EFFECTS OF NANOPARTICLES ADDITIVES ON PERFORMANCE AND EMISSIONS CHARACTERISTICS OF A DI DIESEL ENGINE FUELLED WITH BIODIESEL

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ABSTRACT

This study investigates the use of copper oxide for Linseed oil based biodiesel. The metal based additive was added to biodiesel at a dosage of 40 μmol/L, 80 μmol/L and 120 μmol/L with the aid of an ultrasonicator. Experiments were conducted to study the effect of copper oxide added to biodiesel on performance and emission characteristics of a direct injection diesel engine operated at a constant speed of 1500 rpm at different operating conditions. Results show that maximum increase in brake thermal efficiency was found to be B20+ 80 PPM CuO and also reduces specific fuel consumption at full load conditions. The copper oxide additive is effective in control of hydrocarbon (HC), carbon monoxide (CO), smoke and oxides of nitrogen (NOx) at full load conditions.

KEYWORDS: *Linseed biodiesel, copper oxide nanoparticles, ultrasonicator, diesel engine, Performance, Emissions.*

I. INTRODUCTION

The compression ignition engines are widely used due to its reliable operation and economy. As the petroleum reserves are depleting at a faster rate due to the growth of population and the subsequent energy utilization, an urgent need for search for a renewable alternative fuel arise. Also the threat of global warming and the stringent government regulation made the engine manufacturers and the consumers to follow the emission norms to save the environment from pollution. Biofuels are one of the alternate fuels to reduce the dependency on fossil fuel and can replace petroleum fuels. Biodiesel from vegetable oils is one of the renewable fuels that can be used in a diesel engine with or without some minor modifications. Using Biodiesel increases the oxygen content resulting in better combustion. Other properties of biodiesel are also similar to diesel. However, with the rapid growth of nanotechnology in past decade, nanoparticles are now widely commercialized in many products such as paint, coatings, catalysts, biomedicine, cosmetics, skin creams, toothpastes and many other applications. Unique physicochemical characteristics (e.g. magnetic, optical and electrical features) make the use of nanoparticle ideal in manufacture industries. Nano particles such as Cerium oxide (CeO2) and copper oxide (ZnO) nanoparticles have been popular in recent years and they have been applied widely in many fields. CeO2 , CuO nanoparticle have been used as fuel catalyst to reduce Ignition delay , Specific fuel consumption ,harmful emission, smoke and also increases brake thermal efficiency of the engine.

Addition of some metal and metal oxide in the form of nano-powder to the base fuel may enhance the properties of the fuels. This is due to the interesting properties of nanoparticles like higher specific surface area, thermal conductivity, catalytic activity and chemical properties as compared to their bulk form. Many researchers have used nano-particles as additives in diesel as well as biodiesel as new hybrid fuel blends. The use of fuel-borne catalyst has the advantage of increase in the fuel efficiency and reducing harmful greenhouse gas emissions. However, the stability of liquid-based fuels with the metal additives was a major concern because of the rapid settling of the metal particles. The addition of nanoparticles in the fuel increases the surface area to volume ratio that enables rapid oxidation process.

II. LITERATURE VIEW

T. Senthil Kumar et al. [1] had conducted the experiment on single cylinder direct injection diesel engine and the performance and exhaust emissions of the engine were also studied for the different blends of Kapok methyl ester. The exhaust gas temperature and specific fuel consumption are increased for rich blends of Kapok methyl ester, but the brake thermal efficiency is decreased for the same blends. The NOx emission is higher than that of diesel at all load conditions of the engine. The CO emission and smoke density are reduced for the lean blends B20 and B40 of Kapok biodiesel for all the load conditions. Similarly, the HC emission is also low for the same blends.

Sajith V etc al. [2,3] studied the effect of cerium nanoparticles on the major physical properties of the biodiesel. Addition of nanoparticles increases the fluid layer resistance and results in the increase of viscosity of the fuel blend. The cerium oxide nanoparticles present in the fuel blend promotes complete combustion compared to the base fuel and increases the fuel efficiency.

