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Production and performance analysis of biodiesel from algae

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Abstract: Energy is of vital importance to the society and human life. The world is entering into a period of declining non-renewable energy resources. Bio-diesel seems to be a good remedy for this problem. Microalgae is a potential source for the continuous production of biodiesel. Moreover, the productivity of biodiesel from microalgae is much higher compared to other sources of biodiesel. The present study deals with the performance characteristic of the Algae biodiesel run diesel engine. For analysis, two biodiesel blends namely, B10 and B20 (10 % and 20 % algae oil respectively mixed with diesel) were selected. The study revealed that with increasing engine load, the brake thermal efficiency was enhanced for B10 blend compared to diesel. For 75 % load, the brake thermal efficiency of B10 blend was found to be around 21.8 %. Moreover, the brake specific fuel consumption of B10 blend was observed to be very less as compared to diesel and B20 blend. In addition, at 75 % load, the mechanical efficiency of B10 blend was found to be around 37.7 %.

Keywords: Biodiesel, Microalgae, Nutrients, Blend, Brake thermal efficiency.

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1. Introduction: Fossil Fuels is one the largest used fuels in present civilization. It has been the primary source of energy for the past few decades. Due to its high rate of energy production it has continuously been used as a source of energy production in household, industrial and transportation purposes. But with increasing population and also with the advancement in technology the energy demand is increasing as a result nonrenewable energy sources are declining. Atmospheric pollution created by the use of petroleum diesel is the major disadvantages of petroleum based fuels. The combustion of diesel fuel emits several greenhouse gases and other air pollutants (such as NOx, SO_x, CO), particulate matter and volatile organic compounds **[1]**. A significant attention has been focused on the development of renewable-alternative fuel to reduce the amount of greenhouse gas emissions. In this context biodiesel has become a key source as a substitution fuel and is making its place as a key future renewable energy source **[2]**. Moreover, biodiesel is also non-toxic and biodegradable renewable fuel. It is mostly produced from mahua oil, jatropha oil, soybean oil, sunflower oil, used cooking oils, animal fats etc. However, the sustainability production of biodiesel has been concerned because of less amount of oil content and necessity of large area of plantation **[3]**. Over the last decade, algae have been found out as a new source of biomass for the production of biofuels. The algae are high yield biomass per unit of area and high oil or lipid content **[4]**. Algal cells have 30 % lipid content, which is higher than other biodiesel sources **[5]**. Besides, for the growth of algae, fresh water or agricultural land is not required; wastewater can supply the essential nutrients for its growth **[6]**. From waste water algae can efficiently remove the toxic components for which it can be used for waste water treatment. The remediating role in waste water treatment and high lipid content of algae, makes it as a suitable source of biodiesel to be grown on large scale **[7]**.

In this study, the experiments are being conducted in the diesel engine using blends of algae oil biodiesel in percentage of 10 % and 20 % with conventional diesel (namely, B10, B20 blend) at variable load condition of 0 %, 25 %, 50 %, 75 % load at engine. A comparative investigation has been done on the various performance parameters using those blends in order to provide an effective replacement for diesel fuel.

2. Experimental

2.1 Fuel Characterization: Biodiesel was produced from the extracted algae oil through the transesterification reaction. For getting maximum extraction efficiency, the extraction was carried out for 3 hours at 80 °C **[8]**. The physical and chemical properties of the conventional diesel and prepared biodiesel including pour point, cloud point, freeze point, viscosity, density, flash point, calorific value, fire point were determined and summarized in Table (1) and (2).

Table 1: Properties of algae oil.

Acid Value	3.381 % FFA
Cloud Point	-5°C
Pour Point	-8°C
Viscosity	13.1193 m^2/s
Density	0.9166 g/cm^3

Table 2: Characteristics of diesel and biodiesel.

