PERFORMANCE AND EMISSION STUDIES OF A DIESEL ENGINE WITH PONGAMIA METHYL ESTER AT DIFFERENT LOAD CONDITIONS

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ABSTRACT

Transesterified vegetable oil, known as biodiesel, is increasingly popular because of their low environmental impact and has potential as an alternative fuel for diesel engine without any modification of the engine. This paper investigates the performance and emission characteristics of a single cylinder constant speed direct injection diesel engine using neat Pongamia methyl ester and its diesel blends (PME) at different load conditions. The experiment was conducted on a single cylinder, water cooled direct injection (D.I) diesel engine with Pungamia methyl ester (PME) diesel blend such as B20 and B100 as fuel for diesel engine. The results showed that the brake thermal efficiency decreased and BSFC slightly increased for Pungamia methyl ester blends as compared with diesel fuel. It is also seen that the carbon monoxide (CO) and smoke emissions were reduced by about 34% and 25% respectively for B20 at full load the nitrogen oxide (NO) emission was increased about 8.5% for B20 blend. On the whole, it is concluded that the 20% Pungamia methyl ester can be used as diesel fuel without any engine modifications.

Keywords: Pongamia methyl ester, emission, tranesterification, diesel engine, Biodiesel.

1. INTRODUCTION

Diesel engines are being efficient prime movers for automotive applications and capable of reducing fuel consumption and emission of carbon dioxide, which is a potent cause for green house effect. The rising cost of petroleum diesel fuel, stringent emission regulations and depletion of petroleum reserves are forcing us to search alternative fuels like biomass and biodiesel for diesel engines. In India, there are several non-edible oil plants such as Jatropha, Pongamia, Neem, Mahua and etc. Out of these plants, Jatropha and Pongamia have shown good promise for biodiesel production **[1, 2].** Vegetable oils have properties comparable to diesel and can be used to run CI engines without modifications. Usages of biodiesel will al low a balance to be sought between agriculture, economic development and the environment **[3, 4].**

Agarwal et al [5] observed that engine operated on Jatropha oil (preheated and blends), performance and emission parameters were found to be very close to mineral diesel for lower blend concentration. How ever, for higher blend concentrations, performance and emissions were ob served to be marginally inferior. **Pramanik [6]** have tried to reduce viscosity of Jatropha oil by heating it and also lending it with mineral diesel**.** It has been reported that the acceptable thermal efficiencies of the engine had obtained with blends containing up to 50% of Jatropha oil. **Pradeep et al [7]** have studied the performance and combustion parameters of a diesel engine with rubber seed oil and its blends. They reported that smoke, HC and CO emissions are higher and NO emissions are lower at peak load for neat rubber seed oil methyl ester.

Suresh Kumar et al [8] studied the performance and emissions of diesel engine with Pongamia pinnatta methyl ester at various blends and they reveal that 40 % blends by volume provide better performance and improved exhaust emissions. **Pandian et al [9]** studied experimentally the performance of a pongamia methyl ester with twin cylinder diesel engine at various injection timings. They reported that the BSFC and NOx are decreased with retarding the injection at 18^{o} bTDC .But the CO and HC are increased with retarding the injection timing and it decreases with advancing the injection timing. The objectives of the present study are to investigate the performance and emission characteristics of a single cylinder direct injection diesel engine with Pongamia oil methyl ester blends as fuel. The measured values are analyzed and compared with the base engine.

2. MATERIALS AND METHODS

2.1 Preparation of Pongamia methyl ester

Transesterification is a chemical process of transforming large, branched, triglyceride molecules of vegetable oils and fats into smaller, straight chain molecules, almost similar in size to the molecules of the species present in diesel fuel. The process takes place by the reaction of vegetable oil with alcohol in the presence of a catalyst. Pongamia oil contains high free fatty acids (FFA) upto 20 %. It requires two step processes to convert into biodiesel. The first step is acid-catalyzed esterification by using 0.5% H_2SO_4, alcohol 6:1 molar ratio with respect to the high FFA Pongamia oil to produce methyl ester by lowering the and the next step is alkali-catalyzed transesterification **[10].**

