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Performance and Emission Characteristics of Different Blends of Linseed Methyl Ester on Diesel Engine

S.K. Mahla* and Arvind Birdi**

**Department of Mechanical Engineering, GGS College of Modern Technology, Kharar, (Mohali), (PB), India*

***Incitec Pivot Ltd, Phosphate Hill, (QLD) Queensland, Australia*

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ABSTRACT : Biodiesel fuel can be made from new or used vegetable oils and animal fats, which are non-toxic, biodegradable and renewable resources. The vegetable oils were not acceptable in diesel engine because it poses problems such as injector choking, cylinder deposits, piston ring sticking and higher smoke emissions. Biodiesel has become more attractive recently because of its environmental benefits. Methyl ester of linseed oil is derived through transesterification process. The biodiesel can be used in diesel engine without major hardware modifications. Experimental investigations have been carried out to examine the properties, performance and emission of different blends (B15, B20, and B30) of linseed oil methyl ester in comparison to diesel. Results indicate that B20 is an optimum fuel blend in terms of better performance and reduced emission than diesel fuel. However, B15 and B30 blend shows reasonable efficiencies, lower smoke, CO and HC emission.

Keywords: Biodiesel, Transesterification, Methyl Ester, Vegetable oil.

I. INTRODUCTION

Biodiesel [1] generally comprises of mono alkyl esters of long chain fatty acids derived from vegetable oil or animal fat (or mixture thereof). The designation of biodiesel blended with diesel indicates the percentage of it in the blend, e.g. B2 (2% biodiesel 98% diesel (v/v)) and B100 is pure biodiesel. Globally, the feedstock for biodiesel production in great supply is soyabean oil, palm oil and rapeseed oil. Biodiesel has a tremendous potential in terms of energy contents and conversion efficiencies, even though the petroleum based fuels require more energy to produce than what they contain. The life cycle analysis [2] concluded that biodiesel yields 3.2 units of fuel product energy for every unit of fossil fuel used to produce it; other projections go as high as 3.6 [3].

The major sources of energy in the world are oil, coal, natural gas, hyrdo energy etc. Oil is the most popular and abundant source of energy worldwide. However so, the price of crude oil is very volatile and supply is driven by price. While developed industrialized countries consume around 43 million barrels daily on an average, whereas developing countries only consume 23 million barrels a day on average. Something similar goes for coal and natural gas as well. Renewable energy sources are gaining popularity. In Asia, 3.7% growth has been projected over the ten year period from 2000 to 2010 [4].

As we are well aware of the depletion of fossil fuels, also the use of fossil fuels is degrading the environment in various ways. The pollution created by the increasing number of vehicles on the road, use of old technology also vents many pollutants in the atmosphere. There have been reported cases of new diseases linked with pollution, and increasing use of fossil fuel is solely responsible for these causes.

Knowing the present global energy scenario, it is almost desperately important and essential to come up with an alternative solution. Alternative fuels are an option and the abundance of resources for producing biofuels can be successfully implemented. Biofuels consumption leaves us with less pollution or no pollution and can be produced without using the already depleting resources of fossil fuels. Global bioenergy potentials estimated could provide adequate supplies to the entire population in the future [5].

There are affluent resources of biofuels in India seeing the country's strong agricultural aspect. For instance, biodiesel is beneficial in terms of enhanced biodegradation, lower levels of toxics and lower emission levels [6]. The demand of diesel in India is way higher than that of petrol. Biodiesel industry in India is still in its growing stages. Keeping in mind that the country's expected energy demand growth at the rate of 4.8% over the next two decades, the Government of India has formulated an ambitious National Biodiesel Mission to meet 20% of the country's diesel requirement by 2011–2012 [7].

On the other hand, at present, the main hurdle in the commercialization of biodiesel is the cost of its raw material. 60–90% of the biodiesel cost arises from the cost of the feedstock oil [8, 9]. Biodiesel produced from linseed oil is one example, it has been discussed in the following paragraphs.

Linseed is an important oilseed and fibre crop grown for its seed as well as which is used to manufacture linen. Global output of linseed is estimated around 2.60 million ton per year with Canada, China, U.S and India on the top of the list. Canada, the leading producer, accounts for 80% of the global trade in linseed. India is the third largest producer of linseed. In India, linseed is mainly cultivated as a rabi crop which is sown during October–November and harvested in February–April. Linseed oil mercilessly extracted from the linseed constitutes 35% on oil content in the seeds. Global production of linseed oil is estimated from 600,000 to 700,000 ton [10].