Properties	Diesel	Biodiesel
Cloud Point	-8 °C	0 °C
Pour Point	-16 °C	-4 °C
Freeze Point	-10 °C	-6 °C
Density	0.832 gm/cm^3	0.85 gm/cm^3
Viscosity	3.9 m^2/s	4.856 m^2/s
Calorific Value	39480 J/g	34852.24 J/g
Flash Point	60 °C	132 °C
Fire Point	83 °C	145 °C

2.2 Blending of Biodiesel: Biodiesel and petroleum-based diesel have similar chemical characteristics, so biodiesel can also be used in place of commercial diesel for running an engine. The most common biodiesel blends are B10 (10 % biodiesel) and B20 (20 % biodiesel). B100 (pure Algae biodiesel) is used for producing the lower biodiesel blends. For the production of B10 blend 100 ml of pure algae biodiesel is added with 900 ml of diesel by using measuring flask. Both the samples were taken in a conical flask and mixed properly with the help of magnetic stirrer and the mixed sample was stored in a volumetric flask. In the similar way, B20 blend is prepared by mixing 800 ml of diesel with 200 ml algae biodiesel.

3. Results and analysis:

Engine test was done to analyze and compare the performance of the conventional diesel, B10 and B20 blends. The test was performed in a 4-cylinder, 4-stroke, natural aspirated, water cooled, diesel engine manufactured by Tata Indica. The engine specification is shown in the Table (3) below.

Table (3): Engine Specification.

Engine make	Tata Indica Engine
Compression ratio	22:10
Swept volume	351.22 cc
Engine Power	39 kW
Connecting Rod length	127 mm
Stroke Length	79.50 mm
Engine RPM	5000 rpm

The engine testing was done by gradually loading the dynamometer (0 %, 25 %, 50 %, 75 % load) and the resulting changes in performance was recorded. The different sensors attached at the various locations of the engine provide the necessary data for the analysis of performance. Figure (1) shows the variation of brake thermal efficiency at different engine loads. It was observed that for all the three fuels with increasing the loads, the brake thermal efficiency of the engine increases. The maximum efficiency was observed for B10 blend followed by diesel fuel and B20 blend. The maximum brake thermal efficiency (21.8 %) was observed for B10 blend at 75 % load.

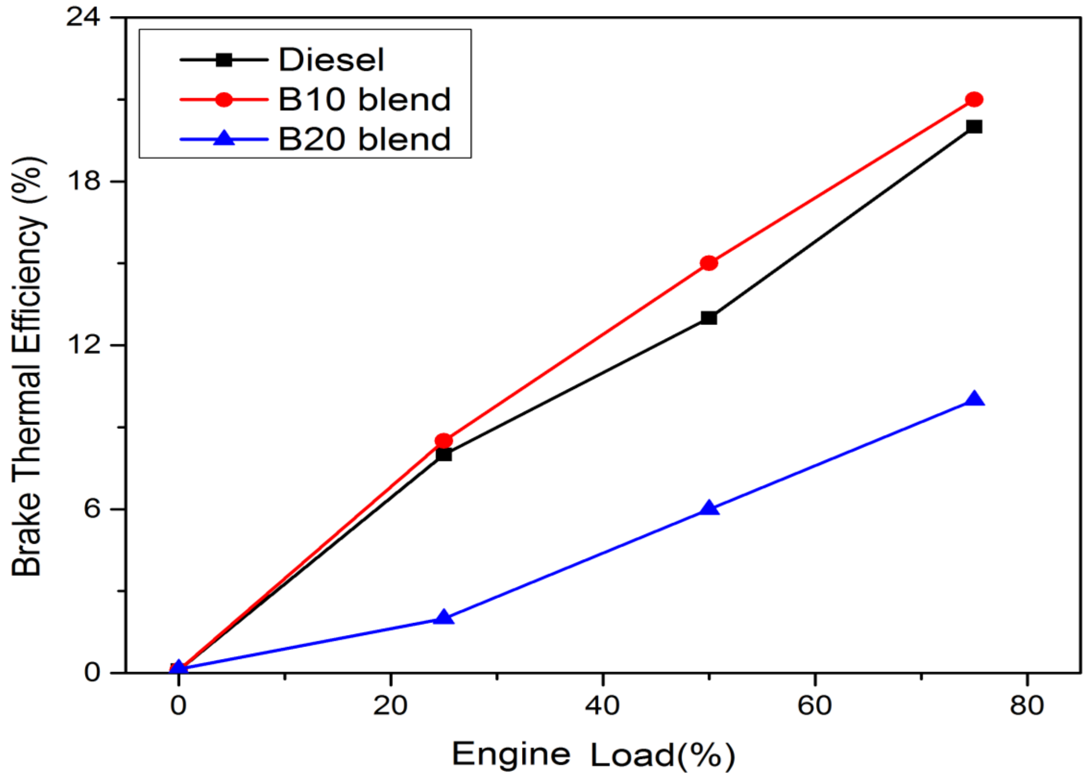

Figure (1): Variation of brake thermal efficiency at different engine loads.

