Study, Analysis of Performance and Emission Characteristics of Transesterificated Biodiesel -An Experimental Approach with Diesel-Rice Bran Biodiesel Blends

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***Abstract* - In view of the crude oil crisis and the effects on human and environment. Now it is the time to go for alternative solution in the direction of non- conventional fuel sources. This work is an attempt to provide some information in this regard for next generation.**

In this present investigation the oil is used rice bran oil which is generated by the waste rice husk . In the tests are conducted 4-stroke single cylinder diesel engine, air cooled direct injection, diesel engine by using the diesel. During second step experimental investigations are carried out on the same engine with same operating parameters by using rice bran oil blending with the diesel in different proportions such as RB20, RB30,RB40, RBE20, RBE30, RBE40 to find out the performance parameters and emissions. this work presents the experimental investigation carried out on 4-stroke single cylinder diesel engine with ethanal and ethyle Hexyl nitrate as additives to the diesel- bio diesel blends.

Ethanal was added as 10% by volume to the diesel, bio diesel blends and ethyl Hexyl Nitrate was added 2% to the diesel-bio diesel blends. It is observed that brake thermal efficiency increases in proportions to the blend percentage. The Co, Hc and Nox emissions are decreased when compared with diesel.

Keywords: Diesel, Rice-Bran oil, Diesel-Bio diesel blends, BTE ,ME, Indicated power, CO emissions,Co2,Nox.

1.INTRODUCTION:

1.1 Biodiesel As An Alternative Fuel:

Alternative fuels, known as non-conventional or advanced fuels, are any materials or substances that can be used as fuels, other than conventional fuels. Conventional fuels include: fossil fuels (petroleum, coal, propane and natural gas), as well as nuclear materials such as uranium and thorium, as well as artificial radioisotope fuels that are made in nuclear reactors, and store their energy.

Some well-known alternative include biodiesel, bio-alcohol (methanol, ethanol and butanol), chemically stored electricity (batteries and fuel cells), hydrogen, non-fossil methane, non-fossil natural gas and other biomass sources.

1.2 . Biodiesel

Bio-diesel is not your regular vegetable oil and is not safe to swallow. However, biodiesel is considered biodegradable, so it is considered to be much less harmful to the environment if spilled. Biodiesel also has been shown to produce lower tailpipe emissions than regular fuel. The best thing about biodiesel is that it is made from plants and animals, which are renewable resources.

1.3. Transesterification

Transesterification is otherwise known as alcoholisms. It is the reaction of fat or oil with alcohol to form esters and glycerin. A catalyst is used to improve the reaction rate yield.Among these methods transesterification process is the best process to produce the cleaner and environmentally safe form of vegetable oils.

1.4. Emissions

Since bio-diesel is made entirely from vegetable oil, it does not contain any sulfur, aromatic hydrocarbons, metals or crude oil residues. The emissions are which generate sulfuric acid in atmosphere. The reduced sulfur in absence of sulfur means a reduction in the formation of acid rain by sulfate the blend will also decrease the levels of corrosive sulfuric acid accumulating in the engine crankcase oil over time.

The lack of toxic and cryogenic aromatics (benzene, toluene and xylene) in bio-diesel means the fuel mixture combustion gases will have reduced impact on human health and the environment. The high cetane rating of bio-diesel (ranges from 49 to 62) is another measure of the additive’s ability to improve combustion efficiency.
Unfortunately, current “low aromatic, low sulfur” diesel still contains 20 to 25% aromatics. The cetane number enhancers can lower emissions to level equivalent to 10% aromatics.

But an engine running on 100% bio-diesel would have no aromatic emissions and the bio-diesel would me much safer to store and handle. In addition, bio-diesel blends have reduced emissions of polyaromatic hydrocarbons, another group of potentially carcinogenic substances found in petroleum.

1.5. Calorific Value

The total quantity of heat liberated by completely burning of one unit mass of fuel. The calorific value of a substance is the amount of energy released when the substance is burned completely to a final state and has released all of its energy.

