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Experimental Investigation of Performance and emission characteristics of Various Nano Particles with Bio-Diesel blend on Di Diesel Engine

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Abstract. Present study provides the effect of Zinc Oxide (ZnO) and Cerium Oxide (CeO_2) nanoparticles additives on the Performance and emission uniqueness of Jatropha. Jatropha blended fuel is prepared by the emulsification technique with assist of mechanical agitator. Nano particles (Zinc Oxide (ZnO)) and Cerium Oxide (CeO_2)) mixed with Jatropha blended fuel in mass fraction (100 ppm) with assist of an ultrasonicator. Experiments were conducted in single cylinder constant speed direct injection diesel engine for various test fuels. Performance results revealed that Brake Thermal Efficiency (BTE) of Jatropha blended Cerium Oxide (B20CE) is 3% and 11% higher than Jatropha blended zinc oxide (B20ZO) and Jatropha blended fuel (B20) and 4% lower than diesel fuel (D100) at full load conditions. Emission result shows that HC and CO emissions of Jatropha blended Cerium Oxide (B20CE) are (6%, 22%, 11% and 6%, 15%, 12%) less compared with Jatropha blended Zinc Oxide (B20ZO), diesel (D100) and Jatropha blended fuel (B20) at full load conditions. NOx emissions of Jatropha blended Cerium Oxide is 1 % higher than diesel fuel (D100) and 2% and 5% lower than Jatropha blended Zinc Oxide, and jatropha blended fuel.

1. Introduction

Due to higher kinematic viscosity, reduced smoke emission and rich oxygen content, Biodiesel is considered as promising alternative fuel for CI engines. The 10% of oxygen content in biodiesel provides better combustion of fuel [3]. On the contrary, The NOx emissions are higher due to the formation of high local temperature. Nearly 12% of increase in NOx emission for biodiesel fuel noted when compared with petrol and diesel fuel [4].To control such NOx emission numerous methodologies have been trailed by analysts around the nations, for example, blending of biodiesel, changes in engine specifications, fumes gas decrease strategies and adjustment in fuel definitions [2]. Among them, fuel plan systems are considered as the most useful method for controlling the level of toxins at the engine fumes. In continuation of such methods, the nanoparticle addition with biodiesel results in pollution reduction and increase in engine performance are noticeably due to the higher surface area to volume ratio [6]. In order to determine the performance and emission characteristics of Jatropha bio diesel, the experiments were conducted in a constant speed single cylinder 4 stroke CI engine. The Jatropha biodiesel causes reduction in carbon monoxide (CO), unburned hydrocarbon (HC) emissions, but they cause increases in nitrogen oxides (NOx) emissions [1]. Brake thermal efficiency of Jatropha biodiesel was lower when compared with neat diesel for the same test condition [5]. An analyst was conducted few experiments on diesel and Jatropha biodiesel fuels with cerium oxide nano particle (at 20, 40 and 60 ppm (parts per million)) as an additive. The results showed that there was 30% reduction in NOx emission and 40% reduction in hydrocarbon emission and 1.5%

increase in brake thermal efficiency [7]. In this study, experiments were conducted in a constant speed(1500rpm) 4stroke single cylinder direct injection diesel engine for diesel(D100), B20(Jatropha 20%+Diesel 80%), B20ZO (Jatropha 20%+Diesel 80%+Zinc oxide), B20CE(Jatropha 20%+Diesel 80%+Cerium Oxide) to investigate the performance and emission characteristics.The Nano particles (100 ppm) were dispersed in the fuel by an ultrasonicator. The tests were conducted with the condition of 220 bar injection pressure and 21° BTDC ignition timing. The specifications of the engine are given in Table1.The properties of test fuels are given in Table 2. The experimental setup has been shown in Figure 1.An AVL model gas analyser is used to measure and carbon monoxide (CO) in percentage volume (%vol) and Unburnt hydro carbon (HC) and Nitric Oxide (NOx) in parts per million(ppm).

