EXPERIMENAL INVESTIGATION OF PERFORMANCE AND COMBUSTION CHARACTERISTICS OF PONGAMIA BIODIESEL AND ITS BLENDS ON DIESEL ENGINE AND LHR ENGINE

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Abstract

Over the last two decades there has been a tremendous increase in the number of automobiles and a corresponding increase in the fuel price. In this regard, alternative fuels like vegetable oils play a major role. Use of pure vegetable oil in diesel engines causes some problems due to their high viscosity compared with diesel fuel. To solve the problems due to high viscosity various techniques are used. One such technique is fuel blending. In the present work the pongamia methyl esters (B25, B50, B75, and B100); prepared by transesterification process was used as an alternative fuel in a diesel engine. Investigations were carried out for the performance and combustion characteristics of pongamia methyl esters. The results were compared with diesel fuel. For this experiment, a single cylinder, four stroke, water cooled diesel engine at a rated speed of 1500 rpm was used. Tests were carried out over the entire range of engine operation at varying load of 0,1, 2, 3, 4, 5.2 at rated speed of 1500rpm and results are compared with diesel. The thermal efficiency, bsfc, mechanical efficiency, volumetric efficiency are well comparable with diesel for diesel engine and low heat rejection engine and better performance and combustion characteristics are observed in case of LHR engine. From investigation it can be stated that up to 25% blend of pongamia biodiesel can be substituted for diesel engine without any modification and with modification we can blend up to 25% we can get better performance and combustion characteristics than normal engine.

***Keywords**: Pongamia biodiesel, low heat rejection engine*

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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 tones 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.

The drawbacks associated with vegetable oils and biodiesels for use in diesel engines call for LHR engines. It is well known fact that about 30% of the energy supplied is lost through the coolant and the 30% is wasted through friction and other losses, thus leaving only 30% of energy utilization for useful purposes. In view of the above, the major thrust in engine research during the last one or two decades has been on development of LHR engines. The study also focuses on coating method for Plasma Spray aluminum oxide to improve coating under high load and temperature cyclical conditions encountered in the real engine. The effect of insulation on engine performance, heat transfer characteristics, combustion and emission characteristics are studied and compared with standard (STD) diesel engine

2. THE PROPERTIES OF DIESEL FUEL AND POME

The different properties of diesel fuel and POME are determined and given in below table1. After transesterification process the fuel properties like kinematic viscosity, calorific value, density, flash and fire point get improved in case of biodiesel. The calorific value of methyl ester is lower than that of diesel because of oxygen content. The flash and fire point temperature of biodiesel is higher than the pure diesel fuel this is beneficial by safety considerations which can be stored and transported without any risk.

Table 2.1 Fuel properties

Properties	Diesel fuel	POME
Kinematic viscosity at 40^0 C (cSt)	4.1	12.5
Calorific value(kJ/kg)	42000	40723
Density (kg/m^3)	0.831	0.900
Flash point (^{0}C)	51	144
Fire point(^{0}C)	57	155

3. EXPERIMENTATION

3.1 Engine components:

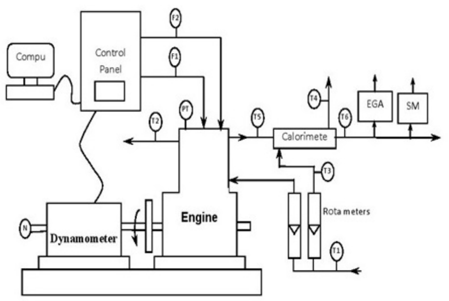

Figure.3.1 Experimental set up

The various components of experimental set up are described below. The figure.3.1 shows line diagram of the experimental set up. The important components of the system are

(i) The engine

(ii) Dynamometer

Table 3.1 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 3.2 Engine specifications

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/230 bTDC
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 1deg

4. RESULT AND DISCUSSIONS

4.1Comparative Analysis of Performance And Combustion Characteristics of Castor Biodiesel Blends And Diesel on Normal Engine And Low Heat Rejection Engine:

4.1.1 Variation of Brake Thermal Efficiency With Brake Power

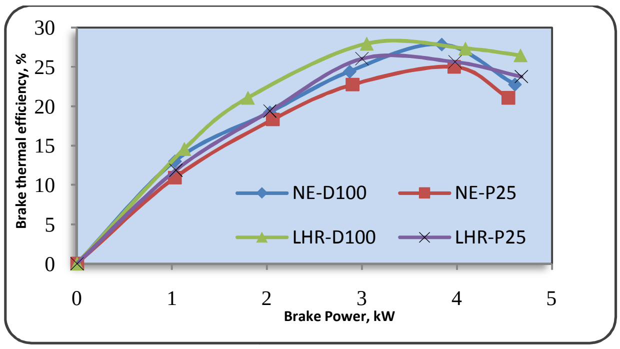

Figure 4.1 Variation of brake thermal efficiency with brake power

The variation of the brake thermal efficiency with load for diesel and POME blends are shown in figure 4.1. We can observe that P25 with LHR has higher brake thermal efficiency than normal engine D100 this is because of increased combustion rate which provides complete burning of fuel and due to low heat rejection. The thermal efficiency of P25 is lower than diesel due to large difference in viscosity specific gravity and volatility.

