Investigation of the Performance and Emission Characteristics of CI Engine Using Simarouba Biodiesel as Fuel

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Abstract - *There is an increasing interest in world to search of alternative, renewable and environmental friendly fuels. In this context vegetable oils are proposed to be promising alternatives to diesel, as they are produced in rural areas. Transesterification of vegetable oils is carried out using methanol and sodium hydroxide. The properties of biodiesel are determined and nearly match to that of diesel. The Simarouba Oil Methyl Ester (SOME) has been tested in a single cylinder four stroke diesel engine coupled with eddy current dynamometer. The blend S40 at 80% loading shows higher performance and less emission for all blends at 220 bar injection pressure. BSFC for S40 nearly matches to that of diesel. BTE is low for S40 blend by 0.52% compared to S0. CO and smoke emission are less for blend S40. Compared to S0, NOx and HC are lower by 6.49% and 42.50% for blend S40.*

***Key Words*: Simarouba oil methyl ester, performance, exhaust emissions.**

1.INTRODUCTION

Alternative fuels have received much attention due to the depletion of world petroleum reserves and increased environmental concerns. Thus processed form of vegetable oil (Biodiesel) offers attractive alternative fuels to compression ignition engines. Different areas of work is carried out on biodiesel, used in variety of engines with and without modifications and different methods of producing biodiesel for its compatibility as a fuel for CI engine, are studied. In addition to this amount of pollutants produced are noticed along with performance parameters using fuel from variety of tree borne oil seeds.

The basic and the important need of today's human being's life in the world are of the alternative fuel. There are so many sources exit in the form of a) renewable energy b) non-renewable energy, such as coal, mineral, diesel and petrol. There is huge demand for this non-renewable energy sources and this demand is increasing day by day, which could create a critical problem in the future because of unbalance demand-supply ratio of these non-renewable energy sources, this could cause the energy crises, which could become an abstracts in the development of human being. During recent years high activities can be observed in the field of alternative fuels, due to supply of petroleum fuels strongly depends on a small number of oil exporting countries. The demand for diesel and gasoline is increased drastically. It has been estimated that the demand for diesel will be increasing day by day. Hence, government of India has taken necessary steps to fulfil future diesel and gasoline demand and to meet the stringent emission norms. Bio-diesel and alcohol are being considered to be supplementary fuels to the petroleum fuels in India.

2. OBJECTIVES

Biodiesel is not a hydrocarbon fuel, but it is a methyl or ethyl ester having properties compatible to use as a fuel for CI engine. Physical properties of biodiesel are not same as that of petro-diesel, which are measured using equipments like, Cleveland's apparatus for flash and fire point measurement, Redwood viscometer for viscosity, Bomb calorimeter for calorific value of the fuel. Biodiesel and diesel are blended proportionately and found miscible with each other without separation during the test. All the blends are tested in the engine at constant speed up to the rated load, performance parameters and emittents are evaluated and compared between the blends. However the objectives are summarized as below.

1. Investigating the properties of the biodiesel as well as blends of biodiesel with diesel.
2. To study the performance of CI engine using biodiesel (Simarouba) oil as fuel.
3. Smoke and various emittents are measured using smoke meter and exhaust gas analyzer.
4. Evaluating the optimum blend for maximum efficiency & minimum pollution.

3. EXTRACTION OF BIODIESEL

The most common way of producing biodiesel is the transesterification of vegetable oils and animal fats, S.R. Mishra et.al [10]. Esterification is a chemical reaction in which two reactants (typically an alcohol and an acid) form an ester. Transesterification involves changing one ester into another one. Table 1. Summarizes the results of fuel test of diesel fuel and simarouba biodiesel.

TABLE-1:properties of pure Diesel and Simarouba oil biodiesel

Property	Diesel	Simarouba oil biodiesel
Density (kg/m3)	811	861.2
Higher Calorific value (kJ/kg)	46100	40500
Kinematic viscosity at 40°C (Cst)	2.74	6.5
Flash point (°C)	58	168
Fire point (°C)	67	180

