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Effect of Al_2O_3 and CeO_2 Nano-Additives on Performance and Emission Characteristics of Diesel Engine Fueled with Neem Oil-Biodiesel

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Abstract

Due to the rapid depletion of petroleum reserves, many countries recommended the use of vegetable oils as diesel engine fuel. The best way to use edible and non-edible oil as a diesel fuel is to convert it into biodiesel. Biodiesel is a fuel which can be used instead of diesel fuel as an alternative for the existing system of CI engines. The usage of biodiesel causes a few disadvantages like high nitrogen oxides, utilization of high fuel and higher density. To conquer these problems some promising nano-additives are identified for having been used in the production of biodiesel. However, the addition of Nanoparticles will possibly enhance the performance and reduce the emissions. Therefore, the present investigation focuses on the influence of Al_2O_3 and CeO_2 nano-additives on the performance and emissions characteristics of CI engine fueled with methyl esters of Neem. As nano-additives Al_2O_3 and CeO_2 contain high oxygen content, it leads to complete combustion of fuel thereby increasing performance and reducing the oxide formation. In the experimentation, 50ppm, 100ppm of Al_2O_3 and CeO_2 nano-additives were mixed in methyl esters of Neem. Subsequently, the fuel blends of Neem biodiesel (B20N) alone and Neem biodiesel with 50ppm, 100ppm of Al_2O_3 and CeO_2 nano additives in CI engine were employed. The results revealed that, there is a increase in the break thermal efficiency and decrease in specific fuel consumption for B20N and B20N additive blends. Significant reductions in the parameters like CO, UBHC and NO_x emissions are attained at B20N in conjunction with 50ppm, 100ppm of Al_2O_3 and CeO_2 Nano-additives blends as compared with diesel. However, there is a slight increase in NO_x emissions for B20N and and additive blends.

Keywords: *Al_2O_3 Nano-Additive, CeO2 Nano-Additive, CI Engine, Neem Biodiesel*

1. Introduction

Internationally, there has been a tremendous establishing over the Globe in last two decades. The population of motor vehicles in India is about one hundred million. This has increased the need for fossil fuel. Due to the exhaustion of fossil fuel, the world is facing the inadequacy of energy and rise of petroleum price. 'Transportation' section is distinct and is mainly depending upon the petroleum fuel. This will greatly affect the country's economy. Petroleum based fuels are non-renewable energy sources and cannot be restored again. Because of ever growing population,

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the demand for the requirements of petroleum based fuels has increased. This ever-increasing energy demand made us to think to find alternatives[1–7]. Biodiesel is one of the hopeful alternative resources to petroleum fuel in the world today and its production and demand has been growing at a very fast rate[8]. As the Bio diesel emits the same quantity of CO_2 while it absorbs during the plant growth, the biodiesel is neutral[9]. The emissions like unburnt hydrocarbons, carbon monoxide, particulate matter, smoke intensity is less in biodiesel when it is compared with diesel[10].

2. Materials and Methodology

2.1 Preparation of Nano Particle Blended Neem Oil Biodiesel

Transesterification process is one of the most commonly used method to produce biodiesel. In transesterification, 6.5gms NaOH and 150ml of Methanol is dissolved in the Neem oil. By keeping the flask on the magnetic stirrer, the mixture was stirred for half an hour without heating. Now turn on the heater and heat the mixture for 2hrs by maintaining the temperature around 50^{0}C-60^{0}C. Then, transfer the mixture into the separating funnel and the mixture has allowed overnight to settle by gravity in a separating funnel. Then Glycerol was separated and the obtained Neem Methyl ester has collected. The Neem Methyl ester is then heated till 120^{0}C to evaporate the Methanol if present. Thus, the Neem Biodiesel is obtained.

Figure 1. Aluminium oxide nano-particles.

Figure 2. Cerium oxide nano-particles.

After obtaining the methyl esters of Neem using transesterification process, the Al_2O_3 and CeO_2 nanoparticles are dispersed in the Neem biodiesel using Ultra-sonicator device. 35nm of Aluminium oxide nanoparticles and 21nm of Cerium oxide nano particles are dispersed in the neem methyl esters. 50 ppm and 100ppm of Aluminium oxide and Cerium oxide nanoparticles was weighed by using an electronic weighing machine. This

Figure 3. Ultrasonicator devic.

