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Effects of injection pressure on performance and exhaust emissions of CIDI diesel fuelled with synthesized biodiesel (fish oil and honge oil)

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Abstract. To assess the emissions and performance of a test engine fueled by biodiesel - blends made from mixed fish oil extracted from processing by-products with honge oil in equal proportions. The experimental investigation was utilized to examine the effects of injection pressures on compression ignition engine testing and correlation of these effects the biodiesel blends. Consequently, commercial diesel fuel intermingled with various concentrations of fish-oil biodiesel with B0, B10, B20, B30, B40 and B50 were utilized for the test engine. Compared to B0, the average decline in brake power of the methyl esters was reduced proportionally with the biodiesel ratio in the fuel blends. The brake specific fuel consumption (BSFC) and oxides of nitrogen emissions improved together with a decline in hydrocarbons and carbon monoxide emissions as the proportion of biodiesel rises. As injection pressure increases, the brake power increases for all kinds of fuels tested.

1. Introduction

Diesel engines consume larger amount of diesel fuel and emits emissions which is very harmful to the ecosystem. CI engines are used widely because of its increase in fuel efficiency and reliability. Increase in population and industrialization, its usage increases, consequently due to inadequate oil reserves have led to the research for alternative fuels the engine was operated at 1500 rpm keeping hemispherical combustion chamber (HCC) shape and compression ratio of (CR) of 17.5. IT of 27 0 BTDC, IOP of 240 bar and injector of 5 holes yielded better performance. Maximum BTE for CPOME found to be 27.25, 27.6 and 28 % respectively for 3, 4 and 5 holes injector at 80% load against 31.25% for diesel with 3 holes injector and 0.3 mm orifice size. Bio diesel is a fuel that is generated from animal fat or vegetable oil. It is renewable energy source since agriculture is the main source. The main advantage of using bio diesel as a fuel is, it reduces the greenhouse effect by reducing carbon dioxide released during burning which results in the reduction of global warming.

Acid oil consists of fewer amounts of mineral acids (2-3%) along with long chain free fatty acid mixture, phospholipids and free moisture (4-9%) thus makes the acid oil to dark brown in colour. In this paper, the main concentration is on emission, performance and combustion characteristics using diesel and acid oil methyl ester as fuel for single cylinder diesel engine. To estimate brake thermal efficiency, HC and CO emission and combustion duration, test was conducted at different injection timings of 190,230,270 and 310 BTDC, keeping constant injection pressure at 205 bar and rated speed of 1500 rev/min. [1-3]. Corrosive oil that is a subordinate of vegetable petroleum processing plant tasks is a plausible source as its far shabby and without trouble accessible in broad amounts as an unutilized result. Acid oil because of its oxygenated nature and chain kind setup, it has gas homes that are stand-out than diesel gas. Warming qualities are scarcely lower while the thickness and start esteem are higher than diesel fuel. On the off chance that the thickness of Acid oil is diminished and carried nearer to diesel fuel, it might also be utilized as elective diesel fuel. Biodiesel is an alternative fuel for diesel fuel obtained using trans esterification process from animal fat or vegetable oil through a complex chemical process and can be employed as any direct substitute, extender or as an improver to conventional diesel fuel in compression ignition engines. The vital factor is that biodiesel fuel could be directly utilized in existing automobile engines with minute hardware modifications in engine design. These biodiesels are produced through a chemical reaction of animal fat or vegetable oils with methanol/ethanol in the occurrence of a catalytic agent to make glycerol as the main by product [4-8]. The use of oily fish unwanted parts in the fish canning industry was utilized as feedstock for the production of biodiesel. The research is under process for utilization of such raw material and challenging waste management problem for the industries. The oil extraction is performed in the main in marine oily fishes like codfish mackerel, tuna and, salmon that gift substantial oil content. The calorific values of by-products acquired from the fish oil had almost same as petroleum distillates and is a non-conventional energy source. Several studies were carried out for fish oil as an alternative fuel for Compression ignition engines [9–13]. The current work is aimed at determining the effects injection pressure with the varying load on emission and performance characteristics of a single-cylinder direct injection diesel engine when fueled with blends of methyl esters of honge oil and fish oil and its comparison with diesel fuel.

