

## **Performance Testing of Single Cylinder Di Diesel Engine Using Rice Bran Bio-Diesel Blends**

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### **ABSTRACT**

The consumption of fuel in the world is increasing rapidly and it affects the global economy of all the Countries so this factor forced all the countries to find the alternative fuel to reduce and even replace the Usage of petroleum fuel. Thus use of biodiesel from non-edible oil sources serves as an alternative fuel to Overcome this problem. The present study focuses on impact assessment of rice bran and crude rice Brand biodiesel and its blends with diesel on diesel engine performance and testing. The experimental analysis provides in study detail of the biodiesel production process, fuel properties evaluation and impact on engine performance testing. The study also investigates the optimization of the Compression ratio (CR) of a compression ignition engine fueled with blends of biodiesel. In order to find out the optimum CR of the engine, experiments were conducted at different CRs ranging from 12 to 18. Then the experiments were conducted using B10, B20 and B30 blends of crude rice bran bio-diesel and diesel at CR of 14 and 16 and these results were compared with the results obtained when the same engine was tested on conventional diesel fuel. Similarly the experimental results of B10, B20 and B30 blends of rice bran bio-diesel at CR 14 were investigated and analyzed. Based on the experimental investigation the blends of crude rice bran bio-diesel can be used as fuel in diesel engine without making any modification to the diesel engine.

**KEYWORDS:** Biodiesel; Transesterification; Crude rice bran oil; Rice bran oil; Diesel Engine.

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### **I. INTRODUCTION**

More than 90% world's rice production coming from Asia. Rice production first among Agricultural commodity of Indonesia. Rice bran is a brown layer present between rice and the outer husk of the paddy. Rice bran oil is an important derivative of rice. Depending on variety of rice and degree of milling, the bran contains 16-32 wt% of oil. About 60-70% of the oil produced from this bran is non-edible oil, due to the problems attributed to the stability and storage of the rice bran and the dispersed nature of rice milling. Rice bran oil (RBO) is considered to be one of the most nutritious oils due its favorable fatty acid composition and unique combination of naturally occurring biologically active and antioxidant compounds.<sup>[1,2]</sup> Biodiesel can be produced from a great variety of feedstock's which includes most common vegetable oils (e.g., soybean, cottonseed, palm, peanut, rapeseed/canola, sunflower, coconut) and animal fats (usually tallow) as well as waste oils (e.g., used frying oils). The choice of feedstock depends largely on availability. Biodiesel has a higher cetane number than diesel fuel, no aromatics, no sulfur, and contains 10–11% oxygen by weight.<sup>[3,4]</sup> Generally the direct use of vegetable oils in the diesel engine is not recommended due to their high viscosity, which affects combustion. So in order to reduce its viscosity so that it can be used in common diesel engines without making any modification in the engine the transesterification method is used to reduce the high viscosity of oil.<sup>[5-8]</sup> The results obtained show a 49% reduction in smoke, 35% reduction in HC and 37% reduction in CO emissions for the blends whereas the brake power and BTE are reduced by 2.4% and 3.2% respectively with 4.3% increase in the SFC . Therefore it is concluded from the present experimental study that the blends of RBO and Diesel fuel can successfully be used in Diesel engines as an alternative fuel without any modification in the engine and it is also environment friendly by the emission standards. The present research is aimed to investigate experimentally the performance and exhaust emission characteristics of a direct injection (DI) diesel engine when fuelled with conventional diesel fuel, rice bran oil biodiesel, a blend of diesel and rice bran oil biodiesel and three blends of diesel-biodiesel-ethanol over the entire range of load on the engine.<sup>[9-10]</sup> Rice bran oil ranks first among the non-conventional, inexpensive, low-grade vegetable oils. Furthermore, crude rice bran oil is a rich source of high value-added byproduct. Therefore, use of rice bran oil as raw material for the production of biodiesel not only makes the process economical but also generates value added bio-

