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Experimental Investigation on CI Engine Using Neem Seed Oil as Biodiesel at Different Injection Pressures

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***Abstract*— In recent years, much research has been carried to find suitable alternative fuel to petroleum products. The experiments were conducted at compression ratio 17.5 for various engine nozzle opening pressure (200bar, 250bar, &300bar) and for various blends of neem biodiesel.Biodiesel is produced by the transesterification of triglycerides of edible/non edible oils and waste vegetable oils using methanol with alkaline catalyst like NaOH /KOH. In this research, the fatty acid methyl esters of neem oil is produced through transesterification process under lab setup and blended with petroleum diesel for various ratios (10%, 20% and 30%) to evaluate fuel properties. The performance parameters evaluated were brake thermal efficiency, break specific fuel consumption and the emissions measured were carbon monoxide (CO), carbon dioxide (CO2), hydrocarbon (HC), and oxides of nitrogen (NOx).The results of experimental investigation with biodiesel blends are compared with that of diesel. Injector opening pressure increases from the rated value from 200 bar to 250 bar shows significant improvement in performance and emission characteristics with neem biodiesel blends. At injector opening pressure 300 bar performance inferior than injector opening pressure 250 bar.The brake thermal efficiency of the engine decreased for all blends in comparison with diesel, and the break specific fuel consumption was considerably more for B10, B20& B30. The results indicated that the CO emissions are slightly less, HC emissions were also observed to be less for B10 and B20, and NOx emissions increased for B10 and for B20 compared with diesel.**

***Keywords*— Biodiesel, Diesel engine, Neem biodiesel, Injection pressure, Performance, Exhaust emissions**

I. INTRODUCTION

Energy is the most fundamental requirement for human existence and activities. As an effective fuel, petroleum has been serving the world to meet its need of energy consumption. But the dependence of mankind entirely on the fossil fuels could cause a major deficit in future. The worldwide concern about the protection of environment and the safety of non-renewable natural resources, has given rise to alternate development of sources of energy as substitute for traditional fossil fuels.

The major part of all energy stimulated worldwide comes from fossil sources (petroleum, coal and natural gas). However, these sources are inadequate and will be exhausted. Thus, looking for alternative sources of new and renewable energy such as hydro, biomass, wind, solar, geothermal, hydrogen and nuclear is of fundamental importance. Alternative and renewable fuels are the possible solution for many of the current social problems and concerns, from air pollution and global warming to other environmental improvements and sustainability issues The main advantages of using biodiesel is that it is eco-friendly, can be used without modifying existing engines, and produces less harmful gas emissions such as carbon monoxide, hydrocarbon and sulpur di oxide.

II. BACKGROUND

In this characterization of neem biodiesel , performance and emission studies are carried out by earlier researchers with regards to the use of various types of non edible oils as fuel in diesel engines are presented and also various method to Evaluate the performance and emission characteristics are discussed.

Shraddha R jogdhanka, S D Rahul bharadwaj [1]-have conducted the performance of a stationary single cylinder diesel engine running on neem oil and neem biodiesel blended with diesel with varying proportion of 10%, 20%,and 30% by volume and also on diesel fuel. Diesel fuel results were considered as the base line data for comparison of performance parameters. The brake thermal efficiency of B20 was higher at 220 bar than that of other fuel at different injector opening pressure with neem biodiesel and lower than that of diesel. An increase in brake thermal efficiency of about 1.1 % is observed at 220 bar than 200 bar at different injector opening pressure with neem biodiesel.

D. Subramaniam, A.Murugesan And A, Avinash [2]-have studied the performance and emission characteristic of neem biodiesel blended with diesel as an alternative fuel in a diesel engine.

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The test were conducted for neem biodiesel and its blends at different proportion (10%, 20%,30%,40%,and 50%) by volume for conventional engine.

A Single Cylinder Four Stroke Compressed Ignition Engine was operated successfully using the neem biodiesel and diesel blends as fuel. The following conclusions are made based on the experimental results. The brake thermal efficiency increased with increase in load. Biodiesel blends up to B30 have maximum brake thermal efficiency than diesel. With the increase in biodiesel blends the value of BSFC also increased. Carbon monoxide emission from the exhaust gas is reduced as the output power increases but this concentration is increased as the neem biodiesel blend increases with the diesel fuel. Hydro carbon emission concentration is found lesser than the diesel at all load conditions.