2. Material and Methods

2.1 Fuel properties

The diesel fuel, second -generation honge oil biodiesel, third-generation fish biodiesel are used in this present study. The properties of the tested fuels before blending are shown in Table 1. Then the fish oil biodiesel and honge oil biodiesel are mixed equally by volume and then blended with diesel fuel. The properties of the blends as shown in Table 2. The methyl esters of honge oil and fish oil were produced in transesterification set up. B10, B20, B30, B40, and B50 were used to test the Performance and Emission parameters by blending with diesel and comparing the results with that of diesel fuel. A Kirloskar AV-1, single-cylinder CI DI engine was used for the experimentation and Eco gas-4 analyzer was used for an emission test.

3. Experimental Setup

The performance and emission test of diesel engine were carried out in engine laboratory. Figure 1 shows the line diagram of engine setup. The engine specifications are summarized in Table 3.

Table 1. Properties of bio diesel and diesel fuel.

	Viscosity cst	Flash Point (0C)	Fire Point (0C)	Calorific Value(kJ/kg)
Diesel		65	72	44648
Honge Oil Bio diesel	4.77	140	165	33156
Fish oil Bio diesel	4.7	135	160	32874

Table 2. Properties of bio diesel blends

	Viscosity cst	Flash Point (0C)	Fire Point (0C)	Calorific Value(kJ/kg)
B10D90	3.9	83	85	38264
B20D80	4.02	86	92	36673
B20D70	4.08	87	93	36423
B20D60	4.1	88	94	36320
B20D50	4.15	90	95	36196

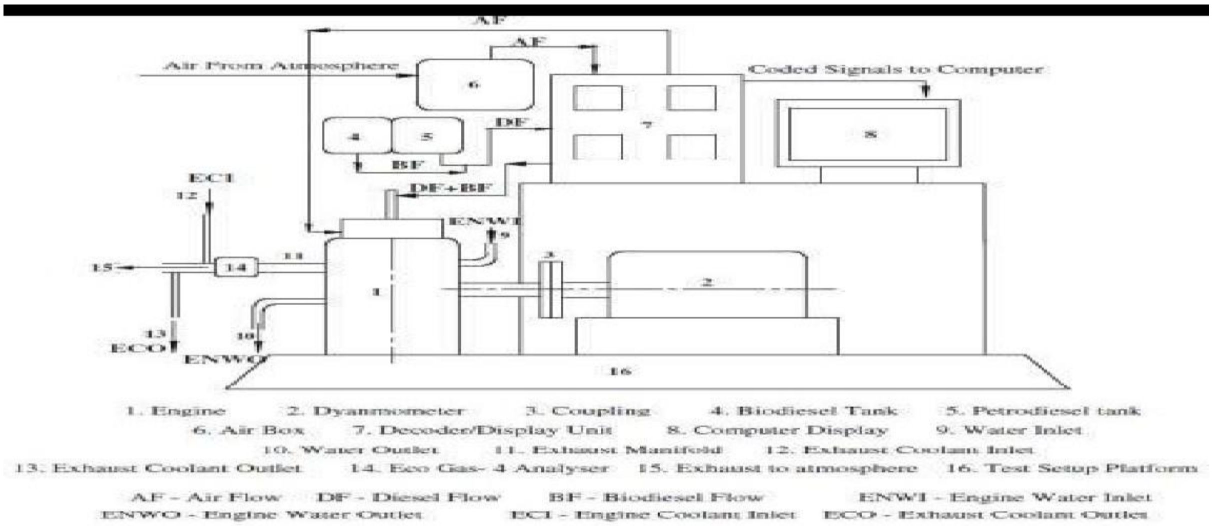

Figure 1. Line diagram of Engine.

