Experimental Analysis on Performance of TiO_2 Coated Piston Diesel Engine Using Pre Heated Jatropha Methyl Ester with Taponal as Additive

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Abstract

The fossil fuels are widely used in diesel engine and continually depleting with increasing consumption and prices day by day. The fatty acid methyl ester has become an effective alternative to diesel. Various types of vegetable oil such as Jatropha, karanja, cottonseed, neem, sunflower, palm, mahua, coconut etc. can be used as fuel in diesel engine. Jatropha oil is one of the fuels used in present work. The viscosity of jatropha oil is very high, so it was reduced by Transesterification process and by oil heating. This study presents effect of Taponal as additive to biodiesel of Jatropha methyl ester on the performance and emission of diesel engine coated with TiO_2 Piston at different load, constant speed and different injection pressures and injection timings. From literature it was observed that very few studies had been conducted on use of neat biodiesel and Taponal blends and use of Jatropha Methyl Ester (JME) in diesel engine found to be very less as compared to different biodiesel. Hence this topic was taken under study. The fuels and its blends used are 100% diesel, 100% JME, B-25 (75% Diesel, 25% Jatropha) without preheating, B-25 (25% JME, 75% Diesel) with preheating and 4% Taponal respectively. It was observed that the performance of engine increases at high injection pres-sure with TiO_2 coated piston. The results indicate that lower BSFC was observed with B25 with preheating in addition with 4% taponal as compared to B100, B-25 without preheating and. Brake thermal efficiency of B-25 decreased at 230 bar injection pressure but it increase at 210 bar. Drastic reduction in smoke is observed with all blends at higher engine loads. 4% Taponal addition to biodiesel reflects better engine performance compared to neat biodiesel.

Keywords

Biodiesel, Jatropha Methyl Ester, Taponal, Injection Pressure, TiO_2 Coated Piston.

I. Introduction

Diesel engine continues to be reliable power source for light, medium and heavy duty applications and as such there can be no replacement for it in agriculture and transportation sectors. Although CI engines have a higher thermal efficiency when compared with SI engine, advanced research in the combustion of diesel fuel in CI engine shows that the Brake thermal efficiency, Brake power can further be increased by allowing the fuel to combine with more oxygen atoms to form complete combustion. The steady increase in energy consumption coupled with environmental pollution has promoted research activities in alternative and renewable energy fuels. Bio-diesel is produced from vegetable oils (edible & non edibles) and animal fats. The methyl ester of vegetable oils, known as biodiesel are becoming increasingly popular because of their low environmental impact and potential as a green alternative fuel for diesel engine and they would not require significant modification of existing engine hardware. Biodiesel cannot be used purely for combustion because of their high viscosity and low calorific value. Transesterification is most attractive method to reduce viscosity of raw vegetable oil [1]. Another approach is it can be blended with diesel fuel as the result, the performance and emission values are found to be nearly same with diesel fuels at high injection pressure [2]. Preheated biodiesel can also used, because preheating of oil decreases viscosity of oil considerably as the temperature increases and are close to diesel fuel [3-4]. Biodiesel is non-toxic and biodegradable. The combustion of biodiesel contributes less CO_2 to the atmosphere. Studies on using biodiesel as fuel in diesel engines have shown greater reduction in emissions of hydrocarbons, smoke, particulate matter, oxides of sulphur and carbon and polyaromatics as compared to diesel. Another option for further reduction of emission and to improve thermal efficiency is to improve oxygen content of fuels. Oxygen contents can be increased by mixing oxygenated additives with diesel or biodiesel. Present study is related to evaluate the effect Taponal as oxygenated additive and its blend with neat biodiesel.

Alcohols are produce from fossil resources such as methanol and ethanol are generally added to diesel fuel to reduce emission. Ethanol fuel blends promote also higher combustion pressure and there-fore better combustion and lower amount of exhaust components [5]. In the transportation sector, ethanol produced from biomass shows promise as a future fuel for SI engine. Because of high octane quality. Taponal is an excellent compression ignition fuel and higher energy density than ethanol. It is also called as cold start aid additive for engine and having very high cetane number compared to diesel.

II. Objective of the Present Study

The main objective of present investigation was to study the effect of Taponal as oxygenated additive on diesel engine performance and emission when blended with neat biodiesel. In this work, Jatropha oil derived from the jatropha seeds was used to produce biodiesel. The fuel blends investigated for performance analysis were 100% diesel (B00), B100, B25 without preheating, B-25 with preheating, and B25 with preheating 4% taponal as additive in TiO_2 Coated piston. These blends were tested on diesel engine at 210, 220,230, and 240 bar injection pressure. Performance parameter considered were brake thermal efficiency, brake sp. fuel consumption, exhaust gas temperature etc.

