Performance and Emission Characteristics Of CI DI Engine Using Blends of Two Biodiesel (Simarouba and Pongamia Biodiesel) and Diesel Fuel

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Abstract – The performance and emission characteristics of single cylinder CI DI engine using mixture of Simarouba and Pongamia biodiesel in the ratios (S50:P50,S75:P25,S25:P75) respectively with mineral diesel have been experimentally investigated. The brake specific fuel consumption increases with higher percentage of biodiesel in the blends. Brake thermal efficiency decreases with the increased percentage of biodiesel in the blends. The maximum efficiency is found to be 29.6% with pure diesel and 27.2% with pure biodiesel (50% simarouba and 50% pongamia). Carbon mono-oxide and hydrocarbon emissions are reduced with the addition of biodiesel to diesel. NOx emission with pure biodiesel is found to be as same as mineral diesel.

Keywords— 50% Simarouba and Pongamia (S50+P50), 75% Simarouba and 25% Pongamia (S75+P25), 25% Simarouba and 75% Pongamia (S25+P75).

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I. INTRODUCTION

Coal, petroleum and natural gas are the main forms of the energy consumed worldwide other than nuclear and hydroelectricity sources. It is well known that these sources are limited and will exhaust in near future. The ever growing environmental and health hazards associated with diesel fuel necessitates to look for alternative fuel to address all the problems. [12]. There are many tree breeds which bear seeds, rich in oil. Some of the important varieties are Pongamia, Jatropha, Rubber, Neem, Mahua, Sal, Undi, Pilu etc.[5]–[9]For CI engine fuelled with jatropha biodiesel and its blends with diesel BSFC is increased in case of biodiesel, CO emission is reduced whereas NOx is increased, observed similar brake thermal efficiency as that of diesel at low and medium engine loads.[2]. Use of bio-fuel requires very little or no modification of engine when blended with diesel. As a renewable and oxygen-containing biofuel, ethanol is a prospective fuel for vehicle, which can be blended with diesel or be injected into cylinder directly[11]. Proponents of biodiesel in India almost exclusively focus on Jatropha and to some extent on Pongamia and Simarouba.

II. OBJECTIVES

In this paper experimental results obtained by using mixture of dual biodiesel at different ratios and blended with diesel by different percentage of biodiesel mixture content in it are compared and the best possible blend results are presented for good performance and lowered engine emissions at constant speed of 1500rpm.

III. BIODIESEL EXTRACTION

Direct use of vegetable oils can clogs diesel engines due to its high viscosity; the oil needs to be chemically modified into mono-alkyl esters whose properties resemble those of fossil fuels. Transesterification process is the universal method used for extraction of biodiesel.

A. Comparision of properties of biodiesel different mixtures.

Fig 1.1 compare the effect of addition of simarouba and pongamia mixuture biofuels that is (S50+P50), (S25+P75), (S75+P25) in diesel on density. With the addition of biofuels in diesel, the density goes on increasing and it has been observed that B100 of S25+P75 has highest density that is 890 Kg/m3 whereas density of pure diesel is 830 Kg/m3. The fuel mixture containing 50% simarouba and 50% pongamia shows higher density values compared to other fuel mixture blends. Increased density of blended fuels reflects its unsuitability as diesel fuel in cold climatic conditions. In general, the injection pressure required will be more and its penetration is also deeper. It may cause problems in fuel atomisation [1]. It should be considered that the density of biodiesel is affected from the sources of raw material in their productions.

