Performance and Emission Characteristics of Diesel Engine Using Rice Bran Oil with Titanium Oxide Piston Coating at Different Pressure

C. Bala Mahesh¹ & J. Kishore².
⁰Department of mechanical engineering, G.Pulla Reddy Engineering College Kurnool, Andhra Pradesh, India
* Assistant professor Department of mechanical engineering, G.Pulla Reddy Engineering college, Kurnool, Andhra Pradesh, India

Abstract -- In recent years, the usage of vehicles has been increased and this leads to the demand for fossil fuels. It has become an urgent need to carry out the research work on alternate source of energy to reduce the demand of fossil fuels and also to reduce the emission. Biofuel is one of the alternative sources of energy. Bio-fuel is a clean burning fuel made from natural renewable energy resource; it operates on IC engine similar to the petroleum diesel. The rising cost of diesel and the danger caused to the environment has led to an intensive and desperate search for alternative fuels. The aim of the paper is to blend the camphor oil with diesel fuel at various proportions by volume. The Rice bran oil is directly blended with diesel fuel without any trans-esterification process, because of its low viscous property. A 4-stroke, single cylinder, constant speed, direct injection diesel engine was operated on rice bran oil-biodiesel of different blends. Four different blends of 20, 40, 60 and 80% by volume were used for this study. Various engine performance, combustion and emission parameters such as Brake Thermal Efficiency, Brake Specific Fuel Consumption, Exhaust Gas Temperature, etc. were recorded from the acquired data.

To minimize these losses the combustion chamber Piston crown is coated with ceramic materials without changing the original dimensions. Tests were conducted and comparison is done between coated and uncoated engines. Many authors/researchers have made one step ahead by using bio-diesel or by altering the injection timing. Their results have showed improved engine performance and emission characteristics. Titanium and Alumina is considered to be the most suitable material for ceramic coating. Plasma spray coating is widely accepted technique.

Key words: Diesel, Rice bran oil, plasma spray coating method, Ceramic coating, engine performance and emission characteristics.

1. INTRODUCTION

The fossil fuels play a very important role in the development of industries, transportation and agriculture and to meet many other basic needs of the human beings. The fossil fuels are limited resources and depleting day by day as the energy consumption is increasing very rapidly. India imports 70% of the oil it uses. Dependence on foreign sources of energy has always been a bane for the Indian economy. It is the single biggest drain on the foreign exchange reserves of the country and the uncertainty in the prices of international crude has always kept Indian government and planners on tenter hooks. An increase of $1 per barrel of crude oil prices adds $425 million to our oil import bill.

Compression ignition engines are employed particularly in the field of heavy transportation and agriculture on account of their higher thermal efficiency and durability. The diesel engines are the major contributors of oxides of nitrogen and particulate emissions. Hence more stringent norms are imposed on exhaust emissions. So, the search for alternative renewable fuels is required. Most suitable alternative kinds of fuel for diesel engines may be considered vegetable oil or fuel obtained from the animal fat, because their characteristics are similar to those of common diesel oil. There are number of plants producing oils which can be used in internal combustion engines. Use of straight vegetable oil (SVO) in Diesel engines is not a new idea. Rudolf Diesel first used peanut oil as a fuel for demonstration of CI engine developed by him in the year 1910.

1.2 Rice Bran Oil

More than 90% world’s rice production coming from Asia. Rice production first among agricultural commodity of Indonesia. Rice Bran Oil is a unique vegetable oil produced from the outer brown layer of rice which is removed in the form of rice bran during the polishing process of the rice milling industry. Besides having an almost ideally
balanced fatty acid profile, it is rich in natural anti-oxidants. A number of scientific studies conducted in India & abroad have well documented the better cholesterol lowering properties of rice bran oil as compared to other conventional vegetable oils. All these studies have attributed these properties of the oil to the presence of unique nutraceuticals in this oil known as oryzanol & tocotrienols. Rice bran oil is the world's healthiest edible oil, containing vitamins, antioxidants and nutrients. It is not just delicate and flavourful; but also helps to lower cholesterol, fight diseases, enhance the immune system, and fight free radicals. It contains highest amount of all natural vitamin-E and contains unique component oryzanol which is linked with increase in good cholesterol and lowering down the bad cholesterol and triglycerides. Rice Bran Oil is extensively used in Japan, Korea, China, Taiwan and Thailand as premium edible oil. It is the conventional & the most favourite cooking medium of the Japanese and is popularly known as "Heart Oil" in Japan. It has acquired the status of a "Functional Food" or a "Health Food" in Western Countries. India is the second largest producer of rice in the world next to China.