III. Experimental Setup and Procedure

The engine used was a single cylinder, naturally aspirated four stroke, and direct injection diesel engine with a bowl in piston combustion chamber. The specifications of the engine used are given in Table I. With the liquid fuel injection, a high-pressure fuel pump was used, a three hole injector nozzle. Engine was directly coupled to a dynamometer. Exhaust gas temperatures measured by thermo-couple which indicates reading on digital display, loads are applied by rope brake dynamometer at constant rpm 1500 which is measured by contact type tachometer. Smoke was measured by a smoke meter 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. The smoke meter was also allowed to adjust its zero point before each measurement. To evaluate performance, some operating parameters like speed, power output and fuel consumption were measured.

Table 1: Engine Specifications

S.no	Type	Four-stroke Direct Injection Diesel Engine
1	Engine	Kirloskar-AV 1
2	Type of Cooling	Water Cooling
3	Bore	80 mm
4	Stroke	110 mm
5	Displacement Volume	553 cc
6	Piston (Standard)	Hemispherical
7	Compression ratio	1:16.5
8	Rated power	4.4 kW at 1500 rpm
9	Nozzle opening pressure	250 bar
10	Injection timing	23^o before TDC (static)
11	Fuel Oil	Commercial High Speed Diesel
12	Type of Governor	Mechanical Centrifugal type
13	Lubrication	Forced Feed

IV. Results and Discussion

A. Brake Thermal Efficiency

The trends of the brake thermal efficiency of test fuels are shown in fig. 1. It is observed that the brake thermal efficiency for CE engine is higher than those of uncoated engine for the test fuels. The brake thermal efficiency is increased for B25, 4% taponal with the TiO_2 coated piston as compared to preheated jatropha biodiesel blend with the base engine. This may be due to better atomization and vaporization of air-fuel mixture ceramic coated piston, which retains the higher combustion temperature, resulting in complete combustion of B25, 4% Taponal blend. The thermal efficiency for diesel and B25, 4% taponal are 29%, 29.2% respectively, with the base engine and for B25, 4% taponal with ceramic coated piston it is 30% at full load. The increase in BTE may be due to better vaporization of biodiesel fuel at higher combustion temperature, resulting in better combustion.

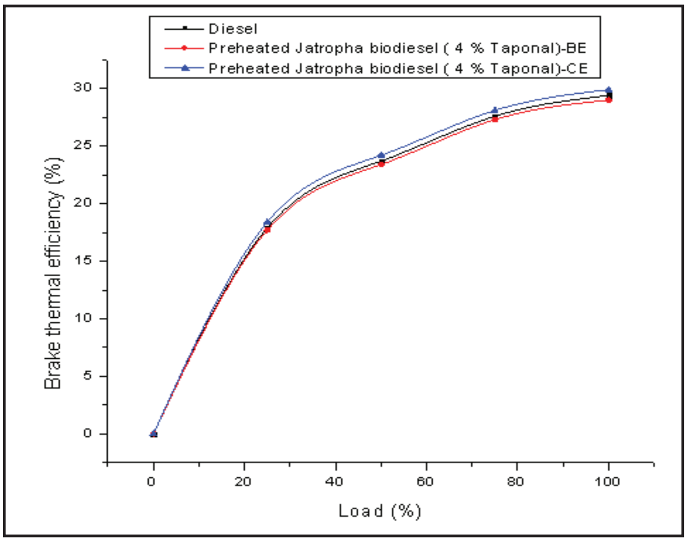

Fig. 1: Variation of Brake Thermal Efficiency With Load

B. Brake Specific Fuel Consumption

Fig. 2 shows the variation of brake specific fuel consumption with brake power for diesel and B25, 4% Taponal for both the piston operations. The average BSFC decrease in the Coated Engine (CE) was determined to be 10% for B25, 4% taponal, compared with that of the base engine. Because the energy content for biodiesel fuel is lower than that of diesel fuel, the BSFC values of B25, 4% Taponal and its mixture are higher than that of diesel fuel for both engine operations. In contrast, the BSFC values for all test fuels decrease in CE operations.

