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The Influence of Cerium Oxide Nano Particles on Performance and Emission Characteristics of DI Diesel Engine Fueled With Neem Oil Bio Diesel.

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Abstract-In the present days the threat to face the consequence of depletion of conventional fuel has become inevitable due to extensive use of conventional fuels that majorly include petroleum-based fuels which are non-renewable in nature. In these days CI engines are essentially run on such non-renewable conventional fuels. Neem biodiesel is a promising back up to diesel fuel. Recent studies have shown that usage of nano particles as additive to the biodiesel blend improves performance, combustion and emission characteristics of the fuel blend. In the present work B20Neem biodiesel (20%Neem biodiesel and 80%diesel) added with cerium oxide (25ppm) is used to carryout experimentation. Brake thermal efficiency of B20NeemCeO225 was increased by 2.7% and 5.7% than B20Neem and diesel respectively. Peak pressure and heat release rate of B20NeemCeO225 were observed to be higher than that of B20Neem and diesel. There was appreciable improvements in Carbon monoxide and Unburnt Hydro Carbon emissions, however there was marginal increase in Nitrogen Oxide emission.

Keywords—CI engine, neem bio diesel, nano particle, break thermal efficiency, carbon monoxide.

1. INTRODUCTION

Increase in petroleum demand and rising hazard to the atmosphere from exhaust emission and global warming have produced extreme global attention in emerging alternative non-petroleum fuels for engines. Based on the recent research, biodiesel has become attractive due to its environmental benefits and the facts that it is non-toxic, ecological and can be made from the renewable resources. But biodiesel is also having few disadvantages, such as higher viscosity, higher molecular weight, lower volatility and higher poor point compared with diesel. These disadvantages are the source for poor atomization and lead to partial combustion. So, to reduce above mentioned drawbacks additives are used. Additives drive the petroleum to improve its engine performance, combustion and emission to ecological standards. Additives can be classified in terms of their applications and disadvantages and are enumerated out as follows.

1) Metal based additives
2) Oxygenated additives
3) Antioxidant additives
4) Cetane number improver additives.

The food crops are not measured as raw resources for biodiesel esterification due to their higher prices and higher consumption in domestic drive which pay the way for non-edible bases for biodiesel making. Numerous vegetal seeds used as non-edible bases such as rubber seed, jatrophacureas, pongamiapinnata, rapeseed, karanja, mahua&neem etc. The seeds of neem tree is one amongst the existing source, which is receiving additional care for biodiesel research since it is plentiful in nature. The cerium oxide nanoparticles behave as a substance in the decrease of toxic gases on the combustion of hydrocarbon fuel and advances the fuel economy. The quantity of oxygen reversibly providing in and detached from the gas stage is called oxygen storage volume of CERIA and the occurrence of CERIA in the fuels supports to renew a diesel particulate filter at inferior temperature.

A. Preparation of Neem Bio diesel

In this experimental study the neem oil biodiesel was produced through the single step alkali catalyst using transesterification process. Transesterification process is used to produce biodiesel from neem oil. In this process take one litre of neem crude oil and heated up to 75c using electric heater. a solution of 300ml of NAOH crystal% by weight and methanol was prepared. The neem oil temperature reaches 75c the mixture of methanol and NAOH was added gradually to the neem oil. The mixture was stirred continuously for few minutes and then 1% by volume of H2SO4 was added. Then after this mixture we give 24h for settle down. So that biodiesel floats above glycerol and glycerol settles down.

RCOOR'+R"OH←→RCOOR"+R'OH (General transestarification equation).

In present study, nanoparticle was used with biodiesel in the form of nano emulsion and the effect of diesel engine characteristics was experimentally investigated. For preparation of the blend, saleable diesel fuel as the base fluid and neem biodiesel are employed. For the experimental test fuels are prepared. Investigation, two types of Denoted as bxcy (x means volume fraction and y means ppm). They are: B20N (comprising 20% biodiesel and 80% diesel in volume percentage). B20N+C25 (containing 20% biodiesel and 80% diesel in volume percentage than 25 ppm cerium oxide). To prepare homogenous fuel blend, it was stirred using magnetic stirrer for 45 minutes, to obtain proper dispersion nanoparticles with fuel.

TABLE I. Properties of cerium oxide nano particle.

