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EFFECT OF SAFFLOWER METHYL ESTER IN A FOUR STROKE NATURAL ASPIRATED DIRECT INJECTION DIESEL ENGINE

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ABSTRACT

The performance of biodiesel obtained from safflower oil and its blend were measured and evaluated in four stroke, single cylinder, direct injection diesel engine. Properties were found to be comparable to diesel and confirming to both the American and European standards. Engine performance (brake thermal efficiency) and emissions (CO, smoke density and NOx) were measured to evaluate and to compute the behaviour of the diesel engine running on biodiesel. The reduction in exhaust emissions and brake thermal. which makes the blend of biodiesel (B40) a suitable alternative fuel for diesel and it could help in controlling air pollution.

Keywords: Diesel, Engine performance, Emission, Safflower methyl ester.

INTRODUCTION

Due to environmental pollution caused by the conventional fossil fuels and the realization that they are non-renewable have led to search for more environment friendly and renewable fuels. Among various options investigated for diesel fuel, biodiesel obtained from vegetable oils has been recognized world over as one of the strong contenders for reductions in exhaust emissions. Worldwide biodiesel production is mainly from edible oils such as soybean, sunflower and canola oils. Since, India is not self sufficient in edible oil production, hence, some non-edible oil seeds available in the country are required to be tapped for biodiesel production. Several countries including India have already begun substituting the conventional diesel by a certain amount of biodiesel. With abundance of forest and plant based non-edible oils being available in our country such as Pongamia pinnata (karanja),

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Jatropha curcas (jatropha), Madhuca indica (mahua), Shorea robusta (Sal), Azadirachta indica A Juss (neem) and Hevea braziliensis (rubber), no much attempt has been made to use esters of these non-edible oils as substitute for diesel except jatropha. Moreover, there are plenty of wastelands available in India, which can be utilized for growing such oil seed crops. Few investigators have already obtained biodiesel from some of these oils[1-6]. However, as compared to other edible oils, not much work has been reported on biodiesel production from safflower oil, which has an estimated annual production potential of 181 thousand tons in India[6]. In the light of the above facts, present study was undertaken at Anna University, Chennai to determine the suitability of safflower biodiesel as a substitute for diesel.

Safflower oil

The fuel used in this study is biodiesel (safflower methyl Ester) derived from safflower oil and a blend of B20, B40, B60, B80 and B100 were used. There are different stages in extraction of oil from safflower. The oil is separated and passed through a chemical reactor, where the transestrification of oil with methanol produces safflower methyl Ester.

Transestrification

Transestrification is the process of using an alcohol (e.g. methanol, ethanol, propanol or butanal) in the presence of a catalyst, to chemically break the molecule of the raw renewable oil. Glycerol is obtained as a by product[2]. Methanol is the commonly used alcohol in this process, because it is derived from agriculture products, it is renewable and biologically less objectionable in the environment. Alkali catalyzed transestrification has been most frequently used in industries for its fast reaction rate[3].

EXPERIMENTAL

The performance of prepared safflower methyl ester is compared with diesel fuel. The compression ignition engine used for study is Kirloskar engine direct injection engine. The details are given in Table 1.

Table 1: Specification of Kirloskar single cylinder engine TAF 1

Properties	Methyl ester	Diesel
Density@15ºC in g/cc	0.880	0.85
Kinematic viscosity @40ºC in cst	5.8	3.06

Cont…

Properties	Methyl ester	Diesel
Cetane index	43	52
Flash point	95ºC	76ºC
Fire point	105ºC	81ºC
Calorific value kJ/Kg	37126	43200

Fuel properties

The properties of biodiesel are important for the long term storage. Table 2 summarises the result of safflower methyl ester and diesel fuel.

Table 2: Properties of safflower methyl ester and diesel

Type	Four stroke, vertical air cooled diesel engine
Rated power	4.4 kW
Rated speed	1500 rpm
Bore diameter	87.5 mm
Stroke	110 mm
Compression ratio	17.5:1

RESULT AND DISCUSSION

Brake thermal efficiency (BTE)

The BTE of Kirloskar engine obtained for different fuels is shown in Fig. 1. It can be seen from this figure that the BTE increases with the increasing concentration of B100 in the blends. The maximum BTE were 34% and 35% for B60 and B80, respectively, as compared to 30% for diesel. This could be attributed to the presence of increased amount of oxygen in B80, which might have resulted in its improved combustion as compared to pure diesel .At full load conditions, the mean BTE of B100 was about 17.1% higher than that of diesel, while at lower loads this variation was as high as 11.7%. Based on these results the performance of the engine with biodiesel blends is comparable to Diesel, in terms of brake thermal efficiency. This is reported by many other researchers[1,2,4] while fuelling diesel engines with biodiesels obtained from soybean, sunflower, canola, olive, karanja, jatropha, mahua and rubber seed oils.

