

Experimental Studies on Effect of Nano particle blended Biodiesel Combustion on Performance and Emission of CI Engine

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Abstract. This article is concerned with the study of effect of addition of Carbon Nano Tube (CNT) on the physiochemical properties of Biodiesel and to investigate its effect on the performance and emission of a single cylinder direct injection CI engine. The fuel selected for the present study were Diesel, Biodiesel blends (B20), and CNT blended –biodiesel. The Biodiesel used is Honge Oil Methyl Ester (HOME). Biodiesel Blends were prepared by adding 80% Diesel and 20% Biodiesel by volume with the help of mechanical homogenizer. CNT blended Biodiesel contains 50 ppm of CNT in one liter of biodiesel blends. The experimental studies were carried out in a single cylinder 4 stroke direct injection CI engine connected to an eddy current dynamometer with computerized test rig facility to measure the performance and emission. The experimentations were carried at a constant speed of 1500 rpm and varying the load on the engine. The results shows that increase in the Brake thermal efficiency with the inclusion of CNT to Biodiesel. The brake thermal efficiency of CNT added Biodiesel fuels were 2.24% better as compared to that of Biodiesel without the addition of nano particle at full load calculation. Also the reformulated fuel (Inclusion of CNT's in the Biodiesel blends) shows considerable reduction in the pollutant emission.

Keywords: Carbon Nano Tube, Honge oil Methyl Ester.

1 Introduction

The growing demand for the primary source such as petroleum is increasing day by day due to the population growth and effective utilization of energy particularly in automobile segment. A lot of research is going in the field of alternate fuels to fulfil the growing demands. The main reason in searching of renewable alternate sources of fuel is the fear of depletion of petroleum fuels and stringent emission rules. Biodiesel is one of the promising alternate fuel in the CI engine as it can successfully replaces the Diesel .The advantage of Biodiesel is it minimizes the dependency on the foreign oil also with the biodiesel it contains more amount of oxygen resulting in better fuel combustion. Now a day's more and more focus is giving to take care of emission rather than performance. Different methods have



been adopted to reduce the exhaust emission in that one of the technique is fuel reformulation technique. From the literatures it has been found that use of nano particles in base biodiesel enhance the properties with respect to biodiesel both in performance as well as in emission wise. The material in nano scale shows better enhanced properties than in bulk form. Nano particles in biodiesel acts as good catalyst. Nano particle has higher surface area to volume ratio and their higher surface area is more relevant for the catalytic reactivity. When suitable proportion nano particle is added to the biodiesel which exposes more surface area to the volume ratio of the fuel which accelerates the combustion.

It is found that the fuel reformulation technique has been adopted in one of the literatures by adding Carbon nano Tube to the base Biodiesel prepared from Jatropa seed which shows little improvement in thermal efficiency also slight reduction in pollutant emission [1]. Adding Graphene Nano particle to the HOME in varying proportion of 25ppm to 50ppm increase the Brake thermal efficiency and reducing harmful pollutants [2]. Magnalium (Al-Mg) and Cobalt Oxide (Co₃O₄) nano particle is blended in Jatropa Biodiesel and tested, the result shows the effect of Magnalium nano particle improves micro explosion which improves the combustion, decreases the energy consumption and reduces pollutant emission also the effect Cobalt Oxide nano additive increase the thermal efficiency and decreases the emission of UHC and NO_x [3]. Cerium oxide Nano particle is tested in a Biodiesel prepared from castor oil, Cerium oxide Nano particle acts as oxygen donating catalyst providing activation energy to burn off the carbon deposit within the cylinder which results in complete combustion and minimal HC emission [4]. A comparison investigation is done for the Diesel spray combustion with and without the addition of Al₂O₃ nano particle to the diesel [5], the result reveals that there is an improvement in the combustion and decrease in the co emission for the Al₂O₃ added fuel, The improvement in combustion is due to the better turbulence between fuel droplets and the air. Experimentation have been done to study the effect of copper oxide nano particle by varying its concentration to the biodiesel prepared from linseed oil and the results shows that the increment in thermal efficiency and copper oxide nano particle succeeded in controlling the pollutant emission [6]. Rhodium oxide nano particles are blended with pongamia Biodiesel and the performance and emissions of a CI engine is investigated and found that rhodium oxide acts as oxygen, improving the performance by lowering the energy consumed and improvise in thermal efficiency and also reduces the emission [7].

