*IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*
*e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 15, Issue 6 Ver. III (Nov. - Dec. 2018), PP 20-27*
*www.iosrjournals.org*

# Emission and Performance testing of single cylinder CI engine with using ricebran biodiesel

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***Abstract:*** *The rate of petroleum reserve is declining while energy demand keeps increasing. The current expansion of the Indian economy has escalated petroleum demand, prices have surged, hurting the economies of poor and developing countries. India is the second largest rice producing country in the world. The estimated yield of crude Rice Bran Oil (RBO)is about 400,000 tons of which only 50% is of edible grade, 50% of the total available rice bran oil is left unutilized due to the presence of active lipase in bran and lack of economic stabilization methods most of the bran is used as animal feed or for industrial application. One of the best ways for the potential utilization of RBO is the production of biodiesel. Thus use of biodiesel from non-edible oil sources serves asana alternative fuel to overcome this problem. This study targets at finding the effects of the engine parameters to compare the performance of diesel and rice bran biodiesel blends. The consumption of fuels 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. The present study focuses on impact assessment of rice bran 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 RB10, RB20 and RB30 blends of 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.*

***Key Words:-Biodiesel; Transesterification; Rice bran oil; Diesel Engine, Blends***

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Date of Submission: 11-12-2018 Date of acceptance: 27-12-2018

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## I. Introduction

Liquid fuels from renewable resources are biodegradable and inexhaustible. In this regard vegetable oils having their physical and combustible characteristics close to diesel fuel may stand as immediate candidate subside for alternative fuel to reduce its dependence on imports. The rural development ministry, government of India hopes to introduce biodiesel for commercial use especially for automobile very soon. Bio-diesel is already in use in Italy, Brazil, US, Malaysia and Japan just that it's made from different natural sources in different places. In India biodiesel will be produced from oil-bearing trees available.

**A.Murugeanetal**. conducted experiment on production &analysis of biodiesel from non-edible oils. Bio diesel has become more alternative recently because of its environmental benefits and it is derived from renewable resources, bio degradable and non-toxic in nature. Several bio diesel production methods have been developed among which transesterification using alkali catalyst gives high level of conversation of transesterification is effected by the reaction condition , molar ratio of alcohol to oil ,type of alcohol, type and amount of catalyst, reaction there temperature , purity of reactants free fatty acids and water content of oil's or fats. Alternative fuels for diesel engines have become increasingly important due to decreasing petroleum resource and environmental consequences of exhaust gases from petroleum fuelled engines. 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 isan 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. Ricebran 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 [1,2].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 cetanenumber than diesel fuel, no aromatics, no sulfur, and contains10–11% oxygen by weight [3,4].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 thetransesterification method is used to reduce the high viscosity of oil [5–8].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% and3.2% 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 [9-10].Rice bran oil ranks first among the non-conventional, inexpensive, low-grade vegetable oils. Furthermore, crude ricebran 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 [11-13].The kinematic viscosity of crude rice bran oil and refined rice bran oil is however several times higher than that of diesel oil [6] 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 [4]. 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 ricebran 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.