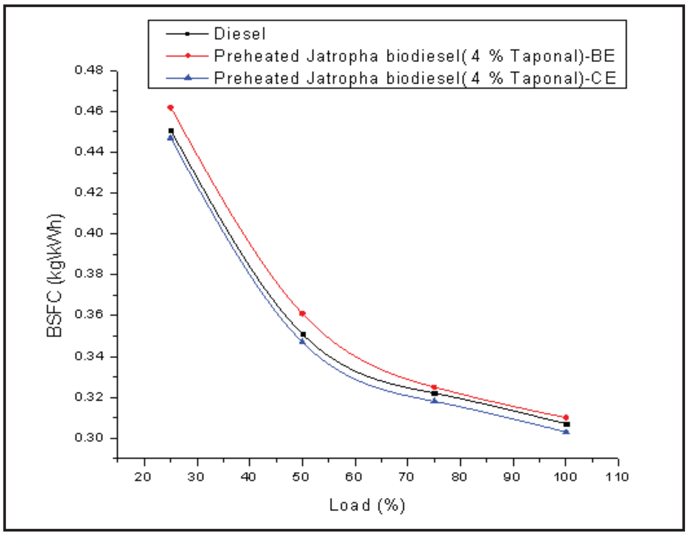

Fig. 2: Variation of BSFC with Load

The positive effect of increased cylinder temperature due to heat insulation the BSFC decreases for all the test fuels in CE operations. The BSFC values for base engine with diesel and B25, 4% taponal are 0.308 kg/kWh and 0.31 kg/kWh respectively at full load. For the coated engine for B25, 4% Taponal coated piston it is 0.30 kg/kWh at full load.

C. Exhaust Gas Temperature (EGT)

Fig. 3 shows the variation of exhaust gas temperature with load for both the engines. The exhaust gas temperature values for base engine with diesel and B25, 4% Taponal are 338°C and 340°C respectively at full load. For the coated engine with B25, 4% taponal it is 350°C at full load. The exhaust gas temperature increased for B25, 4% taponal with coated engine at full load compared to the base engine diesel.

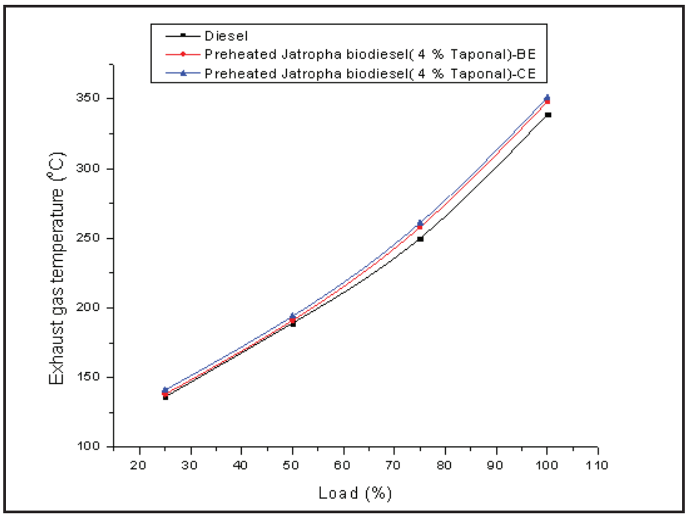

Fig. 3: Variation of Exhaust gas Temperature with load

This may be due to higher combustion temperature by the ceramic coated piston, which retains more heat during combustion and more oxygen present in the biodiesel, resulting in more combustion peak temperature. Thus increases the exhaust gas temperature for biodiesel blend at full load.

C. Carbon Monoxide Emission

Fig. 4 shows the variation of carbon monoxide emissions with load for both the engines. The CO values for base engine with diesel and B25, 4% taponal are 0.07%Vol and 0.065 %Vol respectively at full load. For the coated engine with diesel and B25, 4% taponal it is 0.055%Vol and 0.03%Vol at full load. Average CO emissions for B25, 4% taponal decreases with the CE and the values were determined to be 68% for B25, 4% taponal compared with that of the base engine operations. When CO emissions are compared for all the test fuels used in base engine and CE, a significant decrease was observed in the coated engine. The decrease in CO emission in the CE may be due to increase in combustion temperature as a result of decrease in heat losses, and more oxygen content present in the biodiesel, resulting in complete combustion. Thus reduces the CO emissions for B25, 4% taponal with coated engine at full load compared to the base engine.

