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Experimental Investigation of Performance and Emission Characteristics of Diesel-Bio Diesel (CSOME) with Nano Additive Blends in CI Engine

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Abstract

Increasingly stringent emissions regulations and environmental concerns have caused interest in the development of alternative fuels for internal combustion engines. Recently biobutanol, bioethanol and biodiesel emerged as an alternative fuel due to their oxygenated nature. This paper investigates the physical stability of ethanol-diesel blends using Cottonseed oil methyl esters diesel emulsifier as additives, subsequently analysis of physio-chemical properties. Furthermore, experimental tests were carried out to study the performance (fuel consumption, thermal efficiency, power, exhaust gas temperature) and emissions (CO, NOx, HC and Smoke) of Direct Injection (DI) engine fuelled with the various blends compared with those fuelled by diesel. The blends used for this study were D50B50, D60B30E10, D60B20E15DEE5 And D40B40E10DEE10.

Keywords: Biodiesel; Ethanol; Nano additive; Performance; Emission

Introduction

"It is difficult to imagine a human society without the ease of transportation facilities provided by the Automobiles. The idea that for millennia humans managed to survive, and even to thrive, without such a contraption is inconceivable to many in today's World."

While the invention of the internal combustion engine revolutionized transportation in the 20th century, it also brought with it many inherent problems, including a dependence on natural resources (oil) and air pollution, both of which have spurred research in recent years to find an alternative power source to run public and private forms of transportation [1,2]. The society we live in today has been continuously abused through our exploitation of nature for human progress. This state of affairs has created a scenario where the scientists are predicating terrible straits for the future. Yet, humans have reached such a position that going back to the past is virtually impossible. The problem of vital importance that we face today is pollution. A step further is the prediction that within a few decades we will not have any fossil fuels left to consume (Figure 1).

Production of Bio-Diesel

Trans-esterification process

The most common derivatives of agricultural oil for fuels are methyl esters. These are formed by Transesterification of the oil with methanol in the presence of a catalyst (usually basic) to give methyl ester and glycerol [3-5]. Sodium hydroxide (NAOH) is the most common catalyst, though others such as potassium hydroxide (KOH) can also be used. The technology required for carrying out the Transesterification process is very simple. In its crudest form, it can be in low volumes as a batch process. The methanol and NaOH are premixed and added to the oil, mixed for a few hours, and allowed to gravity settle for about 8 hours. The glycerin settles to the bottom, leaving Biodiesel on the top (Figure 2).

Figure 1: Images of cottonseed.

Figure 2: Transesterification setup.

Biodiesel Benefits

Biodiesel is a substitute or extender for traditional petroleum diesel and you don't need special pumps or high-pressure equipment for fuelling. In addition, it can be used in conventional diesel engines, so you don't need to buy special vehicles or engines to run bio diesel [6,7].

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Scientists believe carbon dioxide is one of the main greenhouse gases contributing to global warming. Neat bio-diesel (100 percent biodiesel) reduces carbon dioxide emissions by more than 75 percent over petroleum diesel. Using a blend of 20 percent biodiesel reduces carbon dioxide emissions by 15 percent.

Since biodiesel can be used in conventional diesel engines, the renewable fuel can directly replace petroleum products; reducing the country's dependence on imported oil [8-10].

Biodiesel mixes readily with petroleum diesel at any blend level, making it a very flexible fuel additive (Table 1).

Properties	Diesel	Biodiesel	Ethanol	DEE
Density (kg/m^2)	850	916	789	713.4
Kinematic viscosity at 40°C (Cst)	3.05	5.8	0.795	0.223
Calorific value (kj/kg)	42,800	39400	29700	33892
Cetane number	47	50	5-7	85-89
Flash point (°C)	85	129	14	-45
Surface tension N/m at 20°C	0.023	0.025	0.02239	0.017
Latent heat of Evaporation kJ/kg	250	240	922	376
Molecular weight	170	200	46.07	74.12
Stoichimetric air to fuel ratio Wt/wt	15	13.5	9	11.1
Autoignition temperature (°C)	316	____	422	160
Boiling point (°C)	188-344	____	78	34
Carbon content % weight	84-87	____	52.2	64.86
Hydrogen content % weight	33-16	___	13.1	13.5
Oxygen content (%) weight	0	10	34.7	21

Table 1: Main properties of blending stock.

Name of Engine	Kirloskar
General details	Single cylinder 4-stroke DI engine
Bore	80 mm
Stoke	110 mm
Compression ratio	16:01
Rated output	3.7 KW
Rated speed	1500 rpm

Table 2: Engine specification.

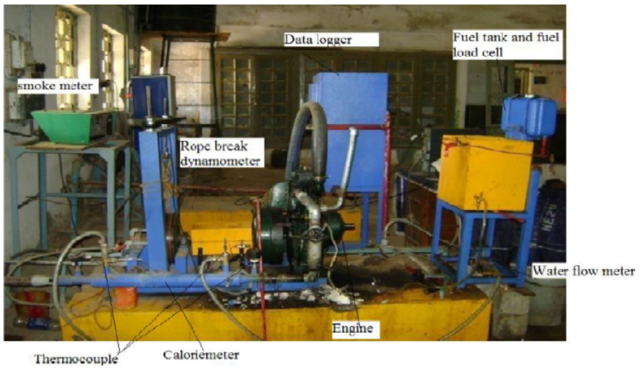

Figure 3: Experimental set up.