active compounds. Isolation and purification of these byproducts

Make the process attractive and remunerative. Thus, if the by-products are derived from crude rice bran oil and the resultant oil is used as feedstock for biodiesel, the resulting biodiesel could be quite economical and affordable. In the present study, crude rice bran oil and refined rice bran oil are chosen as potential alternatives for producing biodiesel and use as fuel in four stroke compression ignition engines.<sup>[11-13]</sup> The kinematic viscosity of crude rice bran oil and refined rice bran oil is however several times higher than that of diesel oil<sup>[6]</sup> and this leads to problems in pumping and atomization in the injection system of a diesel engine so their viscosity must be lowered. The combined effect of high viscosity and low volatility causes poor cold engine start up, misfire and ignition delay. Hence, it is necessary to bring their combustion related properties closer to those of diesel oil.<sup>[4]</sup> The free fatty acid (FFA) content of crude rice bran oil is high depending on the quality of rice bran from which the oil has been extracted. Because of the high FFA content for crude rice bran oil a 2-stage transesterification process is carried out which includes an acid catalyzed transesterification followed by a base catalyzed transesterification. For refined rice bran oil a single stage base catalyzed transesterification was carried out. The present study focuses on production and performance evaluation of rice bran biodiesel as an alternative source of fuel.

In India, total consumption of crude oil was 103.44 million tones (MT) in 2000-2001 and 160.03 MT in 2009-10, whereas production was 32.43 MT in 200-01 and 33.69 MT in 2009- 10. Thus increment in production is only 3.7% as compared to increment in computation of 35.36%. Transportation and agricultural sectors are major consumers of fossil fuel and biggest contributors to environmental pollution. Current price of vegetable oil worldwide is nearly competitive with petroleum based fuels.

## II. Bio diesel Production by Transesterification Method

The idea of using plant-based oils, such as soybean oil or canola oil, to fuel an internal combustion engine is as old as the diesel engine itself. Rudolph Diesel, inventor of the diesel engine, used peanut oil to demonstrate his new invention at the Paris World's Exhibition in 1900. Throughout the 20th century, however, petroleum-based diesel fuel has been relatively cheap and convenient. As a result, diesel engines have been refined through the years to work well with this fuel source. Petroleum diesel flows more easily (i.e. is less viscous) than either plant or animal based fats and oils. As a result, using non-petroleum-based oils in today's diesel engines requires either modifying the vehicle's fuel system to accept these slower flowing oils or modifying the oil or fat itself so that it can be used directly in a diesel engine.

The chemical process commonly used to make bio-oils less viscous, turning them into "biodiesel" is called "transesterification". Rice bran oil and methanol were mixed and poured into the test reactor. Then base catalyst (CAO) in 1% w/w was added into the already present mixture in the reactor. The mixture inside the reactor was heated to a temperature of 65 °C and stirred continuously. The mixture in the reactor was allowed to remain at the same temperature for a period of 3 hrs and the nit was allowed to settle under gravity. After settling two layers were formed, the upper layer was found to be Rice bran Oil methyl esters (RBO) and the lower layer being glycerol.

- Biodiesel is made from the combination of a triglyceride with a mono hydroxy alcohol (i.e. methanol, ethanol...).
- What is a triglyceride? Made from a combination of glycerol and three fatty acids.

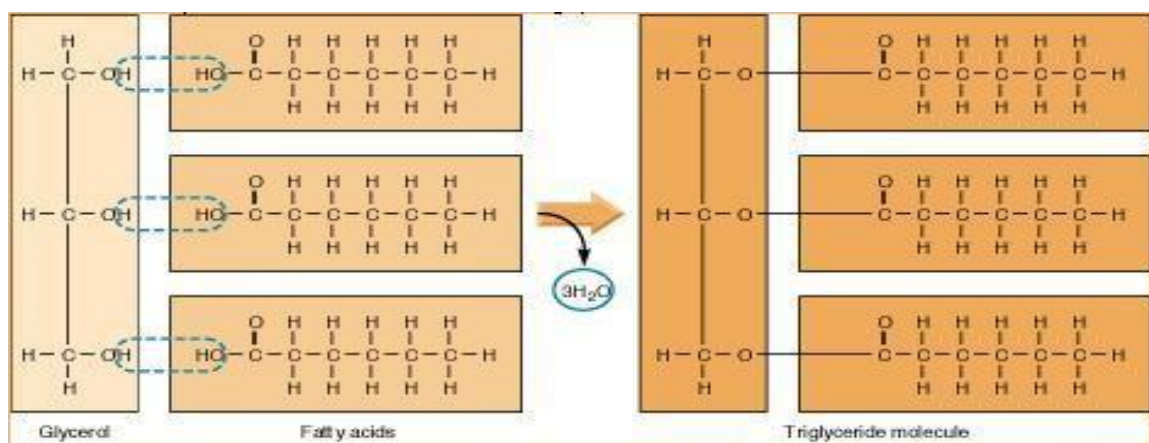
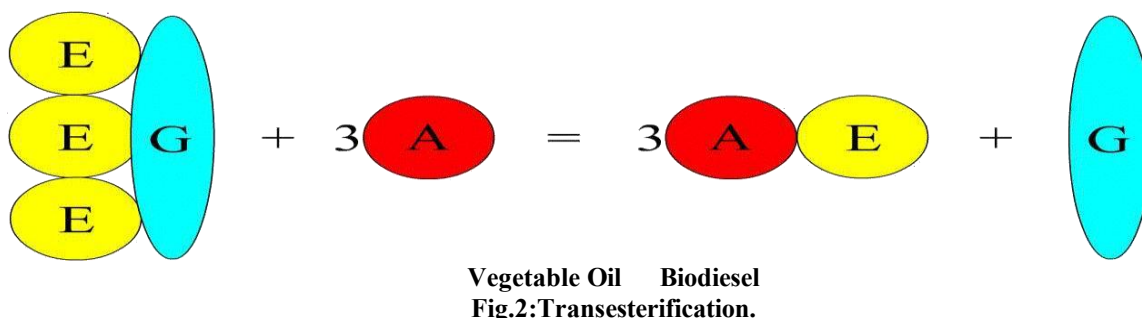


