

# **Performance and Emission Characteristics of a Diesel Engine Fuelled with Biodiesel Extracted from Linseed Oil**

Venkatesan V

Department of Mechanical Engineering, FEAT, Annamalai University, Chidambaram, Tamil Nadu, India

**ABSTRACT:** Biodiesel obtained from various renewable sources has been recognized as one of the alternative fuel due to its biodegradability, high cetane number, no sulphur emissions and low volatility. Biodiesel derived from non-edible feed stocks such as linseed oil are reported to be feasible choices for developing countries including India where consumption and cost of edible oil is very high. The aim of present work is to optimize the biodiesel production from linseed oil through trans esterification process. The various performance and emission parameters like brake power (BP), brake specific fuel consumption(BSFC), Brake thermal efficiency (BTE), CO emissions, CO<sub>2</sub> emissions, HC emissions, NO<sub>x</sub> emissions and smoke were evaluated at different loads in a 4 stroke, single cylinder Diesel engine. These performance and emission parameters of diesel fuel were compared with that of B25, B50, B75 and B100.

**KEYWORDS:**linseed oil, biodiesel, Transesterification process.

## **I.INTRODUCTION**

Fossil fuel is widely used in the world so the resources are decreased in coming future. Due to depletion of fossil fuels and environmental aspect has made engineers and scientists to develop clean, renewable and sustainable energy systems. At present resources of petroleum are decreases day by day. Diesel engines are used in transportation, electric power generation, farming, construction and in many industrial activities. These wide fields of the usage lead to increasing requirement of petroleum derived from fuels. Because of rising oil prices and harms of petroleum based fuels to the environment, researches have focused on more environmentally fuels and new energy sources. So an alternative fuel for diesel engines have become important due to the gradual depletion of world petroleum reserves and the impact of environmental pollution due to increasing exhausts emissions. In our country the sources of vegetable oils in rural areas are widely and it is produced in a cyclic order. It is renewable and heat release rate is similar to diesel and also its emissions rate is relatively low. A number of researchers have investigated the effect of using vegetable oil in diesel engines for long periods of time. Vegetable oils gives higher values of viscosity than diesel fuel at the same temperature with effect of poor atomization in the injections [3]. Therefore, it cannot be used directly as an alternative fuel for diesel engines. So the method of reduced high viscosity of vegetable oils has been approached in several ways, such as transesterification, blending with other fuels, preheating the oils.

Due to scarcity and increasing costs of conventional fossil fuels, biodiesel as a fuel has become more attractive fuel. Experts suggested that current oil and gas reserves would tend to last only for few decades. To fulfil the rising energy demand and replace reducing oil reserves renewable fuel like biodiesel is within the forefront of other technologies. Biodiesel has proved to be a possible alternative for diesel in compression ignition engine. Biodiesel burns like petroleum diesel as it involves regulated pollutants. Diesel fuel can be replaced by biodiesel made from vegetable oils. Biodiesel is now mainly being produced from soybean, rapeseed, and palm oils. In developed countries, there is a growing trend toward using modern technologies and efficient bio-energy conversion using a range of biofuels, which are becoming cost wise competitive with fossil fuels. India enjoys some special advantages in taking up plantation of tree-borne oil seeds for production of bio diesel due to vast unutilized land. The use of biodiesel results in substantial reduction of un-burnt carbon monoxide and particulate matters. It has almost no sulphur, no aromatics and more oxygen content, which helps it to burn fully. Its higher cetane number improves the combustion. Sunflower and

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Vol. 5, Issue 2, February 2016

rapeseed are the raw materials used in Europe whereas soyabean is used in USA. Thailand uses palm oil, Ireland uses frying oil and animal fats. In India vast research has been done on biodiesel from jatropha oil. It is proposed to use nonedible oil for making biodiesel, as consumption from edible oil is very high in India.

## II. LINSEED OIL AS A POTENTIAL FUEL FOR DIESEL ENGINE

Identification of alternative fuels for use in IC engines has been subjected to studies throughout the globe. Performance tests have shown suitability of variety of alternative fuels such as hydrogen, alcohols, biogas, producer gas and various types of edible and non-edible oils. However, in Indian context, the bio-origin fuels like alcohols, vegetable oils, and biogas can contribute significantly towards the problems related to fuel crises. Petroleum based diesel fuels have different chemical structure than vegetable oil. The former contain only carbon and hydrogen atoms which are arranged in normal (straight chain) or branched chain structures as well as aromatic configurations. The normal structure is preferred for better ignition quality.

