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Experimental Investigation of Performance and Emission of CI Engine using Alumina Nanoparticles with Waste Plastic Oil and Honge Bio Diesel

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Abstract: Demand for fuel and the use of petroleum products are increasing day by day which causes serious problems such as petroleum depletion, environment degradation etc. So biodiesel is a good alternative for conventional diesel fuel. By using biodiesel there are also some disadvantages such as high oxides of nitrogen, high fuel consumption and higher density. To overcome this problems from biodiesel using additives. Additives play an significant role in enhancing the properties of biodiesel. In this context, oxygenated additives such as Alimina which are rich in oxygen content are used.

Biodiesel is obtained from honge oil by transesterification process and waste plastic oil is obtained by pyrolysis process. The experiment work is done by a CI engine using honge biodiesel, waste plastic oil and alumina nanoparticles as an additive. The present investigation was to study the combustion and performance characteristics of all the blends by compare them with diesel. Experimental results show that performance and combustion characteristics improved with B20 biodiesel blend with WPO(waste plastic oil) and with or without nanoparticles as additive. The thermal efficiency will increase and SFC(Specific fuel consumption) is better in case of oxygenated additive blend. Considerable reductions parameters like carbon monoxide, unburned hydrocarbon and increases in nitrogen oxide emissions are attained while using B20 biodiesel blend and B20 biodiesel blend with waste plastic oil compared with diesel. However there is a significant reduction in CO, UBHC and NO_x emission parameters for B20 biodiesel blend with WPO and nanoparticles as an additive.

1. Introduction

Over the last two decades in world, there has been a tremendous increase in the number of industries and automobiles. Present Scenario the motor vehicle population in India is about one hundred million. Even though the transport sector plays a essential role in the economic development of any country, it brings an unavoidable specter of environmental deterioration along with it. This is specially a big problem for developing country like India. Development of new energy resources has become important agenda in relation to national energy policy. According to estimates of the oil and gas journal, crude oil production is expected to reach a peak in another one decade, and from then on, it is eventually going to decrease. With this, the crude oil, will be expensive progressively until it becomes unaffordable while putting pressure on the import bill and increasing the import bill deficit. Thus, there is a need to look at other options as far as



energy needs are concerned. Based on the recent research, biodiesel has more attractive because of its performance and environmental benefits and the facts that it is eco-friendly, non-toxic and can be made from the renewable resources. Biodiesel is also having a small number of drawback, such as superior viscosity, superior molecular weight, higher poor point and lower volatility compared with diesel. These drawbacks cause poor atomization and lead to incomplete combustion. So, to reduce above mentioned drawbacks additives are used. Additives will help out the petroleum to recover its engine performance, combustion and emission environmental standards. Additives can be classified in terms of their applications and their drawbacks are listed out.

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

1.1. Plastic oil

Plastic material is a synthetic organic solid that is moldable. Plastic are high molecular polymers, most commonly derived from petrochemicals. They are widely used in making domestic products and in packaging industries. Plastic is a non-biodegradable material. The used plastic products have become a common feature at overflowing bins and landfill. After food and paper wastes, Plastic waste is major constitute of municipal and industrial waste. Daily plastic waste generated is approximately 1150 tons worldwide. Converting waste plastics into fuel hold great promise for both the environmental and economic scenarios.

1.2. Preparation of nano fluids

In present study, nanoparticle was used with biodiesel in the form of nano emulsion and the effect of CI engine characteristics was experimentally investigated. For preparation of the blend, commercial diesel fuel as the base fluid Honge 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: B20H (80%Diesel and 20%Biodiesel in volume percentage). B20H WPO+C25 (70%Diesel and 20%Biodiesel and 10%WPO in volume percentage and 25 ppm aluminium oxide). To prepare homogenous fuel blend, it was stirred using magnetic stirrer for 45 minutes, to obtain proper dispersion nanoparticles with fuel.

