Utilization of Rice Bran Oil and Ethanol blend in a Single Cylinder DI Diesel Engine

Gagandeep Singh, Er. Rupinder Singh, Gurpreet Singh Batth

Abstract: ***The two alarming situations in front of the engineers worldwide are to reduce the load on conventional fuels and to reduce the ever increasing environmental pollution. This study is aimed to investigate experimentally the performance and exhaust emission characteristics of a diesel engine when fuelled with blends of rice bran oil and ethanol, over the entire range of load on the engine. The experiments were conducted on widely used diesel engine without major modifications. Experiment results shows that at full load condition, the RBO, RBO90, RBO80and RBO70 blends produce 1.9%, 4.1%, 7.8% and 6.2% higher brake thermal efficiency than sole Diesel respectively. The level of CO decreases with 26% at full load conditions with RBO80. The % of hydrocarbons and carbon dioxide emissions increases with the increase of ethanol in blends but the hydrocarbon emissions were still lower than that of diesel fuel. The use of rice bran oil as fuel in diesel engine is recommended for the use in diesel engine with ethanol blends on the basis of the results obtained from the study.***

Keywords- Biodiesel, Rice Bran Oil, Transesterification, Ethanol, Performance, Emissions.

I. INTRODUCTION

Diesel engines are the prime source of transportation in India due to their advantages over counterpart gasoline engine. Reliability, lesser fuel consumption, longer life span and consistency are few of the reasons for the extensive use of diesel engines. But the major problem with diesel engines is the tail pipe emission. Increasing worldwide concern over combustion-related pollutants, such as particulate matter (PM), oxides of nitrogen (NOx), carbon monoxide (CO), total hydrocarbon (THC), acid rain, photochemical smog and depletion of the ozone layer, has led regulatory agencies to implement stringent emission regulations. In the last 30 years, the transportation sector has experienced a steady growth especially due to the increasing numbers of cars around the world. Globally, after the industrial sector transportation sector is the second largest energy consuming sector and it accounts for 30% of the world's total delivered energy, of which 80% is road transport. It is believed that transportation sector is currently responsible for nearly 60% of world oil demand and will be the strongest growing sector in terms of energy demand in the future. Chart 1 shows the % of emissions from the different sources.

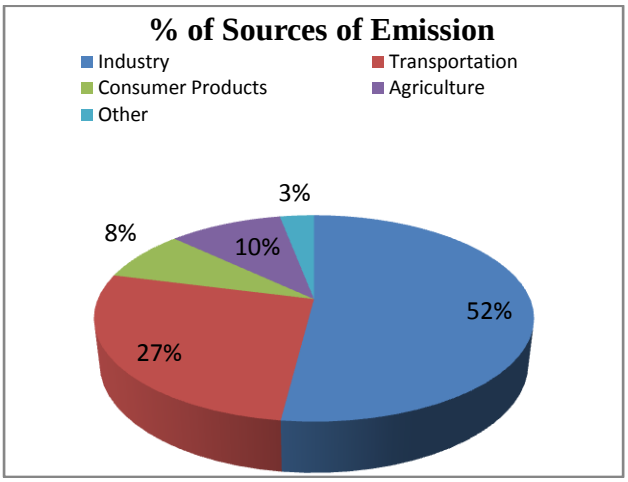

Chart 1 Sources of Emissions of Air Pollution

After going through all these research studies and literature review it was concluded that the need of hour is to look for alternative fuel and additive to reduce the load on conventional fuel and to reduce the environmental pollution. Biodiesel is one of the most promising alternative fuels for diesel engines. Biodiesel is defined as a fuel comprising of mono alkyl esters of long chain fatty acids derived from vegetable oil or animal fat. Biodiesel contains no petroleum but it can blend at any level with petroleum diesel to create a biodiesel blend. There are three types of oil as a possible source for biodiesel production, which are as follows:-

- Vegetable oil.
- Animal fat.
- Used cooking oil.

