

# COMPARATIVE STUDY BETWEEN SIMAROUBA BIODIESEL ON A SINGLE CYLINDER DIESEL ENGINE AND LHR ENGINE USING DIESEL AND MULTI-BLEND BIODIESEL

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## ABSTRACT

Biodiesel is a fatty acid alkyl ester which is renewable, biodegradable and non toxic fuel which can be derived from any vegetable oil by Transesterification process. In the present work, the performance of single cylinder direct injection diesel engine using simarouba biodiesel (SOME) as fuel was evaluated for its performance, emission and combustion characteristics. The properties of SOME thus obtained are comparable with ASTM biodiesel standards. The produced SOME is blended with diesel (Simarouba-S20, S40, S60, S80 and S100) were tested for their use as a substitute fuel for diesel engine. First, the engine was tested at different load conditions without coating. Then, combustion chamber surfaces cylinder head, cylinder liner, valves, and piston crown face were coated with nanoceramic material of  $Al_2O_3$  using plasma spray method. Comparative evaluation on performance and combustion characteristics using diesel, multi-blend biodiesel and its blends was studied in the ceramic coated and uncoated engines under the same running conditions. An increase in engine power, brake thermal efficiency and a decrease in specific fuel consumption were observed in the ceramic coated engine compared to that of normal engine.

**Key words:** Simarouba oil methyl ester, low heat rejection, jatropha oil methyl ester, pongamia oil, transesterification.

## 1. INTRODUCTION

The most harmful effect of our present day civilization is global warming and environmental pollution. With rapid industrialization and urbanization we are also making our planet unsafe for us and for the generations to come. The vehicle population throughout the world is increasing rapidly; in India the growth rate of automotive industry is one of the largest in the world. It is quite evident that the problem cannot be solved with the conventional fossil fuels, however stringent the emission control norms may be. The

consumption of diesel fuels in India was 28.30 million tonnes which was 43.2% of the consumption of petroleum products. This requirement was met by importing crude petroleum as well as petroleum products. The import bill on these items was 17,838 crores. With the expected growth rate of diesel consumption of more than 14% per annum, shrinking crude oil reserves and limited refining capacity, India will be heavily dependent on imports of crude petroleum and petroleum products. From the standpoint of preserving the global environment and to sustain from the large imports of crude petroleum & petroleum products from Gulf countries, alternate diesel fuel is the need of the hour. As world reserves of fossil fuels and raw materials are limited, it has stimulated active research interest in nonpetroleum, renewable, and nonpolluting fuels. With this scenario the need for an alternate fuel arises to maintain the economy of the country. The world has been confronted with energy crisis due to the decrease of fossil fuel resources and the increase of environmental restrictions. Therefore attention has been focused on developing the renewable or alternate fuels to replace the petroleum based fuels for transport vehicles. There are several alternative sources of fuel like vegetable oils, biogas, biomass, primary alcohols which are all renewable in nature. Among these fuels, vegetable oils appear to have an exceptional importance as they are renewable and widely available, biodegradable and non-toxic, and environmental friendly. In a country like India it is observed that biodiesel can be a viable alternative automotive fuel. Biodiesel is a fastest growing alternative fuel and India has better resources for its production. The rapid increase in fuel expenses, the decreasing supply of high-grade fuels on the market, stimulated research on more efficient engines. Thermal barrier coatings provide the potential for higher thermal efficiencies of the engine, improved combustion, and reduced emissions. Lower heat rejection from the combustion chamber through thermally insulated components causes an increase in available energy that would increase the in-cylinder work and the amount of energy transported by the exhaust gases, which could be also utilized.

## 2. MATERIALS AND METHODS

The different properties of diesel fuel, SOME, POME and JOME are given in below table.

