Processing of Biodiesel from Algae and Experimental Investigation on Single Cylinder Diesel Engine

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ABSTRACT

Biodiesel is a non-toxic, highly biodegradable, renewable fuel and emits less amount of CO_2 and NO_x. Burning of petroleum based fuel causes accumulation of carbon dioxide in the environment [1] and fuel price is increasing day by day. Algae is emerging as an alternative raw material to petroleum based fuels and is the highest yielding feedstock for biodiesel. It is very much important recently because of its environmental benefits and the fact that it is made from renewable resources. It is proved that algae grown in CO_2-enriched air can be effectively converted to oily substances. Such an approach definitely solve major problems of air pollution resulting due to CO_2 evolution and future crisis due to a shortage of fossil energy sources. This study was undertaken to know the proper trans-esterification, amount of biodiesel production and physical properties of the biodiesel. In this study we used common species of algae called Oedogonium for biodiesel production [2] which has been collected from Akkulam Lake, Trivandrum. In this study, Biodiesel was processed from algae. The various properties of biodiesel were experimentally estimated. Performance were conducted on a single cylinder diesel engine using diesel and biodiesel. Using algae as raw material, adaptation of continuous trans-esterification process and recovery of high quality glycerol as by product may be options to be considered to lower the cost of bio-diesel.

Keywords: *Algal oil, Biodiesel, Green house, Renewable resource, Trans-esterification.*

1. INTRODUCTION

The global pollution situation is worsening day by day. One of the major causes for this condition is the overwhelming consumption of fossil fuels as power sources [3]. Automotive sector is the major consumer of fossil fuels - mainly petroleum based products. The fossil fuel resources are depleting at a faster rate and this has led to a grave situation because of greater dependence on fossil fuel resources. Automobiles and other industries pollute the atmosphere with 'green house' gases – CO_2 and H_2O, these gases in turn lead to the increase in global temperature, which ultimately results in melting of the polar ice caps. This phenomenon is called global warming. Global warming results in the change of global weather pattern. In addition to the change in global weather phenomenon, fossil fuel pollution is also the reason for many major health problems. There comes the need of using alternative fuels to overcome this problem. This study mainly focuses on the reduction of fossil fuels and the byproduct formed after combustion of biodiesel is environment friendly.

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2. ALTERNATIVE FUELS

Alternative fuels are environmentally beneficial alternatives to conventional fuels. The fuels most commonly used for transportation are gasoline and diesel. The combustion of these hydrocarbon fuels results in the formation and release of carbon dioxide into the atmosphere. Incomplete combustion results in the formation of carbon monoxide, to overcome this defect there comes the need for alternate fuels.

2.1 Biodiesel

The alternative fuel mainly used for the diesel engine is biodiesel. Biodiesel is made from renewable biological sources such as algae, vegetable oil, animal fats and other agricultural products. It is biodegradable, non-toxic and possesses low emission profiles. Biodiesel is much cleaner than fossil fuel diesel. It can be used in any diesel engine with no major modifications - in fact diesel engines run better and last longer with biodiesel. In this study we used common species of algae called Oedogonium for biodiesel production which has been collected from Akkulam Lake, Trivandrum.

3. MATERIALS AND METHODS

Many standardized procedures are currently available for the production of biodiesel.

a) Blending
b) Micro Emulsification
c) Trans-esterification
d) Thermal Cracking

3.1 Trans-esterification [4]

Trans-esterification is the process by which an oil or fat react with an alcohol to form esters and glycerol. A catalyst is used to enhance the yield and reaction rate, because the reaction is reversible. Excess alcohol is used to shift the equilibrium to the products side. The alcohols that can be mainly used in the trans-esterification process are methanol, ethanol, propanol, and butanol. Methanol and ethanol are used most frequently, especially methanol because of its low cost factor, its chemical and physical advantages. The alkalis include sodium hydroxide (NaOH) and potassium hydroxide (KOH). Sulfuric acid, sulfonic acid and hydrochloric acid are usually used as acid catalysts. Alkali-catalyzed trans-esterification is much faster and is most often used commercially than acid-catalyzed trans-esterification.

3.2 Aim of this Study

- Production of biodiesel from algae.
- Determination of its properties.
- Performance test.
- Comparison of performance with diesel.