Linseed is a cool season crop. Its cultivation is confined to low elevations, but it can be successfully grown up to 770 metres. Areas with the annual rainfall ranging from 45–75 cm are best suited for its cultivation. The seed crop does well under moderate cold, but the fibre crop grows best in cool moist climates [11].

Biodiesel is produced from linseed oil through a process called transesterifcation [12], with this process the higher fatty acids are separated to methyl and ethyl esters using methanol and catalyst KOH.

Biodiesel fuel has better properties than that of petroleum diesel fuel such as renewable, biodegradable, non–toxic, and essentially free of sulfur and aromatics. The purpose of transesterification process is to lower the viscosity of the oil. The viscosity values of linseed oil methyl and ethyl ester highly decreases after the transesterification process. The viscosity values of vegetable oils vary between 27.2 and 53.6mm^2/s, whereas those of vegetable oil methyl esters between 3.59 and 4.63 mm^2/s. The flash point values of vegetable oil methyl esters are highly lower than those of vegetable oils. The transesterification of linseed oil in methanol has proved to be the most promising process. Methanol is the commonly used alcohol in this process, due to its low cost. Methyl esters of vegetable oils have several outstanding advantages among other new–renewable and clean engine fuel alternatives. The most important variables affecting the methyl ester yield during the transesterification reaction are molar ratio of alcohol to vegetable oil and reaction temperature. Biodiesel has become more attractive recently because of its environmental benefits. Biodiesel is an environmentally friendly fuel that can be used in any diesel engine without modification or minor modifications.

II. EXPERIMENTAL SETUP

The present study was carried out to investigate the performance and emission characteristics of Linseed oil Methyl Ester and its blend in a stationary single cylinder diesel engine and to compare it with petrol–diesel fuel. It is an air cooled, naturally aspirated constant speed compression ignition engine as per the IS: 10000 [P: 5]:1980 whose major specifications are shown in Table 2. The engine was coupled to a 5 kVA electric generator through which load was applied by increasing the field voltage as shown in Fig. 1. The engine was tested at 20, 40, 60, 80 and 100 percent brake load conditions. The entire test was performed at constant speed of 1500 r.p.m. (rated speed).

The pilot liquid fuel is measured by a calibrated glass tube by measuring the time required for the consumption of 50ml of fuel. During the experiments, engine speed, fuel consumption, air consumption rate and exhaust gas temperature were recorded. Exhaust gases were analyzed on line by an AVL DiGas analyzer, Model 4000 in which UBHC, CO, O_2, CO_2, and NO_X were measured and AVL make Smoke Meter, Model 437 was used to measure the smoke opacity of exhaust gas.

The engine was operated on diesel first and then on methyl ester of linseed blends. The fuel blends tested are B15, B20 and B30 of linseed biodiesel. The different blends and mineral diesel were subjected to performance and emission tests on the engine. The performance data were then analyzed from the graphs regarding brake thermal efficiency, brake specific energy consumption and emission of all fuels.

Fig. 1. Biodiesel reactor 2L capacity.

Fig. 2. Different biodiesel blends sample.

Table 1: Fuel Properties.

Fuels	Calorific Value (MJ/kg)	Density
Diesel	42.56	850
B15	42.18	858
B20	41.94	861
B30	41.73	865

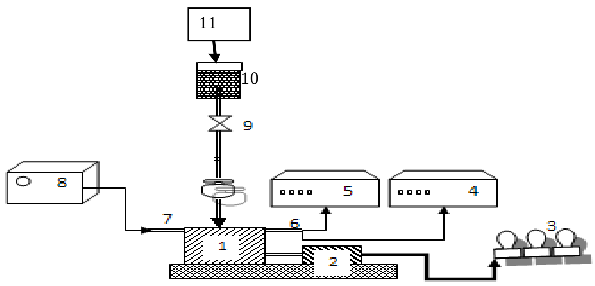

Fig. 3. Experimental Layout.

Table 2: Instrumentation for experimental setup.

1. Single cylinder 4–stroke DI diesel engine
2. Altrenator
3. AC Shunt/Lamp load
4. Gas Analyzer
5. Smokemeter
6. Exhaust manifold
7. Intake manifold
8. Air drum
9. Control valve for actual fuel metering
10. Fuel tank for diesel and blends

Table 3: Engine Specifications.

