

Performance Evaluation of CI Engine Fueled With Blends of Sesame Oil Biodiesel and Diesel

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Abstract

The rapid depletion of petroleum fuels and their ever increasing cost have led to an intensive search for alternative fuels. In the present work tests on a single-cylinder four stroke diesel engine operating on diesel Fuel and blends of diesel with biodiesel prepared from Sesame oil in proportions of 80%/20%; 60/40%; 40%/60%, 20%/80% and 0%/100% by volume are performed. Engine Performance is analyzed by evaluating parameters like brake thermal efficiency, brake specific fuel consumption, mechanical efficiency, volumetric efficiency, air fuel ratio, Indicated power.

Keywords: Diesel engine, Biodiesel, Performance, Emission, Methyl esters

1. INTRODUCTION

In the current scenario, India's oil consumption by end of 2007 reached 136 million tons (MT), of which domestic production will be only 34 MT. India will have to pay an oil bill of roughly \$50 billion, assuming a weighted average price of \$50 per barrel of crude. In 2003-04, against total export of \$64 billion, oil imports accounted for \$21 billion. India imports 70% of its crude needs mainly from gulf nations. The majority of India's roughly 5.4 billion barrels in oil reserves are located in the Bombay High, upper Assam, Cambay, and Krishna-Godavari. In terms of sector wise petroleum product consumption, transport accounts for 42% followed by domestic and industry with 24% and 24% respectively. India spent more than Rs.1, 10,000 crore on oil imports at the end of 2004. Focusing our attention on the fossil fuels, World oil and gas reserves are estimated at just 45 years and 65 years, respectively. Coal is likely to last a little over 200 years. So there is an intense of an alternative fuel which can replace fossil fuels. Fossil fuels are mainly used in automobile sector on large scale which mainly use diesel. Compression ignition engines are employed particularly in the field of heavy transportation and agriculture on account of their higher thermal efficiency and durability. However, diesel engines are the major contributors of oxides of nitrogen and particulate emissions. Fuel which is renewable in nature is need of present day which will also lead to lesser emissions. Oil as a substitute for diesel has been tested by researchers. But it is having major drawbacks gum formation, flow, atomization and high smoke and particulate emissions. As the global debate over reducing the dependence on fossil fuel heats up, discussion of alternative fuels is more and more prevalent. One of the most commonly mentioned is biodiesel; a 100% agriculturally derived liquid fuel, often called B100.

Biodiesel is a renewable and energy-efficient fuel that is non-toxic, biodegradable in water and has lesser exhaust emissions. It can also reduce greenhouse gas effect and does not contribute to global warming due to lesser emissions because it does not contain much pollutants and its sulphur content is also lower than the mineral diesel.

Biodiesel can be used, stored safely and easily as a fuel besides its environmental benefits. Also it is cheaper than the fossil fuels which affect the environment in a negative way. It requires no engine fuel system modification to run biodiesel on conventional diesel engines. The main reason for high viscosity in raw vegetable oils is free fatty acids. Most popular method called transesterification is used to produce biodiesel which is a chemical reaction between vegetable oil and alcohol in the presence of catalyst to yield fatty acid alkyl esters and glycerol. Research is going on to prove the suitability of vegetable oil and their biodiesels as fuels of diesel engines. It was proved from the investigations that properties of bio diesel are similar to petro-diesel and requires little or no engine modifications. Most often used as fuel in diesel vehicle engines, biodiesel can also Biodiesel from

Sesame Oil be used as heating oil. Biodiesel is made from virgin vegetable oils, from waste frying oils or from waste animal fats and oils. It can be used alone or blended with petroleum diesel in any percentage without major modifications to the engine.

