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Effect of Load on the Performance of DI Diesel Engine Running on Rice Bran Bio-diesel and Its Blends

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Abstract: The two alarming situations in front of the engineers worldwide are to reduce the load on the conventional fuels and to reduce the ever increasing environmental pollution. This study is aimed to investigate experimentally the performance of DI diesel engine at varying loads when fuelled with blends of rice bran oil and diesel. The experiments were conducted on widely used diesel engine without major modifications. All the tests were steady state and conducted at constant speed. The effect of varying load was evaluated in terms of brake thermal efficiency, mass flow rate, brake specific fuel consumption and exhaust gas temperature. Experimental results shows that at full load conditions, the B-100, B-75, B-50 and B-25 blends produce 33.23%, 32.81%, 32.39% and 31.97% higher brake thermal efficiency than sole diesel respectively. It was found that brake thermal efficiency of rice bran biodiesel is higher than that of diesel, and it is because of the oxygenated molecule of biodiesel which results in complete combustion of the biodiesel fuel. Also the mass flow rate of biodiesel seems to be higher than that of diesel fuel; it is because the calorific value of biodiesel is higher than that of diesel fuel. On the basis of results obtained from this study the use of rice bran oil as a fuel is recommended for the use in diesel engine with diesel blends.

Keywords: **Bio-diesel, Transesterification, Brake-Thermal Efficiency, Brake Specific Fuel Consumption, Mass Flow Rate, Exhaust Gas Temperature.**

1. INTRODUCTION

As the population increases daily, the demand for energy to meet other lifestyle requirements increase as well. Consequently, the main concern has been on the use of various energy sources. Non-renewable such as fossil fuels like coal, wood, oil, and gas, are likely to be exhausted in the near future since they are non-renewable. These sources of energy cannot be renewed or reused. Alternative fuels from domestic sources are emerging as a solution to the declining reserves of fossil fuels, and the environmental unfriendliness resulting from the combustion of fossil fuels. When fossil fuels are burned, a lot of carbon dioxide is released. Carbon dioxide is a gas that absorbs heat and contributes towards the greenhouse effect. Another gas released when fossil fuel is burned is sulfur dioxide which combines with water in the atmosphere to form sulphuric acid. This leads to acid rain which alter the normal pH of soil that supports plant growth. What makes the world today consider the production and use of bio-fuels on a wide scale is the high level of atmospheric pollution caused by the intense use of fossil fuels leading to the greenhouse effect. Biodiesel, a renewable DI engine fuel, has been accepted by many countries as a partial replacement for diesel fuel. However, its higher NOx emission may limit its use and is therefore a significant barrier for its use[1]. Research work on NOx reduction of diesel engine has advanced significantly in the past two decades and similar kind of investigations were now focused on biodiesel to reduce NOx emission lower than diesel [2-3]. NOx emission of a diesel engine can be controlled by modifying the combustion process through retardation of fuel injection timing, exhaust gas recirculation (EGR)which prevents the NOx formation in the engine cylinder[4]. If the NOx emission standard was not met by the combustion process modification alone, treatment of exhaust gas can be considered to reduce the NOx emission [5] and the same can be achieved with the help of different catalysts to remove NOx emission[6]. When compared with exhaust gas treatment, combustion process modification is the most economical method for NOx reduction [5].The most common method to produce biodiesel is transesterification of vegetable oil, waste animal fats with a short-chain alcohol. These oils are identified as one of the future contenders to fulfill the demand gap produced by the depletion of fossil diesel fuels[2,3]. High purity methyl ester can be achieved by transesterification of fresh vegetable oils with methanol in the presence of an alkaline catalyst [4].

The various alternative fuel options researched for diesel are mainly biogas producer gas, methanol, ethanol and vegetable oil. Out of this which rice bran oil is one of the promising alternate fuel for diesel engine. 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. 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.

2. TRANSESTERFICATION

Due to very high free fatty acid, rice bran oil was converted into methyl ester by the two stage process .In the first stage rice bran oil was reacted with CH3OH in presence of an acid catalyst to convert free fatty acid into fatty ester. A specified amount 1000g of rice bran oil was taken in a round bottom flask and heated up to 60-65°C. In a separate flask CH3OH (200 ml) and KOH (7.5 g) were taken and properly mixed and then stirred for the time until whole KOH pallets gets dissolved in methanol. After then mixture of 1000g obtained from the first stage was taken in around bottom flask and heated upto 60°C and then the solution of methanol(200ml) and KOH (7.5 g) were properly mixed in other flask into the round bottom flask containing the mixture from first stage. Then the mixture is kept on heating mantle for further reaction and maintaining the temperature between 55 -60 °C for about one hour and after then put on rest until the bi-product glycerol settles down at the bottom. After then the glycerol is separated from the round flask and the remaining is put in the separate flask for washing purpose, in order to remove the impurities it is kept for almost 12 hrs to settle down all the impurities, after then the top layer containing rice bran oil methyl el is available.