Table.1 Properties of a Alumina nanoparticles

Properties	Specifications
Name(Chemical)	Gamma Aluminum Oxide (Alumina, Al_2O_3) Nano powder, gamma phase,99.9%
Appearance	White
Density	3.95 g/cm ³
Particle size	22-55nm
Boiling point	2979°C
Melting point	2046°C

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

2. Experimental setup for engine testing

Experiments were carried out on a single cylinder, four stroke, water cooled CI engine [KIRLOSKAR MAKE] to study the Combustion, Performance and Emission characteristics of neem biodiesel with cerium oxide as additive. The above figure illustrates the various parts of the test engine. The test engine was coupled 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 CI engine was run with neat diesel for 20 mins to warm it up before testing other blends. 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.

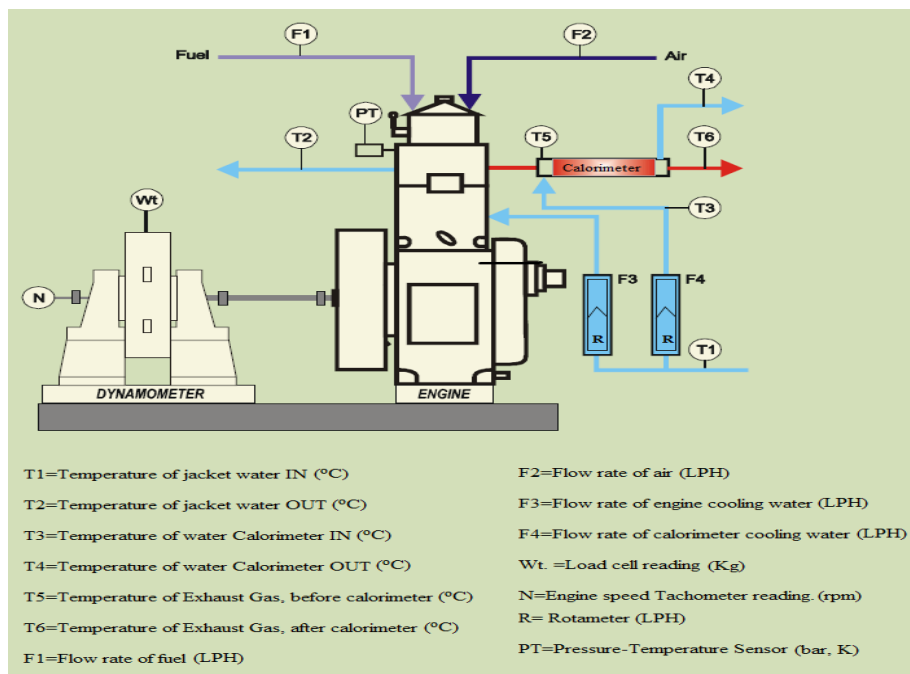


Figure 1 Experimental setup

Table.2 Test Engine Specifications

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

Table.3 Properties of the prepared different biodiesel used for engine testing

Property	Straight Diesel	Honge oil	Pure Plastic Oil	B20H	B20HWPO
Density(kg/m ³)	850	915	835	940	800
Sp gravity	0.85	0.915	0.835	0.940	0.8
Kinematic Viscosity(m ² /s)	2	5.5	2.52	14.7	3.8
Calorific Value(kJ/kg)	42000	35,800	44340	38,996	46,988
Flash Point (°C)	50	225	42	196	87

3. RESULTS AND DISCUSSION

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

3.1 Performance characteristics

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

3.1.1 Brake Thermal Efficiency

Fig shows the BTE variations 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 B20H+WPO(45.74%) and minimum is observed for diesel (36.996%). This shows that there is 8.2% and 4.7% increase in BTE compared to diesel and B20N respectively. This is because of better air fuel mixing, improved combustion. The increase in BTE is also accounted for alumina oxide nanoparticles which provide oxygen for combustion