2. LITERATURE SURVEY

2.1 History of the Diesel Engine and diesel combustion

Rudolph Diesel (1858-1913) developed a theory that revolutionized the engines of his day. He designed an engine that would serve as an alternative for the inefficient fuel consumption of the steam engine. The early diesel engines were neither small nor light enough for anything but stationary use due to the size of the fuel injection

pump. They were produced primarily for industrial and shipping in the early 1900's. Ships and submarines benefited greatly from the efficiency of this new engine, which was slowly beginning to gain popularity (**Encyclopedia Britannica, 1974**). The initial emphasis was to develop products and procedures that could substantially cut down on fuel consumption of the motor vehicle like air deflectors, radial tires and fan clutches. In the 80's, the emphasis was on the development of equipment that could boost the brake mean effective pressure hence minimizing on fuel consumption of the motor vehicle like turbo chargers and intercoolers (**Ensile et al., 2002**). The power developed by the engine depends on the spray quality, the percentage of the combustion chamber volume accessible by the fuel spray and the evenness of distribution of the droplets in the chamber concluded by **Wright and Purdah (1950)**. The combustion process in compression ignition engines is divided into four stages as follows by **Benson and Whitehouse (1979)**- Ignition delay, Pre mixed combustion, Mixed control, Low rate of combustion.

2.2 Vegetable Oils in Diesel Engines

The use of vegetable oils to run a diesel engine was first recorded in 1898 when Rudolph Diesel designed a diesel engine and ran it on peanut oil. A large amount of research has gone into examining Diesel's dream of using raw vegetable oils as fuels. Work has been conducted to examine these oils as petroleum based fuel replacements or additives **Munavu and Odhiambo (1984)**, **Romano (1982)**, **Hofman et al. (1981)**. A study by **Hofman et al. (1981)** indicated that while vegetable oil based fuels and their blends had encouraging results in short term testing, problems occurred in long-term durability tests. **Romano (1982)** noted that under the high temperatures commonly found in the internal combustion engines, the oils decompose to liberate FFAs and glycerol.

According to **Duke (1983)**, the engine can quickly become gummed up with the polymerized oil, and engine failure can occur in as little as 20 hours. **Munavu and Odhiambo (1984)** examined seventeen non-conventional oil seeds as potential source of vegetable oils for use as fuels for diesel engines in Kenya. Other problems that may be encountered with the use of vegetable oils include difficulty in cold starting, gumming up of injectors and choking-up of valves and exhaust reported by **Pullan (1981)**. This may give the oil or fat a temperature range over which solidification occurs, with the oil gradually thickening from a thin liquid, through to a thick liquid, then a semi-solid and finally to a solid analyzed by **Calais and Clark (2007)**. It is summarized by **Pullan (1981)** that high melting points or solidification ranges can cause problems such as partial or complete blockage in the fuel system as the triglyceride thickens and finally solidifies when the ambient temperature falls.

They include: blending with diesel, micro-emulsion with short chain alcohol, thermal decomposition,

catalytic cracking and combining with an alcohol to form the corresponding ester reported by **Schuchardt et al. (1998)**. The transesterification process also neutralizes the FFAs, or transforms them to methyl esters, thus minimizing corrosion that is associated with use of raw vegetable oils analyzed by **Munavu and Odhiambo (1984)**. The methyl esters formed are not susceptible to decomposition under normal engine running conditions and they also reduce carbon build up in the engine concluded by **Romano (1982)**.

3.METHODOLOGY

3.1 Preparation of biodiesel

Biodiesel is prepared from raw sesame oil with the transesterification process. Flowchart of the process of making biodiesel is shown in fig 3.1

Make	Kirloskar
Model	TV-1
Rated Brake Power (bhp/kW)	5/3.7
Rated Speed (rpm)	1500
Number of Cylinder	1
Bore x Stroke (mm)	80x110
Displacement volume (cc)	662 cc
Compression Ratio	16.5:1
Cooling System	Water Cooled
Lubrication System	Forced Feed
Starting system	Manual hand start (with handle)