2 Preparation of fuel Blends

The present study is focused on incorporation of Carbon Nano Tube nano particle in the Diesel - Biodiesel blends and comparing with Diesel and Biodiesel blends. The biodiesel is derived from the transesterification process of Honge oil. Biodiesel blends are prepared by mixing 80% of diesel with 20% of Honge biodiesel with the help of mechanical homogenizer. 50 ppm of CNTs are mixed with small portion of Ethanol and surfactant, Then it is to be keep in the Ultrasonicator for the equal dispersion of the CNT. The CNTs are then added to the biodiesel and better dispersion is achieved with the aid of Ultrasonicator and Mechanical homogenizer.



Figure 1. Carbon nano tube (CNT) powder



Figure 2. Carbon nano tube (CNT) kept in the Ultrasonicator



Figure 3. Blended biodiesel(B20 Blend)



Figure 4. CNT added blended biodiesel.

3 Experimental Setup

The experimental investigations were carried out on a single cylinder, four-stroke water cooled, naturally aspirated, direct injection diesel engine. The injection pressure and injection timing as specified the manufacturer are 200 bar and 23° before top dead center. The engine specification are given in Table 1.

Table 1. Engine Specification

Sl.no	Parameters	Engine
1	Engine Type	Kirlosker make Single cylinder four stroke direct injection diesel engine
2	Nozzle opening pressure	200 to 205 bar
3	Rated power	5.2kW (7HP) at1500 RPM
4	Bore diameter	87.5 mm
5	Stroke length	110 mm
6	Compression ratio	17.5:1

The fuels tested are Diesel, Biodiesel without CNT and biodiesel with CNT inclusion. The engine performance, emissions and combustion characteristics were recorded at different loads ranging from 0% to 80% in increments of 20 by keeping engine speed at 1500 rpm. Thus, the effect of CNT added biodiesel on performance, emission and combustion parameters were investigated at an optimized operating condition of 200 bar injection pressure and 23° bTDC injection timing. Comparison study is made by running the engine for three different fuels. First the fuel physical properties are found for three different fuel separately. Some of the fuel physical properties measured are shown in following table.2.

Table 2. Physical Properties of the fuel

Type of fuel	Flash point, °C	Kinematic Viscosity at 40 °C, cSt	Calorific Value, kg/kW-hr
Diesel	56	2.9	43,000
BBD	170	5.7	36,016
BBD+CNT (50ppm)	164	5.4	35,100



Figure 5. Computer Integrated Diesel Engine



Figure 6. Diesel Engine

4 Results and Discussion

During the experiment, injection pressure, injection timing and compression ratio were kept at 200 bar, 19° BTDC, and 17.5 respectively.

4.1 Variation of Peak Pressure

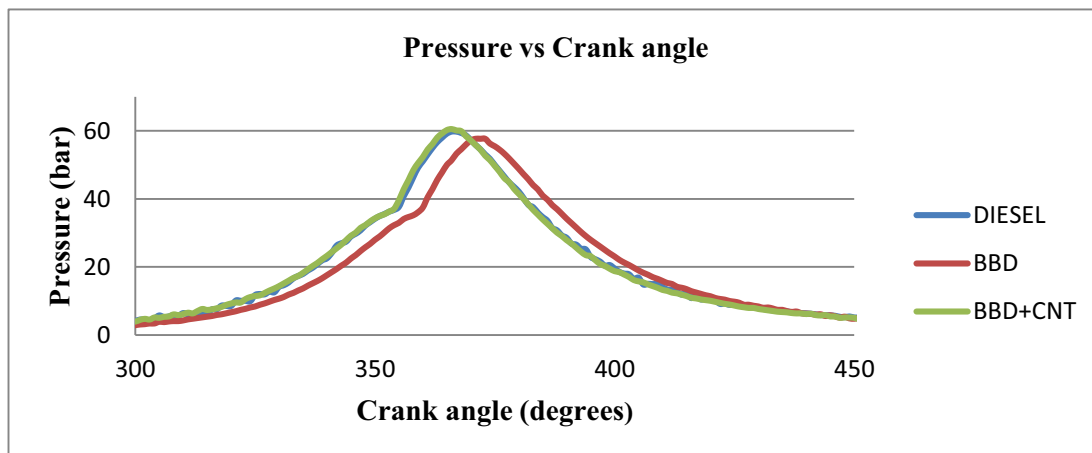


Figure 7. Pressure v/s Crank angle

Figure 7 shows variation of peak pressure for Diesel, Biodiesel and CNT added Biodiesel for different crank angle. The above graph shown is for 80% of load. From the above graph it is observed that the peak pressure obtained for Diesel is 59.8 bar, for BBD it is 57.7 bar. The peak pressure for Biodiesel is found less than diesel because more viscosity and poor atomization as compared to Diesel. Hence peak pressure shifts right. Whereas peak pressure obtained for CNT-BBD is highest i.e. 60.5 bar, because

CNT nano material acts as a catalyst. The nano material does not burn it just helps in providing a good surface area of the fuel, hence complete combustion takes place.