And secondly the oxygenated fuel is nothing more than fuel that has a chemical compound containing oxygen. It is used to help fuel burn more efficiently and cut down on some types of atmospheric pollution. Oxygenates blended into diesel fuel can serve at least two purposes. Components based on renewable feed stocks make it possible to introduce a renewable component into diesel fuel. So in this study the experimental work was done to check the performance and emission characteristics of the rice bran oil biodiesel and ethanol. Rice bran oil is a non conventional, in expensive and low–grade vegetable oil. Crude rice bran oil is also source of high value added by-products are derived from the crude rice bran oil and the resultant oil is used as a feed stock for bio diesel, the resultant bio diesel could be quite economical and affordable. Ethanol, also called ethyl alcohol, is a volatile, flammable, colorless liquid with the structural formula CH_3CH_2OH, often abbreviated as C_2H_6O. Figure 1 shows the chemical structure of the ethanol and table 1 shows the comaparitive properties of the hree fuels used in the study.

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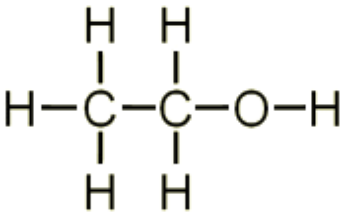

Figure 1 Chemical Structure of Ethanol

Property parameter	Diesel	Rice bran(biodiesel)	Ethanol
Viscosity at 40^0C, mm^2/s	3.4	4.63	1.35
Flash point, ^{0}C	71	165	22
Pour point, ^{0}C	1	3	< -35
Density at 20^0C, g/cm3	0.82	0.87	0.78
Calorific value, MJ/kg	42.5	38.7	28.49
Oxygen content, wt%	0	11	34
Cetane number	45	56	10

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

II. EXPERIMENTAL SET-UP

The present research is aimed to investigate experimentally the performance and exhaust emission characteristics of a light medium diesel engine when running on pure rice brain oil and blend of biodiesel with ethanol.

3.1 Biodiesel Production

For the present work Rice bran oil (edible) is used as feedstock for biodiesel production. Alcohol and catalyst used are methanol and KOH. Following are the steps in biodiesel production:

- **Mixing of alcohol with catalyst:** In the present work, 250 ml of methanol and 7.5 gm of potassium hydroxide (KOH) was mixed in round bottom flask.
- **Reaction:** The alcohol/catalyst mixture is added to 1000 ml of rice bran oil. The reaction is carried out at 60^oC and atmospheric pressure for around 2 hours. Fig 2 shows the different stages during the process.

Figure 2 Different stages during the reaction process

- **Separation of glycerine and biodiesel:** Once the reaction is complete, the two major products are glycerine and biodiesel. The glycerol phase is much denser than biodiesel phase and settles at the bottom of the reaction vessel and can be separated easily. The solution is left for 24 hours to settle down. Figure 3 shows the process.

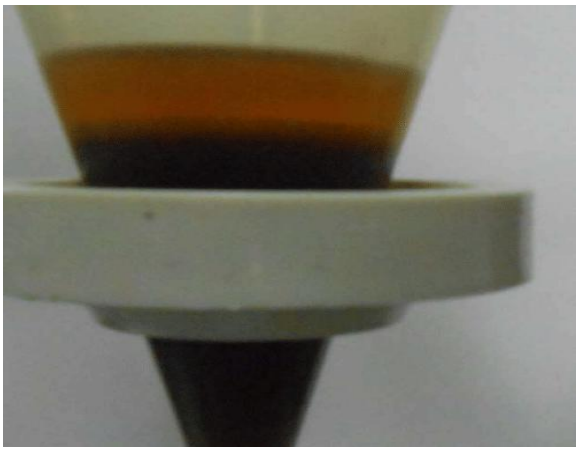

Figure 3 Solution after treatment left in standing funnel for settlement

Purification of crude biodiesel: Water washing is used to remove both glycerol and alcohol as they are soluble in water.

Diesel engine selected for the experimentation is the made of the Kirloskar Oil Engines Limited, India. It is a single-cylinder, 4-Stroke, water-cooled diesel engine of 5 hp rated power. Table 2 shows the specifications of the diesel engine used in the study. Figure 4 shows the view of the schematic arrangement of the test rig with all the equipments used to perform the experiment.