Pongamia oil was converted into its methyl ester by the transesterification process. This involves making the triglycerides Pongamia oil react with methyl alcohol in the presence of catalyst (NaOH) to produce glycerol and fatty acid ester. The methyl alcohol (200 ml) and 8 gram of sodium hydroxide were taken in a round bottom flask to form sodium methoxide. Then the methoxide solution was mixed with Pongamia oil (1000 ml). The mixture was heated to 65^{o}C and held at that temperature with constant speed stirring for 2 hours to form the ester. Then it was allowed to cool and settle in a separating flask for 12 hours. Two layers were formed in the separating flask. The bottom layer was glycerol and upper layer was the methyl ester. After decantation of glycerol, the methyl ester was washed with distilled water to remove excess methanol. The transesterification improved the important fuel properties like specific gravity, viscosity and flash point. Table 1 lists the properties of diesel, Pongamia oil and its methyl ester. The properties of diesel, Pongamia oil and methyl ester of Pongamia oil are shown in table.1.

Table 1. Properties of diesel, Pongamia oil and its methyl ester

Sl.No	Properties	Diesel	Pongamia oil	PME
1.	Density (kg m^{-3})	830	928.	890
2.	Calori1c value(MJ kg^{-1})	42.50	38. 86	37.91
3.	Viscosity at 40^{o}C (cSt)	3.01	46.5	6.87
4.	Cetane number	45 –50	40	49
5.	Flash point ($^{\circ}$C)	50	248	187

2.2 Experimental setup

Experiments were conducted on a four-stroke single cylinder direct-injection water-cooled diesel engine, specifications of which are given in Table 2. The engine was operated at constant speed of 1500 rev/min. The tests were conducted with diesel, Pongamia oil methyl ester with load, from no load to full load by steps of 25%. The engine was coupled with dynamometer to provide the brake load. Two separate fuel tanks were used for the diesel fuel and Pongamia oil methyl ester (PME). The performance and emissions were measured and analyzed. The schematic of the experimental set up is shown in Figure 1. The emissions values like CO, HC, and NO were measured by using AVL-444 five gas analyser and the smoke was measured by smoke pump and smoke meter.

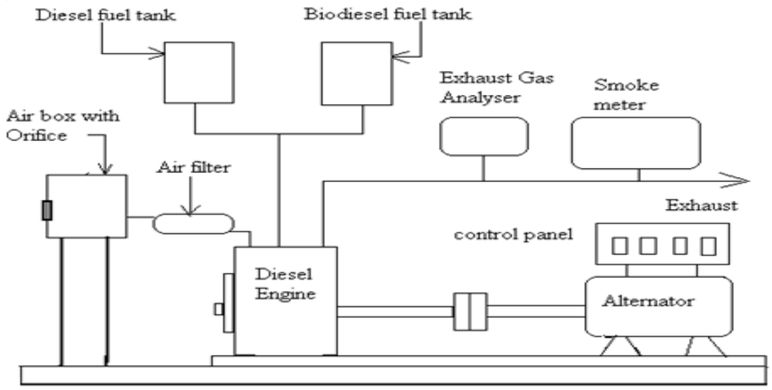

Figure 1. Schematic of the experimental setup

Table 2.Test engine specifications

Engine	Kirloskar,Model AV-I,
Type	4S,Single cylinder, water cooled
Power	3.7 kW
Bore (mm)	80
Stroke(mm)	110
Compression ratio	16.5
Speed (rpm)	1500

