# Evaluation of a diesel engine using rice bran oil as a Bio-Diesel

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Abstract
*The rapid depletion of petroleum fuels and their ever increasing costs and concern for vehicular emissions have led to an intensive search for alternative fuels. At present, biodiesel is commercially produced from the refined edible vegetable oils such as sunflower oil, palm oil and soybean oil, etc. esterification process. The various parameters that have been considered for the Research in this direction with edible oil has yielded encouraging results with rice bran oil which is edible has been considered as an alternative fuel. It also observed that with bio-diesel, the engine is capable of running without difficulty but with a deviation from its optimum performance. This process is not suitable for production of biodiesel from many unrefined non-edible vegetable oils because of their high acid value. The blends of varying proportion of RBO oil and diesel were prepared, compared and analyzed with diesel fuel and calculated using HC, CO, NOx Brake specific fuel consumption, smoke density, Exhaust gas temperatures were analyzed. The biodiesel production method consists of pretreatment followed by an alkaline-catalyzed transesterification. RBO is the best biodiesel to use the internal combustion engine and give the better result and compared with the others. The important properties of methyl esters of rice bran oil are compared with other esters and diesel.. The lower blends of biodiesel increase the brake thermal efficiency and reduce the fuel consumption. The exhaust gas emissions are reduced with increase in biodiesel concentration. The experimental results proved that rice bran oil can be substituted for diesel without any engine modification as a fuel. In this research work 40to 60% of the RBO is effective combination to give the better results. Finally Pure rice bran oil, diesel and biodiesel are used as fuels in the compression ignition engine and the performance and emission characteristics of the engine are analyzed*

***Keywords**: Transesterification, Rice bran oil, Bio-Diesel, CI engine,*

## 1.INTRODUCTION

The consumption of diesel oil is several times higher than that of petrol. Due to the shortage of petroleum products and its increasing cost, efforts are on to Depleting petroleum reserves, rising petroleum prices, threat to the environment from exhaust emissions and global warming demands an intensive international interest in developing alternative non petroleum fuels for engines develop alternative fuels especially, to the diesel oil for full or partial replacement [3, 5]. It has been found that the vegetable oils are promising fuels because their properties are similar to that of diesel and are produced easily and renewably from the crops which is considered a potential alternative fuel for engine, has been chosen to find out its suitability for use as fuel oil.

The properties of rice bran oil compares well against other Vegetable oils have comparable energy density, cetane number, heat of vaporization and stoichiometric air-fuel ratio with that of the diesel fuel can be easily mixed with diesel in any proportion and can be used to partially substitute diesel. Therefore, in this study a simple method of increasing the efficiency and reducing the exhaust gas emissions of the diesel engine without any compromise on the power output of the engine has been adopted. None other than Rudolph Diesel, the father of diesel engine, demonstrated the first use of vegetable oil in compression ignition engine. He used peanut oil as fuel for his experimental engine. However in practice of diesel, rice bran oil and their Viscosity of vegetable oils is several times higher than that of diesel. Conversion of vegetable oil to biodiesel is affected by different parameters of Viscosity of liquid fuels affects the flow properties of the fuel, such as spray atomization, consequent vaporization, and air-fuel mixing in the combustion chamber. Also the rapid depletion of petroleum fuels and their ever increasing demand have led to an intense search for alternative fuels. [1,2,4]

Alternative fuels are being explored worldwide to reduce environmental pollution. In recent years, systematic efforts were under taken by many researchers to determine the suitability of vegetable oil and its derivatives as fuel, Blending, emulsification, thermal cracking and transesterification are the commonly adoptable methods to use the vegetable oil as fuel in diesel engines [4]. Recent years, biodiesel have received significant attention both as a possible renewable alternative fuel and as an additive to the existing petroleum-based fuels. Biodiesel exhibits several merits when compared to that of the existing petroleum fuels. It is well known fact that fuel is critical to any strategic plan for economic researchers have shown that particulate matter, unburned hydrocarbons, carbon monoxide, and sulfur levels are significantly less in the exhaust gas while using biodiesel as fuel. However, an increase in the levels of oxides of nitrogen is reported with biodiesel [11]. Presently, considerable research has been undertaken to understand the performance of alternative fuels.

Biodiesel is a chemically modified alternative fuel for use in diesel engines, derived from vegetable oils and animal fats. Biodiesel is produced commercially by the transesterification of vegetable oils with alcohol. Methanol or ethanol is the commonly used alcohols for this process. These can also be produced from the biomass sources. The direct use of alcohols as fuel causes corrosion of various parts in the engine. The fuel has assumed serious economic

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consequences in the form of budget deficits caused by oil imports and ecological degradation of the material. The carbon cycle of vegetable oils consists of release and absorption of carbon dioxide. Combustion and respiration process release carbon dioxide and crops for their photosynthesis process absorb the carbon dioxide. Thus, the accumulation of carbon dioxide in atmosphere reduces [6, 9]. The carbon cycle time for fixation of CO2 and its release after combustion of biodiesel is operated at the rated speed of the engine.

The engine was used to started in neat diesel fuel and dynamometer is used to warm up to conducted some tests in America and some other north African states are using biodiesel as the alternative fuel for in-service motor coaches. This was an exploratory investigation to determine the effect of fuel on the engine is very useful biodiesel to run the engine without increase blends level to improve the performance of the engine [12]. This testing proved that the biodiesel could easily be used as a feasible alternative fuel. The biodiesel is carried out experiments on a direct injection turbocharged diesel engine using methyl esters of rapeseed oil. It has been reported by them that, at the same injection timing, methyl ester promoted a rise in $NO_x$ emissions and decrease of HC and CO together with a strong reduction of smoke.

At high loads using single injection, particle and CO emission were decreased. A slight increase in $NO_x$ was observed as the biodiesel concentration is increased [10]. But in the case of multiple injection, decrease in particulate emission was observed with little or no effect on $NO_x$. At low loads, addition of biodiesel and multiple injection schemes were found to be detrimental to particulate matter and CO emission.

The Present investigation focuses on the use of neat Rice bran oil, transesterified Karanja oil and their blends with diesel as fuel in Compression Ignition (CI) Engines while Rice bran oil and its blend with Mineral oil as crankcase lubricating oil. Experimental results of various researchers support the use of biodiesel as a viable alternative to the diesel oil for use in the internal combustion engines. It is also important to note that most of the experiments conducted on biodiesel are mainly obtained from refined edible type oils only [3]. The price of refined oils such as sunflower, soybean oil and palm oil are high as compared to that of diesel. This increases the overall production cost of the biodiesel as well. Biodiesel production from refined oils would not be viable as well as economical for the developing countries like India [5,9]. Hence, it is better to use the non-edible type of oils for biodiesel production. In India, non-edible type oil yielding trees such as linseed, castor, karanji, neem, rubber, jatropha and cashew are available in large number Utilization of these oils/biodiesel as fuels in internal combustion engines are not only reducing the petroleum usage, but also improve the rural economy. Efforts are to be maintained objective of the study is to investigate the performance and emission characteristics of the CI Engine at different load conditions [7]. Chemical modification of vegetable oils and/or the use of antioxidants can address this problem, but increase the cost. Another negative to vegetable oils is their high pour point.

