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Performance, Combustion and Emission Evaluation of Vegetable De-oiled Neem Cake-Diesel Blends on Diesel Engine

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ABSTRACT

Alternative sources for petroleum fuels have been the prime concern of most of the environmentalists. It is also a concern for economists due to the depletable nature of the fossil fuel. Vegetable oils are considered as good alternatives to diesel as their properties are close to diesel. At present biodiesel is commercially produced from the vegetable oils by esterification processes and its cost restrict the uses. In this paper neem de-oiled cakes after crushing the seeds is aimed in this study. The fuel is prepared by just adding dry de oiled cake powder at various proportions with diesel. Experiments were carried out in a single cylinder, water cooled, four stroke diesel engine for various blends of neem de oiled cake powder (NDOCP) and diesel fuel as 5%, 10% 15 % 20% and 25% by weight. The fuel has the potential to reduce smoke, CO emissions simultaneously with 2.5% increase in efficiency and a small increase in HC and NOx emission. The experimental results show that NDOCP blend operation results in higher brake thermal efficiency with reduced emissions compared to the neat diesel and slightly less when comparing with pure oil blends

Key Words: *Neem de oiled cake powder, blended fuel, performance and emission characteristics and bio-fuels*

1. INTRODUCTION

The petroleum based diesel fuel needs to be substituted with alternate fuel to meet the energy demands in the future for developing countries. The fossil fuels are depleting drastically which increases the demand in the international market that affects the economy and nation.Thus an alternate energy source has to be identified to overcome the problems with the petroleum based diesel fuel. One such energy source is fuel derived from vegetable oil that is bio diesel. Many bio diesels in the form of esters are being experimented to suit the diesel engine without any major

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engine modification. Pure neem oil usage in diesel engine shows lesser smoke, carbon monoxide (CO), hydrocarbon (HC) emissions compared to diesel fuel since it has oxygen molecules which results in enhanced oxidation.[1] The increase in brake power is expected due to larger fuel droplets and oxygen content in neem oil, which contribute to better combustion. The fuel can be categorized as oxygenated fuel since it has oxygen molecules and this oxygen can enhance the oxidation during the combustion resulting in lesser CO, HC and smoke emission6-9. The de oiled cakes contains oxygen with very minimum fatty substances and is available at very low cost, and hence in this work a fuel is produced by adding different proportions of de oiled cake with diesel and experiments were conducted to find out the performance, emission and combustion characteristics

1.1 FUEL PREPARATION

The major problems in direct use of vegetable oil as fuel in diesel engine are fuel filter plugging, choking of injector nozzles, sticking of piston rings and crankcase oil dilution. The kinematic viscosity of the vegetable oil is generally higher than diesel fuel and can be brought down by various techniques such as preheating, blending, emulsification and transesterification. The de oiled cakes of edible and non edible oils are now used as cattle feed and manure which is a good oxidizer having less fat and will be dissolved in diesel up to some extend. The de oiled cake was dried and pulverized and the fuel was prepared by adding known amount of pulverized de oiled cake with known amount of diesel and the blend is allowed to settle for 5 to 7 days to get completely dissolved blend. The sediments are filtered and the fuel is used in diesel engine without any engine modification. The properties of diesel fuel, neem oil blends and NDOCP blends were measured and given in Table 1

1.2 FUEL PROPERTIES

Table 1 Properties of Fuels

Sl. No	Properties	Diesel	Neem oil blends					Neem de oiled cake blends(NDOCP)				
			5%	10%	15%	20%	25%	5%	10%	15%	20%	25%
1	Sp.gravity	0.820	0.824	0.828	0.832	0.836	0.840	0.819	0.819	0.820	0.820	0.820
2	Kinemetic viscosity cSt at 40^0	3.366	3.58	3.92	4.06	4.24	4.42	3.37	3.48	3.507	3.64	3.67