Arul et al. [4]. studied the effect of cerium oxide nanoparticles on the performance and emission characteristics of a CI engine. The ceria acts as an oxygen donating catalyst and provides oxygen for the oxidation of CO and/or absorbs oxygen for the reduction of NOx. Therefore, nano-particles can function as both catalyst and an energy carrier when used in base fuels in diesel engines. **Karthikeyan et al.** [5,6] studied the effects of addition of zinc oxide nano particles in palm oil biodiesel and the results indicate that there was increase in BTE, NOx, EGT and decrease in emissions of CO, HC and smoke.

Metin Guru et al, [7]. conducted experiments on a single-cylinder, direct injection (DI) diesel engine fueled with chicken fat biodiesel with synthetic Mg additive 12 µmol/L and its effects on engine performance and exhaust emissions were studied. Engine torque was not changed significantly with the addition of 10% chicken fat biodiesel, while the specific fuel consumption increased by 5.2% because of the lower heating value of biodiesel. In-cylinder peak pressure slightly rose and the start of combustion was earlier. CO and smoke emissions decreased by 13% and 9%, although NOx emissions increased by 5% with the addition of biodiesel to diesel fuel.

A.Selvaganapthy et al., [8]. studied the zinc oxide nano additive added to diesel shows the ignition delay reduced, peak pressure and heat release rate increased due the presence of particles. Due to these observation, and we found that the brake thermal efficiency increased minutely. As a drawback, it was also found that the emissions NOx, increased.

R. Sathiyamoorthi et al. [9]. Studied the performance, emission and combustion characteristics of single cylinder direct injection diesel engine using Neem oil biodiesel with nano additive CeO2 shows brake thermal efficiency for nano particles blended BN20 is higher than that of BN20 and diesel fuels and the harmful gases like, CO, HC, smoke and NOx emissions reduce significantly due to the addition of nano additive in the BN20 fuel blend. The cerium oxide additive influences the better combustion process which yields the peak pressure and heat release rate than BN20 and diesel fuel blends.

III. EXPERIMENTAL STUDY:

2.1. Nano particle blending:

The process of adding nanoparticles to the fuel is done with the aid of an ultrasonicator. The ultrasonicator technique is the best suited method to disperse the nanoparticles in the base fuel, as it facilitates possible agglomerate nanoparticles back to nanometer range.

In this experiment copper oxide nanoparticles are weighed to a predefined mass fraction say 50ppm, 100ppm and 150ppm dispersed in the biodiesel with the aid of ultrasonicator set at a frequency of 20 kHz for 30 minutes. The resulting nanoparticles blended biodiesel is named as BIODIESEL+50NANO. For analyzing the stability characteristics of nanoparticles blended biodiesel, the blends were kept in bottles under static conditions.

Properties of fuel

Properties	Diesel	Biodiesel	B20
Calorific value (KJ/Kg)	43000	37270	41850
Density(Kg/m³)	850	900	860
Flash point °C	55	161	68
Fire point °C	59	156	71
Kinematic Viscosity(mm²/s)	3.9	4.6	4.1

2.4. Experimental setup:

The experimental setup is as shown in Fig. 1 and the specifications are tabulated in Table 5. The test fuel was checked for performance and emission in a single cylinder, four stroke, direct injection, constant speed, Kirloskar diesel engine. The time taken (in sec) for the consumption of 10cc of fuel is noted at every load and Exhaust gas analyzer is used to measure exhaust gases like CO, NOx, HC. Experiments are conducted with pure diesel, diesel blend of Linseed for B20 and with blend of diesel and biodiesel by using nano-CuO as additive. The effects are plotted against brake power (BP).

