ISSN: 2096-3246
Volume 54, Issue 02, December, 2022

Special Issue

EXPERIMENTAL INVESTIGATIONS OF PERFORMANCE AND EMISSION CHARACTERISTICS OF A DIESEL ENGINE FUELED WITH JATROPHA METHYL ESTER USING NANO ADDITIVES.

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ABSTRACT

The present study is to analyze the effect of nano additives of Zinc oxide particles on engine performance and emissions characteristics of a diesel engine fuelled with Jatropha Methyl Ester (J20) as a fuel. The zinc oxide particles such as 50ppm & 100ppm were added to various blends of J20. Results show that addition of zinc oxide additive improves the brake thermal efficiency and is effective in control of hydrocarbon (HC), carbon monoxide (CO), smoke and oxides of nitrogen ($NO_{x)}$ at full load conditions.

Keywords: Jatropha Methyl Ester, Transterification, Zinc oxide, Performance, emissions, Diesel engine.

1. Introduction

The concept of using biodiesel in diesel engines was originated by the inventor " Rudolf Diesel" using peanut oil as a fuel at the World Exhibition in Paris in 1900[1]. Jatropha, mahua, neem, rape, coconut, karanja, cotton, mustard, linseed and castor have been tried in many parts of the world, which fulfill the present need [2]. The result proved that when direct injection diesel engine run neat vegetable oil, injectors get choked up and loads to poor atomization and less efficient combustion [3].One possible method to overcome the problem of higher viscosity is transesterification oils to produce Biodiesel. [4]. It reported that addition of diesel fuel additives improving the fuel economy and lowers the exhaust emissions of diesel engine [5]. It is reported that addition of nano sized particles will act as liquid fuel catalyst which leads to combustion characteristics of the engine [6]. This work shows that Carbon Nano Tubes act as nano additive to the fuel which improves the burning rate of the fuel and cetane number of the fuel [7]. In this work, the addition of nano particles in the biodiesel emulsion fuel shows the better performance and reduced in the emissions [8]. Even though, the alumina nano particles blended diesel fuels imparts better performance of the diesel engine [9]. The development of improved NOx reduction technologies is therefore of critical importance to the global environment [10]. It was reported that the addition of nano additive acts as an oxygen buffer which improves the combustion and brake thermal efficiency [11].

In this present study, Jatropha Methyl ester is used as a test fuel and Zinc oxide as nano additive. This present study shows the effect of nano additives on performance and emissions.

2. Materials and methods

2.1. Transesterification

Transesterification is the process of using an alcohol (e.g. methanol or ethanol) in the presence of catalyst such as sodium hydroxide (NaOH) or potassium hydroxide (KOH), which chemically breaks the molecule of the raw oil into methyl or ethyl esters with glycerol as a by-product, which reduces the high viscosity of oils. This method also reduces the molecular weight of the oil to 1/3 of its original value, reduces the viscosity and increase the volatility and cetane number to levels comparable to diesel fuel. Conversion not greatly affects the gross heat of combustion.

2.2. Experimental setup

Experiments are carried out in a single-cylinder, water-cooled, naturally aspirated direct injection diesel engine coupled with an eddy current dynamometer. An eddy current dynamometer coupled to the engine is used as a loading device. Exhaust emissions are measured with an AVL 444Di-gas analyzer. A smoke meter is used to determine the smoke density of the engine exhaust. The experimental setup is shown in Fig.1.

Zinc oxide nano additive particles of average size of less than 100nm is accurately weighted(0.001g) using a high precision electronic weighing balance and added to measured quantity of Jatropha Methyl Ester with the aid of ultrasonicator. The performance and emissions characteristics from the engines were studied for three different blends such as 80% Diesel + 20% Jatropha methyl ester (D80J20), 80% Diesel + 20% Jatropha methyl ester + 50ppm ZnO (D80J20ZnO50), 80% Diesel + 20% Jatropha methyl ester + 100ppm ZnO (D80A20ZnO100). The effect of nano particles additive on performance and emissions in a methyl ester of Jatropha oil fuelled DI diesel engine at different loads have been studied.

2.3.Testing Procedure

Engine was started and warmed up at low idle, long enough to establish the recommended oil pressure, and was checked for any oil leaks. The engine was run on no-load condition and speed was adjusted to 1800 rpm by adjusting fuel injection pump. Experiments were conducted at different load levels. The engine was run for 10 minutes and data were collected during last 4 minutes. The experimental uncertainties are shown in Table 2.