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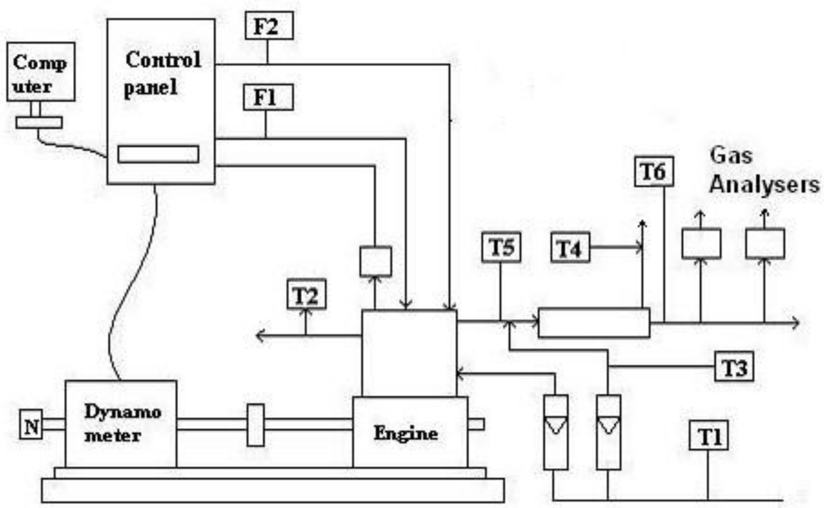
	C											
3	Calorific value KJ/Kg	42000	40242.6	38399.15	37862.88	36748.42	35992.9	40485	39297	38106	36415	35724

2. EXPERIMENTAL SETUP AND TEST PROCEDURE

A single cylinder air-cooled four stroke direct injection diesel engine was used for this experimental work. The schematic of the experimental setup is shown in Fig. 1.

Fig 1-Experimental Setup



T1&T3 - Inlet water temp oC

T6 – Exhaust gas temp oC after calorimeter

T2 - Outlet engine water temp oC

N – RPM decoder

T4 – Outlet calorimeter water temp oC

F1 – Fuel flow differential weight unit

T5 – Exhaust gas temp °C before calorimeter F2 – Air flow differential velocity unit.

Initially the test engine was operated with diesel fuel. The observations on the engine performance parameters and pollutants emissions were noted for various load conditions. After that it was operated with fuel blends, and the observations were noted. The experimental system includes the engine, air flow and emission measurement system. Airflow rate was measured by

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means of anemometer. An exhaust gas analyzer (AVL Five gas analyzer) was used for measuring the exhaust emissions like oxides of nitrogen, hydrocarbons, carbon monoxide and carbon dioxide (NOx, HC, CO, CO_2) Exhaust gas temperature was measured by means of a K – type thermocouple. Smoke levels were measured using a AVL smoke meter. An AVL combustion analyzer was used to measure the combustion characteristics of the engine

3. RESULTS AND DISCUSSION

The variation of brake thermal efficiency with brake power is shown in Fig. 2. It can be seen that for all the cases the maximum brake thermal efficiency occurs at maximum load. For the neat diesel fuel operation it is 35 % and is increased by 2.5% for 10% NDOCP blends. The presence of oxygen molecules in NDOCP enhanced the combustion and increases the efficiency.