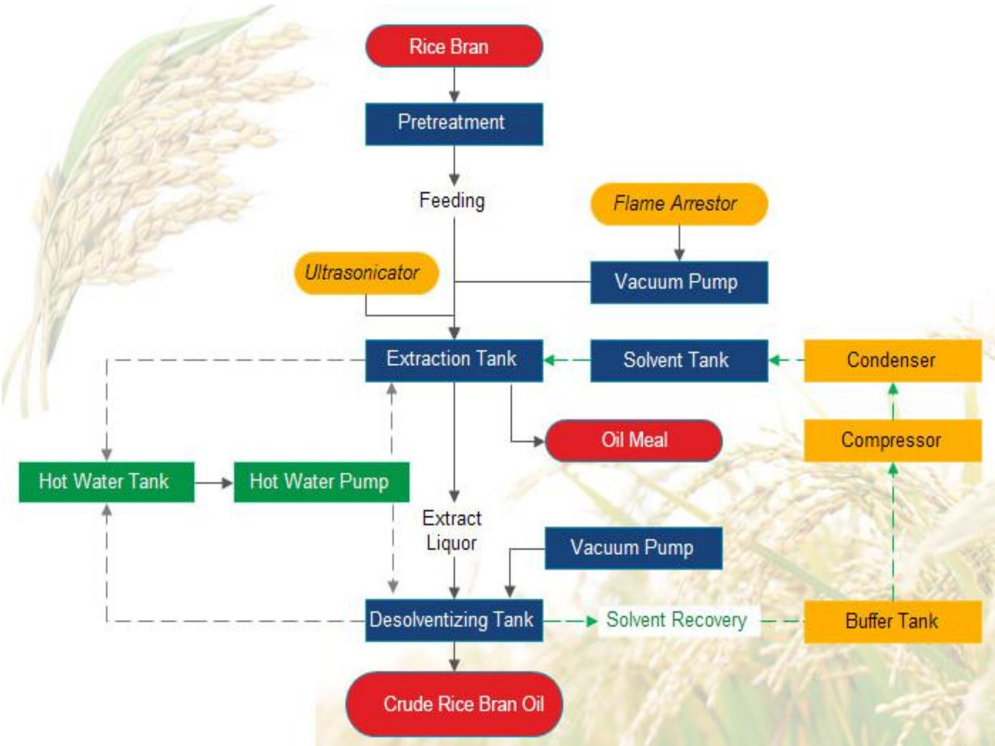


**Fig .1 Rice Bran Oil Extraction Process**

## II. Preparation of Biodiesel Blends

After production the RBO was blended with neat diesel fuel invarious volume concentrations to prepare biodiesel blends. These blends were subsequently used in the engine tests. Thelevel 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.

**Fig.2Rice bran powder and oil**

## III. 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-chemicalproperties is given in Table 2. of all the above test fuels 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 0–50 kg |
| Speed indicator | Digital with non-contact type speed sensor |
| Rated power | 3.5 Kw at 1500 RPM |
| Temperature sensor | Thermocouple |
| Rotameter | Engine cooling 40–400 LPH; calorimeter 25–250 LPH |
| 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 400c (Centi stokes) | 6.29 | 5 |
| Cloud point ($^0$C) | 7 | -6 |
| Pour point ($^0$C) | -3 | 3 |
| Carbon Residue(%) | 0.48 | 0.1 |
| Calorific value ( KJ/kg) | 37900.8 | 42,500 |
| Flash point, 0C | 152 | 159 |
| Fire point, 0C | 159 | 150 |