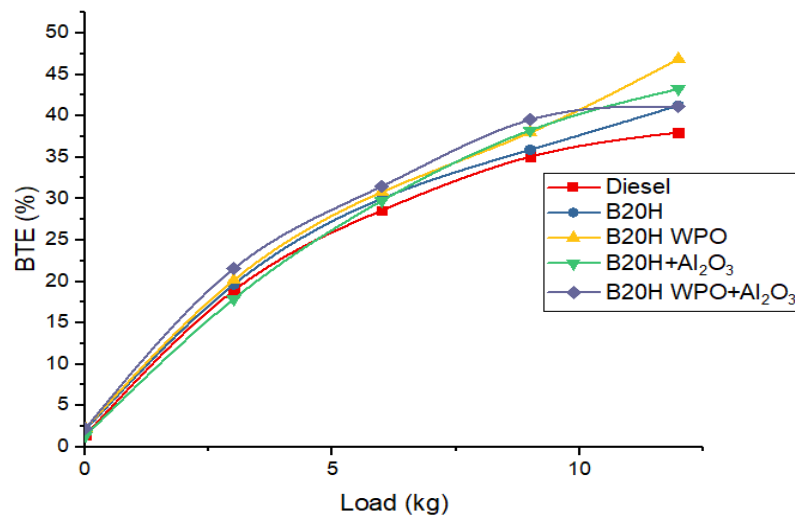


Figure 2-Variations of brake thermal efficiency

3.1.2 Specific Fuel Consumption

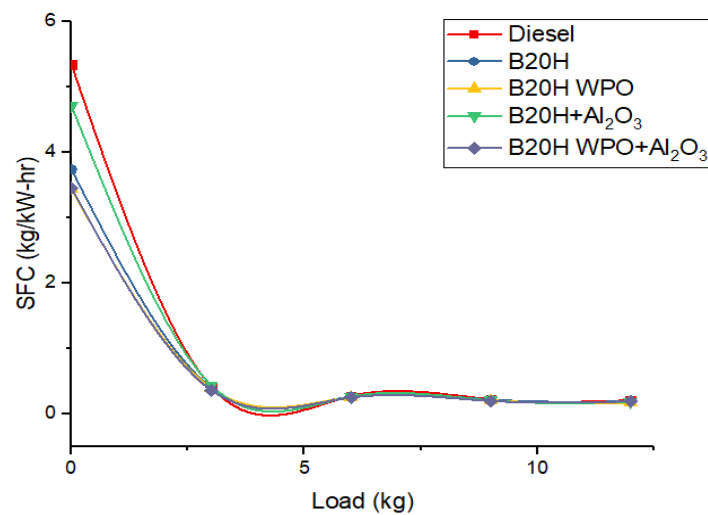


Figure 3-Variation of SFC

Fig shows the SFC variations with respect to load applied for all tested fuels. It is clear from the graph that SFC decreases with increase in load. At full load the maximum SFC is observed for diesel (5.3 Kg/kw-hr) and minimum for B20H WPO+AL₂O₃ (3.5 Kg/kw-hr). So there is 33.65% decrease in SFC of B20H WPO+AL₂O₃ than diesel. This is because of lower calorific values of blended oils and also because of better combustion, due to good atomization AL₂O₃ nanoparticles.

3.2 Combustion Characteristics

The combustion process can affect the emission and performance characteristics of CI engine. In this section the combustion Characteristics such as HRR and Peak cylinder pressure are discussed.