Diesel fuel can contain both saturated and straight or unbranched chain unsaturated hydrocarbons, but the later are not present in large amounts to make oxidation a problem. Vegetable oils consist of triglycerides to about 97%; the other 3% distribute among di and mono glycerides and furthermore 3 fatty acids and the fat accompanying which are mostly removed with refining. Structurally, a triglyceride is a reaction product of one molecule of glycerol with three fatty acid molecules to yield three molecules of water and one molecule of triglyceride.

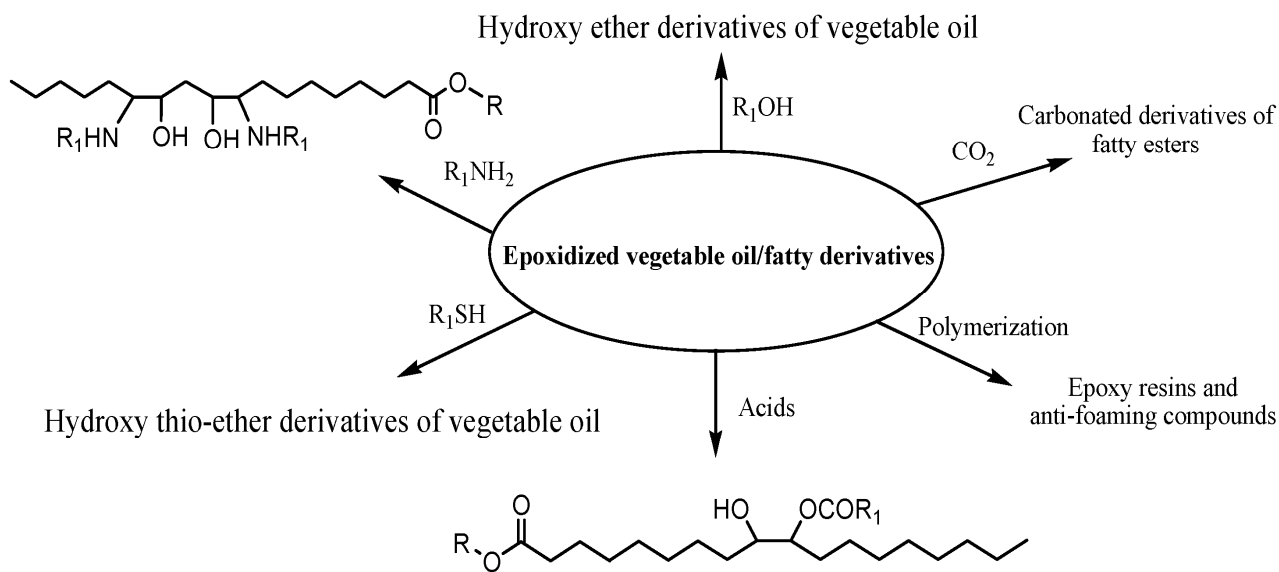


Fig 1 Vegetable oil derivatives

The large size of the vegetable oil molecules and the presence of oxygen in the molecules suggest that some fuel properties of the vegetable oils would differ markedly from those of hydrocarbon fuels [8]. Linseed oil consists of primarily of the mixed glycerides of Oleic acid, Linoleic acid and Linolenic acid. The kinematic viscosity of Linseed oils varies in the range of 26-30 mm<sup>2</sup>/s at 40°C. The high viscosity is due to their larger molecular mass and chemical structure. Vegetable oils have high molecular weights of 600-900, which are three or more times higher than that of diesel fuel. The flash point of linseed oil is also very high (about 222°C). The auto-ignition temperature is about 343°C. Specific gravity is 0.93 and density 931 kg/m<sup>3</sup>. Calorific value is about 40 MJ/kg, comparatively lower than that of diesel fuels (about 45 MJ/kg). This is because the presence of chemically bonded oxygen in vegetable oils lowers the heating value by about 10%. The cetane number is in the range of 32-40, while the iodine value ranges from 0-200, depending on unsaturation. The cloud and pour point of vegetable oils is higher than that of diesel fuel

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 2, February 2016

## III. EXPERIMENTAL SETUP

A Kirloska AV1 make, single cylinder, constant speed, air cooled, direct injection, CAF 8 model diesel engine was selected for the present research work, which is primarily used for agricultural activities and household electricity generations. It is a single cylinder, naturally aspirated, four stroke, vertical, air-cooled engine. It has a provision of loading electrically since it is coupled with single phase alternator through flexible coupling. The engine can be hand started using decompression lever and is provided with centrifugal speed governor. The lubrication system used in this engine is of wet sump type, and oil is delivered to the crankshaft and the big end by means of a pump mounted on the front cover of the engine and driven from the crankshaft.

