PERFORMANCE AND EMISSION ANALYSIS ON 4-STROKE DIESEL ENGINE BY USING RICE BRAN BIODIESEL

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Abstract: The world's fuel consumption is rising quickly, which has an impact on every nation's economy globally. As a result, every nation is under pressure to develop alternative fuel sources to help cut back or even completely replace the use of petroleum. As a result, switching to other alternative energy sources like biodiesel, biogas, solar energy, wind energy, etc. is necessary. One alternate energy source that can be used in diesel engines without further engine changes is rice bran oil. Our project focuses on the assessment of the effects of crude rice bran biodiesel, and its mixes with diesel on the performance of diesel engines. This work focuses on the engine's performance and exhaust emission characteristics as well as the manufacture of biodiesel from rice bran oil. Primarily, we have taken diesel fuel as the baseline data for the performance and emission analysis. Later, we have chosen to use a variety of biodiesel blends made from rice bran oil. In this experimental project, we used B10, B20, and B30 blends of already-used rice bran biodiesel. The experimental investigation of the blends of used rice bran biodiesel is carried out on a single cylinder 4 stroke diesel engine without making any modification to the diesel engine. The current work explored experimentally the impact of biodiesel blends on the efficiency and emissions of diesel engines when operating under a variety of loads at a constant speed. The experimental analysis shows that rice bran biodiesel bends can be utilized as a fuel in a diesel engine without requiring any modifications to the engine and of all the blends B10 showed the optimum output in terms of performance and emissions than the other two blends.

Keywords: Biodiesel, Diesel engines, Rice bran oil, Biodiesel blends, emissions.

1.INTRODUCTION

The 21st century's global environment is fraught with serious difficulties. The atmosphere is one of the biggest obstacles. There is rising concern that there won't be enough energy to heat our houses and power the vehicles we rely on so heavily as the population grows and the standard of living rises. Additionally, we must keep in mind the need for clean air, water, clean-burning fuels, and biodegradable fuels. As a result, a lot of studies have been done on renewable materials. Technology advancements have made it possible to produce alternative energy sources. Compared to conventional fuels, alternative energy sources are more dependable, greener, and renewable. Environmental worries about vehicle emissions have grown. This problem, which has greatly accelerated climate change, has been ignored by numerous governments. The improvement of efficiency and the restriction of emission levels are the main goals of this field's research. Due to its similarities to conventional diesel in terms of characteristics, biodiesel is said to provide a good solution to the issues.

The process of transesterification, which transforms vegetable oils into fatty acid methyl ester, is currently the most suitable way to utilize them in compression ignition (CI) engines. When the engine is fueled with diesel, the power output and fuel consumption of the vegetable oil and its blends are practically identical. In a diesel engine, jatropha oil can also be used in place of diesel. Vegetable oils are transformed into biodiesel due to lower calorific values and higher viscosity compared to diesel. Transesterification of alcohol and vegetable oil triglycerides occurs in the presence of a catalyst to make biodiesel. The finished item is made up of fatty acids and alkyl esters.

Researchers used biodiesel made from various vegetable and animal fat oils in research and simulation studies on diesel engines, and they discovered that among affordable, low-grade, and renewable vegetable oils, biodiesel performed best. When the possibility of employing Rice bran, Palm, and Pongamia oil biodiesel as the pilot fuel for a biogas-powered, dual-fuel diesel engine was investigated, it was discovered that Rice bran methyl ester had the greatest performance of all the biodiesel oils.

1.2 Rice Bran oil

Rice is a staple food for half the world's population. Rice bran finds little application in India. Most of the rice bran is dried out or burned. But we can produce oil from it that is effective for cooking and for making biodiesel. The process also produces bioactive compounds with added value. Using rice bran oil as a raw material for biodiesel manufacturing not only makes the process more affordable but also produces bioactive compounds with added value. The procedure is appealing and profitable since these byproducts can be isolated and purified. This oil is a suitable substitute for making biodiesel and using it as fuel for four-stroke diesel engines. The kinematic viscosity of rice bran oil is several times greater than that of diesel oil and this causes issues with pumping and atomization in a diesel engine's injection system. It is suitable as a substitute for making biodiesel and using it as fuel for four-stroke diesel engines. A process called transesterification is followed so to obtain the biodiesel from vegetable oils.

1.3 Transesterification

Transesterification is the most popular and effective method for reducing the viscosity of vegetable oils. An alkyl ester, glycerol, and a variety of fatty acids are produced when a triglyceride interacts with three molecules of alcohol in the presence of a catalyst as shown in Fig.1. This product is a fuel with characteristics comparable to petroleum-based diesel fuel, allowing it to be used in existing diesel engines without changes. Transesterification typically proceeds by mixing the reactants, frequently under heat and/or pressure, and is a reversible reaction. However, if a catalyst is given to the process, it will proceed more quickly.