Fig.1: Chemistry of triglycerides.

### Transesterification

While actually a multi-step process, the overall reaction looks like this.



### III. Preparation of Biodiesel Blends

After production the RBO was blended with neat diesel fuel in various volume concentrations to prepare biodiesel blends. These blends were subsequently used in the engine tests. The level of blending for convenience is referred as RBXX. Where XX indicates the percentage of biodiesel present in the blend. For example a RB10 blend is prepared with 10% biodiesel and 90% diesel oil by volume. During the present engine experiments the blends prepared and used were RB10, RB20, and RB30.

### IV. Properties of biodiesel comparison with diesel

The specification of the engine used for experimentation is given in Table 1. The set-up enables the study of engine brake power, fuel consumption, air consumption, heat balance, thermal efficiency, volumetric efficiency etc. The performance tests were carried out on the variable CR single cylinder four stroke diesel engine using various blends of crude rice bran oil biodiesel and refined rice bran oil biodiesel and diesel as fuels. The tests were conducted at variable loads. The experimental data generated were documented and presented here using the biodiesel– diesel mixture for the engine test operation. In each experiment, engine performance parameters such as brake specific fuel consumption (BSFC), brake thermal efficiency (BTE) and variation of cylinder pressure with crank angle were measured. Fig. 3 shows variable CR compression ignition engine test Rig. RB10, RB20, RB30 and Diesel oil. Before application on the engine, various physico-chemical properties were determined and compared to each other.

**Table 1: Engine specification.**

|                    |   |
|--------------------|---|
| Engine Make type   | Kirloskar                                       |
| Engine Type        | Single cylinder four stroke water cooled        |
| Bore               | 87.5mm  |
| Stroke length      | 110mm   |
| Loading Device     | Eddy current dynamometer                        |
| Load indicator     | Digital, Range 0-50kg                           |
| Load sensor        | Load cell, type strain gauge, range 0-50kg      |
| Speed indicator    | Digital with non-contact type speed sensor      |
| Rated power        | 3.5Kw at 1500 RPM                               |
| Temperature sensor | Thermocouple                                    |
| Rota meter         | Engine cooling 40-400LPH; calorimeter 25-250LPH |
| Engine capacity    | 661cc   |
| Variable CR range  | 12 to 18  |
| Fuel used          | Diesel, Biodiesel                               |

**Table 2: Fuel characterization.**

| Properties                       | Rice bran oil | Pure diesel |
|----------------------------------|---------------|-------------|
| Density, g/cc                    | 0.876         | 0.82        |
| Viscosity at 40°C (Centi stokes) | 6.29          | 5           |
| Cloud point (°C)                 | 7             | -6          |
| Pour point (°C)                  | -3            | 3           |

|                         |         |        |
|-------------------------|---------|--------|
| Carbon Residue(%)       | 0.48    | 0.1    |
| Calorific value( KJ/kg) | 37900.8 | 42,500 |
| Flashpoint,0C           | 152     | 159    |
| Firepoint,0C            | 159     | 150    |