3. Results and discussion

3.1. Fuel properties

The fuel properties of D80A20, D80A20ZnO50 and D80A20ZnO100 are compared with neat diesel as shown in Table 1. From the Table 1, it was observed that addition of zinc oxide nano particles in the JME blends shows the slight improvement in kinematic viscosity, flash point and calorific value compared to J20[10].

3.2. Brake specific fuel consumption(BSFC)

Figure 2 shows the variation of brake specific fuel consumption (BSFC) with brake power for D80J20, D80J20ZnO50 and D80J20ZnO100 blends. The BSFC value of D80J20ZnO100 is decreased by 3.82% when compared to the D80J20 blend at full load conditions. This is because of improved atomization which leads to complete combustion.

3.3. Brake thermal efficiency (BTE)

Figure 3 shows the variation of brake thermal efficiency (BTE) with brake power for D80J20, D80J20ZnO50 and D80J20ZnO100 blends. The BTE value of D80J20ZnO100 is increased by 2.79% when compared to the D80J20 blend at full load conditions. It is due to better combustion characteristics of nano particles which mean that allowed more amount of fuel to react with air [11].

3.4. Hydro carbon emission (HC)

Figure 4 shows the variation of hydrocarbon emission with brake power for D80J20, D80J20ZnO50 and D80J20ZnO100 blends. The HC emission of D80J20ZnO100 is decreased by 4.76% when compared to the D80J20 blend at full load conditions. This is due to shorten in ignition and ignition characteristics of higher catalytic activity which improves fuel air mixing in the combustion chamber [14].

3.5. Carbon monoxide emission (CO)

Figure 5 shows the variation of carbon monoxide emission with brake power for D80J20, D80J20ZnO50 and D80J20ZnO100 blends. The CO emission of D80J20ZnO100 is decreased by 14.75% when compared to the D80J20 blend at full load conditions. This is due to catalysts effect of zinc oxide nano particles which improves combustion efficiency and combustion characteristics of nano particles [16].

3.6. Oxide of nitrogen emission (NO_x)

Figure 6 shows the variation of NO_x emission with brake power for D80J20, D80J20ZnO50 and D80J20ZnO100 blends. The NO_x emission of D80J20ZnO100 is decreased by 3.82% when compared to the D80J20 blend at full load conditions. This is due to less fuel accumulated in the combustion chamber which leads to reduction in NO_x emissions [16].

3.7. Smoke emission

Figure 7 shows the variation of smoke emission with brake power for D80J20, D80J20ZnO50 and D80J20ZnO100 blends. The smoke emission of D80J20ZnO100 is decreased by 7.14% when compared to the D80J20 blend at full load conditions. This is due to improved ignition characteristics of zinc oxide nano particles, quick evaporation rate and shorter ignition delay [16].

4. Conclusion

In this present work, the effects of Zinc oxide nano particle additives with JME at different dosing level of the nano additives on performance and emission characteristics of a diesel engine have been studied. The main conclusions of the present study are given below.

1. It was observed that the calorific value and kinematic viscosity were improved with the

addition of Zinc oxide nano particle additives compared with B20 blend.

2. BTE of ZnO nano particle blends is increased by 2.79% when compared to the D80A20 blend. However, The BSFC of ZnO nano particle blends is decreased by 3.87% when compared to the D80J20 blend at full load conditions.

3. The CO and HC emission of ZnO nano particle blends is decreased by 14.75% and 4.75% respectively when compared to the D80J20 blend at full conditions.

4. The NO_x and smoke emission of ZnO nano particle blends is decreased by 3.82% and 7.14% respectively when compared to the D80J20 blend at full load conditions.

Finally it can be concluded that addition of zinc oxide nano particle additives in the Jatropha Methyl Ester (J20) is simple and cost effective method to improve the performance and lowering the emissions without change in any engine modification.

Acknowledgement

The author would like to thank the staff members of Internal Combustion Engineering Department, University College of Engineering Villupuram for their support in carrying these tests.