Table 1.5.1
Properties of bio diesel compared with diesel

Properties	Bio diesel	Pure diesel
Pour point (^{0}c)	3	3
Carbon Residue(%)	0.48	0.1
Calorific value(kj/kg)	37900.8	42500
Cloud point (^{0}c)	-7	-6
Viscosity at 40^{0}c (Centi Stokes)	6.29	2.7
Densityat15^{0}c(gm/cc)	0.92	0.82

1.5.1.Preparation Of Blends:

The obtained rice bran oil is blended for conducting the performance test, the rice bran oil is mixed in proper proportions as shown in table 1.5.2

1. The rice bran oil is first filtered form impurities.
2. Required amount of fuel and rice bran oil is taken into the measuring jar and mixed thoroughly.

Notation	Fuel quenty(ml	Bio-diesel qty	Diesel qty	Additives ethanol ml	EHN ml
RB20	1000	200	800	------	-----
RB30	1000	300	700	----	----
RB40	1000	400	600	----	----
RBE20	1000	200	680	100	20
RBE30	1000	300	580	100	20
RBE	1000	400	480	100	20

Table 1.5.2. Blending Percentage of Fuel

2.EXPERIMENTAL WORK:

It is a 4 stroke, vertical, single cylinder, air cooled, constant speed diesel engine which is coupled to rope brake drum arrangement to absorb the power produced. The engine crank started. Necessary dead weights and spring balance are included to apply load on brake drum. Suitable air arrangement for the brake drum is provided. The air should be provided for engine cooling. A measuring system for fuel consumption consisting of a fuel tank, burette, and a 3- way cock mounted on stand and stop watch are provided. Air intake is measured using an air tank fitted with an orifice meter and a water U- tube differential manometer. Also digital temperature indicator with selector switch for temperature measurement and a digital rpm indicator for speed measurement are provided on the panel board. A governor is provided to maintain the constant speed.

3. EXHAUST GAS ANALYZER:

Exhaust emissions was measured with exhaust gas analyzer model. The measurement of emissions is based on the principle of light absorption by particle. The signal from the transducer was transmitted to allow noise cable to a charge amplifier and then was connected to the oscilloscope. Continuous charging of the analyzer is essential to work in an effective way. A valve is fitted in the exhaust pipe of the engine to obtain a part of the engine exhaust for monitoring. All emissions like carbon monoxide, carbon dioxide, un-burnt hydrocarbons, nitrogen oxide and unused oxygen are found.

4.OPERATING PRINCIPLE:

- The instrument detects the CO/HC/CO_2 content according to the principle by which the selective absorption of infrared is measured for each gas. O_2 sensor is measured by means of electrochemical sensor.
- The sample gas is taken through the exhaust by means of the probe. The intake exhaust gas is further made free from the moisture with the help of moisture separator element. Dust is removed with the help of dust element & inward filter. Then condensed moisture is routed to exhaust of the analyzer through pump. Dust / Moisture free sample gas is feed to the measuring cell.
- Infrared light beam is directed to the measurement components (like optical filter & sensor), which is weakened at a certain wavelength by the sample gases in the cell.
- Weakening occurs at specific wavelengths according to the type of gas in question (absorption spectrum). Molecules of gas with same type atoms (H_2/N_2/O_2) cause no absorption in the infrared region of the spectrum. On the other hand, molecules with different types of atoms (CO, HC, and CO_2) show different absorption bands in the infrared region. The greater the gas concentration is, the greater the absorption with be. These variations can be detected with the aid of electronic sensors preceded by respective optical filters which allow infrared rays to pass only at the specific wavelengths.
- The oxygen percentage is detected by means of sensor of the electrochemical type that transmits a linear electrical signal according to the effective percentage of oxygen.

4.1.Experimental Observations For Diesel:

Experiment is conducted on the specified diesel engine using diesel and observations are tabulated below upon using various loads (like 0%, 25%, 50%, 75% and 100%) at constant speed and same injection pressure. Note down the exhaust temperature, time taken for 10cc of fuel consumption and the manometer readings. The readings are used to evaluate the performance parameters and results are tabulated. Connect the exhaust pipe to the exhaust gas analyzer and corresponding readings are tabulated.

