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# EXPERIMENTAL INVESTIGATION AND BIODIESEL PREPARATION USING TRANSESTERIFICATION PROCESS AND PERFORMANCE CHARACTERISTICS ON A VARIABLE COMPRESSION ENGINE

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**Abstract**

Rapid increase in global population, demand for utilization of transportation is prevailing as one of the main concerns in releasing the dangerous exhaust gasses which causes harm to environment. Due to rapid usage of the fossil fuels like diesel fuel, there occurred scarcity and increase in pollution though the diesel gives better efficiency for transportation. An alternative looks up is necessary to mitigate the environmental pollution and increase the awareness by using vegetable oils as a potential alternative source. These vegetable oils are not directly suitable to use in existing engines since the kinematic viscosity is more. Hence by converting to biodiesel using transesterification process these biodiesel fuels are used in CI engine. In the present investigation an attempt to estimate the performance characteristics of variable compression engine using rice bran oil at various blend ratios RBrBD5, RBrBD10 RBrBD15, RBrBD20 were investigated as an alternative to mineral diesel fuel.

***Keywords:*** *Rice bran Oil, Transesterification, Biodiesel, Engine Performance.*

## 1. Introduction:

Globally the utilization of the transportation ad power sector is increasing with huge demand of the supply of the fuel. In developing country like India, [1] it is a known fact that very less crude oil deposit is witnessed casing the rise in the oil imports from other countries which shows impact on the foreign exchange of our country. Huge demand in usage of crude oil is observed due to the increase in the demand in usage of power, transportation, industrial, agricultural sectors etc. [2]. For this an alternative solution is Biofuels. Biodiesel are the prominent source of energy fuel working as an alternative source in the area of transportation especially and gaining wide range of attention by replacing the conventional fuels. Among the biodiesel's fuels rice bran oil is one of the emerging sources which meets the requirement of the Indian standards and also it is a positive sign that India is one of the largest producers of Paddy [6]. This positive sign draw attention in reducing the amount of paddy cost and reduce the bulk price cost as well which is a stepped solution for the preparation of biodiesel. In the recent years the demand for the utilization of rice bran oil is increasing since the rice bran oil (RBr) [3] is available abundantly which is used as an alternative source of renewable energy. Diesel engines have a negative effect on environment since they include high amounts of Sulphur and aromatics. CO, $SO_X$, $NO_X$ and smoke [8] are produced from fossil fueled diesel engine exhaust emissions. It has been observed that

engine parameters such as injection timing, compression ratio have considerable effects on the performance and emissions of diesel engines [4] running on biodiesel blends. Many innovative technologies are developed to tackle these problems. In the present investigation the rice bran oil is converted into rice bran biodiesel (RBrBD) using transesterification process. The performance characteristics of the engine is tested on variable compression engine by blending the biodiesel at various blend ratios of RBrBD5, RBrBD10 RBrBD15, RBrBD20 at varying loads for a compression ratio. Using the alternative biodiesel oil will result in reducing the environmental pollution and emissions which stands as a source of renewable energy.

### 1.1 Detailed specification of Rice Bran

The work presented in this paper is mainly focused on one of the vegetable oils [5] known as rice bran oil. This oil is used as a raw material to produce biodiesel. Rice bran oil is majorly found in Vietnam, Bangladesh, Japan, China, India. The rice bran [6] is obtained after milling process of rice i.e. brown rice converted to white rice and the rice bran oil (RBrO) is extracted from the outer hard layer of rice after husk. There are many benefits observed in rice bran oil one among is various anti-oxidants are present in the oil which is beneficial to the human health aspects. The composition of the rice bran oil (RBrO) consists of saturated acids of 15-20 %, Oleic acids of 42 to 52%, and Linoleic acid of 30-42%. The pictorial representation of the rice bran oil is shown in the figure 1 below.