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Figure Captions

Fig 1 Experimental setup

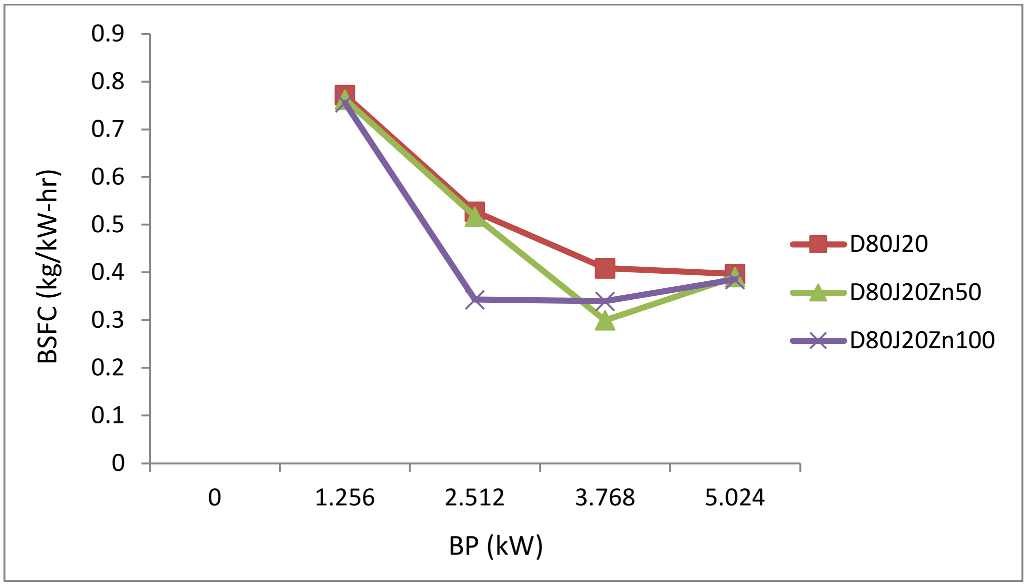

Fig 2 BP Vs BSFC

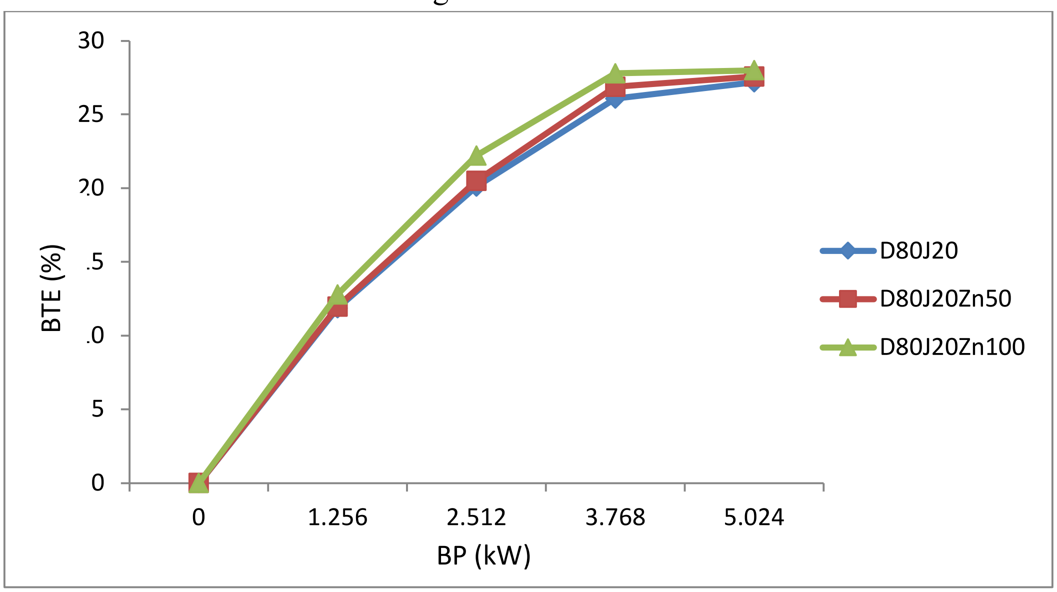

Fig 3. BP Vs BTE

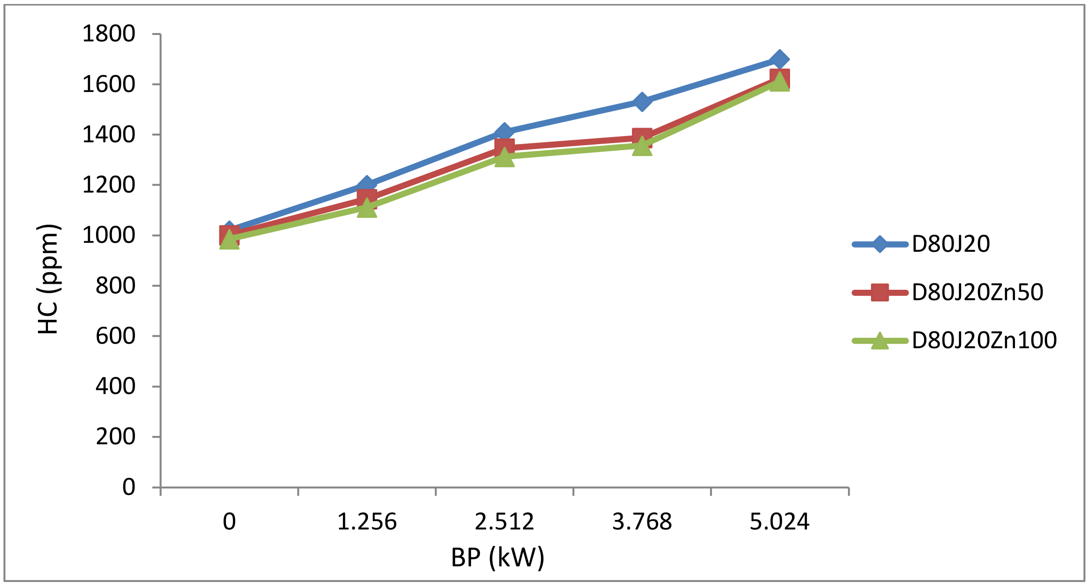

Fig 4 BP Vs HC

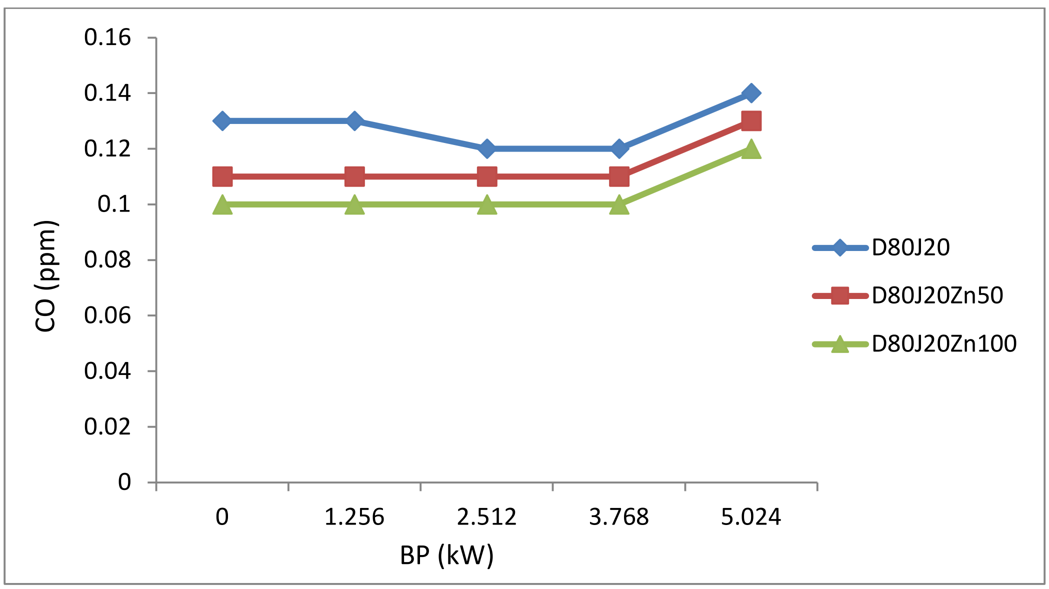

Fig 5 BP Vs CO

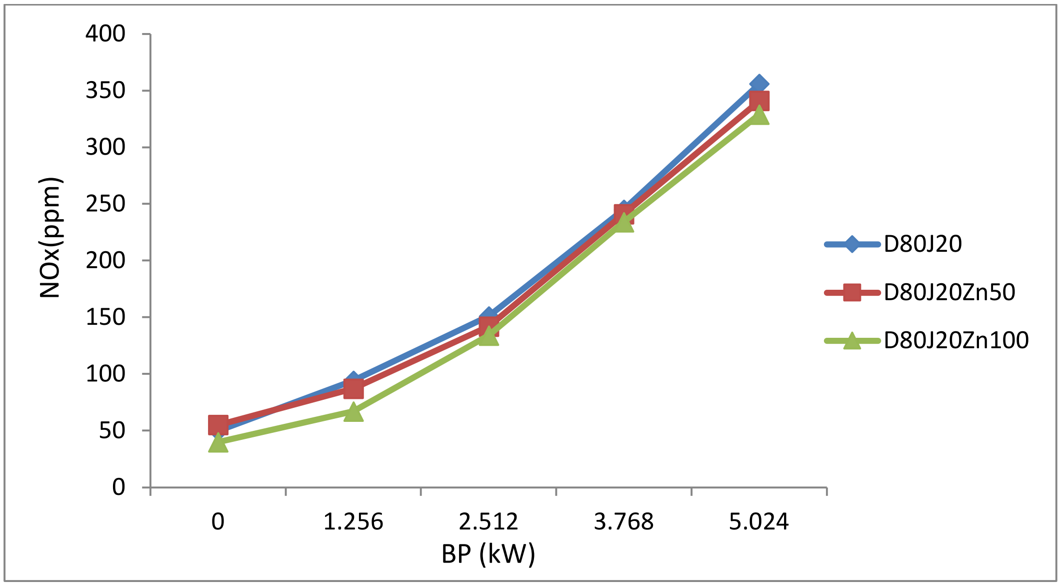