Table4.11 Experimental Observations for Diesel FUEL

S.NO	Load (%)	Voltage (volts)	Current (Amp)	Exhaust Temp(C)	Sped (rpm)	Time for fuel consumption 'X'cc (sec)	H= (manometer)
1	0	235	0	197	1500	59	122
2	25	230	4.5	248	1500	45	118
3	50	225	9	307	1500	37	113
4	75	220	13.5	375	1500	28	108
5	100	215	18	487	1500	20	103

Table 4.12 Experimental Results for Diesel FUEL

SNO	BP(KW)	IP(KW)	η_{mech} %	η_{BTE} %	η_{ITE} %	BSFC (kg/kW-hr)
1	0	3.3392	0	0	53.100	---
2	1.1	1.0978	28.7015	14.2648	49.700	0.593
3	2.2	5.5521	41.4460	22.9477	55.367	0.369
4	3.3	6.5184	51.776	25.4699	49.192	0.332
5	4.4	7.7018	57.099	23.7058	41.516	0.357

Table 4.13 Experimental Observations of Exhaust Emissions for Diesel FUEL

S. No	Load (%)	BP (kW)	CO (%)	HC (ppm)	CO2 (%)	NOx (ppm)
1	0	0	0.06	25	2.3	223
2	25	1.1	0.05	27	3.2	312
3	50	2.2	0.04	27	4.3	563
4	75	3.3	0.05	30	5.9	793
5	100	4.4	0.05	47	7.9	971

5. RESULTS AND DISCUSSION

5.1.Introduction :

The experiments are conducted on the four stroke single cylinder water cooled diesel engine at constant speed (1500 rpm) with varying loads with diesel and different blends of Rice bran oil like RB25,RB35,RB45,RBE25,RBE35 andRBE45. Various performance parameters such as brake thermal efficiency, mechanical efficiency, indicated thermal efficiency, brake specific fuel consumption, indicated power and emission parameters in the sense of unburned hydrocarbons, carbon monoxide, carbon dioxide and oxides of nitrogen are discussed below.

5.2.Performanceanalysis Using Diesel And Rice Bran Oil Blends

The experiments are conducted on the four stroke single cylinder air cooled diesel engine at constant speed (1500 rpm) with varying loads. Various performance parameters such as brake thermal efficiency, mechanical efficiency, indicated thermal efficiency, brake specific fuel consumption, indicated power are evaluated and discussed below.

5.3. Brake Thermal Efficiency

The variation of brake thermal efficiency with brake power is shown in Fig. 6.1. From the plot it is observed that as load increases brake thermal efficiency is also increases for diesel as well as the blends of rice bran oil. At full load condition, the brake thermal efficiencies are obtained 25.96%, 24.72%, 25.83%,26.45%,27.47%,29.87%,and 23.7%for fuels of diesel,RB20,RB30,RB40,RBE20,RBE30 andRBE40 respectively. Among the six blends of Rice bran oil the maximum BTE is 29.87% which is obtained for RBE30. The BTE of Rice bran oil is increases up to 4.56% as compared with diesel at full load condition. The increment in brake thermal efficiency is due to the better combustion because of high calorific value and less viscosity of the Rice bran oil.

Table 5.1.Variation of Brake Thermal Efficiency with Brake Power

S. NO	BRAKE POWER (KW)	BRAKE THERMAL EFFICIENCY (%)						
		RB 20	RB 30	RB 40	RBE 20	RBE 30	RBE 40	DIESEL
1	0.6	10.80	12.16	11.64	13.88	14.88	16.11	9.554
2	1.17	15.20	15.86	16.23	16.22	16.99	18.22	14.264
3	2.3	23.28	23.28	25.0	24.66	25.77	27.55	22.947
4	3.3	26.56	26.56	27.75	27.34	26.99	28.99	25.469
5	4.3	25.96	24.72	25.83	26.45	27.47	29.87	23.705