Parameter	Cerium oxide
Nano powder	(ceo2)
Nanoparticle purity	99.97%
Nanoparticle aps	10-30mm
Nanoparticle ssa	30-50 m2/kg
Nanoparticle colour	Light yellow
Nanoparticle bulk density	0.8-1.1 g/cm3
Nanoparticle true density	7.132 g/cm3

Nanoparticles behave has solid surfactants and are capable of aligning themselves at the water oil interface. One of the rarest earth element. It has dual valence state and excellent catalytic activity. Ball mill process is the one of the most preferred process for the preparation of nanoparticles. The illustration of the cerium oxide nanoparticles. (Properties are given in table).

Cerium oxide has significant uses such as solid oxide fuel size (sofc,s). Semiconductor, fabricator, gas sensor and newly in biomedicine. In preparation of the fuel mixture, the sonication and surfactant adding are the key influences towards consuming a homogenous steady and extended term suspension. For suspension of chemical stabilization, surfactants with dominant Vander walls forces among particles of the mixture must assistance. Cerium oxide when added in different dosing level improves performance and efficiency of engine.

2. EXPERIMENTAL SETUP FOR ENGINE TESTING

Experimentations were carried out on a single cylinder, four stroke, water cooled C.I engine [KIRLOSKAR MAKE] to study the performance, combustion and emission characteristics of neem biodiesel with cerium oxide as additive. The above Figureure illustrates the various parts of the test engine. The test engine was united with an eddy current dynamometer to control the engine torque for loading the engine. A high speed computer digital based data acquisition system consisting of a sensor is used to measure fuel intake, load, speed and BMEP etc.

Exhaust emission parameters were measured with i3sys gas analyser and i3sys smoke meter EDM 1601 was used for measuring amount of smoke emitted.

Experimental tests were carried out at five different levels with an increment of 25% along the consecutive loads ranging from 0%, 25%, 75% and 100% loads keeping the speed constant at 1500 rpm. Initially the test engine was run with diesel for 20 mins to warm it up before testing otherblends. Then, the test was carried for diesel, biodiesel and biodiesel with additive.

Performance, emission and combustion characteristics for various loads were measured using eddy current dynamometer and corresponding emissions with gas analyser and smoke meter. The obtained results were compared for diesel, biodiesel and biodiesel with cerium oxide at standard operating conditions.

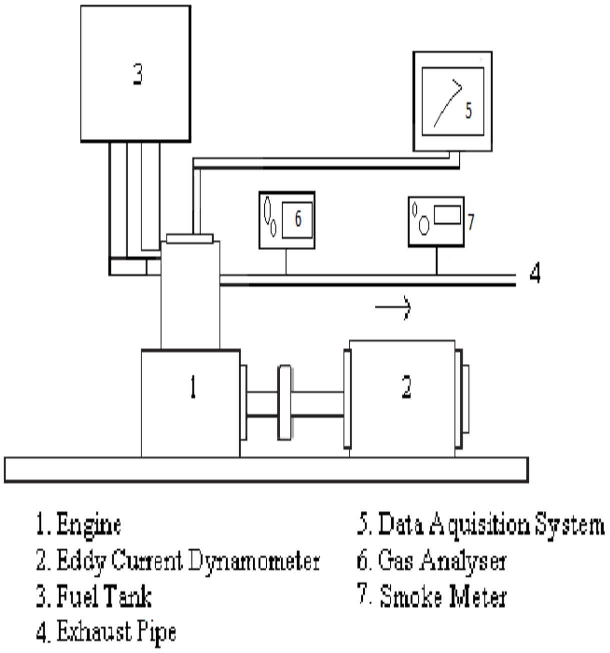

Figure.1. Schematic diagram of the test rig

TABLE II. Properties of fuel and blends used in testing.

Properties	Diesel	B20N	B20N+C25
Specific gravity	0.82	0.88	0.862
Kinematic viscosity(cst)	2.5	5.7	4.3
Net calorific value(KJ/kg	44800	39501	41052
Flash point(0c)	58	152	146

TABLE III. Test engine specifications.

Engine make	Kirloskar AVI
Type of engine	CI engine,4-Stroke, Single Cylinder
Cooling method	Water cooled
Rated B.P	3.5KW
Rated Speed	1500rpm
Compression Ratio	16.5:1
Fuel injection	Direct injection
Injection pressure	175 bar
Stroke length	210.00mm
Arm length	150.00mm
Clearance volume	38.00cc

3. RESULTS AND DISCUSSION

With the above described experimental setup, the diesel engine is tested for performance, combustion and emission characteristics with test fuels. The engine is tested under constant speed of 1000rpm with varying load from zero load to full load.