Table 1.The test engine specifications

Parameters	Values
Bore	87.5mm
Stroke	110.0mm
Speed	1500(constant speed)
Compression ratio	17.5:1
Rated power	4.4 kW
Number of cylinders	One
Type of cooling	Air cooled - eddy Current dynamometer
Injector opening	21°BTDC
Pressure	220 bar
No. of stroke	4 stroke

Table 2 Properties of fuels used in the experiment

Property	Diesel	Jatropha Oil
Sp. Gravity	0.74	0.96
Viscosity at 40^0C(mm2/s)	4.15	4.4
Calorific Value (KJ/kg)	42000	39500

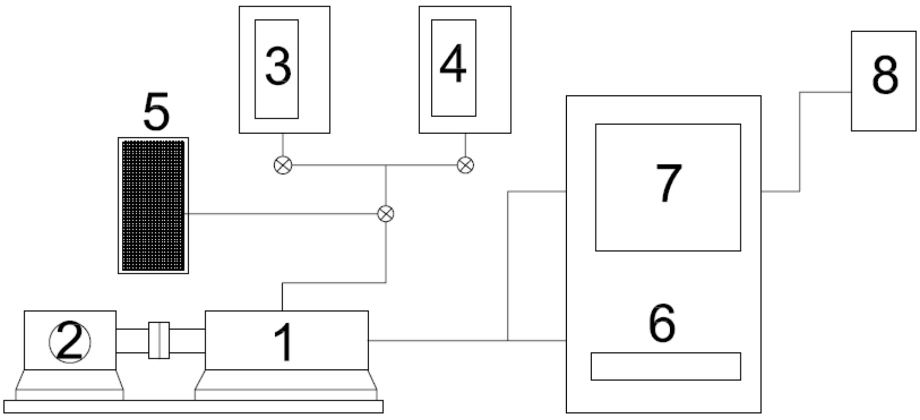

Figure 1. Experimental setup

1. Engine 2.Alternator 3.Diesel Tank 4. Air inlet 5. Biodiesel tank 6. AVL meter 7.Display 8.Smoke Meter

2. Result and discussion:

2.1 Variation of Brake Thermal Efficiency

The variation of Brake Thermal Efficiency with load is shown in figure 2.The results show that the brake thermal efficiency of the diesel engine is improved by the addition of Zinc oxide and cerium oxide nanoparticle in the Jatropha biodiesel. The nano particle presents in the fuel act as an oxygen buffer and lead the combustion to complete. Lower brake thermal efficiency noted for B20 biodiesel compared to D100 due to its lower calorific value, higher density and poor atomization property. The observed values of brake thermal efficiency for D100 and B20 are 32%, 27.8% at full load condition. However, improvement in brake thermal efficiency is observed for B20ZO, B20CE test fuels as 29.9% & 30.75% respectively at full load condition. Due to its high surface area to volume ratio of the nanoparticle increases the atomization of biodiesel and brake thermal efficiency is improved near to that of diesel fuel.