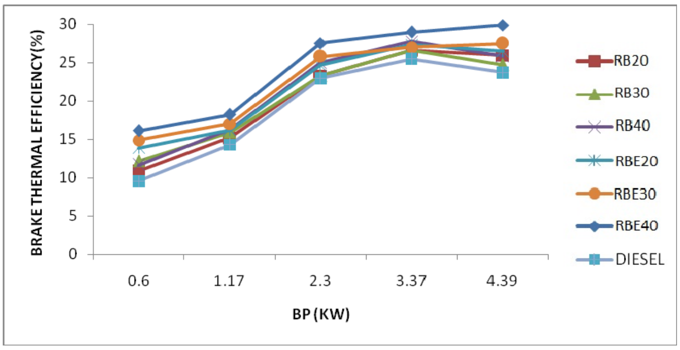

Fig 5.1.Brake power Vs Brake thermal efficiency

5.4. Mechanical Efficiency

The variation of mechanical efficiency with brake power is shown in Fig. 5.2.From the plot it is observed as load increases mechanical efficiency is also increases for diesel as well as the blends of rice bran oil. At full load condition the mechanical efficiencies obtained 70.11%,71.48%,73.34%,69.66%,67.43%,79.76% and 57.09% for fuels of diesel,RB20,RB30,RB40,RBE20,RBE30 andRBE40 respectively. From the above results the mechanical efficiency of Rice bran blend RBE30 increases with compared diesel at full load condition

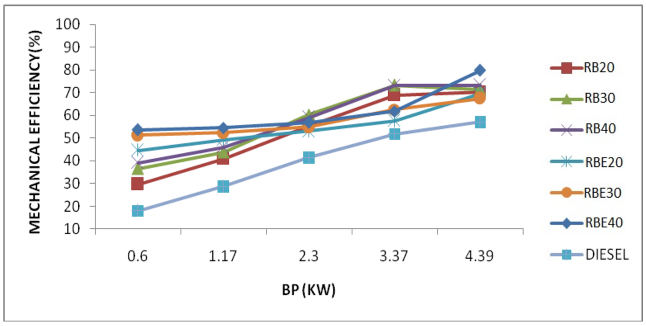

Fig 5.2.Brake Power Vs Mechanical Efficiency

5.5. Brake Specific Fuel Consumption

The variation of brake specific fuel consumption with brake power is shown in Fig 5.3 The plot it is reveals that as the load increases the fuel consumption decreases. At full load condition the BSFC obtained are 0.34kg/kw-hr, 0.35 kg/kw-hr, 0.35kg/kw-hr, 0.35kg/kw-hr,034kg/kw-hr, 0.33kg/kw–hr and0.35kg/kw-hrfor fuels of diesel, RB20,RB30,RB40,RBE20,RBE30 andRBE40 respectively. The minimum fuel consumption is for RBE40 is 0.36 kg/kW-hr. The BSFC of rice bran oil blend RBE40 is decreases with compared to diesel at full load condition. The rice bran oil blends shows minimum BSFC value than diesel due to the rice bran oil calorific value is high as compared to diesel fuel.

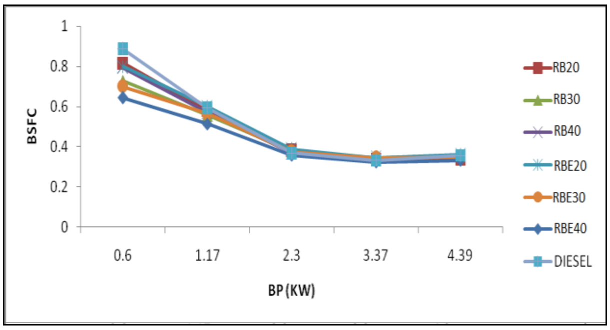

Fig5.3BrakePowerVsBrake specific fuel consumption

5.6. Indicated Power:

The variation of indicated power with brake power is shown in Fig 5.4The plot it is reveals that as the load increases the indicated power decreases. At full load condition the Indicated Power obtained are 6.27kw,6.15 kw,5.99 kw,4.85 kw 4.59 kw,4.33 kw, and 7.70 kw for fuels of diesel, RB20,RB30,RB40,RBE20,RBE30 andRBE40 respectively. The Indicated Power of rice bran oil blend RB25 is decreases with compared to diesel at full load condition.

