International Journal of Emerging Science and Engineering (IJESE)
ISSN: 2319–6378, Volume-1, Issue-12, October 2013

Rice Bran Oil Biodiesel as an Alternative in Single Cylinder CI Engine with DI Ethyl Ether Blends

Jasanpreet Singha, Narinder Kumarb, S. K. Mahlac

Abstract- The increased attention on alternative fuels in the recent years was mainly driven by increasing oil prices, strong emission norms and the concern on clean environment. The biodiesel has emerged as a potential substitute for diesel fuel on account of its renewable source and lesser emissions. An experimental investigation has been carried out to analyze the performance and emission characteristics of a compression ignition engine fuelled with rice bran oil and its blends (5%, 10% and 15%) with di ethyl ether at different load conditions. The results of the experimental investigation show that the RBO-DEE blend can be used efficiently in diesel engine without much change in the engine hardware. In performance characteristics the thermal efficiency increases by 11.6% at 10% DEE addition in the RBO at full load conditions and brake power also increases as oxygen addition improves the combustion process. In exhaust emission characteristics the unburnt hydrocarbon and carbon monoxide emissions decreases with the increase in DEE percentage in the blend. A significant reduction in smoke emissions can be seen with RBO-DEE blend investigated.

Keywords- Biodiesel, Rice Bran Oil, Transesterification, Di Ethyl Ether, Performance, Emissions.

I. INTRODUCTION

In order to meet the energy requirements, there has been growing interest in alternative fuels like biodiesels, alcohol, biogas, hydrogen and producer gas to provide a suitable diesel oil substitute for internal combustion engines. Vegetable oils present a very promising alternative to diesel oil since they are renewable and have similar properties. Vegetable oils offer almost the same power output with slightly lower thermal efficiency when used in diesel engine. Furthermore, contribution of bio-fuels to greenhouse effect is insignificant, since carbon dioxide (CO_2) emitted during combustion is recycled in the photosynthesis process in the plants. Alternative fuels should be easily available at low cost, be environment friendly and fulfill energy security needs without sacrificing engine's operational performance. For the developing countries, fuels of bio-origin provide a feasible solution to the twin crises of fossil fuel depletion and environmental degradation. Vegetable oils and their derivatives in diesel engines have a higher cetane number than diesel because of long chain fatty acids with 2-3 double bonds, heat of vaporization, and stoichiometric air/fuel ratio with mineral diesel. In addition, they are biodegradable, non-toxic; it has no aromatics and contains 10– 11% oxygen by weight.

Manuscript received October, 2013.

Er. Jasanpreet Singha, PG Student, Rayat & Bahra Institute of Engineering and Bio-Technology, Sahauran, Punjab,India.

Er. Narinder Kumarb, Assistant Professor, Rayat & Bahra Institute of Engineering and Bio-Technology, Sahauran, Punjab, India.

Dr. S. K. Mahlac, Associate Professor, Mechanical engineering department, Thapar University, Patiala, India.

Rice bran oil is a non-conventional, inexpensive and low-grade vegetable oil. Crude rice bran oil is also source of high value added by-products. Thus, if the by-products are derived from the crude rice bran oil and the resultant oil is used as a feedstock for biodiesel, the resulting biodiesel could be quite economical and affordable. Di ethyl ether is a promising renewable oxygenated fuel for engines, and many experimental studies has shown reduction in exhaust emission using DEE as a blend in the fuel. Table 1 shows the properties of the fuels used during the experimentation.

Property parameter	Diesel	Rice bran(biodiesel)	Di Ethyl Ether
Viscosity at 400C, mm2/s	3.4	4.63	1.35
Flash point, 0C	71	165	22
Pour point, 0C	1	3	< -35
Density at 200C, g/cm3	0.82	0.87	0.78
Calorific value, MJ/kg	43.5	38.7	26.8
Oxygen content, wt%	0	11.25	34.8
Cetane number	45	56.2	10

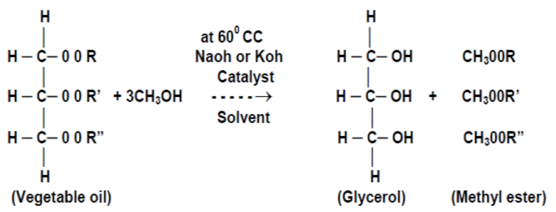
Table 1 The comparative values of the different properties of the three fuels used in the study.