2. Methodology

Extraction Of Biodiesel From Rice Bran Oil By Transesterification Process:

The transesterification is an equilibrium reaction and the transformation occurs essentially by mixing the reactants. However, the presence of a catalyst (typically a strong acid or base) accelerates considerably the adjustment of the equilibrium. In order to achieve a high yield of the ester, the alcohol has to be used in excess.

Mild Acid Catalyzed Transesterification

This is a type of reaction that takes place in the presence of methanol (30%) and orthophosphoric (0.6%) acid at 60°C with constant stirring, helps in the separation of impurities which were dissolved in the methanol as an upper layer and oil in the lower layer.

Strong Acid Catalyzed Transesterification

The first stage product is reacted with the sulphuric (0.6%) acid and methanol (20%) for 2 hours at 60°C with constant stirring. The reaction product is allowed to settle. The FFA and the other impurities were removed in this stage as an upper layer and oil in the lower layer. The product of earlier stages i.e. pure triglycerides is made to react with methanol (30%) and catalyst, KOH (3gms) for 2 hours at 60°C with constant stirring rate. The reacted product of this third stage is made to settle down under gravity. The lower contains which contain glycerol and other impurities are removed and further excess of alcohol and other impurities present are removed by water wash process after the pH neutralization. The water wash product then heated above 100°C in order to remove the moisture content.

1.3 Properties of Rice Bran Oil Comparison with diesel

<table>
<thead>
<tr>
<th>Properties</th>
<th>Rice bran oil</th>
<th>Pure diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density at 15°C (gm/cc)</td>
<td>0.808</td>
<td>0.82</td>
</tr>
<tr>
<td>Viscosity at 40°C (Centistokes)</td>
<td>4.94</td>
<td>4.85</td>
</tr>
<tr>
<td>flash point (°C)</td>
<td>130</td>
<td>50</td>
</tr>
<tr>
<td>fire point (°C)</td>
<td>153</td>
<td>72</td>
</tr>
<tr>
<td>Calorific value (KJ/kg)</td>
<td>40164</td>
<td>42,500</td>
</tr>
</tbody>
</table>

Table 1: Properties of Rice Bran Oil Comparison with diesel

1.4 Emissions

Diesel engines are the primary power source of vehicles used in heavy duty applications. The heavy duty engine includes buses, large trucks, and off highway construction and mining equipment’s. Furthermore, diesel engines are winning an increasing share of the light duty vehicle market worldwide. The popularity of the diesel engine revolves around its fuel efficiency, reliability, and durability. High compression ratios along with relatively high oxygen concentrations in the diesel combustion chambers are responsible for the good fuel efficiency and low CO and hydrocarbon emissions when contrasted to a comparable gasoline engine. The CO present in residual gas in diesel engine is also less compared with petrol engine. However, these same factors result in high NOX emissions.

1. Hydrocarbon

Hydrocarbon emission is the consequence of incomplete combustion of the hydrocarbon fuel. The level of unburned hydrocarbon in the exhaust gases is generally specified in terms of the total hydrocarbon concentration expressed in parts per million carbon atom. The fuel which escapes from normal combustion process leads to the emission of unburnt hydrocarbon. In diesel engines, the fuel can escape from combustion process due to two reasons; the fuel-air mixture is too lean or to rich to ignite or to support a propagating flame at the conditions prevailing inside the combustion chamber of diesel engine. This fuel then can be consumed only by
slower thermal oxidation reaction later in the expansion process.

2. Carbon monoxide

Carbon monoxide is the product to incomplete combustion when the engine is operated with fuel rich equivalence ratio. CO is not only considered a sun desirable emission, but also represents loss of chemical energy. The exhaust of typical spark ignition engine contains 0.2 to 5% CO whereas the diesel engine exhaust contains very low percentage of CO as the engine is normally operated at lean conditions.

1.5 THERMALBARRIERCOATINGS

Thermal barrier coatings are duplex systems, consisting of a ceramic top coat and a metallic intermediate bond coat. The top coat consists of ceramic material whose function is to reduce the temperature of the underlying, less heat resistant metal part. The bond coat is designed to protect the metallic substrate from oxidation and corrosion and promote the ceramic top coat adherence. A thermal barrier application is shown in figure 1

![Thermal barrier coating diagram](image)

**ADVANTAGES OF THERMAL BARRIER COATINGS FOR DIESEL ENGINES**

Some advantages of thermal barrier coatings on diesel engines are below.

- Low cetane fuels can be burnt.
- Improvements occur at emissions except NOx.
- Waste exhaust gases are used to produce useful shaft work.
- Increased effective efficiency.
- Increased thermal efficiency.
- Using lower-quality fuels within a wider distillation range.
- The fast evaporation and the better mixing of the fuel.
- Reduced specific fuel consumption.
- Multi-Fuel capability.
- Improved reliability.