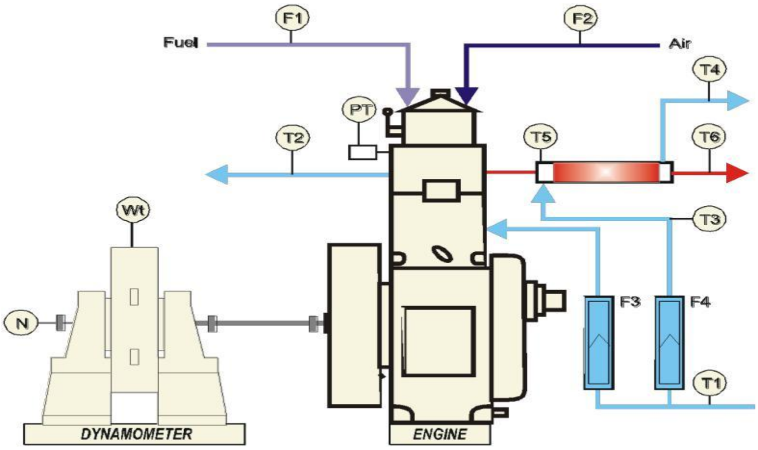


**Fig.3 Schematic arraignment**

## IV. Result and Conclusion

***1.Brake thermal efficiency*** - Results of performance characteristics of engine at CR 14 and 16 was conducted for pure diesel fuel which is base line fuel and then for different blends such as RB10, RB20 and RB30 samples. It was observed that BTHE increases when the break power was increased for all operations of diesel and bio-diesel blends. This was due to reduction in heat loss and increase in power with increase in brake power. The BTHE of RB10 and RB20blend was almost similar to conventional diesel fuel. The reason for comparable efficiency up to RB20 may be because of better combustion due to inherent oxygen and higher cetane number. But beyond RB20, the BTHE was slightly lower to that of diesel which may be due to lower calorific value and higher viscosity which was more dominant over inherent oxygen and higher cetane number. Because of higher viscosity of blends beyond RB20, the atomization of fuel will not be as good as it will be for lower viscosity at the same level of pressure developed by injector pump. Only RB30 showed value on the lower side. Maximum thermal efficiency achieved is about 17.54%for RB10. Minimum thermal efficiency achieved is about16.45% for pure diesel. Results from Fig. 4 and Fig.5 show that RB10has the maximum thermal efficiency whereas pure diesel has minimum thermal efficiency at full load conditions at CR 16.

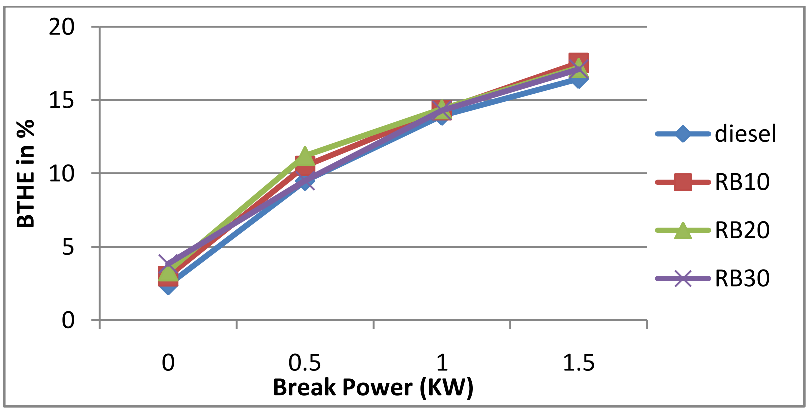


**Fig.4 Variation of BTHE with BP at C.R 14**

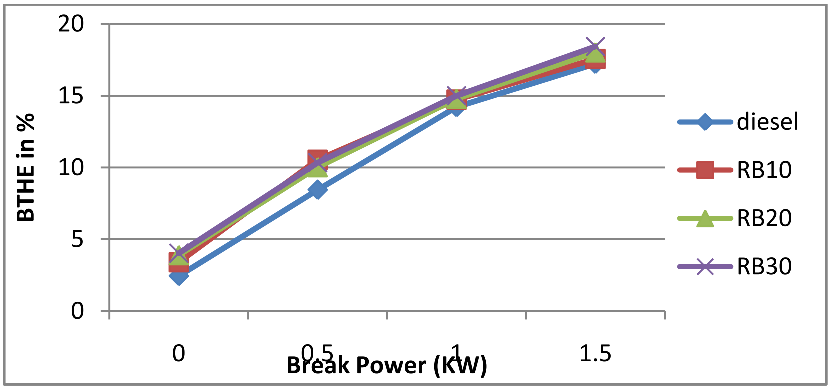


**Fig.5 Variation of BTHE with BP at C.R 16**

***2. Brake specific fuel consumption analysis:*** -The BSFC for different blends of fuel and that of conventional diesel at different brake power is reported in Fig. 6 and Fig.7. The test was conducted for pure diesel fuel which is base line fuel and then for different blends such as RB10, RB20 and RB30 samples. It was observed experimentally that the BSFC decreases when the break power was increased for all operations of diesel and bio-diesel blends. This reduction could be due to higher percentage of increase in brake power with load as compared to increase in fuel consumption. Also as break power increases the cylinder wall temperature also increases, which reduces the ignition delay. Thus shortening of ignition delay improves combustion and reduces fuel consumption. However the rate of decrease in BSFC was more during lower loads than that of higher loads. Also for RB30blend, the increase in BSFC was more than that of other blends and diesel operations at higher load conditions. This was due to the higher viscosity and lower calorific value ofRB30 as compared to other blends and conventional diesel fuel. At full load conditions the lowest BSFC obtained is about340 g/kWh for RB30 and highest obtained is 445 g/kWh for pure diesel.

