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Research Article

Experimental Investigations of Performance of Rice Bran Biodiesel and its Blends in a C.I. Engine

Amarpreet Singh†*, K. S. Dhillon† and Jagpreet Singh‡

†Mech. Engg. Deptt. Sri Sukhmani Institute of Engineering & Technology, Derabassi, India
‡Mech Engg Deptt. Chandigarh University, Gharuan, India

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Abstract

The Fossil fuels such as gasoline and diesel fuel are the most central basis of energy for our society. The advantages of diesel engines are high fuel efficiency, reliability and durability. Use of biodiesel as an alternative to diesel could reduce the dependency on petroleum products and the pollution problem. Also fuel injection pressure plays vital role in the performance of engine. Injected fuel droplets get smaller as the injection pressure increases which contributes to better atomization of the fuel. Hence the effect of injection pressure on the performance of compression ignition engine fuelled with biodiesel and its blends with diesel is studied in this experimental study. Tests are conducted on CI engine fuelled with diesel to get base line data for comparing engine performance with various blends of Rice bran oil and diesel as test fuels at different injection pressures. The results indicate that the performance of engine is improved with R75 compared to other test fuels at different injection pressures. The BHP of R75 increases by 5.9 % at full load conditions when compared to Diesel. The brake specific fuel consumption with R 75 % decreases by 9 % as compared to diesel. Hence it can be concluded that the R 75 % can be used to increase the performance of the engine and without making any major changes to the engine hardware.

Keywords: *Rice bran Oil, I.C. Engines, Brake Horse Power, Brake Thermal Efficiency, Brake Specific Fuel Consumption, Brake Specific Energy Consumption*

Introduction

With the gradual depletion of the world petroleum supplies, a possibility occurs that petroleum-based fuels will be available neither in sufficient quantities nor at reasonable price in the near future.

According to the International Energy Agency (IEA) report, in the year 2030 the world will need 50% more energy than today, of which 45% will be accounted or consumed by China and India. 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. Oil is the major source of energy (97.6%) in the transportation sector, with a small amount coming from natural gas.

*Corresponding author **Amarpreet Singh** is a Post Graduate student; **K. S. Dhillon** and **Jagpreet Singh** are working as Assistant Professors

Fig. 1 shows total world oil consumption by transportation and other sectors between 2007 and 2035. (International Energy Outlook, 2011).

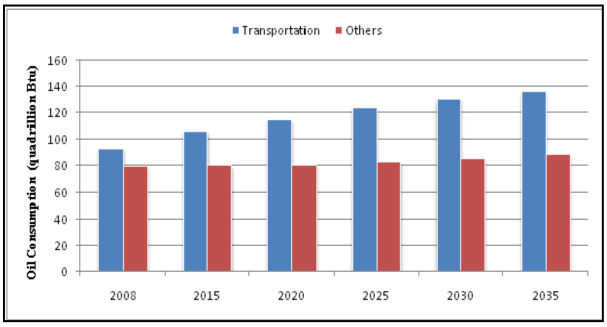

Fig. 1 Total World Oil Consumption by Transportation and other sectors between 2008 and 2035 (IEO2011)

Until the middle of 19th century, animal force was the driving source of transportation. The industrial revolution that followed was sparked by the invention of the internal combustion engine, promising to deliver autonomous power to individual vehicles, thereby releasing their owners from the need to use livestock. But with the current challenges imposed by climate change, and the amount of carbon dioxide released in the atmosphere by burning gasoline through the engine of a car, our current modes of transportation no longer seem like realistic way to live sustainably. However, getting rid of a system of distribution that encompasses a large network of filling stations and refineries is far from the most efficient way to ensure that more vehicles will be powered by carbon-neutral sources. The natural successor of gasoline is the still relatively new bio fuel – fuel derived from biomass, such as agricultural crops – that can be used in current combustion engines with no need for modifications. Recently, researchers from the Oak Ridge National Laboratory have developed genetically engineered switch grass in an effort to produce a plant with a higher energy density and a simpler conversion process.

