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Performance Analysis of CuO_2Nanoparticles Addition with Neochloris Oleoabundans Algae Biodiesel on CI Engine

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An experimental research is performed to determine the performance qualities of a variable compression engine at constant speed using copper oxide nanoparticles as being fuel-borne additives in diesel–biodiesel blend. In this research, the effects of adding CuO2 nanoparticles to neochloris oleoabundans methyl ester-diesel blended (B20) fuel on compression-ignition engine had been experimentally investigated. The B20 with 25, 50, 75, and 100ppm dosage of CuO2 nanoparticles were examined at various engine loads and constant engine speed. The fuel blends were labelled as B20, B20+25ppm, B20+50ppm, B20+75ppm and B20+100ppm. Moreover, even without the any engine alterations, the performance properties of those fuel blend samples were investigated through the experimentally measured standards like viscosity, density, cloud point, calorific value and pour point while the engine performance has also been examined through the factors like EGT, BSFC, and BTE. The experimental outcomes show that the use of biodiesel blend along with CuO2 nano particles in diesel fuelled engine has revealed good improvement in performance.

Keywords: Neochloris Oleoabundans algae oil, B20, CuO_2 Nano additives, Ultrasonication, Performance

Introduction

Fast depletion of non-renewable fuels has recommended research and development on substitute renewable fuels. In this situation, vegetable oils are observed to be a possible energy resource which can replace fossil fuels. The oil have been gathering popularity as a substitute fuel for the diesel fuelled engines since its characteristics are nearly the same as those of diesel fuel[1].Biodiesel is the crucial renewable alternative to diesel fuel in diesel engine uses. Many analysis works has been practiced to analyze the efficiency as well as engine emissions of unmodified diesel fueled engines, operated with biodiesels produced from eatable vegetable oils as well as non-eatable vegetable oils correspondingly[2]. At this regards biodiesel is non-risky, eco-friendly and biodegradable for environment compared to diesel fuel. Alternate fuel for compression ignition engine is made from agricultural feed stocks as well as pure vegetable oil, such biodiesel are being used as a substitute of standard diesel fuel. For that reason, the feed stocks of those renewable sources such as agricultural wastes, edible and also non-edible organic oils are viewed as the possible fuel for complete substitution of diesel fuel in CI engines[3].

Materials and methods

Fuel property test

The test fuel standards are kinematic viscosity, density, flash point, calorific value, cloud point and pour point for B20 and its blends B20+25ppm, B20+50ppm, B20+75ppm, B20+100ppm are described in Table 1. The benefits of increasing flash point in biodiesel consist of greater safety, which makes it easier to transport when compared to diesel fuel; less fire risk, more safer to storage as well as limited chances of uncontrolled explosion. This will lead to enhanced operation heat, greater losses, higher pressures and temperatures and also decreased overall cycle efficiency. However, rise in density of biodiesel in a fuel sample decreases its calorific. It causes greater fuel consumption[4].

Preparation of nano blends

The nano blends are prepared separately through B20 extracted from neochloris oleoabundans algae methyl ester with the CuO_2 nano particle, added to every blend B20, at the dosages of 25, 50, 75, as well as 100 ppm with the aid of an ultrasonicator. The CuO_2 nanoparticles at average size of 50 to 100nm are

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Table 1 — The specifications measured based on ASTM standard for B20 and Al_2O_3 blend fuels

Properties	ASTM	B20	B20+25 (CuO_2)ppm	B20+50 (CuO_2)ppm	B20+75 (CuO_2)ppm	B20+100 (CuO_2)ppm
Density (g/cm^3)	D-4052	0.830	0.831	0.8317	0.8318	0.8319
Kinematic viscosity at 40 ˚C (mm^2/s)	D-445	4.73	5.1875	5.6449	5.6671	5.6894
Flashpoint (min ˚C)	D-92	176	176.5	177	177.5	178
Cloud point (˚C)	D-2500	-1	-4	-4	-4	-4
Pour point (˚C)	D-97	-4	-4	-4	-4	-4
Calorific value (kJ/kg)	D-240	43540	44511.5	45483	45501	45519
Cetane index	D-613	58	54.75	51.5	51.75	52
Water and sediment (% vol.)	D-2709	0.05	0.05	0.05	0.05	0.05