3.2.1 Production of biodiesel

Site: The experiment was carried out in the college laboratory under the guidance of faculties.

Sample collection: Algae samples were collected from Akkulam Lake, Trivandrum.

Oil extraction: Algae were ground with motor and pestle as much as possible. The ground algae were dried for releasing water. Hexane and ether solution were mixed with the dried ground algae to extract oil. Then the mixture was kept for about 36 hours for settling.

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Biomass Collection: The biomass was collected after the filtration and it is weighted.

Evaporation: The extracted oil was evaporated to release ether solutions and hexane by using rotary evaporator.

Mixing up of Catalyst and Methanol: NaOH was mixed with methanol and stirred properly for about 30 minutes.

Biodiesel production: The mixture of catalyst and methanol was poured into the algal oil in a conical flask. The following steps were followed.

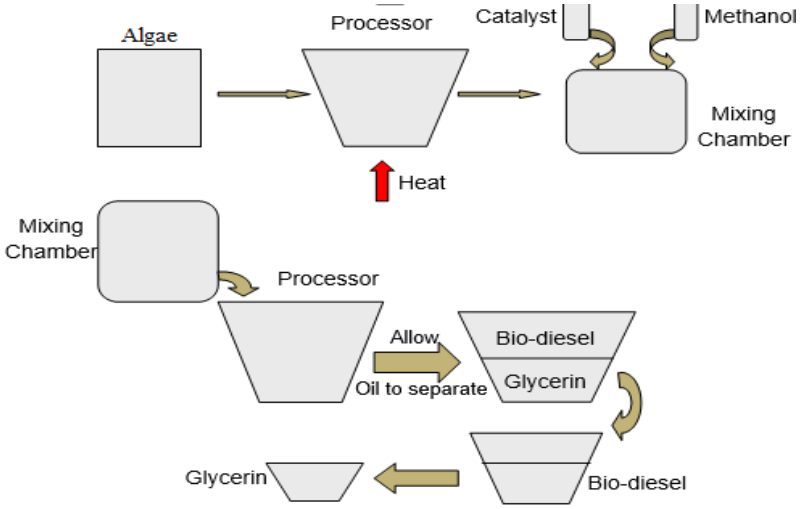

Fig. 1 Shows the Steps Involved in Biodiesel Extraction from Algae

4. DETERMINATION OF FUEL PROPERTIES

The fuel properties such as viscosity, flash point, fire point, density and calorific value were determined.

4.1 Experimental Setup and Procedure

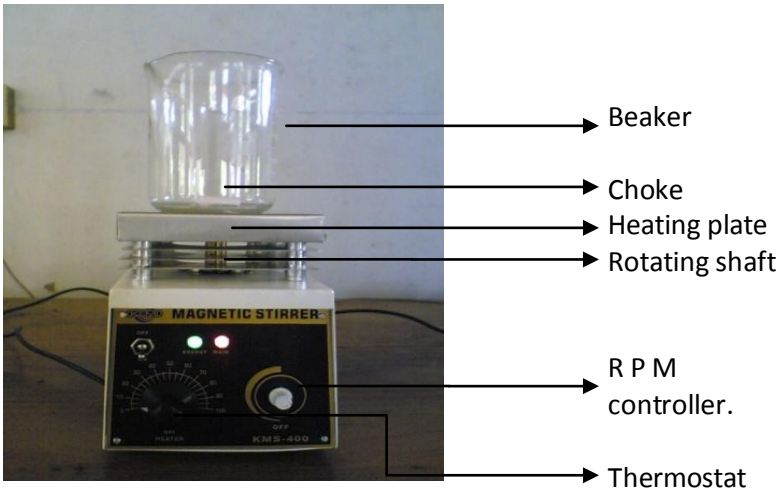

Fig. 2 Shows Apparatus Used for Oil Extraction

A glass beaker was used for the setup. Thermocouple with digital indicator directly gives the oil temperature. A thermostat is used to control the temperature. Temperature is an important factor during biodiesel production. Adjust the thermostat to a fixed temperature (60° C). Magnetic stirrer with hot plate equipment is used for heating and stirring process. After processing of biodiesel, the glycerin is separated.