H. M. Dharmadhikari, Puli Ravi Kumar, S. Srinivasa Rao [5]– have studied the Performance and emissions of C.I.engine using blends of biodiesel (karanja and neem) and diesel at different injection pressures .The tests were conducted for karanja and neem and its blends with different proportions (10%,20%,60%,100%).The following conclusions were made based on the experimental results. Karanja and neem based biodiesels can be directly used in diesel engines without any modifications. The performance is slightly reduced while brake specific fuel consumption is increased when using biodiesels. The brake thermal efficiency of B10, B20 and B60 are better than B100 but still inferior to that of diesel. Compared with conventional diesel, exhaust emissions of CO and HC are reduced while NOx emissions are increased with biodiesel and its blends with diesel.

T.Venkateswara Rao, G. Prabhakar Rao, and K. Hema Chandra Reddy [6]-have conducted the Experimental Investigation of Pongamia (PME), Jatropha (JME) and Neem Methyl Esters (NME) as Biodiesel on C.I. Engine. The Experimental investigations have been carried out to examine properties, performance and emissions of different blends (B10, B20, and B40) of PME, JME and NME in comparison to diesel.

The single cylinder diesel engine fuelled with biodiesel from Pongamia, Jatropha and Neem seed oils and their diesel blends. Brake thermal efficiency of B10, B20 and B40 blends are better than B100 but still inferior to diesel. Properties of different blends of biodiesel are very close to the diesel and B20 is giving good results. It is not advisable to use B100 in CI engines unless its properties are comparable with diesel fuel.

Smoke, HC, CO emissions at different loads were found to be higher for diesel, compared to B10, B20, B40 blends.

III. METHODOLOGY

3.1 Steps for Production of Biodiesel from Vegetable Oil

Fig1 explains the methodology to produce biodiesel from vegetable oil. There are two approaches/ processes for the production of the biodiesel. The criterion for the selection of the process is based on the presence of the Free Fatty Acid (FFA) content in the neem oil.

a) If the FFA content of raw oil is less than 4%, alkali base catalyzed transesterification process is to be done.

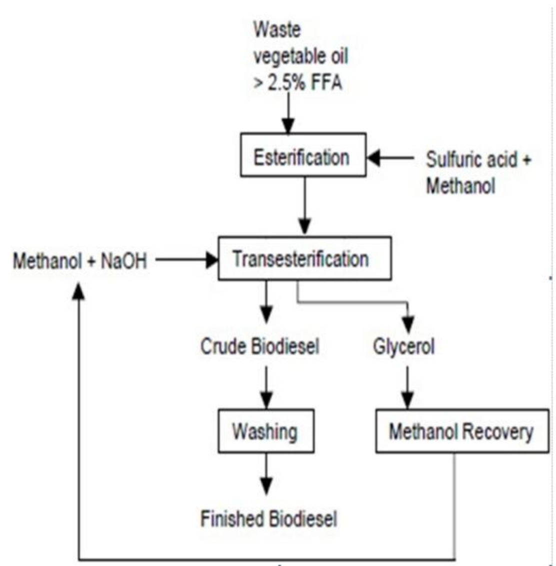

Fig 1 Steps for Production of Biodiesel from Vegetable Oil

Table 1
Fuel properties of diesel & different blends of neem biodiesel (B10, B20, &B30)

Fuel/properties	Kinematic viscosity 40°C(cSt)	Flash point (°C)	Density (kg/m^3)	Calorific value (kJ/kg)
Diesel	3.02	52	806	43796
B10	4.5	65	837	44840
B20	4.8	73	844	43898
B30	5.1	78	852	39950

3.2. Fuel properties of Diesel, neem biodiesel and its blends.

Table 1 shows the fuel properties of Diesel, neem biodiesel and its blends. Biodiesel blends of neem methyl esters with diesel on 10, 20 and 30% volume basis is prepared and the fuel properties such as viscosity, density, calorific value, flash point, fire point are determined.

3.3 Performance Study

Experiments are conducted on a single cylinder four stroke compression ignition engine without any hardware modifications. Neem biodiesel blends and diesel is used to run conventional engine. Results are tabulated for different load conditions. Performance parameters like Brake Power (BP), Total fuel consumption (TFC), Brake Specific Fuel(BSF) consumption and Brake Thermal Efficiency(BTE) are evaluated using equation 1,2, 3 and 4.

