Experimental Investigation of Performance and Combustion Characteristics of Rubber Seed Biodiesel and Its Blends on Diesel Engine and Lhr Engine

[1] Taufeeq ur Rahman [2] Prakash S Patil [3] Omprakash Hebbal

[1]PG Student, Thermal Power Engineering PDACE Gulbarga, Karnataka, India

[2]Associate professor, Dept of Mechanical Engineering PDACE Gulbarga, Karnataka, India

[3] Professor, Dept of Mechanical Engineering PDACE Gulbarga, Karnataka, India

Abstract:

The use of biodiesel, the methyl esters of vegetable oils are becoming popular due to their low environmental impact and potential as a green alternative fuel for diesel engine. The aim of this study is to potential use of rubber seed oil methyl ester as a substitute for diesel fuel in diesel engine. Various proportions of rubber seed and diesel (B25, B50, B75, and B100) are prepared by transesterification process on volume basis and used as fuels in a four stroke single cylinder direct injection diesel engine to study the performance and emission characteristics of these fuels and compared with neat diesel fuel. The engine tests have been carried out with the aim of obtaining brake thermal efficiency, mechanical efficiency, air fuel ratio, BSFC, and the behaviour of the diesel engine running on rubber seed oil and its blend. This blend R25 substantially reduces the CO emission and emission of NOx in exhaust gases.

***Keywords**: Rubber seed oil, biodiesel, transesterification, low heat rejection engine.*

1. Introduction:

In the scenario of increase of vehicle population at an alarming rate due to advancement of civilization, use of diesel fuel in not only transport sector but also in agriculture sector leading to fast depletion of diesel fuels and increase of pollution levels with these fuels, the search for alternate fuels on has become pertinent for the engine manufacturers, users and researchers involved in the combustion research. Vegetable oils and alcohols are the probable candidates to replace conventional diesel fuel, as they are renewable. Most of the alcohol produced in India is diverted to petro-chemical industries pollution levels are increasing with the fossil fuels. And also there is burden on govt. of India in importing crude oils. In the context of depletion of fossil fuels, the search for alternate and renewable fuels has become pertinent. It has been found that the vegetable oil is a promising fuel, because of its properties are similar to those of diesel fuel and it is a renewable and can be easily produced in international market, the search for alternate fuels has become pertinent for the engine manufacturers, users and researchers involved in the combustion research. Hence much emphasis was given for an alternate fuel, which could substitute for diesel fuel. Due to gradual depletion of world petroleum reserves and the impact of environmental pollution of increasing exhaust emissions, there is an urgent need for suitable alternative fuels for use in diesel engines. Continued and increasing use of petroleum will intensify local air pollution and magnify the global warming problems caused by carbon dioxide. In a particular case, such as the emission of pollutants in the closed environment of underground mines, biodiesel has the potential to reduce the level of pollutants and the level of potential for probable carcinogens

Thermal barrier coatings are used to improve the engine performance and efficiency of internal combustion engines. The engine with thermal barrier coating is called low heat rejection (LHR) engine, which is based on suppressing the heat rejection to the coolant and recovering the energy. The engines parts such as piston, cylinder head, cylinder liners and valves are coated. The superior advantages of LHR engines are improved fuel economy, higher energy in exhaust gases and capability of handling higher viscous fuel. The transesterification process brings down the properties of fuel closer to the diesel fuel. The higher temperature of the LHR engine increases the possibility of using biodiesel without preheating. In the present study the use of rubber seed oil (biodiesel) in diesel engine to save the environment as well as to ensure independency of fuel resources is discussed. In this present investigation rubber seed oil methyl ester (ROME) is selected for the test and its suitability as an alternate fuel is examined. This is accomplished by blending of rubber seed biodiesel with diesel in B25 (25:75), B50 (50:50), B75 (75:25) and 100% on volume basis. Then the performance and emission characteristics of diesel engine using various blends and compared the results with those of neat diesel fuel.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 9, September - 2013

2. The properties of diesel fuel and ROME

The term esterification means conversion of one ester into the other. In the present case glycerol was replaced with methyl alcohol, the fatty acids remaining the same. The chemical conversion reduced viscosity four fold. As it is evident glycerol was the byproduct of the reaction and a valuable commercial commodity. The process of converting the oil into methyl esters was carried out by heating the oil with the methanol in the presence of the catalyst (Sodium hydroxide). In the present case, vegetable oil (Rubber seed oil) was stirred with methanol at around 60-70°C with 4gms of NaOH for 1litre of crude oil, for about 1.5hours. At the end of the reaction, excess methanol is removed by distillation and glycerol, which separates out was removed. The methyl esters were treated with dilute acid to neutralize the alkali and then washed to get free of acid, dried and distilled to get pure vegetable oil esters. The properties of the vegetable oil ester and the diesel used in this work are presented in Table-2.1.

