The effects of silicon oxide as an additive with a cotton seed oil biodiesel blend in a CI engine

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KEYWORDS

Cotton Seed Oil Methyl Ester,
Silicon Oxide,
Performance,
Emission,
Combustion.

ABSTRACT

Experimental investigation was carried out to study the combustion, engine performance and emission characteristics of a single cylinder, naturally aspirated, air cooled, constant speed compression ignition engine, fuelled with five modified fuel blends, Diesel, B20 (Diesel–cotton seed oil biodiesel) and Diesel– cotton seed oil biodiesel –with silicon oxide as a Nano additive with three different concentration 50ppm, 75ppm, 100ppm, and the results are compared with those of neat diesel. The Nano additive was mixed in the fuel blend along with a suitable surfactant by means of an ultrasonicator, to achieve stable suspension. The properties of B20, B20 + silicon oxide fuel blend are changed due to the mixing of cotton seed biodiesel and the incorporation of the with silicon oxide Nano additives. Some of the measured properties are compared with those of neat diesel, and presented. The cylinder pressure during the combustion and the heat release rate, are higher in the B20 + with silicon oxide 100-ppm fuel blend, compared to neat diesel. Further, the exhaust gas temperature is reduced in the case of the B20 with silicon oxide 100ppm of fuel blend, which shows that higher temperature difference prevailing during the expansion stroke could be the major reason for the higher brake thermal efficiency in the case of B20 with silicon oxide 100ppm of fuel blend. The presence of oxygen in the Cotton seed biodiesel and the better mixing capabilities of the nanoparticles, reduce the CO and UBHC appreciably, though there is a small reduce in NO_x *at full load condition.*

1. Introduction

The number of vehicles currently on the road is rapidly increasing. This scenario will create a lot more challenges for the oil supply industries to meet the demand on another side as well as increasing the depletion of fossil fuels day by day. The global warming caused by increased emissions from these vehicles leads to an increase in carbon footprint. To order to meet the demands of vehicle users, fossil fuels are increasingly declining and therefore need a change to alternative energy sources [1]. In addition, the harmful emissions that deteriorate the atmosphere are created by burning the petroleum-based fuels in a combustion engine. Therefore, due to concerns such as the scarcity of fossil fuels and the rising cost of fossil fuels, the need for the production of alternative fuels has arisen [2]. Bio fuels have certain specific characteristics features such as lower viscosity, better atomization, density, evaporation and net calorific value making them equivalent to diesel [3]. bio fuels are alternative fuels that researchers pay more attention to because of their environmentally friendly nature and their ample availability on Earth [4]. During the implementation of these bio fuels in diesel engines have significant benefits were noted such as major reduction in the engine exhaust pollutants like UBHC, Smoke emissions and CO. Majority of the scientist and researches