### Titanium Oxide (TiO2)

Titanium dioxide has been used for many years (ca. 90 years) in a vast range of industrial and consumer goods including paints, coatings, adhesives, paper and paperboard, plastics and rubber, printing inks, coated fabrics and textiles, catalyst systems, ceramics, floor coverings, roofing materials, cosmetics and pharmaceuticals, water treatment agents, food colorants and in automotive products. Titanium dioxide is produced either in the anatase or rutile crystal form. Most titanium dioxide in the anatase form is produced as a white powder, whereas various rutile grades are often off-white and can even exhibit a slight colour, depending on the physical form, which affects light reflectance. Titanium dioxide may be coated with small amounts of alumina and silica to improve technological properties.

Commercial titanium dioxide pigment is produced by either the sulfate process or the chloride process. The principal raw materials for manufacturing titanium dioxide include ilmenite (FeO/TiO2), naturally occurring rutile, or titanium slag. Both anatase and rutile forms of titanium dioxide can be produced by the sulfate process, whereas the chloride process yields the rutile form.

Titanium dioxide can be prepared at a high level of purity. Specifications for food use currently contain a minimum purity assay of 99.0%. Titanium dioxide is the most widely used white pigment in products such as paints, coatings, plastics, paper, inks, fibres, and food and cosmetics because of its brightness. The food applications of titanium dioxide are broad.

**TEST RIG:**

![Test rig image](image)
2. EXPERIMENTAL SETUP

This experimental setup consists of four stroke diesel engine connected with electrical loading. By using this experimental setup estimating the performance and emission analysis at different loading conditions and different diesel blends and with piston coating and without piston coating. The engine specifications are:

- **Bore**: 80 mm
- **Stroke**: 110 mm
- **RPM**: 1500
- **BHP**: 5
- **CR**: 16:1
- **Generator efficiency**: 80%

**Experimental procedure**

Initially the engine is running with diesel fuel for the duration of 10 to 15 minutes before using camphor oil blends in order to attain stable working environment. After that diesel fuel is completely drained out from the fuel tank and then the sample of (500 ml) camphor oil-diesel blends are poured into the fuel tank. It is important to note that whether the engine has attained its optimum (warm) temperature conditions. At constant speed of 1500 rpm, engine is loaded with 0%, 5%, 25%, 50%, 75%, 100% load by using an eddy current dynamometer. The B15 & B20 proportions of camphor oil blends are tested at all load conditions running at constant speed, where the experimental procedure is same for every proportion to be tested.

3. pressure at 180 bar without coating

![Fig:3.1 Performance of diesel blends at 180 bar pressure BP vs SFC](image)

Fig: 3.1 Performance of diesel blends at 180 bar pressure BP vs SFC

![Fig:3.2 Performance of diesel blends at 180 bar pressure BP vs η_mech](image)

Fig: 3.2 Performance of diesel blends at 180 bar pressure BP vs η_mech

![Fig:3.3 Performance of diesel blends at 180 bar pressure BP vs η_bth](image)

Fig: 3.3 Performance of diesel blends at 180 bar pressure BP vs η_bth

Pressure at 210 bar without coating:

![Fig:3.4 Performance of diesel blends at 210 bar pressure BP vs SFC](image)

Fig: 3.4 performance of diesel blends at 210 bar pressure BP vs SFC
Comparing with above results 180 bar and 210 bar pressure, 210 bar (20% RBO) is giving better performance.

Emissions of pressure 180 bar without coating:

Emissions at pressure 210 bar without coating:

The emissions characteristics of the diesel engine with 210 bar is giving less emissions when compared with 180 bar. The emission characteristics of the diesel engine with diesel blends is giving more emissions compared with pure diesel when operating at 210 bar.
After all the evaluation of the results the performance and emissions characteristics of the diesel engine with 20% Rice Bran Oil and 80% Diesel Oil is giving better results.

6. Conclusion
In the diesel engine mainly using without piston coating, with piston coating. In this engine TiO₂ coating used. Compare to the pressures 180 bar, 180 bar coating and 210 bar, 210 bar coating. The pressure 210 bar coating consists of better performance than the 180 bar, 180 bar coating, and 210 bar. Brake specific fuel consumption for B20 is lower than the diesel fuel and it increases as blend ratio increase. The maximum thermal efficiency for B20 at 210 coating (27.78%) was higher than that of diesel. The brake thermal efficiency obtained for B40, B60, B80 were less than that of diesel. The exhaust temperature increases as a function of the concentration of biodiesel blend i.e. higher the percentage of blend. The fuel properties of rice bran biodiesel except calorific...
value, all other properties of RBO found to be higher compared to diesel. Viscosity of Biodiesel is higher than that of any other blend & as its concentration increases in the blend, the viscosity of blend increases.

REFERENCES