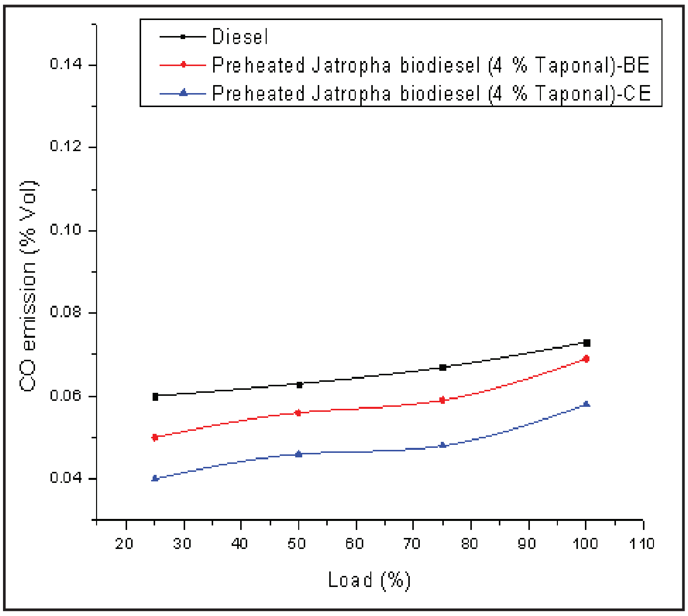

Fig. 4: Variation of CO Emissions With Load

D. Hydro Carbon Emission (HC)

The variation of hydrocarbon emission with load for both the engines is shown in fig. 5. The hydrocarbon emission for diesel and B25, 4% taponal are 136 ppm and 142 ppm respectively for the base engine at full load. For the ceramic coated piston with B25, 4% taponal, it is 132 ppm at full load. It can be seen that the HC emission decreased for B25, 4% taponal with the coated piston compared to that of the base engine. This may be due to the better vaporization of biodiesel fuel, by higher combustion temperatures of the coated piston and more oxygen content present in the biodiesel, resulting in complete combustion. Thus reduces the HC emissions for B25, 4% taponal with coated engine at full load compared to the base engine.

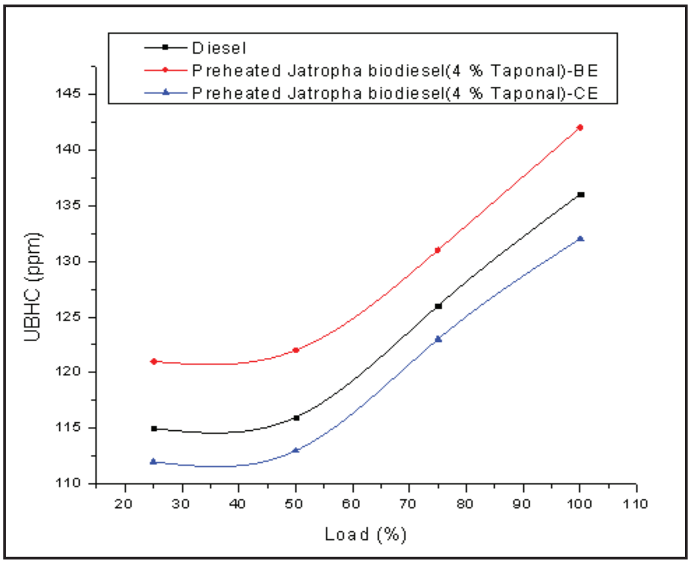

Fig. 5: Variation of HC Emissions With Load

E. Nitrogen Oxide Emission (NO)

The variations of nitrogen oxide emissions at different engine load for all the test fuels are shown in fig. 6. The NO forms by oxidation of atmospheric nitrogen at sufficiently high temperatures. It is observed that the biodiesel and its mixture used in both the engines cause more NO emissions. The increase in NO emission for all the test fuels in the CE may be due to the result of an increase in after-combustion and combustion temperature due to the coating. The average NO emissions increase in the CE was determined to be 10.5 % for B25, 4% taponal at full load. The NO values for base engine with diesel and B25, 4% taponal are 1880 and 1900ppm, respectively at full load. For the coated engine with B25, 4% taponal it is 2080 ppm at full load.