4. EXPERIMENTAL SETUP AND METHODOLOGY

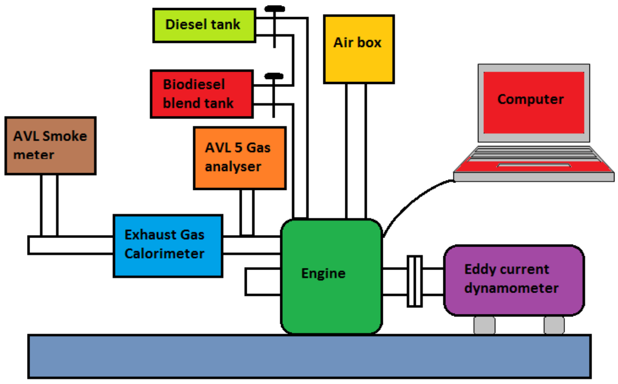

Fig -1: Layout of the experimental setup

The experiments are conducted on direct injection, single cylinder four stroke Kirloskar diesel engine. The layout of experimental test rig and its instrumentation is shown in Fig 1. It is a water cooled engine with a rated power of 5.2 kW at 1500 rpm, having bore 87.5mm and stroke 110mm, compression ratio of 17.5, injection pressure of 220 bar at 23o bTDC injection time. It consists of a test bed, a diesel engine with an eddy current dynamometer, a computer with a software called engine soft, an AVL444 make (5-gas analyzer) exhaust gas analyzer, AVL437 make smoke meter, a pressure sensor to measure the cylinder pressure, TDC sensor records pressure for every two degrees of crank rotation, with which P-θ curve is plotted. The engine is connected to eddy current dynamometer. The eddy current dynamometer is mounted on base frame and connected to engine. The engine is subjected to different loads with the help of dynamometer. A rotameter is provided for engine cooling water flow measurement. A pipe in pipe type calorimeter is fitted at the exhaust gas outlet line of the engine.

The calorimeter cooling water flow is measured and adjusted by the rotameter. Temperature sensors are fitted at the inlet and outlet of the calorimeter for temperature measurement. The pump is provided for supplying water to eddy current dynamometer, engine cooling and calorimeter. A fuel tank is fitted inside control panel along with fuel measuring unit. An air box is powered for damping pulsation in airflow line. An orifice meter with manometer is fitted at the inlet of air box for flow measurement. Piezo-electric type sensor with water cooled adapter is fitted in cylinder head for combustion pressure measurement. This sensor is connected to an engine indicator fitted in control panel, which scans the pressure and crank-angle data is interfaced with computer through COM port. An encoder is a device, circuit, transducer, software program, algorithm that converts information from one format to another. Rotary encoder is an optical sensor used for speed and crank angle measurement. The sensor is mounted on dynamometer shaft and connected to engine indicator. Thermocouple type temperature sensors measure cooling water inlet, outlet and exhaust temperatures. These temperatures are digitally indicated on indicator suited on control panel. The exhaust gas analyzer is used to measure the relative volumes of gaseous constituents in the exhaust gases of the engine.

The engine used for this study is a single cylinder, four stroke, direct injection, water cooled, and diesel engine. The engine is coupled to an electrical generator through which load was applied. A fixed 220 bar injection pressure and 17.5 compression ratio are used throughout the experiments. Indicators on the test bed show the following quantities which are measured electrically: engine speed, brake power and various temperatures. The computer is interfaced with engine. The PCI 1050 IC card is connected to COM port of CPU. Engine soft is the software used to control the entire engine readings. It is lab view based software. The engine is tested at constant rated speed of 1500 rpm.

5. Result and Discussion.

Blends S0, S20, S40, S60 and S100 are tested for 23°bTDC normal injection timing and performance is studied. A test is conducted on a single cylinder four stroke diesel engine. In this test the engine is loaded from 0 kg to 18.3kg (Rated load) and the readings are noted and again unloaded from 18.3kg to 0kg. Experiments are conducted on the engine at different loads from 0 kg to 18.3 kg (Rated load) with constant speed, varying the load up to the rated load keeping cooling water flow and calorimeter water flow constant. Observations are made at constant injection pressure of 220 bar, to evaluate various performance parameters and emissions characteristics are discussed below.