**2. Rice bran oil**

Rice is the one of the world's most important food crops than half of the people in the world eat rice as the main part of their diets. A typical kernel is 6.4mm to 9.25mm long. In the present investigation, the rice bran oil, a non-edible type vegetable oil is chosen as a potential alternative for producing biodiesel and use as fuel in compression ignition engines [8]. The annual rice bran production potential in India is to varies 8% of rice is produced by milling process of paddy depending on variety of rice of degree of milling At present, rice bran oil does not find any major application and hence even the natural production of seeds itself remains underutilized[5]. The resulting bran is typically a by- product of the milling process which is unfit for human consumption. The significant properties of rice bran oil are found out during the present investigation. The comparisons of properties of rice bran oil with that of other oils are given. The characteristics of the vegetable oils fall within a fairly narrow band and are quite close to those of the diesel oil. Rice bran oil have about 15% less heating value than that of diesel oil due to the oxygen content in their molecules. The kinematic viscosity of rice bran oil is, however, several times higher than that of diesel oil [4, 6]. The high viscosity leads to problems in pumping and atomization in the injection system of a diesel engine. The combination of high viscosity and low one quintal paddy in a milling process yields about 65% of polished rice 8% of rice bran and 275 husk oil. Oil is extracted from rice bran may have low or high acidity depending on the conditions and duration of storage volatility of rice bran oil causes poor cold engine start-up, misfire, and ignition delay. Hence, it is necessary to bring their combustion-related properties closer to those of the diesel oil. This fuel modification is mainly aimed at reducing the viscosity of vegetable oils to get rid of the flow related problems.

The principal cause of oil deterioration in the bran during storage is the activity of the lipase enzymes in the presence of moisture. The free fatty acid (FFA) content of unrefined rice bran oil is about 17% to 21.5%. It has been established that the ester yield decrease with increase in. Investigation revealed that crude vegetable oil as a fuel in diesel engine created various problems due to its high viscosity found that transesterification would not occur. Rice bran oil of non edible grade can be used as biodiesel in CI engine after modifying the rice bran oil by the process of transesterificatioin.

***3. Transesterification***

Tranesterification is the most common method to produce biodiesel, which refers to a catalyzed chemical reaction involving Vegetable oil, and an alcohol to yield fatty acid alkyl esters and glycerol i.e. crude glycerin. The process of 'transesterification' is sometimes named methanolysis or alcoholysis. After transesterification, viscosity of RBO is reduced by 75-85% of the original oil value. It is also called fatty acid methyl esters, are therefore products of transesterification of RBO and fats with methyl alcohol in the presence of a KOH catalyst. During the reaction, high viscosity oil reacts with methanol in the presence of a catalyst KOH to form an ester by replacing glycerol of triglycerides



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with a short chain alcohol.

| Test Parameter | B5 | B 15 | B 25 | B 50 | B 75 | B100 |
|---|---|---|---|---|---|---|
| Calorific Value, Kcal/Kg | 9882 | 9885 | 9606 0 | 9069 | 9368 | 8430 |
| Kinematic Viscosity | 3.4 | 3.6 | 3.8 | 4.0 | 5.7 | 15.0 |
| Density | 0.809 | 0.811 | 0.812 | 0.814 | 0.821 | 0.832 |
| Ash Content, w/w | 0.001 | 0.003 | 0.005 | 0.009 | 0.01 | 0.02 |
| Carbon Residue, % w/w | 0.69 | 0.70 | 1.2 | 1.5 | 2.6 | 9.9 |
| Sulfur Content, ppm | 2.6 | 3 | 5 | 7 | 12 | 30 |
| Flash Point, °C | 66 | 68 | 68.5 | 69 | 76 | 111 |
| Water Content, % w/w | 0.06 | 0.08 | 0.085 | 0.09 | 0.19 | 0.45 |

[Triglycerides (RBO) + Methanol → RBO methyl ester + Glycerol]

Methanol/methyl alcohol is preferred for KOME preparation by using transesterification as it provides better separation of methyl ester and crude glycerin thus facilitating the post-reaction steps of obtaining bio-diesel. The mixture of NaOH solution in methanol and raw RBO was stirred continuously, heated in a reflux condenser and then allowed to settle under gravity in a separating funnel. Two distinct layers form after gravity settling.

## 4. Biodiesel characterization

Both biodiesel and ethanol, in addition to being renewable and indigenously available, also help in improving the environment [4]. The important properties of rice bran oil methyl esters are found out and compared with that of other esters and diesel improves the efficiency and durability of the engine. It can be seen that the properties of rice bran oil methyl esters are quite comparable to that of bio fuel are non toxic, biodegradable and non flammable with very high flash points. The result shows that, transesterification improved the important fuel properties of the oil like specific gravity; viscosity; flash point and acid value. The comparison shows that the methyl ester has relatively closer fuel properties to diesel than that of original unrefined rice bran oil.

**Table 1 Properties of Rice bran oil methyl esters in comparison with other esters and diesel**

The viscosity was substantially got reduced from a value of 66 to 30 mm /s The calorific value of methyl ester is lower than that of diesel because of its oxygen content has lower value than the other materials or oil values that can be gradually reduced mixing proportion of the oil blends. The flash point of the ester is higher than that of diesel. A small percentage of biodiesel addition with diesel can definitely improve the flash point of the resultant mixture. It will also result in utilization as waste and fallow land in addition to the land on agricultural field boundaries, along publics transports.

## *5. Engine tests*

### 5.1. *Experiments setup*

A series of experiments were conducted on compression ignition engine using biodiesel to find optimum blend of biodiesel by varying the concentration of blends. A Kirloskar four stroke, constant speed, direct injection, vertical, water cooled, naturally aspirated single cylinder diesel engine is employed for the present study. The detailed specifications of the engine used are given Kane make KM82 exhaust gas analyzer was used to measure the concentration of gaseous emissions such as carbon monoxide and carbon dioxide. A smoke meter is employed to measure the smoke intensity of exhaust gas emitted from the diesel engine.

The test have been conducted at different stages at the normal injection timing and injection pressure Performance and emission tests are carried out on the compression ignition engine, using various blends of biodiesel and diesel as fuels. The tests are conducted at the rated speed of 1500 rpm at various loads. The experimental data generated are documented and presented here using appropriate graphs. These tests are aimed at optimizing the concentration of oil to be used in the biodiesel-diesel mixture for long-term engine operation. In each experiment, engine parameters related to thermal performance of the engine such as fuel consumption and applied load are measured. In addition to that, the engine emission parameters such as carbon monoxide (CO), carbon dioxide ($CO_2$), smoke density and exhaust gas temperature are also measured. The results are compared with the characteristics of 100% rice bran oil fueled engines as well. Diesel and rice bran oil blends of 5%,15%, 25%, 50%, 75%, 100%, RBO by volume were prepared and tried in the diesel engine at the rated speed of 1500 rpm

**Fig.1.Experimental setup**

***The main objective***

1. To maintain the viscosity of the oil by blending with the diesel in the different proportion
2. To determine and to evaluate to do the experiments to calculate the engine performance using the prepared blends as fuel
3. To calculate the emission levels of the different blends of the varying proportion of the different blends.



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### *5.2. Parameters of RBO*

#### *5.2.1. Density*

Density is an important property of CI engine fuel. Figure shows density for diesel, biodiesel and their blends. It is observed that B5, B15, B25, B50, B75, B100, RBO almost same density as that of diesel at room temperature (30°C). So preheating is not required for using B5, B15, B25, B50, B75 has about 1.75% higher density than diesel and it attains same density as that of diesel fuel of 45°C.SO preheating B75 at this temperature is necessary for using it in CI engine. Similarly B100 has 2.7% higher than that of diesel fuel. We find that density of the fuel increase with the increase in blending number, the intake manifold of the engine should be redesigned so that preheating can be done utilizing the exhaust of CI engine.