Figure 4. Methyl esters of Neem with Alumina and Cerium oxidenano particles.

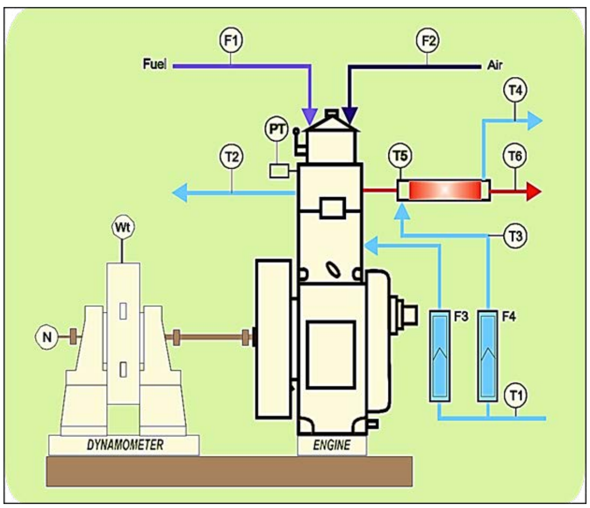

Figure 5. Various parts of test engine.

weighed nano additives are added into the B20N blend and kept about 30min in the Ultra-sonicator to ensure that the dispersed nano particles are homogeneously distributed in the biodiesel.

3. Experimental Set Up and Measurement

The various components and specifications of the engine used in the present study is shown in Figure 5, Figure 6 and Table 1 respectively.

Table 1. Technical specification of engine

SL. No.	Product	ResearchEnginetestsetup1cylinder,4 stroke, Multi-Fuel VCR with open ECU for petrol mode (Computerized)
1.	Engine	Type 1 cylinder, 4 stroke, water cooled, stroke110mm, bore 87.5 mm. Capacity 661cc. Dieselmode: Power 3.5 KW, Speed 1500rpm. BTDCECU Petrolmode: Power 3.5KW@1500rpm, Speed range1200-1800rpm, CR range 6:1-10:1
2.	Dynamo meter	Eddy current type, water cooled, with loading unit
3.	Fuel tank	15 lit Capacity, Duel compartment, with fuel Metering pipe of glass
5.	Crankang lesensor	Resolution1Deg, Speed 5500RPM with TDC pulse.
6.	Engine control unit	PE3 series ECU, full build potted enclosure.
7.	Sensors for ECU	Airtemp, coolant temp, Throttle position and trigger.
8.	Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
9.	Fuel flow transmitter	DP transmitter, Range0-500 mm WC
10.	Airflow transmitter	Pressure transmitter, Range (-)250mmWC

4. Results and Discussion

4.1 Performance Characteristics

The performance characteristics of CI Engine fueled with B20N, B20N with nano additives and Diesel was comparatively evaluated at different loading conditions. The test on CI engine was done at a constant speed of 1500rpm by varying the load from zero percent to 100%. In this section, Brake thermal efficiency and Specific fuel consumption were discussed.

4.1.1 Brake Thermal Efficiency (BTE)

Figure 7 shows the variation of brake thermal efficiency versus load for all tested fuels. It clearly shows that, the brake thermal efficiency of blending fuel with additive

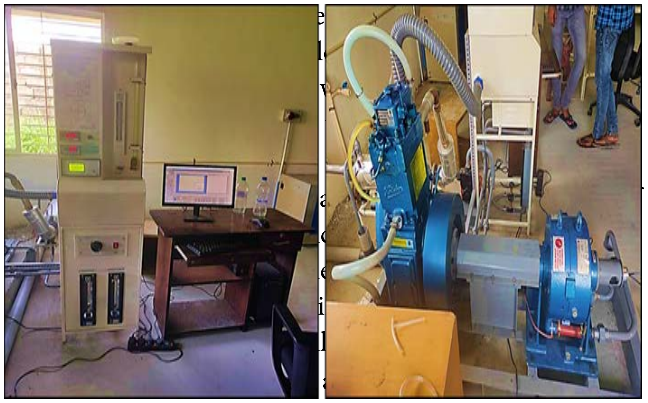

Figure 6. Computerized Single cylinder 4 stroke diesel engine.