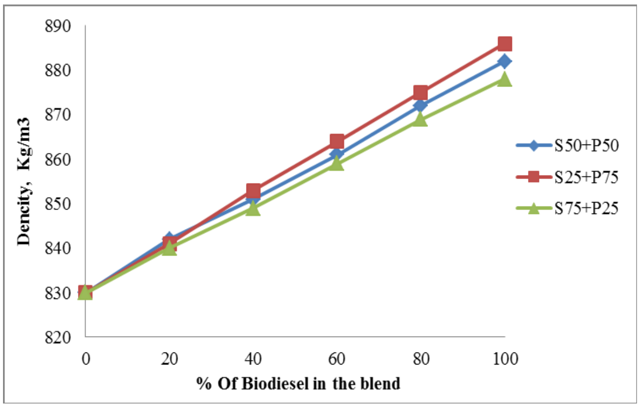

Fig 1.1 Change in Density with increase in % of biodiesel

Fig 1.2 shows the effect of addition of biodiesel in diesel on calorific value. The calorific value of S25+P75 mixture biodiesel was found less than those of calorific value of S50+P50 and S75+P25 biofuel. The decrease in CV of biofuel compared to diesel is due to lower hydrocarbon to carbon ratio and presence of chemically bonded oxygen in biodiesel blended fuel. The lowest CV found is 36000 KJ/Kg for the blend B100 of S25+P75 mixture fuel. Lower calorific value causes the percentage increase in specific fuel consumption with increased amount of biodiesel fuel in blend. This also leads to lower brake thermal efficiency of the engine [8].

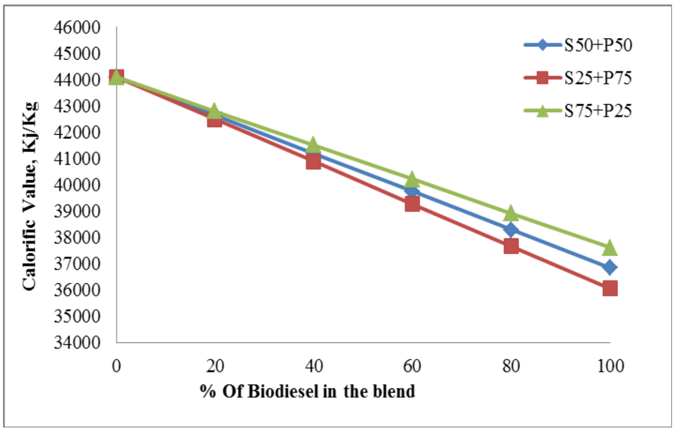

Fig 1.2 Change in CV with increase in % of biodiesel

IV. EXPERIMENTAL SETUP AND METHODOLOGY

The experiments are conducted on compression ignition direct injection; single cylinder 4-stroke Kirloskar diesel engine. The layout of experimental test rig and its instrumentation is shown in fig. 2. It is a water cooled engine with a rated power of 5.2 kW at 1500 rpm having bore 87.5 mm and stroke 110 mm, compression ratio of 17.5, and constant injection pressure of 205bar at 23˚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 AVL 444 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.

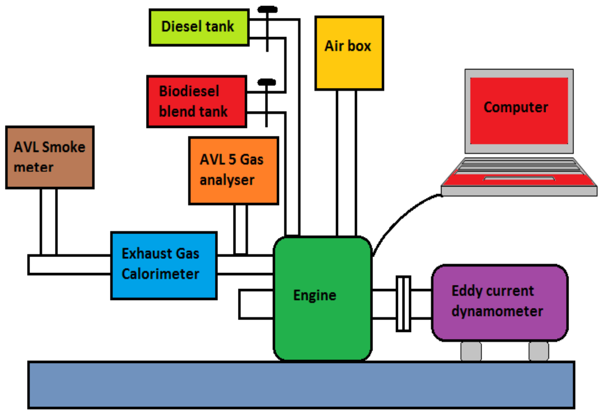

Fig. 2. Line diagram of experimental Setup

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 situated on control panel. Smoke opacity meter is distributary sample type. It equips gas temperature pressure and distributor control cell in order to ensure metrical stability and repeat. It measures the whole burthen opacity smoke degree continuously and free speed up opacity smoke degree. The exhaust gas analyzer is used to measure the relative volumes of gaseous constituents in the exhaust gases of the engine. 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.

Table 1 Engine Specifications

Make	Kirloskar Engine
Bore & stroke	87.5mm x110mm
Type of cooling	Water cooled
Speed	1500 rpm
Compression ratio	17.5.1
Number of cylinder	1
Rated power	5.2 kW
Start of injection	23˚ bTDC
Injection pressure	205 bar

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 throughout its power range using B0, B20, B40, B60, B80 and B100 blends. Experiments are conducted on the engine at different loads from 0 kg to 18 kg at an interval load of 3kg (rated load). Blends B0, B20, B40, B60, B80 and B100 are tested for 23˚bTDC and at an injection pressure 200bar.