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suggested that 20% implementation of biodiesel to the existing diesel engine will not affects the hardware components [5]. Most Nano particles such as aluminium oxide, zinc oxide, cerium oxide, titanium oxide and carbon nano particles have been successfully used in recent time by many experts, providing many advantages such as low volume density and good thermal properties [6]. Prabhu et al., [7] used alumina and cerium oxide as biodiesel fuel additives. They blended 30 ppm of these fuel additives with the blend of biodiesel. For the experimental study they examined the impact of biodiesel mixed with diesel and nanoparticles. The experimental results showed that the biodiesel mixed with nanoparticles improved engine performance and reduced emissions of NOx, CO, HC and smoke compared to the biodiesel mixed with diesel. Ranjbarzadeh et al., [8] developed eco-friendly silicon oxide Nano particles from rice plant sources. Such Nano fluids also have roughly 6 months of high thermal conductivity and stability. The advantage of the Nano size metal additive is that it does not block the injector and can be conveniently mixed in the fuel using an ultrasonic system to create a uniformly mixed fuel [9]. Tiyagi et al., [10] reported that DF blend nanoparticles may also improve the engine's ignition delay and ignition temperature during combustion. Duple Sinha. et al., [11], presented that brake thermal efficiency waste cotton seed oil found to be decreased at higher load than diesel, due to poor air fuel mixing, higher viscosity and poor atomization. Specific fuel consumption for biodiesel will be higher than the neat diesel due to less quality of fuel injection. But emission parameters CO and HC shows lesser release rate than the diesel for all loading condition but maximum decrement obtained at maximum load. Anbarasu Augustine et al., [12], was carry out the experimental study on different preheated cotton seed oil methyl ester. BSFC for all preheated CSOME will shows higher than the diesel, this is due to poor mixture formation and higher viscosity. BTE exhibits marginal increment till 80^0C, once it reaches 100^0C the BTE start diminishing due to formation of high dense vapour. CSOME 100 shows higher CO formation due to formation of high dense vapour and causes improper atomization. HC emission characteristics were observed to be decreasing as the load increases till 80^0C preheating temperature. Huseyin Aydin. et al., [13], have demonstrated that performance and emission characteristics of cotton seed oil (5, 20, 50, 75 and 100%) in single cylinder diesel engine. At higher load, minimum speed B20 shows lesser BSFC than all fuel mixture and diesel, this is due to at lesser load B20 mixture leads complete combustion activity. CO emission for 50, 75 and 100% shows signification decrement due to presence of oxygen. B5 shows higher NOx releasing rate than all other fuel due to lesser availability of oxygen in the B5 fuel compared to other leads to less combustion performance. Basavaraj M. Shrigiri et al., [14], carried out an experiment on cotton seed oil and neem kernel oil methyl ester in semi adiabatic diesel engine. It was found the BTE shows -5.91% and BSFC shows -28.57% variation than the diesel. The emission parameters like NOx , CO, HC and smoke shows marginal increment than the diesel. Current Research Work Cotton seed is one of the main sources for biodiesel production, Cotton seed oil, B20CSME with and without SiO can be used in diesel engines with Improvement on efficiency and significant diminution of Smoke opacity, CO, HC and NOx emissions with respect to diesel.

2 Experimental Materials

2.1 Preparation of biodiesel

The importance as a textile and in the food manufacturing, the cotton crop has played evident part in the manufacture of cotton seed oil, Cotton seed function as an lavish source of oil over and above protein. it was found that fewer hydrocarbons, carbon monoxide and nitrogen oxide expend discharges were produced in comparison with diesel fuel blends. As well as the reduction density of the cotton seed oil Using transesterification method is employed in presence of alkali catalyst was performed to obtain the cotton seed oil methyl ester (CSME) as biodiesel as shown in the figure 1.

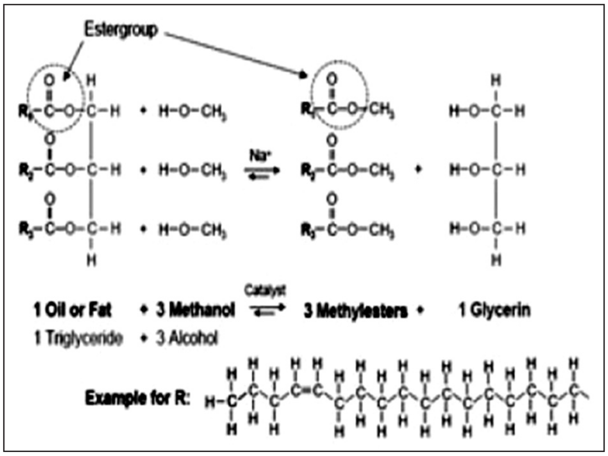

Fig. 1. Schematic representation of transesterification.

2.2 Nano fluid preparation

Silicon oxide is used as a Nano additive to CSME blends in present experimental approach. SEM analysis will employed to observe the structure, shape and size of SiO. Three different proportions 50ppm, 75ppm and 100ppm are used. Ultrasonicator helps to consistent distribution of SiO in the blend.

2.3 Fuel properties

The properties of diesel, B20CSME, B20CSME with and without additive has were determined and tested to meet the ASTM standard norms. All the properties of verified biofuels are tabulated in Table 1.

2.4 Engine setup

A Kirloskar made diesel engine has been employed to conduct the experiment at varied load. In this experiment Diesel has been considered as baseline reading and Four other fuels, that is Biodiesel and Biodiesel + additives has been considered for comparison purpose. The engine has been run from 0% to 100% load using the fuels and the results have been evaluated, tabulated and plotted on graphs for discussion

Table 1
Properties of fuels used for testing.