Table1 . Fuel properties

<i>Properties</i>	<i>Diesel fuel</i>	<i>SOME</i>	<i>Multi blend biodiesel</i>
Kinematic viscosity at 40° C (cst)	3.0	4.7	6.5
Calorific value(KJ/Kg)	42680	37933	40498
Density (Kg/m <sup>3</sup> )	830	865	880
Flash point (°C)	50	160	153
Fire point(°C)	57	170	163

### 3. EXPERIMENTATION

#### A. ENGINE COMPONENTS

The important components of the system are:

1. The engine
2. Dynamometer

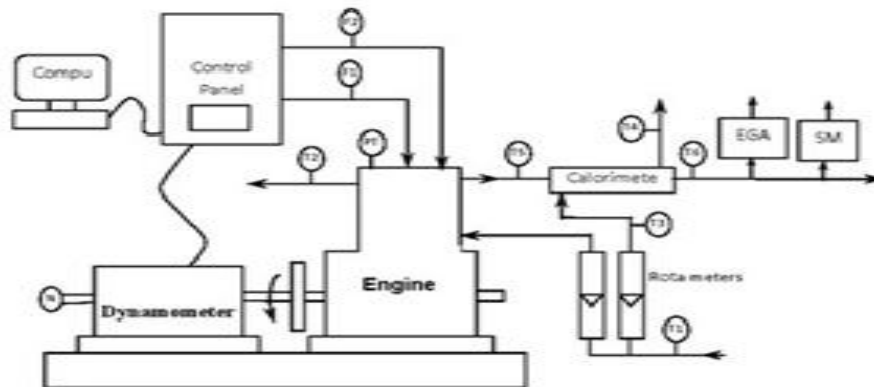


Fig 1. Experimental setup

Table 2. Notations

PT	Pressure transducer
N	Rotary encoder
Wt	Weight
F1	Fuel flow
F2	Air flow
F3	Jacket water flow
F4	Calorimeter water flow
T1	Jacket water inlet temperature
T2	Jacket water outlet temperature
T3	Calorimeter water inlet temperature = T1
T4	Calorimeter water outlet temperature
T5	Exhaust gas to calorimeter temperature
T6	Exhaust gas from calorimeter temperature

Table 3. Engine specification

Manufacturer	Kirloskar oil engines Ltd. India
Model	TV-SR, naturally aspirated
Engine	Single cylinder, DI
Bore/stroke	87.5mm/110mm
C.R .	16.5:1
speed	1500r/min, constant
Rated power	5.2kw
Working cycle	four stroke
Injection pressure	200bar/23 def TDC
Type of sensor	Piezo electric
Response time	4 micro seconds
Crank angle sensor	1-degree crank angle
Resolution of 1 deg	360 deg with a resolution of 1 deg

### 3. RESULTS AND DISCUSSIONS

#### a) Brake thermal efficiency

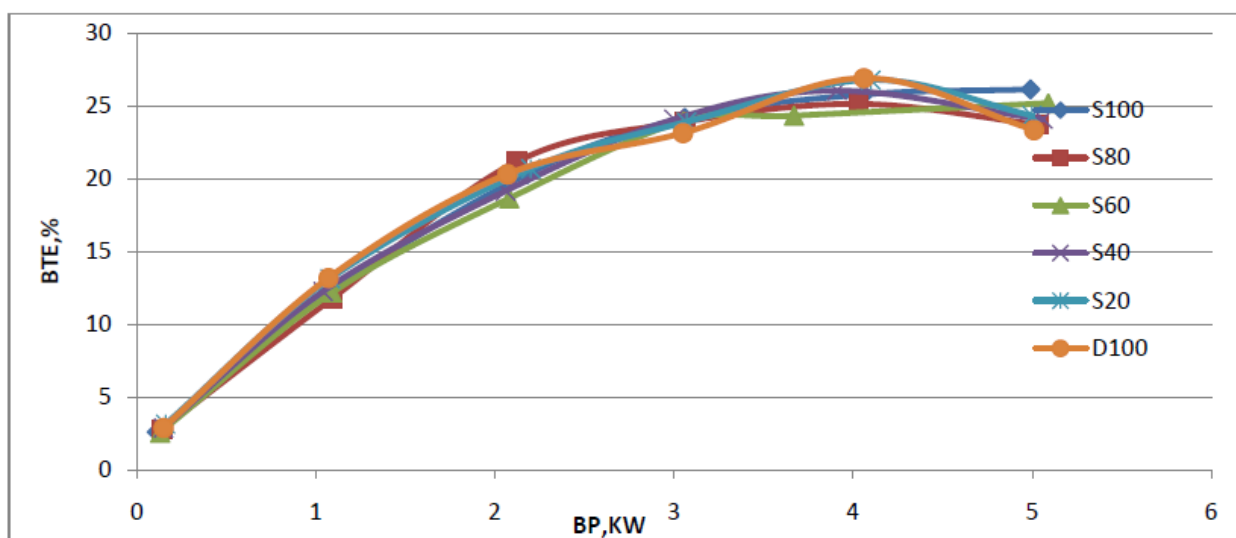


Fig 2. Variation of brake power v/s brake thermal efficiency for simarouba biodiesel

