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Behaviour Of Cottonseed Oil Blended With Single-Walled Carbon Nanotubes In, Direct Injection Single Cylinder Diesel Engine

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Abstract

Nano fuel was prepared by trans-esterification of the pure cottonseed oil mixed with ethanol (99%) and KOH as a catalyst. The physical and chemical properties of cottonseed oil blended with Single-walled Carbon Nanotubes (SWCNT) and Ethanol Dispersion for possible fuel in the single-cylinder 4 stroke diesel operated engine was characterized through ASTM standards for fuel tests. The experiment was conducted to investigate the emission, combustion and performance behavior of single cylinder with the help of nano fuels blended with SWCNTs. The blended fuel is used to investigate while pure cottonseed oil was used for reference data acquisition. The SWCNTs and Ethanol dispersion were blended with the mass of the cottonseeds oil in the amount of 30 and 60 PPM by the help of homogenization tools followed by an ultrasonic bath. The experiment conducted with the help of experimental set-up having a single- cylinder direct ignition 4 stroke diesel operated engine connected with a cartridge smoke meter, eddy current dynamometer, load, data acquisition and gas analyzer MRU 1600s. All experiment was investigated at 1500 RPM and outcomes show the increase in calorific value, substantial decrease in the harmful gases and brake thermal efficiency because of the uses of SWCNTs in the cottonseed oil was found.
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Keywords: *CSO-SWCNT; Ignition delay; Cottonseed Oil; nano fuels; Ultrasonicator;*

1. Introduction

Diesel engine is sturdier and fuel efficient than the gasoline engine. However they are producing particulates of matter, obnoxious odor, smoke and NOx which are hazardous. To enhance in production and decrement in emission from the diesel operated engine, different-different procedure like, alteration in engine design, treatment of exhaust gas and modification in fuel and many others has been incorporated. Regards of this so many advanced and new

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methods in nanotechnology are showing the potential use of nano fuel[1]. compared to diesel the fuel blended with nano particles are showing different thermal and physical properties significantly. Since at nano scale the ratio of surface area to volume increases which gives a more surface area of during the rapid oxidation[2]. Energy providing materials can provides more than two times the energy even compared to explosion in molecules due to size dependent properties[3]. Many researchers found that lower the heat of fusion and lower melting points if the size of the metal particles decreases[1], [4].

2. Use of Single Walled Carbon Nanotubes (SWCNTS)

Yeter et al[5]. discussed that combustion of metal-nano particles and depicted the nano size powder having higher potential and specific surface area for storing the energy that allows for higher reactivity. They also stated, by mixing the nano catalyst in hydrocarbon fuel cause decrease in ignition delay and emissions soot.

Marquis and Chibante's[6] found that the suspended carbon nanotubes in base fuel increases the settling time as well as surface area volume ratio.

Sadhik Basha & Anand[7] shows the emission and performance behaviour when diesel is blended with CNT is used in diesel engine. They found the appreciable decrease in hazardous emission and increment in brake thermal efficiency compare to diesel. They also shows that the application of nano fluids in diesel operated engines and found that by mixing in particular amount of carbon nanotubes in the diesel decreases the time of evaporation, and hence shorter the ignition delay.

3. Experimental Set Up

The experiment was conducted in two steps. In step one, physical and chemical characteristics of new 'Cottonseed Oil mixed with Ethyl-Single walled carbon nanotubes' (CSO-SWCNT) were found and differentiated with the reference fuels. The characteristics which was noted that are calorific value, kinematic viscosity, flash point, cloud & pour point etc. In step two, the combustion and emission test, extensive performance was investigated on direct injection 4 stroke single cylinder diesel engine with new and reference fuels. For loading on engine eddy current dynamometer was used. Using stop watch and burette the rate of fuel flow were measured by volumetric basis. For steady state operation of equipment AVL and for emission characteristics Hartridge smoke meter was used. The tests performed by using diesel, pure cottonseed oil and CSO-SWCNT and differentiated with the operation on diesel. The details of the experimental diesel operated engine are given below in table 1. Pressure and timing of injection in CSO-SWCNTs and diesel operation was set at their optimum condition Viz. 230 bar and 20^0 BTDC in CSO-SWCNTs and 230 bar and 23^0 BTDC for diesel. The method of blending of the cottonseed oil and the SWCNTs and the experimental procedure for getting the characteristics of fuels are as given in table 2 and 3. The experimental set up is shown in figure 1.