Type of engine	High speed diesel engine
Make	Kirloskar AV-1
No. of cylinders	1
Brake power	5HP
RPM	1500rpm(constant)
Bore	80mm
Stroke	110mm
Loading type	Mechanical

IV. RESULTS AND DISCUSSION:

4.1 specific fuel consumption:

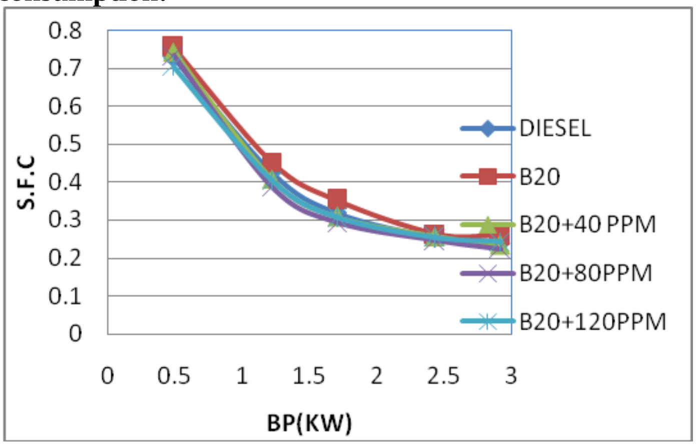

Figure.3.1 Load v/s Brake Thermal Efficiency

The variation of the specific fuel consumption with engine loads, for different nano additives blends of Linseed methyl ester blends (B20) and diesel are shown in Figure 3.1. The specific fuel consumption decreases with an increase in the engine loads. . Lower SFC is observed for B20 blended nano additives this occurs due to the enhanced surface area to volume ratio by the catalytic effect during the combustion inside the engine cylinder and also for B20 blends there is a slight increase in specific fuel consumption due to the decrease in the calorific value. From the above graphs it is concluded that B20+ 80 PPM CuO shows lesser specific fuel consumption than diesel due to the increase in calorific value and also catalytic effect.

4.2 Brake Thermal Efficiency:

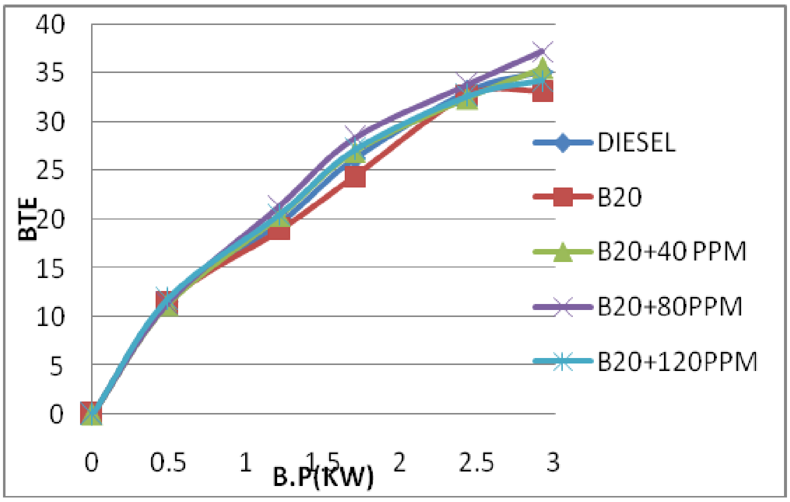

Figure.3.2 Load v/s Brake Thermal Efficiency

The variation of the BTE with respect to the load is shown in the Figure 3.2. The BTE of the Linseed methyl ester blends (B20) was lower than the diesel due to the lower calorific value and also higher viscosity and density. However, a small improvement in BTE was found when addition nano particles to the base fuel. From the above graphs it is observed B20 added nanoadditives gives 1-2% increase in BTE and also the maximum increase in BTE was found for B20+ 80 PPM CuO is 3-4% .increase in the Brake Thermal Efficiency.