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Fig. 3 Shows the Single Cylinder Diesel Engine

Engine	- Kirloskar made 4 stroke single cylinder vertical hand cranking type diesel engine
Stroke	- 110mm
Bore	- 80mm
Rated speed	-1500RPM
Cooling system	-Water cooled

5. RESULT AND DISCUSSION

5.1 Properties of Processed Oil

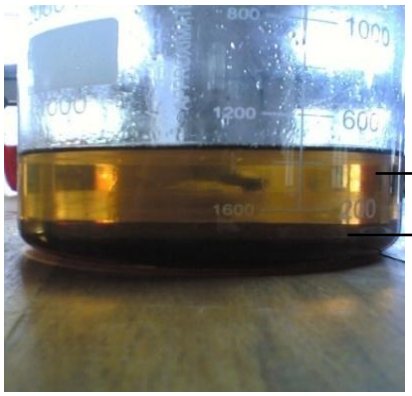

Fig. 4 Shows the Biodiesel Extracted from Algal Oil

Lower Calorific value	= 41239 KJ/Kg
Density	= 844 Kg/m^3
Viscosity	=7.65 centistokes (at 30^{o}c)
Flash point	=73^{0}c
Fire point	=97^{0}c

5.2 Properties of Diesel

Lower Calorific value	=42250 KJ/Kg
Density	= 835 Kg/m^3
Viscosity	=1.3 - 4.1centistokes (at 30^{o}c)
Flash point	=60^{0}c - 80^{0}c
Fire point	=90^{0}c- 102^{0}c

5.3 Performance Curves [5]

Performance test was performed with diesel, biodiesel from algae and compared performance curves are show below.

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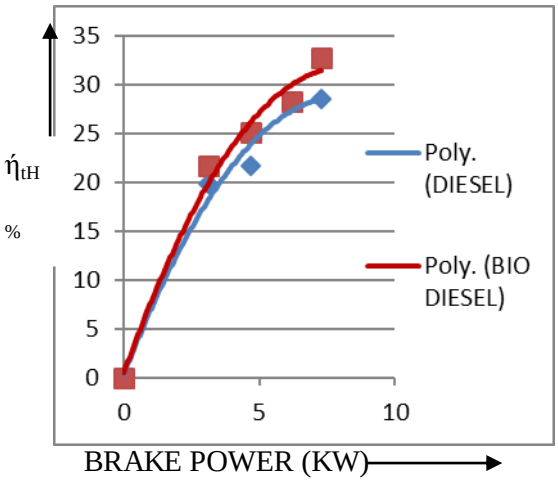