4.1.2 Variation of mechanical efficiency with brake power

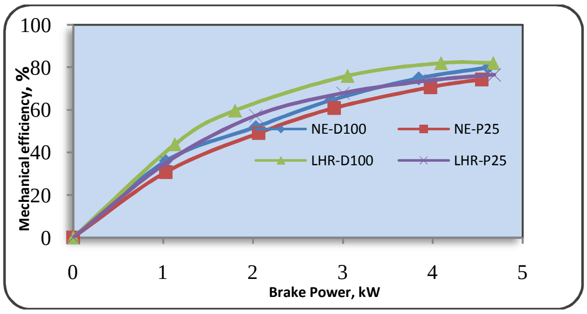

Figure 4.2 Variation of mechanical efficiency with brake power

The variation of mechanical efficiency with brake power, for diesel and pongamia biodiesel blends are as shown in figure.4.2 for normal engine and LHR engine. The mechanical efficiency of diesel is slightly higher than the pongamia biodiesel in case of normal engine and similar case we can observe in LHR engine. From the graph it is evident that with increase in the concentration of pongamia biodiesel in diesel decreases the mechanical efficiency. Here we can see the effect of thermal barrier coating which increases the mechanical efficiency. At full load D100 and P25 in LHR has maximum efficiency of 81.99% and 76.45% respectively which are 2.07% and 2.12% higher than D100 and N20 of normal engine. This is due to fuel burning completely in LHR engine due increased temperature in combustion chamber.

4.1.3 Variation of specific fuel consumption with brake power

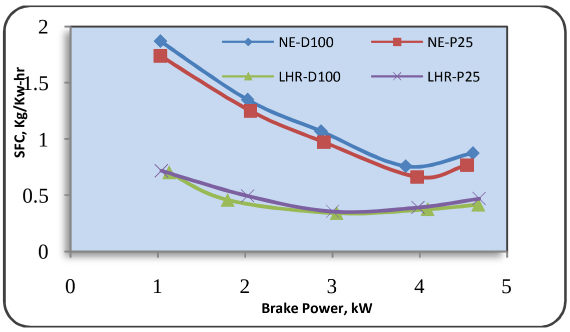

Figure 4.3 Variation of specific fuel consumption with brake power

Figure 4.3 shows the specific fuel consumption for pongamia 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 fueled 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.

4.1.4 Variation of indicated mean effective pressure with brake power

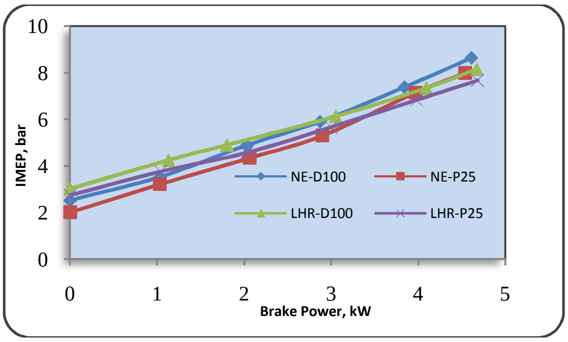

Figure 4.4 Variation of indicated mean effective pressure with brake power

The variation of the mean indicated pressure with load for diesel and POME blends are shown in figure 4.4. Indicated mean effective pressure is low for POME compared to diesel this is because of volatility and caloric value of POME. By using thermal barrier coating there is slight increase in indicated mean effective pressure as compared to normal engine. Here we can observe that as the load increases the mean pressure of an engine increases.

4.1.5 Variation of air-fuel ratio with brake power

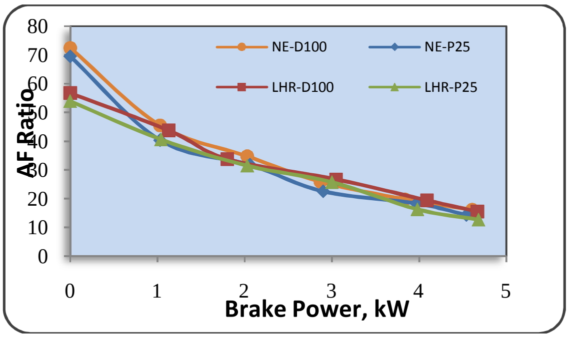

Figure 4.5 Variation of air-fuel ratio with brake power

The variation of air fuel ratio for diesel and 25% POME blend is shown in fig-4.5 for both normal engine and LHR engine. Fuel consumption is higher in case of LHR engine due to increased temperature and completes combustion. 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.