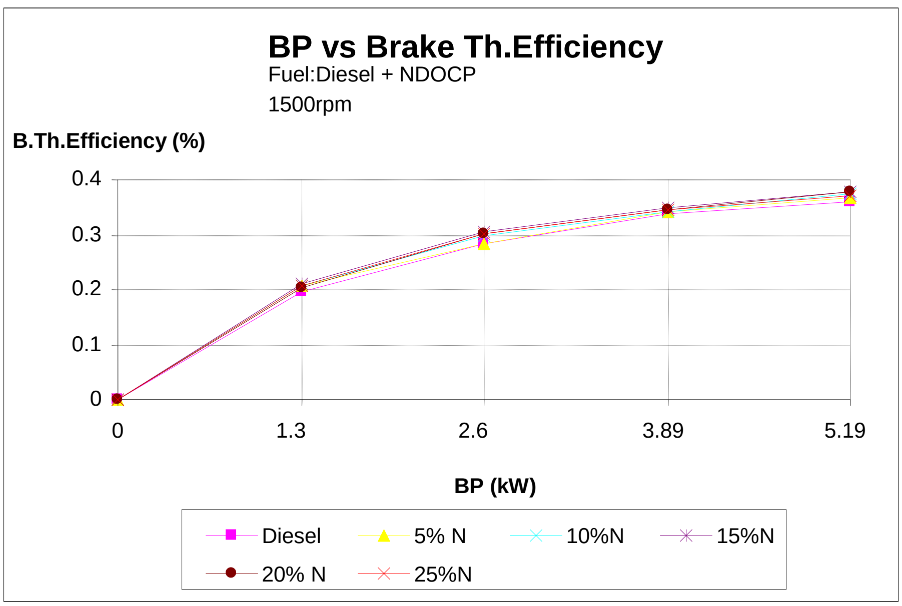

Figure 2- variation of brake thermal efficiency for NDOCP blends

The variation of brake specific energy consumption with load is shown in Fig. 3. It is the valid parameter to compare the performance of diesel fuel and any other bio diesel. The maximum reduction in specific energy for 10% NDOCP blend is recorded as 38.14% at 75% of load and 4% at full load with respect to neat diesel.

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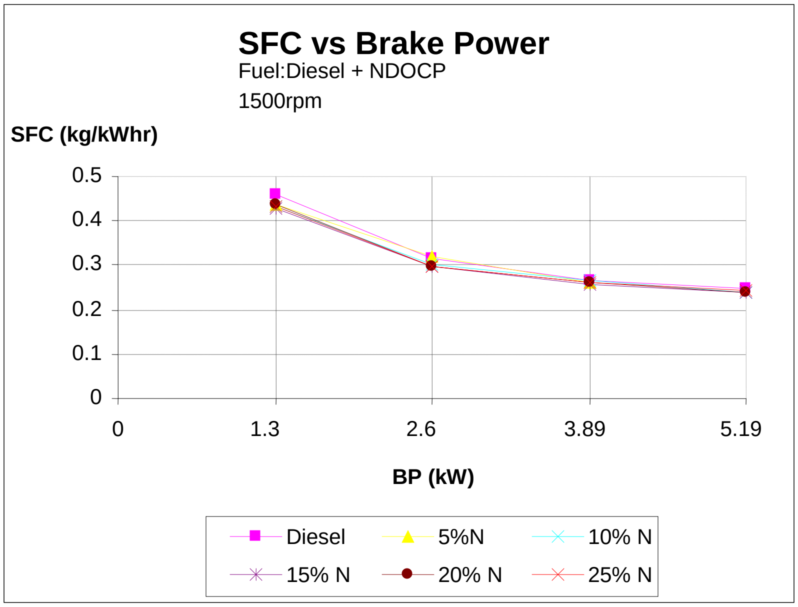

Figure 3- Specific Energy consumption for NDOCP blends

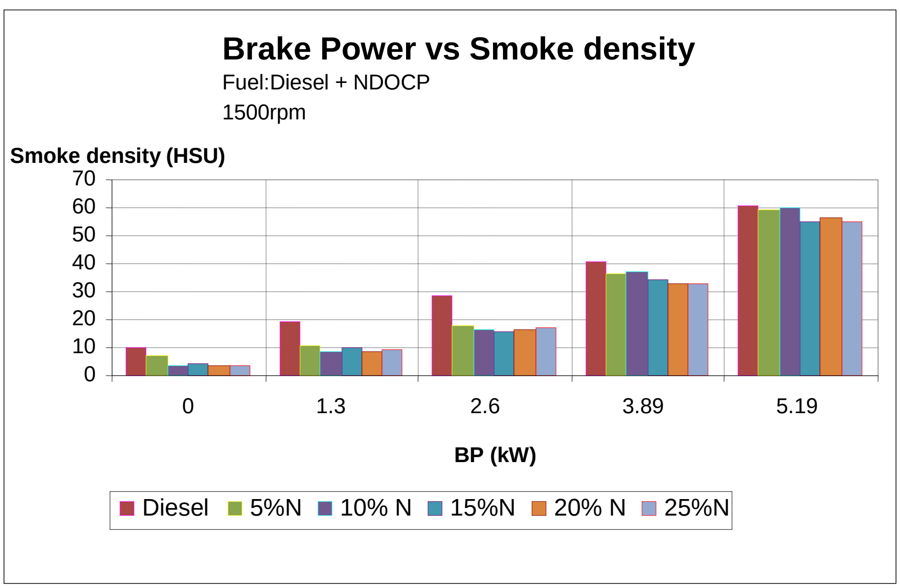

Figure 4 - Smoke density for NDOCP blend.