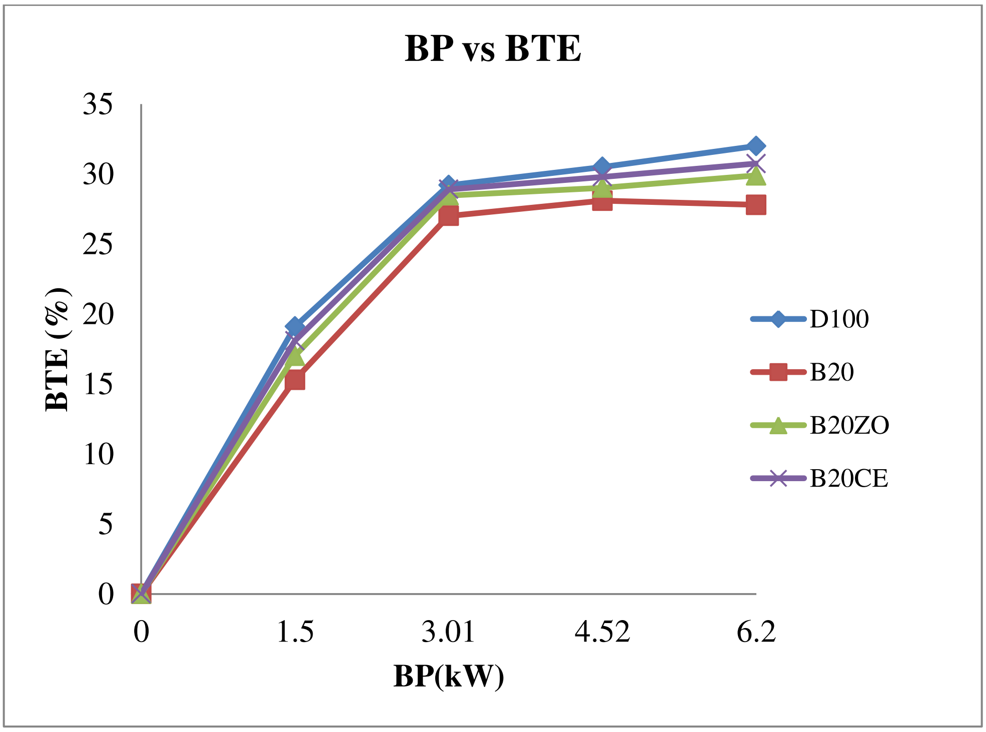

Figure 2. Brake Power vs. Brake Thermal Efficiency

2.2Variation of Hydrocarbon (HC) Emissions

The variation of hydrocarbon emission with engine load is shown in figure 3.Formation of lean charge during the delay period is the primary reason for hydrocarbon (HC) emission. The observed values are 88ppm, 80ppm, 76ppm, 72ppm for D100, B20, B20ZO, and B20CE respectively at full load condition and the percentage reduction Unburned HC for B20ZO, and B20CE are 14% and 18% respectively compared with D100 and 9% and 5% respectively compared with B20.The zinc oxide and cerium oxide nanoparticles in the biodiesel lowers the carbon combustion activation temperature and enriches the hydrocarbon oxidation. Thus unburned HC emissions lowered.