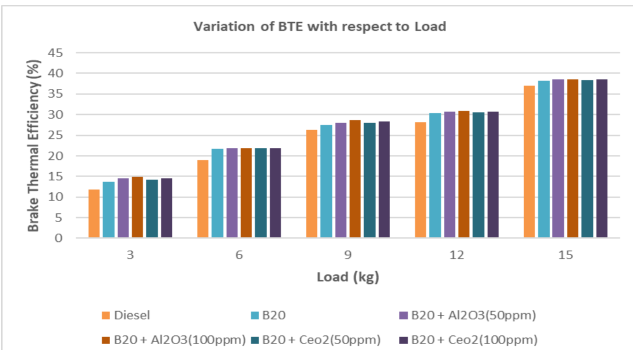

Figure 7. Variation of BTE with load.

4.1.2 Specific Fuel Consumption

Figure 8 shows the Specific Fuel Consumption variation with respect to load applied for all the blended fuels. It is observed from the graph that, as the load increases, the specific Fuel Consumption decreases. At full load, the maximum specific fuel consumption is seen for diesel and least for B20N+100ppm Al_2O_3. So, there is a decrease in specific fuel consumption for all B20 blends with Al_2O_3 and CeO_2 nanoparticles (50ppm and 100ppm) than diesel.

This is a consequence of lower calorific value of blended oils and furthermore considering better consumption, as a result of the more oxygen present in Al_2O_3 and CeO_2 nanoparticles. SFC for the biodiesel and its blends decreases because of the low calorific value of biodiesel in comparison with diesel.

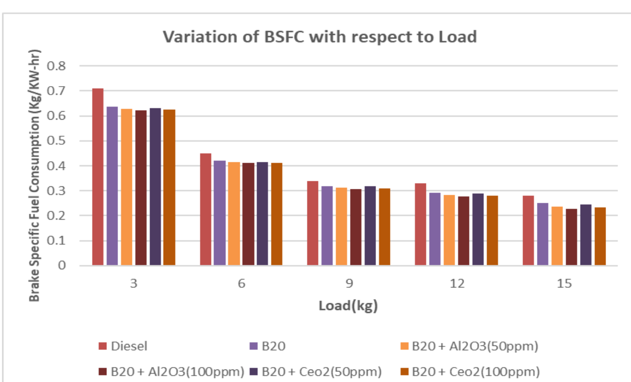

Figure 8. Variation of SFC Vs Load.

4.2 Emission Characteristics

In this segment, the various emission characteristics like Carbon monoxide, unburnt hydrocarbons and nitrogen oxide emissions are studied for all test fuels with varying load.

4.2.1 Unburnt Hydrocarbon (UBHC)

Figure 9 shows the variation of unburnt hydrocarbons versus load. At all loads, the unburnt hydrocarbons emission is low for all the blended test fuels compared with diesel. It is also observed from the graph that, When Al_2O_3 and CeO_2 nanoparticles (50ppm and 100ppm) are added to neem biodiesel, the hydro-carbon emissions are reduced.

The greatest and least unburnt hydrocarbons emissions are noted for diesel and B20N+100ppm Al_2O_3 individually. unburnt hydrocarbons emissions are lower than diesel because the high catalytic property of Neem fuel expands the surface to volume proportion and gives oxygen to increase combustion rate thereby decreasing UBHC.

4.2.2 Oxides of Nitrogen (NO_X)

Figure 10 shows NOx emission variation with respect to load. Nitrogen reacts with oxygen at abrupt expansion in

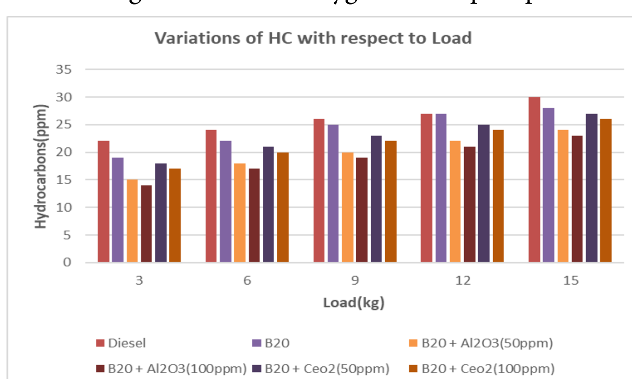

Figure 9. Variation of UBHC vs load.

temperature and pressure, the high temperature in the chamber achieves reaction of nitrogen with oxygen, oxides of nitrogen emission increases with temperature. From the Figure 10 the best and least NOx releases were seen for B20N+100ppmCeO_2 and diesel separately. Compared to diesel, the NOx for B20N+ 100ppm CeO_2 oil increases nearly about 3.06%.