Biodiesel production:

The present work in which Rice Bran oil is used as feedstock for biodiesel production. Alcohol and catalyst used are methanol and KOH

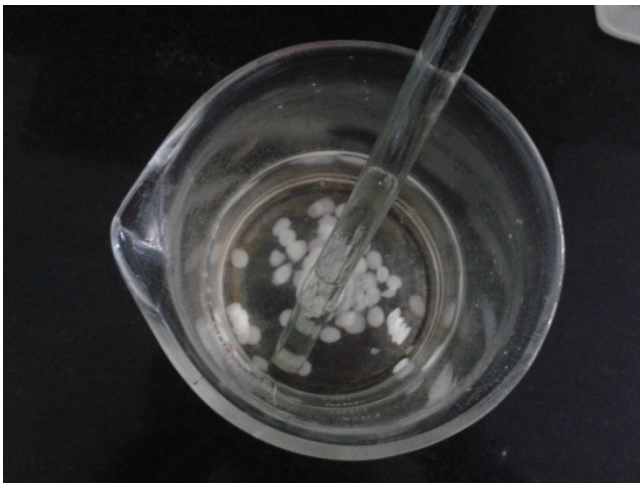


Figure 1 Mixing of methanol with catalyst

Figure 2 Solution after treatment left in standing funnel for settlement

Figure 3 Showing glycerol level at the bottom after the whole reaction process

Figure 4 showing the pure Rice Bran Biodiesel

3. EXPERIMENTAL SETUP:

The experimental setup is consists of:-

- Engine and Generator.
- Fuel Supply System.
- Electric Dynamometer.
- Exhaust Gas Recirculation (EGR) System.

Engine and Generator

The engine used in the experiment is single cylinder, air cooled, four stroke, diesel engine. The specification of the engine is given in table below. The test engine via generator is connected to electric dynamometer.

Specification of the engine

Engine Type	Single cylinder, constant speed, air cooled, direct injection
Bore x stroke	80 x 110 mm
Rated power	2.5 Kw
Rated speed	1500 rpm

Figure 4 Showing the whole setup for the testing of Biodiesel.

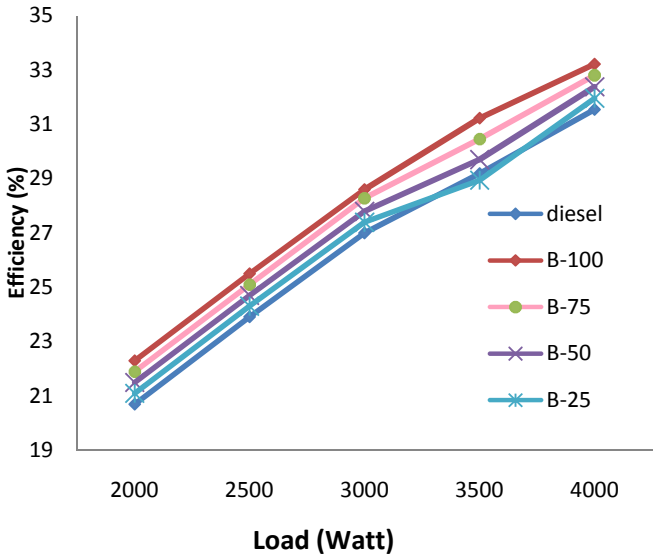
4. RESULT AND DISCUSSION

In order to get the base line data of the engine, initially the experiment is performed with diesel, pure rice bran biodiesel and then with blends of rice bran biodiesel and diesel (B-75, B-50 and B-25) are notations of biodiesel blends respectively and the pure rice bran biodiesel is denoted by B-100.

The performance of engine is evaluated on the basis of following parameters;

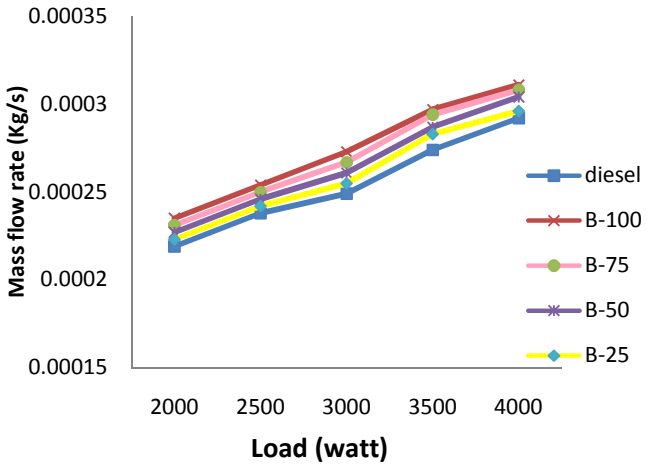
- Brake thermal efficiency
- Mass flow rate
- Brake specific fuel consumption
- Exhaust gas temperature