Fig. 1. Experimental Set Up

4. Blends preparation of CSO-SWCNT

SWCNTs was weighed first 30 PPM (by mass fraction) as predetermined which allow to dispersed in the CSO by using ultrasonicator which was set to the frequency of 40 kHz, 120 watt for around 40-45 minutes[4], [8]. The SWCNTs blended-CSO nano fuel was prepared and by the same method for 60 PPM was also prepared.

Table 1. Specification of diesel engine

Engine Details (Parameters)	Engine
Engine type	Single cylinder direct injection 4 stroke diesel operated water cooled bare engine
Manufacturer	Kirlosker
Model	TV1
Pressure for Nozzle opening	200-205 bar
Power rated	AT 1500 RPM 5.2 kW (7 hp)
Bore Diameter of cylinder	8.75 cm
Overloading capacity	10% of rated output
Specific fuel consumption	185+5% , gm/hp-hr
Length of stroke	11.0 cm
Compression Ratio	17.5/1

Table 2. Properties of SWCNTs sample

Parameters	SWCNT
Manufacturing Company	ADNANO Technologies Private Ltd.
Bulk Density, gm/cc	0.04-0.16
Particle Size, mm	5-25 Length- >5µm
Specific Surface Area - m^2/g	330
Purity - %	90

Table 3. Properties of blended samples used in this study.

Fuel Type	Flash Point (^0C)	Kinematic Viscosity- mm^2/s at 40^0 C	Total Calorific value in MJ/Kg	Density at 15^0 C
Diesel	58	20-35	43.300	840
CSO	3	4	4	4
CSO30SWCNT	154	31.727	36.405	898
CSO60SWCNT	149	31.90	37.363	900

5. Results and Discussions

While performing the investigation, compression ratio, pressure and timing of injection for CSO-SWCNTs and diesel operation was at their optimum viz. 17.5, 230 bar and 20^0 BTDC for CSO-ECN and 17.5, 230 bar and 23^0 BTDC for diesel respectively. During the investigation it was found that at full load the properties mentioned below changes abruptly so hence our all investigation was limited up to 75% load only.

5.1. Variation In Brake Thermal Efficiency

The Brake Thermal Efficiency[7], [9], [10] (BTF) variation in CSO and CSO-SWCNTs blended fuels are shown in figure 2. Due to high viscosity the CSO operation resulted in inferior performance and lower calorific value and lower volatility. However CSO-SWCNTs brake thermal efficiency was observed better compare to pure CSO operation, probably this could result because of combustive properties of SWCNTs. Normally nano particle having higher reactive surface and surface area allows for greater chemical reactive property for being a prospective catalyst[5], [11]. By this perspective, SWCNTs catalytic activity could have enhanced because of greater surface area. Additionally, in the case of CSO60SWCNT fuel may be the catalytic activity increased because of higher dosage of SWCNTs compared to the CSO30SWCNT. Because of this, CSO60SWCNT having greater brake thermal efficiency compared to CSO30SWCNT. CSO60SWCNT having maximum brake thermal efficiency is 24% whereas for CSO30SWCNT it is 23% compared to 22% for neat CSO and 27% for neat diesel at the load of 75%.