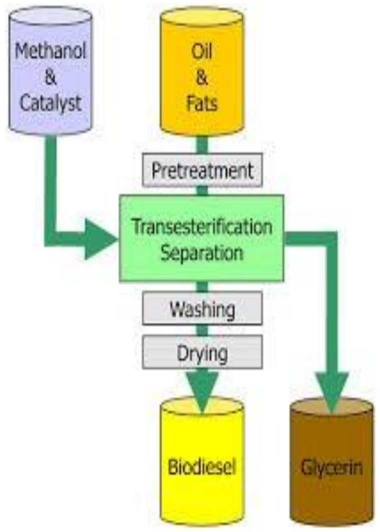

Fig.1 flow chart of the transesterification process

2, LITERATURE REVIEW

This chapter discusses prior analyses, investigations, and research on the performance of diesel engines with rice bran biodiesel, as well as their method of preparation, emissions, etc. These are some of the other journals we referred.

Dr.K. Prasad Rao et al [1] This work says that particulate matter and oxides of nitrogen are the main pollutants in the tailpipe emissions of bio-diesel fueled engines. In this investigation, Mahua methyl ester along with diethyl ether (DEE) is used as fuel for the single-cylinder DI-Diesel engine, analysis of performance and emission is presented. This paper presents an investigation into the effect of biodiesel blending on the performance and emission characteristics of diesel engines. The effect of fuel additives was to control the emission from diesel engines and to improve their performance. But still, research work is going on the bio-diesel application to make it environmentally friendly.

S Naga Prakash Chokka et al [2] In this present investigation the oil is used rice bran oil which is generated by the waste rice husk. The tests are conducted 4-stroke single-cylinder diesel engine, air-cooled direct injection, and diesel engine by using diesel. During the second step, experimental investigations are carried out on the same engine with the 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

Dr.K. Prasad Rao et al [3] This research article aims to study the optimization of performance parameters to improve diesel engine efficiency. An attempt has been made to solve the correlated multiple criteria optimization problem of performance parameters of diesel engine. The process environment has been assumed to consist of four variables load, time is taken for 10cc fuel consumption, type of fuel, and valve opening position. Taguchi method has been adopted to convert multiple objectives of the optimization problem into a single objective function. Taguchi's technique has been applied to determine the optimal setting, which can be maximized.

Mayank Chhabra et al [4] The present study focuses on impact assessment of rice bran and crude rice bran biodiesel and its blends with diesel on diesel engine performance. The experimental investigation provides in depth detail of the biodiesel production process, evaluation of fuel properties and impact on engine performance. 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. 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.

Bhaskaran et al [5] This paper is focused on biodiesel production from Rice bran oil and the performance and exhaust emission characteristics of the engine. We decided to use various blends of Rice Bran oil biodiesel and vary the injection parameters such as injection pressure and injection timings to increase the performance of the engine and also to decrease the emission from the engine.

Prof. M.K. Chopra et al [6] The present study focuses on the impact assessment of rice bran and crude rice bran biodiesel and its blends with diesel-on-diesel engine performance and testing. The experimental analysis provides 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 fuelled with blends of biodiesel

- **Manzoor Sheikh et al [7]** In this research paper say that biodiesel is an alternative to petroleum-based fuels derived from a variety of feedstocks, including vegetable oils, animal fats, and waste cooking oil. At present, biodiesel is mainly produced from conventionally grown edible oils such as soybean, rapeseed, sunflower, and palm. The cost of biodiesel is the main obstacle to the commercialization of the product. Biodiesel produced from edible oils is currently not economically feasible. On the other hand, extensive use of edible oils for biodiesel production may lead to a food crisis.

Dr.K. Prasad Rao et al [8] In this present work Experimentation has been carried out with the additive Diethyl Ether (DEE) and Mahua biodiesel in diesel engines to replace conventional fuels. This idea is being floated with the objective that low-temperature combustion can be maintained and thereby reducing NOx emission. Biodiesel application reduces other emissions substantially, but for NOx. This is because of the reason that transesterified vegetable oil contains oxygen in its molecular structure. DEE possesses different properties altogether with higher Cetane number, lesser auto-ignition temperature, etc. may show the way for a smoother start of combustion at lower atmospheric temperatures also.

Syed shakeer et al [9] The use of biodiesel, the methyl esters of vegetable oils are becoming popular due to their low environmental impact and potential as a green alternative fuel for diesel engine. With this objective, the present work has focused on the performance and emission characteristics of diesel engine using rice bran oil and its blends with diesel. In this investigation, the blends of varying proportions of rice bran biodiesel with diesel (RB20, RB40, RB60, RB80 & RB100) were prepared, analyzed, and compared the performance and exhaust emission with diesel using 5.2 kW Single cylinder, 4stroke diesel engine. The performance and emission characteristics of blends are evaluated at variable loads and constant rated speed of 1500 rpm and found that the performance of RB20 blend of rice bran oil gives result, that is near to the diesel and also found that the emission CO, CO2, HC, smoke & NOX of this blend is less than the diesel.

Bhaskor J.Bora et al [10] The present work attempts to unfold the effect of compression ratio on performance, combustion and emission characteristics of a rice bran biodiesel-biogas run dual fuel diesel engine. For experimentation, a single cylinder, direct injection (DI), natural aspirated (NA), water cooled, variable compression ratio (VCR) diesel engine is converted into a biogas run dual fuel diesel engine. Experiments were conducted at three different compression ratios (CRs) of 18, 17.5 and 17, and at a fixed injection timing of 23° bottom top dead centre (BTDC) under different loading conditions.