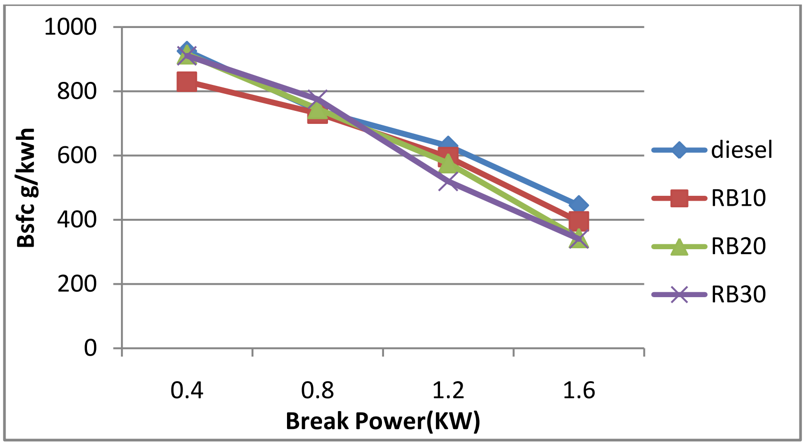


**Fig.6 Variation of BSFC with BP at C.R 14**

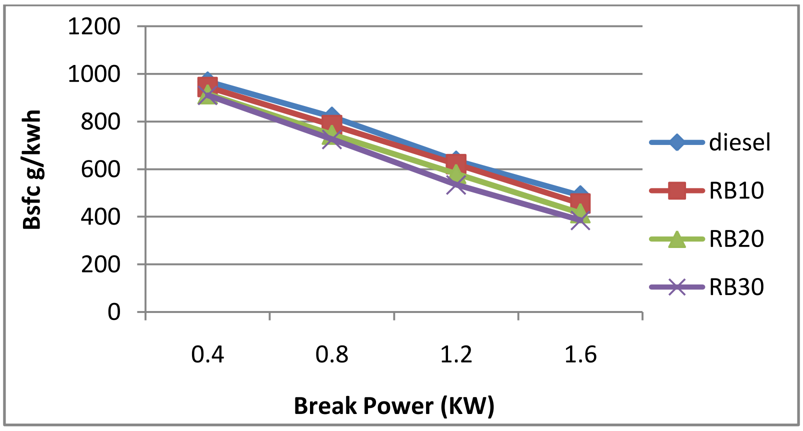


**Fig.7Variation of BSFC with BP at C.R 16**

***3. CO emission analysis:*** -Fig.8 and 9 shows a variation in carbon monoxide (CO) with brake power. At full load conditions lowest carbon monoxide of about 390 ppm was observed for RB10 followed by RB20(530 ppm), diesel (550 ppm) at CR 14 and highest of about 650 ppm for RB30 at CR 16. This can be due to the longer ignition delay observedfor RB30. Longer ignition delay along with increased BSFC decreases the air–fuel ratio inside the cylinder leaving less amount of air for complete combustion which in turn gives rise to higher CO emissions.RB10 and RB20 had carbon monoxide emission on the lower side whereas diesel andRB30 had emissions on the higher side.