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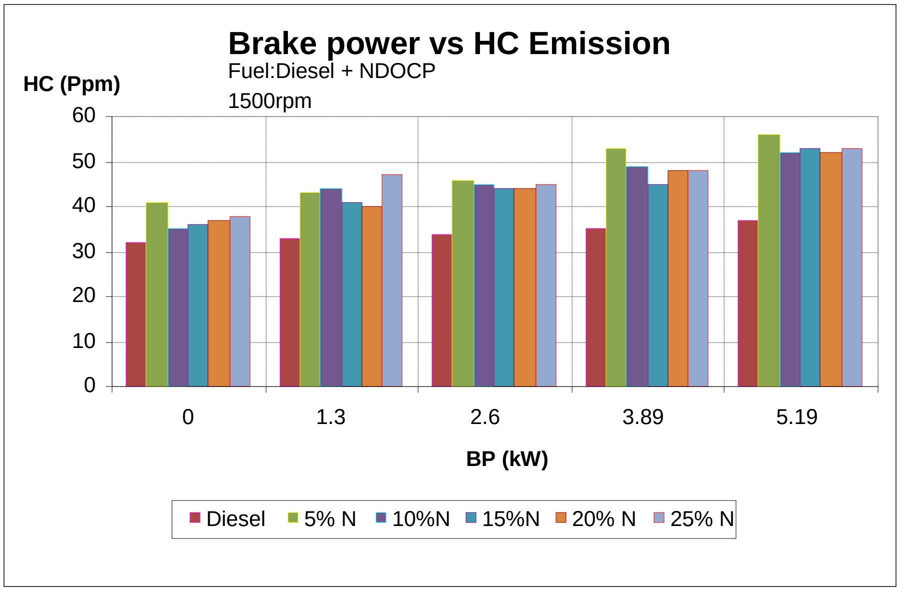