The above figure shows that the variation of brake thermal efficiency (BTE) with Brake power for different blends. Brake thermal efficiency is defined as the ratio between the brake power output and the energy of the fuel combustion. Graph shows as the Brake power increases the brake thermal efficiency increases to an extent and then decreases slightly at the end. The brake thermal efficiency reduces due to heat loss and increase in power developed with increase in brake power. The decrease in brake thermal efficiency for higher blends may be due to the combined effect of its lower heating value and increase in fuel consumption. The curve S80 is running nearer to the Diesel curve, which shows S80 blend can be a favourable to existing diesel engine.

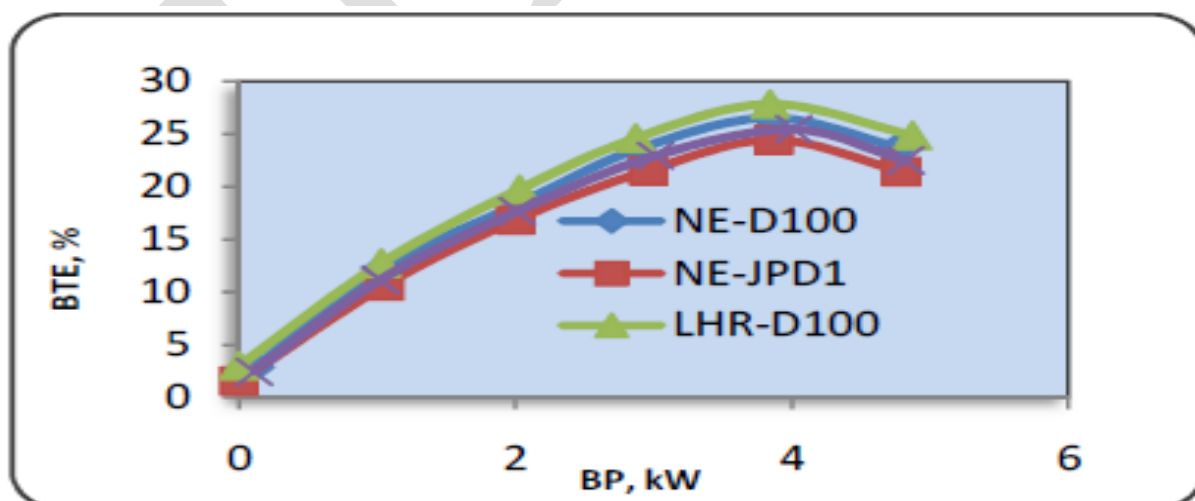


Fig 3. Variation of brake power v/s brake thermal efficiency for multiblend biodiesel of jatropa and pongamia

The above figure shows the break thermal efficiency for multi blend biodiesel and its blends with respect to brake power for normal engine and low heat rejection engine. The maximum efficiency obtained in the case of LHR engine fueled with biodiesel at full load was lower than LHR engine fueled with diesel and higher than normal engine fueled with diesel and biodiesel. The efficiency of normal engine JPD1 and LHR JPD1 at full load are almost same this is due to complete combustion of fuel in thermal barrier coated engine.