4.2 Variation of Brake Thermal Efficiency with respect to the load, BTE

Figure 8 shows variation of brake thermal efficiency (BTE) for Diesel, BBD (Blended Biodiesel) and CNT-BBD. From the graph it is observed that the thermal efficiency of biodiesel is less due to its more viscosity, lower volatility and lesser heating value. At the same time CNT added Biodiesel shows improvement in the thermal efficiency. This is because of the complete combustion of the fuel. The Nano size particles possess high surface area and reactive surfaces that gives higher chemical reactivity acting as a Fuel Bourne Catalyst. The maximum brake thermal efficiency CNT-BBD is 25.22% compared to 22.98 % of BBD and 26.9% for diesel, at the 80% load respectively.

Table 3. Variation of BTE with load

Load (%)	Diesel (%)	Biodiesel (%)	CNT added Biodiesel (%)
20	15.9	13.2	14.58
40	19.53	16.7	17.9
60	22.9	20.1	21.4
80	26.9	22.98	25.22

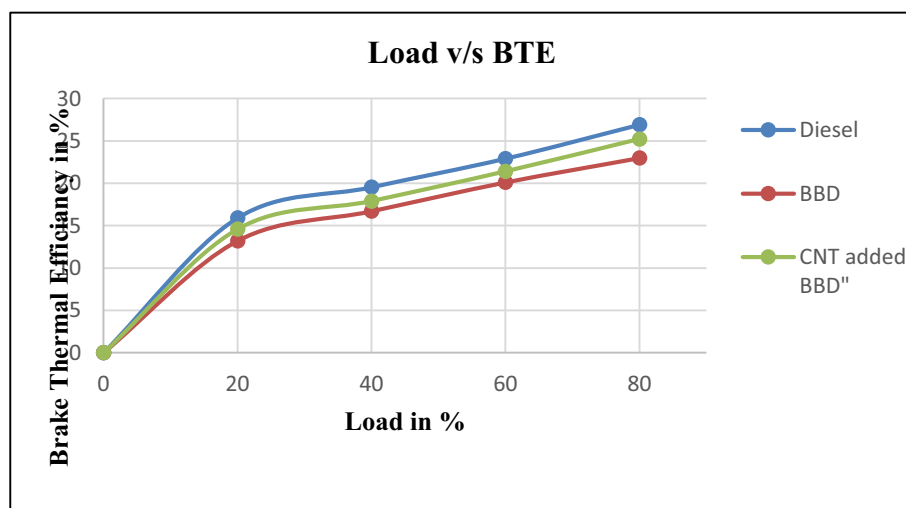


Figure 8: Load vs BTE

4.3 Variation of Specific Fuel Consumption, SFC

Table 4. Variation of SFC with load

LOAD (%)	DIESEL (Kg/Kw-hr)	BBD (Kg/Kw-hr)	BBD+CNT (Kg/Kw-hr)
20	0.514	0.75	0.7
40	0.3	0.44	0.38
60	0.28	0.38	0.32
80	0.23	0.35	0.29