B. Performance characteristics.

In this section various performance characteristics like Break thermal efficiency and Specific fuel consumption were discussed.

1) Brake Thermal Efficiency:

Figure. 2. Demonstrate the discrepancy of BTE with load for all test fuels. It has been observed that for all test fuels, the BTE is higher than the neat diesel. The maximum BTE is accounted for B20N+C25 (43.74%) and minimum is observed for diesel (37.996%). This shows that there is 5.7% and 2.7% increase in BTE compared to diesel and B20N respectively. This is because of better air fuel mixing, improved combustion [3]. The increase in BTE is also accounted for Cerium oxide nanoparticles which provide oxygen for combustion [4].

2) Specific Fuel Consumption.

Figure. 3. Demonstrate the discrepancy of SFC with respect to load applied for test fuels. It is clear from the graph that SFC decreases with increase in load. At full load the maximum SFC is observed for diesel (0.206 Kg/kw-hr) and minimum for B20N+C25 (0.172 Kg/kw-hr). So there is 16.5% decrease in SFC of B20N+C25 than diesel. This is because of lower calorific values of blended oils [1,2] and also because of better combustion, due to the fine atomization property of Ceo2 nanoparticles[3].

B) Emission Characteristics.

This section deals with the emission characteristics such as CO, UBHC and NOx emissions for all test fuels with varying load.

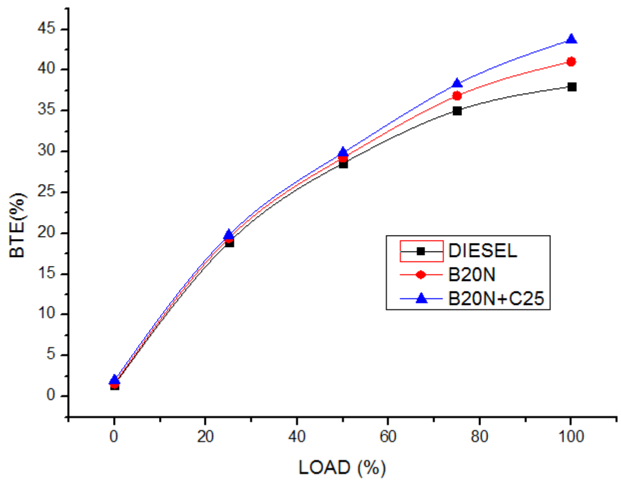

Figure. 2. Variation of break thermal efficiency with load.

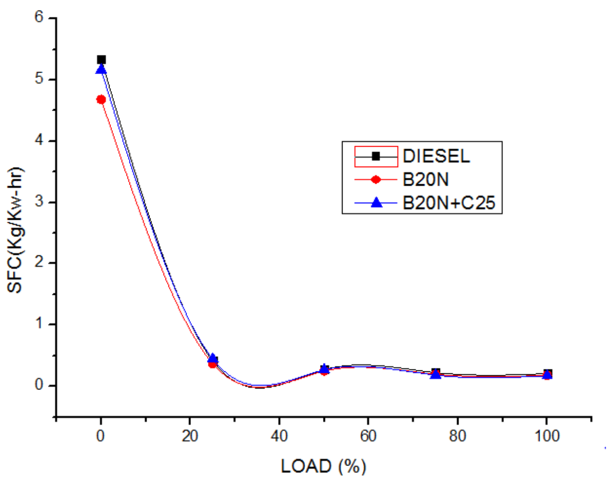

Figure. 3. Variation of specific fuel consumption with load.

1) Carbon Monoxide Emissions.

CO is one of the colourless, odourless and poisonous gas present in the emission gases. Figure. 4. shows the variation of emission of CO with respect to load. The graph clearly shows the decrease of biodiesel blends compared to neat diesel. The CO emission is maximum for diesel and minimum for B20N+C25. From the graph it is clear that, the emission of CO in B20N+C25 is reduced by 28.93% compared to diesel. This is because of the fine atomization and oxygen content in the fuel which results in complete combustion [5].The Ceo2 nanoparticles acts as a catalyst, they provide oxygen for the fuel due to which CO is converted into CO2[6].

2Ceo2+Co → Ce2o3+ Co2

2) NOx Emissions.