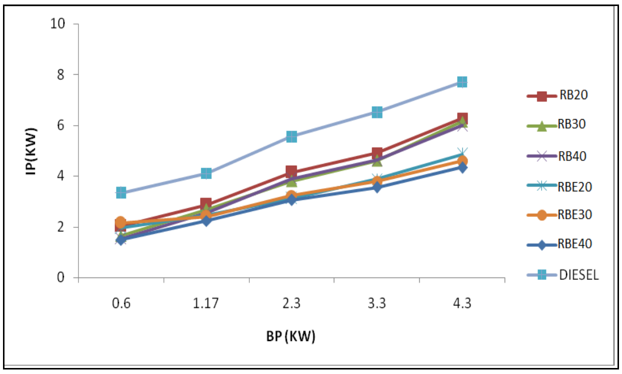

Fig 5.4.Brake Power Vs Indicated power

6. EMISSIONANALYSISUSING DIESEL AND RICE BRAN OIL BLENDS

6.1.Carbon Monoxide (CO) Emissions

The variation of CO emission with brake power is shown in Fig 6.1 The plot it is observed that is interesting to note that the engine emits more CO for diesel as compared to biodiesel blends under all loading conditions. At full load condition the CO emission obtained are 0.45%, 0.61%, 0.77%, 0.67%, 0.62%, 0.59% and 0.07% for fuels of diesel RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The CO concentration is decreases for the blends of RBE30 with compared to diesel and all other blends. At lower rice bran oil concentration, the oxygen present in the biodiesel aids for complete combustion. However as the rice bran oil concentration increases, the negative effect due to viscosity and small increase in specific gravity suppresses the complete combustion process, which produces small amount of CO.

Table 6.1.Variation of Carbon Monoxide With Brake Power

S. NO	BRAKE POWER (KW)	Carbon Monoxide (CO)						
		RB 25	RB 35	RB 45	RBE 25	RBE 35	RBE 45	DIESEL
1	0.6	0.06	0.06	0.06	0.05	0.05	0.05	0.06
2	1.17	0.07	0.06	0.06	0.06	0.06	0.04	0.05
3	2.3	0.05	0.05	0.04	0.05	0.05	0.03	0.04
4	3.3	0.06	0.06	0.05	0.05	0.05	0.04	0.05
5	4.3	0.45	0.61	0.77	0.67	0.62	0.59	0.70

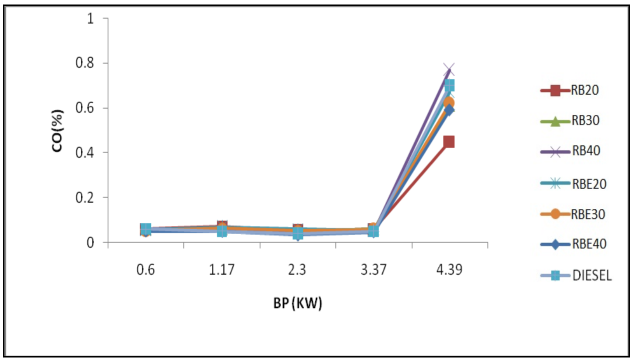

Fig 6.1.Brake Power Vs Carbon monoxide

6.2. Carbon Dioxide (CO_2) Emissions

The variation of carbon dioxide with brake power is shown in Fig 6.2. The plot is revels that as the the load increases theCO2 emission decreases. At full load condition the CO2 emissions obtained are 7.8%,7.7%,7.5%,7.2%,6.9%, 5.3% and 7.9% for fuels of diesel,RB20, RB30, RB40, RBE20, RBE30 and RBE40respectively. The CO2 emissions of rice bran oil blend RBE20decreased when compared to the diesel at full load condition.

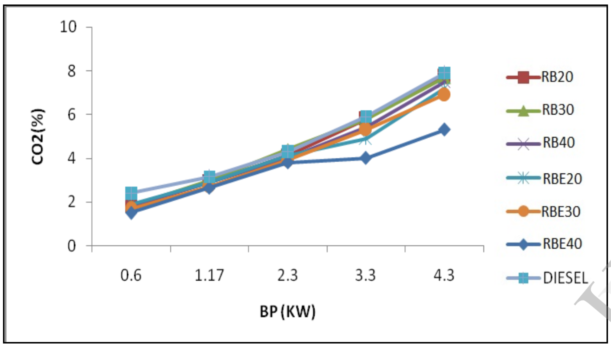

Fig 6.2.Brake power Vs Carbon dioxide

6.3.Unburned Hydrocarbon (HC) Emissions

The variation of HC emission with brake power is shown in Fig 6.3 The plot it is observed that the load increases the HC emission decreases. At full load condition the unburned hydrocarbons are obtained are40ppm, 42ppm, 38ppm, 39ppm, 37ppm, 19ppm and 47ppm, for fuels of diesel, RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The HC emission of rice bran oil blend RB20 decreased when compared to the diesel at full load condition.