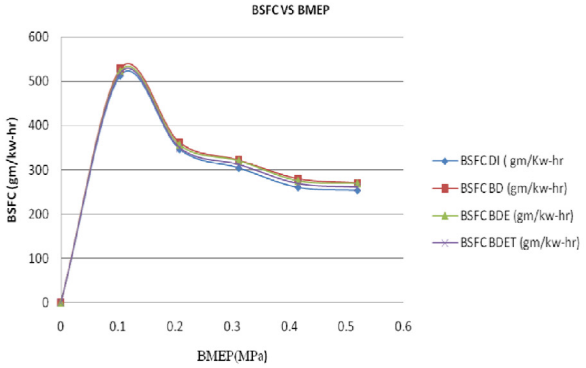

Figure 4: Comparison of brake specific fuel consumption vs. brake mean effective pressure.

Equipment and Experiments

Experimental fuels

The various phases of tests on the above setup are carried out on the following phases (Table 2 and Figure 3):

> Running the engine with Diesel alone [11,12].

> Running the engine with different blend ratios of Diesel and Cottonseed Oil Methyl Ester and DEE

- Diesel-50% + Biodiesel-50%
- Diesel-60% + Biodiesel-30% + Ethnol-10%
- Diesel-60% + Biodiesel-20% + Ethnol-15% + Dee-5%
- Diesel-40%+ Biodiesel-40% +Ethnol-10% + DEE-10%

Experimental setup and Procedure

The engine used was a single cylinder, naturally aspirated, four strokes, and direct injection diesel engine with a bowl in piston combustion chamber. The basic data of the engine used are given in Table 2. With the liquid fuel injection, a high-pressure fuel pump was used, a three hole injector nozzle. The injector nozzle was located in the center of the combustion chamber and has an opening pressure of 0.5MP. A load cell was used for measuring applied load on rope break dynamometer also A load cell was used to measure the fuel flow. Smoke was measured by apex 2000 II smoke meter. The test installation is shown in Figure 1. To ensure that the accuracy of the measured values was high [13-15]. The smoke meter was also allowed to adjust its zero point before each measurement. The experiments were carried out by four test fuels at different engine loads. Before running the engine to a new fuel, it was allowed to run for sufficient time to consume the remaining fuel from the previous experiment. To evaluate the performance parameters, important operating parameters such as engine speed, power output, and fuel consumption were measured. Significant engine performance parameters such as brake specific fuel consumption (BSFC) and brake mean effective pressure (BMEP) for the test fuels were calculated.

Result and Discussion

Performance and emissions characteristics

The BSFC variation of the test fuels with respect to BMEP at engine speed of 1500 r/min is shown in Figure 4. The fuel mass flow rate is calculated from the respective measured volume flow rate value and the

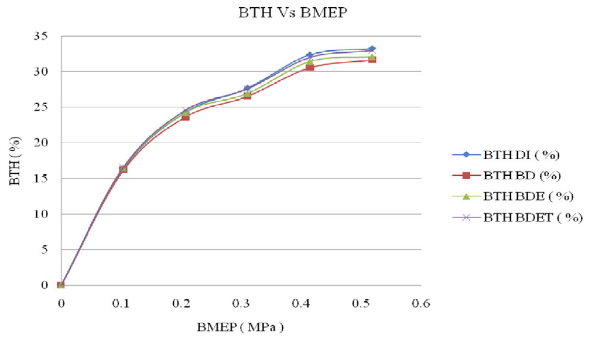

Figure 5: Comparison of brake thermal efficiency vs. brake mean effective pressure.

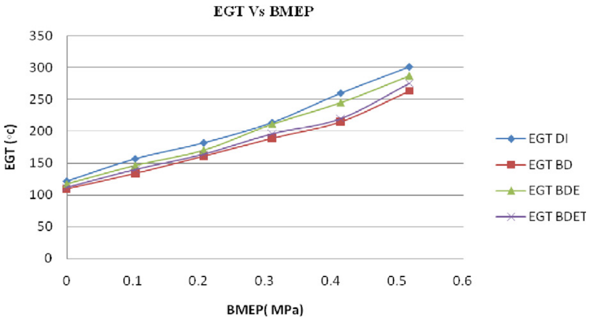

Figure 6: Comparison of exhaust gas temperature vs. brake mean effective pressure.