3.2.1 Peak Cylinder Pressure

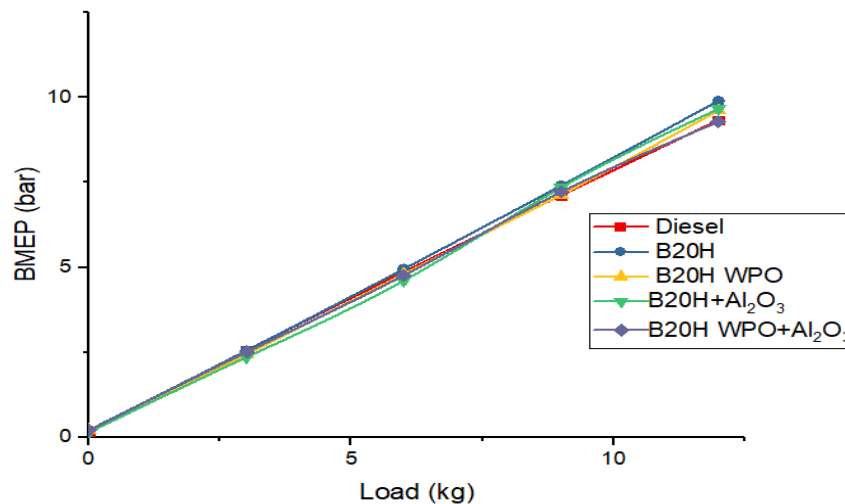


Figure 4. Variation of BMEP

Fig shows the variations of peak cylinder pressure with respect to load. The peak cylinder pressure increases with increase in load. It is comparatively high for blended fuels than neat diesel. It is maximum for B20H WPO+AL₂O₃ than B20N due to the addition of AL₂O₃ nanoparticles. This higher peak cylinder pressure is because of the high catalytic activity of AL₂O₃ nanoparticles and reduced ignition delay, which promotes complete combustion there by increasing the cylinder pressure.

3.3 Emission Characteristics

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

3.3.1 CO Emissions

Fig 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 B20H WPO. From the graph it is clear that, the emission of CO in B20H WPO is reduced by 16.66% compared to diesel. This is because of the fine atomization and oxygen content in the fuel which results in complete combustion. The AL₂O₃ nanoparticles acts as a catalyst, they provide oxygen for the fuel due to which CO is converted into CO₂.