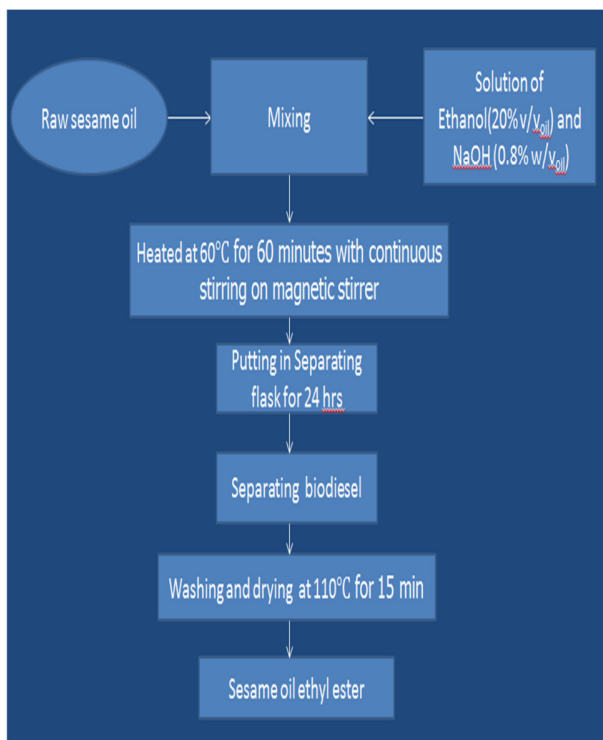


Fig. 3.1 Process developed for production of sesame oil ethyl ester or sesame oil biodiesel

3.2 Characteristic of fuel

Table 3.1. Properties of fuel prepared for testing

Property	Diesel	Sesame oil Biodiesel
Calorific Value (MJ/kg)	43.5	38.34
Viscosity at 38°C (cS)	2.82	4.85
Flash point(°C)	51	132
Relative Density(at 20°C)	0.835	0.870

3.3 Experimental Set up

Table 3.2 Parameters of the engine used in performance tests



Fig.3.2 Engine set-up used for testing the fuel

4. RESULTS AND DISCUSSION

A constant speed, single cylinder diesel engine of 3.7 kW rating was tested on diesel and selected SOEE-diesel blends. The fuel consumption test of the engine were conducted as per IS: 10000 [P: 8]:1980 and brake power, brake specific fuel consumption, brake thermal efficiency were estimated.

4.1 Brake Power

The speed of the engine and brake power when operating on diesel, SOEE20, SOEE40, SOEE60, SOEE80, SOEE100 at no load, 25, 50, 75 and 100 percent brake load are shown in table 3.5 and 3.6. It was observed that the engine was able to develop similar power on all fuel types at every selected brake load condition. This could be due to the reason that the volumetric fuel flow rate on biodiesel was higher thus contributing energy supply near to diesel.

The above observation are in line with the findings of Srinivas et al. (2012), Bhawe et al. (2013) and Patel et al. (2013) who reported that an engine operating on vegetable oil ester- diesel blends produces as much power as that of diesel fuel.

Table 4.1 Speed of the engine on selected fuel types

BRA KE LOA D (%)	ENGINE SPEED (RPM)					
	DIES EL	SOEE 20	SOEE 40	SOEE 60	SOEE 80	SOEE 100

NO LOAD	1560	1560	1560	1560	1560	1560
25%	1525	1557	1559	1559	1561	1560
50%	1513	1518	1530	1532	1527	1520
75%	1503	1492	1477	1473	1481	1500
100%	1475	1457	1444	1437	1445	1451

Table 4.2 Brake power developed by the engine on selected fuel type

BRAKE LOAD (%)	BRAKE POWER (kW)					
	DIESEL	SOEE20	SOEE40	SOEE60	SOEE80	SOEE100
NO LOAD	0	0	0	0	0	0
25% LOAD	0.80	0.817	0.818	0.818	0.819	0.819
50% LOAD	1.58	1.59	1.606	1.608	1.603	1.596
75% LOAD	2.36	2.349	2.318	2.312	2.325	2.355
100% LOAD	3.08	3.045	3.017	3.003	3.024	3.032

4.2 FUEL CONSUMPTION

The observed fuel consumption (l/h) of the engine on diesel and SOEE-diesel blends is shown in Fig 4.1 shows the relationship between brake load and the fuel consumption of the engine on different fuel types.