Properties	DIESEL	B20CSME	B20CSME SiO +50	B20CSME +SiO 75	B20CSME+ SiO 100
Kinematic Viscosity(40°C,Cst)	3.05	2.2	3.219	3.41	3.92
Heat Value (MK/Kg)	44500	42437	42697	42663	43000
Density (Kg/m^3)	850	835	840	845	850
Flash Point °C	56	68	71	69	62
Cetane Number	51	54	57	56	55

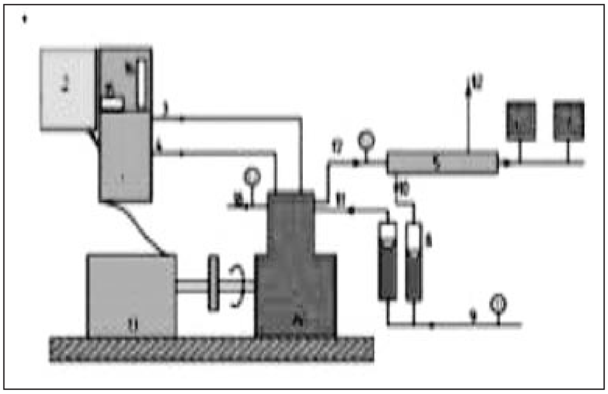

Fig. 2. The engine setup.

2.5 Error analysis and uncertainty

The experimental results will certainly have error and uncertainties, which can rise from the incorrect calibration of instruments due to excessive handling and mishandling, surrounding conditions, experimental test conditions and planning, surveillance and reading. The errors which are gotten become a hindrance to obtain accurate results. Thus to nullify these errors, tools and methods from mathematics and statistics are used. Generally the method used is repetition of the taking data from the experimentation (atleast 3 times) and finding the mean in order to minimize the error which may occur. Measurements of uncertainties were calculated and results are shown in Table 2.

3. Results and Discussion

3.1 Performance analysis

3.1.1 Brake Thermal Efficiency (BTE)

Figure 3 correlates between BTE and Load for diesel and different proportions of biodiesel blends. It has been noted that BTE magnitude increases as the load rises. This is due to increases in the quality of the fuel by addition of SiO to biodiesel blends. Addition of SiO provides higher surface area /volume ratio, which provides well atomization of the fuel. As addition of SiO supplies oxygen, hence combustion intensity is also increases. It was evident that at full load

Table 2
Error analysis and uncertainty table.

Measurements	Accuracy	Uncertainty
Speed	±3 RPM	± 0.3%
BSFC	±3 kg/KWh	± 0.35%
Power(KW)	±0.3KW	± 0.40%
CO	±0.02%	± 1.0%
NOx	±7 ppm	± 0.7%
In cylinder pressure	±0.1 bar	± 0.2%
Temperature	±1°C	± 0.1%
HC	±7 ppm	± 0.7%
Torque	± 0.1Nm	± 1%

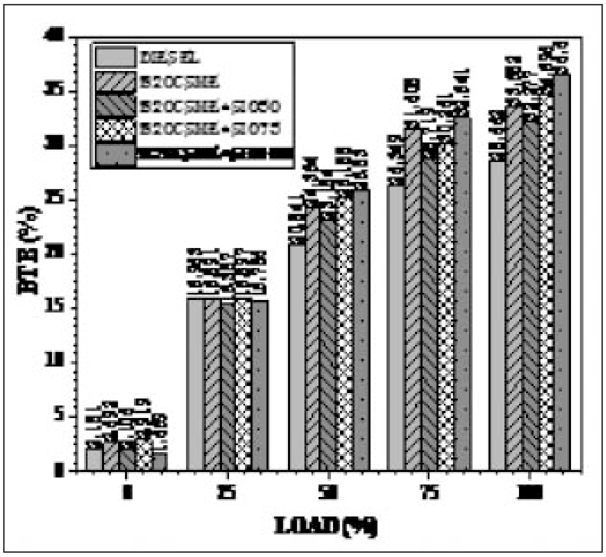

Fig. 3. BTE VS Load.