The objective of this paper is to investigate the performance and exhaust emission characteristics of a single cylinder diesel engine fuelled with Rice Bran oil (RBO) and its blends 5%, 10% and 15% with Di Ethyl Ether.

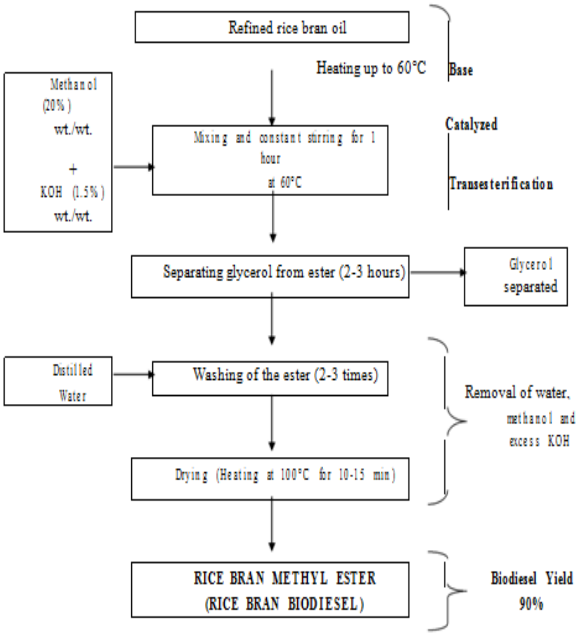
II. EXPERIMENTAL SETUP

The biodiesel was synthesized by transesterification process. Transesterification is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification. This esterified vegetable oil is called bio-diesel. Biodiesel properties are similar to diesel fuel. It is renewable, non-toxic, bio-degradable and environment friendly transportation fuel. After esterification of the vegetable oil its density, viscosity, cetane number, calorific value, atomization and vaporization rate, molecular weight, and fuel spray penetration distance are improved more. So these improved properties give good performance in CI engine.

Transesterification reaction equation:



Refined Rice Bran Oil Biodiesel Preparation (Single Stage Transesterification)



Schematic diagram of procedure employed for production of rice bran biodiesel

The flow chart shows the production process of bio diesel. Physical and chemical properties are more improved in esterified vegetable oil because esterified vegetable oil contains more cetane number than diesel fuel. These parameters induce good combustion characteristics in vegetable oil esters. So unburnt hydrocarbon level is decreased in the exhaust. It results in lower generation of hydrocarbon and carbon monoxide in the exhaust than diesel fuel. The vegetable oil esters contain more oxygen and lower calorific value than diesel. So, it enhances the combustion process and generates lower nitric oxide formation in the exhaust than diesel fuel.

Diesel engine selected for the experimentation is the make of the Kirloskar Oil Engines Limited, India. It is a single-cylinder, 4-stroke, water-cooled diesel engine of 5 hp rated power. Direct injection CI engine that has been designed for petroleum diesel combustion. The fuel injector is located near the combustion chamber centre. The single cylinder diesel engine test rig consists of a generator machine coupled to a load cell and it is used to load the engine. The starting of the engine is done by manual cranking with the help of detachable pawl type handle. The fuel is supplied to the engine from the fuel tank through fuel filter after fuel measurement using burette. The pressure and temperature of the air supplied to the engine is also measured. The rotation is clock-wise facing the flywheel in the engine. Figure 1 shows the schematic arrangement of the set up used for experimentation.