Figure. 5. shows the variations of NOx emission with respect to load. Nitrogen reacts with oxygen only at high temperature and pressure, the high temperature in cylinder results in react-ion of nitrogen with oxygen, NOx emission increases with increase in temperature. From the graph the maximum and minimum NOxemission were showed for B20N+C25 (602.788PPM) and diesel (518 ppm) respectively. So there is a difference of 84.788ppm compared to diesel. This is due to higher surface to volume ratio of Ceo2 nanoparticles which improves the combustion thereby increasing the cylinder temperature [4], which results in higher NOx emission.

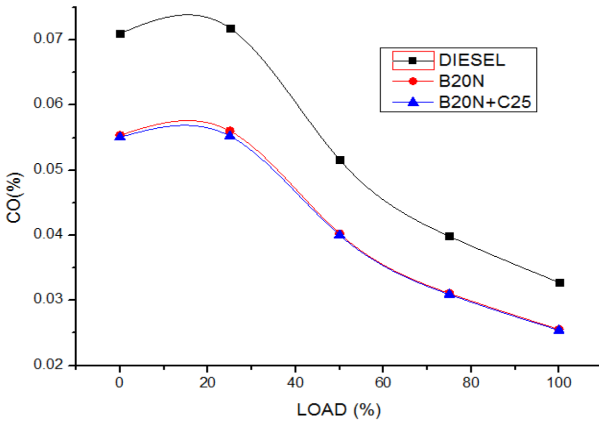

Figure. 4. Variation of Carbon monoxide with load.

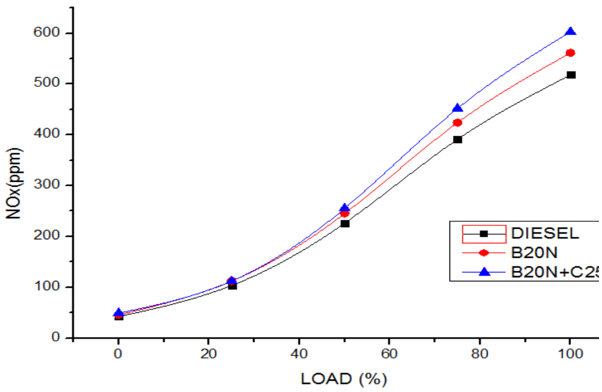

Figure. 5. Variation of NOx emissions with load.

2) UBHC Emissions.

Figure. 6. shows the variation of UBHC with respect to load. At all loads the UBHC emission is low for all the test fuels compared to diesel. The maximum and minimum UBHC emissions are observed for diesel (28.2 ppm) and B20N+C25 (17.484ppm) respectively. UBHC emissions are 38% lower than diesel due to high catalytic property of Ceo2 nanoparticles which provide oxygen for complete combustion there by reducing UBHC [7].

4. CONCLUSION

Based on the investigated various characteristics like performance, combustion and emission of C I diesel engine with test fuels, the following conclusions were made.

- Due to the high catalytic activity of Ceo2 nanoparticles, there is a 5.7% and 2.70% increase in BTE of B20N+C25 compared to neat diesel and B20N. And also SFC reduces significantly with the addition of nanoparticles. We can observe there is a 16.5% decrease in SFC.
- The Ceo2 nanoparticles which provide oxygen for complete combustion reduces the emission of CO and UBHC, However we can see NOx is increased for B20n+C25 due to high oxygen content and increased cylinder pressure.
- Due to the reduced ignition delay and advancement of premixed combustion zone, we can see that the cylinder peak pressure and Heat release rate are reduced.

Finally we can conclude that the metal based additive plays an important role in controlling emissions and improving performance and combustion.

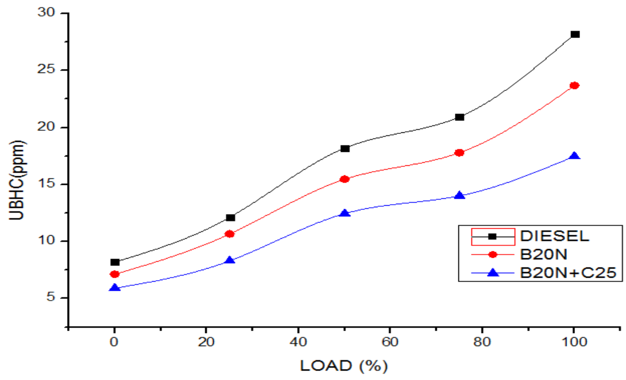

Figure. 6. Variation of UBHC emissions with load.

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