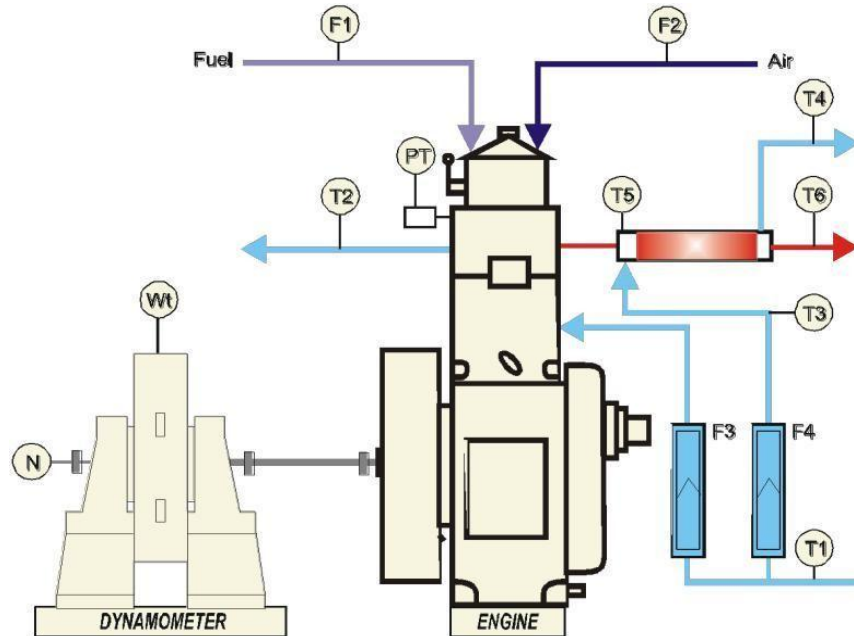


Fig.3: Schematicarrangement.

## V. RESULTANDDISCUSSION

### Objectives of Project

Keeping in mind the benefits of biodiesel and so the consequential importance renewable in the near future, the work was undertaken with following specific objectives:

1. To conduct short term field test on C.I. engine.
2. To study performance of C.I. engine with biodiesel produced Rice bran oil.
3. By varying C.R and Load.

**1. Brake thermal efficiency analysis:** - The variation of thermal performance parameters at different values of CRs at 14 and 16 with a load of 2 kg, 4kg, 6kg and 8 kg and IP of 200 bar it represented in figure 4 to 5. It can be observed that BTHE increases continuously with increase in Load. The increasing trend is due to higher air temperature achieved at diesel due to better combustion of fuel. From above two results clearly indicates at full load condition only Brake thermal efficiency increases continuously in RB20 as compare than pure Diesel at

C.R14. The nearest result obtained at RB20 at same like as pure Diesel as shown in figures.4

to5. It depicts the variation of brake thermal efficiency with variation of engine load at CR of 16 for the good one in X-axis load and Y-axis BTHE.

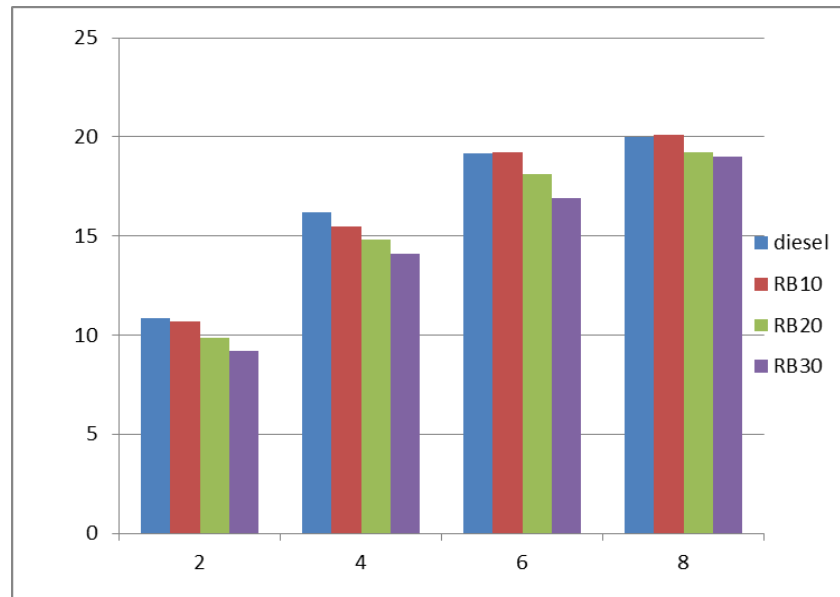


Fig.4: at C.R14(Load vs BTHE).