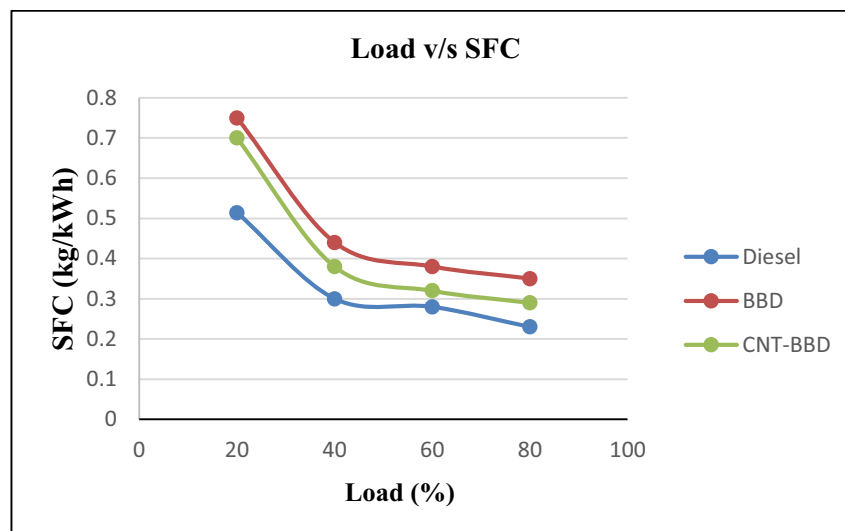


Figure 9. Load v/s SFC

Figure 9 shows variation of SFC for Diesel, BBD (Blended Biodiesel) and CNT-BBD. Since Specific Fuel Consumption of Biodiesel is found more as compared to Diesel this is due to the lesser calorific value of the Biodiesel compared to Diesel, In order to obtain the same magnitude of power biodiesel requires more fuel. Hence SFC for BBD is higher. But with the addition of CNT Combustion efficiency improves and also CNT acts as a catalyst improves the secondary atomisation hence combustion improves. Hence with the addition of CNT to Biodiesel blends SFC reduces.

4.4 VARIATION OF HC EMISSION

Table 5. Variation of HC with load

LOAD (%)	Diesel (ppm)	CNT (ppm)	BBD (ppm)
20	3	3.5	3.9
40	4	4.4	5
60	5	6	7
80	6	7	8

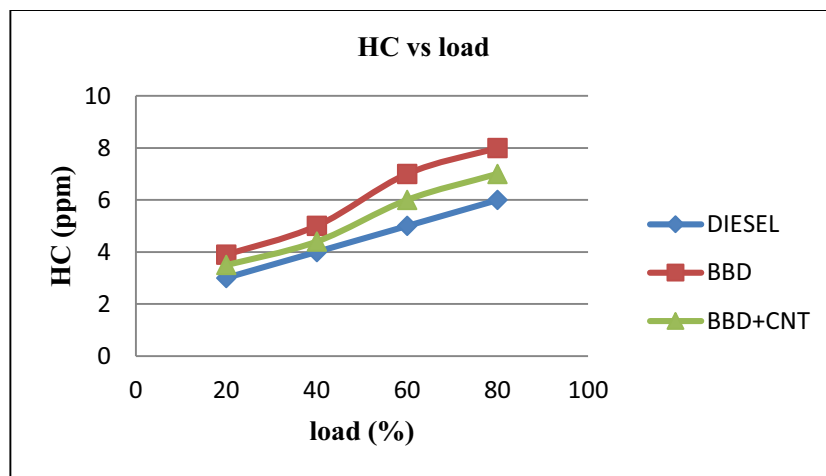


Figure 10. Load v/s HC Emission

Figure 10 shows variation of Hydrocarbon emission (HC) for Diesel, BBD (Blended Biodiesel) and CNT-BBD for different loads. It is clear from the graph that HC emission is more for biodiesel blends due to its lesser combustion efficiency. However HC emissions are marginally lower for CNT-BBD fuels than BBD. This is due to the action of CNT as a good catalyst which improves the combustion.

4.5 Variation of Co Emission

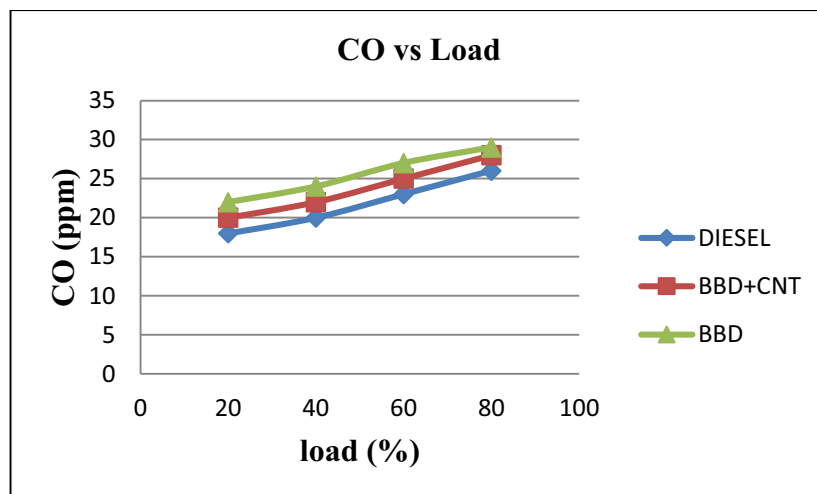


Figure 11. Load v/s CO Emission

Figure 11 shows the variation of Carbon-Monoxide emission (CO) for Diesel, BBD (Blended Biodiesel) and CNT-BBD for different loads. The main factor for CO emission is incomplete combustion. It is clear from the graph as CO formation is higher with increase in load, as the load increases fuel required is also high it demands a rich mixture due to the inadequate supply of air. But with the addition of CNT to biodiesel it improves the secondary atomization of the fuel resulting in better combustion and significant reduction in the CO emission.