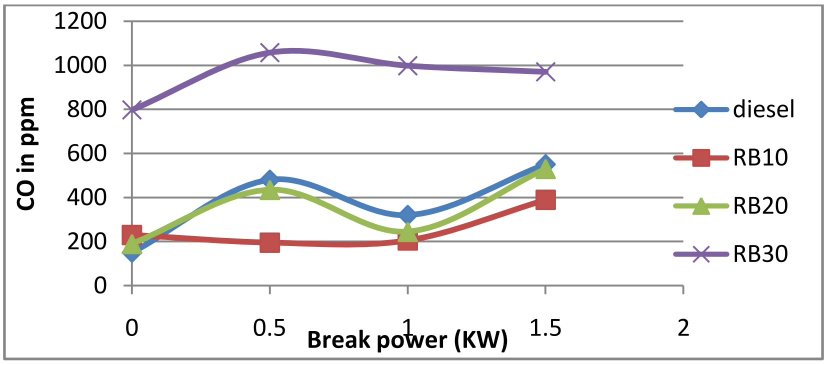


**Fig.8 Variation of CO with BP at C.R 14**

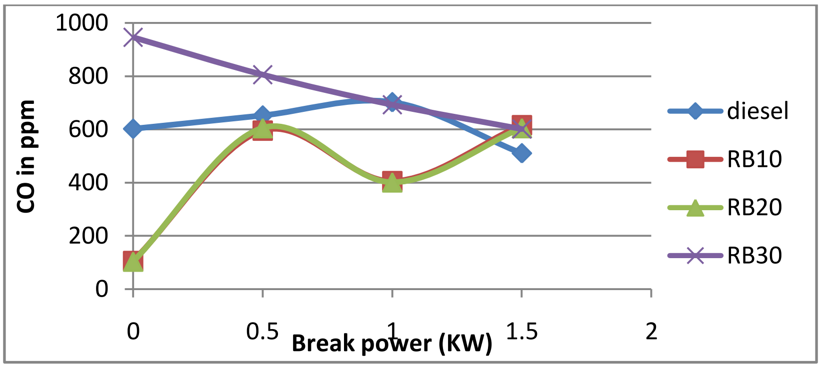


**Fig.9 Variation of CO with BP at C.R 16**

***4. $CO_2$emission analysis:*** - Fig 10 shows a variation in carbon dioxide (CO2) with brake power at CR 14. Full load conditions graphs show that RB10 has lower value of carbon dioxide, whereas RB30 showed a higher value of carbon dioxide emission at all load conditions. At full load conditions lowest value obtained is about 2.45% for RB10 and highest of about 3.65% for both RB30. Fig. 11 shows a variation in carbon dioxide ($CO_2$) with brake power at CR 16.From no load condition to full load conditions graphs show that RB10 and RB20 have the same type of variation. Only differences that carbon dioxide emissions for RB10 were on the higher side of the graph whereas RB20 were on the lower side.