#### b) Mechanical efficiency

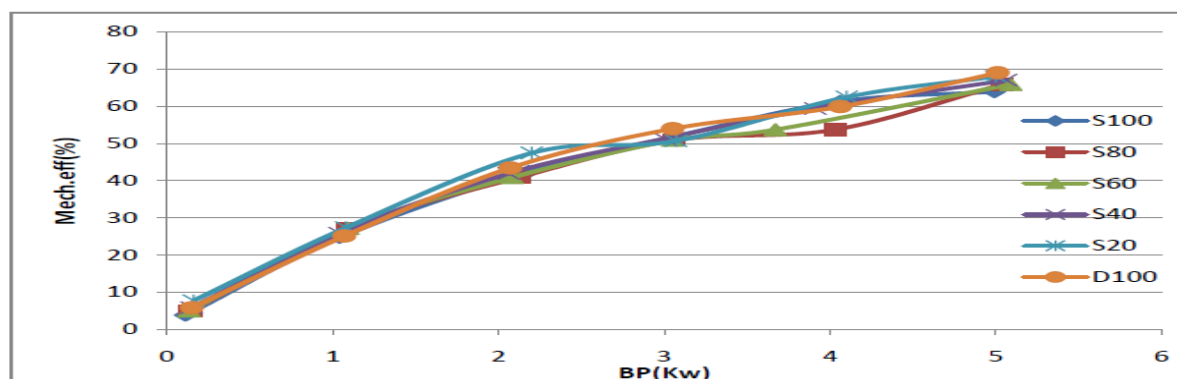


Fig 4. Variation of brake power v/s mechanical efficiency for simarouba biodiesel

The variation of mechanical efficiency with brake power, for diesel and Simarouba biodiesel blends are as shown in figure 4. The mechanical efficiency of diesel is slightly higher than the Simarouba biodiesel. From the graph it is evident that with increase in the concentration of Simarouba biodiesel in neat diesel decreases the mechanical efficiency. Mechanical efficiency of both diesel and biodiesel are equal at 20% of blend.

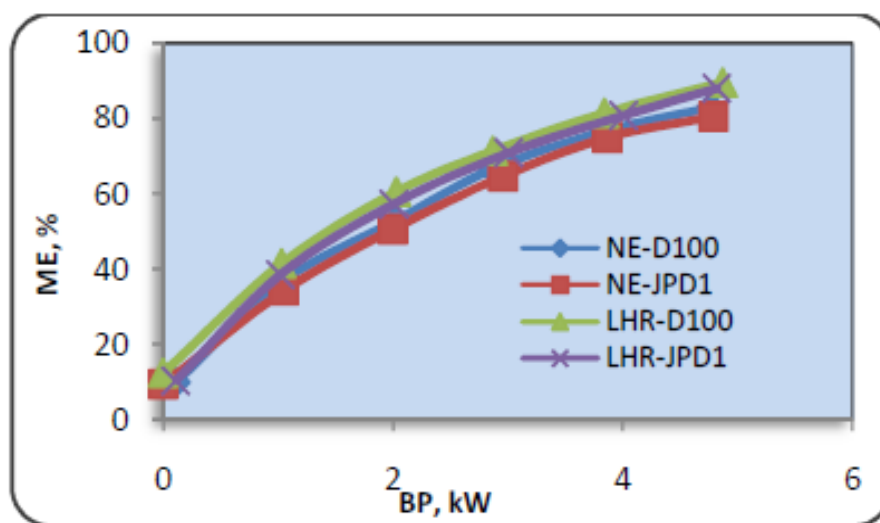


Fig 5. Variation of brake power v/s mechanical efficiency for multiblend biodiesel of jatropha and pongamia

The variation of mechanical efficiency with brake power, for diesel and multi-blend biodiesel blends are as shown in figure 5 for normal engine and LHR engine. The mechanical efficiency of diesel is slightly higher than the multi-blend biodiesel for both normal engine and LHR engine. From the graph it is evident that with increase in the concentration of multi-blend biodiesel in diesel decreases the mechanical efficiency. The maximum mechanical efficiency at full load for LHR engine with D100 and JPD1 is 89.45 and 87.96 which is higher than the normal engine with D100 and JPD1 is 82.86 and 80.47 Here we can see the effect of thermal barrier coating which increases the mechanical efficiency.