Table 3. Engine Specifications

	Particulars	Specification
1	Type	Four stroke
2	Make	Kirloskar AV-1
3	Bore	80mm
4	Stroke	110mm
5	Swept Volume	553cc
6	Cylinder Capacity	624.19cc
7	Dynamometer	Electrical, Swinging Field Resistive Loading
8	Cylinder Pressure	By Piezo Sensor, Range: 500 psi
9	Compression Ratio	16:1 to 25:1
10	Rated Power	3.75KW @ 1500 RPM
11	Loading Type	Direct Current Generator, Voltage 140V, Maximum Current 23 amps
12	Torque, Fuel Flow	By transducer and Digital Sensors
13	Cooling System	Water Cooled

4.Results and Discussion

4.1Performance characteristics of the diesel engine
The test was conducted by varying the load from 0% to 75% for mixed biodiesel derived from honge oil and fish oil and its blends varying from B10 to B50 by maintaining the constant engine speed of 1500 rpm, by changing the IPs as 180 bar, 200 bar, and 220 bar. The outcomes got were contrasted, with those of regular diesel fuel. The tests were performed for different load condition at 5 different blends from B10, B20, B30, B40, B50 and their contrast of brake thermal efficiency, specific fuel consumption for mixed methyl esters of honge oil and fish oil with regular diesel fuels were observed. The experiments were tested at different blends of biodiesel for investigating the BTE, SFC on the performance parameters of the compression ignition engine utilising mixed methyl esters of honge oil and fish oil and pollutants such as CO (%), HC (ppm), CO2 (%), and NOx (ppm). The results obtained at different blends of mixed methyl esters of honge oil and fish oil were contrasted with those of regular diesel fuel. The optimised results obtained for the blend B20 for tested performance and emission parameters compared to other blends of mixed methyl esters of honge oil and fish oil.From figures, 2 to 4 show the BTE deviations with changing engine loads for different injection pressures of 180 bar, 200 bar and 220 bar. The deviations of BTE with engine load at changing IPs of 180 bar, 200 bar and 220 bar are shown in figures from 4 to 7. BTE for diesel fuel is 20.4%, 24%, and 25.4% and for the B20 blend of biodiesel is 21.2%, 23%, and 24.5% respectively. Biodiesel showed BTE of 3.77%, 4.16%, and 3.54% improvement over diesel fuel at an IP of 160 bar, 180 bar and 200 bar respectively. As load increases, the BTE increases for all 220 bar got the highest efficiency of 25.4% for B20 blend of biodiesel. Results revealed from experimentation that BTE escalations with augment in IP caused by greater oxygen content; atomization is good at higher IPs as the complete combustion occurs even though fuel quantity injected in same quantity at various injection pressures.

4.2 Specific fuel consumption
The Figures from 5 to 7 show the deviation of BSFC with changing loads for different blends of methyl esters and regular diesel fuel at different IPs such as 180 bar, 200 bar and 220 bar. At IP of 180 bar, 200 bar and 220 bar, SFC for diesel fuel is 0.39 kg/kW-hr, 0.37 kg/kW-hr, and 0.35 kg/kW-hr, for B20 blend of biodiesel is 0.43 kg/kW-hr ,0.42 kg/kW-hr, and 0.4 kg/kW-hr respectively at full load condition. Biodiesel showed SFC (kg/kW-hr) of 9.3%, 11.9%, and 12.5%increased over diesel fuel at an IPs of 180 bar, 200 bar and 220 bar correspondingly at maximum load conditions. As load increases, the BSFC decreases for every blend of biodiesel fuels and regular diesel fuel. BSFC at an IP of 220 bar got lowest of 0.4 kg/kW-hr for B20 blend of biodiesel. Results revealed from experimentation that BSFC reduced with an augment in IP due to a higher temperature, higher oxygen content and atomization is good at higher IPs as the complete combustion occurs even though fuel quantity injected in same quantity at various injection pressures.