supplied by M/s. Alfa Aesar, USA. The properties of CuO_2 nanoparticles are described in Table 2. The nano particles were weighed to a quantity of 25 ppm and also distributed in all biodiesel blends with the help of ultrasonicator set at a power as well as frequency of 110 W and 35 kHz, correspondingly, for 30 minutes, to generate the nanoparticles mixed biodiesel fuel (B20+25ppm). A similar process is tried for the mass portions of 50, 75 and 100 ppm to the CuO_2 nanoparticles added biodiesel fuels placed in test tubes in stable conditions for evaluating the stability properties. Through the characterization tests, it was found which they were stable for more than a month[5].

Table 2 — Properties of CuO_2 nano particles

Item	Specifications
Manufacturer	M/s. Alfa Aesar, USA
Chemical name	Copper oxide (CuO_2)
Average particle size	< 50 nm
Specific surface area	> 40 m^2/g
Appearance	White colour

Experimental setup

A Kirloskar single cylinder, four-stroke diesel engine with load arrangement of eddy current dynamometer had been used to carry out the different experimental researches for the combustion, performance as well as emission. For this analysis, Kirloskar engine is recommended as test engine, because it can also not be difficult to carry out the necessary modifications. AVL 444DI gas analyzer as well as AVL 437C smoke meter had been employed for testing the emissions from the test engine. The engine specifications are indicated in Table 3. The fuel consumption had been calculated with the burette for various loading through the eddy current dynamometer. All the testing measurements were done after enabling the engine to perform for specific period without including load for warm-up and also to achieve the steady operating condition. All the test readings had been taken at a constant speed of 1500 rpm to make the various analyses[6].

Table 3 — Technical specifications of the test engine

Engine specifications	
Make	Kirloskar
Number of cylinders	One
Stroke	110 mm
Cycle	Four stroke
Displacement volume	661 cc
Bore	87.5 mm
Type of cooling	Water cooling
Injection timing	23°BTDC
Rated power	5.2 KW @ 1500 RPM
Nozzle opening pressure	210 bar
Compression ratio	16.5:1
Lubrication system	Splash system
Type of governor	Mechanical centrifugal type
Valve timing	
Inlet valve opening	12° before TDC
Inlet valve closing	33° after BDC
Exhaust valve opening	38° before BTC
Exhaust valve closing	3° after TDC

Result and Discussion

Performance Analysis

Brake Thermal Efficiency

Figure 1 indicates the change in BTE with load for various fuel blends. Even without the load, all fuel blends showed the same BTE. When the load applied on the engine was increased, the BTE also get increased because of the BTE is a function of Brake power. The BTE of B20 along with CuO_2 nanoparticles added fuels were marginally increased when compared with B20 blend. According to the results, it can also be determined that the addition of CuO_2 nanoparticles has a significant effect on engine performance. This can be probably caused by the better combustion properties of the CuO_2

