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Characterization and Effect of Using Mahua Oil Biodiesel as Fuel in Compression Ignition Engine

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There is an increasing interest in India, to search for suitable alternative fuels that are environment friendly. This led to the choice of Mahua Oil (MO) as one of the main alternative fuels to diesel. In this investigation, Mahua Oil Biodiesel (MOB) and its blend with diesel were used as fuel in a single cylinder, direct injection and compression ignition engine. The MOB was prepared from MO by transesterification using methanol and potassium hydroxide. The fuel properties of MOB are close to the diesel and confirm to the ASTM standards. From the engine test analysis, it was observed that the MOB, B5 and B20 blend results in lower CO, HC and smoke emissions as compared to diesel. But the B5 and B20 blends results in higher efficiency as compared to MOB. Hence MOB or blends of MOB and diesel (B5 or B20) can be used as a substitute for diesel in diesel engines used in transportation as well as in the agriculture sector.

Keywords: Alternative fuel, mahua oil, biodiesel, engine performance

Introduction

During recent years high activities can be observed in the field of alternative fuels, due to rapid decrease in world petroleum reserves. It has been estimated that the demand for diesel in India will be 66.90 million metric tons, for the year 2011-2012. Hence, government of India has taken necessary steps to fulfill future diesel and gasoline demand. Biodiesel and alcohol are considered as alternative fuels. These fuels are being looked to provide employment generation to rural people through plantation of vegetable oils and can be beneficial to sugarcane farmers through the ethanol program [1]. Mohibbe et al. [2] reported that the fatty acid methyl esters of oils of 26 species were found most suitable for use as biodiesel. Jamieson [3] listed over 350 oil-bearing crops while Duke and Bagby [4] identified 70 species of oil seeds with considerable potential.

Mahua name for a medium to larger tree, madhuca longifolia of family sapotaceae with wider and round canopy and attains a height up to 20 meters. As a plantation tree, Mahua is an important plant having vital socio-economic value. This species can be planted on roadside, canal banks etc. on commercial scale and in social forestry programmes, particularly in tribal areas. The drying and decortication yield 70% kernel on the weight of seed. The kernel of seed contains about 50 % oil. The oil yield in an expeller is nearly 34 - 37% [5].

Transesterification is affected by type of catalyst, reaction time and temperature and purity of reactants [6]. Generally a two step procedures is used to produce biodiesel from MO having high free fatty acids [7] and nuclear magnetic resonance test can be used to determine the biodiesel conversion [8]. Engine manufacturers recommend the use of biodiesel up to 20% in the diesel engines [9]. But most of the engine manufacturers prefer

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B5 blend due to its better cold starting and lower lubricating oil dilution characteristics. Hence in the present work, B5 and B20 blends were used as fuel and the performance was compared with neat diesel and MOB.

Materials and methods

In the present work, MOB was produced from refined and filtered MO by transesterification using methanol and sodium hydroxide. The engine tests were conducted on a single cylinder, four stroke, water cooled, direct injection, Kirloskar make diesel engine of capacity 3.7 kW at 1500 rpm, which is most widely used in agricultural machinery in India. The schematic of the experimental setup is shown in Fig.1.

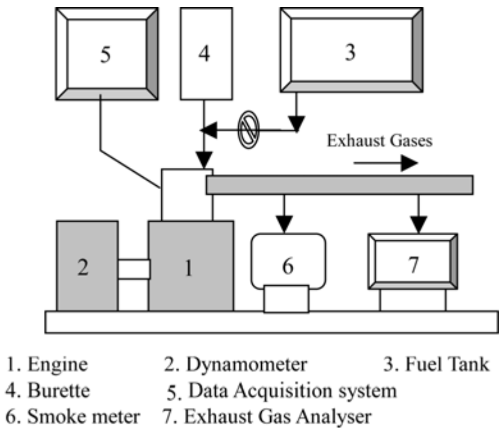

Fig. 1 Engine experimental setup

Results and Discussion

From Table 1, it is observed that the properties of MOB are close to the diesel. The lower viscosity of MOB indicates that the raw MO's ability to flow, which is increased to a significant extent by transesterification. This would induce complete burning of the fuel without much ignition delay. The cetane number of the MO biodiesel also satisfies the fuel standard. The higher flash point of the MOB indicates that the flammability hazard of MOB is much less than that of the diesel.