### c) Specific fuel consumption

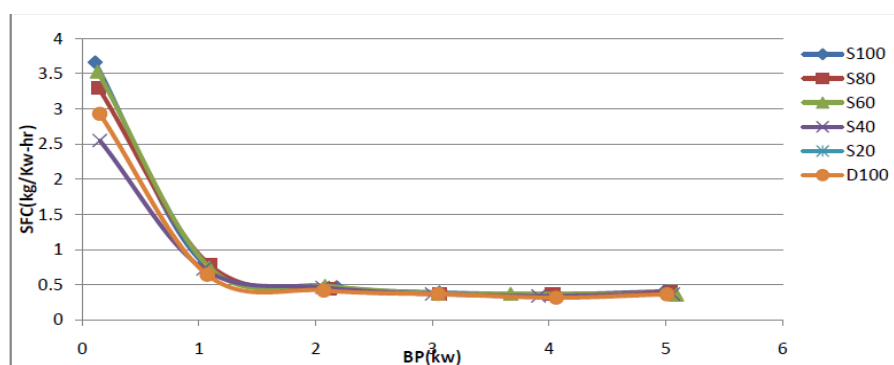


Fig. 6. Variation of SFC with brake power for simarouba biodiesel

The variation of specific fuel consumption with respect to brake power is presented in figure 6 for different blends & diesel. In diesel engine due to less temperature initial combustion takes with maximum fuel consumption. At higher brake power the SFC decreases. This may be due to fuel density, viscosity and heating value of the fuels. The curve S80 is almost tracing the path of diesel curve & this indicates blend S80 can be a favorable to existing diesel engine.

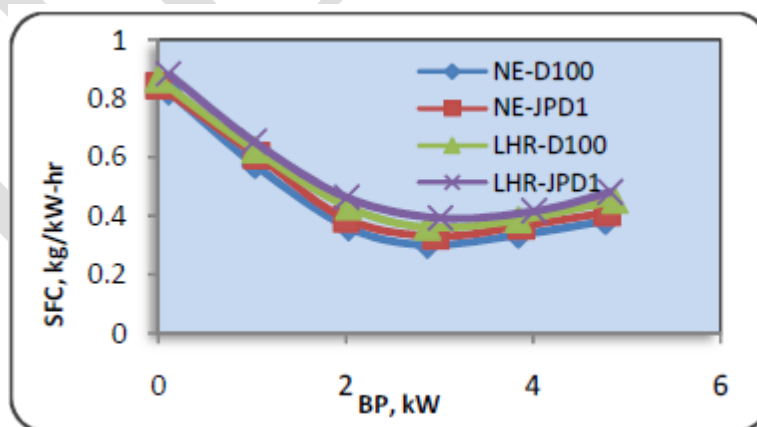


Fig. 7. Variation of SFC with brake power for multiblend biodiesel of jatropha and pongamia

Fig. 7. shows the specific fuel consumption for multi-blend biodiesel and its blends with respect to brake power for both normal engine and LHR engine. At maximum load the

specific fuel consumption of LHR engine fueled with biodiesel is higher than LHR engine fuelled with diesel and lower than normal engine fueled with diesel and biodiesel. This higher fuel consumption was due to the combined effect of lower calorific value and high density of biodiesel. The test engine consumed additional biodiesel fuel in order to retain the same power output.