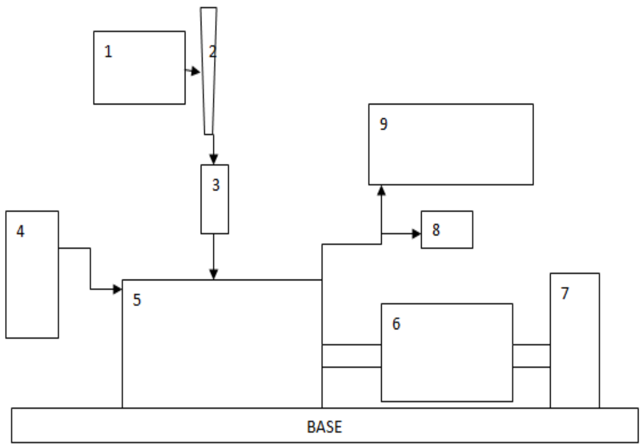


Figure 1 Schematic arrangement of the test rig

Parts of the Test Rig

1. Fuel tank
2. Burette (for fuel measurement)
3. Fuel filter
4. Air filter
5. Diesel engine
6. Generator
7. Load cell
8. Thermocouple
9. Emission gas analyzer

Table 2 shows the technical specifications of the engine used in the experimentation. The engine used is commonly used engine in agriculture and industrial sector to find the viable option for this sector.

Table 2. Specifications of An Engine

Engine Manufacturer	Kirloskar Oil Engines Limited, India
Engine Type	Vertical, 4 Stroke, Single Cylinder, DI
Cooling	Water Cooled
Dynamometer	Eddy Current Dynamometer
Rated Power	3.7 KW at 1500 Rpm
Horse Power	6.5
Bore/Stroke	80/110 (Mm)
Compression Ratio	16.5:1
Injection Pressure	200kg/Cm2
Volts	240
Amps	17.5
Engine Weight (Kg)	175

III. EXPERIMENTAL PROCEDURE AND RESULTS

For getting the base line data of the engine first the experimentation is performed with diesel and then with blends of rice bran oil and di ethyl ether (5%, 10% and 15 %). The performance of engine is evaluated on the basis of parameters:-

- Brake Horse Power
- Brake Thermal Efficiency
- Brake Specific Fuel Consumption

Effect on Brake Horse Power (BHP)

Chart 1 shows the variation of the brake horse power with changing load conditions. The energy densities of DEE, RBO and diesel are 24 Mj/l, 33.4 Mj/l and 37.7 Mj/l respectively. It is clear from the chart that the power of engine increases with the amount of rice bran oil and blend in the fuel. This is due to presence of oxygen available in the blend, which helps in complete burning of the fuel inside the combustion chamber. The overall combustion process improves with oxygen addition.

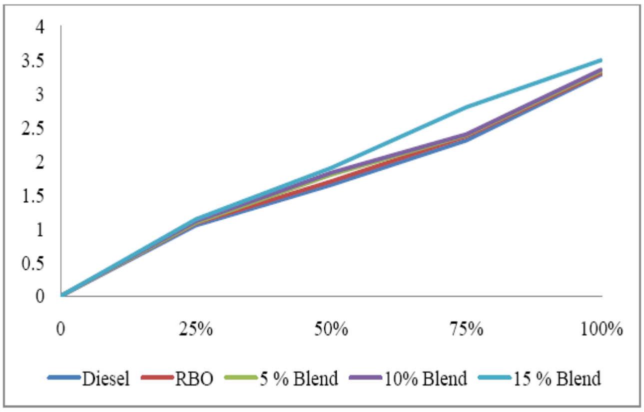


Chart 1 Variation of Brake Horse Power (kW)

Effect on Brake Thermal Efficiency (η)

Chart 2 shows the variation in the BTE with the change in the load on the engine. At full load condition, the RBO, 5%, 10% and 15% blends produce 6.2%, 8.7%, 11.6% and 10.6% higher brake thermal efficiency than sole Diesel respectively. The improvement is due to increase in constant volume combustion and the larger increase of molecules by fuel injection, which leads to better combustion efficiency especially at higher loads. So it is clear from the chart that the 10% gives good result in terms of Brake thermal efficiency as compared to rice bran all other blends.