Figure 5- HC emission for NDOCP blend

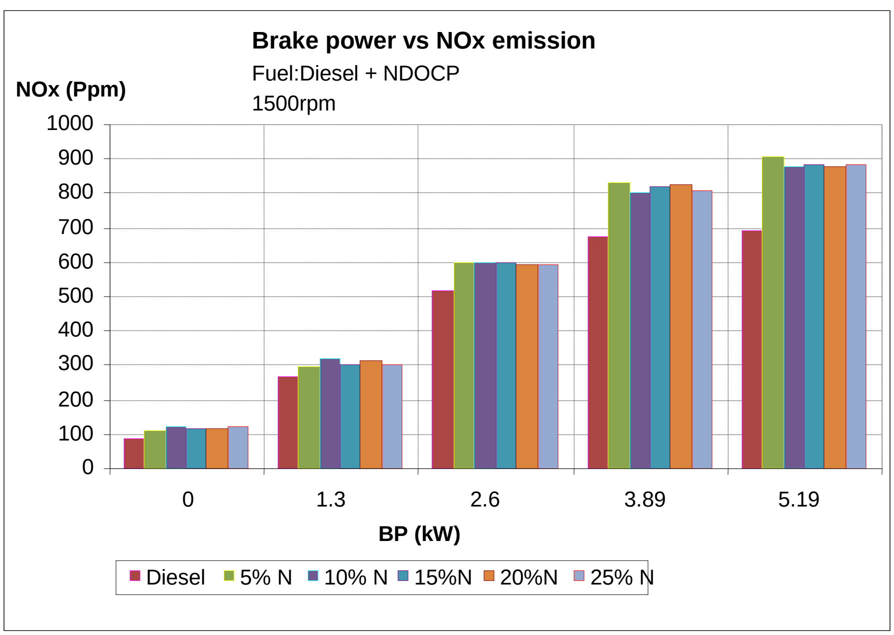

Figure 6- NOx emission for NDOCP blend

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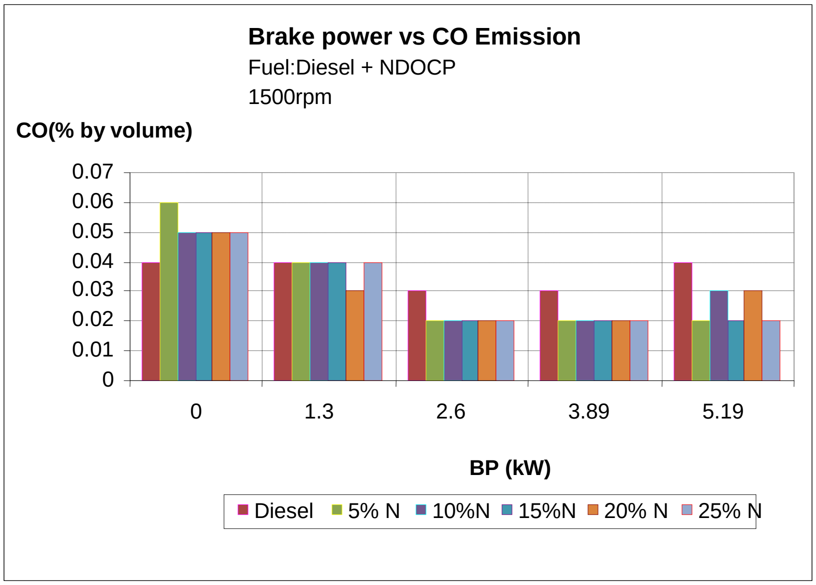