5.1 Influence of load on brake thermal efficiency.

The variations of the brake thermal efficiency (BTE) for diesel and SOME blends are shown in Fig 2. For all blends tested, BTE increases with increase in load. Highest BTE is achieved with blend S0 (Diesel). The BTE is found to be lower for SOME blends than diesel. This drop in BTE is attributed to poor atomization of the blends due to higher viscosity, higher density and lower heat value of the fuel. Fig 4, indicates that blend S40 is having lower BTE compared to S40, S60 and S100 at rated load. At rated load condition, maximum BTE is for S0. At rated load, compared to S0, BTE for S100, S60 S40, S20 decreases by 2.58%, 3.48%, 3.33%, and 4.89% respectively. At 80% loading condition, maximum BTE is for S0. At 80% load, compared to S0, BTE for S100, S60, S40, S20 decreases by 2.82%, 1.18%, 0.5%, and 2.01% respectively.

5.2 Influence of load on brake specific fuel consumption.

The variation of the brake specific fuel consumption (BSFC) with diesel and SOME blends are shown in Fig 3. It is observed that for all the fuels tested, BSFC decreases with increase in load. As the BSFC is calculated on weight basis, obviously higher densities resulted in higher values for BSFC. The BSFC of blend S40 is best amongst all blends and nearly matches to that of diesel. Graph indicates at rated load that blend S20 is having higher BSFC compared to S40 and S100 at rated load. The lowest BSFC is for S0 (diesel). At rated load, compared to S0, BSFC for S20, S40, S60, S100 increases by 7.47%, 8.54%, 11.74%, and 16.72% respectively. At 80% load, compared to S0, BSFC for S20, S40, S60, S100 increases by 5%, 5.42%, 8.96% and 17.2% respectively.

5.3 Influence of load on CO.

The variation of the carbon monoxide emission for diesel and SOME blends are shown in Fig 4. CO is formed mainly due to incomplete combustion of fuel, which may be due to shortage of air. At rated load, in SOME blends CO emission was higher than that of diesel fuel, at rated load incomplete combustion takes place because of which excess CO emissions more for all. SOME contains extra oxygen content which results in complete combustion of fuel and converts CO to CO2. It can be observed from fig 6, that the CO emissions are least for S0 at full load. At rated load, compared to S0, CO for S20, S40, S60, S100 increases by 16%, 20%, 36% and 41% respectively. At 80% load compared to S0, CO for S20, S40, S60 are same as that of diesel but for S100 CO emissions increases by 25%.

5.4 Influence of load on HC.

The variation of the HC for diesel and SOME blends are shown in fig 7. It can be observed from Fig 5, that the HC emissions are least for S40 and S100 at full load. For blends S0 and S20, HC emissions are high. At rated load, maximum HC is for S0. Compared to S0, HC for S20, S40, S60, S100 decreases by 27%, 43%, 51%, 43% respectively. At 80% load, maximum HC is for S0, compared to S0, HC for S20, S40, S60, S100 decreases by 27%, 42%, 37%, and 52% respectively.

5.5 Influence of load on NOx.

The variation of the NOx for diesel and SOME blends are shown in Fig 6. For rated load NOx emission is higher for S100 when compared to that of diesel. At rated load over-all air-fuel ratio increases resulting in increase in combustion temperature in the combustion chamber and oxygen content in biodiesel facilitates for NOx emission.

The NOx emission is affected by injection system, along with variation in fuel characteristics such as cetane number, viscosity, rate of burning etc. For S20 and S40 at NOx emission is low higher when compared to that of diesel because of lower combustion temperature. At rated load, compared to S0, Nox increases for S100 by 5.07% because of higher combustion temperature and presence of extra oxygen in biodiesel and decreases for S20, S40, S60 by 5.76%, 12.96% and 10.4% respectively because of lower combustion temperature. At 80% load, compared to S0, Nox increases for S100 by 1% because of higher combustion temperature and presence of extra oxygen in biodiesel and decreases for S20, S40, S60 by 5.76%, 12.96%, 9.68% respectively because of lower combustion temperature.

5.6 Influence of load on EGT.

The variation of the exhaust gas temperature (EGT) for diesel and SOME blends are shown in Fig. 7. The EGT increases with increase in engine loading for all the blends. At rated load, blend S40 and S100 are having minimum exhaust gas temperature. Compared to S0, EGT increases for S20 by 1.19% and decreases for S40, S60, and S100 by 1.21%, 0.17% and 0.86% respectively. With advanced injection, wall heat transfer is more due to earlier combustion in the cycle leading to lower exhaust temperature. At 80% load compared with S0, EGT increases for S20, S40, S60 and S100 with 6.33%, 3.61%, 4.07% and 3.39% respectively.