4.3 Carbon Dioxide (CO_2)
The Figures from 11 to 13 show the deviation of CO_2 with changing loads for different proportions of methyl esters and regular diesel fuel at different IPs such as 180 bar, 200 bar and 220 bar. The deviations of CO_2 (%) with engine load at changed IPs of as 180 bar, 200 bar and 220 bar are shown in figures from 12 to 15. At IP of as 180 bar, 200 bar and 220 bar, CO_2 (%) for regular diesel fuel was 4%, 3.6% and 3.5% and for B20 blend of biodiesel they were 4.1%, 3.9%, and 3.8% correspondingly at maximum load condition. biodiesel showed CO_2 of 2.43%, 7.69% and 7.89% increase over diesel fuel at injection pressures of 180 bar, 200 bar and 220 bar correspondingly at maximum load conditions. As load increases, the CO_2 (%) augment for all blends of biodiesel fuels and diesel fuel. Results revealed from experimentation that CO_2 (%) augment with the increase in IP because biodiesel contains higher oxygen content results in complete combustion which increases CO2 concentration.

4.4 Carbon Monoxide (CO) (%)
The Figures from 8 to 10 show the deviation of CO with changing loads for different blends of methyl esters of biodiesel and regular diesel fuel at different IPs such as 180 bar, 200 bar and 220 bar. At IPs

of 180 bar, 200 bar and 220 bar, CO (%) for diesel fuel were 0.05%, 0.045%, 0.042% and for B20 blend of biodiesel were 0.048%, 0.043% and 0.040% respectively at full load condition. Biodiesel showed CO of 4%, 4.4% and 4.76% reduced over diesel fuel at an injection pressure of 180 bar, 200 bar and 220 bar correspondingly at maximum load conditions. As load increases, the CO (%) increases for all blends of biodiesel fuels and diesel fuel. CO (%) at an IP of 220 bar got a reduction of 5% for B20 blend of biodiesel. Results revealed from experimentation that CO (%) reduces with an increase in IP because biodiesel contains higher oxygen content resulting in complete combustion which results in a reduction in CO concentration.

4.5 Hydrocarbon (HC in ppm)

The Figures from 14 to 16 showed the deviation of Hydrocarbons (ppm) with changing loads for different proportions of methyl esters of biodiesel and diesel fuel at varied IPs such as 180 bar, 200 bar and 220 bar. At injection pressure of 180 bar, 200 bar and 220 bar, HC (ppm) for diesel fuel were 20 ppm, 18 ppm, and 16ppm and for B50 blend of biodiesel were 16 ppm, 14 ppm, and 13 ppm respectively. Biodiesel showed HC (ppm) of 20%, 22.22%, and 18.75% reduced over diesel fuel at an IP of 180 bar, 200 bar and 220 bar correspondingly at maximum load conditions. As load increases, the HC (ppm) augmented for all blends of biodiesel fuels and diesel fuel. HC (ppm) at an IP of 220 bar got a reduction of 18.75% for B50 blend of biodiesel. Results revealed from experimentation that HC (ppm) reduces with an increase in IP because biodiesel contains higher oxygen content results in complete combustion which results in a reduction in HC (ppm) concentration.