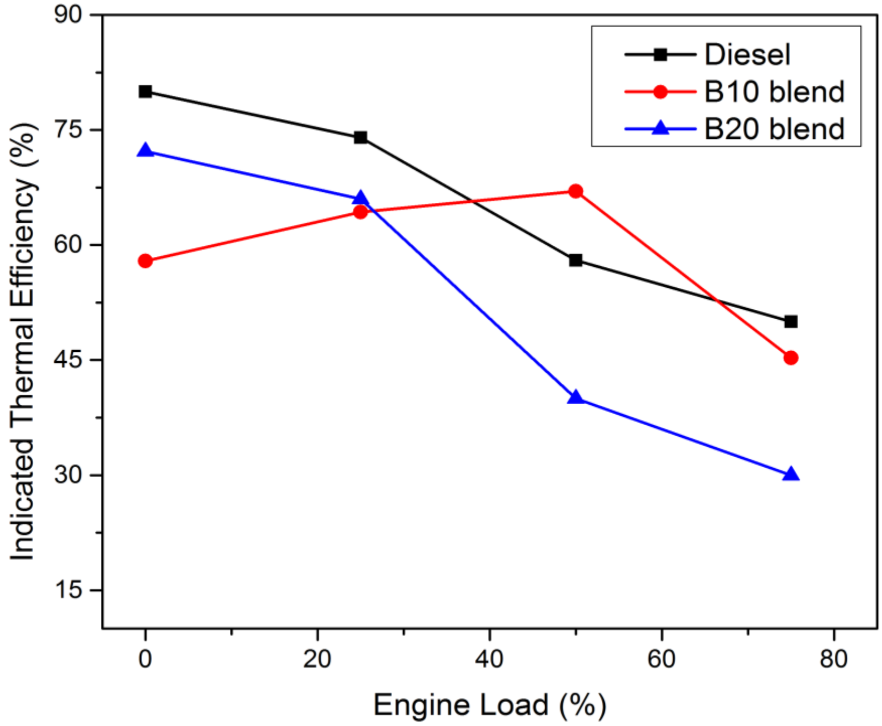

Figure (2): Variation of indicated thermal efficiency at different engine loads.

Figure (2) shows the variation of indicated thermal efficiency with load. The maximum indicated thermal efficiency (80 %) was observed for diesel fuel and it is decreases with increasing load. The B20 blend followed the similar trend. However, for B10 blend, the maximum efficiency (67 %) was obtained at 50 % loading.