4.6 VARIATION OF NOX EMISSION

Table 6. NOX emission

LOAD, %	DIESEL, ppm	BBD, ppm	CNT BBD,ppm
20	35	48	55
40	48	59	129
60	69	78	171
80	87	95	183

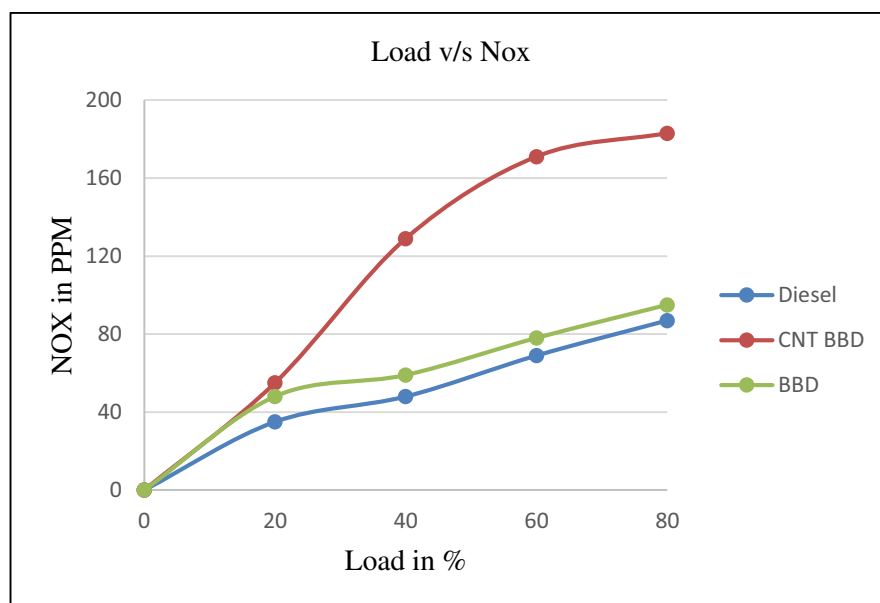


Figure 12. Load v/s NOX Emission

From the figure 12, it has been found that NOx emissions for Biodiesel were higher as compared to diesel operation. NOx liberation mainly depends on peak temperature, also the oxygen content in Biodiesel are higher. The exhaust temperature and oxygen content in the fuel leads to formation of more oxides of nitrogen emission. Furthermore, CNT-BBD results in more NOX emission as described in the graph. This is because of reduction in ignition delay results in higher premixed combustion fraction and higher peak temperatures observed with CNT-BBD. At 80% load the NOX emission for diesel, Biodiesel and CNT-Biodiesel are 87, 95 and 183 respectively.

5 CONCLUSION

The Performance and the Emission characteristics of Diesel, Biodiesel (BBD) and CNT added Biodiesel blends fuel were investigated in a single-cylinder, four stroke, constant speed, direct-injection engine loading with eddy current dynamometer. From the experimentation these conclusion have been drawn.

1. The Brake Thermal Efficiency of CNT added Biodiesel fuel was found to be 2.24% better as compared to that of BBD for full load calculation and 1.68% less compared to Diesel. The inclusion of CNT particle shows a predominant role here in improvising the thermal efficiency of the biodiesel (B20) close to the diesel.
2. The Specific Fuel Consumption for CNT added Biodiesel Blends decreases by 20.68% as compared to the biodiesel blends without CNT addition. Diesel gives maximum reduction in Specific Fuel Consumption than Biodiesel by 21%. This could be due to the increase in
3. Heating value of the Diesel.
4. The Hydro Carbon emission of CNT added biodiesel is lowered by 1 ppm compared to that of Biodiesel.
5. The NO_x emission was found to be comparatively less for Biodiesel blends as compared to that of Biodiesel blends with the addition of CNT. The increased NO_x can be reduced by adopting suitable NO_x reduction techniques such as EGR, Catalytic converter etc.

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