5.7 Influence of load on smoke density.

The variation of the smoke density (SD) with diesel and SOME blends are shown in fig 8. Smoke is an indication of incomplete combustion and it limits the output of the engine. The smoke density increases with increase in blending. The smoke density increases with increase of concentration in simarouba blends. At rated load, smoke density for S20 is higher than that of diesel. This is caused mainly due to the poor atomization, improper mixing of the fuel droplets with air and incomplete combustion because of the higher viscosity of the blends. At rated load, lowest SD is for S0. Compared to S0, SD for S20, S40, S60, S100 increases by 17.65%, 24.28%, 39.44% and 24.47% respectively. At 80% load, lowest SD is for S0. Compared to S0, SD for S20, S40, S60 and S100 increases by 56.11%, 21.66%, 56.66% and 30.55% respectively.

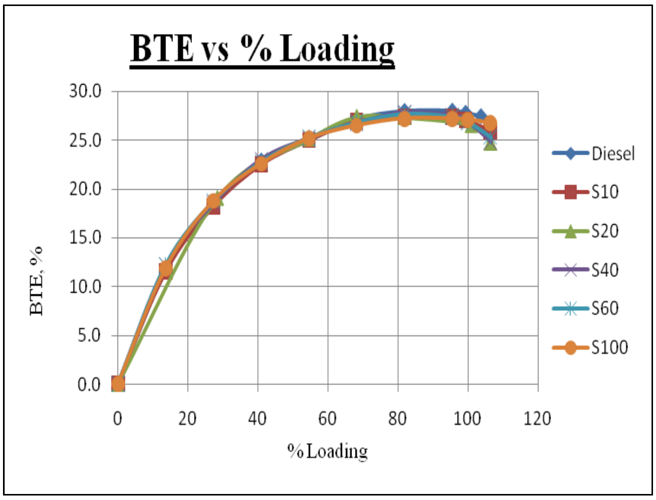

Fig-2: Influence of load on brake thermal efficiency.

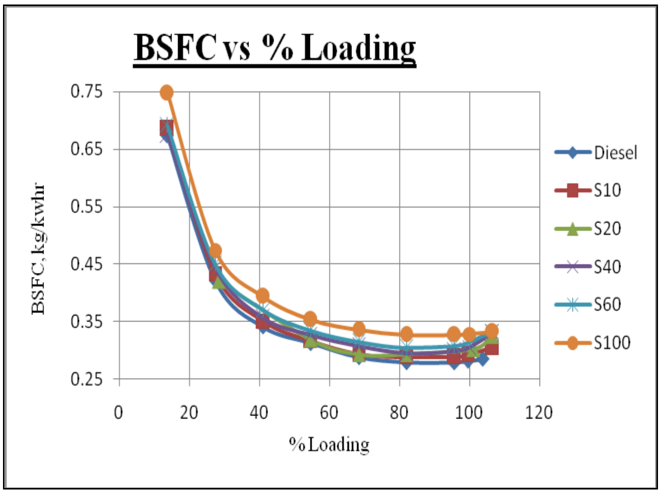

Fig-3: Influence of load on BSFC.

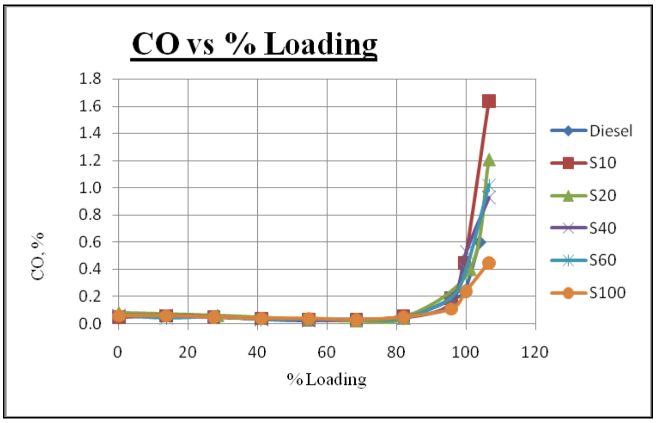

Fig-4: Influence of load on CO.