Make	**Kirloskar (DAF 8)**
No. of cylinders	One
Bore × Stroke	95 × 110 mm
Cubic Capacity	0.553 lit
Compression Ratio	17.5 : 1
Rated Output in kW/BHP	5.9 kW(8.0 bhp) at 1500 rpm.
Injector Opening Pressure	200 bar
Lub Oil Sump Capacity	3.3 lit.
Fuel Tank Capacity	6.5 lit

III. RESULTS AND DISCUSSION

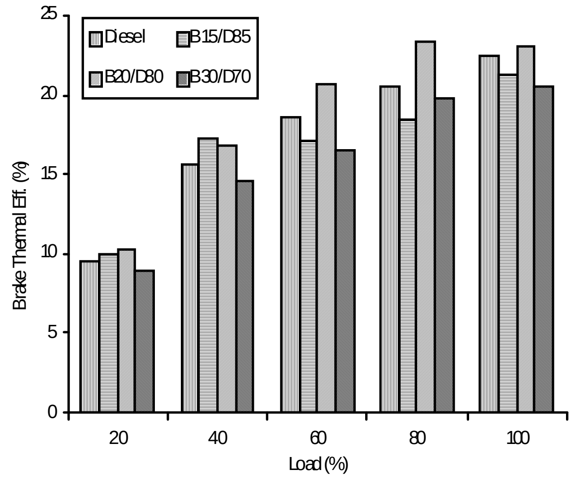

Fig. 3. Brake thermal efficiency Vs load.

In Fig. 3. a slight drop in efficiency was found with B30 blend of linseed methyl ester when compared to diesel. This drop in thermal efficiency must be attributed to low calorific value of methyl ester. It was observed that the brake thermal efficiency of B20 is better than petro–diesel at all load tested. B15 blend had better thermal efficiency than compared with diesel at light loads. So, B20 blend can be suggested as best blend for biodiesel preparation with linseed oil.

A. Effect on brake specific energy consumption

The brake specific energy consumption (BSEC) is a reliable parameter in comparing the fuels of different calorific values. The BSEC decreases with increase in load for all fuel blends. B30 blend shows higher BSEC as compared to diesel at all loads except full load. This is mainly due to the slightly lower calorific value as it consumed more fuel. In Fig. 4 B20 blend shows a decrease in BSEC at all load as compared to diesel.

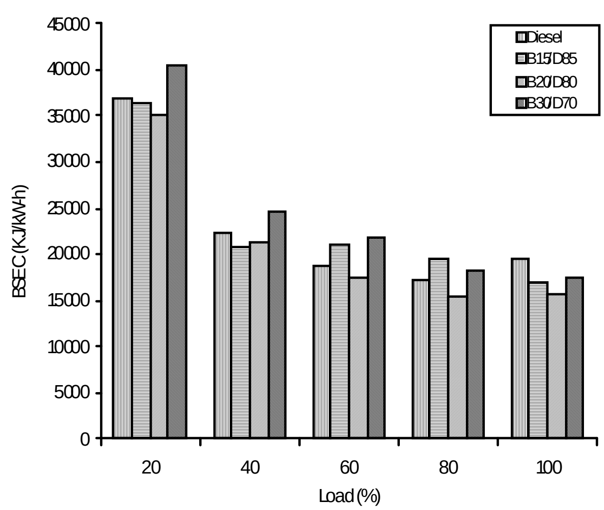

Fig. 4. Brake specific energy consumption Vs load.

B. Effect on carbon monoxide emission

Fig. 5 represents the variation of CO emission Vs load. The rate of CO formation is a function of available amount of unburned gaseous fuel and mixture temperature, both of which control the rate of fuel decomposition and oxidation. Biodiesel blends give lower emission of CO as compared to diesel fuel. B30 blend give slightly higher emission than B15 and B20 blend. This is mainly due to poor atomization which leads to insufficient combustion because of higher density of fuel.