3. RESULTS AND DISCUSSION

3.1. Brake Thermal Efficiency

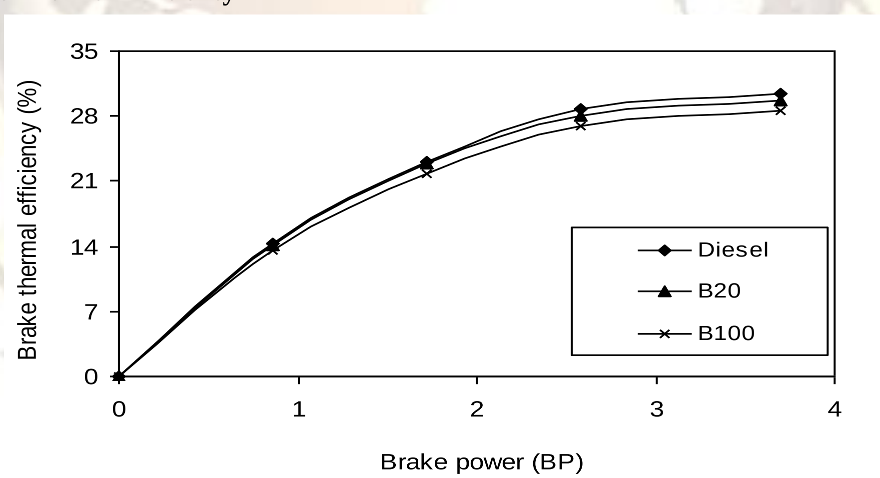

Figure 2 Variation of Brake thermal efficiency with BP

The variation of Brake thermal efficiency with load for different fuel blends are shown in Figure 2. In all the cases brake thermal efficiency is increased with increase in load due reduced heat loss. The maximum efficiency obtained in this experiment was 29.53 for (B20) and 28.6% (B100), whereas for the diesel it is 30.45% at full load. It is observed that the decrease in thermal efficiency is lower for pure biodiesel and its diesel blend at full load. This decrease in efficiency may be due to low calorific value and poor atomization of biodiesel, resulting in poor combustion.

3.2. Brake Specific Fuel consumption

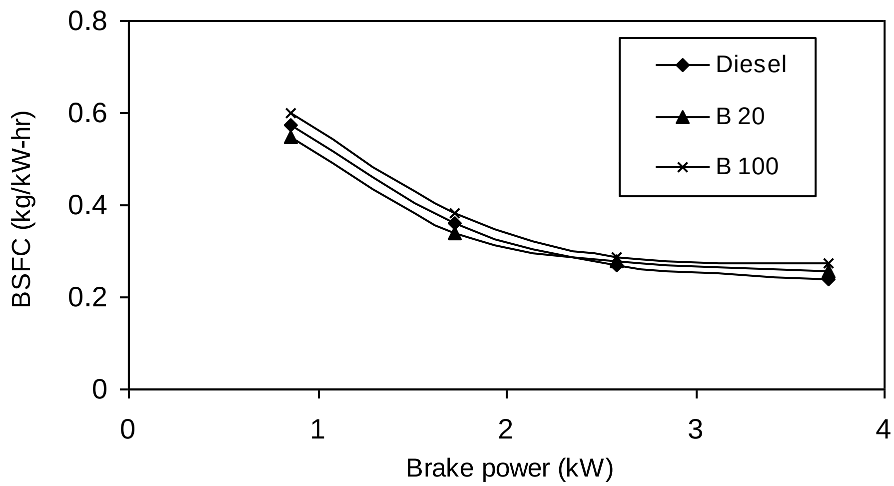

Figure 3 Variation of BSFC with BP

The variation of brake specific fuel consumption with load for diesel and biodiesel is illustrated in Figure 3. For all cases BSFC reduces with increase in load. The reverse trend in the BSFC may be due to increase in biodiesel percentage ensuring lower calorific value of fuel. Another reason for the change in BSFC in biodiesel in comparison to petroleum diesel may be due to a change in the combustion timing caused by the biodiesel's higher cetane number as well as injection timing. The maximum value of BSFC for diesel, B20 and B100 are .2402 kg/kW h, 0.2557 kg/kW h and 0.275 kg/kW h at full load.