The inlet and exhaust valves are operated by an overhead camshaft driven from the crankshaft through two pairs of bevel gears. The fuel pump is driven from the end of camshaft. A voltmeter, ammeter and wattmeter were connected between alternator and load bank. The thermocouples were mounted in the exhaust manifold to measure the exhaust temperature. The AVL 437 smoke meter and AVL Di-Gas Analyzer were also kept in proximity for the measurements of various exhaust gas parameters. The engine was started at no load by pressing the exhaust valve with decompression lever and it was released suddenly when the engine was hand cranked at sufficient speed. Then feed control was adjusted so that engine attains rated speed and was allowed to run about half hour till the steady state condition was reached. With the fuel measuring unit and stop watch, the time elapsed for the consumption of 20cc of fuel was measured. Fuel consumption, RPM, exhaust temperature, smoke density, CO, NO<sub>x</sub>, HC, CO<sub>2</sub> and power output were also measured. The engine was loaded gradually keeping the speed within the permissible range and the observations of different parameters were evaluated. Short term performance tests were carried out on the engine with diesel to generate the base line data and subsequently Linseed Oil and Diesel was used to evaluate its suitability as a fuel. The performance and emission characteristics of Linseed Oil was evaluated and compared with diesel fuel.

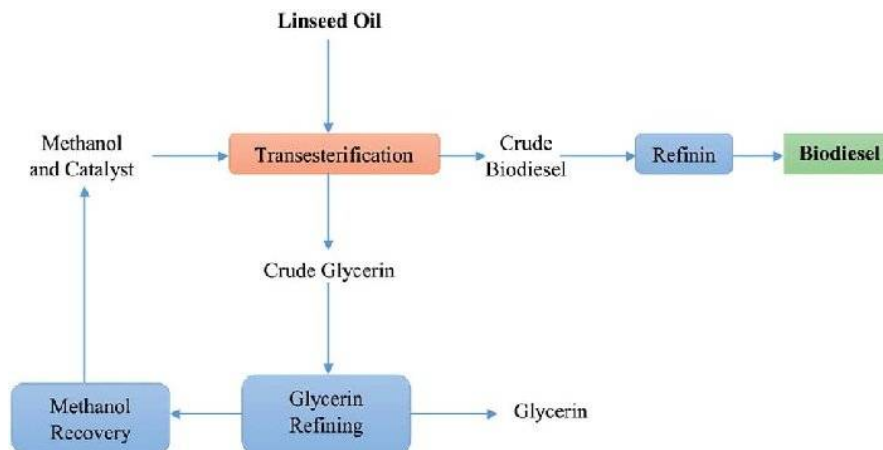


Fig 2 Experimental Process

## IV. TEST ENGINE SPECIFICATION

For the analysis of the biodiesel fuel, a test diesel engine is used in the experiments. This engine is fueled with different blends of biodiesel and pure diesel fuel for the comparison purpose. The performance characteristics were analyzed on this engine. The specifications of the test engine shows in the table 1.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 2, February 2016

S.No.	Parameter	Specification
1	Type of Engine	Compression ignition Engine (Diesel Engine)
2	No. Of Cylinders	Single Cylinder
3	Position of the Engine	Vertical
4	Power of the Engine	5HP
5	Rated Speed	1500 RPM
6	Cooling System	Water cooled
7	Governing System	Self governed
8	Bore Diameter, stroke length	85 mm, 110 mm
9	Dynamometer	Hydraulic Dynamometer with weighing attachment and load control gear
10	Type of Lubricating oil	20w/40 lubricating oil
11	Capacity of Lubricating oil	3 lit.

The experiments were performed on test diesel engine with varying loads ranging from 0% to 100% of full load. Actual load values varying from 0 to 20 kg were applied on the engine with dynamometer. The engine and biodiesel fuel pictures are shown in fig. 2 and fig.3.



Fig 3 Experimental setup Kirloskar AV1



Fig 4 Biodiesel

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 2, February 2016

## V. RESULT AND DISCUSSION

### 1. Brake Power

On the analysis of the brake power of engine in figure 4, it is found that the diesel fuel shows maximum brake power as compare to biodiesel blended fuels. It is also seen that as the load was increasing the brake power is also increasing for all the fuels. B20 fuel shows a higher value of brake power as compared to the B40 fuel. As the concentration of the biodiesel fuel in blends increases, the brake power decreases. It is so because at low concentration of the biodiesel fuel, high combustion of fuel takes place and high brake power produced in the engine. However, it is seen that the B20 fuel shows close results of brake power with diesel fuel.