Figure 7- CO emission for NDOCP blend

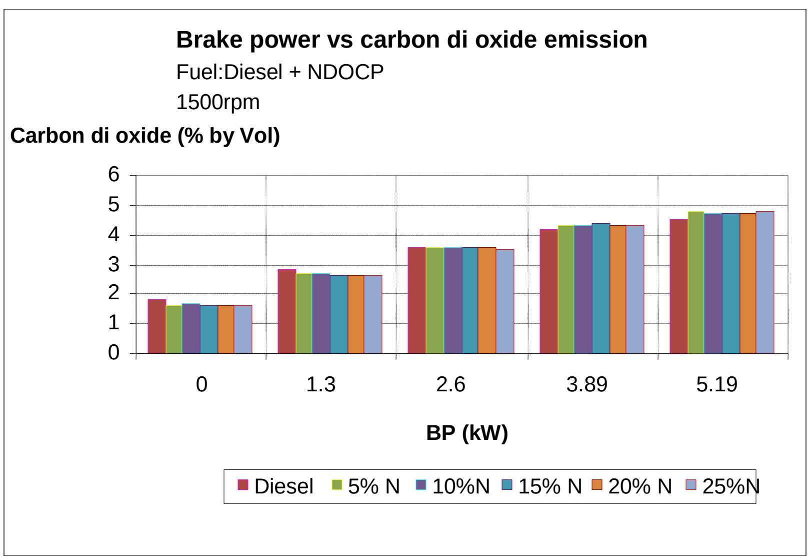

Figure 8- CO_2 emission for NDOCP blend

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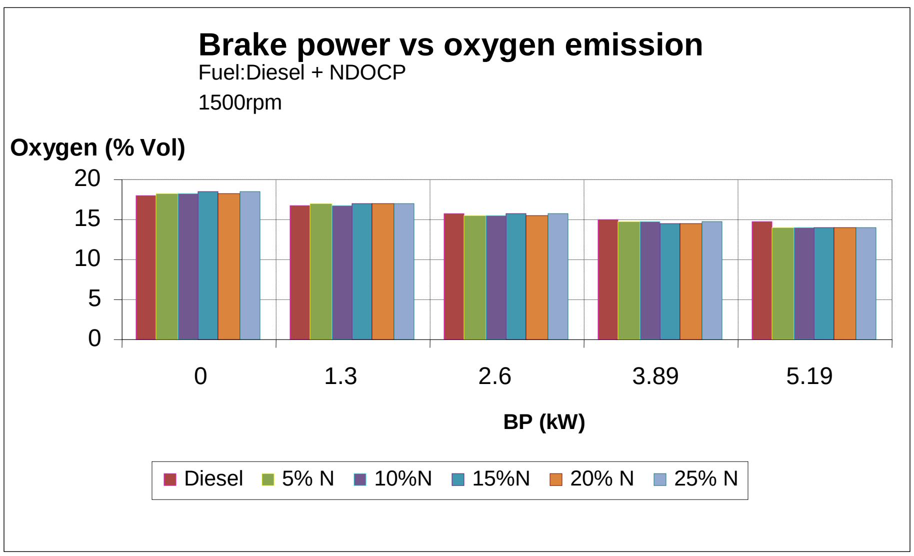

Figure 9- O_2 emission for NDOCP blend

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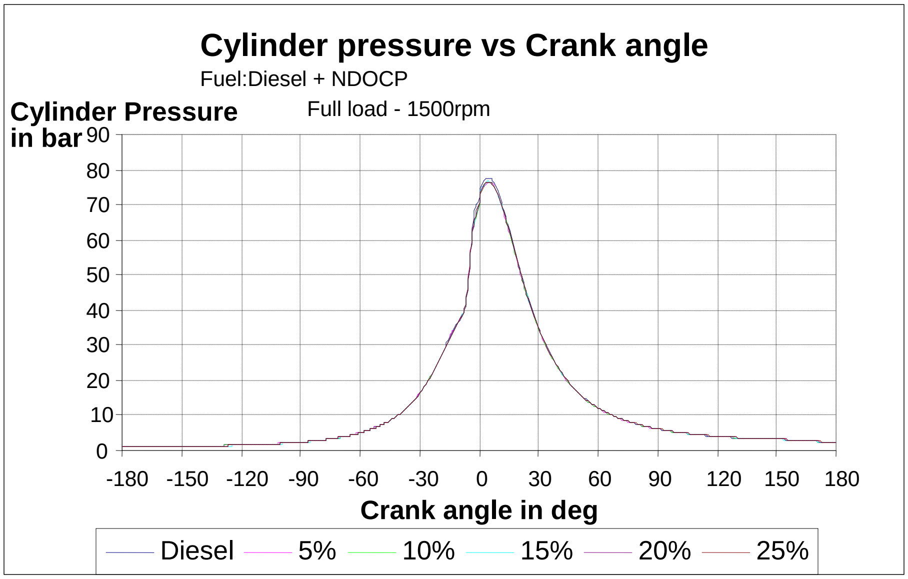

Figure 10: Cylinder pressure Vs crank angle for NDOCP blend.