Fig. 5 Brake Powers Vs Thermal Efficiency

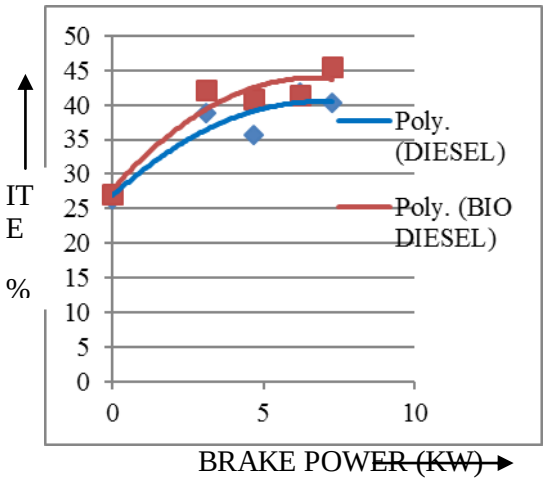

Fig. 6 Brake Power Vs Indicated Thermal Efficiency

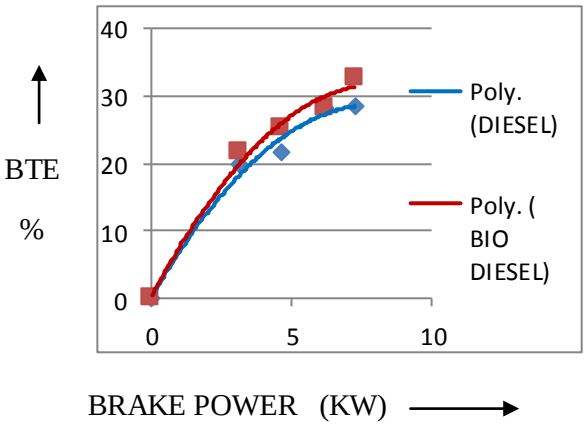

Fig. 7 Brake Power Vs Brake Thermal Efficiency

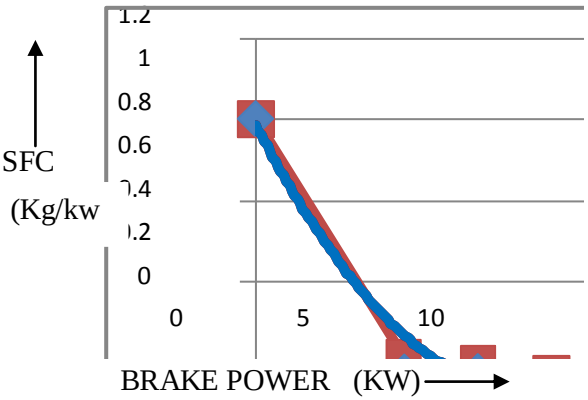

Fig. 8 Brake Power Vs Specific Fuel Consumption

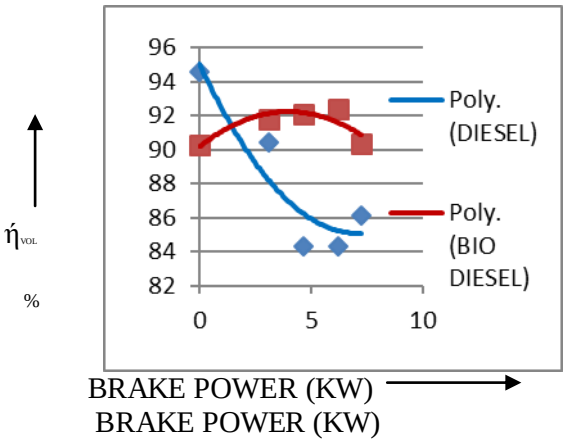

Fig. 9 Brake Power Vs Volumetric Efficiency

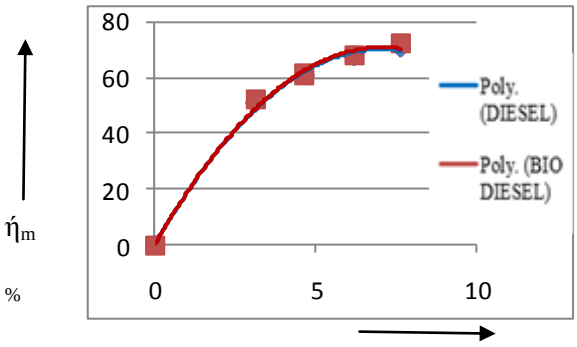

Fig. 10 Brake Power Vs Mechanical Efficiency

As load increases break power increases .Comparing diesel and biodiesel all the curves are same at rated load, it achieves a minimum and beyond that it starts to increase. Brake power curve is just the inverse of the specific fuel consumption curve. Mechanical efficiency never drops, it keeps on increasing. The break thermal efficiency is not decreasing as the engine was not overloaded.

6. CONCLUSION

The biodiesel was successfully extracted from algae and its properties and performances were determined which gave the following conclusions:

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- Acid based trans-esterification is well suited for the production of biodiesel from algae.
- Separation of biodiesel from algal oil was performed successfully and when compared it with diesel it was found better in all aspects.

6.1 Advantages

- It has lesser emission when compared to standard diesel fuel.
- It is biodegradable; it has been found that its degradation rate is four times that of conventional diesel fuel.
- Biodiesel also assists in the process of engine lubrication.
- It is also safer and non-toxic, having higher flash point than conventional diesel oil, accidental fires are less likely [6].
- It makes easier to storage and transport.

6.2 Disadvantages

- Biodiesel also breakdown rubber components.
- Source for massive feedstock.
- In some engines there was slight decrease in fuel power and increase in fuel consumption has been noticed.

6.3 Applications

- Generating electricity.
- Cleaning up of Tools and grease.
- Alternative fuel to diesel Fuel.
- Removing paint and adhesives.

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