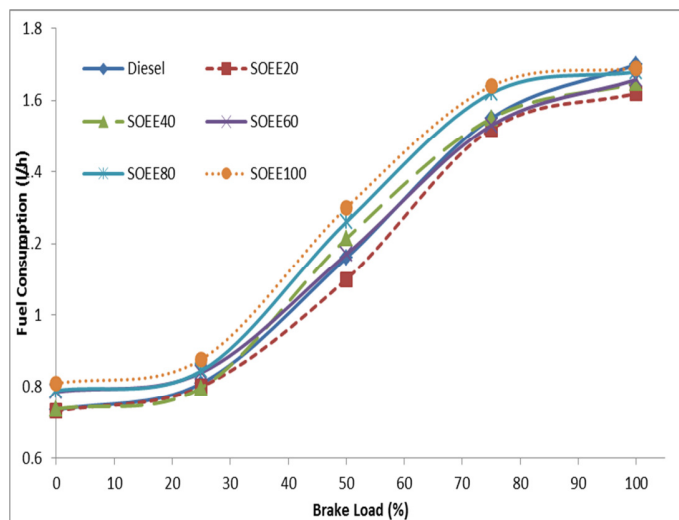


Fig.4.1 Fuel consumption of the engine on diesel, SOEE-diesel blends at different load condition

It is clear from the figure that except SOEE20 the engine consumed more fuel than diesel on almost all the blends of SOEE and diesel. The fuel consumption of the engine on SOEE20 was found lesser than that of diesel.

4.3 BRAKE SPECIFIC FUEL CONSUMPTION

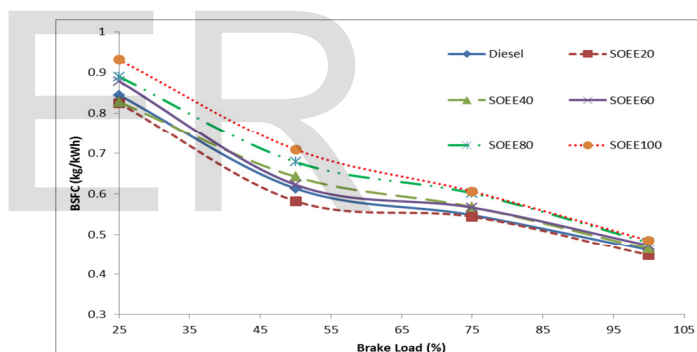


Fig. 4.2 Brake specific fuel consumption of the engine on diesel, SOEE-diesel blends at different load condition.

The relationship between the brake fuel consumption of the engine and brake load on different fuel types is presented in Fig 4.2. The observations on brake specific fuel consumption are in line with the findings of Behave et al. (2013) who reported higher BSFC of 100 percent sesame oil methyl ester than diesel due to lower calorific value of biodiesel in comparison with diesel.

4.4 BRAKE THERMAL EFFICIENCY

The relationship between brake thermal efficiency and the brake load is shown in Fig 4.3