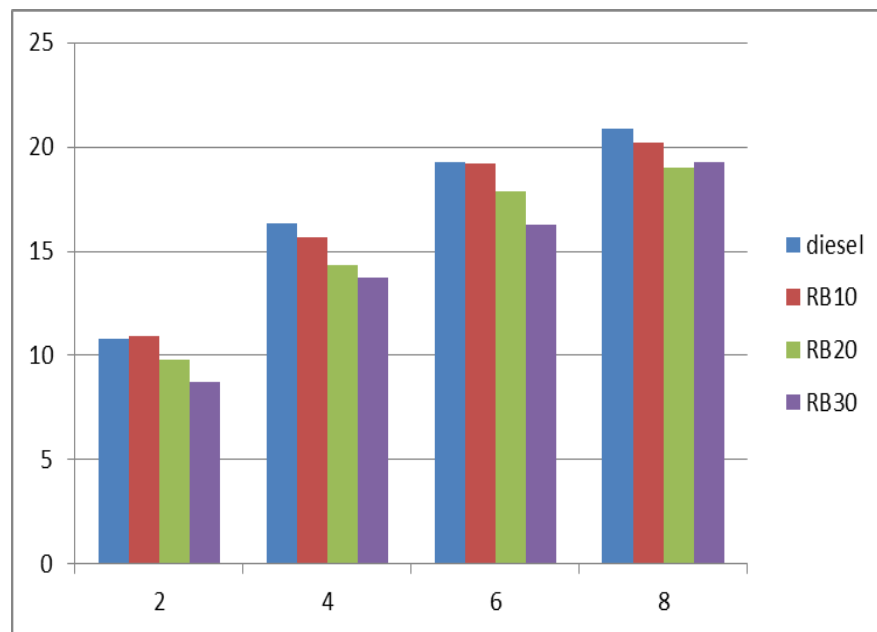


Fig.5: at C.R16(Load vs BTHE).

**2. Brake specific fuel consumption analysis:** - It can be observed (Fig 6 and 7) that as the CR of the engine increases, then BSFC of decreases when load increases and result will obtained nearly RB20 is same BSFC as of pure Diesel but RB30 but in almost all CR the RB20 gives better performance in increased the combustion efficiency. in x- axis is the load in kg y-axis is the BSFC.

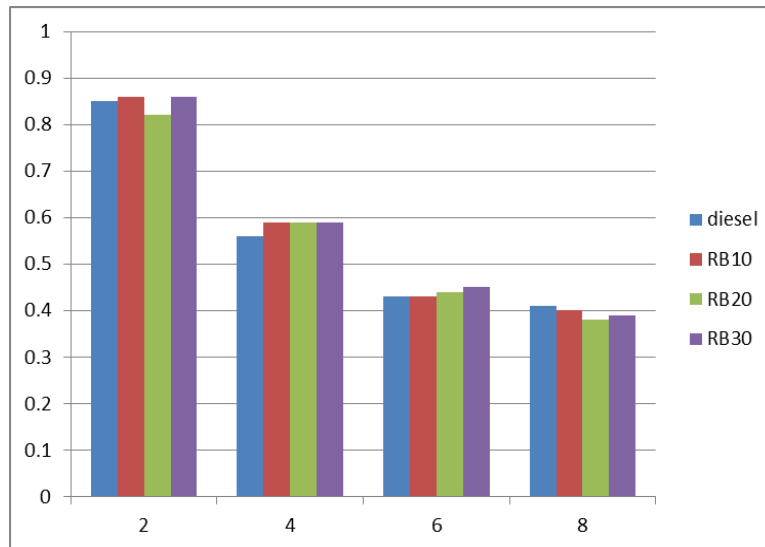


Fig.6:at C.R14(Load vs BSFC).