#### d) Air fuel ratio

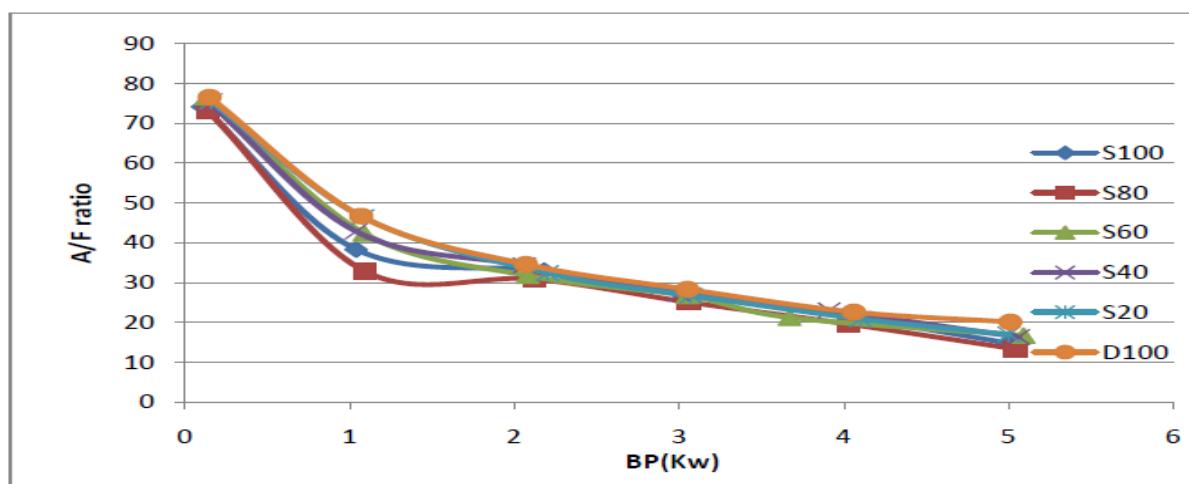


Fig. 8. Variation of air-fuel ratio with brake power for simarouba biodiesel

The variation of air fuel ratio with brake power for diesel and simarouba biodiesel blends are shown in figure (8). It can be observed that air fuel ratio of pure diesel is slightly higher than other Simarouba biodiesel and its blends, and we can also see that the air fuel ratio decreases as the load increases. The airfuel ratio for diesel and biodiesel are equal at 20% blend. The air-fuel ratio for diesel is 20.1 at full load and at 25% blend of biodiesel is 16.99 at full load.

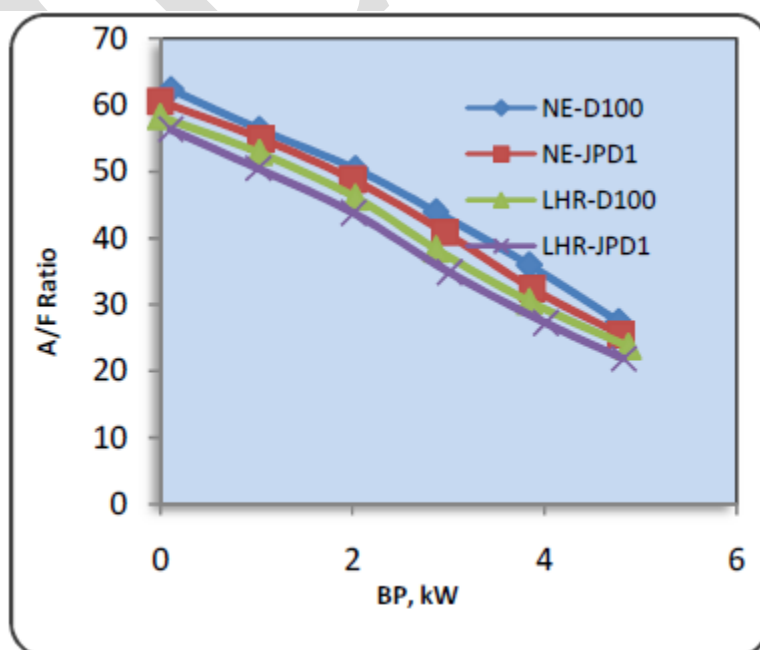


Fig. 9. Variation of air-fuel ratio with brake power for for multiblend biodiesel of jatropha and pongamia.

The variation of air fuel ratio for diesel and multi biodiesel is shown in figure 9 for both normal engine and LHR engine. Because of increased temperature and complete combustion the fuel consumption is higher in case of LHR engine. Air fuel ratio decreases with increase in load because air fuel mixing process is affected by the difficulty in atomization of biodiesel due to its higher viscosity.

#### e) Exhaust gas temperature

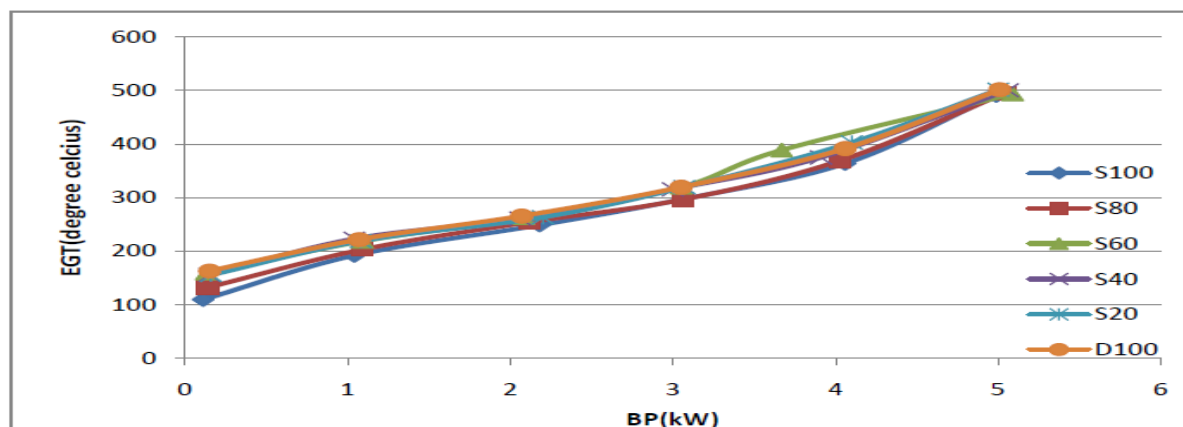


Fig. 10. Variation of exhaust gas temperature with brake power for simarouba biodiesel