4.1.6 Variation of exhaust gas temperature with brake power

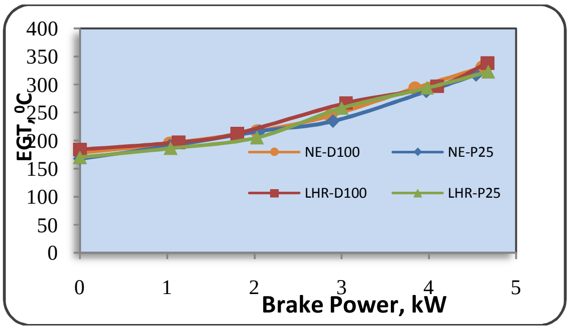

Figure4.6 Variation of exhaust gas temperature with brake power

The variation of the exhaust gas temperature with load for diesel and POME blends are shown in figure 4.6, when bio fuel concentration increases the exhaust temperature increase. The same also when load increases the exhaust temperature increases.

4.1.7 Variation of crank angle v/s cylinder pressure

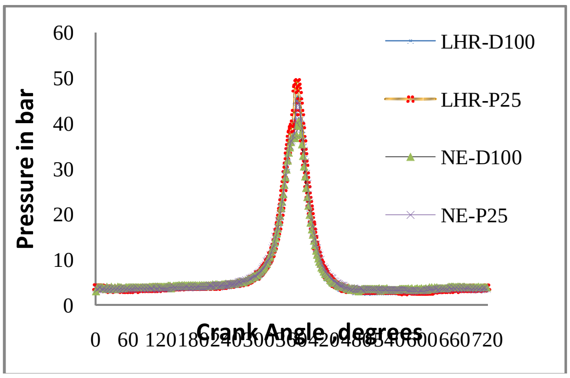

Figure 4.7 Variation of crank angle v/s cylinder pressure

In a CI engine the cylinder pressure depends on the fuel-burning rate during the premixed burning phase, which in turn leads to better combustion and heat release. Figure-4.7 shows the typical variation of cylinder pressure with respect to crank angle. The cylinder pressure in the case of biodiesel fueled LHR engine is about 4.7 % lesser than the diesel fueled LHR engine and higher by about 1.64 % and 12.22% than conventional engine fueled 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. However the cylinder pressure is relatively higher than the diesel engine fueled with diesel and biodiesel. It is noted that the maximum pressure obtained for LHR engine fueled with biodiesel was closer with TDC around 2 degree crank angle than LHR engine fueled with diesel. The fuel-burning rate in the early stage of combustion is higher in the case of biodiesel than the diesel fuel, which bring the peak pressure more closely to TDC.

4.1.8 Variation of volumetric efficiency with brake power

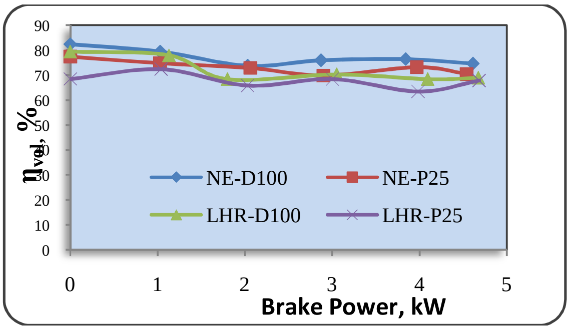

Figure-4.8 Variation of volumetric efficiency with brake power

The variation of the volumetric efficiency with load for diesel and POME blends are shown in figure 4.22. From the above graph we concluded that there is no much difference in volumetric efficiency with each load. But volumetric efficiency for NE-D100 is slightly higher than the LHR-D100, because there is slight decrease in volume of the LHR engine due to coating. And efficiency for NE-P25 and LHR-P25 are almost similar.

4.1.9 Variation of heat release rate with brake power

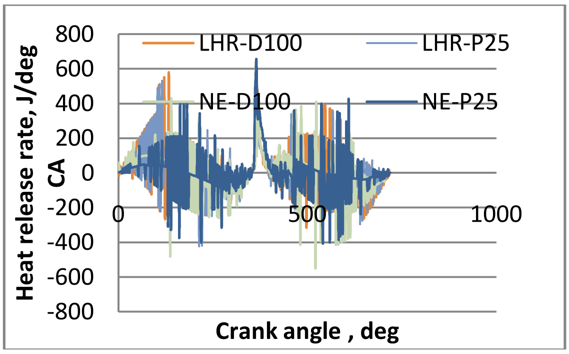

Figure-4.8 Variation of heat release rate with brake power

Comparison of heat release rate with crank angle is shown in figure 4.23, at maximum load for both LHR-D100 and NE-D100. It is observed that the premixed burning is more dominant with diesel expected. Pongamia biodiesel shows lower heat release rate during premixed burning phase compared to diesel. The high viscosity and poor volatility of

POME result in poor atomization and fuel air mixing rates. Hence, more burning occurs in the diffusion phase.