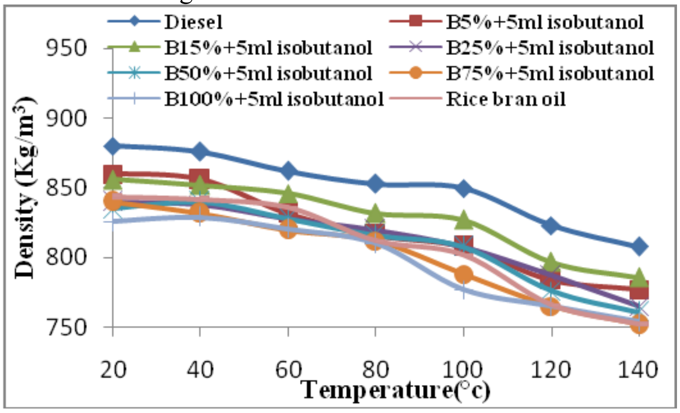


**Fig.2.Density Vs Temperature**

#### *5.2.3. Kinematic viscosity*

Viscosity of the fuel exerts a strong influence on the shape of the spray, high viscosity for example, causes low atomization and high penetration of the spray jet. Note that a cold engine, with higher viscous oil, discharge will almost a solid stream of fuel in to the combustion chamber and starting may be difficult while a Smokey exhaust will almost invariably appear. On the other, hand very low viscous fuel would cause to pass through the leakage of piston and piston prevents accurate metering of the fuel. It indicates that B5, B15, B25 has 1.7 times higher viscosity than fossil diesel at the room temperature. On the other hand B50, B75, B100 and RBO have almost the same viscosity at room temperature, and it is about 3.2 times higher than the diesel. But a slight preheating would cause to achieve comparable viscosity as that of diesel fuel. So using B5, B15, B25, B50, B75, B100 blend would not cause much change in the fuel spray pattern, and thus these fuels can be used in the existing diesel engines without modification of the fuel supply system. On the other hand B100, RBO is a much viscous fuel, and its viscosity is about 6 times higher than that of diesel fuel. The high viscous fuel would exhibits almost a solid stream of spray pattern in the combustion chamber and so cold starting of the engine would be difficult. So using B100, RBO fuel in the existing diesel engine would require modification of the fuel supply system so that the fuel supply system exerts high spray pressure to achieve the desired spray pattern inside the engine cylinder.

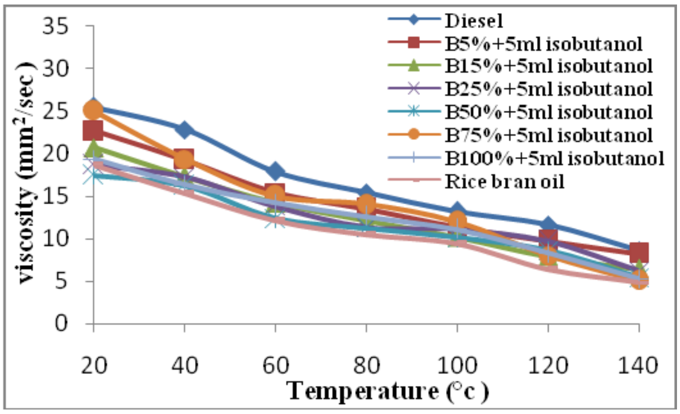


**Fig.3.Viscosity Vs Temperature**

#### *5.2.4. Calorific value*

Calorific value of a substance is the amount of heat released during the burning of specified amount of substance. It is generally determine by the use of bomb calorimeter. It shows the comparison calorific value of diesel, pure biodiesel and their blends .The bomb calorimeter reading gives the various fuel and blends we observed that, diesel fuel has higher calorific value about 43.98 MJ/kg and calorific values of the fuel decreases when we using higher blending of biodiesel. This shows that biodiesel has lower energy density fuel, so more quantity of biodiesel is require for generating the same amount of energy as compared to diesel fuel.

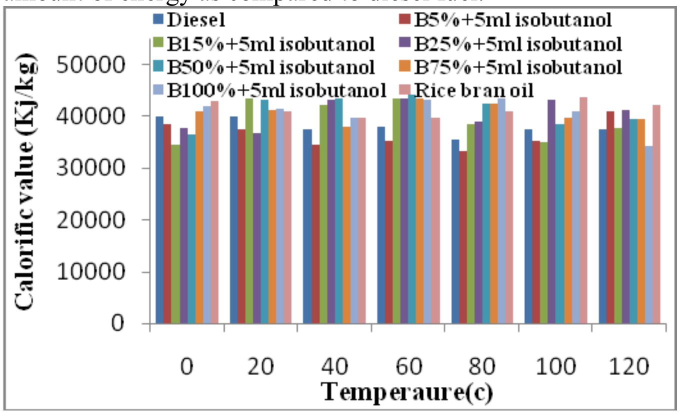


**Fig.4.Calorific value Vs Temperature**

**Table 2 Specifications of the engine used**

| | |
|---|---|
| Make Type | Kirloskar engine |
| Engine type | single cylinder, direct injection, water cooled |
| Stroke | 100 mm |
| Bore | 80 mm |
| Rated speed | 3.75 kW |
| Compression ratio | 16.5:1 |
| Total displacement | 552.64 cc |
| Loading device | BTDC Electrical dynamometer |
| Fuel injection timing | 23°B TDC |



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### *6. Result discussion*

#### *6.1. Brake thermal efficiency*

The brake thermal efficiency with respect to increase the engine in the different combination of the blends increases load for different fuels as the amount of the diesel considered for the present analysis is calculated RBO. Even a small quantity of diesel in the blend improved the performance the engine. Efficiency has the tendency to increase with increase in applied load. This is due to the reduction in heat loss and increase in power developed with increase in load. The maximum brake thermal efficiency obtained while using B50, B75 and B100 are, respectively, and the range of the value may be changed. The mixing of biodiesel in diesel oil yields, in general, good thermal efficiency curves. Initially the thermal efficiency of the engine is improved with increasing concentration of the biodiesel in the blend. The possible reason for this is the additional lubricity provided by the biodiesel. The molecules of biodiesel contain some amount of oxygen, which takes part in the combustion process. Oxygen present in the biodiesel molecules structure may be readily available for combustion for increases in percentage. This lower brake thermal efficiency obtained for B100 could be due to the reduction in calorific value and increase in fuel consumption as compared to B5, B15, and B25 While running the engine with unrefined rice bran oil, brake thermal efficiency is always lower than the biodiesel as well as diesel.

