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Experimental investigation of performance characteristics of diesel engine fueled with linseed - coconut oil bio diesel

K.Rajesh[1], Jana Prakash[2],R.Ganeshkumar[3], R.Vinod Raj[4]
Final Year Student, Mechanical Department, IFET College of Engineering, Villupuram. INDIA [1 2 3]
Asst.Professor, Mechanical Department, IFET College of Engineering, Villupuram. INDIA [4]

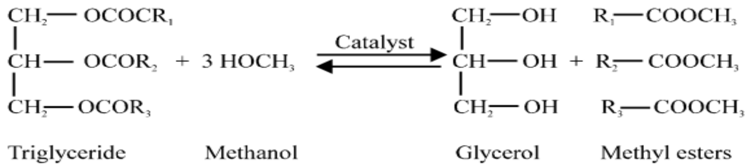
rajeshmech.raji@gmail.com ; n.janaprakash@y7mail.com

ABSTRACT *— Due to industrialization, globalization and green revolution in agriculture have increased the demand for the petroleum products. Petroleum fuels release more emissions like CO, NO_X, CH_4 & CFC which are responsible for global warming & ozone layer depletion. Biodiesel is a less pollutant, biodegradable and renewable alternative fuel that can be used with little modifications. The objective of this study was to investigate the effect of the biodiesel produced from Linseed - Coconut Oil on single cylinder water-cooled diesel engine. In the current research work biodiesel is prepared from Linseed - Coconut Oil. The Experimentation was conducted on four stroke single cylinder water-cooled diesel engine using linseed biodiesel and their performance characteristics were studied. Results of performance using linseed biodiesel were compared with that of diesel fuel.*

Keywords: bio fuels, bsfc, emissions, global warming & linseed methyl esters

1. INTRODUCTION

Biodiesel is one of the potential alternative fuels to replace conventional petroleum diesel. It is a clean-burning fuel with high lubricity for use in existing unmodified diesel engines. This means that no retrofits are necessary when using biodiesel fuel in any diesel powered combustion engine. It is the only alternative fuel that offers such convenience. Biodiesel is a renewable fuel; it produces less air pollution and is biodegradable and less toxic to the environment. Producing biodiesel fuels can help create local economic revitalization and local environmental benefits. Many groups interested in promoting the use of biodiesel already exist at the local, state and national level. Biodiesel can be blended in any ratio from additive levels (2 to 5%) to 100 percent. Biodiesel is a sulphur free renewable fuel, it can be produced from vegetable oils and animal fats. Higher viscosity, higher molecular weight and low volatility cause poor atomization leading to incomplete combustion result in several problems. The physical and chemical properties of straight vegetable oil can be improved by transesterification and reduction in viscosity may be achieved. In general, the vegetable oils are in the form of triglycerides which are converted into esters (Biodiesel). Thus the vegetable oils are chemically subjected to a process called transesterification, in which the oil is made to react with methanol or ethanol in the presence of a base catalyst such as sodium hydroxide or potassium hydroxide which yields biodiesel. India is net importer of vegetable oils, so edible oils cannot be used for production of biodiesel. India has the potential to be a leading world producer of biodiesel, as biodiesel can be sourced and produced from non-edible oils like Jatropha, Linseed, Pongamia Pinnata, Mahua, Castor, etc. These oils are not being properly utilized. Wastelands can be used to grow these plants by multiculture which reduces global warming as plants make food by photosynthesis in which they absorb CO_2. The temperature of earth is increasing at an alarming rate due to green house gases like CO_2, NOx, CH_4 & CFC which are produced by using fossil fuels. Carbon dioxide's share in global warming is 63%. The safe limit of CO2 in environment is 270 ppm. It was around 275 ppm before 1950 but after industrialization it is icreasing rapidly and now it is around 370 ppm which led to 1^{o} C rise in earth's temperature. If it continuous in the same manner, CO_2 will be around 550 ppm by 2100 & earth's temperature will be raised by 4^{o} C which causes the ice at Greenlands & Himalayas to melt and increase the sea levels. This creates major threat for coastal areas and Iceland. Linseed oil is a triglyceride. It is converted into ester using transesterification reaction. The reaction requires heat and a strong catalyst (alkalis, acids, or enzymes) to achieve complete conversion of the vegetable oil into the separated esters and glycerin. The reaction is shown as follows



2. ENVIRONMENTAL BENEFITS OF BIO-DIESEL

Environmental benefits in comparison to petroleum based fuels include:

- Biodiesel reduces emissions of carbon monoxide (CO) by approximately 50% and carbon dioxide by 78% on a net lifecycle basis because the carbon in biodiesel emissions is recycled from carbon that was in the atmosphere, rather than the carbon introduced from petroleum that was sequestered in the earth's crust.
- Biodiesel can reduce as much as 20% the direct emission of particulates, small particles of solid combustion products, on vehicles with particulate filters, compared with low-sulfur diesel. Particulate emissions as the result of production are reduced by around 50% compared with fossil-sourced diesel.
- Biodiesel produces between 10% and 25% more nitrogen oxide NO_X tailpipe emissions than petrodiesel. As biodiesel has low sulphur content, there is no sulphur di oxide emission.
- Biodiesel has higher cetane rating than petrodiesel, which can improve performance and clean up emissions compared to crude petrodiesel.

- Biodiesel is biodegradable and non-toxic – the U.S. department of Energy confirms that biodiesel is less toxic than salt and biodegrades as quickly as sugar.

3. PREPARATION OF BIODIESEL

Raw vegetable oils requires certain modifications of their properties like viscosity and density before using in IC Engines. Trans esterification is a process in which viscosity & density of oil can be reduced. In the transesterification of vegetable oils, a triglyceride reacts with alcohol in the presence of either acid or base catalyst to produce a mixture of fatty acid alkyl ester and glycerol. In this process Linseed oil is made to react with methanol in the presence of base catalyst (NaOH). The biodiesel is obtained from Linseed oil in the following way.

Fig.1 Photograph of Raw Linseed oil.

Fig.2 Linseed oil after acid treatment.

Fig.3 Linseed oil after base treatment

Fig.4 Linseed biodiesel

In the Trans esterification of vegetable oils, a triglyceride reacts with alcohol in the presence of either acid or base catalyst to produce a mixture of fatty acid alkyl ester and glycerol. In this process Linseed - Coconut Oil Blend is made to react with methanol in the presence of base catalyst (NaOH). The biodiesel is obtained from Linseed - Coconut Oil Blend in the following way.

1. A 1000 ml sample of raw linseed oil is taken and is filtered and heated upto 100₀C to remove water.
2. When the temperature of the oil reaches to a range of 50 - 60° C, add 120 ml of methanol and heat the oil on a mechanical stirrer for 5 more minutes and then add 3 ml of sulphuric acid (H_2SO_4).
3. After heating the solution for 1.5 hrs at the temperature range 50-60 °C, heating is stopped and the solution is allowed to separate into glycerin and methylester where the glycerin is settled at the bottom.
4. The settled glycerin is drained out and then oil is again purified using cotton and treatment is started.
5. The sample from the acid treatment is again kept for heating on a mechanical stirrer and waits till the temperature reaches to a range of 50 - 60° C.
6. Meanwhile methoxide solution is prepared by adding 200 ml of methanol with 5 gm of NaOH. Methoxide is added to the oil sample and heated on mechanical stirrer for 1.5 hrs at constant temperature in the range of 50-60° C.
7. After the sample, containing methoxide is heated for 1.5 hr. The sample is poured into a separating funnel.
8. Settling time of minimum 1.5 hr or more is given for the formation of glycerin left in the sample after the acid treatment and other free fatty acids which settles to the bottom of the separating funnel.
9. Then water wash is carried out in order to remove any excess glycerin or acids added.

4. EXPERIMENTAL SETUP

The specifications of the engine used for the experimentation is given in the Table 1& the specifications of the alternator coupled with the engine is given in the Table 2

TABLE I: ENGINE SPECIFICATION

Make	Kirloskar
Speed	1500 RPM
No. of cylinder	One
Bore	80mm
Stroke	110mm
Rated output	3 kW
Compression ratio	16.5:1

TABLE II: ALTERNATOR SPECIFICATION

Make	Himalaya
Type of power	A.C
Power	4 kVA
Volts	230 volts
Phase	single phase
Speed	1800rpm
Frequency	50 Hz

A single cylinder four stroke diesel engine is coupled with the alternator having the provision of electrical loading. The specifications of the engine and the alternator are given in the Table I and II respectively. Continuous water supply is given to the engine for the cooling. The air box with an orifice meter and water manometer is used to measure the flow rate of air supplied to the engine. The volumetric flow of fuel is measured using burette and a stop watch.

Fig.5 Photograph of Experimental engine and alternator.