The variation of Exhaust gas temperature with respect to brake power is presented in Figure 10 for different blends & diesel. The engine starts running with low temperature at low load. As the load increases the temperature inside the engine increases exponentially till it reaches full load. This rise of temperature is because of continuous flow of exhaust gas through outlet port.

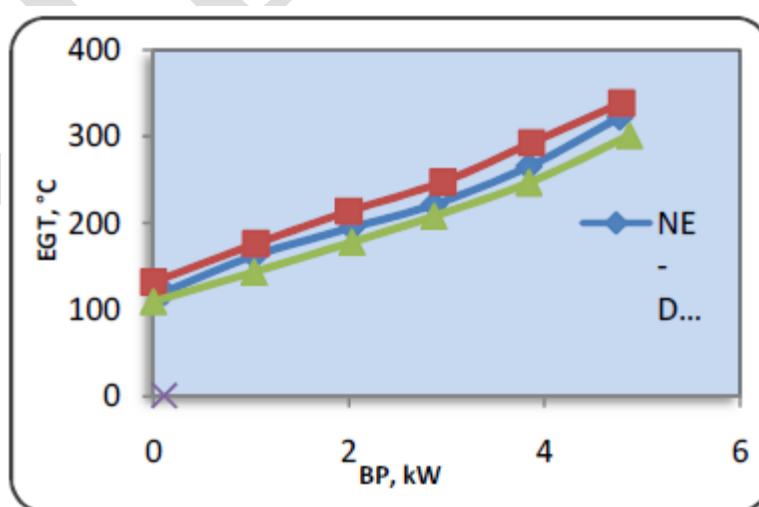


Fig. 11. Variation of exhaust gas temperature with brake power for for multiblend biodiesel of jatropha and pongamia.

The variation of exhaust gas temperature for diesel and multi blend is shown in figure 11 for both normal engine and LHR engine. When bio fuel concentration increases in the diesel the exhaust temperature increases due to thermal barrier coating. Also as the load increases the exhaust gas temperature increases.

e) Variation of crank angle v/s cylinder pressure.

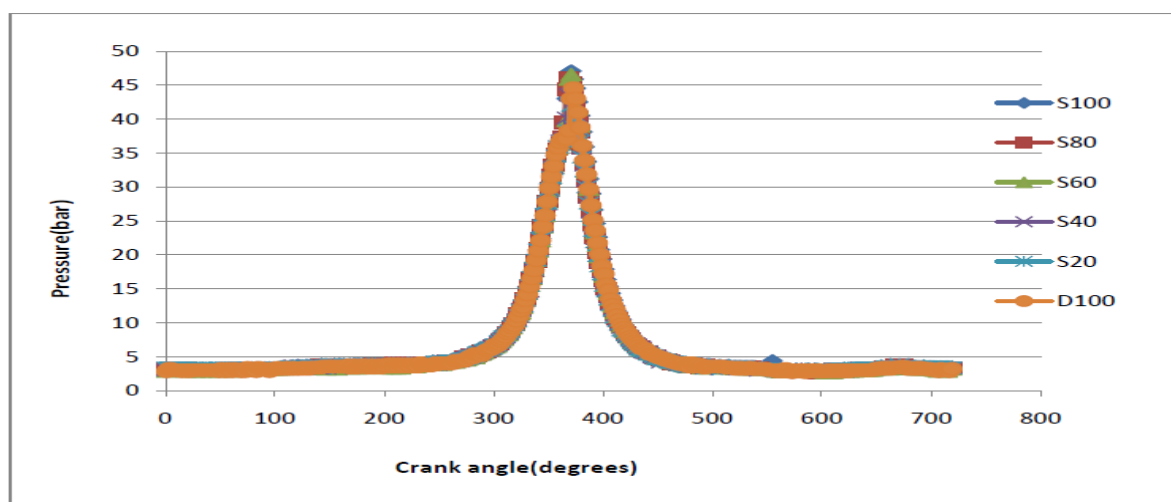


Fig. 12. Variation of crank angle with cylinder pressure for simarouba biodiesel.