Table 1 Properties of MO, MOB and diesel

Property	MO	MOB	Diesel	ASTM
Flash point (°C)	212	129	56	130
Pour point (°C)	14	5	–20	–
Calorific value(MJ/kg)	35.6	36.9	42.9	–
Viscosity at 40°C (cSt)	27.63	4.85	2.68	1.9-6.0
Density at 15°C	915	883	846	–
Carbon Residue (%)	0.43	0.01	0.01	–
Cetane Number	-	51	48	>47

Brake Thermal Efficiency (BTE) is defined as the ratio of brake power to the heat supplied. Figure 2 shows the variation of the BTE with load. From the figure, it is observed that the efficiency of the MOB is lower than diesel at all loads. This is due to slightly higher viscosity and lower volatility of the MOB, which results in lower brake thermal efficiency. But the B5 and B20 blends results in BTE close to the diesel operation. This is due to the better volatility, atomization and spray formation of the B5 and B20 blends as compared to MOB. The B5 blend results in higher BTE as compared to the B20 blend.

The variation of exhaust emissions with load is shown in Figure 3 to 5. From the figures, it is observed that the exhaust emissions such as carbon monoxide (CO), hydro carbon (HC) and smoke emissions of the MOB is lower than the diesel and blends. This is due to the presence of oxygen in the molecular structure of the MOB which results in better combustion of the MOB. This leads to lower CO, HC and smoke emissions. The B20 blend results in lower exhaust emissions due to better combustion as compared to the B5 blend and diesel.

Conclusion

The biodiesel was produced from MO by transesterification. The fuel properties of MOB are closer to the diesel and satisfy the American, European, German, Austria and Sweden standards. From the engine test results,

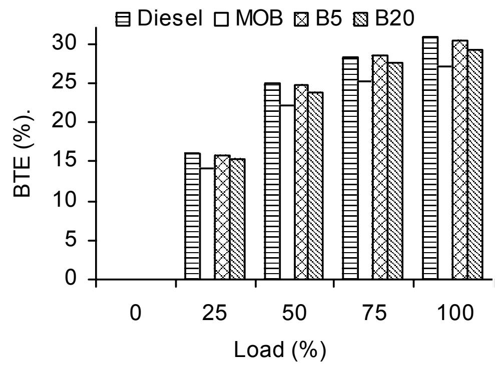

Fig. 2 Brake Thermal Efficiency Vs Load

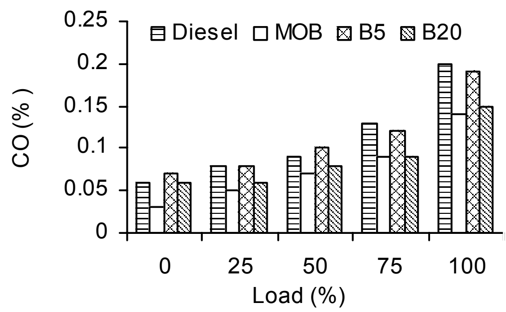

Fig. 3 CO Vs Load

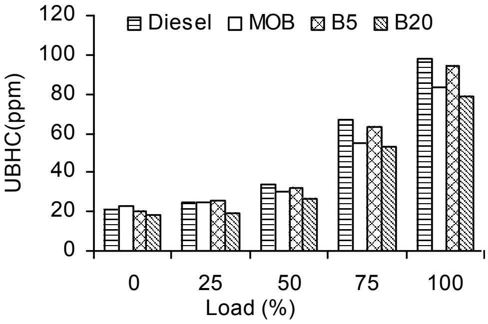

Fig. 4 UBHC Vs Load

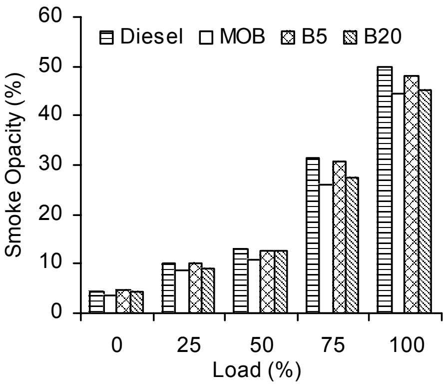

Fig. 5 Smoke Vs Load

the following conclusions are drawn. When MOB was used as sole fuel in diesel engine, it results in lower thermal efficiency due to its higher viscosity and poor-volatility. But it results in lower CO, HC and smoke emission. The B5 and B20 blends results in higher thermal efficiency and higher exhaust emissions as compared to the MOB. The B5 blend results in higher efficiency than the B20 blend. Based on the engine tests, it can be concluded that the MOB or its blends can be adopted as an alternative fuel for application in agricultural diesel engine as a renewable fuel replacement for diesel. Use of MOB as fuel in agricultural diesel engine will improve rural economy, sustainability and increase the environmental benefits of India.

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