4.6 Oxides of Nitrogen (NOx)

The Figures from 17 to 20 showed the deviation of NOx (ppm) with changing loads for various proportions of methyl esters and diesel fuel at different IPs such as 180 bar, 200 bar and 220 bar. At injection pressure of 180 bar, 200 bar and 220 bar NOx for diesel fuel were 715ppm, 659 ppm, and 648ppm and for B50 blend of biodiesel were 851 ppm, 804 ppm, and 798 ppm respectively. Biodiesel showed NOx (ppm) of 16%, 18%, and 18.75% reduced over diesel fuel at an IP of 180 bar, 200 bar and 220 bar correspondingly at maximum load conditions. NOx formation in compression ignition engines is due to flame temperature which in turn is also related to peak pressure inside the cylinder which results in augmenting in-cylinder temperature. The physicochemical factors such as kinematic viscosity and density are the factors for the rise-in cylinder pressure of diesel engine fuelled with biodiesel will cause the advanced combustion process which results in higher NOx formation. The concentration of O_2 and N_2 present in the combustion zone is also the main reason for NOx formation. As the engine load incremented, NOx formation increased because of drop-in heat loss and amplified power with augmenting in load consequently increase in temperature inside the cylinder. NOx emission formation will be higher for biodiesel and its blend compared to diesel fuel, and also NOx concentration will be greater with the escalation in methyl esters concentration.