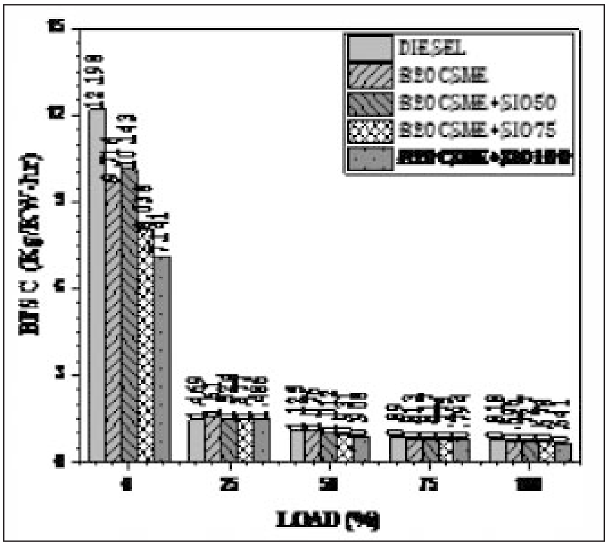

Fig. 4. BSFC VS LOA.

B20CSME + SiO100 shows maximum BTE than neat diesel and different fuel blends. B20CSME + SiO100 shows +27.69% and +8.98% than diesel and B20CSME.

3.1.2 Brake Specific Fuel Consumption (BSFC)

The variation of BSFC vs Load Figure 4 exhibits. BSFC shows depressions characteristics as load increases. Methyl ester chain contains oxygen molecule thereby increases in the power output than diesel. As the addition of SiO nano catalyst enhances the quality of the fuel by limiting the consumption and provides higher output per unit mass of the fuel. At peak load BSFC for B20CSME + SiO100 shows least value and it variation was found to be -21.63% and -7.90% than diesel and B20CSME

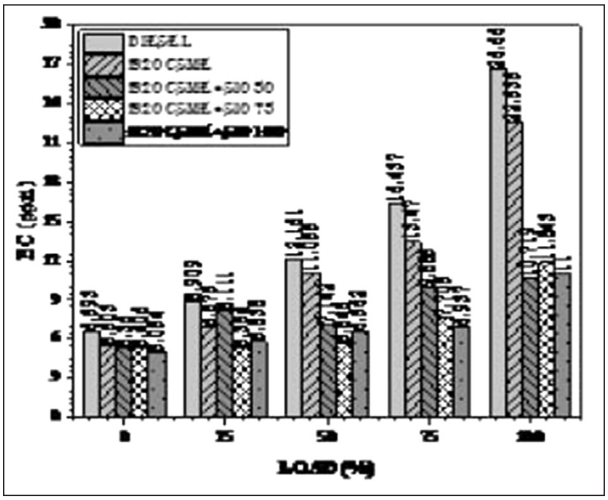

Fig. 5. HC VS Load.

3.2 Emission analysis

3.2.1 Hydrocarbon (HC)

Figure 5 exhibits the relation between HC vs Load. It was evident that UBHC for biodiesel with and without nano additive shows lesser value than the neat diesel. Due to presence of oxygen molecule in the biodiesel leads to increase in the combustion hence B20CSME will shows lesser UBHC than diesel. As addition of SiO nano additive to biodiesel provides the addition oxygen for the combustion activity. B20CSME + SiO100 show lesser UBHC than diesel. UBHC for B20CSME + SiO100 shows -60.42% variation than neat diesel.

3.2.2 Carbon Monoxide (CO)

Variation of CO with Load as Figure 6 exhibits. CO mainly depends upon the air fuel ratio. it was observed that B20CSME + SiO100 shows lesser CO content due to addition of nano additive will improves the combustion activity of the fuel by reducing the ignition delay period. Due to minimum ignition delay period of air fuel mixing and consistent burning of fuel will accelerate the combustion. At higher load CO showed -25% and -14.28% than the diesel and B20CSME.