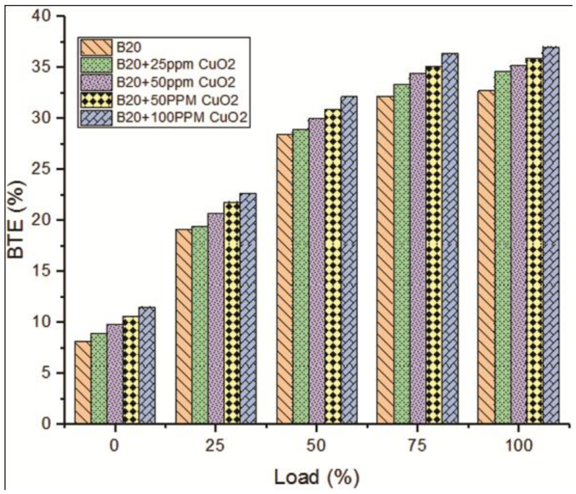

Figure 1 — Variation of Brake thermal efficiency with load

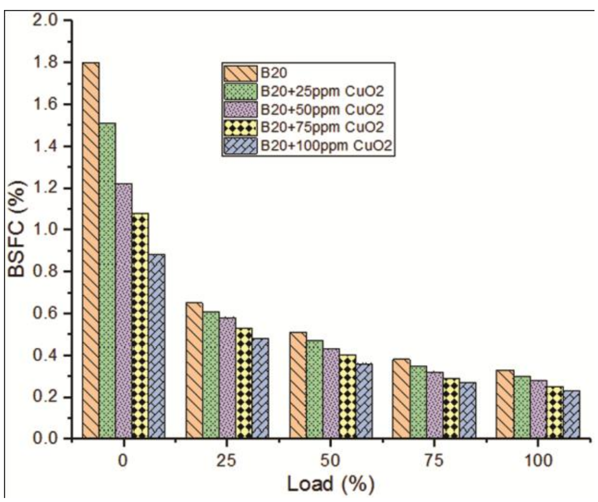

Figure 2 — Variation of Brake specific fuel consumption with load

nanoparticles added fuels[7].The increase in BTE for the nanoparticles spread out testing fuels is a result of the enhanced combustion, atomization as well as fast vaporization with the nanoparticles spread test fuel, producing improved air fuel mix that allows higher surface area of the fuel to work with O_2 molecules

Brake Specific Fuel Consumption

The change of BSFC emissions with the load for all the test fuel samples was indicated in Figure 2. The BSFC value of B20 with CuO_2 nanoparticle added fuel blends was decreased when increasing the dosage level of CuO_2 nanoparticles. According to these results, the CuO_2 nanoparticles affected the better atomization as well as increased combustion, and so, the fuel consumption was decreased while increasing the power. Generally, the BSFC of the CuO_2 nanoparticles added fuel blends had been lowered

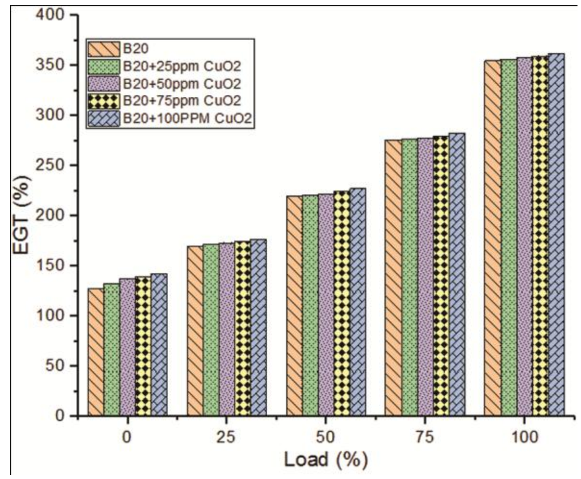

Figure 3 — Variation of Exhaust gas temperature with load

when compared with B20. This is likely because of the lower calorific value of the B20 fuel[8].

Exhaust Gas Temperature

Figure 3 indicates the change of exhaust gas temperature with respect to load. It can be observed that the EGT had been improved while increasing the load for all the test fuels. The EGT for B20, B20+25ppm, B20+50ppm, B20+75ppm, and B20+100ppm at full load respectively. From this Figure, it can be found that the EGT of the CuO_2 nanoparticles added fuel blends were higher than that of the B20. This can be related to the advanced fuel injection. Moreover, the higher utilization of oxygen content by the CuO_2 nanoparticles added fuel blends raise the combustion process that enhanced the peak temperature as well as thereby improved the EGT[9].

Conclusion

Experimental investigation of CuO2 nanoparticle additives burning in diesel fuel engine had been performed at different dosage of the nanoparticle. The fuel properties of all test fuel blends met the ASTM specifications. The fuel classification data revealed some similarities as well as differences with regards to B20 and also B20 along with CuO_2 nano additives. Nanoparticles added fuel blends had greater BTE, EGT and lesser BSFC than B20. B20 with CuO_2 nanoparticle added fuels emitted less CO, HC as well as smoke opacity than B20. NOx emissions of the nanoparticle added biodiesel blends were more compared to B20. B20 along with CuO_2 added fuel blends showed high peak cylinder pressure, rate of pressure rise and also lesser net heat release when compared with B20. As a result of this research, the

CuO_2 nanoparticles at 100ppm quantity can be used as fuel additives for the biodiesel to increase the performance and combustion properties and also to reduce the exhaust emissions when used in diesel engines.

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