V. RESULTS COMPARISION AND DISCUSSIONS

Performance of engine with different volume percentage of two biodiesel (pongamia and Simarouba) and dieselblends and pure diesel are compared. Pure biodiesel is presented with nuber-1, 25% Pongamia and 75% Simarouba as numbrer -2(P25+S75), 50% Pongamia and 50% Simarouba as numbrer -3 (P50+S50), and 75% Pongamia and 25% Simarouba as numbrer - 4 (P75+S25). The type fuels are represented with number on x-axis and othe variables are taken on y-axis. The results are preseted for mid range loads.

4.1 Brake specific fuel consumption (BSFC) at 15 Kg. Load:

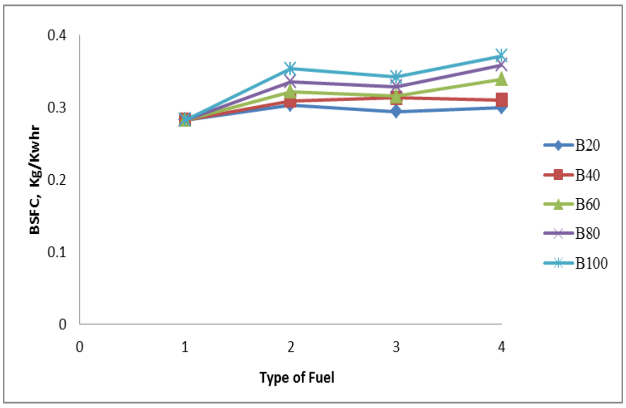

Fig. 4.1 Variation of BSFC for different blends at 15 Kg load.

Figure 4.1 presents the variation of BSFC for different binds of biodiesel and diesel and pure diesel fuel at 15 Kg load. It is observed that BSFC for diesel (B0) is the lowest and for 100% biodiesel (B100) is the highest for all the three blends. This is because of lower energy contents of bio-diesel fuel. Among the blends BSFC of B20 is close to the diesel, for other blends BSFC is higher. Among the three types of fuels BSFC of fuel-3 is the better fuel than other two fuels.

4.2 Brake Thermal Efficiency (BTE)at 15Kg. Load:

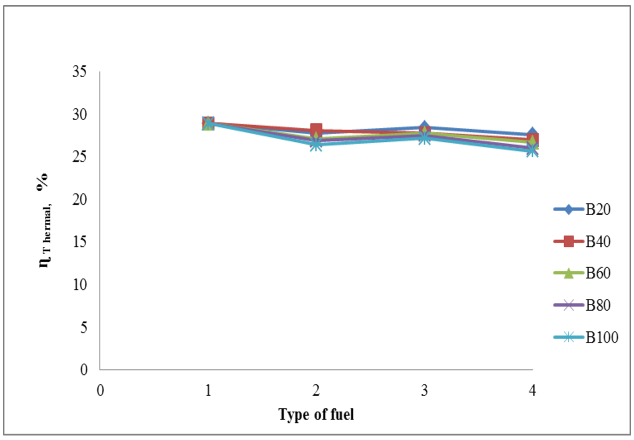

Fig 4.2 Variation of thermal efficiency for different blends at 15Kg load.

Figure 4.2 presents the varying of thermal efficiency for the individual fuels at 15 Kg. load. BTE for diesel

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(B0) fuel is the highest and for 100% biodiesel (B100) is the lowest. B20 and B40 blends of the types of are close to diesel fuel. The comparison is made among the types of fuel, the type-3 fuel (P50+S50) is the better combination of fuel than other two type of fuel i.e, type-1 (P25+S75) and type -4 (P75+S25).

4.3 Carbon Monoxide Emission:

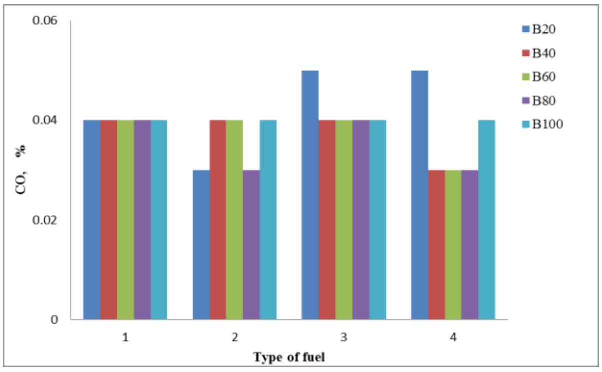

Fig 4.3 Variation of carbon monoxide for different blends at 15Kg load.