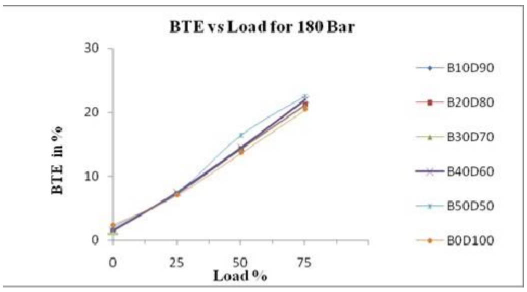

Figure 2. BTE vs Load at 180 bar

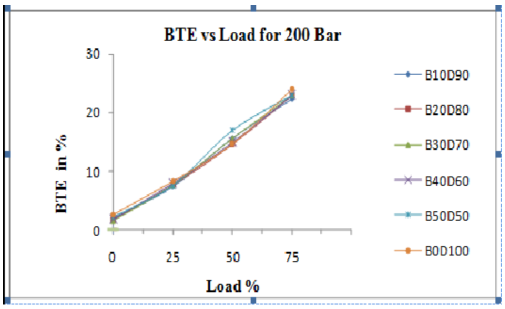

Figure 3. BTE vs Load at 200 bar

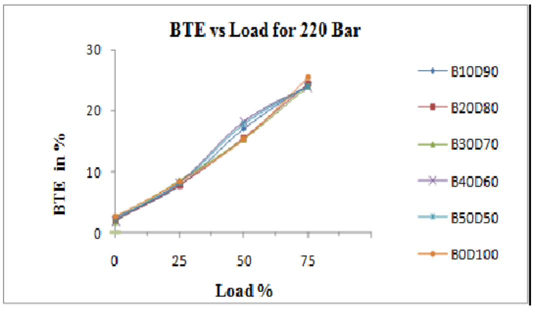

Figure 4. BTE vs Load at 220 bar

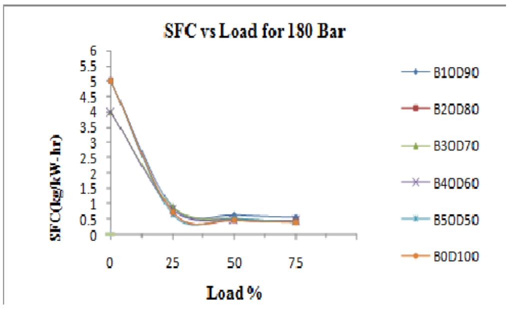

Figure 5. SFC vs Load at 180 bar

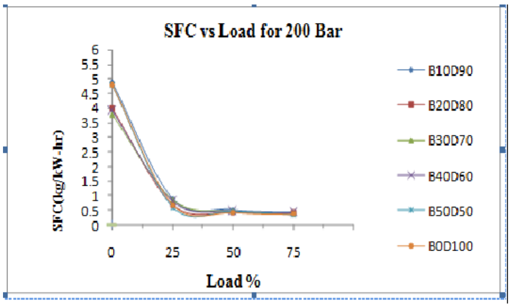

Figure 6. SFC vs Load at 200 bar

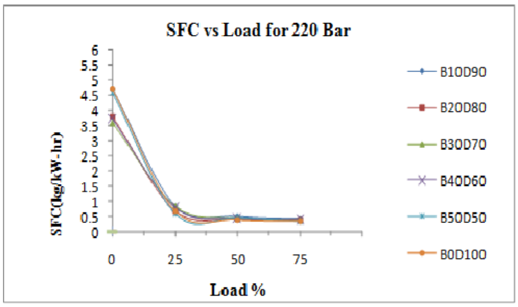

Figure 7. SFC vs Load at 220 bar

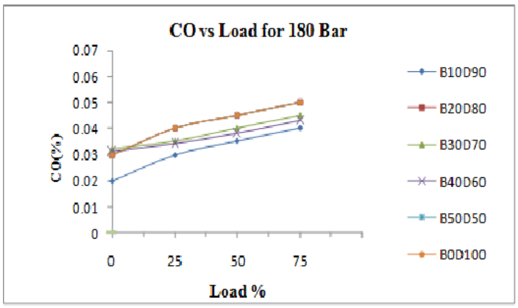

Figure 8. CO vs Load at 180 bar

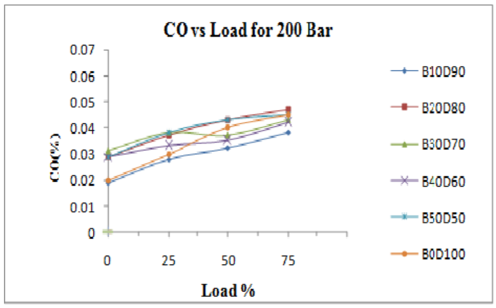

Figure 9. CO vs Load at 200 bar

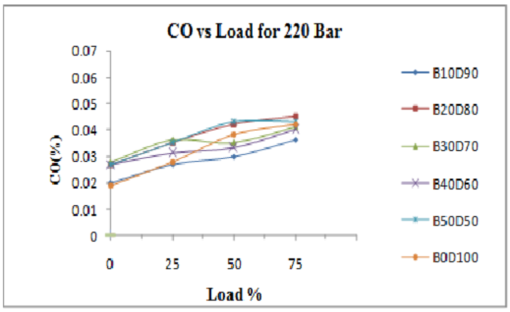

Figure 10. CO vs Load at 220 bar

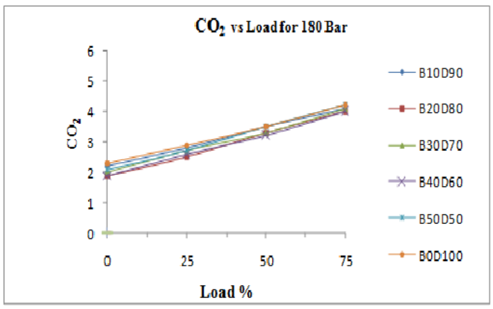

Figure 11. CO2 vs Load at 180 bar

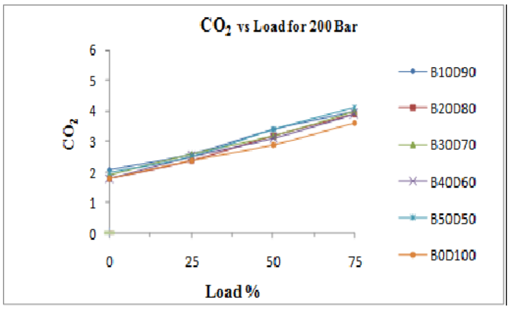

Figure 12. CO2 vs Load at 200 bar

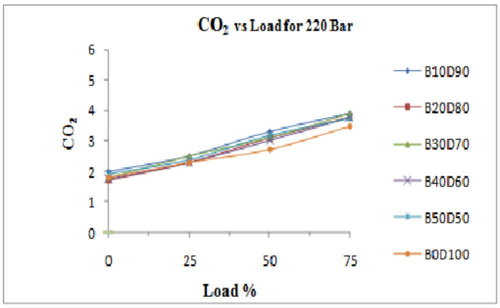

Figure 13. CO2 vs Load at 220 bar

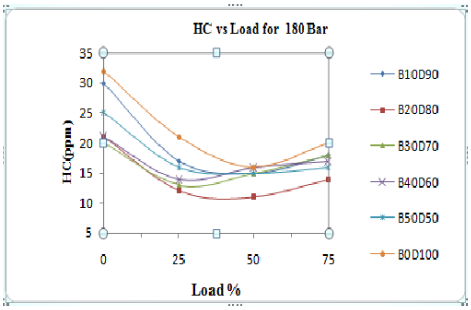

Figure 14. HC vs Load at 180 bar