4.2.3 Carbon Monoxide (CO)

Figure 11 shows the variation of CO emission with respect to load. It is also observed from the graph that when Al_2O_3 and CeO_2 nanoparticles (50ppm and 100ppm) are added to neem biodiesel, the Carbon monoxide emissions are reduced. CO is one of the odorless, colorless and toxic gases present in the exhaust gas which is higher for diesel and least for B20N+100ppm Al_2O_3 at higher load. This is a consequence of the fine atomization and oxygen

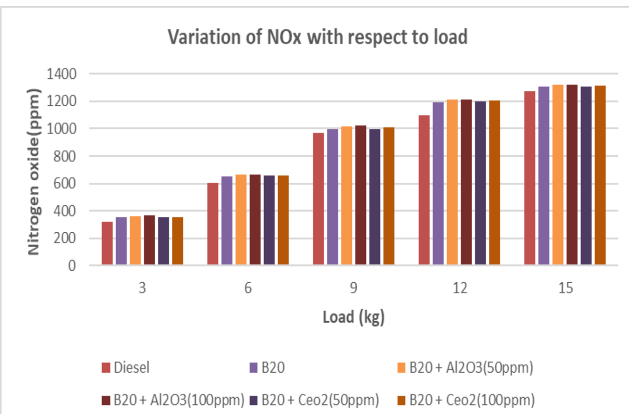

Figure 10. Variation of NO_X vs load.

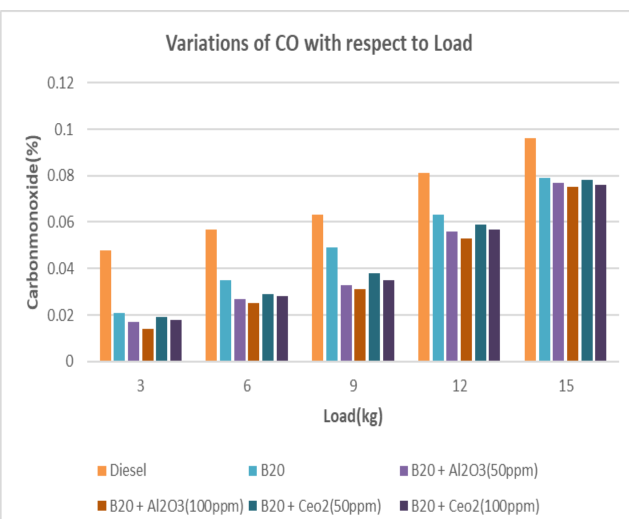

Figure 11. Variation of CO vs load.

content in the fuel which improves combustion rate. The Al_2O_3 goes about as an impetus; they give oxygen to the combustion because of which CO is converted into CO_2.

5. Conclusions

- The Neem biodiesel, Al_2O_3 and CeO_2 nanoparticles acts like an oxygenated additive, noticed superior atomization, ignition and showed better emission attributes.
- The brake thermal efficiency is higher for all the blended fuels than diesel. The maximum BTE is noticed for B20N+ 100ppm Al_2O_3 and least is noticed for diesel.
- The specific fuel consumption is lower for all the blended fuels than diesel. The minimum SFC is noticed for B20N+ 100ppm Al_2O_3 and maximum is noticed for diesel.
- The unburnt hydrocarbon emissions are lower for all the blended fuels than diesel. The minimum UBHC is noticed for B20N+ 100ppm Al_2O_3 and maximum is noticed for diesel.
- The nitrogen oxide emissions are slightly higher for all the blended fuels than diesel. The maximum NOx is noticed for B20N+ 100ppm Al_2O_3 and minimum is noticed for diesel.
- The carbon monoxide emissions are lower for all the blended fuels than diesel. The minimum CO emission is noticed for B20N+ 100ppm Al_2O_3 and maximum is noticed for diesel.

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