Brake Power

$$BP = \frac{2\times\pi\times N\times T}{60000}\ kW \text{ ------------(1)}$$

Total Fuel Consumption

$$TFC = \frac{20\times \text{density of the fuel}\times 10^{-3}}{\text{Time}} \text{ ---- (2)}$$

Brake Specific Fuel Consumption

$$BSFC = \frac{TFC\times 3600}{BP}\ Kg/kW\text{-}hr \text{----- (3)}$$

Brake Thermal Efficiency

$$\eta_{bth} = \frac{BP}{TFC\times CV} \text{ - - - - - - - - (4)}$$

Where,

N = speed of engine in rpm

T = torque in N-m

Cv = calorific value in kJ/ kg

Table 2
Specifications of Engine Test Rig

Company And Model	Kirloskar Oil Engine , Tv1
Type	Single Cylinder,4-Stroke,Diesel Engine
Bore	87.5mm
Stroke	110mm
Rpm	1500rpm
Rated Power	5.2kw(7HP)
Type Of Cooling	Water Cooling
Compression Ratio	17.5:1

IV. EXPERIMENTAL SETUP AND PROCEDURE

A four stroke, Single cylinder, water cooled diesel engine was used for the performance test. The technical specification of the test engine is shown in Table.2 The experimental setup diagram is shown in figure.1. Experiments were carried out initially using neat diesel fuel to generate the base line data. After recording the base line data, tests were carried out using 10%,20% and 30% biodiesel blends. The engine tests were conducted at various loads and the parameters related to performance were recorded.

Figure 2 computerized diesel engine

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V. Results And Discussion

A series of engine tests were carried out using diesel and biodiesel to find out the effect of various blends on the performance of the engine with varying injection pressure and injection timings. Investigations are carried out on the engine mainly to the effect of brake thermal efficiency, brake specific fuel consumption.

6.1 Brake thermal efficiency

From fig 6.1, 6.2, & 6.3 shows the variation of brake thermal efficiency versus brake power for standard injection timing and with the pure diesel and neem bio-diesel blends (10%,20% & 30%).The effect of increase in injection opening pressure has been brought out in the same. The BTE increases with an increase in load from 0% to 100% for all the injection pressure. The brake thermal efficiency is maximum at 250bar of B30 is giving the best results of 27.78% at higher loads compared to all other cases; this is due to fine spray formed during injection and improved atomization. Further the BTE tends to decrease, these may be due to that the higher the IP the size if the fuel droplets decreases and a very fine spray will be injected because of this penetration of fuel spray reduces and momentum of fuel droplets will be reduced. But there is slight decrease in the BTE for the blends B10 and B20 which is due to the lower energy content of biodiesel.