M. C. Navindgi et al [11] The present work has focused on the performance and emission characteristics of diesel engines using rice bran oil and its blends with diesel. In this investigation, the blends of varying proportions of rice bran biodiesel with diesel (RB20, RB40, RB60, RB80 & RB100) were prepared, analyzed, and compared the performance and exhaust emission with diesel using a 5.2 kW Single cylinder, 4stroke diesel engine. The performance and emission characteristics of blends are evaluated at variable loads and a constant rated speed of 1500rpm.

S.N. Singh et al [12] This paper deals with the performance Analysis of a Compression Ignition Engine using alternative fuels such as Rice bran oil and their ester after esterification for different engine loads from 1.8 kg to 6.6 kg and different blending ratios like B0, B25, B50, B75, B100. Alternative fuels are typically produced through the reaction of vegetable oil or animal fat with alcohol in the presence of the catalyst to produce their esters.

J Powell et al [13] The objective of this research was to determine the relationship between engine performance and emissions of cottonseed oil biodiesel used in a 14.2 kW diesel engine. When using cottonseed oil biodiesel blends, CO, total hydrocarbon (THC), NOx, and SO2 emissions decreased as compared to petroleum diesel. Carbon dioxide emissions had no definitive trend in relation to cottonseed oil biodiesel blends. Carbon monoxide emissions increased by an average 15% using B5 and by an average of 19% using B100. Hydrocarbon emissions decreased by 14% using B5 and by 26% using B100. Nitrogen oxide emissions decreased by four percent with B5, five percent with B20, and 14% with B100.

NL Panwar et al [14] In this investigation, castor methyl ester (CME) was prepared by transesterification using potassium hydroxide (KOH) as catalyst and was used in four stroke, single cylinder variable compression ratio type diesel engine. Tests were carried out at a rated speed of 1500 rpm at different loads. Straight vegetable oils pose operational and durability problems when subjected to long term usages in diesel engines. These problems are attributed to high viscosity, low volatility and polyunsaturated character of vegetable oils.

Ashok kumar Yadav et al [15] In this study, production, performance and emission characteristics of methyl esters of Oleander, Kusum and Bitter Groundnut oil in a transportation diesel engine were studied. Oleander oil methyl esters (OOME), Kusum oil methyl esters (KOME) and bitter Groundnut Oil Methyl Esters (BGOME) were prepared by transesterification process. The effects of three methyl esters on engine performance and exhaust emissions were examined at different engine speed and full load condition.

Yie hua tan et al [16] In this research work, the experimental investigation of the effect of diesel-biodiesel-bioethanol emulsion fuels on combustion, performance, and emission of a direct injection (DI) diesel engine are reported. Four kind of emulsion fuels were employed: B (diesel-80%, biodiesel-20% by volume), C (diesel-80%, biodiesel-15%, bioethanol-5%), D (diesel-80%, biodiesel-10%, bioethanol-10%) and E (diesel-80%, biodiesel-5%, bioethanol-15%) to compare its' performance with the conventional diesel.

P. Usha sri et al [17] Investigations were carried out to evaluate the performance with low heat rejection combustion chamber with crude cotton seed biodiesel. It consisted of an air gap insulated piston, an air gap insulated liner and ceramic coated cylinder head with different operating conditions of cotton seed biodiesel with varied injection timing and injector opening pressure. Exhaust emissions were determined at full load operation of the engine.

M. Senthil kumar et al [18] In this work various methods of using vegetable oil (Jatropha oil) and methanol such as blending, transesterification and dual fuel operation were studied experimentally. A single cylinder direct injection diesel engine was used for this work. Tests were done at constant speed of 1500revmin−1 at varying power outputs. In dual fuel operation the methanol to Jatropha oil ratio was maintained at 3:7 on the volume basis. This is close to the fraction of methanol used to prepare the ester with Jatropha oil.

Panithasan et al [19] The present research work deals with the improvement of performance characters and reduction of emission characters of a single cylinder 4 stroke diesel test engine powered by 20 & 40% by volume mixtures of Jatropha bio-diesel. Jatropha was selected considering the higher yield and also the easy availability of the fuel locally. Jatropha oil extracted was subjected to transesterification process to reduce its higher viscosity and is converted into Jatropha methyl ester. The blends were subjected to stability checks and then tested for its performance, emission, and combustion characters.

Wang, J. et al [20] This paper describes the emission characteristics of a three compounds oxygenated diesel fuel blend (BE-diesel), on a Cummins-4B diesel engine. BE-diesel is a new form of oxygenated diesel fuel blends consisted of ethanol, methyl soyate and petroleum diesel fuel. The blend ratio used in this study was 5:20:75 (ethanol: methyl soyate: diesel fuel) by volume. The results from the operation of diesel engine with BE-diesel showed a significant reduction in PM emissions and 2%–14% increase of NO_x emissions. The change of CO emission was not conclusive and depended on operating conditions.