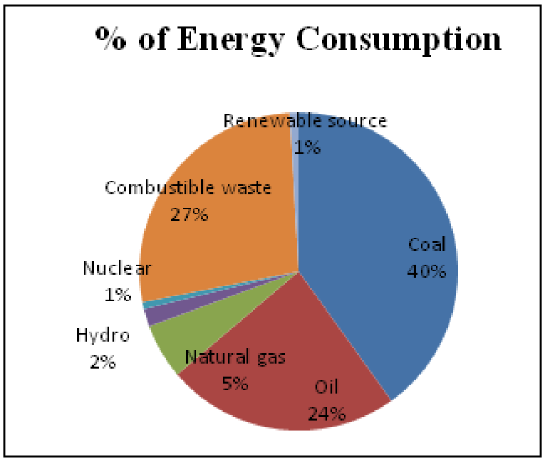

Fig. 2 Energy Consumption in India by Fuel Type (IEA in 2007)

Rice bran oil as a biodiesel

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 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. Rice bran oil is the oil extracted from the germ and inner husk of rice. It is the notable for its very high smoke point of 490° F (254° C) and its mild flavor, making it suitable for high temperature cooking method such as stir frying and deep frying. It is popular as cooking oil in several Asian countries including Japan and China. Rice bran oil is an edible vegetable oil, which is available in large quantities in rice cultivating countries, and very little research has been done to utilize this oil as a replacement for mineral Diesel.

Fuel Characteristics of Rice Bran Oil

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress. For liquids, it corresponds to the informal notion of "thickness". For example, honey has a higher viscosity than water.

The cloud point of a fluid is the temperature at which dissolved solids are no longer completely soluble, precipitating as a second phase giving the fluid a cloudy appearance. This term is relevant to several applications with different consequences. In the petroleum industry, cloud point refers to the temperature below which wax in diesel or bio wax in biodiesels form a cloudy appearance. The presence of solidified waxes thickens the oil and clogs fuel filters and injectors in engines.

The flash point of a volatile material is the lowest temperature at which it can vaporize to form an ignitable mixture in air. Measuring a flash point requires an ignition source. At the flash point, the vapor may cease to burn when the source of ignition is removed. The flash point is not to be confused with the auto ignition temperature, which does not require an ignition source, or the fire point, the temperature at which the vapor continues to burn after being ignited. Neither the flash point nor the fire point is dependent on the temperature of the ignition source, which is much higher.

Table 1 Properties of Comparative Fuels

Property parameter	Diesel	Rice bran(Biodiesel)
Viscosity at 40^0C, mm^2/s	3.4	4.63
Flash point, ^0C	71	165
Pour point, ^0C	1	3
Density at 20^0C, g/cm3	0.82	0.87
Calorific value, MJ/kg	42.5	38.7
Oxygen content, wt%	0	11
Cetane number	45	56

Biodiesel Production

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 60oC and atmospheric pressure for around 2 hours.
- **Separation of glycerin and biodiesel:** Once the reaction is complete, the two major products are glycerin 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.

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

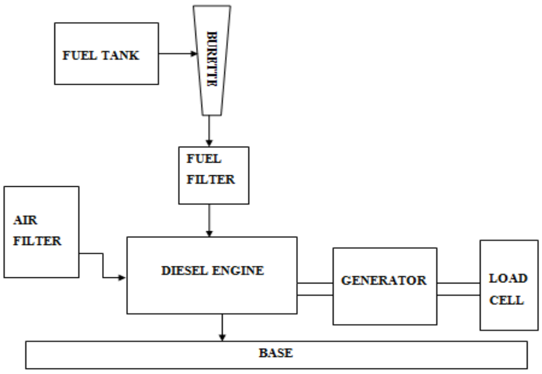

Fig. 3 Schematic Arrangement of the Test Rig

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 diesel (75-25%, 50-50% and25-75 %) and it is denoted by R75,R50 and R25 respectively.

Effect on Brake Horse Power (BHP)

Fig. 4 shows the engine power output (Brake Horse Power) under the changing load operating conditions. The energy densities of rice bran oil and diesel are 33 Mj/l and 37.6 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 shows that the BHP at R75 it is maximum, the BHP at R25decreases due to decrease in the energy density of the fuel. Because the amount of heat produced decreases with increase in the blend ratio

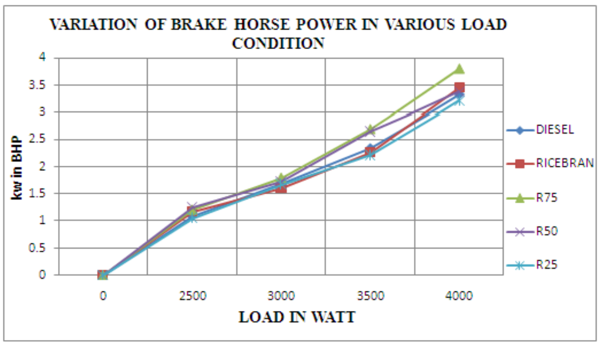

Fig. 4 Variation of Brake Horse Power (Kw)

Effect on Brake Thermal Efficiency (η)

Fig. 5 shows the brake thermal efficiency (BTE) variation with respect to load for Diesel and rice bran oil blends. At full load condition, R75 has 0.93 % higher brake thermal efficiency than sole Diesel. 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 R75gives good result in terms of Brake thermal efficiency as compared to all other blends.