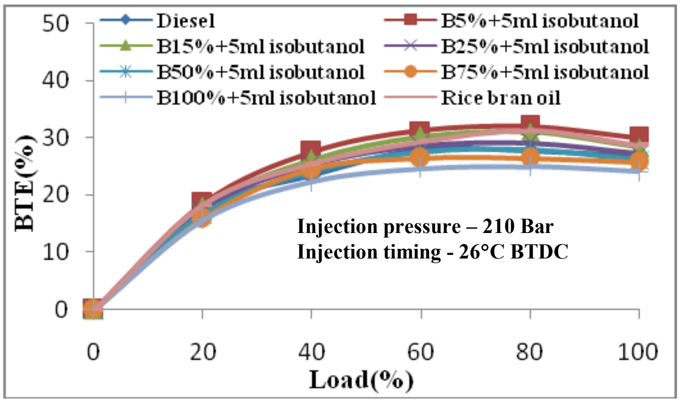


**Fig.5. BTE Vs load**

#### *6.2. Brake Specific fuel consumption*

The of brake specific fuel consumption with load for different fuels gives the high load condition For all fuels tested, brake specific fuel consumption is found to decrease with increase in the load. This is due to the higher percentage increase in brake power with load as compared to the increase in fuel consumption. Using lower percentage of biodiesel in biodiesel-diesel blends, the brake specific fuel consumption of the engine is lower than that of diesel for all loads. In case of B5, B15 B25, B50 to B100, the brake specific fuel consumption is found to be higher than that of diesel. At maximum load condition, the specific fuel consumption of 100% biodiesel is more than 17% of the higher value that can be calculated in the viscosity and density of the properties method. It may be given the calorific value of biodiesel is 18% lower than that of diesel. With increase in biodiesel percentage in the blends, the calorific value of fuel decreases. It can be operated with the similar manner of the biodiesel operation to give the better performance of the arrangement with the modification of the engine. Hence, the specific fuel consumption of the higher percentage of biodiesel in blends increases as Compared to that of diesel. The specific fuel consumption of rice bran oil is higher than that of diesel for all loads. This is cased that the value might to give the slowest arrangements of the calorific value and viscosity to easily Calculate the percentage.

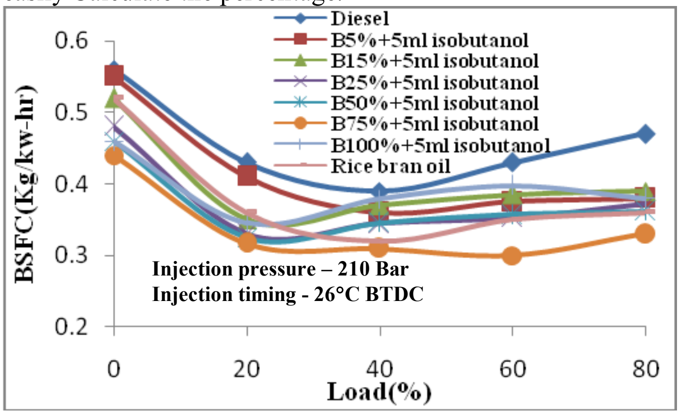


**Fig.6. BSFC Vs load**

#### *6.3. Carbon monoxide emission*

The emission of CO in diesel engine is mainly due to the improper mixing of the fuel and air resulting in incomplete combustion. The emission characteristics of biodiesel are of special interest in relation to meeting the environmental norms. Shows the plots of carbon monoxide emissions of the rice bran oil and various blends of biodiesel operation at the rated engine speed of 1500 rpm at various load conditions and to give the proper values of B15, B25, B50, B75.The fuels are producing low amount of carbon monoxide emission at lighter load levels and are giving more emissions at higher loading conditions. At medium load it is found that the CO emission is higher for all the fuels variants. The carbon monoxide emissions are found to be increasing with increase in load. This is typical with all internal combustion engines since the air-fuel ratio decreases with increase in load. The CO emissions increase as the fuel-air.It is the process to be easily calculated the air fuel ratio to high viscosity of the fuel results in poor spry and atomization CO concentration in the exhaust emission is negligibly small when a homogeneous mixture is burned at stoichiometric air-fuel ratio mixture or on the lean side stoichiometric. It is interesting Biodiesel itself has about 23 % oxygen content in it. This helps for the complete combustion. Hence, CO emission level decreases with increasing biodiesel percentage in the fuel. In the case of, 100% rice bran oil, the carbon monoxide emission is higher than that of biodiesel. The higher viscosity and poor atomization tendency of rice bran oil leads to poor combustion and higher carbon monoxide emission. Similar trends have been observed at high loads with higher CO emissions with B100, RBO.



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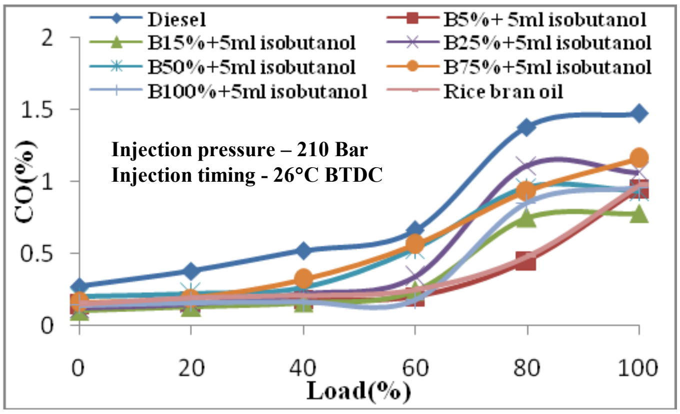

Fig.7. CO Vs load

### *6.4. Brake specific energy consumption*

The Brake Specific Energy Consumption (BSEC) is an ideal parameter for comparing engine performance of fuels having different calorific values. Show the variation of BSEC of the engine for the various fuels and at medium load and high load conditions respectively, relative to Diesel as fuel in crankcase lubricant. On comparing the relative BSEC for various lubricants such as B5,B15,B25,B50,B75 and B100 at medium load condition, it is found that for all fuel variants, RBO gives the minimum BSEC and B25,B50,B75 gives intermediate values of BSEC. This can be attributed to the least viscosity of B5,B15,B25 among the three lubricants considered for the study the Lower viscosity brings down the Friction Power (FP) as could be seen in at high load condition also it is found that RBO as leads to minimum relative BSEC for the different fuel variants. It is also observed that the minimum value of BSEC occurs for B5, B15, B50 lubricant with Diesel, and B20 as fuel at both the loads. This shows that 40% methyl ester blended fuel gives almost same BSEC as that of neat diesel, as reported by many researchers in the literature.

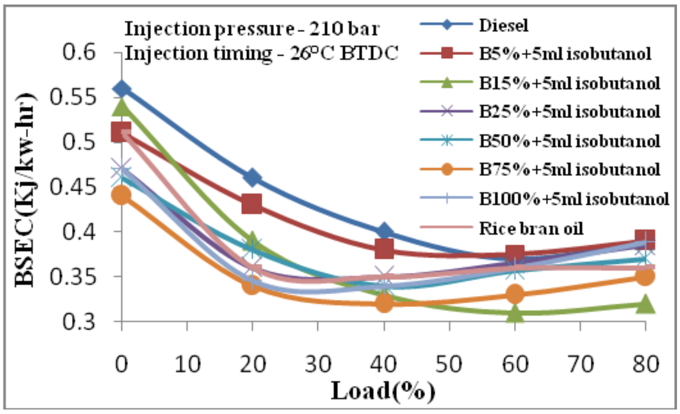

Fig.8. BSEC Vs load

### *6.5. Carbon dioxide emission*

The biodiesel emission of B5, B15, B25, B50, B75 compares the $CO_2$emissions of various fuels used in the diesel engine. The $CO_2$ emission increase with increases in load, as expected. It emits the lower biodiesel for the in convenience process to be given in the accuracy of the diesel level. The lower percentage of biodiesel blends emits very low amount of $CO_2$ in comparison with diesel. B20 emits very low level of $CO_2$ emissions. Using higher concentration biodiesel blends as the fuel, $CO_2$ emission is found to increase. But, its emission level is lower than that of the diesel mode. B100 emits more amount of $CO_2$, as compared to that of diesel operation. More amount of diesel is to improve the combustion rates and hence the CO blend ratio is decided based on the amount of diesel. This supports of diesel to be replaced or the level of emission that can be tolerated the higher value of exhaust gas temperature. The $CO_2$ emission using rice bran oil as fuel is lower because of the incomplete combustion. The combustion of fossil fuels produces carbon dioxide, which are getting accumulated in atmosphere and leads to many environmental problems. The combustion of bio fuels also produces carbon dioxide but crops are readily absorbing these and hence carbon dioxide view the blended ratio based on the amount of diesel to be replaced.