After studying various journals and research works done on the performance of diesel engines with rice bran biodiesel as an alternative to conventional diesel, we came to conclude that biodiesel made from rice bran is perfectly suited for replacing diesel as the fuel for diesel vehicles. To be different from other works we decided not to use crude and refined rice bran oil for biodiesel which costs us more than diesel so we wanted to use already used rice bran oil and dimethyl ether in the preparation of biodiesel. From the above journals, we had been noted that rice bran biodiesel shows much more performance on a diesel engine than with conventional diesel. The performance also has shown in the research works is also shown better in emission analysis.

3. METHODOLOGY

In this project to make rice bran biodiesel, a heterogeneous base-catalyzed transesterification process is used, because, throughout this process, The solution is split into two phases once the reaction is finished. The item is cutting-edge in Glycerol exists in precipitate form, and the necessary product is found above it in liquid form biodiesel. These two phases are distinct from one another. For our biodiesel, the extraction of biodiesel is carried out by the base-catalyzed transesterification method by using Diethyl ether (DME) as the base catalyst and methanol. We have taken 3 liters of already used rice bran oil and heated it to a temperature of 60°C on a magnetic stirrer with the hot plate as shown in Fig. 2. The mixture is maintained at 60-70°C for approximately 2 hours while being continuously stirred on a magnetic stirrer while being heated at a constant temperature.250 ml of methanol and 5 to 7 % of DME (base catalyst) are then added. The mixture is allowed to settle for 24 hours to allow layers of glycerin and biodiesel to develop.

Fig. 2 Magnetic stirrer with the hot plate

During gravity separation, the glycerin forms a lower layer, the biodiesel is separated from the glycerin in a funnel. After that, distilled water was used to wash the biodiesel to get rid of any leftover methanol or DME Utilizable biodiesel made from rice bran oil is now available as shown in Fig.3.

3.1 Preparation of Biodiesel Blends:

1)Preparation of B10 Blend: It is prepared by taking 900ml of diesel + 100ml of rice bran biodiesel

B10: 90% of Diesel + 10% of rice bran biodiesel

2)Preparation of B20 Blend: It is prepared by taking 800ml of diesel + 200ml of rice bran biodiesel

B20: 80% of Diesel + 20% of rice bran biodiesel

3)Preparation of B30 Blend:

It is prepared by taking 700ml of diesel + 300ml of rice bran biodiesel

B30: 70% of Diesel + 30% of rice bran biodiesel.

The prepared biodiesel blends are marked as B10.B20, B30 as shown in Fig.4.

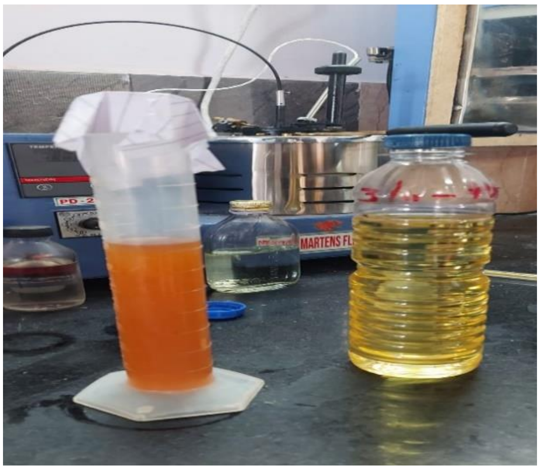

Fig.3 Rice bran biodiesel

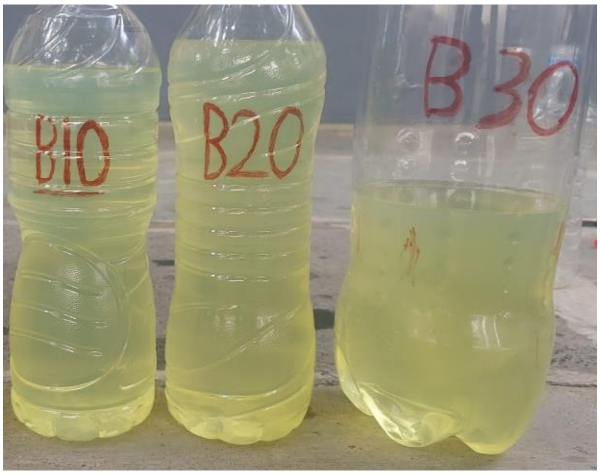

Fig.4 Biodiesel Blends

3.2 Properties of Diesel, Rice Bran Biodiesel, And Its Blends

Over the last century, the development of engine design and fuel qualities have worked in tandem to increase the performance of CI engines. Using the appropriate tools, we compute the fuel's parameters, such as its flash point, fire point, specific gravity, calorific value, and viscosity for the diesel, rice bran biodiesel, and their blends. Table.1 consists of the measured properties of diesel, rice bran biodiesel, and their blends. The properties had been measured on various apparatus in a Laboratory on our city premises and we measured the following properties.

- **Flashpoint:** It is the lowest temperature at which a liquid can form an ignitable mixture in air near the surface of the liquid. The lower the flash point, the easier it is to ignite the material.
- **Fire point:** The fire point of a fuel is the lowest temperature at which the vapor of that fuel will continue to burn for at least 5 seconds after ignition by an open flame. At the flash point, at a lower temperature, a substance will ignite briefly, but vapor might not be produced at a rate to sustain the fire.