3.3 Carbon monoxide emission (CO)

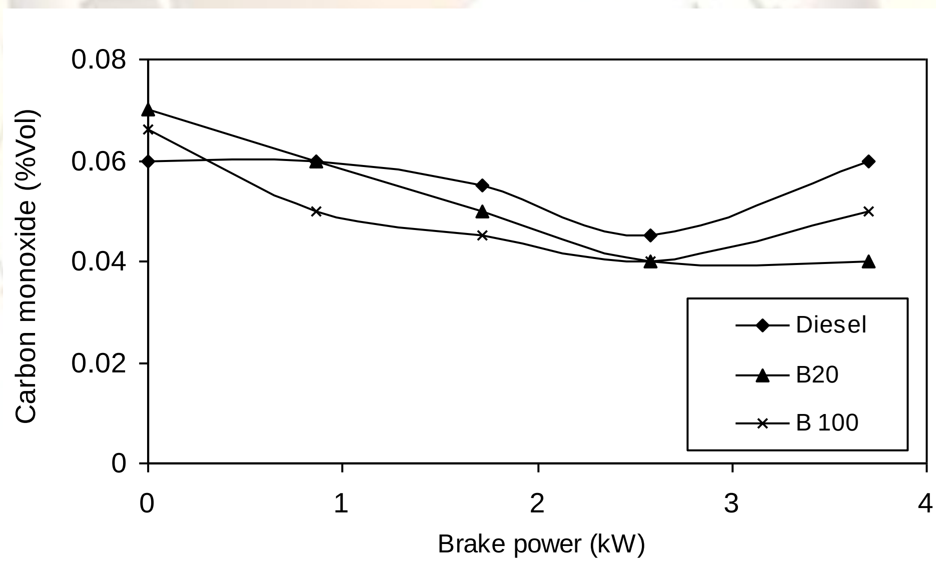

Figure 4 Variation of CO emissions with BP

The variation of carbon monoxide produced with diesel and diesel blend are presented in Figure 4. For B20 blend the maximum CO emission produced is 0.04 %Vol and for the B100 it is 0.05 %Vol and for the diesel it is 0.06 %Vol at full load. The lower CO emission for the biodiesel blend B20 at full load is an indication of the complete combustion of biodiesel being an oxygenated fuel. The decrease in carbon monoxide emission for biodiesel and its blend is due to more oxygen molecule present in the fuel as compared to that of diesel.

3.4 Hydrocarbon emission (HC)

The variations of un-burnt hydrocarbon emissions at different engine load for different diesel blends are shown in Figure 5. The shorter ignition delay associated with biodiesel higher cetane number could also reduce the over mixed fuel which is the primary source of un-burnt hydrocarbons. For B20 the maximum HC produced is 37 ppm and for B100 is 48 ppm at full load. The HC emission for B20 is almost equal to that of diesel fuel, which is 35 ppm at full load. The decreases in HC emission may be due to better combustion of biodiesel blend which\h contain more oxygen contents, resulting in better combustion.