Properties	Diesel fuel	ROME
Kinematic viscosity at 40^0C(cSt)	4.1	5.53
Calorific value(KJ/Kg)	42000	37500
Density (Kg/m^3)	0.831	0.875
Flash point (^{0}C)	51	148
Fire point(^{0}C)	57	158

Table 2.1 fuel properties

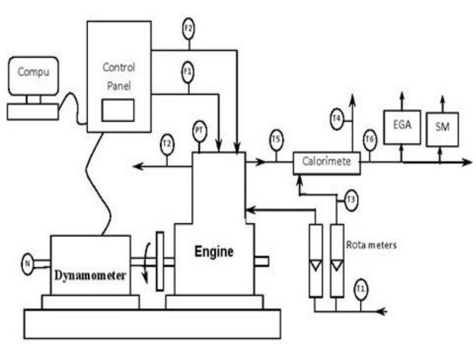

Figure.3.1 experimental set up

Table 3.1 Notations

The figure.3.1 shows line diagram of various component of experimental setup. The main component of the system is

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

The engine
Dynamometer
Smoke meter
Exhaust gas analyser.

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/23^0 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 rubber seed biodiesel blends and diesel on normal engine and low heat rejection engine:

4.1.1 Variation of brake thermal efficiency with brake power:

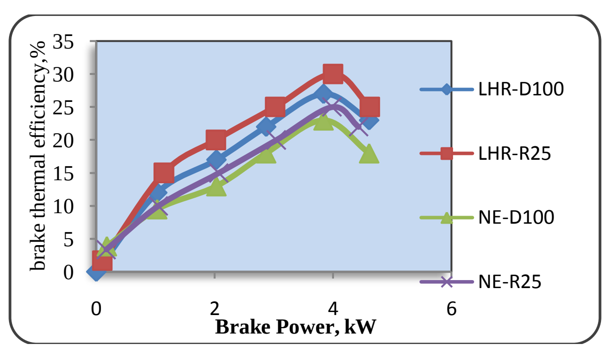

Figure 4.1 Variation of brake thermal efficiency with brake power.

The variation of the brake thermal efficiency with load for diesel and ROME blends are shown in figure4.1. It was observed that with the increase of the load brake thermal efficiency increase in all cases. We can observe that R25 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 R25 is lower than diesel due to large difference in viscosity specific gravity and volatility. The maximum efficiency obtained in the case of LHR engine fueled with (R25) biodiesel at full load was higher by about 2.42% than LHR engine fueled with diesel and higher by about 5.6% and 4.34% respectively than conventional diesel engine fueled with diesel and biodiesel. In overall, it is evident that, the thermal efficiency obtained in the case of LHR engine fueled with biodiesel is substantially good enough within the power output range of the test engine.

4.1.2 Variation of mechanical efficiency with brake power:

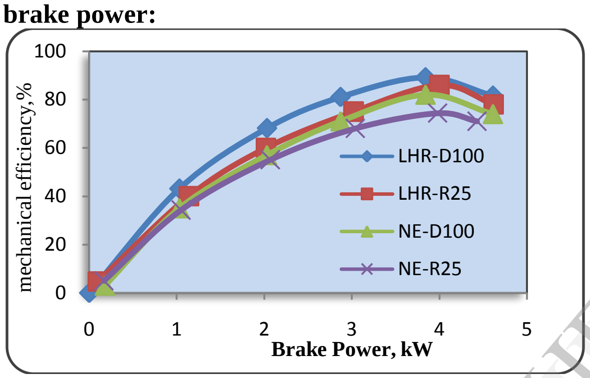

Figure 4.2 Variation of mechanical efficiency with brake power

The variation of mechanical efficiency with brake power, for diesel and rubber seed 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 rubber seed 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 rubber seed 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 R25 in LHR has maximum efficiency of 86% and 80% respectively which are 5.1% and 4.7% higher than D100 and R25 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:

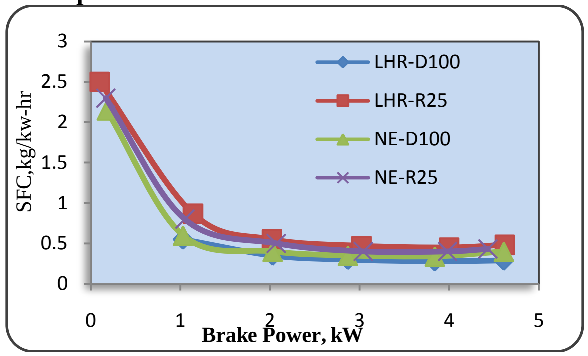

Figure 4.3 Variation of specific fuel consumption with brake power

Figure 4.3 shows the specific fuel consumption for rubber seed biodiesel and its blends with respect to brake power for both normal engine and LHR engine. From graph it is observed that the specific fuel consumptions decreased with the increase of brake power. 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:

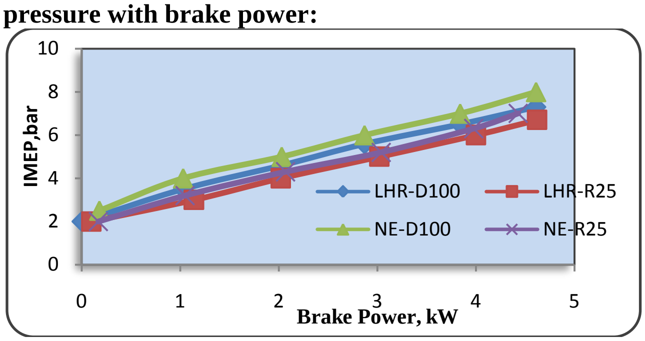

Figure 4.4 Variation of indicated mean effective pressure with brake power

The variation of the mean indicated pressure with load for diesel and ROME blends are shown in figure 4.18. Indicated mean effective pressure is low for ROME compared to diesel this is because of volatility and calorific value of ROME. 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:

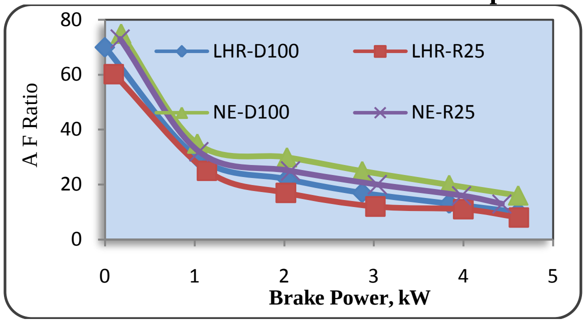

Figure 4.5 Variation of air-fuel ratio with brake power

The variation of air fuel ratio for diesel and 25% ROME 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:

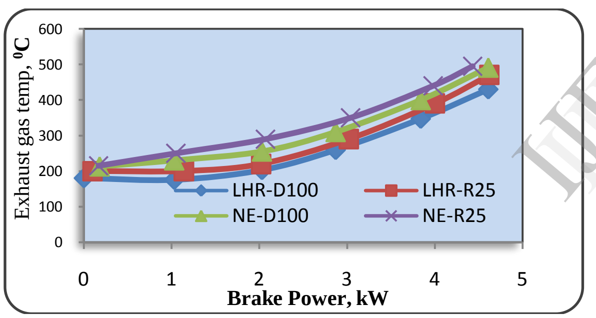

Figure4.6 Variation of exhaust gas temperature with brake power

The variation of the exhaust gas temperature with load for diesel and ROME blends are shown in figure4.6. From the graph it is observed that the exhaust gas temperature increases with the increase of the brake power. At full load, the exhaust gas temperature of LHR engine fueled with biodiesel gives lower value by about 2.32% than LHR engine fueled with diesel and higher by about 2.73% and 6.53% respectively than conventional engine with diesel and biodiesel. The higher operating temperature of LHR engine is responsible for the higher exhaust temperature. When biofuel concentration increases the exhaust temperature increase.

4.1.7 Variation of volumetric efficiency with brake power:

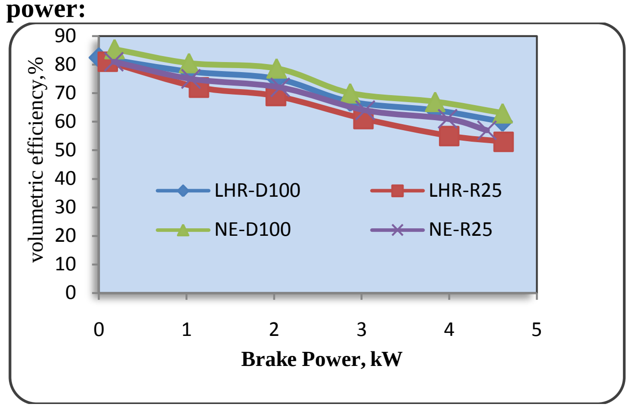

Figure 4.7 Variation of volumetric efficiency with brake power

The variation of the volumetric efficiency with load for diesel and ROME blends are shown in figure 4.7. 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-R25 and LHR-R25 are almost similar.