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- **Specific gravity:** It is the ratio of the density of any substance to the density of some other substance taken as standard, with water being the standard for liquids and solids, and hydrogen or air being the standard for gases.
- **Calorific value:** The amount of energy produced by the complete combustion of a material or fuel. Measured in units of energy per amount of material, e.g., kJ/kg.
- **Viscosity**: It is a measure of a fluid's resistance to flow.

Table.1 Properties of diesel, rice bran biodiesel, and their blends

PROPERTIES	DIESEL	RICE BRAN BIODIESEL	B10	B20	B30
Density (kg/m^3)	830	862	833.2	836.4	839.6
Viscosity (CST)	3.26	4.64	3.398	3.536	3.674
Calorific Value (KJ/kg)	42500	40268	42276.8	42053.6	41830.4
Flash Point (^0C)	76	130	81.4	86.8	92.2
Fire Point (^0C)	108	155	112.7	117.4	122.1

4. EXPERIMENTATION

A single-cylinder diesel engine, a dynamometer, an exhaust gas analyzer, and a smoke analyzer make up the experimental setup. Table.2 contains the specifications of the engine. A rope brake is wrapped around the brake drum and is directly attached to the engine test rig. The rope's other end is attached to a weight platform, and one end is attached to a spring balance. By placing slotted weights on the end of the rope, the load on the engine can be changed. In Fig.5, the engine test setup is displayed. The fuels used are rice bran biodiesel with B10, B20, and B30 mixes and neat diesel fuel, as indicated in Fig.6. By keeping the engine speed constant at 1500 rpm, these mixes are tested under five distinct load scenarios, including 0%, 25%, 50%, 75%, and 100% loads. Analysis of engine performance can be done in terms of brake power, indicated power, frictional power, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio, indicated specific fuel consumption, and brake-specific fuel consumption thanks to the configuration. An analytical tool called a gas analyzer is used to determine the concentration of known gases in a gas mixture. It is used to monitor progress and aid in a variety of initiatives, such as process safety improvement, quality research, efficiency testing, and emissions monitoring. We note down the emission parameters of diesel and biodiesel blends with AVL 5 Gas Analyzer. Smoke analyzers, often referred to as opacity analyzers, are devices used to measure the amount of light that is blocked by smoke from diesel engines found in cars, trucks, ships, buses, motorcycles, locomotives, and huge stacks from industrial activities. The smoke values in percentage and different emissions CO, CO_2, NO_X, and O_2 values are calculated and compared with diesel to know which blend gives good performance and low emission.

Table.2 Specifications of the engine

Manufacture	Kirloskar
Brake Power	5 HP
Speed	1500 RPM
No. of Cylinders	1
Compression Ratio	16:5: 1
Bore Diameter	80 mm
Stroke Length	110 mm
Orifice Diameter	20 mm
Type of Ignition	Compression-Ignition
Method of Loading	Rope Brake
Method of Starting	Crank Shaft
Method of Cooling	Water Cooling

A rope brake is attached to a weight platform which can be switched from one end to the other to change the load on the engine. Slotted weights on the platform may be added to change the load on an engine. A brake drum is attached to the engine, and a rope is wrapped around it with a deadweight platform at one end (the bottom end) and a spring balance at the other (the top end). By adding the appropriate dead weight to the platform, the engine may be loaded in terms of 0%, 25%, 50%, 75%, and full load conditions

Fig.5 engine test rig

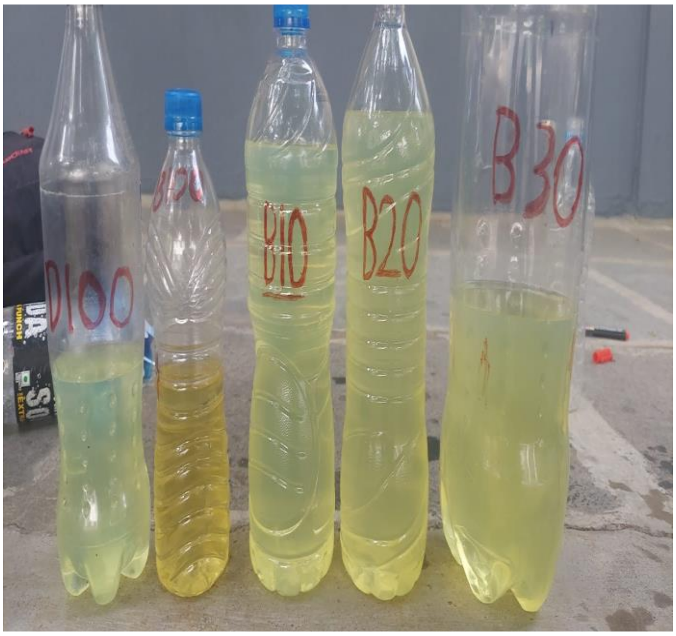

Fig.6 diesel, rice bran Biodiesel, and their Blends

5. RESULTS AND DISCUSSIONS

5.1 Performance Analysis:

5.1.1: Mass flow rate of fuel(m_f):