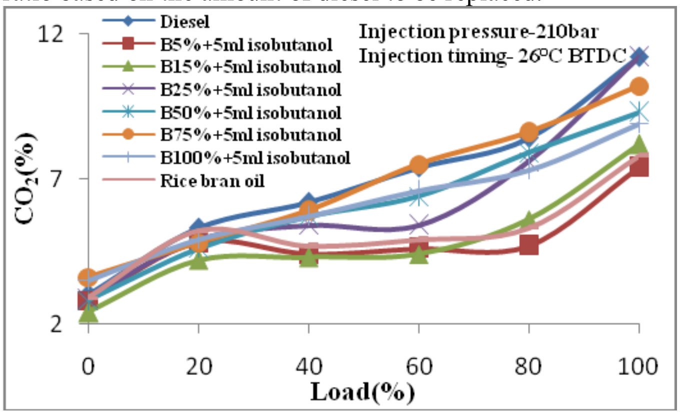

Fig.9. $CO_2$ Vs load

### *6.7. Smoke density*

It is found that the Smoke density increases with increases in load on the engine, for all the variants. Smoke density for biodiesel blend is noticed to be generally lower than that of the diesel oil. Higher thermal efficiency indicates better and complete combustion of fuel. it has been observed that the fuel variants gave higher smoke emission in the diesel That is, lesser amount of un burnt hydrocarbons present in the engine exhaust emission. So, the smoke density was the highest B100, RBO as fuel having the highest viscosity among the different fuel variants considered for the study. Lower smoke density values are achieved with biodiesel blends as compared to that of the diesel. B20 blends gave smoke density of 36% as compared to 55% in the case of diesel. The smoke density of the exhaust emission of 100% increased with the load as more fuel burnt per unit of all time at higher load.

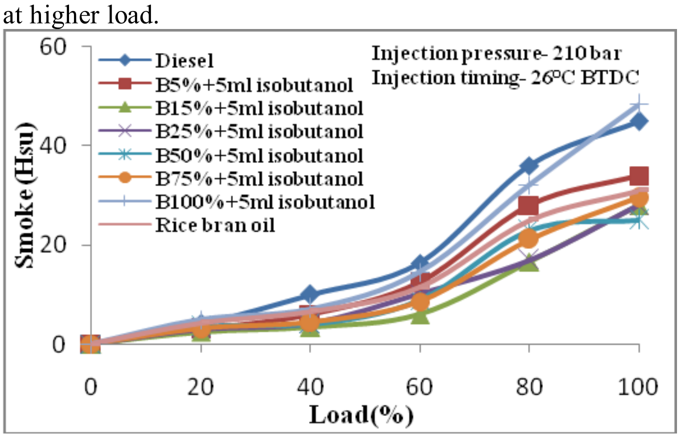

Fig.10. Smoke density Vs load.

### *6.8. Exhaust gas temperature*

Exhaust gas temperature for all diesel and blends of RBO with diesel with increase in the load, the temperature of the engine decreases. The variation of exhaust gas temperature



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with respect to applied load for different fuels tested is increases with brake power in all cases. The biodiesel also contains some amount of oxygen molecules in the ester form. It is also taking part in the combustion. B25, B50, B75 and B100 the exhaust gas temperature is lower. This reveals that the effective combustion is used to fact is reflected in brake thermal efficiency and brake specific fuel consumption as well. When biodiesel concentration is increased, the exhaust gas temperature increases by a small value. This may be attributed in the to the higher oxygen content of RBO, which might accelerate the combustion process and in turn increases the combustion temperatures and the exhaust temperature While using 100% rice bran oil, higher exhaust temperature is attained, which is indicating more energy loss in this case. The exhaust gas temperature slightly higher in 45% of the oil mode of operation. The nitrogen oxides emission is directly related to the engine combustion chamber temperatures, which in turn indicated by the prevailing exhaust gas temperature. With increase in the value of exhaust gas temperature, $NO_x$ emission also increases. That is, biodiesel fueled engines has the potential increase in the oil blends.

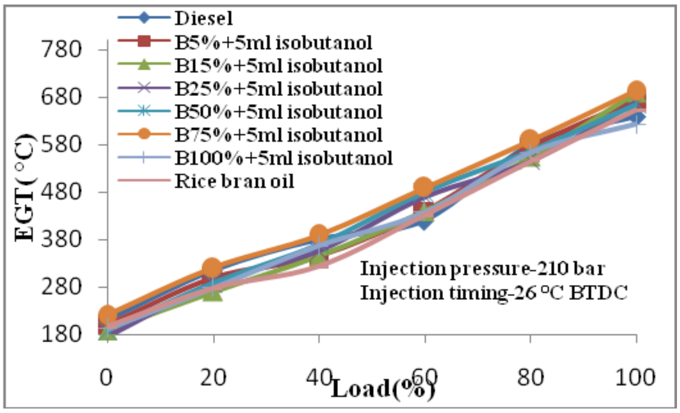


**Fig11. EGT Vs load.**

***6.9. Hydro carbon***

The Hydro carbon emission reduces with the blends as compared to neat RBO oil. These trends indicate the combustion efficiency to improve with the blends of RBO with diesel. Since increase in the quantity of the diesel in the blends improves the performance from the emission point of view, the blended ratio is decided based on the amount of diesel to be replaced. It has been found that the HC emission has increased with the increases in the load for most of the fuel variants. This is attributed to the larger amount of fuel injected for combustion at higher loads. Further it is observed that HC emission is higher foe all the fuel variants compared to diesel. This may be due to the higher viscosity larger droplet size increases the values of the biodiesel to have the higher capacity of the blendsB5, B15, B25, B50, B75 to penetration of fuel droplets, leading to in complete combustions. In order to prevent the lubricants to give the better performance of the engine to mix with correct proportion of B100, RBO 14% of the combustion in the cylinder wall with the blended ratio of the quantity of the diesel in the blend improves the performance from the emission point of view can be tolerated.