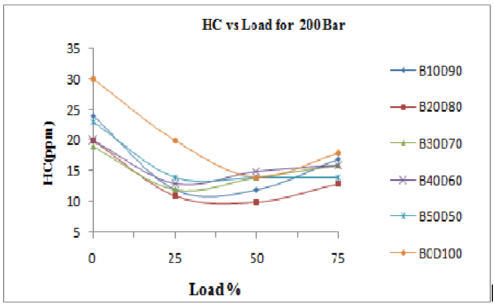

Figure 15. HC vs Load at 200 bar

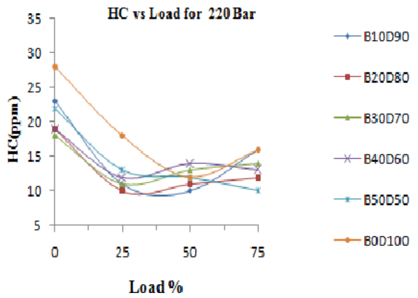

Figure 16. HC vs Load at 220 bar

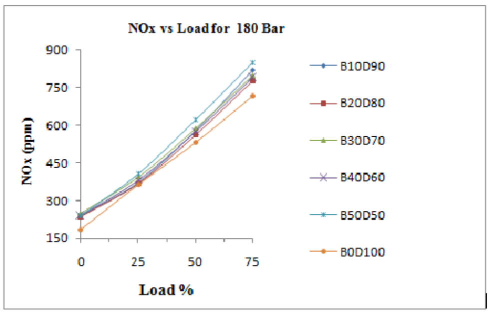

Figure 17. NOx vs Load at 180 bar

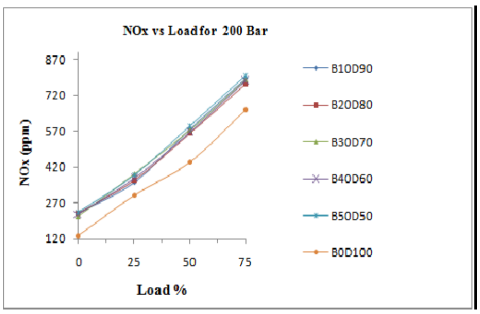

Figure 18. NOx vs Load at 200 bar

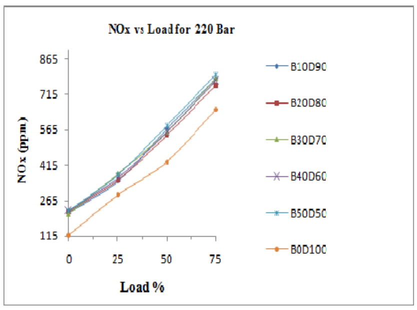

Figure 19. NOx vs Load at 220 bar

5 Conclusion

1. After the exhaustive study of all the methyl esters and blends of biodiesel and mineral diesel, the optimized biodiesel combination obtained was B20.
2. After transesterification of methyl esters the kinematic viscosity declined, and specific gravity reduced and the calorific value augmented.
3. The compression ignition engine performed with biodiesel as fuel, so that the methyl esters and diesel blend can be utilized as a substitute fuel in existing compression ignition engine without any alteration in the system.

6. Reference

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