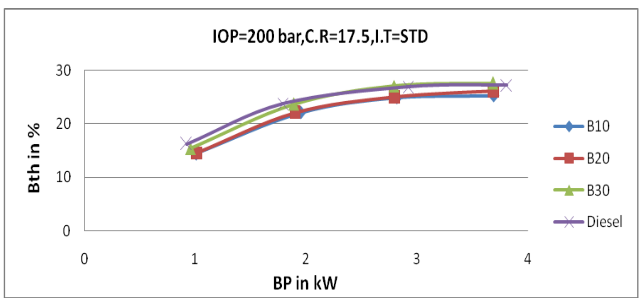

Fig 6.1 Brake thermal efficiency v/s Brake power

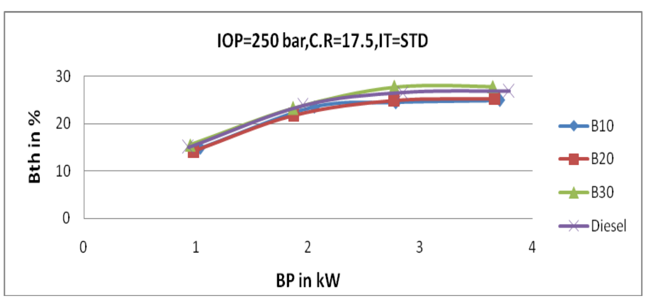

Figure 6.2 Brake thermal efficiency v/s Brake power

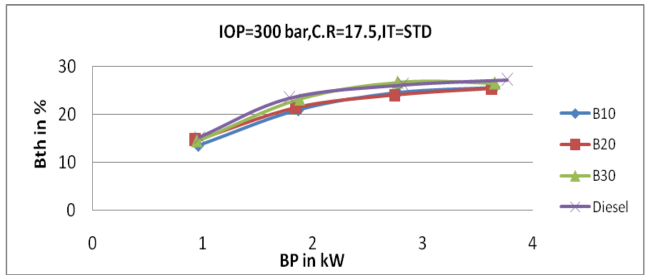

Fig 6.3 Brake thermal efficiency v/s Brake power

6.2 Brake Specific Fuel Consumption

Variation of BSFC with BP at different IP is shown in figure 6.4, 6.5, & 6.6.the BSFC of neem biodiesel blends are higher than diesel; it may be due to lower calorific value of biodiesel. Figure shows the variation of BSFC with varying of IP for neem biodiesel. It was found that the BSFC is decreased with increase in injection pressure up to 250bar; these may be due to that as IP increases the penetration length and spray cone angle increases. From figure 5 and 6, the BSFC for B30 is 0.30 kg/kw-hr at 250 bar and in increase in IP from 250 to 300 bar, the BSFC is increased to 0.34 kg/kw-hr.

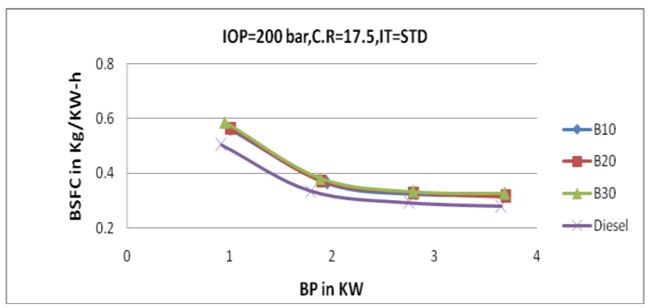

Fig 6.4: Brake specific fuel consumption v/s Brake power

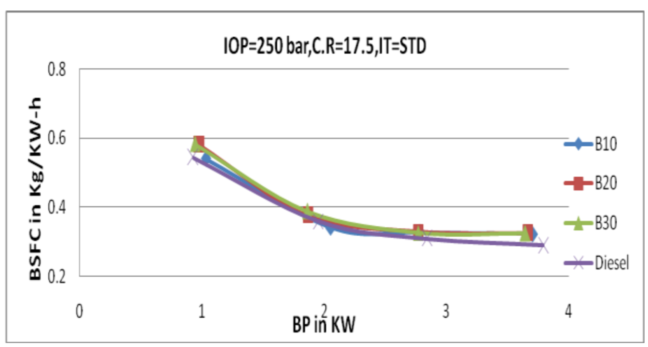

Fig 6.5: Brake specific fuel consumption v/s Brake power

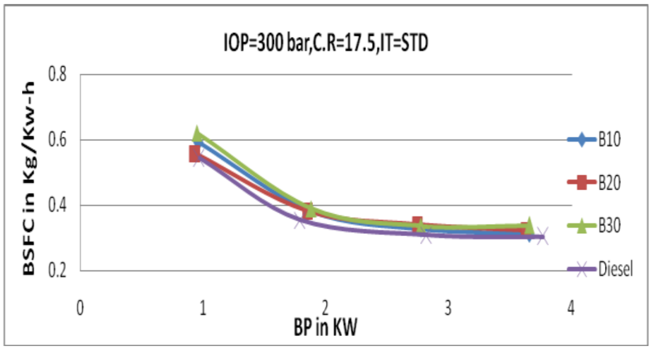

Fig 6.6: Brake specific fuel consumption v/s Brake power

6.3 Carbon Monoxide Emission (CO)

Variation of carbon monoxide with BP is as shown in the fig 6.7,6.8,&6.9.carbon monoxide in diesel engine is mainly depends upon the physical and chemical properties of the fuel. The biodiesel itself contains 11% of oxygen which helps for complete combustion .From figures it is found that the amount of CO increases at part loads and again greater increase at full load condition for neem biodiesel. This is common in all the internal combustion engines, since the air –fuel ratio decreases with increase in load. The carbon monoxide emission increases when fuel air ratio becomes greater. The CO emission for fuels used at full BP is approximately 30% lower than diesel. The lowest carbon monoxide emission is observed at 250bar as 0.04% for B20 is shown in figure 6.5.