5. RESULTS AND DISCUSSION

In this section we investigate the performance characteristics of a high speed diesel engine at various loads from one fourth loads to full load fuelled with linseed - Coconut biodiesel and compared with standard diesel.

5.1 Brake specific fuel consumption

Figure 6 shows the variation of specific fuel consumption with load. It is found that as load increases the brake specific fuel consumption decreases for both diesel & linseed - Coconut biodiesel. This is due to the reason that at higher loads complete combustion tends to take place, thus lesser amount of fuel is required to deliver unit power. Thus bsfc decreases with increase in load. When we compare diesel and biodiesel, the specific fuel consumption is higher for biodiesel, as it has lesser calorific value than that of diesel. At part loads the increase in specific fuel consumption is 22.15% but as the load increases this value decreases and reached to 3.66% at full load.

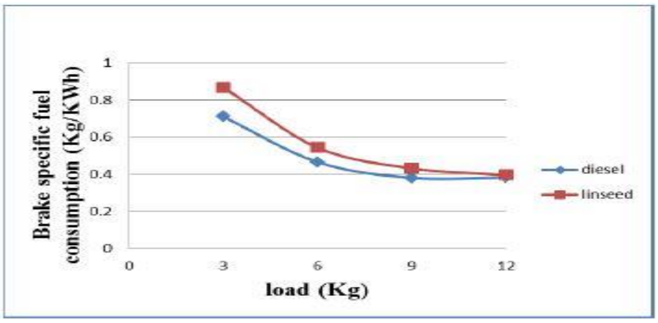


Fig.6 Variation of brake specific fuel consumption with load

5.2 Mechanical efficiency

Figure 7 shows the variation of mechanical efficiency with load. It is observed from the figure that mechanical efficiency is increasing with respect to load for both biodiesel & diesel. It is clear that at any load the mechanical efficiency of diesel is higher than that of Linseed - Coconut

Oil Blend. At part loads the increase in mechanical efficiency 16.3% but as the load increases this value decreases and reached to 8.55% at full load.

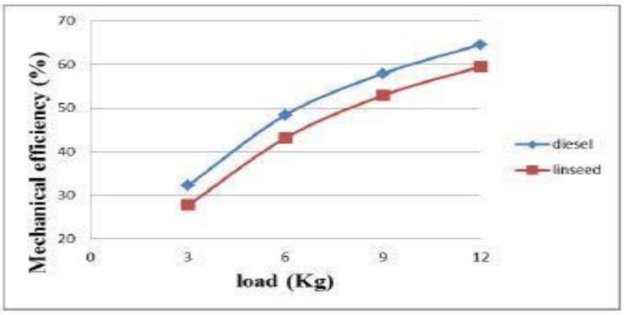


Fig.7 Variation of mechanical efficiency with load

5.3 Brake thermal efficiency

Figure 8 shows the variation of brake thermal efficiency with load. It is found that with increase in load the brake thermal efficiency is also increasing for both diesel & linseed - coconut biodiesel. It is observed that at any load condition the brake thermal efficiency of diesel is greater than that of linseed biodiesel except at full load. At part load conditions the percentage increase in brake thermal efficiency is 9.5% and it is decreasing up to three fourth load and again increasing to 7.8at full load

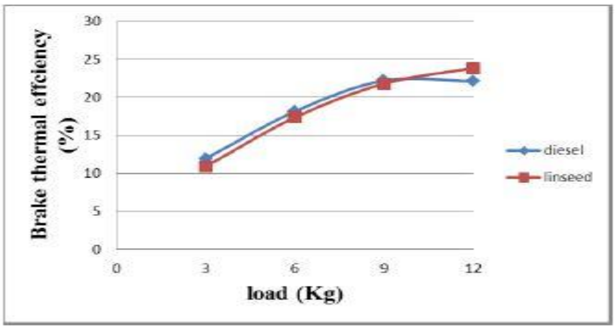


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Fig.8 Variation of brake thermal efficiency with load

6. CONCLUSIONS

Conclusions are drawn from the experimentation are as follows-

- Linseed - Coconut Biodiesel showed high brake specific fuel consumption than that of diesel for same power developed due to its lower calorific value
- Brake thermal efficiency of diesel is greater than that of linseed - Coconut biodiesel except at full load
- At any load, mechanical efficiency of diesel is higher than that of Linseed - Coconut Oil Blend. At part loads the increase in mechanical efficiency is 16.3% but as the load increases this value decreases and reached to 8.55% at full load.

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