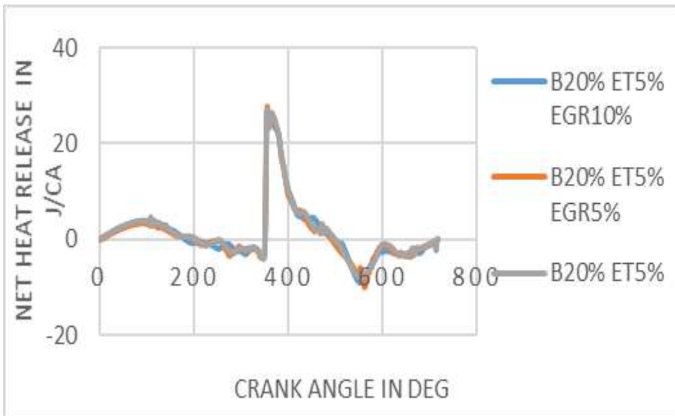

Fig -32: Variation of net heat release rate with crank angle for blend B20% with ethanol 5% without EGR, with EGR 5% and 10%.

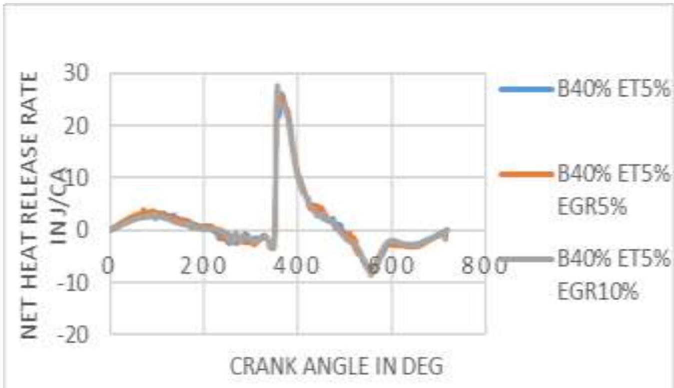

Fig -33: Variation of net heat release rate with crank angle for blend B40% with ethanol 5% without EGR, with EGR 5% and 10%.

The variation of Net Heat Release Rate with respect to crank angle for diesel and different blends B20% and B40% of neem biodiesel, at constant pressure 180 bar is shown in figures 32 and 33. At full load condition without EGR heat release rate of 20% and 40% blends with ethanol values found to be 27 j/deg CA and 25.77 j/deg CA.The blends B20% and B40% with ethanol 5% with EGR 5% the values found to be 27.88 j/deg CA and 25.76 j/deg CA. The blends B20% and B40% with ethanol 5% with EGR 10% the values found to be 26.5 j/deg CA. and 27.62 j/deg CA. The pure diesel shows the 28 j/deg CA. It was observed from the graph that there is an increase in the ignition delay for the blends. Among the fuels tested B40% with ethanol 5% with EGR 10% is found to have higher ignition delay. It is observed that the heat release rate curves of the diesel, neem biodiesel and their blends show similar patterns. The peak heat release rates of neem biodiesel and their blends are lower than that of diesel. There is decrease in peak heat release rate for EGR usage. Decrease in heat release rate is indication of incomplete combustion due to a less oxygen content because of using EGR 5% and 10%

4. CONCLUSIONS

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.
- Properties of 20% of biodiesel are very close to the diesel compared to other blends.
- 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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