Study of C I Engine performance with Diesel - Biodiesel (sterculia foetida) Blend as fuel

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Abstract-*The depletion of fossil fuel reserves and the environmental concerns have made to search for new alternative source of energy. Biodiesel seems to be a solution for future because it is a naturally available, renewable and reduces environmental pollution. Biodiesel can be produced from edible/nonedible oils of plants by transesterification process and can be used to replace diesel fuel. In this study non edible oil of Sterculia foetida is used to make biodiesel (**SFME**) and tested for its properties like density, fire point, flash point and viscosity. Experiments were conducted on engine for performance with diesel, biodiesel and diesel-biodiesel blends (**D95BD5, D90BD10, D85BD15 and D80BD20**) at different percentages. The obtained performance results were compared with diesel fuel.*

Key Words*: Engine, Biodiesel, Performance, Transesterification, Blend Fuel*

I. INTRODUCTION

Biodiesel is emerging and promising substitute of diesel as an alternative fuel. The biodiesel gained significant attention due to environmental pollution concern and the predicted depletion of conventional fuels availability in near future. Utilization of biodiesel produced from Jatropha, pongamia, mahuva, neem oil etc. and ***Sterculia foetida oil*** by transesterification process is one of the most promising options to replace conventional fossil diesel fuel without any modification in the existing diesel engine **[1, 2]**. The biodiesel prepared from *Sterculia* foetida oil using sodium hydroxide as catalyst and the resultant biodiesel physico-chemical properties were compared with that of sunflower, soybean and rapeseed oil-based biodiesels and found suitable except for the pour point **[3, 4]**.

Highly pure methyl esters were prepared from *Sterculia foetida* seed oil by using sodium methylate-catalyzed transmethylation, followed by cooling (6°C) the hexane solution of crude methyl esters and separation of insoluble fatty acid methyl esters by centrifugation in the case of *Sterculia foetida*. The formed saturated straight chain fatty acid methyl esters were almost quantitatively removed **[5]**. *Sterculia foetida* are called as Medicinal trees. They are being used for both in the prevention and cure for various diseases of human and pet animals with the advent of human civilization. Many systems of therapy have been developed primarily based on plant. These medicinal plants gain further importance in the region where modern medical health facilities are either not available or not easily accessible **[6, 7]**. In the present work oil is extracted from the collected seeds of ***Sterculia foetida***. This non edible oil is used to make biodiesel of *Sterculia foetida oil Methyl Ester* (SFOME). Experiments were conducted with Biodiesel-Diesel blend fuel and the results compared with diesel fuel.

II. MATERIALS AND METHODS

A) Oil Extraction

Sterculia foetida oil is selected to make biodiesel. This is a tropical plant belonging to the Sterculiaceae family which is also called as 'Java-Olive', 'Bastard poon tree', '*Hazel sterculia*', 'Skunk tree', 'Poon tree'. In India it is known as 'Janglibadam' in Hindi and is shown in figure 1 and 2. The seeds (figure 3) of *S. foetida* were collected, dried, cleaned and removed the shell manually then finely powdered. Oil is extracted from the powder by oil mill. The obtained ***Sterculia foetida*** seed oil is used to prepare biodiesel by transesterification process.

Fig. 1 Sterculia foetida tree with fruits

Fig. 2 Sterculia foetida dry fruits

Fig. 3 Open *sterculia foetida* fruit with seeds

B) Preparation of Biodiesel

Raw oil is filtered and heated to 105^0C temperature to remove water content. Methanol of 120ml and 2ml of H_2SO_4 per liter of oil are added and heated with stirring at 60^0C in a closed conical flask. The mixture is allowed to settle in a decanter, and then glycerin is separated from methyl ester. *Sodium Methoxide* is prepared by mixing 200ml of methanol (20% by vol.) and 6.5 grams of NaOH per liter of oil. This solution is added to the oil, stirred continuously at 60^0C in a conical flask till the completion of reaction as shown in figure **6**. This mixture is allowed to settle in decanter and glycerin is separated from methyl ester (**Fig. 4**). The collected *Sterculia foetida* oil methyl ester as shown in figure **5** is bubble washed with water to remove soaps and heated to evaporate water from biodiesel **[8, 9].**

Fig. 4 Glycerol separation

Fig. 5 Heating of biodiesel

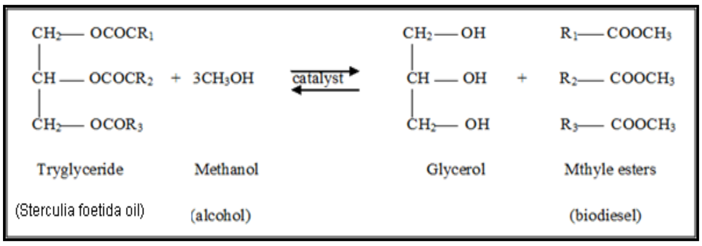

Fig. 6 Reaction of Biodiesel formation

C) Experimentation

Four stroke single cylinder diesel engine (**Table 1**) was used for the experimental work. Experiments were conducted with diesel, biodiesel (***SFME***) and diesel-biodiesel blends (***D95BD5, D90BD10, D85BD15 and D80BD20***). The biodiesel blends are tested for its properties like fire point and viscosity and compared with diesel as shown in table **2**. During the test, performance parameters were measured by using appropriate instruments and analyzed to compare the results with diesel fuel.