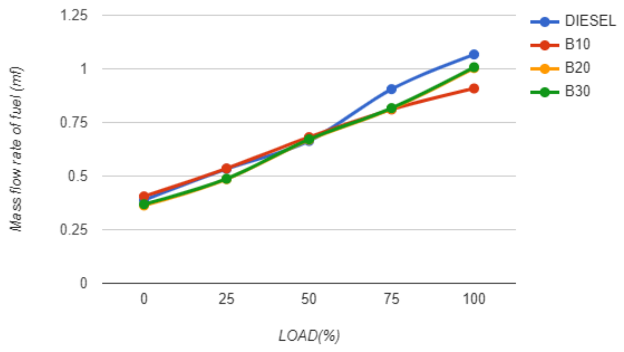

Fig.7 Load vs mass flow rate of fuel

From Fig.7, the diesel fuel mass flow rate is higher than that of biodiesel at 75% and full load conditions because biodiesel burns completely because oxygen is present. A mass flow rate of fuel increases with larger loads since diesel has a high calorific value. Mass flow rate at full load when compared to diesel, B10 biodiesel is 0.16 Kg/hr lesser. We can see that of all the blends B20 shows the least mass flow rate of fuel than other blends and diesel at almost all the conditions.

5.1.2 Mechanical efficiency (η_m):

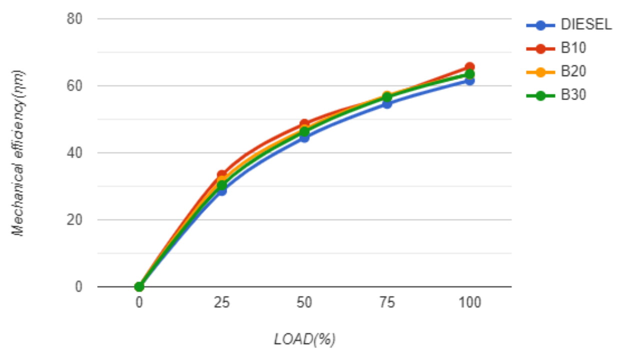

Fig.8 Load vs Mechanical efficiency(η_m)

From Fig.8, it can be shown that the mechanical efficiency is greater in blends than in diesel. Diesel's mechanical efficiency decreases because of its high indicated power. At full load conditions, B10 shows the highest efficiency than other fuels. Over all B20 blend mostly shows higher values in mechanical efficiency than other blends.

4.1.3 Brake thermal efficiency (η_{BTE}):

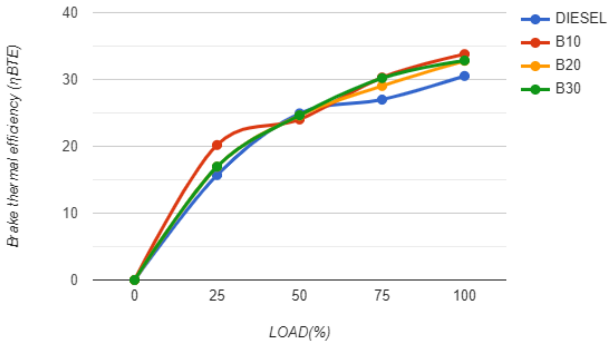

Fig.9 Load vs Brake thermal efficiency (η_{BTE})

From Fig.9, It has been noted that B10 BLEND has a higher brake thermal efficiency than other fuels. Brake thermal efficiency does not consider friction power. The efficiency of diesel and the other two blends are nearly comparable at small loads. at full load condition, B10 shows a peak BTE of almost 36%.

4.1.4 Indicated thermal efficiency (η_{ITE}):

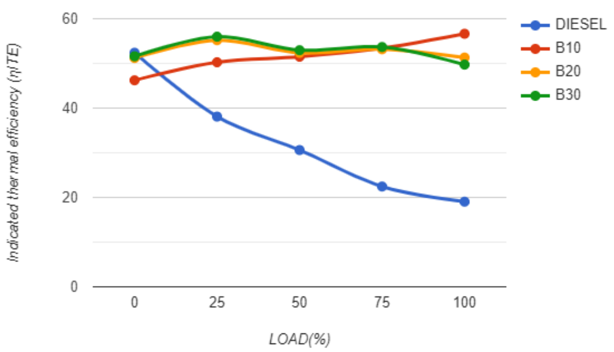

Fig.10 Load vs Indicated thermal efficiency (η_{ITE})

From Fig.10, it has been noted that diesel shows a constant inclination in ITE whereas the blends show identical ITE at all loads. At full load condition, B10 has a higher ITE than other blends, but it shows the highest ITE at half load condition. B30 blends show an alternative increase and decrease throughout the chart. B20 shows almost the same ITE at all loads.

4.1.5 Indicated specific fuel consumption (ISFC):

It has been noted that diesel vehicles have higher ISFC. The efficiency of all three fuels is nearly comparable at small loads. The same loads have the almost same ISFC.B20 shows a constant ISFC than the other two blends. If we look at the chart clearly B10 shows a continuous decrease in ISFC with the increase in load as shown in Fig.11.