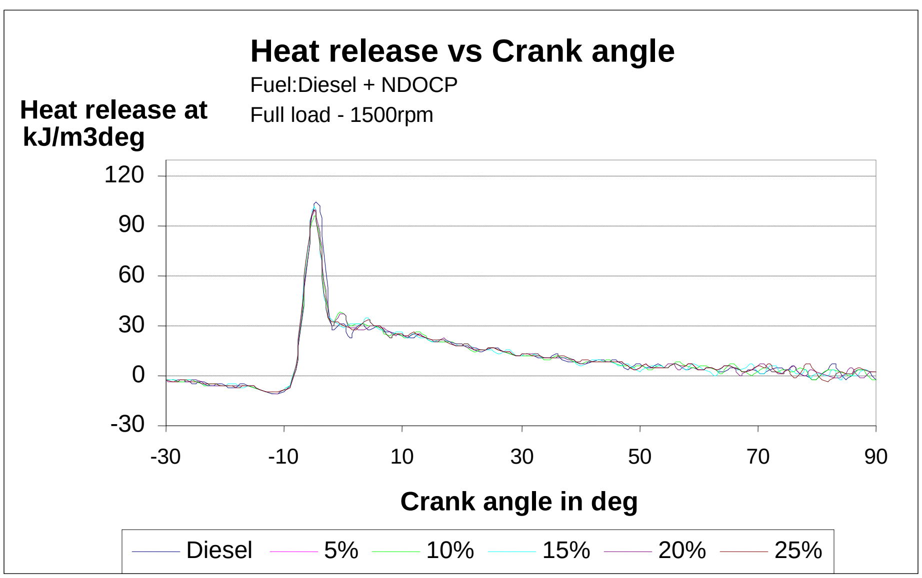

Figure 11: Heat release Vs crank angle for NDOCP blend

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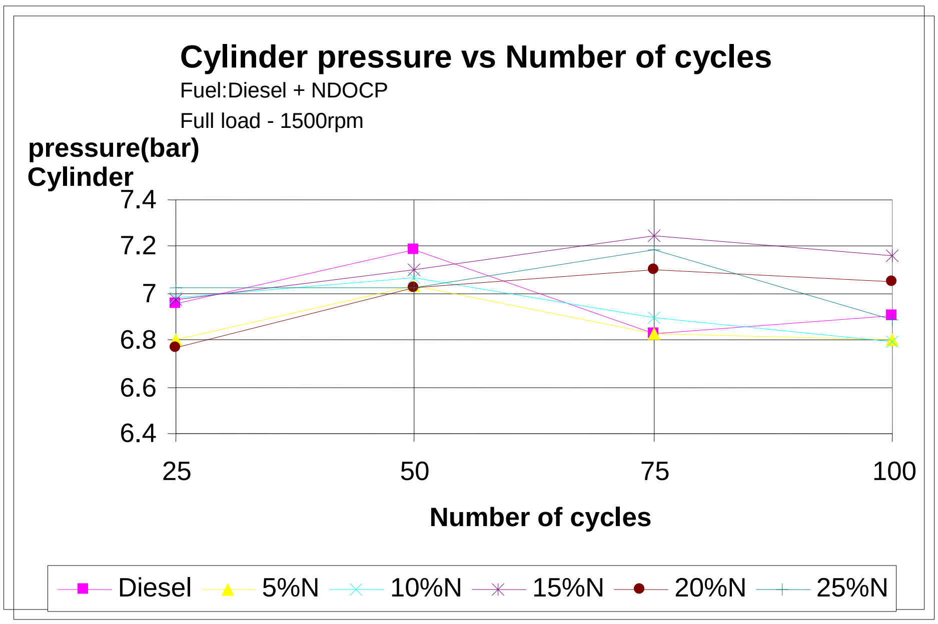

Figure 12: Cylinder pressure Vs number of cycles for NDOCP blend

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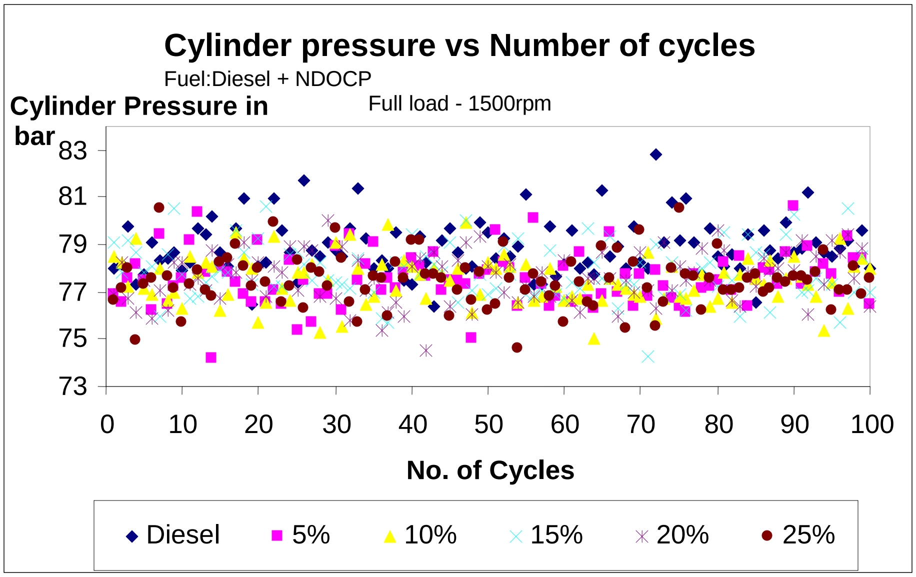