**Figure 1: Pictorial Representation of the Rice Grains**

## 2. Bio fuels

Biofuels are energy sources made from recently grown biomass (plant or animal matter). Biofuels have been around for a long time, but petroleum and coal have been used primarily as energy sources due to their high abundance, [4] high energy value, and cheap prices. Fossil fuels such as coal and petroleum also come from biomass but the difference is that they took millions of years to produce. Biofuels [7] are making a resurgence due to increasing oil prices, dwindling fossil fuel reserves, the desire to have a renewable, reliable source of energy [2] and as a way to mitigate the effects of climate change. Biofuels are a renewable resource as they are continually replenished. Fossil fuels on the other hand are not renewable since they require millions of years to form. Biodiesel is a form of diesel fuel derived from plants or animals and consisting of long-chain fatty acid esters. It is typically made by chemically reacting lipids such as animal fat (tallow), soybean oil or some other vegetable oil [5] with an alcohol, producing a methyl, ethyl or propyl ester. Unlike the

vegetable and waste oils used to fuel converted diesel engines, biodiesel [1] is a drop-in biofuel, meaning it is compatible with existing diesel engines and distribution infrastructure. Biodiesel can be used alone or blended with petro diesel in any proportions.

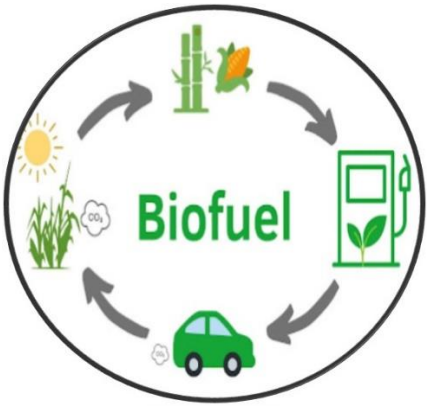


**Figure 2: Renewable source of fuel - Biofuels**

## 3. Materials and Methods:

### 3.1 Materials:

The rice bran oil is directly obtained from the supplier Indiamart, further for transesterification Methanol, Sulphuric acid ($H_2SO_4$), NaOH pellets were purchased from the Merck Solutions. And the heater and glass ware were used from the thermal laboratory.

### 3.2 Methods:

#### 3.2.1 Transesterification Process:

The process of converting raw rice bran oil to pure rice bran biodiesel is done by transesterification process. Initially the viscosity of the raw rice bran oil ranges from 10 to 40 $mm^2$/sec which is not suggestible to used in the existing engine, there exists engine damage in operations. Hence conversion to biodiesel is very important to reduce the engine problems [9] and environmental pollutions. For this the transesterification process is carried out in two process, one is acid treatment and base treatment. First the raw oil is heated up to it reaches boiling process 100 $^oC$, then after the solution cools down, the acid treatment must be initiated. 10 drops of $H_2SO4$ and 110 ml of methanol were mixed properly and poured in the conical flask and start heating and stirring continuously for 4 hours. Ensure that the temperature must not cross 60oC, else the methanol escapes and biodiesel oil formation fail. After continuous heating and stirring for 4 hours, stop the heater and let it cool down completely. Now the second process, base treatment is started, heat the solution up to 40 $^oC$ by adding 100 ml of methanol and 7gms of NaOH. The solution must mix properly without any particles left over and strain in a filter paper. For about hours the solution must be heated and stirred by maintaining the temperature > 60 $^oC$, and the conical flask must be wrapped with cotton to ensure methanol not to escape.

Then glycerin and biodiesel are formed, then water wash with distilled water and finally rice bran biodiesel was obtained as shown in the figure 3.

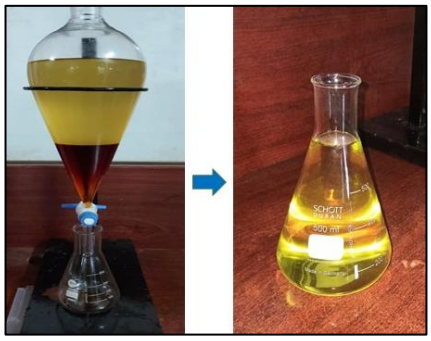

**Figure 3: Preparation of Rice Bran Biodiesel**

## 4. Performance Characteristics of Engine:

### 4.1 Experimental Setup

The engine used for present investigation is a four stroke, water cooled, single cylinder VCR, direct injection vertical diesel engine. Lab view based Engine Performance Analysis software package. The engine is running at a rated speed of 1500 rpm. Fresh lubricating oil [8] was filled in the engine sump tank before starting the experiments. The engine is connected to eddy current type dynamometer for loading. The compression ratio can be changed without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement.