Engine manufacturer	**Kirloskar Oil Engines Limited, India**
Engine type	Vertical, 4stroke, 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

Table 2 Specifications of the engine

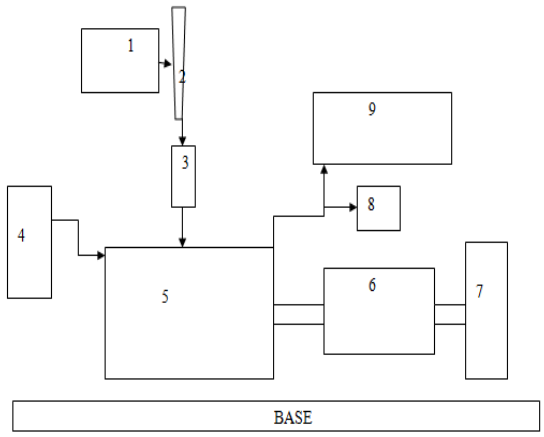

Fig 4 Schematic arrangement of the test rig

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

III. RESULT AND DISCUSSION

For getting the base line data of the engine, first the experiment is performed with diesel, pure rice bran oil and then with blends of rice bran oil and ethanol (90-10%, 80-20% and70- 30 %) and it is denoted by RBO90, RBO80 and RBO70 respectively and pure rice bran oil is denoted by RBO.

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)

The energy densities of ethanol, rice bran oil 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. Chart 2 shows variation of BHP with the changing load.

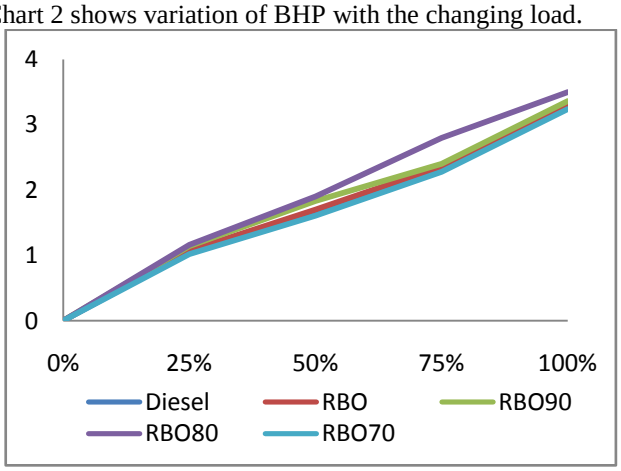

Chart 2 Variation of Brake Horse Power (kW) Effect on Brake Thermal Efficiency (η)

Chart 3 shows the variation in the BTE with the change in the load on the engine. At full load condition, the RBO, RBO90, RBO80and RBO70 blends produce 1.9%, 4.1%, 7.8% and 6.2% 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 RBO80 gives good result in terms of Brake thermal efficiency as compared to rice bran all other blends.

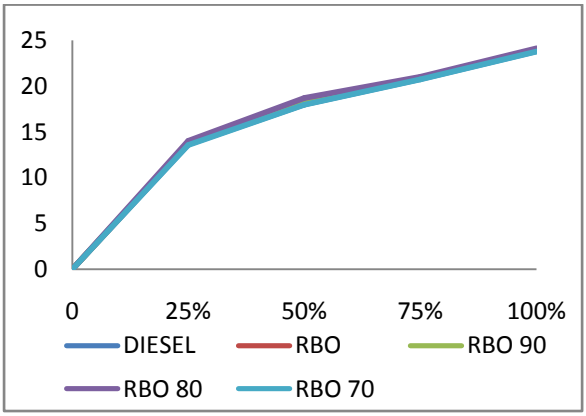

Chart 3 Effect on Brake Thermal Efficiency (η)

Effect on Brake Specific Fuel Consumption (BSFC)

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. The variation of BSFC with changing load conditions is shown in chart 4.

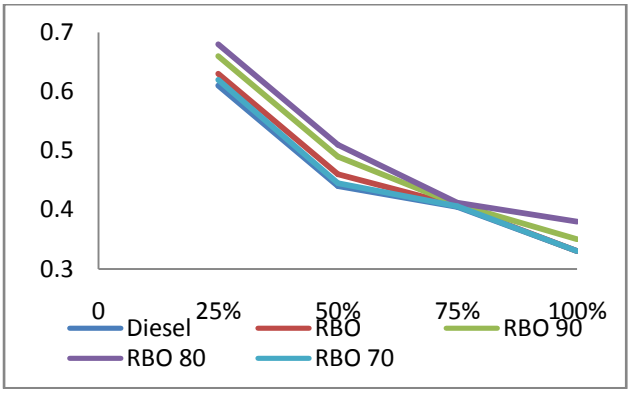

Chart 4 Variation of Brake Specific Fuel Consumption

The exhaust emissions from the engine are evaluated on the basis of parameters:-

- Carbon Monoxide (CO)
- Hydro Carbons (HC)
- Smoke

Effect on CO

The amount of CO decreases with oxygen addition. The decrease in CO shows the change in chemical reactions involved in the combustion of an oxygenated fuel. The CO gets converted to CO_2 after getting an extra oxygen atom. Chart 5 shows the variation.