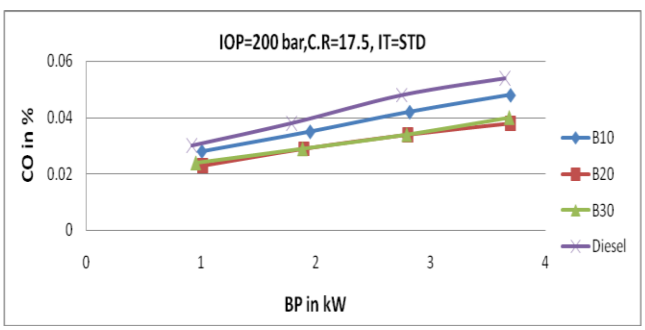

Fig 6.7: Carbon monoxide v/s Brake power

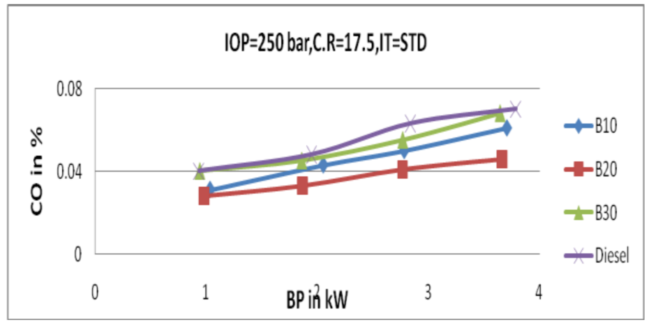

Fig 6.8: Carbon monoxide v/s Brake power

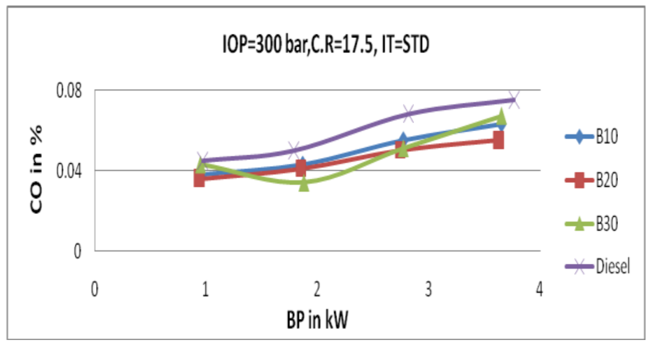

Fig 6.9: Carbon monoxide v/s Brake power

6.4 Carbon Dioxide Emission (CO2)

The variation of CO_2 with three different injection pressures under the investigation on pure diesel and neem biodiesel has been brought out in fig 6.10, 6.11, & 6.12 for standard injection timing. It can be observed in the figure the variation of carbon dioxide with brake power is almost the same at an injection pressure of 200bar and 250bar. The blends B20 and B30 neem biodiesel has given lowest carbon dioxide emission in all the cases, because the biodiesel itself contains 11% of oxygen which helps for complete combustion.

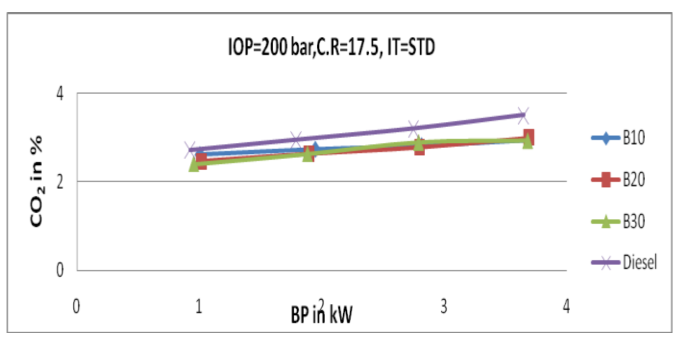

Fig 6.10: Carbon Dioxide v/s Brake Power

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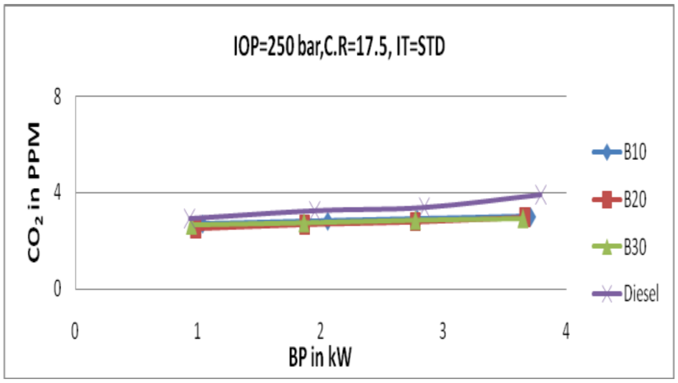