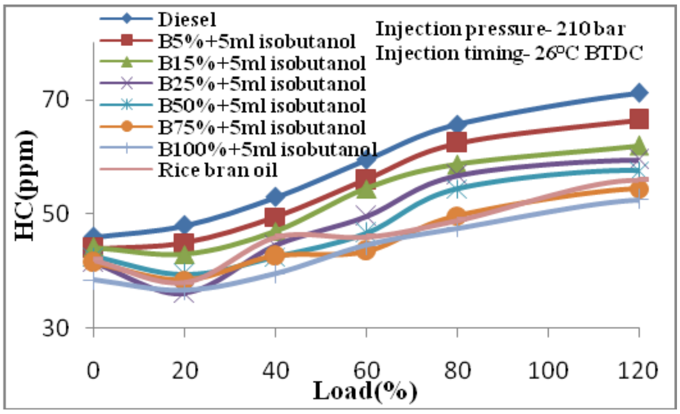


**Fig.12.Hc Vs load**

***6.10.NOx***

NOx is the main problem to find out the percentage of the fuel variants that are how much produced the gases in order to prevent engine performance. This reduction of NOx emission is due to the premixed burning rate following the delay period. The rate of heat release during the pre mixing burning phase is lower with the RBO and the oil blends as compared to the diesel. It is observed that at medium load the relative NOx emission is higher for all the fuel variants compared to diesel as fuel and B5, B15, B25, B50, B75 as lubricant. Show the emission characteristics of the engine for the various fuel and lubricant variants at medium load and high load conditions. In this process the mineral oil slowly arises the engine capacity to improve the efficiency of the engine. The emission gives the combustible arrangement of The NOx emission depends upon the combustion temperature and availability of excess oxygen to give the proper injection of the advancement of the fuel injection materials. When both of these are high the NOx emission will also be higher. It is observed that the NOx emission increases with load for all the fuel variants considered for the study. This is expected because with increasing load, the temperature of the combustion chamber increases and NOX formation is strongly temperature from the biodiesel fuel engine. This is due to the higher combustion temperature at higher loads, as more and more fuel gets burnt as load increases.

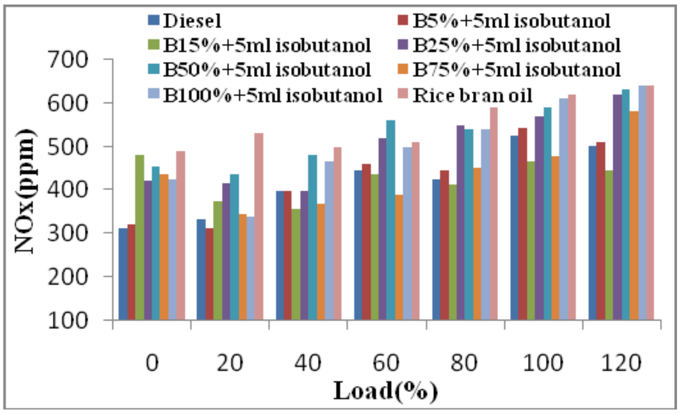


**Fig.13.NOx Vs load**

***6.11. Volumetric efficiency***

The volumetric efficiency of rice bran oil with diesel is shown in fig. The volumetric efficiency of rice bran oil is lower than that for diesel. This trend may be because of the increase in exhaust gas temperature of rice bran oil. The high temperature of the cylinder and the exhaust gas retained inside the cylinder will heat the incoming fresh air which



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lowers the volumetric efficiency. Again it is clearly seen that the volumetric efficiency variation of the rice bran oil is on the same line as that for diesel. This trend is again seen because esterification the viscosity is reduced while the volatility is improved which results in producing a lower value of exhaust temperature which in turn increases the volumetric efficiency.

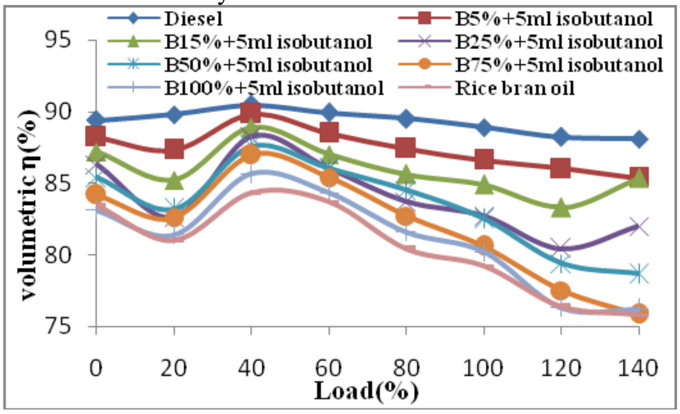


**Fig.14.Volumetric η Vs Load**

***6.12. Indicated thermal η***

The graph represent to show that the indicated thermal efficiency (which is the ratio of indicated power to the heat energy supplied by the fuel during combustion) of B100, RBO mixture shows a lead than diesel and blends of biodiesel. It give s the perfect mixture that eventually give the correct proportion of the material blending with each other in the ratio of the various ratio that can be calculated the reducing viscosity, calorific values. Indicated thermal efficiency depends on both brake power produced by the engine as well as frictional power offered by the engine, as it is the summation of both. Diesel curve leads all the blends of biodiesel as load applied on an engine increases, except B100. Diesel curve also shows a smooth linear curvature. B100 shows a characteristic curve of increase from the start till 1.62KW, but after that it decreases then increases with minor raise till the end. B5, B15, B25 shows a smooth linear curve overall. Among the blends B75 leads B50 and B25 till half load of 2.3H.P (1.86 KW). Thus B100 has shown competent and satisfactory performance characteristics results when compared mainly with petroleum-diesel and other blends of biodiesel.

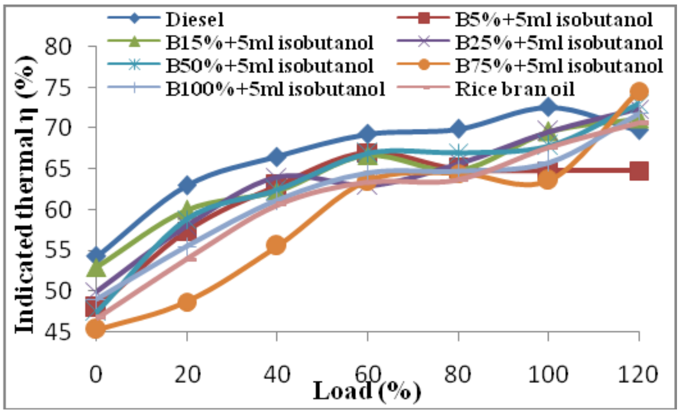


**Fig.15.Indicaated thermal η Vs Load**

***7. Engine Performance***

***7.1. Blends of Different Injection Pressure***

Fig.16 and 17 shows the power output of blends at varying fuel temperature and fuel injection pressure for all the blends studied. In pure diesel as a fuel, the power output of engine showed increasing trends, but a decreasing trend was observed with an increase in the concentration of RBO in diesel. The minimum power output of 4.51 kW was obtained using B100 fuel at temperature of 30°C at an injection pressure of 170 bar to 190 bar, the power output increased with the increase in fuel temperature. For the all the blend the power output increased with the increase in injection pressure. The increase in power output with increase in injection pressure may be due to improved atomization of RBO. The decreasing trend in power output with increase in concentration of RBO in diesel may be because of lower energy input of RBO than that of diesel. It may also be poor atomization of RBO for its higher viscosity. The increased power output with the increase in fuel temperature might be influenced by the better atomization of the blends due to their reduced viscosities at higher temperature.

When the injection pressure increased from210 bar to 230 bar the rate in increase of power output for all bends was more at fuel temperature of 65°C than at 35°Cin fig 18 and 19. The slight increase in power output with the increase in the injection pressure may be attributed to improved atomization and reduce viscosity due to increase in fuel temperature which might have improved combustion characteristics of the blends.