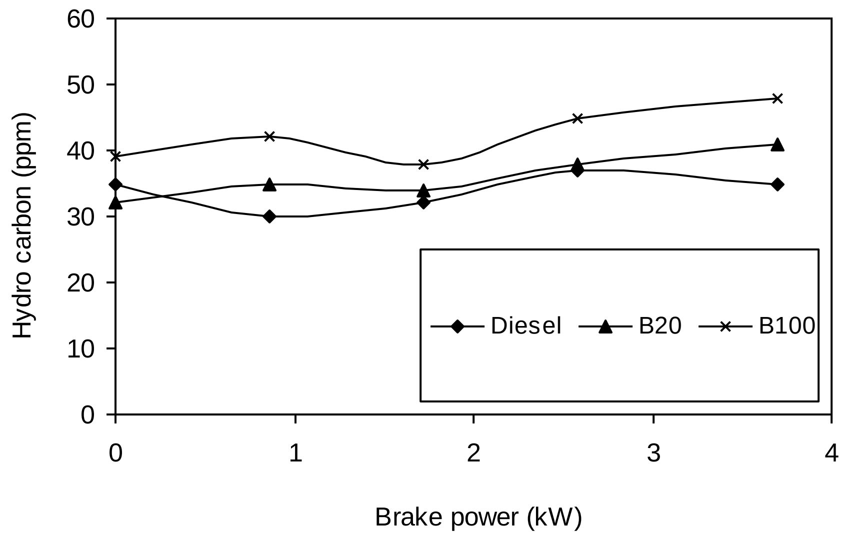

Figure 5 Variation of HC emissions with BP

3.5 Nitrogen Oxide Emission (NO)

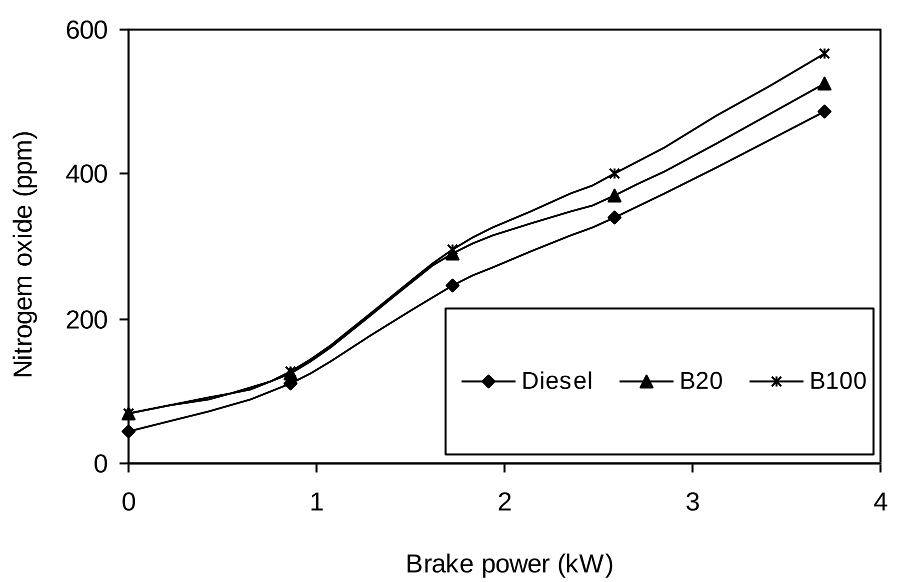

Figure 6 Variation of NO emissions with BP

The variation of nitrogen oxide emissions at different engine load are presented in Figure 6. The formation of nitrogen oxides is significantly influenced by the cylinder gas temperature and the availability of oxygen during combustion. The NO emission for B20 is 526 ppm and for B100 is 568 ppm whereas for the diesel it is 486 ppm at full load conditions. It is observed that the increase in NO emission for the biodiesel may be due to more oxygen atom present in the biodiesel.

3.6 Smoke emission

The variation of smoke emissions at different engine load are presented in Figure 7. The exhaust of the CI engines contains solid carbon particles that are generated in the fuel-rich zones within the cylinder during combustion.

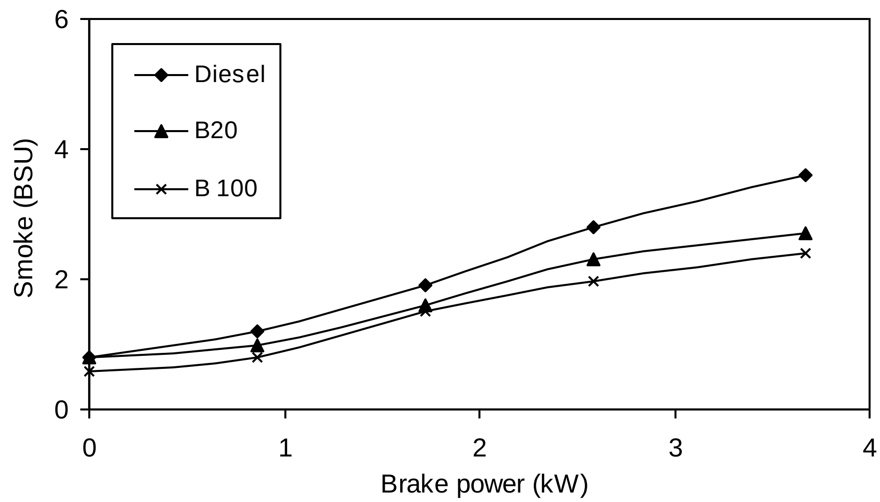

Figure 7 Variation of NO emissions with BP

These are seen as exhaust smoke and cause an undesirable odorous pollution. The smoke emission increases with an increase in the load for all fuels. The smoke density for diesel is 3.6 BSU at full load, whereas for B20 and B100 it is 2.7 BSU and 2.5 BSU at full load. The decrease in smoke may be due to more oxygen atom present in the biodiesel, resulting in better combustion of biodiesel.

4. CONCLUSIONS

Based on the result of this study i.e. physical and chemical properties of Pongamia oil suggest that it can be used directly as CI engine fuel. From the experimental results the following conclusions were drawn.

The brake thermal efficiency obtained for B20 is closer to diesel fuel. The BSFC are slightly increases for biodiesel due to lower calorific value of biodiesel. The CO and HC emissions are lowered by 34% for B20 compared to diesel fuel. The NO emissions for B20 are increased about by 8.5% and the smoke emissions were decreased about by 25% for B20 at full load compared to diesel. On the whole it is concluded that up to 20% blend can be used to run the stationary CI engine at short term basis with out any modifications.

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