4.1.8 Variation of crank angle v/s cylinder pressure:

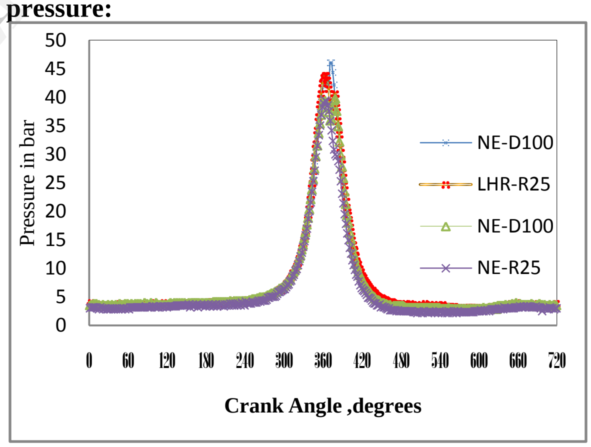

Figure 4.8 Variation of crank angle v/s cylinder pressure.

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 4.8 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 brings the peak pressure more closely to TDC. 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 closer to TDC.

4.1.9 Variation of crank angle v/s heat release rate:

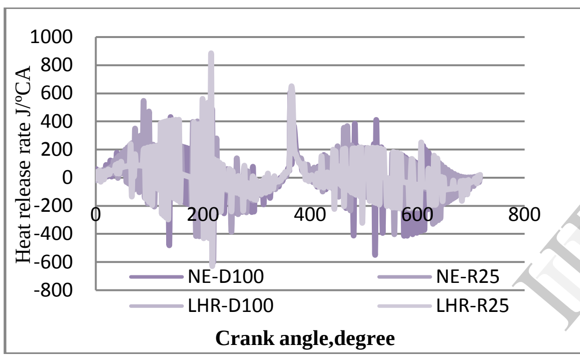

Figure 4.9 Variation of crank angle v/s heat release rate

Figure 4.9 shows the effect of crank angle on heat release rate at maximum load for R25 and D100 for both NE engine and LHR engine. Rubber seed 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-R25 compared to LHR-D100 and heat release rate in NE-D100 and NE-R25 are almost similar. The maximum heat release of LHR engine with biodiesel is lower about 9.1% than LHR engine fueled with diesel and higher about 3.2% and 7.8% respectively than conventional engine fueled with diesel and biodiesel. It was found that, premixed combustion in the case of biodiesel fuel starts earlier than the diesel fuel and it may be due to excess oxygen available along with higher operating temperature in the fuel and the consequent reduction in delay period than that of diesel fuel. It may be expected that high surrounding temperature and oxygen availability of fuel itself (bio diesel) reduce the delay period. Hence, more burning occurs in the diffusion phase, leads to a faster heat release (combustion), improved remixed combustion.

5. CONCLUSION

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 rubber seed biodiesel and its blends on normal engine we can observe that 25% blend of rubber seed 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 rubber seed 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 R25 is the best blend and in future rubber seed 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.

REFERENCES

[1] Hemant Y. Shrirame, N. L. Panwar, B. R. Bamniya Bio Diesel from rubber seed Oil - A Green Energy Option, Low Carbon Economy, 2011, 2, 1-6 doi:10.4236/lce.2011.21001 Published Online March 2011 (http://www.SciRP.org/journal/lce) Copyright

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

[3] CH.S.NAGA PRASAD (2010) experimental investigation on performance and emission characteristics of diesel engine using bio-diesel as an alternate fuel.

[4] Mohammed Chakrabarti, Mehmood Ali, "performance of compression ignition engine with rubber seed oil bio diesel", Ned University Journal of Research, Vol VI, No. 1, 2009.

[5] Bello E.I and Makanju A, "Production, Characterization and Evaluation of rubber seed oil Biodiesel as Alternative Fuel for Diesel Engines", Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS), 2011 (ISSN: 2141-7016).

[6] G.Durga Devi, Mahesh.C, "Performance evaluation of a diesel engine fueled with methyl ester of rubber seed oil", International Journal of Engineering Science and Technology (IJEST) Vol. 4 No.07 July 2012.

[7] Vinay Kumar Domakonda, Ravi Kumar Puli Application of Thermal Barrier Coatings in Diesel Engines: Review Copyright 2012 Scientific & Academic Publishing. All Rights Reserved.

[8] T. Ratna Reddy , 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.

[9] C. Sundar Raj S. Sendilvelan S. Arul Performance of a Thermally Insulated Constant Speed Diesel Engine with Dioxane Blended Fuels Global Journal of Researches in Engineering Vol. 10 Issue 2 (Ver 1.0) June 2010.

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