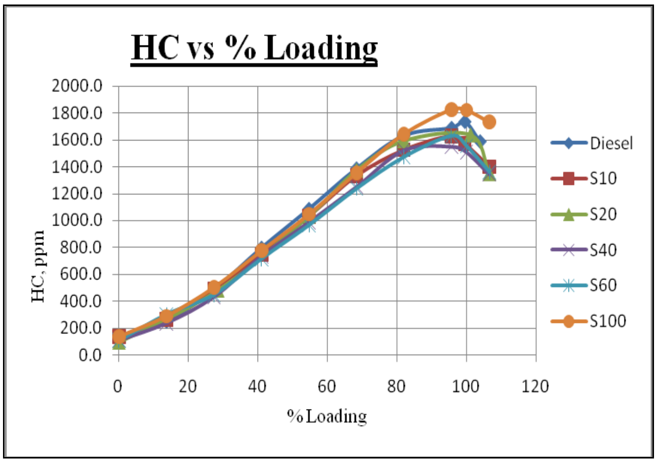

Fig-5: Influence of load on HC.

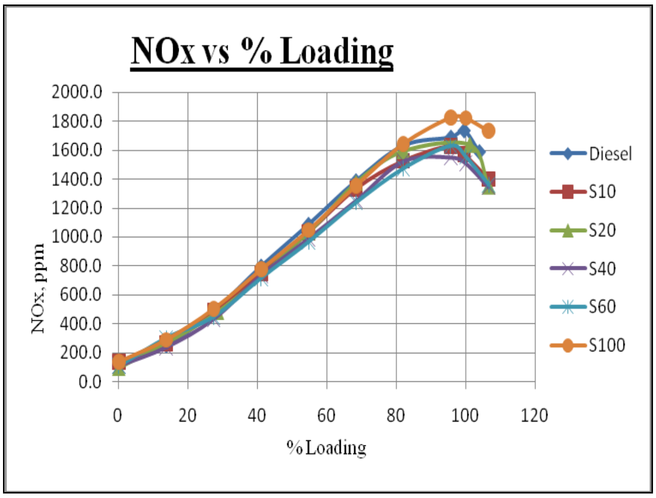

Fig-6: Influence of load on NOx.

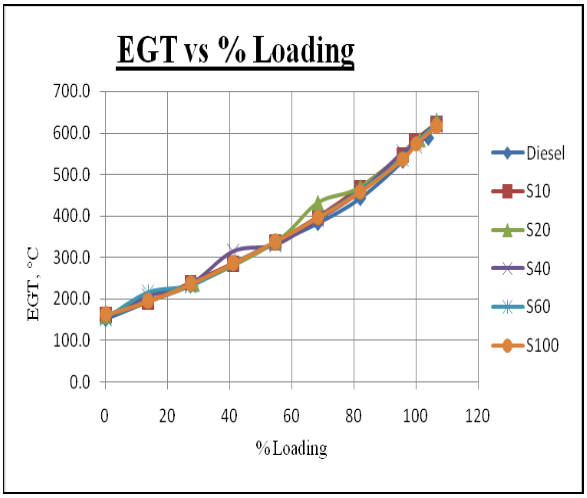

Fig-7: Influence of load on EGT.

6. CONCLUSIONS

As availability of diesel is reducing day to day, an alternative fuel is to be used. Researchers have found that addition of oils extracted from plants to the available diesel reduces the overall consumption of the diesel. In this work performance of biodiesel which is obtained by addition of Simarouba oil methyl ester to the diesel is studied. In order to study the performance in CI engine using bio-diesel (Simarouba) as fuel, Kirloskar single cylinder 4 stroke diesel engine is used with constant injection pressure of 220 bar. Studies is also been performed on different blends of biodiesel.
Engine analysis:

- The blend S40 at 80% loading shows higher performance and less emission for all blends at 220 bar injection pressure.
- BSFC is more for blends. S40 matches nearly to that of diesel.
- BTE is low for S40 blend by 0.52% compared to S0.
- CO and smoke emission are less for blend S40.
- Compared to S0, NOx and HC are lower by 6.49% and 42.50% for blend S40.
- It is recommended that blend S30 and S40 can be used as alternate fuel without engine modification, blend S40 can be used as alternate fuel.

Blends had better emission properties when compared to diesel. At rated load CO, HC and smoke emission were less. In Simarouba oil methyl ester (SOME) blends CO emission was lower than that of diesel, as SOME contains extra oxygen content which results in complete combustion of fuel. At rated load diesel had the highest HC emission.

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