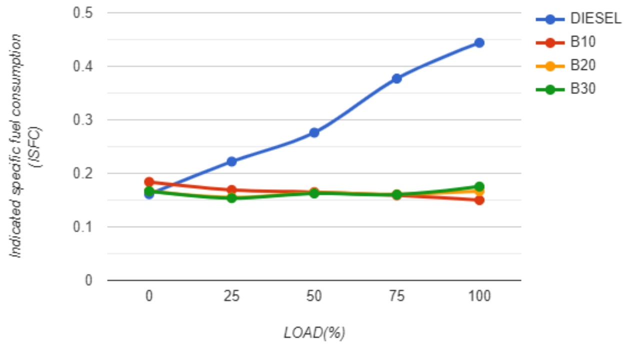

Fig.11 Load vs Indicated specific fuel consumption (ISFC)

4.1.6 Brake-specific fuel consumption (BSFC):

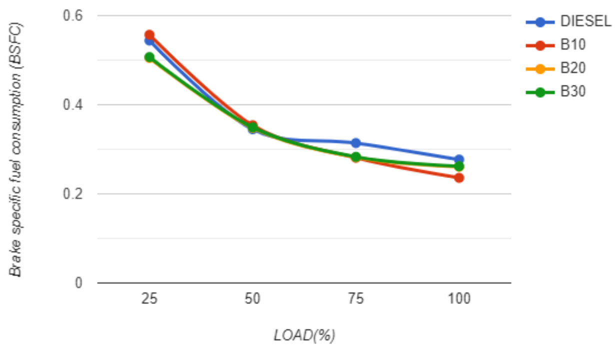

Fig.12 Load vs Brake specific fuel consumption (BSFC)

Fig.12 depicts the fluctuation of brake-specific fuel consumption with an increase in loads. The graphic shows that fuel consumption lowers as the load increases. B10 rice bran oil blend's BSFC falls when compared to diesel when operating at full capacity. Because rice bran oil has a lower calorific value than diesel fuel, rice bran oil blends have lower BSFC values than diesel. B20 Blends show the lower than other 2 blends except at full load condition.

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4.1.7 Air fuel ratio (A/F):

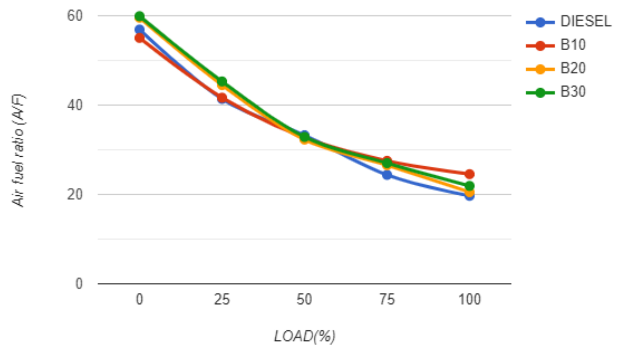

Fig.13 Load vs Air fuel ratio (A/F)

Fig.13 illustrates how the air-fuel ratio varies with brake power for diesel and rice bran biodiesel mixes. We can see that the air-fuel ratio of pure diesel declines as the load increases and that it is larger for B30 BLEND than for other rice bran biodiesel and its mixes. We can note that the B10 blend shows the least A/F ratio in most of the load conditions.

5.2 Emission Analysis:

5.2.1 Unburnt Hydro Carbons (HC):

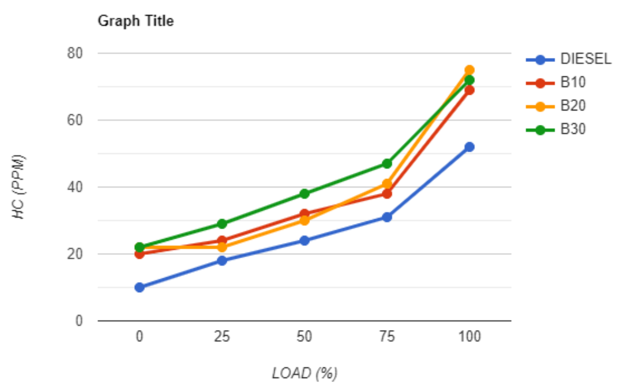

Fig.14 Load vs HC (ppm)

Unburned hydrocarbons found in exhaust pipes indicate that the fuel has been partially or not at all burned. This might be caused by an insufficient temperature and oxygen level. According to Fig.14, biodiesel has higher unburned hydrocarbons than diesel. When compared between the blends, the B10 blend shows the least HC than the other 2 blends.

5.2.2 Carbon monoxide (CO):

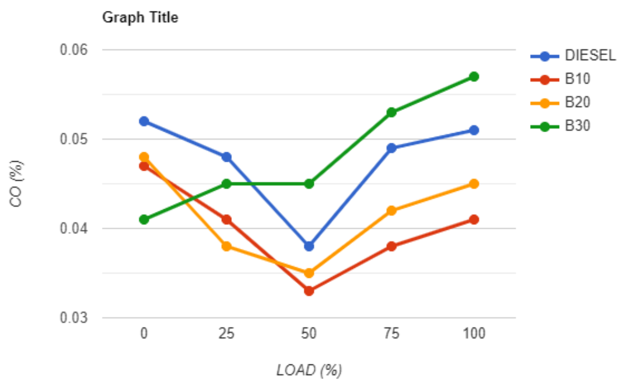

Fig.15 Load vs CO

CO is the result of incomplete combustion of HC in the fuel.CO depends on the A/F ratio, lack of ample amount of air does not allow all the carbons to convert into C02 and results in CO emission. Of all the blends of rice, bran B10 shows the least C0 at all load-applied conditions. The maximum CO can be shown at full load condition for each blend and B30 blend emission has more than diesel as shown in Fig.15.