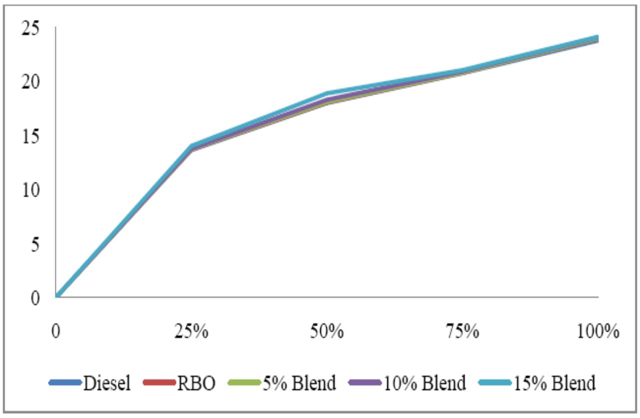


Chart 2 Variation of Brake Thermal Efficiency (η)

Effect on Brake Specific Fuel Consumption (BSFC)

The variation of BSFC with changing load conditions is shown in chart 3.It is observed from the chart that the BSFC for all the fuel blends tested decrease with increase in load. This is due to higher percentage increase in Break power with load as compared to increase in the fuel consumption. For RBO, the BSFC is almost same as that of diesel. For blends with Oxygen fuel greater than 10%, the BSFC was observed to be greater than that of diesel. This could be due to the presence of oxygen in the blend that enables complete combustion and the negative effect of increased viscosity would not have been initiated.

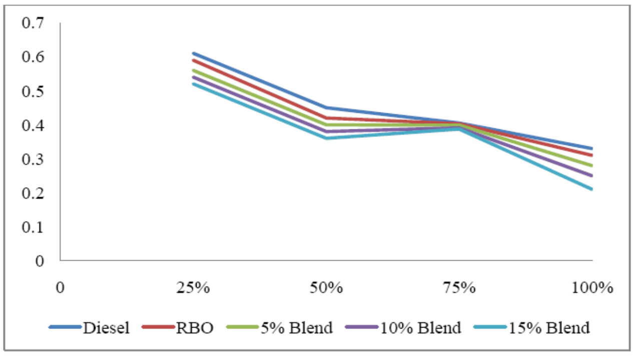


Chart 3 Variation of Brake Specific Fuel Consumption

Emission Characteristics

The exhaust emissions of the engine are checked by finding the CO, HC and smoke opacity from the engine and then those readings are tabulated in the form of charts. Chart 4 shows the variation in CO emissions under various load conditions. CO emissions decreases as the wt. % oxygen is increased, for each load, for the 5 wt. % and 10 wt. % oxygen by DEE-RBO blends the change is not much but with increase in % the decrease is significant. The decrease in CO shows the change in chemical reactions involved in the combustion of an oxygenated fuel.

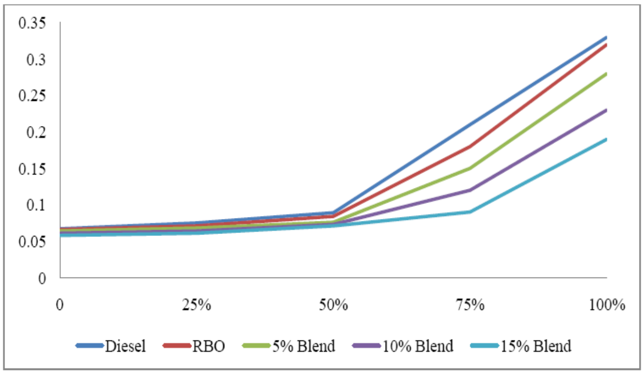


Chart 4 Variation of CO %

Effect on HC with changing load

Chart 5 shows the variation in HC. As the proportion of oxygen is increased, the reduction in HCs increases due to the ethanol increase within the blend. As the Cetane number of ester based fuel is higher than diesel, it exhibits a shorter delay period and results in better combustion leading to low HC emission.