Fig 6.11: Carbon Dioxide v/s Brake Power

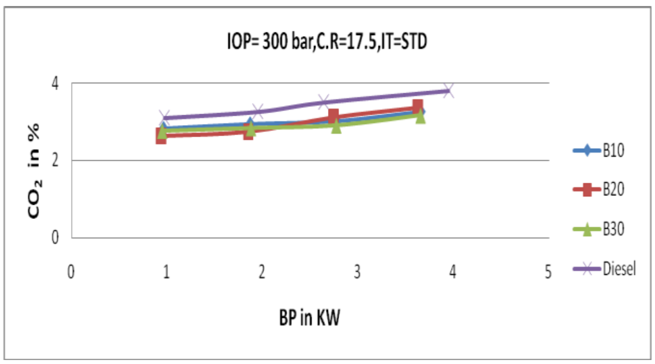

Fig 6.12: Carbon Dioxide v/s Brake Power

6.5 Hydro Carbon Emission (HC)

Figure 6.13, 6.14,&6.15 shows the variation of HC with BP. The HC is increased with increase in BP for neem biodiesel. It is observed from figures, that the HC emission for neem biodiesel is lower than diesel fuel, indicating that the heavier hydrocarbons particles that are present in the diesel fuel increases HC emissions. The HC emission of neem biodiesel at full load is approximately 25 to 30% lower than diesel value. The presence of oxygen in the fuel was thought to promote complete combustion that leads to lowering the HC emissions. This reduction indicates more complete combustion of the fuel.

As the IP increases the HC emission will decrease as seen in the figure 6.13, 6.14, &6.15 for neem biodiesel and at 200bar, IP there is minimum HC emission. And at 250 bar it seems to be increase in HC emission which may be due to finer spray, which reduces the momentum of the droplets resulting in less complete combustion.

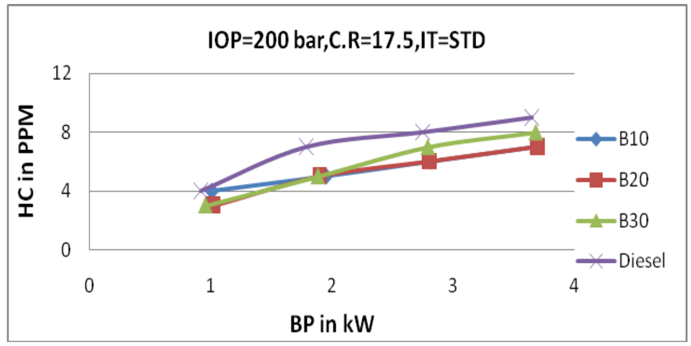

Fig 6.13: Hydro Carbon v/s Brake Power

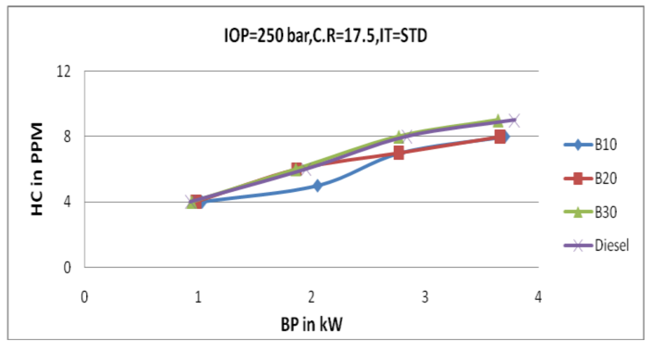

Fig 6.14: Hydro Carbon v/s Brake Power

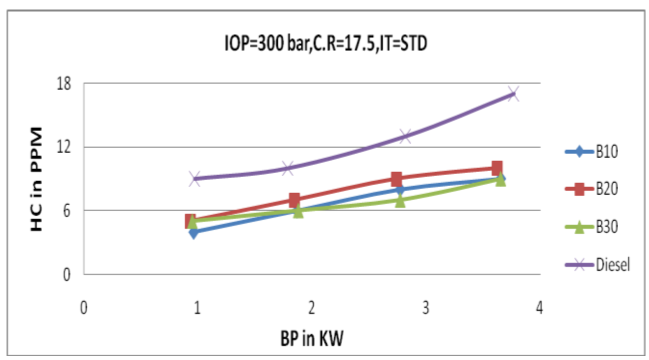

Fig 6.15: Hydro Carbon v/s Brake Power

6.6 Nitrogen Oxide Emission (NO_X)

Variation of NO_X with BP is shown in the figure 6.16, 6.17, &6.18.The NO_X results from the oxidation of atmospheric nitrogen at high temperature inside the combustion chamber of the engine rather than resulting from the contaminant present in the fuel.