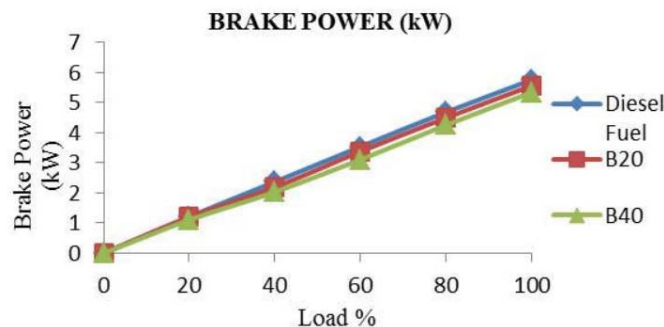


Fig. 5 Analysis of the Brake Power with different fuels

### 2. Brake Thermal Efficiency

For the analysis of the performance characteristics of the engine, brake thermal efficiency is a main important parameter. In the analysis of the brake thermal efficiency in figure 5, it is seen that the diesel fuel has high efficiency as compare to the biodiesel blended fuels. As the load was increasing, the efficiency of the diesel fuel is also increasing. It is also seen that the B20 fuel shows high efficiency up to 60% of the load as compared to the B40 fuel. However, at high load conditions, B40 blended fuel shows little bit higher increase in the efficiency value as compared to the B20 fuel. It is also observed that at full load condition, all the fuel i.e. diesel, B20 and B40 were having approximately similar values of efficiencies. At high load conditions, better combustion of fuel takes place and efficiency is increasing. This is on account of the diminishing Calorific Value of the Blends due to increase in the quantity of linseed oil.

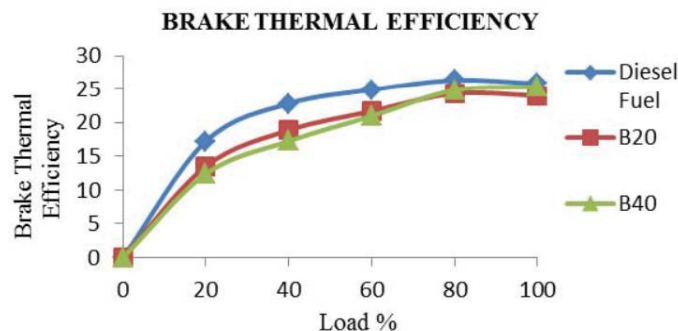


Fig. 6 Analysis of the Brake Thermal Efficiency with different fuels



## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 2, February 2016

### 3. Brake Specific Fuel Consumption

Brake specific fuel consumption basically shows the amount of fuel used in the experiment to run the engine. In the analysis of the brake specific fuel consumption of the engine, three different fuels were used in the engine. The fuels were used as g/hr basis in the engine. The analysis of brake specific fuel consumption in figure 6 shows that B40 fuel shows higher value of specific fuel consumption as compared to B20 and diesel fuel. It is also observed that the initial value of the specific fuel consumption of all the three fuels was having highest values. However, as the load increases, the specific fuel consumption decreases. This is because, as the loads on engine increases, fuel consumption also increases, but the Brake power output outweighs the fuel consumption increase.

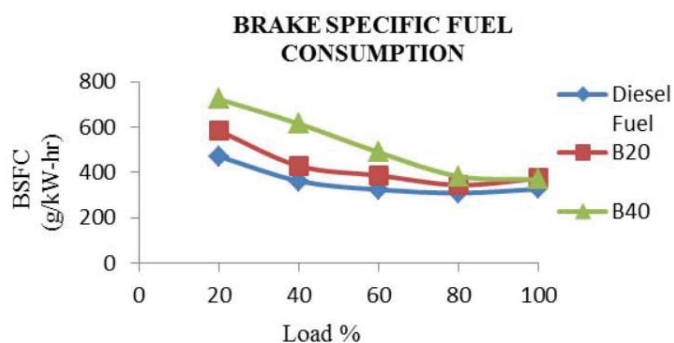


Fig 7 Analysis of the Brake Specific fuel consumption with different fuels

### VI.CONCLUSION

The results of the experiment showed that the performance of the engine on Linseed oil was slightly inferior to that on diesel fuel. The thermal efficiency of the engine was lower and the brake specific energy consumption of the engine was higher when the engine was fueled with Linseed oil compared to diesel fuel. The oxides of nitrogen from during the whole range of experiment were lower than diesel fuel. The Carbon monoxide, unburned hydrocarbon from the fuel was found higher than diesel fuel during the whole experimental range. The results from the experiments suggest that linseed oil is potentially good substitute fuel for diesel engine and performance and emissions characteristics were found to be comparable to diesel fuel.

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\*V.Venkatesan, Assistant Professor, Department of Mechanical Engineering, Annamalai University.