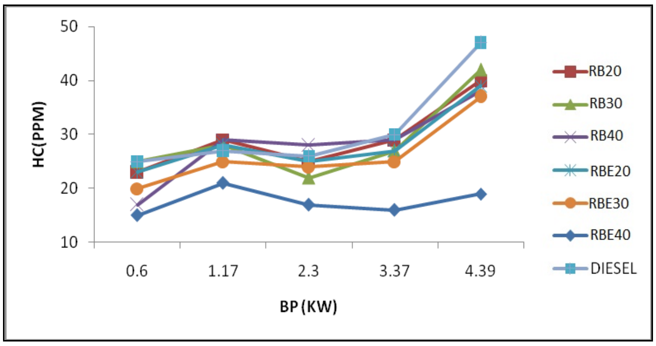

Fig 6.3BrakePower versus Unburned Hydrocarbons

6.3.5.Oxides of Nitrogen (NOx) Emissions

The variation of NOx emission with brake power is shown in Fig 6.4 the plot it is reveals that as the the load increases the NOx emission decreases. At full load condition the NOx emissions obtained are 592ppm, 579ppm, 541ppm, 875ppm, 783ppm, 530ppm and 971ppmfor fuels of diesel, RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The NOx emission ofRice bran oil blend RBE30 decreased when compared to the other blends at full load condition.

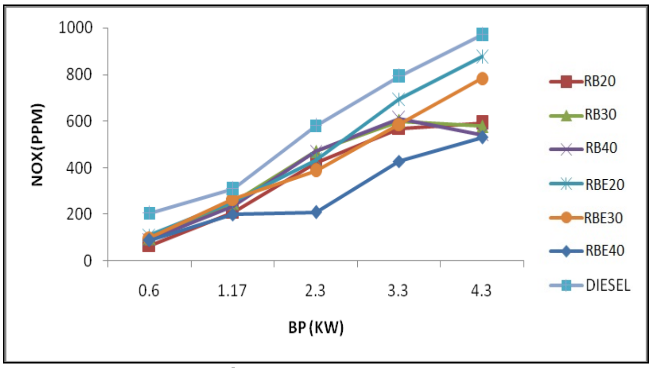

Fig 6.4 Brake Power versus NO x Emissions

7.CONCLUSION:

A single cylinder compression ignition engine was operated successfully using blends of rice bran oil like RB20, RB30, with diesel fuel. The following conclusions are drawn based on the experimental results.

- At full load condition the BSFC obtained are 0.34kg/kw-hr, 0.35 kg/kw-hr, 0.35kg/kw-hr, 0.35kg/kw-hr, 034kg/kw-hr, 0.33kg/kw-hr and 0.35kg/kw-hr for fuels of dieselRB20, RB30, RB40, RBE20, RBE30 and RBE40,. The minimum fuel consumption is for RBE40 is 0.33kg/kW-hr as to that of diesel are 0.35kg/kW-hr. The BSFC of Rice bran oil blend RBE40 is decreases as compared with Diesel at full load condition. RB40, RBE20, RBE30 and RBE40respectively as an alternative fuel and the performance and emissions are compared
- At full load condition the brake thermal efficiencies are obtained 25.96%, 24.72%, 25.83%, 26.45%, 27.47% and 29.87% for fuels of diesel, RB20, RB30, RB40, RBE20, RBE30 and RBE40respectively., among the six blends of Rice bran oil the maximum BTE is 27.47% which is obtained for RBE30. The BTE of Rice bran oil is increases as compared with Diesel at full load condition.
- At full load condition the unburned hydrocarbons are obtained 40ppm, 42ppm, 38ppm, 39ppm, 37ppm, 19ppm and 47ppm, for fuels of diesel,RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The unburned hydrocarbons of Rice bran oil blend RB20 is decreases as compared with Diesel at full load condition.
- At full load condition the CO emission obtained are 0.45%, 0.61%, 0.77%, 0.67%, 0.62%, 0.59% and 0.7% for fuels of diesel,RB25, RB35, RB45, RBE25, RBE35 and RBE45 respectively. The carbon monoxide (CO) of Rice bran oil blend RBE35 is decreases as compared with Diesel at full load condition.