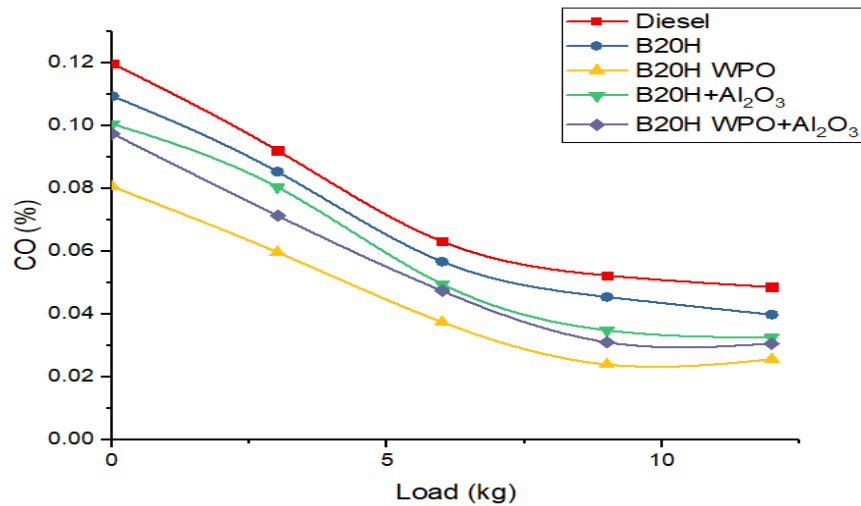


Figure 5. variations of CO

3.3.2 NO_x emissions

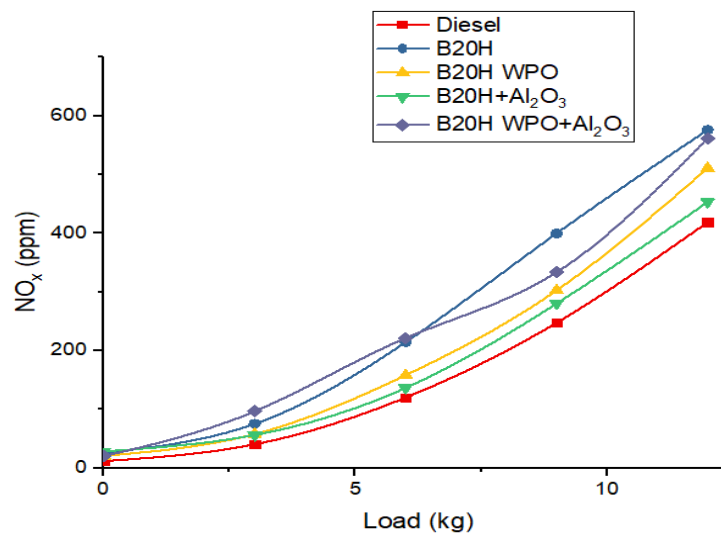


Figure 6. variation of NO_x

Fig shows the variations of NO_x emission with respect to load. Nitrogen reacts with oxygen only at high temperature and pressure, the high temperature in cylinder results in reaction of nitrogen with oxygen, NO_x emission increases with the temperature raise. From the graph the maximum and minimum NO_x emissions were showed for B20H WPO+AL₂O₃(550PPM) and diesel (410 ppm) respectively. So there is a difference of 140ppm compared to diesel. This is due to higher surface to volume ratio of AL₂O₃ nanoparticles which improves the combustion there by increasing the cylinder temperature, which results in higher NO_x emission.

3.3.3 UBHC Emission

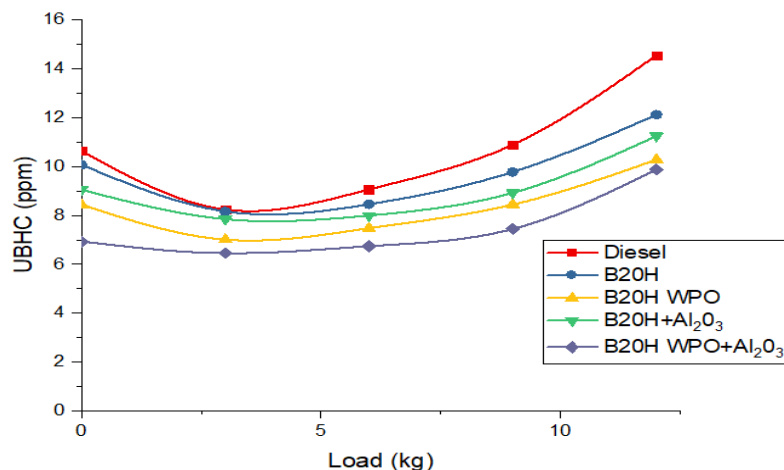


Figure 7. Variation of UBHC

Fig shows the variation of UBHC with respect to load. At all loads the UBHC emission is low for all the test fuels compared to neat diesel. The maximum and minimum UBHC emissions are observed for diesel (14.2 ppm) and B20H WPO+AL₂O₃ (7.1ppm) respectively. UBHC emissions are 50% lower than diesel due to high catalytic property of AL₂O₃ nanoparticles which provide oxygen for complete combustion there by reducing UBHC.

4. Conclusions

Based on the investigated various characteristics like Combustion, Performance and emission of CI diesel engine with test fuels, the following conclusions were made.

- The maximum BTE is accounted for B20H+WPO (45.74%) and minimum is observed for diesel (36.996%). This shows that there is 8.2% and 4.7% increase in BTE compared to diesel and B20N respectively. We can observe there is a 16.5% decrease in SFC.
- The AL₂O₃ nanoparticles which provide oxygen for complete combustion reduces the emission of CO and UBHC, However we can see NO_x is increased for B20H+AL₂O₃ 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 HRR and cylinder peak pressure are reduced.

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

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