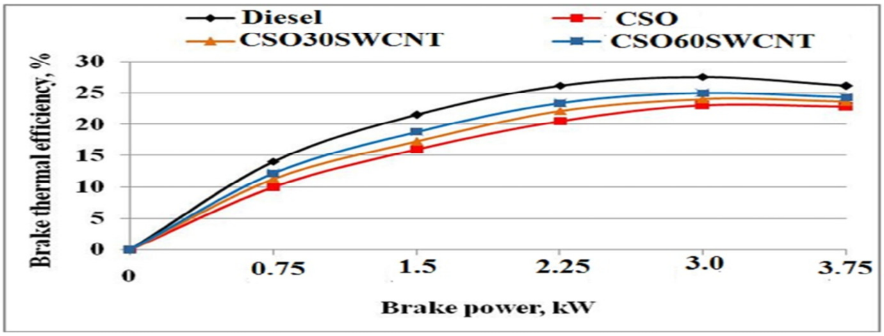

Fig. 2. Variation of Brake thermal efficiency vs. Brake power

5.2. Variation In Smoke Density

Smoke density in CSO and blended CSO-SWCNTs fuels are shown in figure 3. Results in CSO operation greater smoke density compare to diesel operation because of molecular structure heavier and volatility was lesser. While decreased smoke density was found in CSO-SWCNTs blended fuel. This results shorter delay in ignition properties of CSO-SWCNTs blended fuels. Smoke density for CSO60SWCNTs is 60 HSU while 64 HSU for CSO30SWCNT, compare to 76 HSU in CSO and 52 HSU in diesel at 75% load.

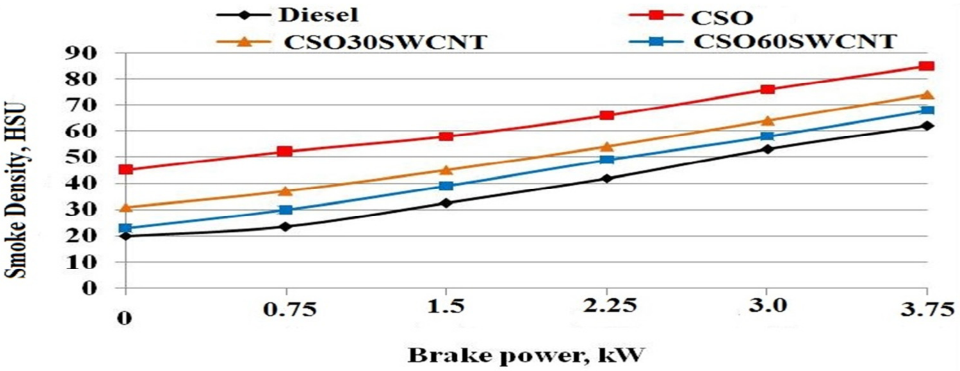

Fig. 3. Variation of Smoke density vs. Brake power

5.3. Variation In Hydrocarbon

The unburnt hydrocarbon (HC) emission for CSO and blended CSO-SWCNTs fuels are shown in figure 4. The emission of hydrocarbon in diesel operation was lower than the CSO operation because of lower thermal efficiency of CSO results incomplete combustion. While Hydrocarbon emissions was lower in the blended CSO-SWCNTs fuel than CSO. This could happen because of increased combustion properties and catalytic activity of SWCNTs which causes combustion improvement. The hydrocarbon emission in CSO60SWCNTs was 60 PPM while 70 PPM in CSO30SWCNTs, in comparison to 84 PPM in CSO and 32 PPM in case of diesel at 75% load.

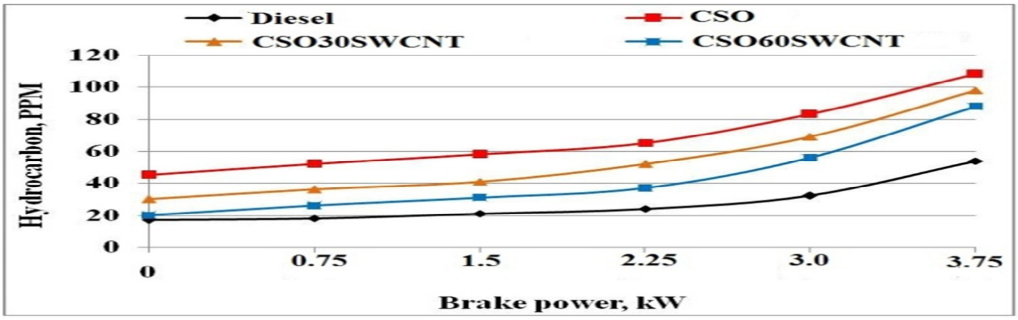

Fig. 4 Variation in hydrocarbon vs. brake power

5.4. Variation In Carbon Monoxide Emission

Emission of Carbon Monoxide(CO)[9] in CSO and blended CSO-SWCNTs fuels are shown in figure 5. The emission of CO in CSO operation was greater compare to diesel operation because of lesser combustion of CSO. While emission of CO was comparatively lesser in blended CSO-SWCNTs fuel than the CSO. The improved combustion and greater catalytic activity of SWCNT improves the performance. Emission of CO in CSO60SWCNT was 0.22% while it was 0.28% in CSO30SWCNT,compare to 0.44% in CSO and 0.1% in pure diesel at 75% load.