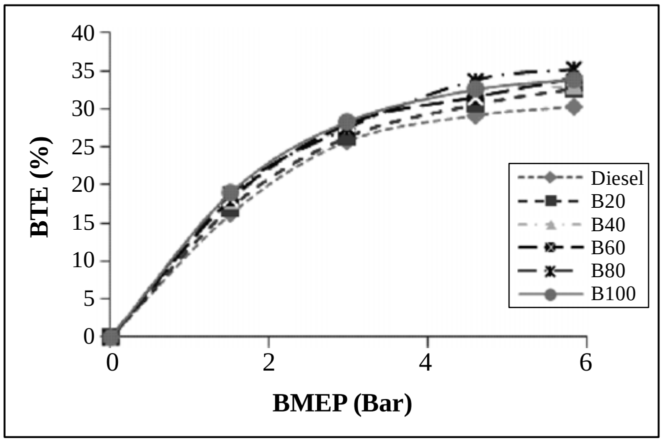

Fig. 1: Brake thermal efficiency

Carbon monoxide (CO) emission

The variation of CO emissions with engine loading for different fuels is compared in Fig. 2. The minimum and maximum CO produced were 0.04-0.09% resulting in a reduction of 50 % to 12%, respectively, compared to diesel. These lower CO emissions of biodiesel blends are due to the more complete oxidation. Some of the CO produced during combustion of biodiesel might have converted into CO_2 by taking up the extra oxygen molecule present in the biodiesel chain and reduces the CO formation. It can be observed from Fig. 2, that the CO initially decreases with load and later increases sharply up to full load. This trend was observed for all the fuel blends tested. Initially, at no load condition, cylinder temperatures might be too low, which increases with loading due to more fuel injected inside the cylinder.

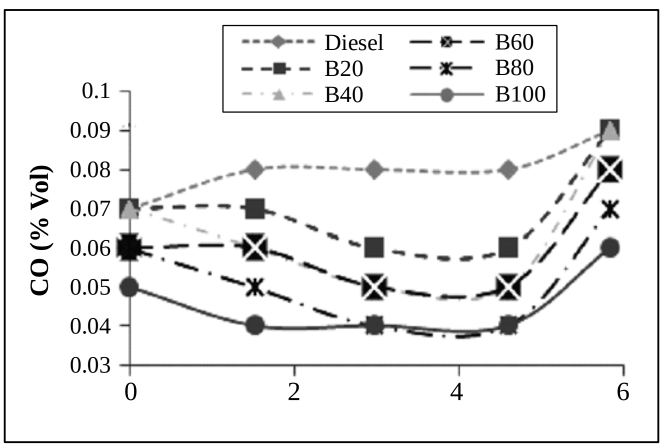

Fig. 2: CO Emission

At elevated temperature, performance of the engine improved with relatively better burning of the fuel resulting in decreased CO. Further loading, the excess fuel required led to formation of more smoke, which might have prevented oxidation of CO into CO_2, consequently increasing the CO emissions sharply. Similar findings were also reported by researchers[1,2,4,7-9] while testing different biodiesels.

NO_x Emission

The NOx values as parts per million (ppm) for different fuel blends of HSD and B100 in exhaust emissions of Kirloskar engine are plotted as a function of load in Fig. 3. The amount of NOx produced for B20 to B100 varied between 165 and 1472 ppm, for diesel it is 173 to 1166 ppm. From the Fig. 3, it can be seen that the increasing proportion of biodiesel in the blends increase NOx emissions slightly (within 6%) when compared that of diesel. This could be attributed to the increased exhaust gas temperatures and the fact that the biodiesel has some oxygen content in it, which facilitates NOx formation. In general, the NOx concentration varies linearly with the load of the engine. As the load increases, the overall fuel–air ratio increases resulting in an increase in the average gas temperature in the combustion chamber and NOx formation, which is sensitive to temperature increase. It can be observed from these values and the graphs in Fig. 3 that the peak occurred at full load conditions. Similar trend was observed in case of all the fuel blends tested. As the blend percent increases diffusion combustion is enhanced than pre mixed combustion. This might be diffusion combustion always have after burning which increases the temperature inside the combustion chamber. The increase of temperature increases the Nox emission for blends comparing to diesel. It is found to be high for B100 at full load condition which has the maximum value since large quantity of fuel has to be injected at full load condition.