Fig 6 BP vs. NO_X

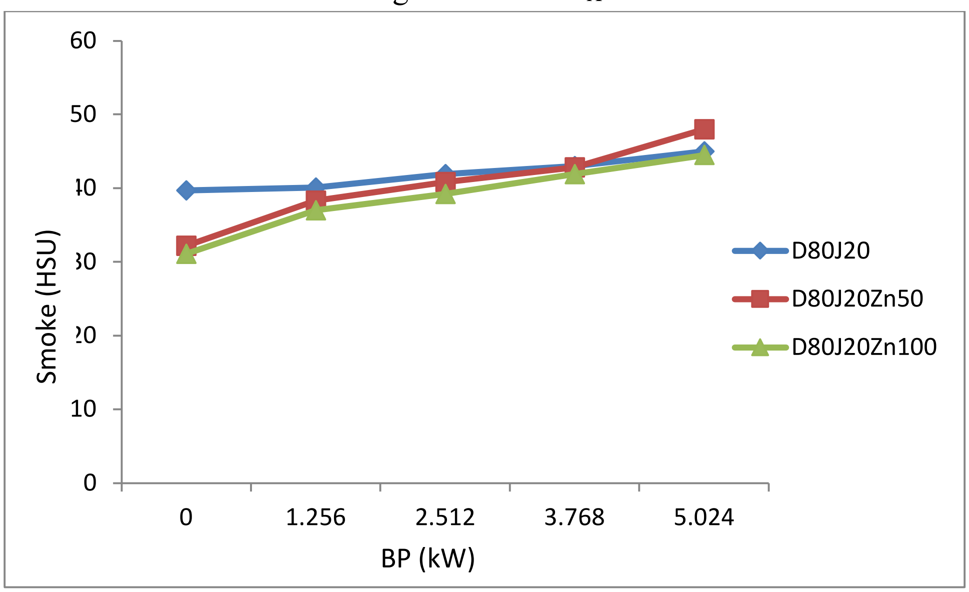

Fig 7 BP vs. Smoke

List of Tables

PROPERTY	Diesel	AOME	D80A20	D80A20ZnO50	D80A20ZnO100
Kinematic viscosity in cst at 40^0 C	4.0	5.18	3.8	3.9	4.1
Calorific value in Kj/kg	43200	39575	42475	42723	42946
Density at 15^0C in kg/mm^3	830	880.2	835	836	838
Cetane no.	46.4	52	54	57	57
Flash point (^{0}C)	50	76	52	53	55
Fire point (^{0}C)	56	92	58	60	62

Table.1.Comparison of important properties of test fuels.

Parameters	**Systematic Errors (±)**
Speed	1 ± rpm
Load	± 0.1 N
Time	± 0.1 s
Brake power	± 0.15 kW
Temperature	± 1°
Pressure	± 1 bar
NO_x	± 10 PPM
CO	± 0.03%
CO2	± 0.03%
HC	± 12 PPM
Smoke	± 1 HSU

Table.2. Experiment uncertainties