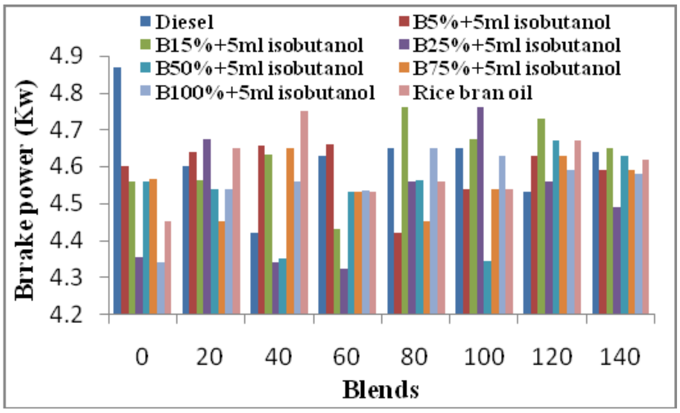


**Fig.16. Blends at injection pressure of 170bar**

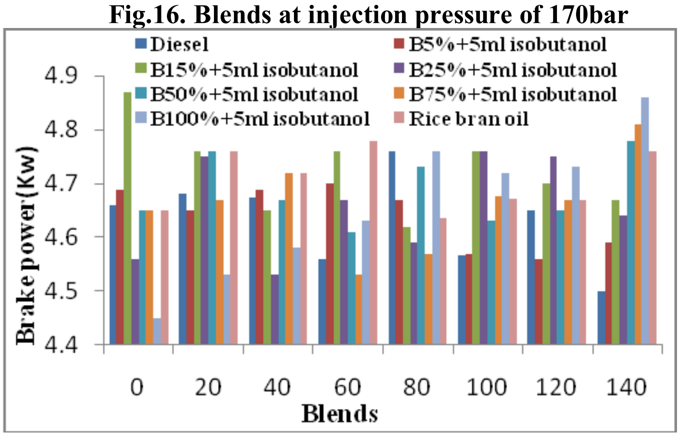


**Fig.17.Blends at injection pressure of 190bar**



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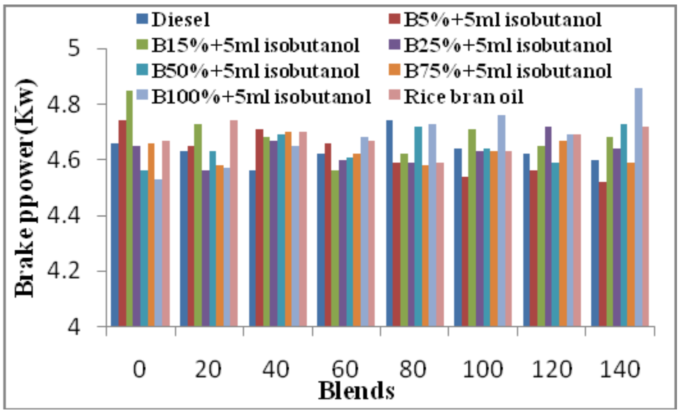


**Fig.18.Blends at injection pressure of 210bar**

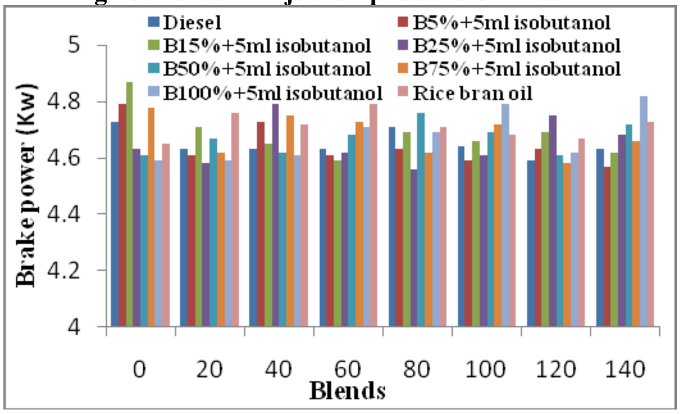


**Fig.19.Blends at injection pressure of 230bar**

***8. Heat Balance Sheet***

The Performance of an Engine is generally given by heat balance sheet. The various quantities involved such as the amount of total Heat produced by the combustion of the fuel, to produce brake power, Heat driven away by the usage of coolant and the surroundings: have been found out and the corresponding results of them are compared to display their Efficacy. It is the important process to find the useful fuel which is arranged in the useful characteristics methods of the heat passed from the fuel work to find out them. The main concept of this sheet is, all the heat energy produced during the combustion of the fuel is not converted into useful work: which is harnessed at the crank shaft of the engine, some goes as wastage as described above the percentage of B5, B15, B25, B50 and B75. The various results obtained have been plotted in pie-charts and the inference has been discussed hereby. It can be noted from the pie-chart that B100 has higher utilization of heat produced from the combustion of the fuel inside the engine, to produce Brake power than diesel. Of all the blends of biodiesel B100 has shown more productive for the transmission of output power. Heat loss unaccounted are produced due to conductive, convective and radiation losses; more heat has been enhanced by the engine when fueled with B100 than diesel, thereby the heat taken away by the exhaust gas can be utilized by using exhaust gas recirculation technique to increase the thermal and volumetric efficiency of an engine. Among the blends of biodiesel, B25 leads more effective to B50 and B75, in overall comparison of utilization of heat. A heat balance characteristic shown by B100 and RBO is more effective when compared to diesel.