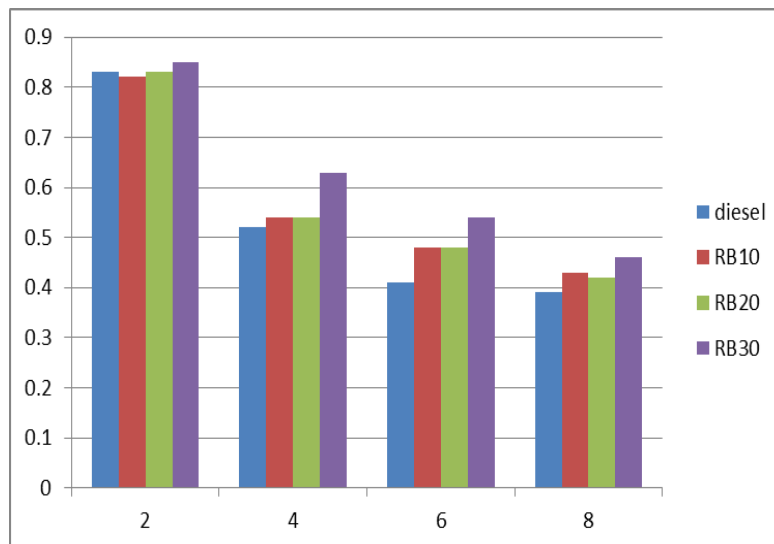


Fig.7:at C.R16(Load vs BSFC).

**2. BMEP analysis:** -Figure 8 to 9 shows a comparison of the variation of BMEP with CR 14 and 16 and with load Rice bran oil with Diesel oil at 2kg, 4kg, 6kg and 8kg at IP 200 bar. Brake Mean Effective pressure (BMEP) is the external shaft work per unit volume displacement of the engine. From the figures, it can be observed that CR effect is slightly significant effect on BMEP. It can be observed that BMEP increases linearly with load for all the rates of blends. As the load on the engine increases, the rate of fuel consumption resulting in Grate thermal energy release and hence effective pressure on the piston increases to develop the required brake power.

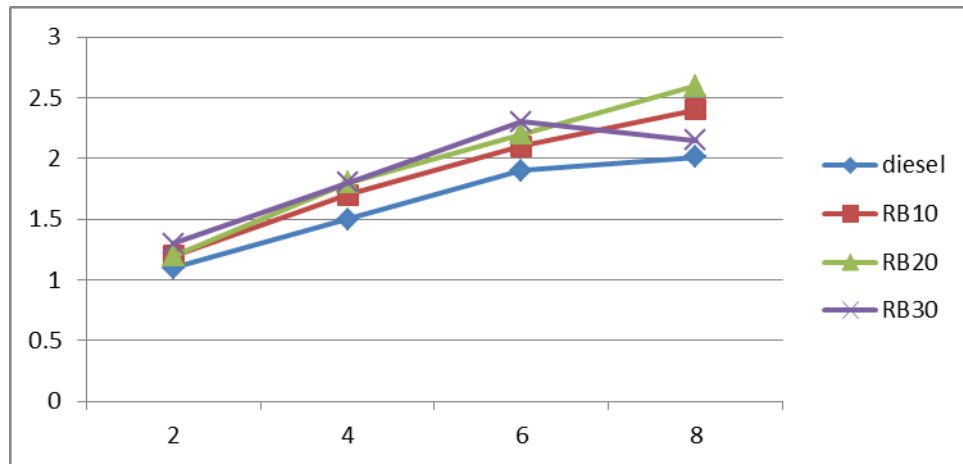


Fig.8: at C.R14(Load vs BMEP).

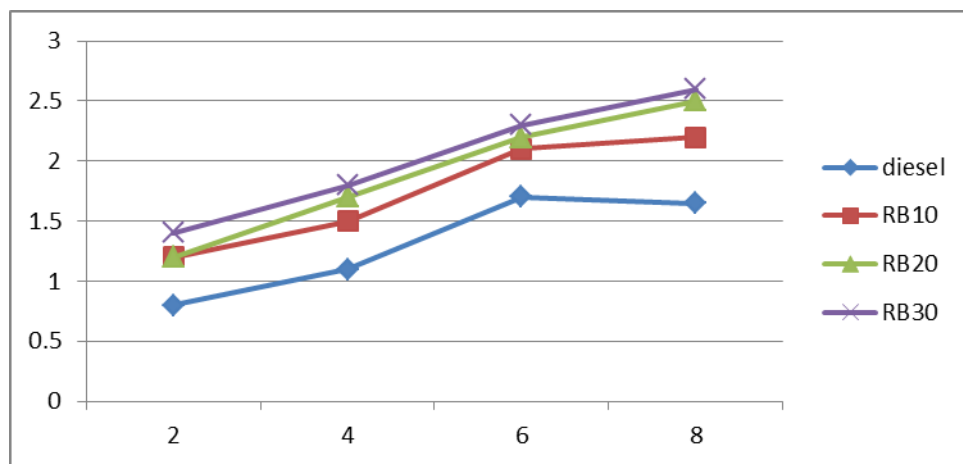


Fig.9: at C.R16(Load vs BMEP).

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