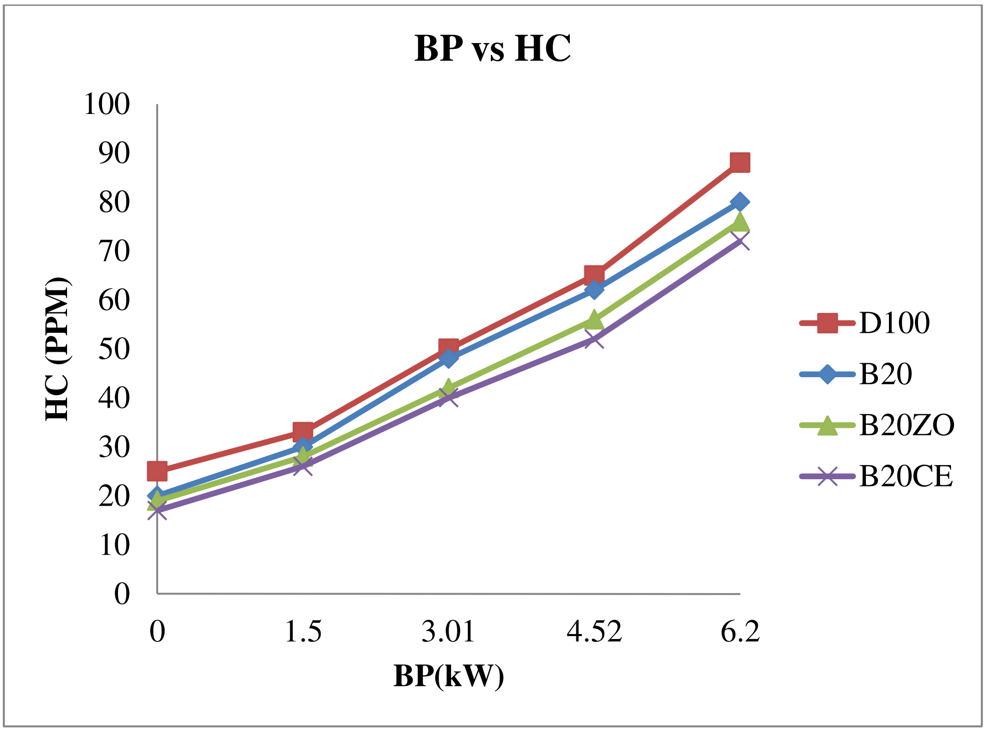

Figure 3. Brake Power vs. Hydrocarbon

2.3 Variation of Carbon Monoxide (CO) Emissions

Figure 4 illustrates the effect of test fuels on CO, under different load conditions. CO emission is formed mainly due to partial combustion of fuel and also by inadequate supply of air during combustion. Lower CO is witnessed for Jatropha biodiesel (B20) when compared with neat diesel (D100), owing to its rich oxygen content that helps to burn the charge completely. The observed CO emission for D100, B20, B20ZO, and B20CE are 0.38% Vol, 0.37% Vol,0.35% Vol,0.33% Vol respectively at full load conditions and the percentage reduction of CO emission for B20ZO, and B20CE are 8 % and 13 % respectively, when compared with diesel(D100), and 5% and 11% respectively, when compared with 20% Jatropha biodiesel(B20).

2.4 Variation of Nitrogen Oxide (NOx) Emissions

Figure 5 illustrates the effect of test fuels on NOx under different load conditions. Biodiesel being an oxygenated fuel enrichesthe rate of oxidation during combustion and results in high exhaust temperatures. At higher temperature, the nitrogen presentin air combines with oxygen and forms a series of gas phasereactions resulting in NOx emission. The observed NOxemission for D100(diesel), B20 (Jatropha biodiesel), B20ZO, and B20CEare 1226 ppm,1300 ppm,1260 ppm,1240 ppm, respectively at full load conditionand the percentage reduction of NOx emission for B20ZO, and B20CE are 3 % and 5 % respectively, when compared with Jatropha biodiesel and 3% and 1% higher than diesel(D100).

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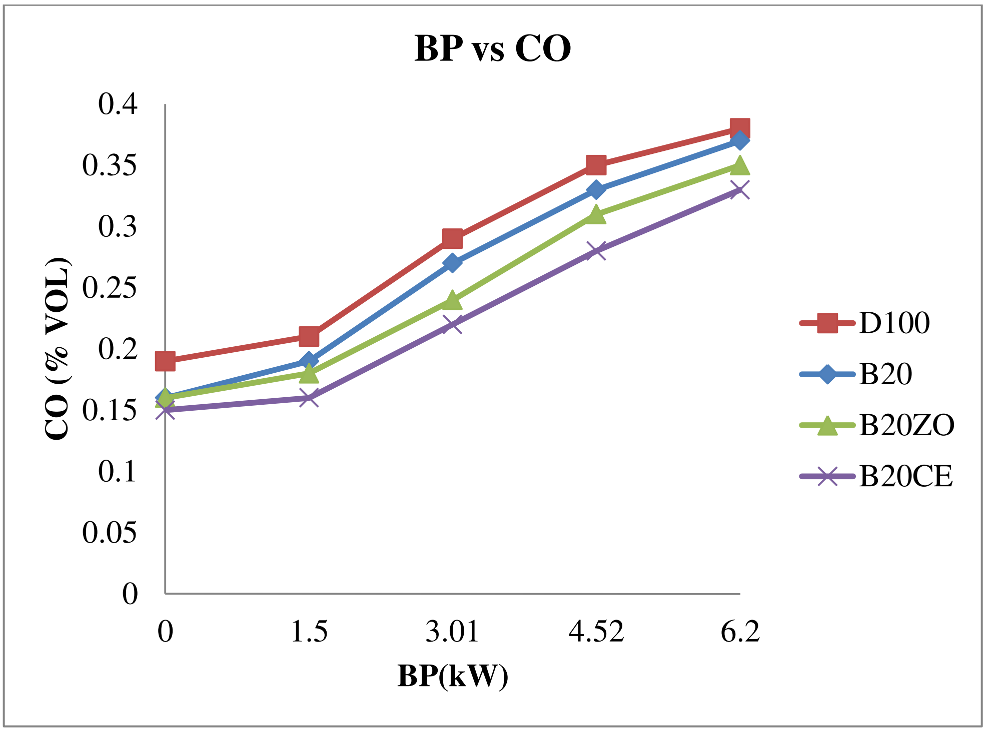