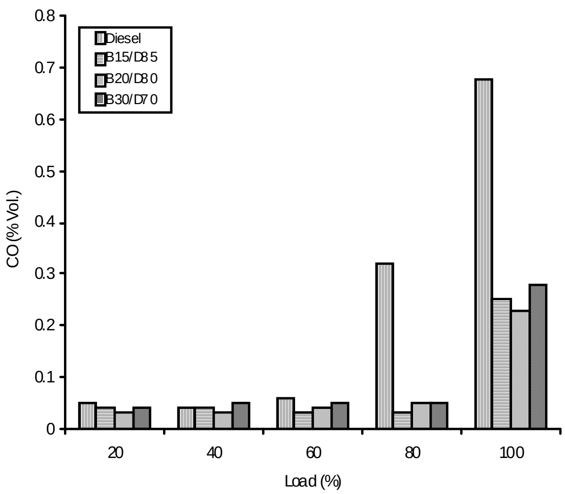

Fig. 5. Co emission Vs load.

C. Effect on hydrocarbon emission

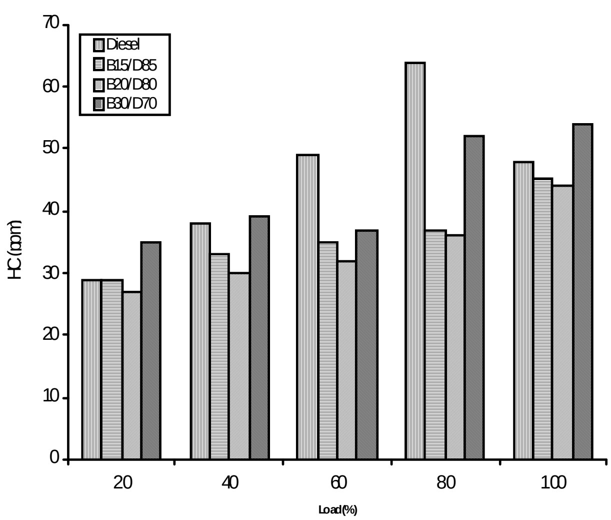

Fig. 6. Hydrocarbon emission Vs load.

Fig. 6 represents the variation of HC emission with different loads. The HC emission increases with increasing load. The B15 and B20 blend of linseed methyl ester give lower emission of hydrocarbon as compared to diesel. B30 blend give slightly higher HC emission mainly due to higher density of fuel which leads to slow combustion. It requires changes in injection pressure and combustion chamber design [13].

D. Effect on Smoke opacity emission

Fig. 7. represents the smoke opacity variation with biodiesel blends. Smoke opacity was calculated by opacity test for various blends of biodiesel and diesel. Biodiesel gives lower smoke emission as compared to petroleum diesel. With increase in biodiesel percentage the smoke opacity increases as shown in Fig. 6. Smoke opacity increases with increase in load. B30 blend give higher smoke emission than B15 and B20 blend at all load conditions. This could be due to higher density of fuel which results in slow mixing and insufficient combustion which leads to higher smoke emission.

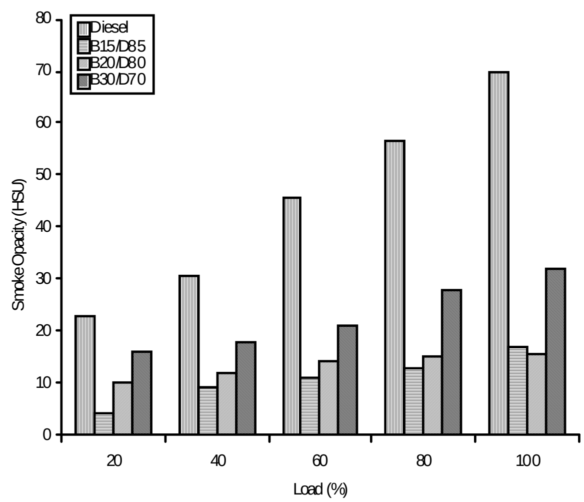

Fig. 7. Smoke opacity emission Vs load.

V. CONCLUSION

Following are the conclusions based on the experimental results obtained while operating single cylinder diesel engine fueled with linseed oil methyl ester blends in different proportion with diesel fuel.

- The lower blends of linseed oil methyl ester can be used in diesel engine without any engine modifications. The fuel filter needs to be changed after some interval of time.
- Brake thermal efficiency of B20 is superior to diesel at all load conditions.
- B20 gave best results so it could be considered as an optimum fuel blend in terms of performance and reduced emission.
- Smoke, HC and CO emission for diesel at different loads was found to be higher as compared to biodiesel blends of B15, B20 and B30.

With the properties of linseed biodiesel close to diesel fuel it can provide a useful substitute fuel for diesel engine.

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