CONCLUSIONS

The following conclusions were drawn from these investigations carried out on normal engine and LHR engine for different loads.

- As detail study of performance and combustion characteristics of pongamia biodiesel and its blends on normal engine we can observe that 25% blend of pongamia biodiesel in diesel fuel has almost same mechanical efficiency, same specific fuel consumption and same indicated thermal efficiency .we can also see that there is slight increase in brake thermal efficiency which is a positive sign with this blend. In case of peak pressure we can see that there is almost same pressure as that of diesel fuel. So we can conclude that without any modification in engine we can save diesel fuel for certain extent without any compromise with standard performance and combustion characteristics and in future pongamia biodiesel can be a best alternative fuel which can replace the diesel.
- As same parameters studied with engine modification, here we observed that there is increase in performance parameters than normal engine. There is increase in parameters like brake thermal efficiency, mechanical efficiency and brake mean effective pressure and there is decrease in specific fuel consumption, volumetric efficiency and fuel consumption which can be observed in comparative graph. There is also increase in peak pressure which higher than that of biodiesel with normal engine. With use of thermal barrier coating we can blend up to 50% which can help to conserve diesel fuel.
- By studying performance and combustion characteristics on normal engine and low heat rejection engine it can concluded that with 25% blend we can achieve same characteristics as that of diesel fuel so P25 is the best blend and in future pongamia oil methyl ester can be a best and most suitable alternative fuel which can replace diesel fuel for years to come and with thermal barrier coating we can meet needy requirements.
- Pongamia biodiesel shows lower heat release rate during premixed burning phase compared to diesel. The high viscosity and poor volatility of NE-D100 result in poor atomization and fuel air mixing rates. Heat release rate is more in LHR-P25 compared to LHR-D100 and heat release rate in NE-D100 and NE-P25 are almost similar.

REFERENCES

[1] Divya Bajpai., Tyagi.V.K. (2006) Biodiesel: source, production composition, properties and its benefits. *Jounal of oleo science*, **55**(10): 487-502.

[2] GuoqingGuan, Katsuki Kusakabe, Nozomi Sakurai, Kimiko Moriyama. (2009) Transesterification of vegetable oil to biodiesel fuel using acid catalysts in the presence of dimethyl ether. *Fuel*, **88**: 81-86.

[3] Titipong Issariyakul (2011) Development of Biodiesel Production Processes from Various Vegetable Oils

[4] Dr. K.VIJAYA KUMAR REDDY (2010) Experimental investigation on performance and emission characteristics of diesel engine using bio-diesel as an alternate fuel.

[5] V.Dhana Raju, P.Ravindra Kumar, "experimental investigation of linseed and neem methyl esters as biodiesel on CI engine", International Journal of Engineering Science and Technology (IJEST), Vol. 4 No.06 June 2012.

[6] Ashish Jawalkar, Kalyan Mahantesh, "Performance and Emission Characteristics of Mahua and Linseed Biodiesel Operated at Varying Injection Pressures on CI Engine", International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.3, May-June 2012.

[7] Sivalakshmi, S., et al.: Experimental Investigation on a Diesel Engine … THERMAL SCIENCE, Year 2011, Vol. 15, No. 4, pp. 1193-1204

[8] A. Siva Kumar, D. Maheswar, K. Vijaya Kumar Reddy, "Comparison of performance parameters by using jatropha and fish oil as biodiesel", *Proc of the International Conf. & XX National Conf. on I.C. Engines and Combustion*, pp. 235-239, (2007).

[9] T. Ratna Reddy1 , M.V.S. Murali Krishna2, Ch. Kesava Reddy3 and P.V.K.Murthy4* Performance Evaluation of a Medium Grade Low Heat Rejection Diesel Engine with Mohr Oil Based Bio-Diesel International Journal of Recent advances in Mechanical Engineering (IJMECH) Vol.1, No.1, May 2012

[10] Ilker Turgut Yilmal, Metin Gumus, Mehmet Akcay, Thermal Barrier Coatings For diesel Engines. International scientific conference 19-20 November 2010, Gabravo Turkey.

[11] Rajendra Prasath, B., P. Tamilporai ,P. and Mohd.Shabir, F., " Analysis of combustion, performance and emission characteristics of low heat rejection engine using bio-diesel" International Journal of Thermal Sciences , Volume-49, pp: 2483-2490, 2010.