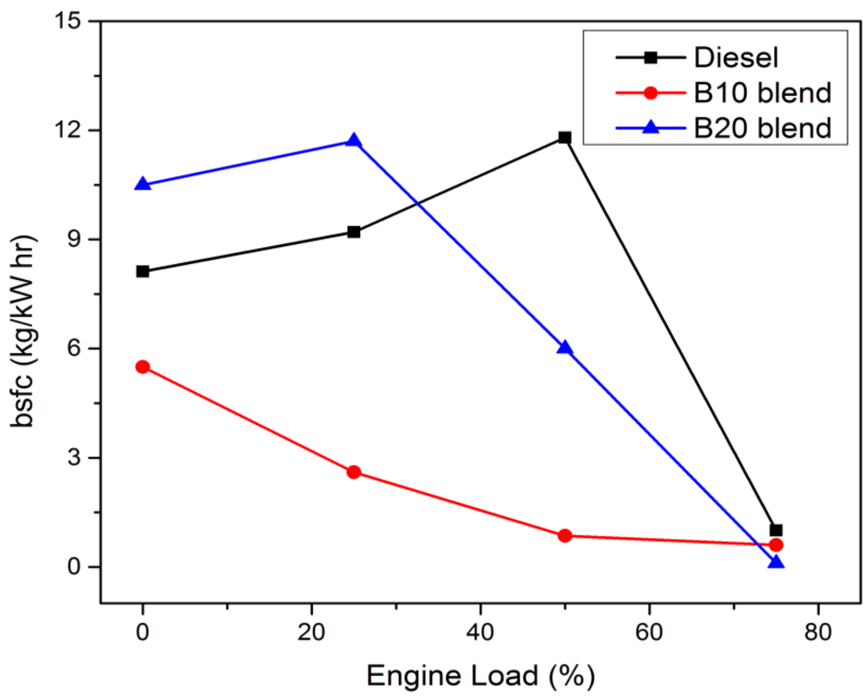

Figure (3): Variation of brake specific fuel consumption at different engine loads.

Figure (3) shows the variation of brake specific fuel consumption with engine loading. It was observed that the brake specific fuel consumption (bsfc) of B10 blend is least compared to both diesel and B20 blend in all load conditions. A gradual decrease in brake specific fuel consumption is seen in B10 blend. This result may be attributes to the proper combustion of the blend in engine.

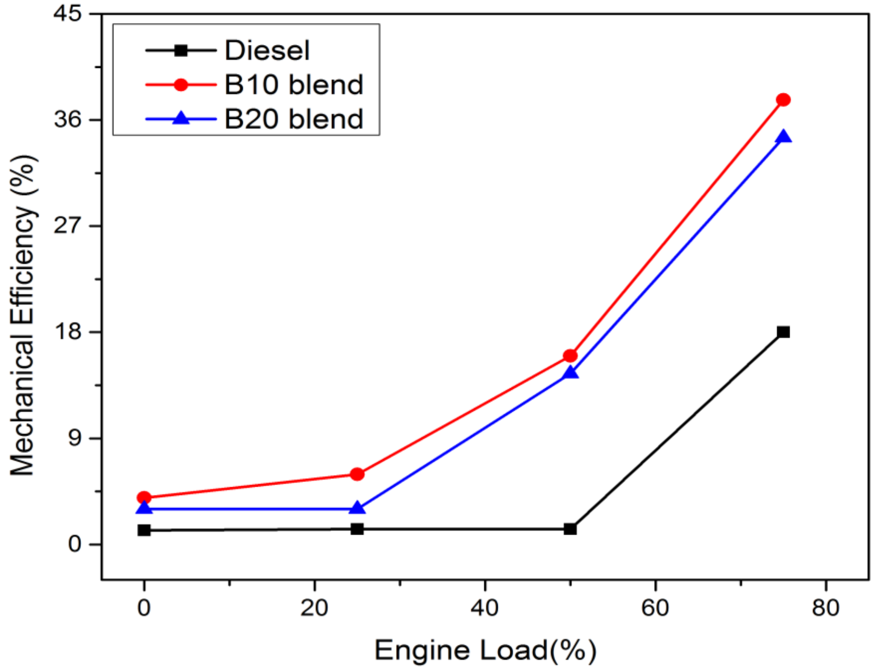

Figure (4): Variation of mechanical efficiency at different engine loads.

Figure (4) shows the variation of mechanical efficiency with engine loading. It was observed that there is an increase in mechanical efficiency with increasing load. However, B10 blend gives better results of 37.7 % at 75 % loading whereas, diesel and B20 blend shows a maximum of 18 % and 34.5 % of mechanical efficiency. The increase in mechanical efficiency is mainly because of higher brake power.

4. Conclusions: The present study deals with performance analysis of biodiesel extracted from algae oil and compared the results with diesel. It was found that the brake thermal efficiency increases with increasing engine load and the maximum brake thermal efficiency (21.8 %) was obtained for B10 blend at 75 % loading. The maximum indicated thermal efficiency was observed for diesel fuel and it is decreases with increasing load. However, for B10 blend the maximum indicated efficiency (67 %) was obtained at 50 % loading. A gradual decrease in brake specific fuel consumption was seen in B10 blend due to proper combustion. An increase in mechanical efficiency was found for B10 blend with respect to Diesel and B20 blend for all load conditions. The mechanical efficiency of B10 blend at 75 % load was found around 37.7 % which was quite high in comparison to conventional diesel.

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