Figure 13: Cyclic pressure change for NDOCP blend

Figure 4 illustrates that pure oil blends slightly less smoke reduction as the oxygen content is high for all operating conditions. The reduction rate was decreased when the blend ratio increases due to the higher molecular weight; where as in NDOCP blends the smoke reduction rate is high at half loads and almost same at the maximum load conditions since the oxygen availability is less. The reduction rate was increased with increase in blend ratio due to the increase in oxygen content and is 42.4% for 10% NDOCP blend at 50% load.

3.1.2 HC emission

The variations of CO and HC are comparable with neat diesel. Except at no load conditions the CO level is totally decreased for pure oil and NDOCP blends. The higher molecular weight may be the reason for the same. The HC emission for NDOCP blends is slightly high comparing with pure oil blends due to the low oxygen content and the maximum increase is 29% at full load for 10% NDOCP as shown in fig.5

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3.1.3 NOx emission.

The variation of NOx with load NDOCP blends are shown in Fig.6. The NOx emission increases with load. Temperature is one of the major factors for NOx formation when load increases, the peak combustion temperature increases and thus NOx emission increases. Even though the oxygen content is more in pure oil blends the NOx formation is less and 885 ppm due to its higher molecular weight. Since the NDOCP blends are more viscous than the pure oil blends it is highly atomized and helps complete combustion and hence a slight increase in NOx emission at full load as shown in fig 6

3.1.4 Combustion analysis

In cylinder pressure data collected at full load has been analyzed for total pressures, peak pressures, change in pressure with respect to crank angle for each blends of pure oil and NDOCP and was compared with the diesel fuel in terms of peak pressure magnitude. Factors that affect the peak pressure are specific heat, energy content and quality of the fuel. It was observed that the peak pressure are almost same for all blends of NDOCP at full load to that of diesel fuel as shown in fig 11.

3.1.5 Heat release rate

Heat release analysis of engine pressure data is a means of indirectly depicting the combustion process occurring in the engine. The heat release rate from the pressure data collected at full load with NDOCP and neat diesel fuel comparisons were made to that of the respective cases with the diesel fuel. At full load diesel release 103 kJ/m^3 of heat at 5^0 before TDC where as NDOCP blends releases 96 to 103 kJ/m^3 of heat at the same crank angle as shown in fig14.

4. CONCLUSION

The major conclusions drawn from the experiments were as follows:

- The brake thermal efficiency for NDOCP blends increased by 2.5 % at 10% NDOCP diesel blend compared to neat diesel fuel operation.

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- The brake specific energy consumption was found to be lesser for NDOCP blends at lower loads compared to neat diesel fuel operation and the maximum decrease was 38.14 % at 75% of load at 10% NDOCP diesel blend. However at full load, the decrease is by 4%.
- The oxides of nitrogen (NOx) emissions for NDOCP blends are slightly more at low and medium loads compared to neat diesel and it gets increased by 21.29 % at maximum load for 10% NDOCP blend.
- The smoke reduction for pure oil blends isslightly less for all operating conditions compared to neat diesel fuel, where as it is around 42.4% at half load and almost same at high load.
- CO emission is considerably reduced at medium and at high loads and it is slightly increased at low load for all blends
- 8% to 29% increase in HC emission were found at peak loads for all blends
- Maximum pressure and heat release rate are almost same as that of diesel for NDOCP blends
- 10% NDOCP blend was found to be optimum in all cases.

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FIGURE CAPTIONS

Figure Number	**Caption**
Figure 1	Experimental setup
Figure 2	variation of brake thermal efficiency for NDOCP blends
Figure 3	specific energy consumption for NDOCP blends
Figure 4	Smoke density for NDOCP blends

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