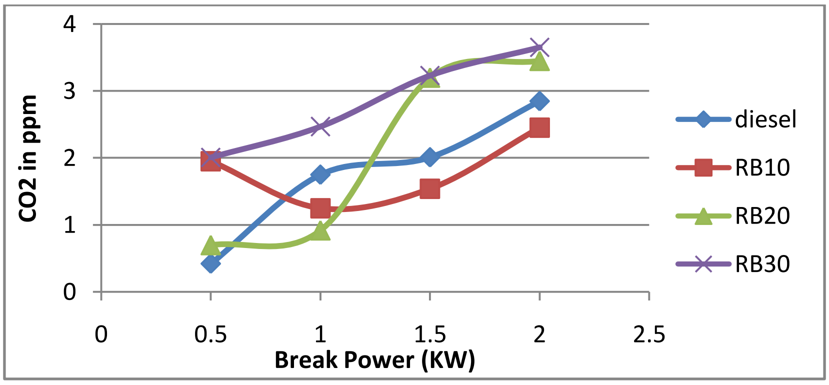


**Fig.10 Variation of CO2 with BP at C.R 14**

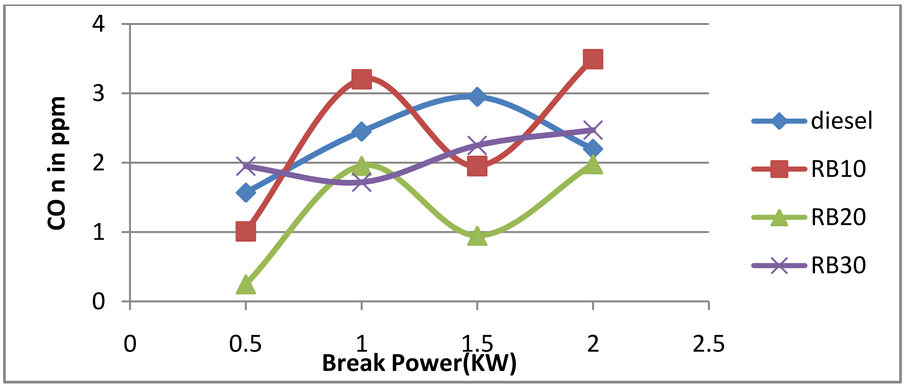


**Fig.11 Variation of CO2 with BP at C.R 16**

***5. HC emission analysis:***-shows a variation in hydro carbon (HC) with brake power. Diesel and RB10 showed same hydrocarbon emissions from no load to full load conditions at CR 14. This is due to their nearly same BSFC. Lowest hydro carbon emission of about 19 ppm was observed for RB20 at part load condition; whereas maximum hydro carbon emission of about 45 ppm was observedfor RB30 at full load conditions. Fig. shows that higher hydrocarbon emission for RB30 is due to its higher BSFC.Diesel and RB10 showed same hydrocarbon emissions from no load to full load conditions.

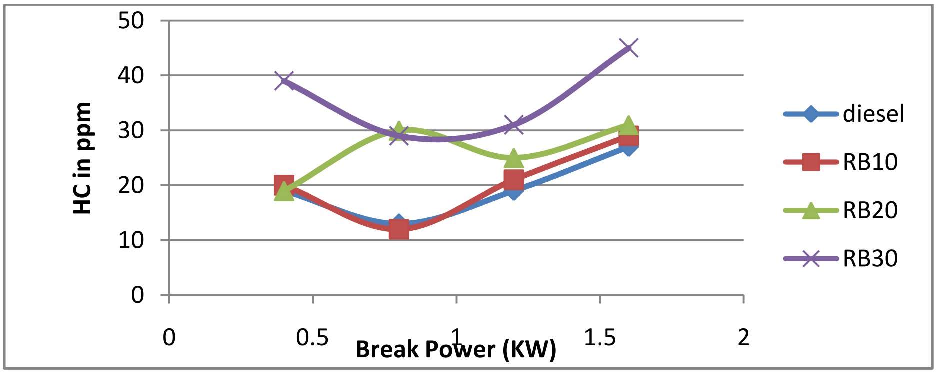


**Fig.12 Variation of HC with BP at C.R 14**

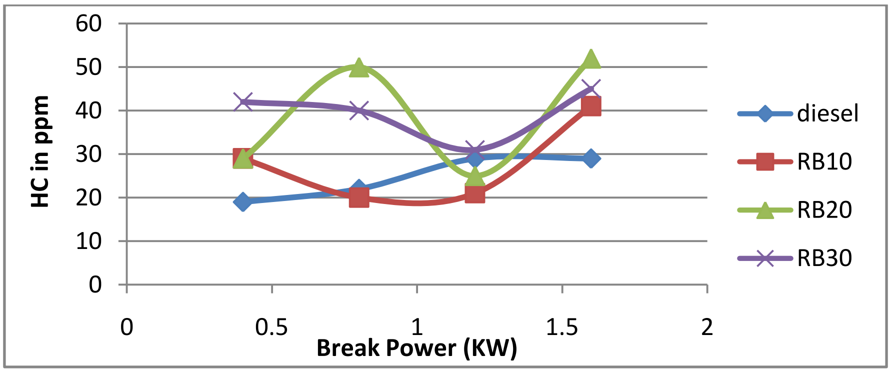


**Fig.13 Variation of HC with BP at C.R 16**

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Mr.SagarA Salunkhe. "Emission and Performance testing of single cylinder CI engine with using ricebran biodiesel." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), vol. 15, no. 6, 2018, pp. 20-27.