Table 1 Engine specifications

Sno	Particulars	Specifications
1.	Engine	Kirloskar make, 4 stroke single cylinder
2.	Rated power	3.67 kW
3.	Rated speed	1500 rpm
4.	C R	16:1
5.	Bore/stroke	80mm/110mm
6.	Dynamometer	Mechanical type

Table 2 Blend fuel properties

Property/ Fuel	Viscosity at 40^0c cSt	Fire point at 40^0c	C V kJ/Kg
Diesel	3.12	64	43000
Biodiesel	5.4	143	40420
D95BD5	5.2	69	42870
D90BD10	4.9	77	42740
D85BD15	4.6	86	42610
D80BD20	4.4	106	42480

III. RESULTS AND DISCUSSIONS

A) Performance Analysis

i) Brake thermal efficiency (η_{Bth}): From the graph (**Fig. 7**) drawn between load and brake thermal efficiency it shows that brake thermal efficiency values for biodiesel are lesser than diesel because the lower calorific value of biodiesel. It is observed that as the percentage of biodiesel increases the efficiency decreases. The blend fuel with 5% biodiesel is better and has 2.8% less brake thermal efficiency than diesel.

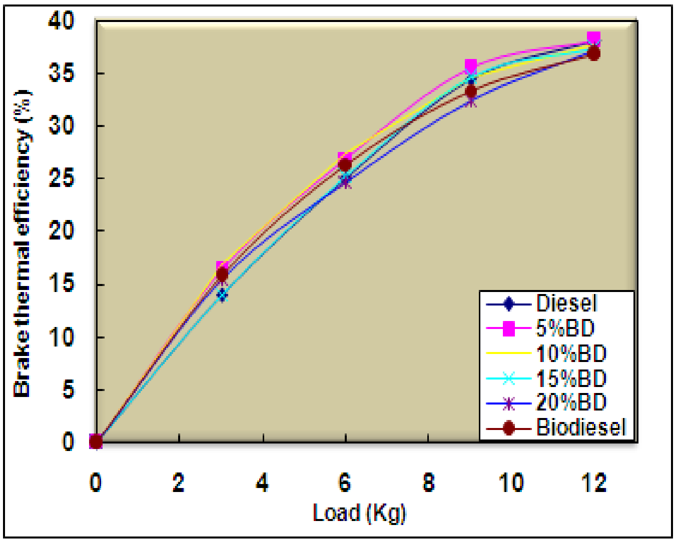

Fig. 7 Variation of brake thermal efficiency with Load

ii) Brake Specific fuel consumption (*BSFC*): From the graph (**Fig. 8**) drawn between load and BSFC it is clear that the values of BSFC for biodiesel are higher compared to diesel because of its lower calorific value. For complete combustion, less amount of air is required because up to 11% of oxygen availability in biodiesel when compared to diesel.

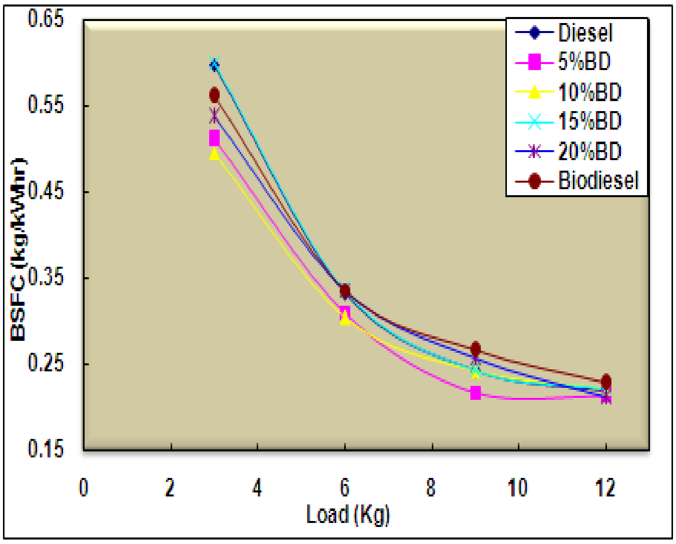

Fig. 8 Variation of BSFC with Load

iii) Mechanical efficiency (η_{Mech}): From the graph (**Fig. 9**) drawn between load and mechanical efficiency it is observed that mechanical efficiency is higher for blend fuel having more biodiesel due to lower frictional power. Engine running with biodiesel is 14.2% higher efficient than diesel fuel.

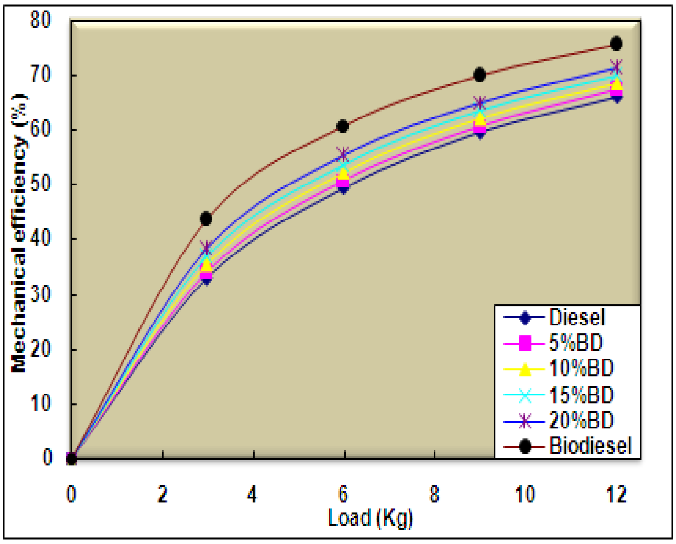

Fig. 9 Variation of Mechanical efficiency with Load

CONCLUSIONS

- It is concluded that as the percentage of biodiesel increases engine runs very smoothly but efficiency decreases. The blend fuel with 5% biodiesel is better and has 2.8% less brake thermal efficiency than diesel.

- The values of BSFC for blend fuel are higher compared to diesel because of its lower calorific value.
- Engine running with biodiesel as fuel is 14.2% higher efficient than diesel fuel due to low frictional losses.

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