Figure 4. Brake Power vs. Carbon Monoxide

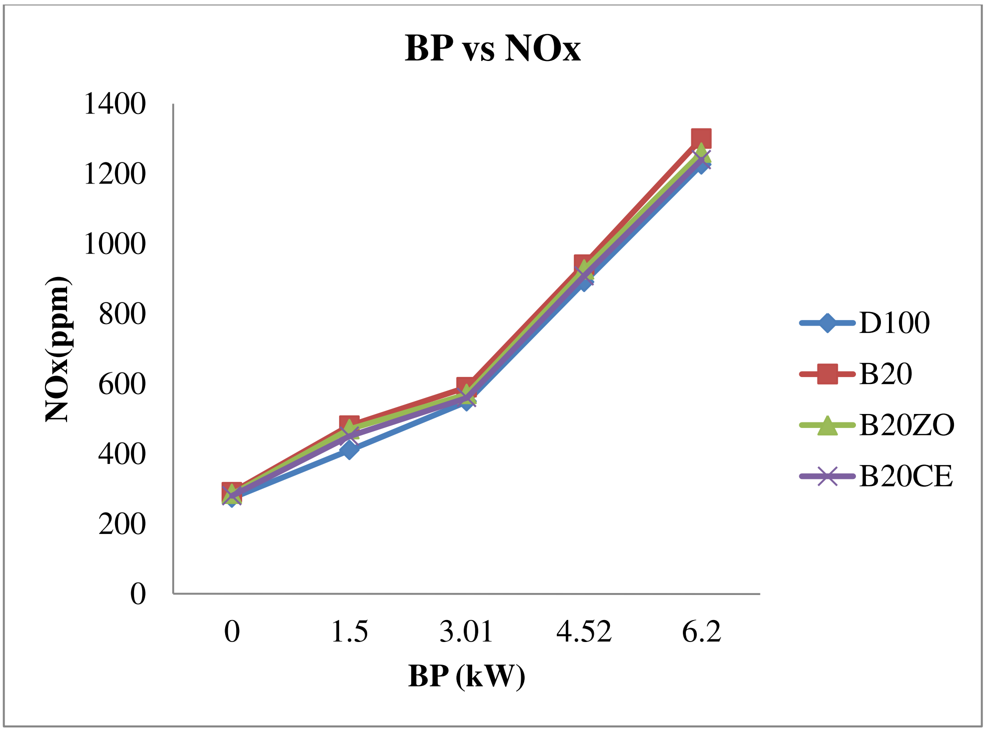

Figure 5. Brake Power vs. Nitrogen oxide

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3. Conclusion

The following conclusions are drawn from the experimental investigation of Zinc oxide and cerium nanoparticle as addition in Jatropha biodiesel.

1. For B20ZO test fuel - Percentage reduction of NOx by 3 %, Unburned HC by 9 %, and CO by 5 % are observed when compared to Jatropha biodiesel (B20) and Percentage increase of NOx by 3 %, reduction in Unburned HC by 14 %, and CO by 8 % are observed when compared to neat diesel(D100).
2. For B20CE test fuel - Percentage reduction of NOx by 5 %, Unburned HC by 9 %, and CO by 11 % are observed when compared to Jatropha biodiesel (B20) and Percentage increase of NOx by 1 %, reduction in Unburned HC by 18 %, and CO by 13 % are observed when compared to neat diesel(D100).
3. 8% and 11% increase in BTE is observed for B20ZO, B20CE test fuels compared to Jatropha biodiesel (B20) and, due to the improvement in atomization.

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