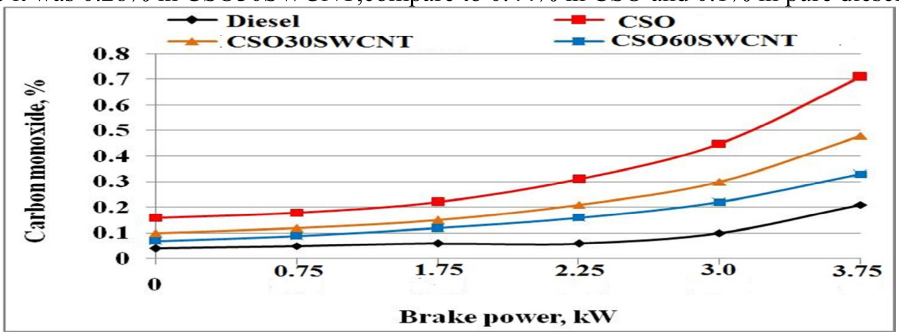

Fig. 5. Variation in Carbon monoxide vs. brake power

5.5. Variation In NOx Emission

NOx emission[7], [11], [12] in CSO and blended CSO-SWCNTs fuels are shown in figure 6. For CSO-SWCNTs operation emission of NOx was lesser compared to diesel operation. In premixed phase of combustion rate of heat releasing in CSO-SWCNTs was lesser which cause the decrease in peak temperatures which causes the NOx formation, while blended CSO-SWCNTs fuels having higher emission of NOx compared to CSO because of reduced delay in ignition which results in greater premixed combustion fraction and hence greater peak temperature was observed in blended CSO-SWCNTs fuels. The emission of NOx in CSO60SWCNT was 730 PPM while it was 600 PPM in CSO30SWCNT, compare to 570 PPM in CSO and 800 PPM in neat diesel at 75% load.

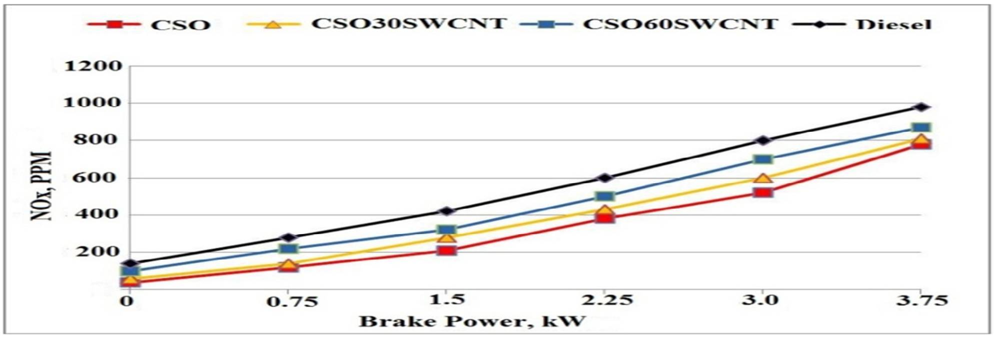

Fig. 6. Variation in NOx vs. Brake power

6. Conclusions

The emission and performance characteristics of CSO, CSO-SWCNT blended fuels were tested in a direct injection 4 stroke single cylinder diesel operated engine with constant speed. Conclusion has been estimated based on experimental data are as follows:

- CSO-SWCNT blended fuel having better brake thermal efficiency compared to CSO
- In terms of increased smoke, HC, CO emission CSO having poor performance compare to pure diesel operation.
- The oxides of Nitrogen emission in CSO-SWCNTs blended fuel operation is relatively more compared to CSO operation.
- Fortifying greater dispersion of SWCNTs in CSO is still a research topic. This investigation is restricted up to a maximum of 60 PPM of SWCNTS.

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