The schematic diagram of the experiment set up is shown in Fig.4. The technical specification of the engine is given in Table 1. The set-up has stand-alone panel box consisting of air box, fuel tank for duel fuel test (Diesel and Rice Bran Biodiesel) manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. The engine specification and the schematic diagram and pictorial representation of the engine is shown in the figure 4 and table 2 below.

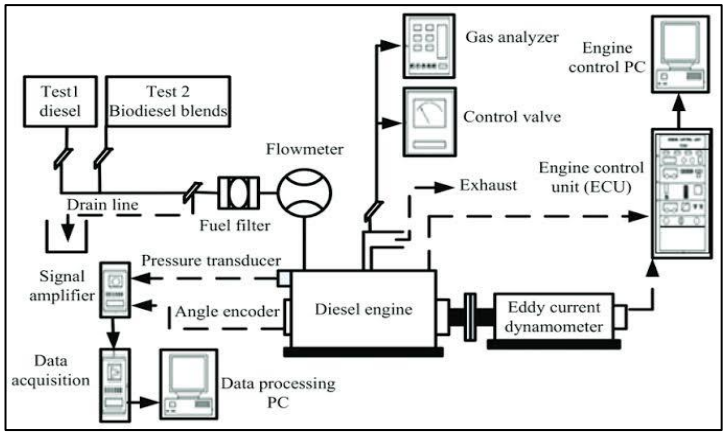


**Figure 4: Schematic Representation of the Engine Set Up**

### 4.2 VCR Engine Specifications

**Table 1: Engine Specifications**

| S.NO | FEATURES | SPECIFICATIONS |
|---|---|---|
| 1 | Make | KIRLOSKAR DIESEL ENGINE |
| 2 | TYPE | FOUR STROKE WATER COOLED |
| 3 | NO OF CYLINDERS | ONE |
| 4 | COMBUSTION | COMPRESSION IGNITION |
| 5 | MAX SPEED | 1500 |
| 6 | CRANK RADIUS | 55MM |
| 7 | CONNECTINGROD LENGTH | 300MM |
| 8 | CYLINDER DIAMETER | 80MM |
| 9 | STROKE LENGTH | 110MM |
| 10 | COMPRESSION RATIO | 14.0 TO 20.0 |
| 11 | LOADING | EDDYCURRENT DYNAMOMETER |
| 12 | LOAD(MAX) | 24N-M |
| 13 | POWER | 3.8KW |

### 4.3 Blends Preparation:

Blends of mineral diesel fuel and the Rice Bran Biodiesel at varying blends were prepared and tested on the engine at RBrBD5, RBrBD10, RBrBD15, RBrBD20. Several blends of varying concentrations are prepared. The engine is started with diesel and once the engine warm-up; it is switched over to rice bran biodiesel oil. Engine start at no load at CR of 16 and varying the load from idle to rated load in a number of steps and a set of reading is obtained for 5%, 10%, 15%, 20% (Rice Bran Biodiesel) and another set of readings are recorded for the operation of the engine in diesel fuel mode. The notations of diesel and algae are shown in the table 2 below.

**Table 2: Notations of Diesel and Rice Bran Biodiesel Blends**

| Notation | Parameters |
|---|---|
| DF | Diesel Fuel |
| RBrBD5 | Rice Bran Biodiesel B5 |
| RBrBD10 | Rice Bran Biodiesel B10 |
| RBrBD15 | Rice Bran Biodiesel B15 |
| RBrBD20 | Rice Bran Biodiesel B20 |

The performance of the engine at different loads and settings are evaluated in terms of Brake power, brake thermal efficiency and mechanical efficiency [10] and checked the performance of the engine when algae biodiesel is loaded at various blends ranging from RBrBD5, RBrBD10, RBrBD15 and RBrBD20.

## 5. Results:

### 5.1 Thermal Fuel Properties:

The obtained rice bran biodiesel fuel properties [10,11] were tested in the college thermal laboratory and were represented in the table 3 below.