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Figure shows the amount of NO_X is increased with increase in BP for neem biodiesel. It can be observed in the figure 16 NO_X emission were lower at 200 bar injection pressure indicating that the effective combustion is taking place during the early part of expansion.

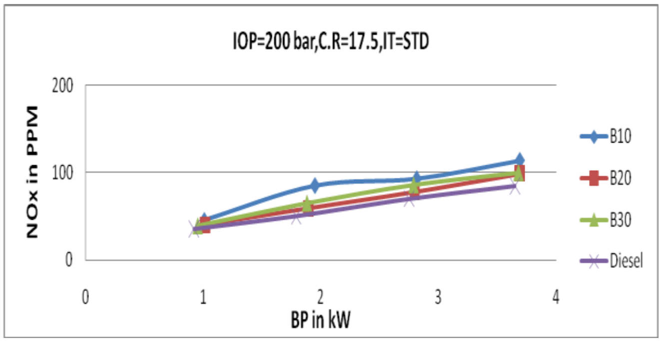

Fig 6.16: Nitrogen Oxide v/s Brake Power

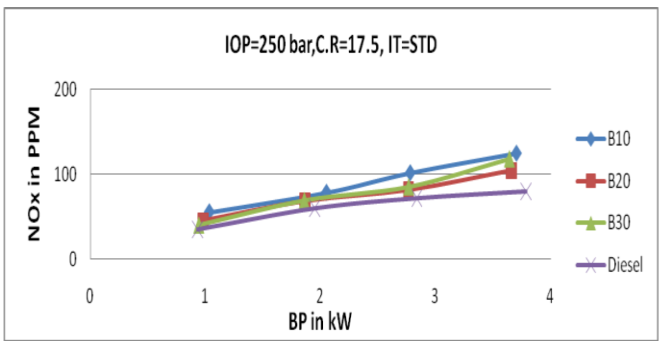

Fig 6.17: Nitrogen Oxide v/s Brake Power

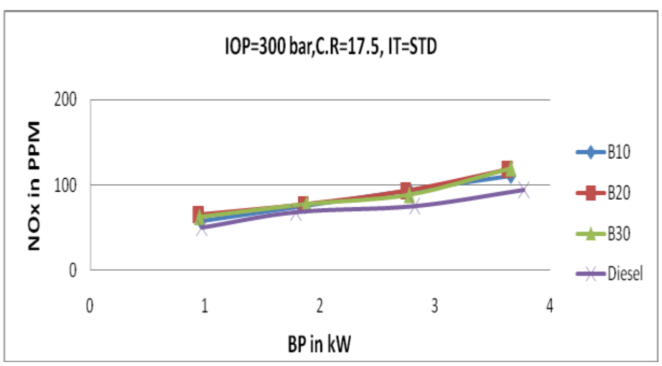

Fig 6.18: Nitrogen Oxide v/s Brake Power

VI. CONCLUSION

A single cylinder, compression ignition engine was operated by using neem biodiesel successfully and the performance and exhaust emissions were compared with pure diesel fuel. The Following conclusions were drawn from this investigation.

1. Important fuel properties like kinematic viscosity, density, flash point, fire point, specific gravity and calorific value of the produced neem biodiesel are found to be within the limits of biodiesel ASTM standards and thus can be used as an alternative to diesel fuel.
2. Usage of bio diesel there is a significant improvement in the performance and emission characteristics when the injector opening pressure properly optimized (say 250 bar), when a diesel engine is operated with neem biodiesel.
3. Injector opening pressure increases from the rated value from 200 bar to 250 bar shows significant improvement in performance and emission characteristics with neem biodiesel blends. At injector opening pressure 300 bar performance inferior than injector opening pressure 250 bar.
4. It was observed that the injection pressure increases BTE with increase in BP but the BTE for 300 bar is less than other lower pressure. And the BSFC is also decreased with increase in injection pressure up to 250 bar.
5. The results indicated that the CO emissions are slightly less, HC emissions were also observed to be less for B10 and B20, and NOx emissions increased for B10 and for B20 compared with diesel.

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