- At full load condition the NOx emission obtained are 592ppm, 579ppm, 541ppm, 875ppm, 783ppm, 530ppm and 971ppm for fuels of dieselRB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The oxides of nitrogen(NOx) of rice bran blend RBE30 is decreases as compared with Diesel at full load condition
- Exhaust emissions like unburned hydrocarbons, carbon dioxide, carbon monoxide and NOx are decreases of Rice bran oil blends as compared to diesel fuel.

From the above analysis the blend RBE30 shows the better performance compared to other blends (RB20, RB30, RB40, RBE20 and RBE40) in the sense of performance parameters like brake thermal efficiency, mechanical efficiency, indicated thermal efficiency, brake specific fuel consumption, indicated power and emission parameters like unburned hydrocarbons, carbon monoxide, carbon dioxide and oxides of nitrogen. Hence due to the better performance RBE35 is taken as optimum blend.

8. REFERENCES:

1. Ram Prakash,S.P.Pandey,S.Chatterji, S.N. Singh," Emission Analysis of CI Engine Using Rice Bran Oil and their Esters". JERS/Vol.II/ Issue I/2011,page no.173-178.
2. 2.B.K.Venkanna, C. Venkataramana Reddy, Swati B Wadawadagi, "Performance, Emission and Combustion Characteristics of Direct Injection Diesel Engine Running on Rice Bran Oil / Diesel Fuel Blend". International Journal of Chemical and Bio molecular Engineering vol 2, No.3,2009.
3. T. VenkateswaraRao a, G. PrabhakarRao , and K. Hema Chandra Reddy ," Experimental Investigation of Pongamia, Jatropha and Neem Methyl Esters as Biodiesel on C.I. Engine." Jordan Journal of Mechanical and Industrial Engineering, vol.2, no.2,jun 2008,pg no.117-122.
4. S. Murugana, M.C. Ramaswamy and G. Nagarajan, "The Use of TyrePyrolysis Oil in Diesel Engines". Volume 28, Issue 12, December 2008, Pages 2743-2749.
5. G Lakshmi NarayanaRao, S Sampath, K Rajagopal, "Experimental Studies on the Combustion and Emission Characteristics of a Diesel Engine Fuelled with Used Cooking Oil Methyl Ester and its Diesel Blends". International Journal of Applied Science, Engineering and Technology,vol. 4,no.1, 2008,pg no 64-70.
6. A.S. Rocha, M. Veerachamy, V.K. Agrawal& S.K. Gupta, "Jatropha Liquid Gold – The Alternative to Diesel".1st WIETE Annual Conference on Engineering and Technology Education, page no. 22-25, February 2010.
7. Deepak Agarwal ,Avinash Kumar Agarwal , " Performance and Emissions Characteristics of Jatropha Oil (preheated and blends) in a Direct Injection Compression Ignition Engine". Applied Thermal Engineering an international journal vol.27, (2007),page no. 2314–2323.
8. D.H. Qi, L.M. Geng, H. Chen, Y.ZH. Bian, J. Liu, X.CH. Ren, "Combustion and Performance Evaluation of a Diesel Engine Fueled with Biodiesel Produced from Soybean Crude Oil". Renewable Energy an international journal,vol. 34, (2009),page no. 2706–2713.
9. N.R. Banapurmatha,_, P.G. Tewaria, R.S. Hosmath, "Performance and Emission Characteristics of a DI Compression Ignition Engine Operated on Honge, Jatropha and Sesame Oil Methyl Esters". Renewable Energy an international journal,vol. 33,2008, page no.1982-1988.
10. Ali Keskina, MetinGu¨ ru¨ b,_, Duran Altiparmakc, KadirAydin, "Using of Cotton Oil Soapstock Biodiesel–Diesel Fuel Blends as an Alternative Diesel Fuel". Renewable Energy an international journal. Vol.33 (2008),page no. 553–557.