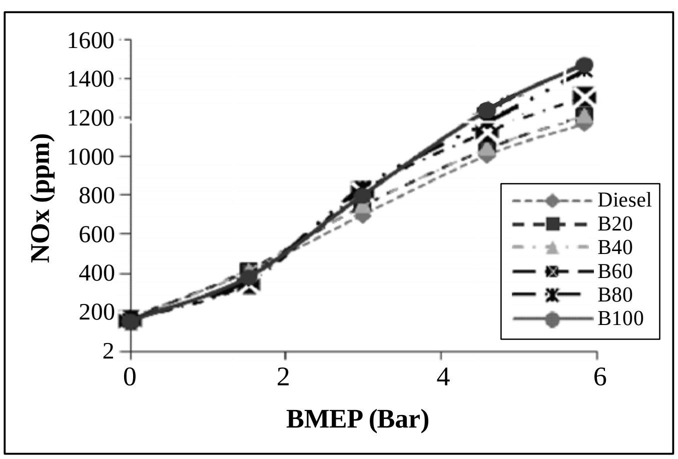

Fig. 3: Nox emission

Smoke emission

Due to the heterogeneous nature of diesel combustion, there will be variation of distribution of air fuel ratio within the cylinder. Smoke emissions are due to either lean air fuel mixture for auto-ignition or high air fuel mixtures for auto-ignition[10-12]. Soot formation mainly takes place in the fuel rich zone at high temperature and high pressure, especially within the core region of each fuel spray. It is caused by high temperature decomposition[13,14]. If the fuel is partially oxygenated, it will reduce smoke formation in primary regions. The Fig. 4 shows the variation of smoke with brake power. It was observed that around 11% of reduction of smoke in safflower methyl ester when compared to Diesel.

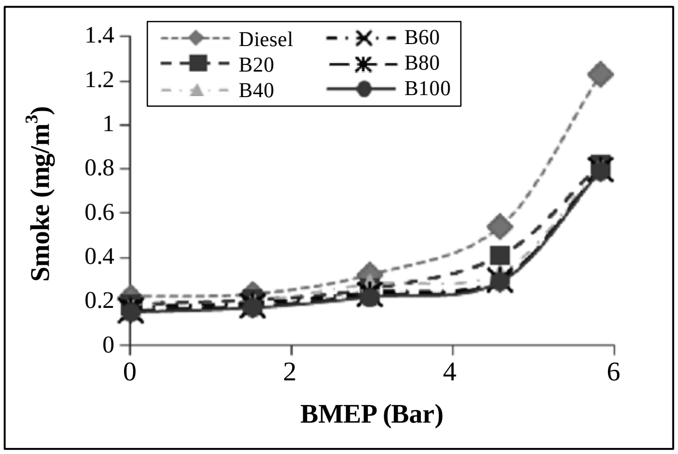

Fig. 4: Smoke emission

CONCLUSION

The fuel properties of biodiesel and their blends in comparison with that of diesel are comparable to diesel. The present results obtained shows that, the transestrification process improved the fuel properties of the oil with respect to density, calorific value, viscosity, flash point, cloud point and pour point. Based on the results of this study, it can be concluded that the, BTE of Kirloskar engine were found to be a function of biodiesel blend and load. For the same operating conditions, performance of the engine increased with increase in biodiesel percentage in the blend. More precisely, biodiesel could be safely blended with Diesel up to 40% for same performance as that with diesel. The smoke level and CO in exhaust emissions reduced, whereas Nox increased with increase in percentage of safflower biodiesel in the blends. However, the level of emissions increased with increase in engine load for all fuels tested. When comparing to emission and performance biodiesel could be safely blended with Diesel up to 40% for same performance as that with diesel. However, pure safflower methyl ester (B100) could be used in the Kirloskar engine without affecting the performance.

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