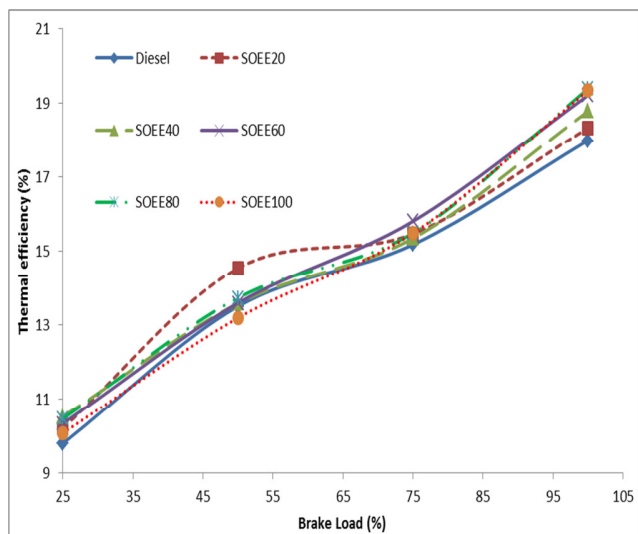


Fig. 4.3 Brake thermal efficiency of the engine on diesel, SOEE-diesel blends at different load condition.

The observations on brake thermal efficiency are in line with the findings of **Shailaja et al. (2013)** who reported higher brake thermal efficiency of 100 percent sesame oil methyl ester than diesel due to presence of oxygen in biodiesel molecules which improves the combustion efficiency of biodiesel.

On the basis of fuel consumption test, engine performance was found satisfactory on all selected fuel blends. All the blends were able to produce as much as power as diesel. The BSFC was high on these blends except SOEE20. The brake thermal efficiency of the engine on the above blends was found higher than diesel.

Based on the above 100 percent sesame oil ethyl ester (SOEE) may be recommended as CI engine fuel. The engine performance was best on SOEE20 as thermal efficiency of the engine was reported highest and BSFC was reported lowest on this fuel blend

5. CONCLUSIONS AND FUTURE SCOPE

5.1 CONCLUSIONS

The characteristic fuel properties such as relative density, kinematic viscosity, gross heat of combustion, cloud and pour point, flash and fire point of diesel, raw sesame oil, its ethyl ester (SOEE) and their blends with diesel were compared. A 3.7 kW, constant speed diesel engine was tested on diesel, SOEE-diesel in 20:80, 40:60, 60:40, 80:20 and 100:0 ratio. The performance of the engine was found to be satisfactory on the blends. On the basis of the results obtained from the whole experiment the following conclusion can be drawn:

- 1) The relative density of raw sesame oil used in the experiment was 7.5 % higher than the diesel and SOEE100 had the relative density 4.19 % higher than diesel.
- 2) The kinematic viscosity of raw sesame oil used to make sesame oil ethyl ester (SOEE) was about 12.34 times higher than the diesel and SOEE100 was about 1.71 times higher than the diesel.

- 3) The gross heat of combustion of raw sesame oil is found to be 9.04 % lesser than the diesel but SOEE100 had the gross heat of combustion 11.841 % lesser than the diesel.
- 4) The performance evaluation of 3.7 kW diesel engine under the fuel consumption test on blends of SOEE and diesel was found satisfactory on the basis of brake power, brake specific fuel consumption and brake thermal efficiency.
- 5) The engine was able to develop power similar to diesel on all the SOEE- diesel blends.
- 6) The brake thermal efficiency of the engine on SOEE100 was found higher than diesel but BSFC of the engine on SOEE100 was also found higher than the diesel.
- 7) The engine performance was the best on SOEE20 as the brake thermal efficiency was found to be highest and BSFC was found to be lowest on this blend.

The above discussion indicate that 100 percent sesame oil ethyl ester (SOEE100) may be recommended as CI engine fuel. However for the better performance of the engine SOEE20 may also be recommended. Further, the engine emission on sesame oil ethyl ester may be investigated.

5.2 FUTURE SCOPE

Environment friendly alternative energy sources need to be developed in order to meet the burgeoning demand for fossil fuels for transportation. Utilization of vegetable oils as biodiesel is most accepted route. In the view of this there are following future scope of the present work:

- Further the emission study of the engine on neem oil ethyl ester (SOEE) may be done.
- To improve the properties of sesame oil ethyl ester (SOEE) alcohol is used in the present study but only three blends are used to investigate the properties. Further investigation may be done on the other blends of SOEE, alcohol and diesel.
- Performance evaluation of CI engine on different blends of SOEE, alcohol may be done.

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