3.3.3 Nitrogen Oxides (NOx)

The variation of NOx with load, Figure 7 exhibits. NOx formation in the engine cylinder is due to presence of foreign particle present in the fuel. At full loading condition B20CSME will shows higher NOx due to accumulation of oxygen molecule at different localized position. As addition of Nano

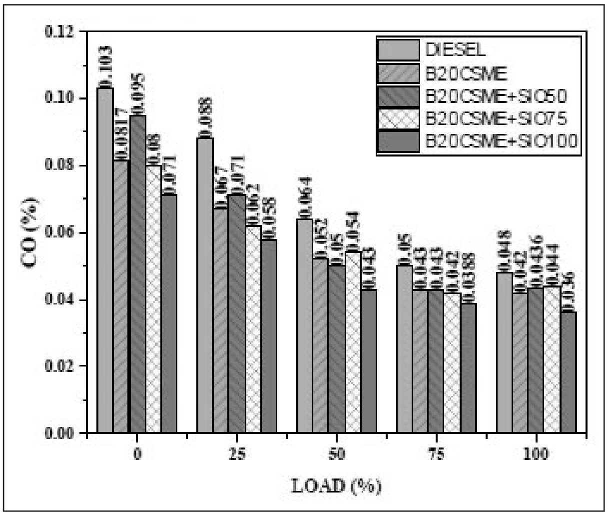

Fig. 6. CO vs Load.

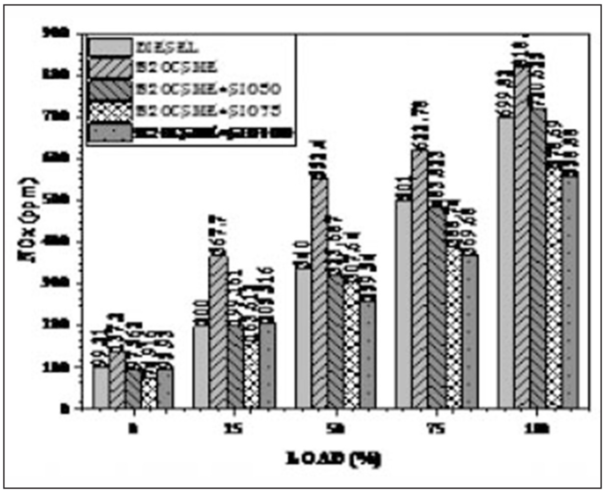

Fig. 7. NOx vs Load.

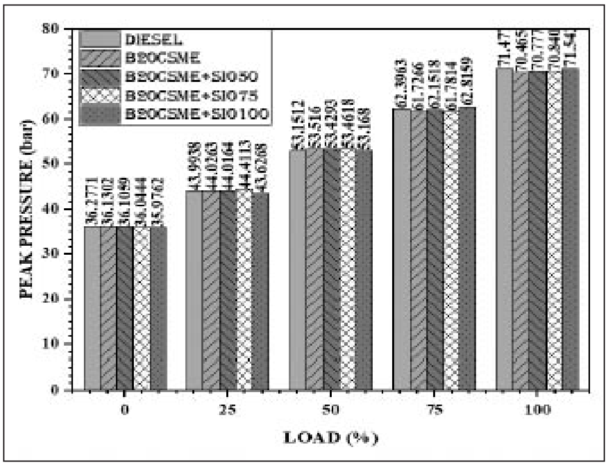

Fig. 8. Pressure Vs Load.

additive to biodiesel provides higher surface to area/volume ratio and promotes the complete combustion activity. B20CSME + SiO100 shows -20.13% and -31.67% variation than the diesel and B20CSME biodiesel.

3.3 Analyses of combustion

3.3.1 Peak Pressure (PP)

Figure 8 correlate between Pressure and Load. Cylinder maximum pressure mainly depends on quantity of mass of the fuel burnt during combustion in the premixed phase. As the proportion of nano additive increases in the biodiesel blends boost the combustion due to reduction in the ignition delay period. At full load condition B20CSME + SiO100 shows marginal increment in the cylinder pressure than B20CSME and Diesel. Cylinder pressure for B20CSME + SiO100 found to be 71.54 bar at full loading condition.

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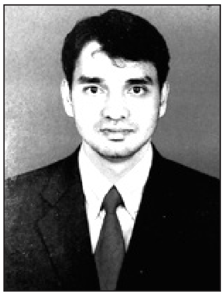

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