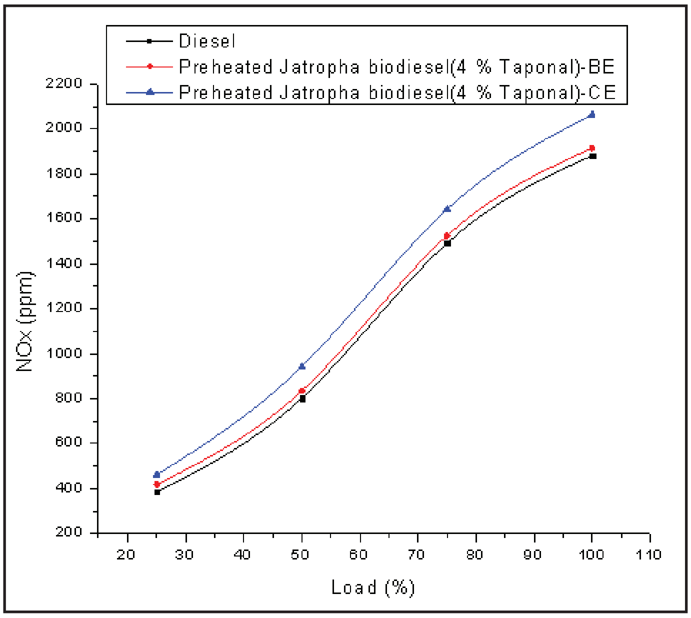

Fig. 6: Variation of NO Emissions With Load

F. Smoke Density

The variations of smoke density for both the engine operations for all the test fuels are shown in fig. 7. The smoke densities decrease in CE was determined to be 25% for B25, 4% taponal at full load compared to that of the base engine. According to these values, a decrease in smoke density for all test fuels in the CE as a result of ceramic coating. However the smoke density of B25, 4% Taponal is lower than that of diesel for the engine operations. Lower smoke density of B25, 4% Taponal may be caused by higher oxygen present in the biodiesel. The oxygen content of fuel can contribute oxidation of biodiesel in fuel rich combustion zones, resulting in reduction in smoke density.

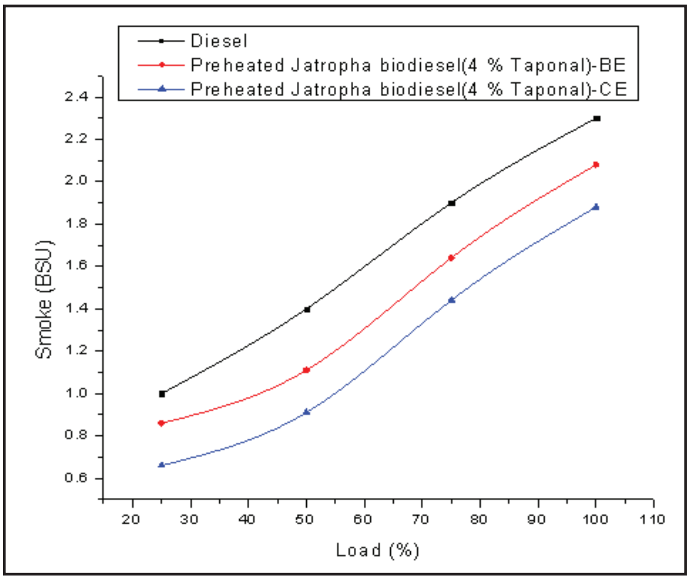

Fig. 7: Variation of Smoke Emissions With Load

The smoke value for the base engine with diesel and B25, 4% Taponal are 2.3 BSU and 2.08 BSU respectively, whereas for the B25, 4% Taponal with CE, it is 1.9 BSU at full load. The decrease in smoke for the CE may be due to better vaporization of biodiesel at higher combustion temperature and also more oxygen present in the biodiesel, resulting in complete combustion.

V. Conclusion

The performance and emission parameters were measured at different loads at standard injection timing and injection pressure for comparisons. The combustion, performance, and emission parameters of preheated Jatropha bio diesel (B25) with different injection timing and injection pressure at full load conditions were measured. From these test results, an optimum injection timing and injection pressure values were evaluated. At these optimum injection timing and injection pressure, combustion, performance and emissions of pre heated jatropha bio diesel and diesel were measured at full load conditions and compared with preheated jatropha biodiesel (B25) with 4% Taponal.

The performance of B-25,4% Taponal/CE increases slightly compared to B-25,4% Taponal/BE

- Brake thermal efficiency and BSFC is better in case of B-25 at 210 bar injection pressure.
- 4% Taponal blend (BD-3) is adjudged as the best combination which yielded better results than other fuel blends tested..
- B-25, 4% taponal with CE perform better in case of BTE and BSFC at 210 bar injection pressure. Because of better mixing and proper utilization of air converted more heat into the useful work resulting in higher BTE.
- Smoke emission have decreased with addition of 4%, additive but it decreased substantially with 8% Taponal addition at full load. Because of high oxygen contents of Taponal. It also reduced at 210 bar injection pressure.
- Higher cetane rating of Taponal and oxygen content are also advantageous for obtaining lower smoke emission.

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