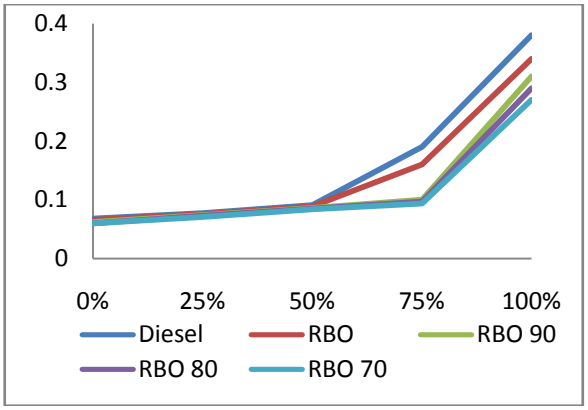

Chart 5 Variations in CO % with Various Load Conditions

Effect on HC with changing load

Chart 6 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.

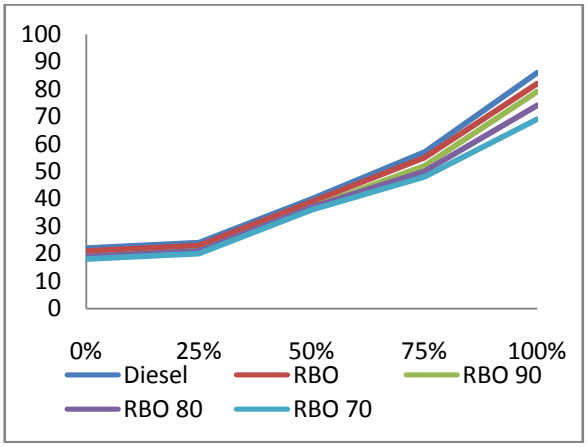

Chart 6 Variation of HC % in Various Load Conditions

Effect on Smoke

Chart 7 shows the variation in smoke level with changing load conditions.

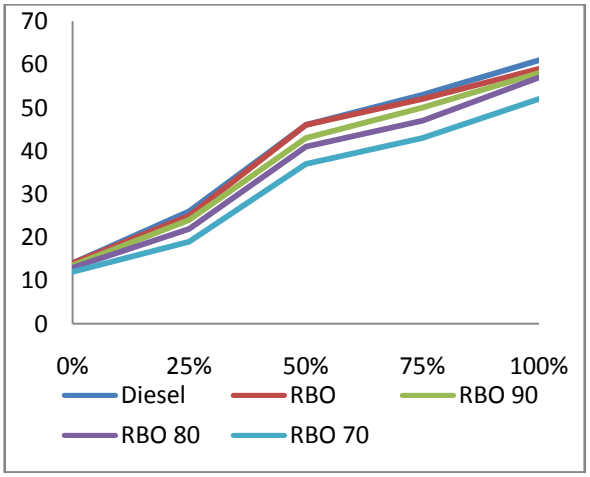

Chart 7 Variation of Smoke % in Various Load Conditions

It is possible to see that all the oxygenated fuels produce lower smoke levels than their diesel counterparts for corresponding speed load conditions.

Comparing the ethanol blends, it is also plausible that as fuel-borne oxygen levels increase, smoke levels go down.

IV. CONCLUSION

The present work is done to study the production, engine performance and exhaust emission characteristics of rice bran oil and ethanol. Based on the results of the present work, following conclusions are drawn:

- The rice bran oil and ethanol blend can be used as an alternative fuel in CI engine without compensating in terms of power and thermal efficiency. This can be helpful to reduce the usage of depleting conventional fuel and also to reduce the environmental pollution.
- Rice bran oil-Ethanol blend has been shown to reduce particulate emissions from a DI diesel engine. The maximum decrease is in the % of HC and smoke level. With RBO80 blend the decrease in CO is 26 %, for HC is 12 % and smoke is 11 % at full load condition.
- The blend of 20% ethanol with rice bran oil has great impact on smoke emission and other gases, and also the performance parameters are almost similar to diesel fuel.

The conclusions from the research completed thus far lead to recommendations for the use of RBO 80 blend in diesel engine without affecting the performance and emissions of the engine.

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