Figure 4.3 shows the variation of CO emission for diesel and for different type of biodiesel blends at 15 Kg.load. It is observed that CO emission for all type of biodiesel blends is lesser matched to neat fuel.” This is because of inherent O_2 present in the biodiesel may convert CO to CO_2. Among the type of fuel considered type-2 (P25+S75) fuel emit lesser CO compared to other two type of fuel i.e., type-(P50+S50)) and type-4 (P75+S25). For type -3 fuel CO emissions are higher compared other two type of fuel. This may be due to the better performance for this fuel may give the higher products of combustion that may give the higher CO emission.

4.4 Hydro Carbon Emissions:

Figure 4.4 presents the emission of HC for diverse type of fuel and diesel at 15 Kg.load. it is detected from the chart that HC emission for some of blends are lesser compared to diesel. for type3 (P50+S50) fuel HC emissions are lesser compared to diesel fuel and other two type of fuel. This may because of O_2 present in the biodiesel may causes the improved combustion and hence the lesser emission of HC.

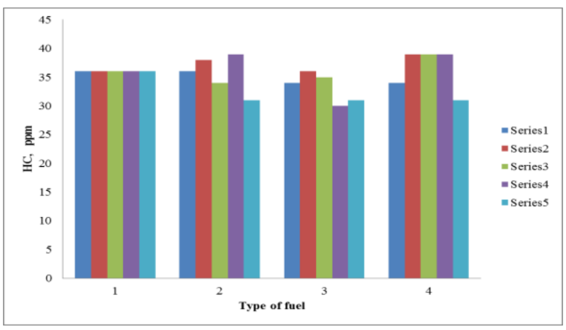

Fig 4.4 Variation of hydro carbon for different blends at 15Kg load.

4.5. Emission of NO_x:

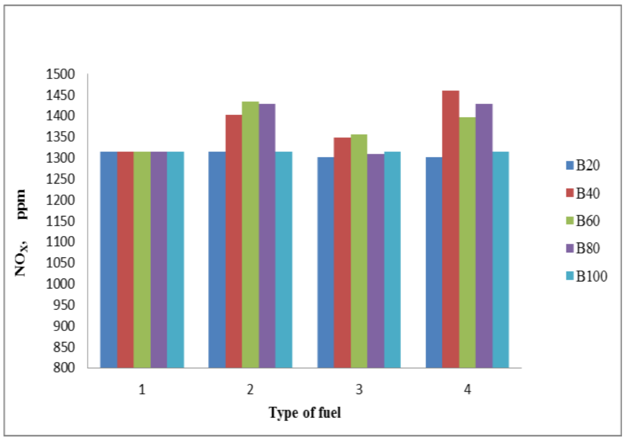

Fig 4.5 Variation of oxides of nitrogen for different blends at 15Kg load.

Figure 4.5 presents the emission of NOx for dissimilar type of fuels and diesel at 15 Kg load. NOx emanations were greater for biodiesel blends paralleled to diesel. This may be due higher combustion temperature for all type fuel than diesel.

CONCLUSIONS

The conclusions or results of suitability of biodiesel fuel mixed in different ratios with diesel are listed below:

- Break specific fuel consumption is increased for all the biodiesel blends compared to diesel.
- Brake thermal efficiency for all the biodiesel blends are less compared to diesel. Exhaust gas temperature increases with increase in load on the engine.
- Emission of CO and HC are reduced with the use of biodiesel in the engine, with increase in biodiesel content in the diesel reduction of emissions is observed during the test, for B80 and B100 up to 50% reduction in emission is observed, for B20 (S50+P50) has shown considerable reduction, that is 33.3% and 15.625% for CO and HC respectively.
- NO_X emission is lesser at lower loads. With the increase of biodiesel concentration in the diesel B20 and B40 of (S50+P50) have shown minimum increase that is 6.9% and 3% respectively.
- Based on the performance and emission characteristics tests the blend prepared by mixed oil (50% Simarouba and 50% Pongamia) and Diesel by blending them in

the ratio B20 and B40 seems to be suitable for long-term usage.

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