4.3 NOx Emissions:

The variations of NOx emissions with respect to the load are shown in the Figure 3.3. The NOx emissions found increased with the increase in load. The NO emissions are increasing with the load due to the more in-cylinder pressure and the corresponding combustion temperature for all the fuel blends. The increasing trends of NO emissions are observed with the use of biodiesel blends as reported by Wail and Khaled (2012). Similar trend was observed for B20 and B20 blended nano additives at almost all loads. From the graph it is observed that addition of Nano-fuel additives resulted in an effective reduction in NOx emission. This is due to that nanoparticles oxidize the nitrogen into nitric oxide at the elevated temperatures during the combustion process.

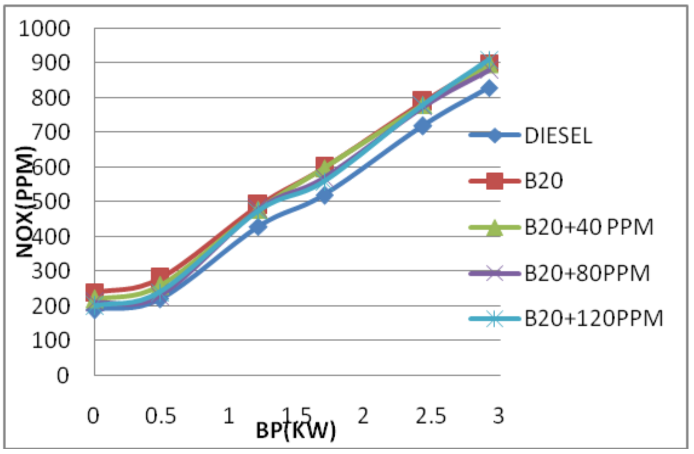

Figure.3.3 Load v/s NOx emissions

4.4. HC Emissions:

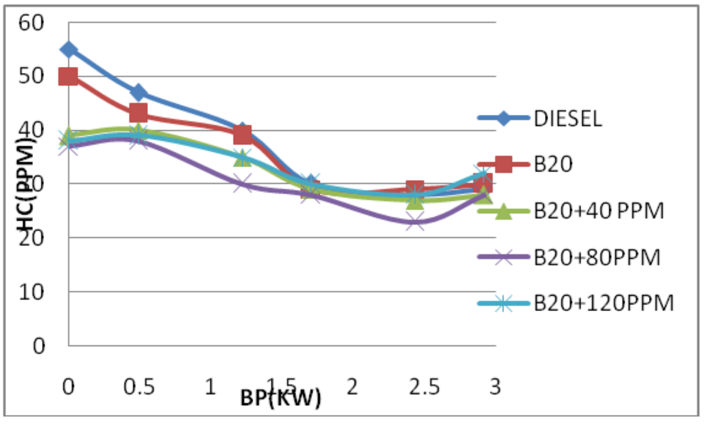

Figure.3.4 Load v/s HC Emissions

The un-burnt HC emission variations for Diesel, Linseed methyl ester blends (B20) and copper oxide nanoparticle blended fuels of B20 are shown in Figure 3.4. The HC emission for B20 operation was higher compared to diesel due to its lower brake thermal efficiency resulting from incomplete combustion. However HC emissions were marginally lower for the blended fuels of copper oxide compared to B20. This could be due to increased catalytic activity and improved combustion characteristics of oxide, copper oxide nanoparticles which lead to improved combustion.