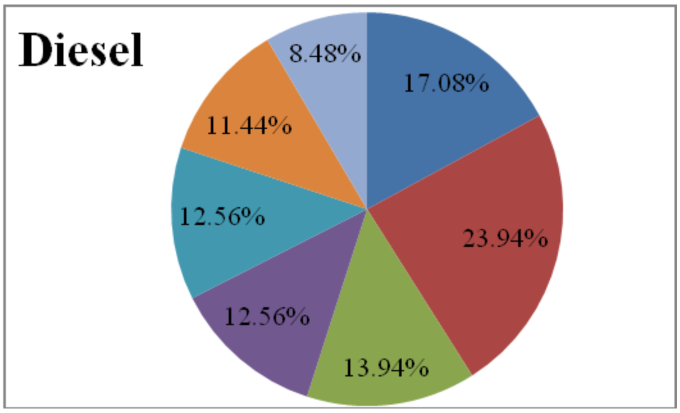


**Fig.20.Diesel**

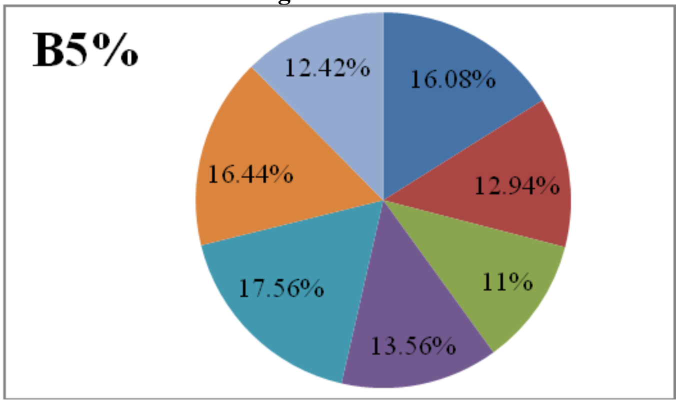


**Fig.21.B5% Blend**

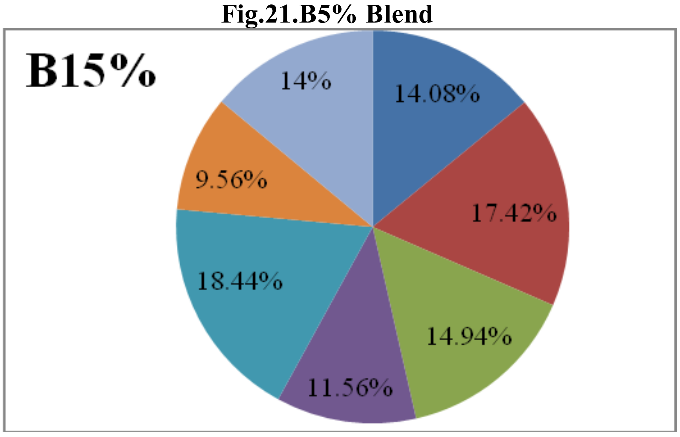


**Fig.22.B15% Blend**

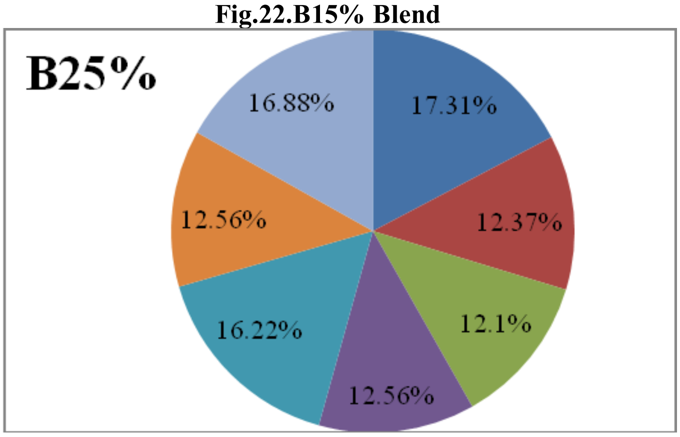


**Fig.23.B25% Blend**



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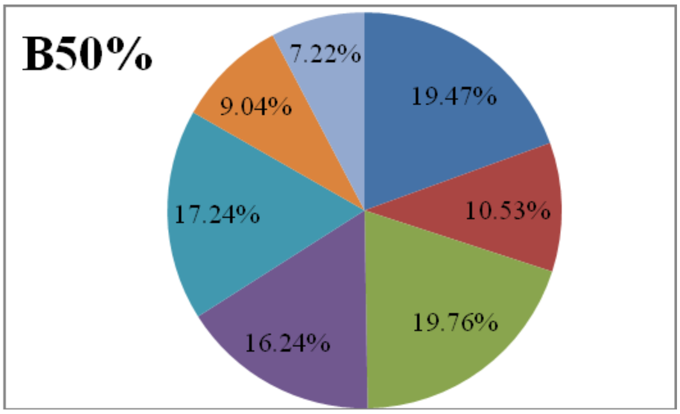

**Fig.24.B50% Blend**

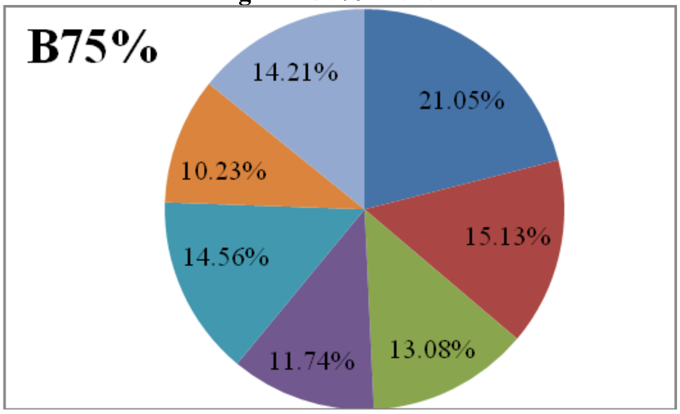

**Fig.25.B75% Blend**

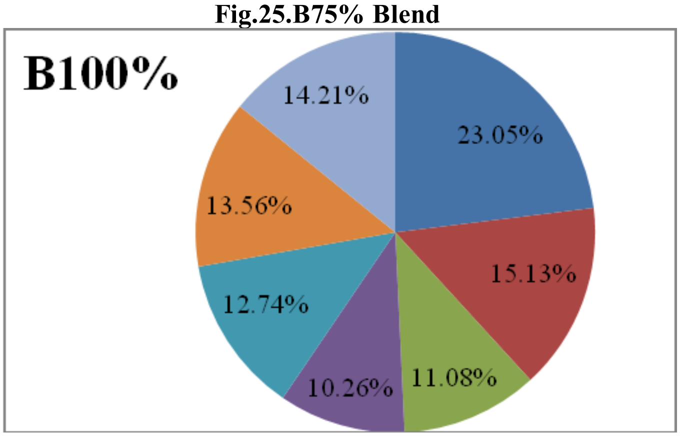

**Fig.26.B100% Blend**

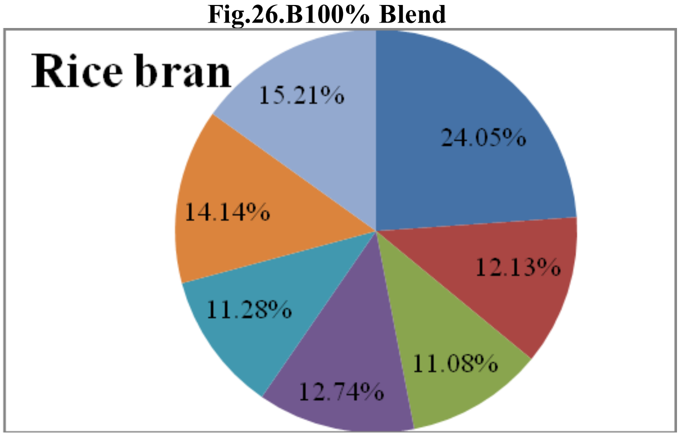

**Fig.27.Rice bran oil**

### *9. Conclusions*

- In case of RBO, the brake thermal efficiency, which was less compared to diesel, increased appreciably with the addition of diesel. However, the increase depends on the quantity of diesel in the blends
- Successful efforts are made here for the production of biodiesel from unrefined rice bran oil. Viscosity and density of methyl esters of rice bran oil are found to be very close to that of diesel.
- Hydrocarbon and carbon monoxide emission are higher for RBO oil as compared to diesel. Blending with diesel reduces from further.
- The calorific value of biodiesel is found to be slightly lower than that of diesel. The flash point of biodiesel is higher than that of diesel.
- The lower concentrations of biodiesel blends found to improve the thermal efficiency. B25% biodiesel blend gives a good improvement in the brake thermal efficiency of diesel engine in order to increase the engine performance.
- It also, reduced emission and brake specific fuel consumption is found out while using B25. Higher the concentration of biodiesel blend, higher is the reduction of smoke density in exhaust gas.
- Nitrous oxide emission of RBO oil and the blends are lower than diesel for all the blends. The exhaust gas temperature increased as a function of concentration of biodiesel in the blend.
- The important process to use of the biodiesel as percentage basis of diesel substitute can the farm economy, reduce uncertainty of fuel availability a Also, this help in controlling air pollution to a great extent.
- Overall, it is concluded that 25% -75% of RBO oil can be added to diesel and it can be used as a substitute fuel for diesel engine without any engine modification.

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