In a CI engine the cylinder pressure is depends on the fuel-burning rate during the premixed burning phase, which in turn leads better combustion and heat release. The variation of cylinder pressure with respect to crank angle for diesel and 40% blend of Simarouba biodiesel. are presented in above Figure. Peak pressures of 44.54 bar and 43.69 bar are found for pure diesel and S40 respectively. From the test results it is observed that the peak pressure variations are less Since the properties such as calorific value, viscosity and density are brought closer to diesel after Transesterification of the vegetable oil, no major variation in the pressures are found.

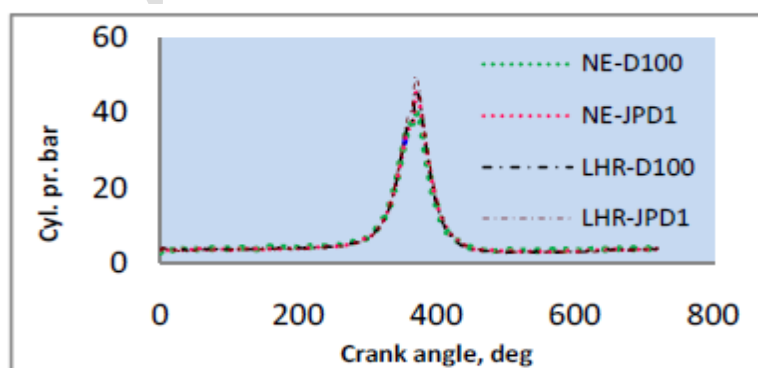


Fig. 13. Variation of crank angle with cylinder pressure for for multiblend biodiesel of jatropha and pongamia.

Figure 13 shows the typical variation of cylinder pressure with respect to crank angle. The cylinder pressure in the case of biodiesel fuelled LHR engine is lesser than the diesel fueled LHR engine and higher than conventional engine fuelled with diesel and biodiesel. This reduction in the cylinder pressure may be due to lower calorific value and slower combustion rates associated with biodiesel fueled LHR engine.

## 5) CONCLUSION

- SOME satisfies the important fuel properties as per ASTM specification of Biodiesel.
- Engine works smoothly on methyl ester of Simarouba oil with performance comparable to diesel operation.
- Methyl ester of Simarouba oil (S80) results in a nearly equal in thermal efficiency as compared to that of diesel.
- The exhaust gas temperature is decreased with the methyl ester of Simarouba oil as compared to diesel.
- The specific fuel consumption of diesel is almost equal S80 at lower loads but at higher loads the SFC of all simarouba blends is equal to diesel.
- The air fuel ratio of diesel is observed that higher than that of the other blends of simarouba oil and air fuel ratio of diesel and other blends of simarouba oil decreases as the load inceases.
- It is observed that JPD1 multi-blend biodiesel has mechanical efficiency, specific fuel consumption and indicated thermal efficiency almost nearer to the diesel fuel.
- There is slight increase in brake thermal efficiency which is a positive sign with this blend. In case of peak pressure it is seen that there is almost same pressure as that of diesel fuel. So it can be concluded that the multi-blend biodiesel can be used without any modification in the existing engine which will result in saving of diesel fuel for certain extent without any compromise with standard performance and combustion characteristics.
- After little modification in engine, it is observed that there is increase in the performance of parameters such as brake thermal efficiency, mechanical efficiency and there is decrease in specific fuel consumption compared to the normal engine.
- The use of multi-blend biodiesel in insulated engine gave the highest brake thermal efficiency at all loads due to the better utilization of the higher amount of energy conserved inside the combustion chamber.
- By the application of the thermal barrier coating, the improvement in the specific fuel consumption caused an increase of the brake thermal efficiency for multi-blend biodiesel in LHR engine.
- By studying performance and combustion characteristics on normal engine and low heat rejection engine it can be concluded that with JPD1 blend we can achieve same characteristics as that of diesel fuel so JPD1 is the best blend.

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