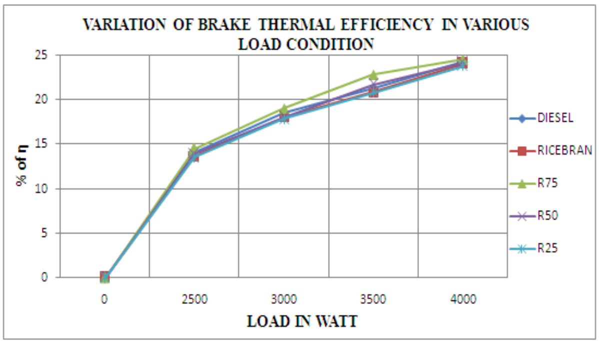

Fig. 5 Variation of Brake Thermal Efficiency (η)

Effect on Brake Specific Fuel Consumption (BSFC)

The variation of BSFC with load for different blends and loads are presented in fig. 6. 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 R75, the BSFC is almost same as that of diesel.

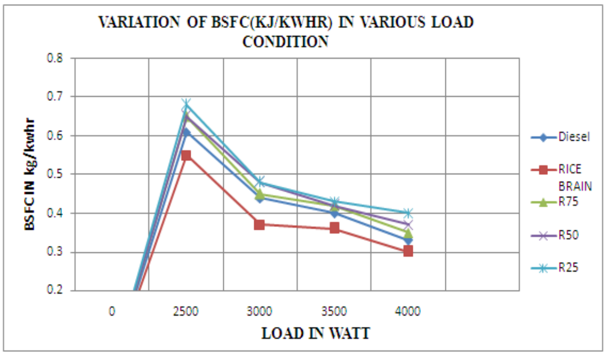

Fig. 6 Variation of Brake Specific Fuel Consumption

Effect on Brake Specific Energy Consumption (BSEC)

The variation of BSEC with load for different blends and loads are presented in fig. 7. It is observed from the chart that the BSEC for all the fuel blends tested decrease with increase in load except base fuel at 50% load. This is due to higher percentage increase in brake power with load as compared to increase in the fuel consumption. For R25 oil the BSEC is higher as compared to that of diesel. For RBO blends with Oxygen fuel greater than 10%, the BSEC was observed to be greater than that of diesel and this is due to the fact that the complete burning of fuel takes place with addition of oxygen and that increases the fuel consumption.

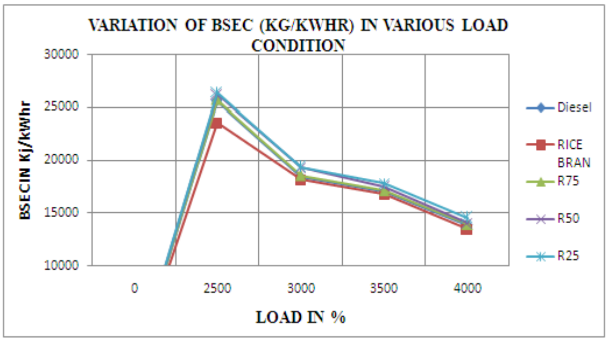

Fig.7 Variation of Brake Specific Energy Consumption (Kj/Kwhr) with changing Load

Conclusion

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

- **Biodiesel Production:** A two stage transesterification process is required for the production of methyl ester from crude rice bran oil (Higher FFA) which includes an acid catalyzed transesterification with sulphuric acid (H2SO4) as catalyst followed by a base catalyzed transesterification with potassium hydroxide (KOH) as base catalyst. For rice bran oil a single stage base catalyzed transesterification with potassium hydroxide (KOH) as base catalyst is required.
- **Comparison Of Properties:** By the comparison of properties Flash Point of pure diesel is 71 and Biodiesel is 165 that show biodiesel is easily storage for long time , Pour point of diesel is 1 and bio diesel is 3 shows that biodiesel is being good performance in low temperature , oxygen content in diesel is 0 and biodiesel have 11 shows that easily burning in cylinder with its own oxygen content, Cetane number of Pure diesel is 45 and biodiesel is 56 shows that the knocking problem in C.I engine is less as compare to diesel.
- **Performance of Engine:** The result from the experimental study highlights the increase in the brake horse power, break thermal efficiency and exhaust gas temperature using rice bran oil blends in C.I. Engines. With R75 (75% Rice bran oil and 25% diesel) blend C.I. Engines produce 3.78% more brake horse power then sole diesel fuel and 0.93 more brake thermal efficiency as compare to diesel fuel Under this experimental study I can conclude that the rice bran biodiesel blend performance in a C.I. Engine as compare to diesel is more efficient and R75 blend gives optimal performance without affecting engine parameters.

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