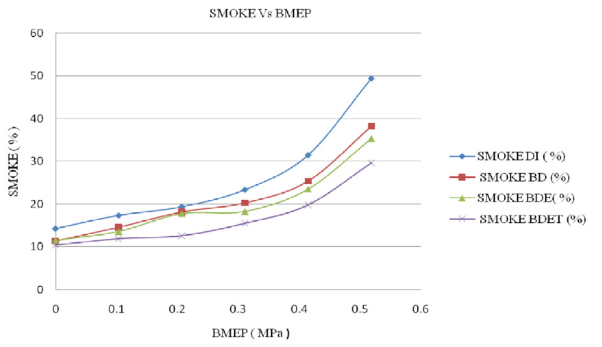

Figure 7: Comparison of smoke opacity vs. brake mean effective pressure.

fuel density. Since the comparison is made at the same engine load and speed, which is translated into the same engine power, the BSFC values are then effectively directly proportional to the fuel mass flow rate.

It is observed that the BSFC of B20 is slightly higher than that of BDET, and almost similar to that of BDE. The main reason may be due to the higher volatility of diethyl ether and ethanol which speeds up the mixing velocity of air/fuel mixture, improves the combustion process and increases the combustion efficiency.

The variations of brake thermal efficiencies at different loads for various combinations have been shown in (Figure 5). BTE of diesel is higher than that of all other fuels due to its higher calorific value. Both of the blends exhibited higher brake thermal efficiencies than BD. This is because the addition of DEE and ethanol reduces the viscosity which in turn increases the atomization. This leads to the enhancement of combustion.

Among the blends BDET showed the higher BTE nearer to the diesel fuel. BDE and BD showed very slight difference in the BTE. BDET shows the lower calorific value but it improves fuel properties because this reason it gives the better BTE than other two blend.

The exhaust gas temperature of the test fuels with respect to BMEP at engine speed of 1500 r/min is shown in Figure 4. In a DI natural aspirated 4-stroke diesel engine. Diesel fuel gave higher exhaust gas temperature. BDET shows very slight change in EGT compared to B20, reason may be due to higher cetane number of DEE which created the shorter ignition delay period, reducing the chance of burning being extended to exhaust stroke. This is evident from exhaust gas temperature plot (Figure 4) wherein reduced temperature levels were seen for the blends BD20 as compared to BDET but in BDE is more significant at high engine loads. Normally, a more complete combustion will get a higher combustion temperature. The evident increase of EGT for BDE may be due to its highest oxygen content of ethanol, which should be the dominant factor for EGT (Figure 6).

The smoke emissions variation of the test fuels with respect to BMEP at engine speed of 1500 r/min is shown in (Figure 3). The smoke is formed due to incomplete combustion. It is obvious that the smoke emissions are reduced with BDET and BDE. This may be attributed to the engine running overall ‗leaner‘, with the combustion being now assisted by the presence of the fuel-bound oxygen of the diethyl ether and ethanol even in locally rich zones. Additionally, diethyl ether is easier to evaporate than ethanol, which seen to have a remarkable effect on the reduction of smoke emissions, especially at high engine loads. So BDET shows the lowest smoke emissions at high engine loads (Figure 7).

The NOx emissions variation of the test fuels with respect to BMEP at engine speed of 1500 r/min can be predicted. NOx emissions are sensitive to oxygen content, adiabatic flame temperature and spray characteristics. Normally, a more complete combustion will get a higher combustion temperature, which will cause a high NOx formation. Exhaust gas temperature for BDE is more than BDET and BD. Due to this reason. NOx may be more for BDE. The evident increase of NOx for BDE may be due to its highest oxygen content of ethanol, which should be the dominant factor for increasing NOx emissions.

The HC and CO emissions variation of the test fuels with respect to BMEP can also be predicted. In any case, HC level is in absolute terms small for diesel engine. As known, the formation of unburned HC originates from various sources in the engine cylinder. It might be observed that HC emissions of BDET and BDE are slightly higher than that of BD. It may contribute the late escape into the cylinder of the fuel left in the nozzle sac volume, because, with the addition of diethyl ether and ethanol, this is easier to evaporate and slipped into the cylinder (at low velocity, late in expansion stroke).

Emissions of CO from a DI diesel engine mainly depend upon the physical and chemical properties of the fuel. DBET and BDE might reduce CO emissions compared to diesel and BD. This is understandable because they have higher oxygen content leading possible complete combustion.

Conclusion

The experimentally studied the addition of diethyl ether and ethanol on engine performance and emissions of a biodiesel-diesel blended fuel engine. Diesel -Biodiesel-diethyl ether blend (BDET) and diesel-biodiesel -ethanol blend (BDE) show better stability and can be used in diesel engine without any modification. The BSFC of BDET is slightly lower, and that of BDE is almost similar to that of B20. BDET and BDE, having higher oxygen content than B20, show excellent ability to eliminate smoke emissions, especially at high engine load. Diethyl ether has higher volatility than ethanol, so BDET exhibits more reduction of smoke.

Prediction for NOx, CO, HC. NOx emissions will increase when BDE is used. CO emissions of BDET and BDE will lower, but HC emissions will higher in comparison with BD. The addition of higher oxygen content and high volatility fuels, such as diethyl ether and ethanol, can be a promising technique for using biodiesel/diesel blend efficiently in diesel engines without any modifications in the engine.

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