Effect of load on brake thermal efficiency



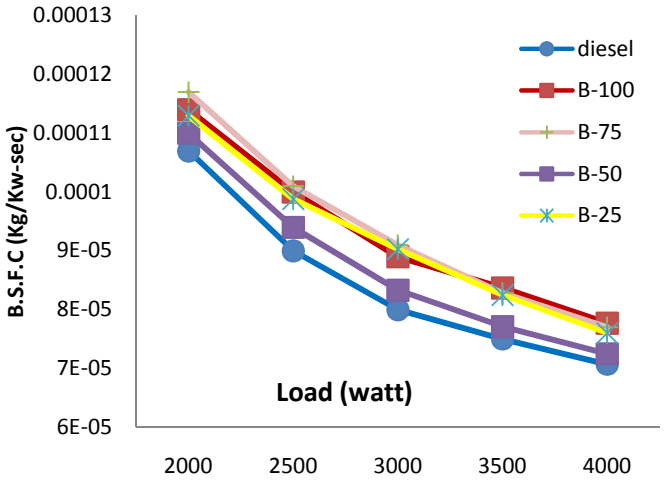
From the chart it is clear that the rice bran biodiesel is more efficient than the diesel and even more efficient than its blends. It is because of the oxygenated molecule of the biodiesel and because of that excess oxygen molecule there occours complete combustion of fuel and which in turn results in maximum efficiency than the diesel fuel. From the experimental results the BTE values are 33.23%, 32. 81%, 32.39%,31.97% and 31.55% for B-100, B-75, B-50, B-25 and diesel respectively.

Effect of load on mass flow rate



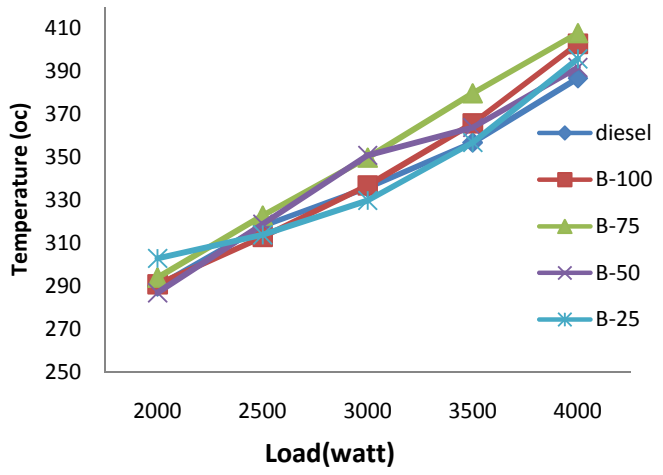
The mass flow rate of biodiesel is more than that of diesel. It is because the calorific value of diesel is more than biodiesel, which is 43800 kj/kg for diesel and 39200 kj/kg for biodiesel. And because of this difference the FCR (fuel consumption rate) of biodiesel is more than that of diesel

Effect of load on brake specific fuel consumption



It is observed from the chart that the BSFC for all the fuels decreases with increase in load. This is due to higher percentage increase in break power with load as compared to increase in the fuel consumption. This could be due to the the presence of oxygen in the biodiesel and its blends that enable complete combustion and the negative effect of increased viscosity would not have been initated

Effect of load on exhaust gas temperature



It could be seen from the figure that exhaust gas temperature for biodiesel is more than that of diesel at all full loads . This is because vegetable usually comprise constituents that have higher boiling point than diesel. These relative higher boiling point constituents were no adequately evaporated during main combustion phase and continued to burn in the late combustion phase.

5. CONCLUSION

The present work is done to study the production of rice bran biodiesel and the effect of load on the engine performance. Based on the results of the present work , following conclusions are drawn;-

- The rice bran biodiesel and its blends can be used as an alternative fuel in DI diesel engine without compensating in terms of power and brake thermal efficiency. This can be helpful to reduce the usage of a non renewable conventional fuel and also to reduce the environmental pollution as the biodiesel is eco-friendly
- Rice bran biodiesel has been shown to reduce the particulate emission from a DI diesel engine. The maximum decrease is in the hydrocarbon and cxarbon monoxide emission.At full load condition the rice bran biodiesel has higher efficiency 33.23%, also its respective blends have more efficiency than that of diesel fuel.

From the above conclusion the rice bran biodiesel and its blends can be recommended for use DI diesel engine without any modification of the engine

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