4.5. CO Emissions:

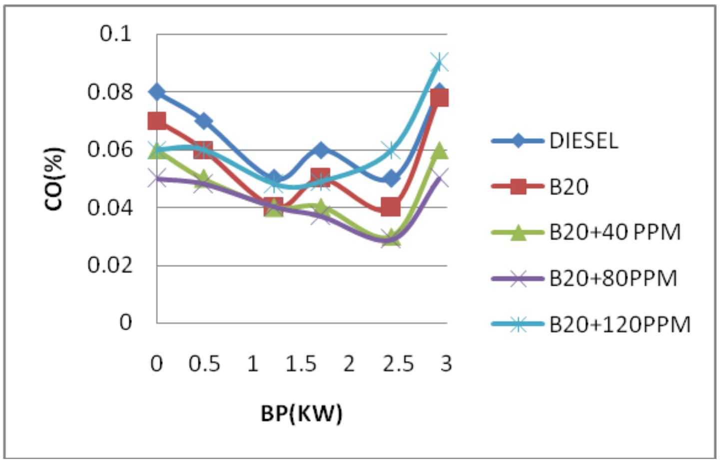

Figure.3.5 Load v/s CO Emissions

The CO emissions for diesel, Linseed methyl ester blend (B20) and nanoparticles blended fuel are shown in Figure 3.5. The CO emission for B20, B50 blends operation was higher compared to diesel due to its lower thermal efficiency resulting in incomplete combustion. However CO emissions were marginally lower for the nanoparticles blended fuels than B20 blends. The higher catalytic activity and improved combustion characteristics of copper oxide nanoparticles and leading to improved combustion could be the reason for this performance.

4.6. Exhaust Temperature:

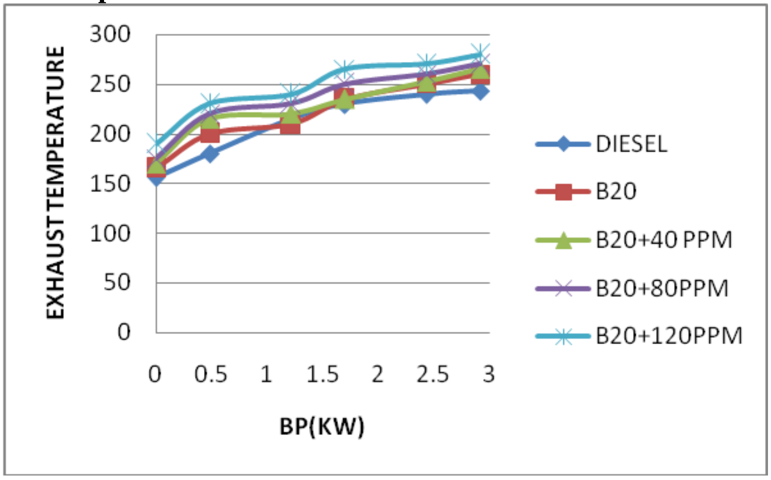

Figure.3.6. Load v/s Exhaust Temperature

The Exhaust gas temperature for diesel, Linseed methyl ester blends (B20) and nanoparticles blended fuels are shown in Figure 3.6. It is observed that all the nanoparticles added blends are having higher exhaust temperature than the diesel values for any load. Due to combustion rate increases at full load, the exhaust gas temperature obtained is also higher at full load.

V. CONCLUSIONS

The experiments were conducted with Linseed biodiesel and CuO as a nano-fluid has been studied and investigated the performance and emission characteristics. The following conclusions based on the experiment are

- B20 is having lower efficiency and higher energy consumption due to these results in lower heat value. The addition of nano fuel additives there is a significant increase in thermal efficiency compare to biodiesel without additives.
- The brake thermal efficiency for B20+80ppm increased by 3-4% when compared with biodiesel without additives.
- The reduction in CO emission by using B20+80ppm has observed when compare with diesel. The CO emissions reduced by 25% when compared with diesel.
- The HC emissions are obtained minimum for B20+80ppm when compared with diesel and other biodiesel nano-fuel additives.
- NOx emissions are decreased for all biodiesel nano fuel additives when compare to biodiesel without additives.

VI. FUTURE SCOPE OF WORK

- The research work can be extended by considering the different nanoparticles with different biodiesel can be studied.
- By increasing the dosage of the nanoparticle we can be study the performance and emissions characteristics.

- The effect of nanoadditives on vibration analysis and wear rate can be taken up for investigation can be taken up as future work.

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