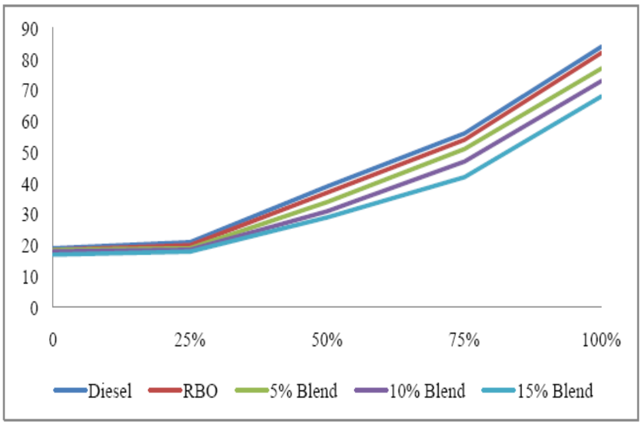


Chart 5 Variation of HC %

Effect on Smoke

Chart 6 shows the variation in smoke level with changing load conditions.

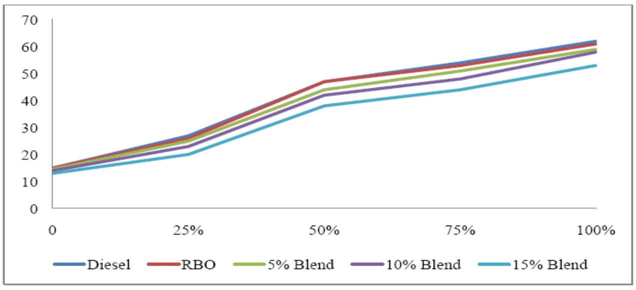


Chart 6 Variation of Smoke %

It is possible to see that Rice Bran Oil and Di ethyl Ether blends produce lower smoke levels than their diesel counterparts for corresponding speed load conditions. It is clearly confirmed from the chart that oxygenation reduces the total amount of smoke and by a more significant margin, reduces the total number of carbon particles. The comparison of two fuels shows that the exhaust emission has decreased to remarkable extent. The value of all the particles in the exhaust has reduced.

IV.CONCLUSION

The results from this research lead to the following conclusions:

- Rice Bran Oil and Di ethyl Ether blends can be use as supplementary fuel in compression ignition engine. The engine operates in a similar manner with the Rice Bran Oil and Di ethyl Ether blend as with the diesel fuel, as reviewed in the engine stability data.
- In the process of using Rice Bran Oil and Di ethyl Ether products to improve the efficiency of an internal combustion engine combustion aid acts more like combustion "catalyst" than a fuel. These improvements in combustion also add energy to the combustion process and allow more of the hydrocarbon fuel’s energy to be released in the engine’s cylinders to produce work.
- The exhaust emissions from the engine are much cleaner then sole diesel. The HC, CO and smoke opacity reduces significantly due to addition of oxygen in the combustion process.

The conclusions from the research completed thus far lead to recommendations for the use of fuel and in the future work in order to improve the engine operation, by further separating the variables affecting the performance and emissions of the engine.

REFERENCES

[1] Mustafa Balat and Havva Balat (24 March 2008). A critical review of bio-diesel as a vehicular fuel. Energy Conversion and Management , Page 2727–2741.

[2] P.K.Gupta, Rakesh Kumar, B.S.Panesar, and V.K.Thapar (April 2007). Parametric Studies on Bio-diesel prepared from Rice Bran Oil. Agricultural Engineering International: the CIGR E journal. Manuscript EE06 007, Vol. IX.

[3] Novy Srihartati Kasim, Tsung-Han Tsai, Setiyo Gunawan, Yi-Hsu Ju. (November 2008).Biodiesel production from rice bran oil and supercritical methanol. Bioresource Technology 100 Page 2399–2403.

[4] Fangrui Maa, Milford A. Hannab, 2 February 1999)Biodiesel production: a review. Bioresource Technology 70, Page 1-15.

[5] Ulf Schuchardta, Ricardo Serchelia, Rogério Matheus Vargas(1998)Transesterification of Vegetable Oils: a Review. J. Braz. Chem. Soc., Vol. 9, No. 1, Page 199-210.

[6] M.Mathiyazhagan, A.Ganapathi, B. Jaganath, N. Renganayaki, And N. Sasireka(April 2011)Production of biodiesel from non-edible plant oils having high FFA content. International Journal of Chemical and Environmental Engineering, Vol. 2, No.2.