**Table 3: Thermal fuel properties of pure a Rice Bran Biodiesel (RBrBD100)**

| Fuel Properties | Units | RBrBD100 |
|---|---|---|
| Kinematic Viscosity | (mm2/sec) | 5.2 |
| Density | kg/m3 | 881 |
| Flash Point | ($^o$C) | 181 |
| Fire Point | ($^o$C) | 190 |

### 5.2 Engine Results:

The data obtained from the VCR engine after running with diesel fuel and Rice Bran Biodiesel at various loads were shown in the below graphs.

The graphical representation showing Load vs. Brake Thermal Efficiency and Load vs. Mechanical Efficiency at various loads at figure 5 & 6.

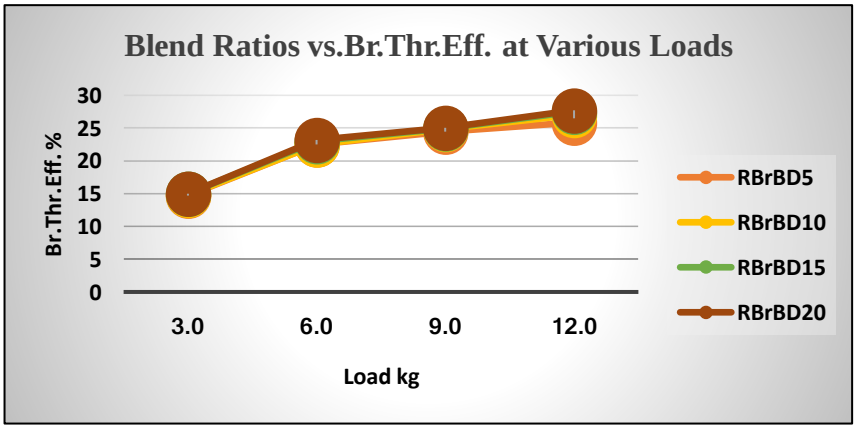


**Figure 5: Graphical representation of Blend Ratios vs. Brake Thermal Efficiency at Various Loads**

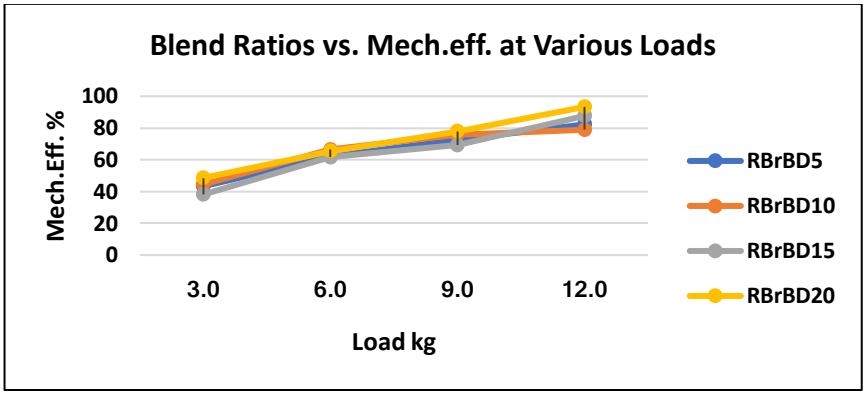


**Figure 6: Graphical representation of Blend Ratios vs. Mechanical Efficiency at Various Loads**

From the above graphs it was observed that the rice bran biodiesel loaded in the variable compression engine shows better results near RBrBD20 with increase in mechanical efficiency and brake thermal efficiency.

## 6. Conclusions

This paper concludes that the biodiesel fuels are the replacement for the fossil fuels. In this paper rice bran oil was opted since the availability of the source of oil is more compared to other fuels and it has low fatty acid composition where base treatment is sufficient for transesterification process. The thermal fuel properties obtained also reveals that the kinematic viscosity is 5.2 mm2/sec which shows that the biodiesel falls under good agreement and can be used in the variable compression engine. The engine performance characteristics at various blends reported that at RBrBD20, the brake thermal and mechanical efficiency values are in good output. Hence the biodiesel at blend RBrBD20 suits to run the engine at safe running operation which leads to reduce the environmental pollution and emissions.

## 7. Acknowledgement

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