5.2.3 Carbon dioxide (CO2):

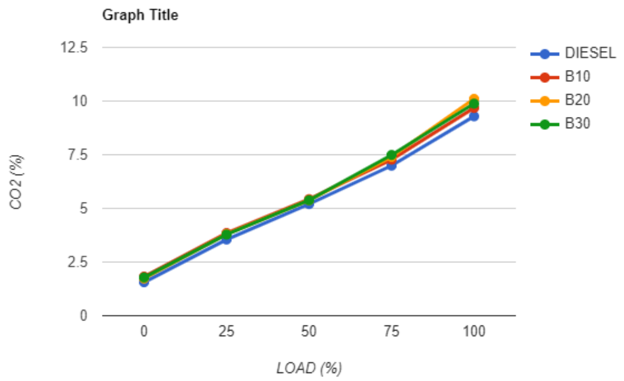

Fig.16 Load vs CO_2

Fig.16 depicts how carbon dioxide changes as load increases. The graphic shows that CO2 emissions rise as the load rises. at maximum load condition CO2 emissions measured for B10, B20, and B30, respectively, are 9.8%,10.1% and 9.88%. In comparison to other blends at full load, the CO2 emissions of the rice bran oil blend B10 were lower.

5.2.4 Oxides of nitrogen (NOx):

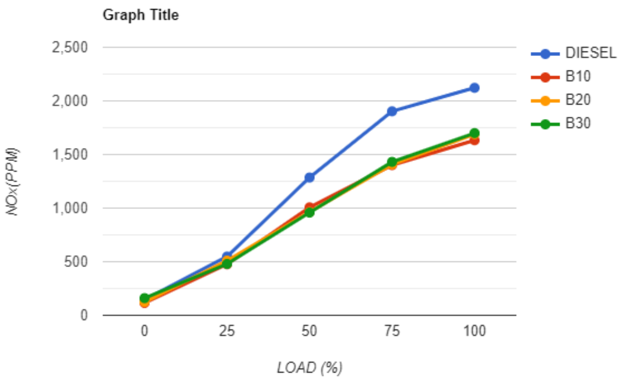

Fig.17 Load vs NOx

Fig.17 depicts the change of NOx emission with the load. The plot shows that when the load increases, NOx emission also increases. Diesel shows the highest NOx under all conditions. When compared to the other blends at full load, the NOx emission of the rice bran oil blend B10 dropped.

5.2.5 Smoke opacity:

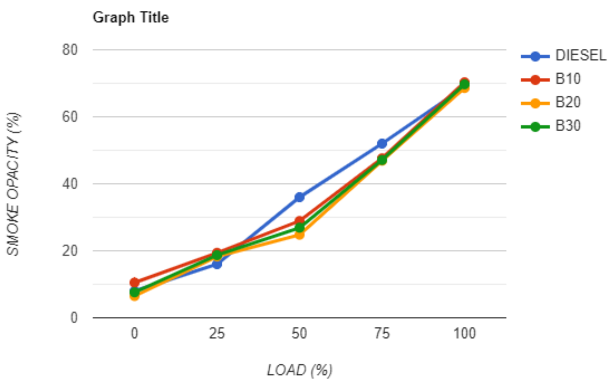

Fig.18 Load vs Opacity

Fig.18 depicts the smoke opacity increasing with an increase in load. The smoke opacity of biodiesel blends was lower than that of diesel at all loads. Diesel shows the highest Smoke opacity under all conditions. When compared to the other blends at full load, the smoke opacity of the rice bran oil blend B20 shows the least among them.

6. CONCLUSION

Using four different types of rice bran biodiesel with their blended fuels, the engine performance of a diesel engine was examined in terms of the mass flow rate of fuel(mf), brake thermal efficiency(η_{BTE}), mechanical efficiency(η_m), indicated thermal efficiency(η_{ITE}), indicated specific fuel consumption, and brake specific fuel consumption, air-fuel ratio.

- The mass flow rate of fuel increases with the increase in load conditions. Diesel shows the highest mass flow rate of fuel and shows the highest of 1.0671 Kg/hr at full load condition whereas biodiesel blends show comparatively less at almost all the loads. B10 shows the minimum mass flow rate of 0.9086 Kg/hr at full load conditions. Over B20 shows the least mass flow rate at most of the load conditions when compared with others.
- In comparison to other fuels, B10 has the best mechanical efficiency at a full load of 63.61%. In comparison to other blends, the B20 blend generally exhibits greater mechanical efficiency values at almost all loads. However, diesel shows the least among all due to its higher indicated power than other fuel-indicated powers.
- Brake thermal efficiency tends to be higher in B10 than in other blends and the maximum value of BTE was observed at full load condition of almost 36%. Diesel and the other two blends' efficiency is essentially the same for light loads.
- It has been observed that blends exhibit similar ITE at all loads, and diesel exhibits a consistent tilt in ITE. B10 has a higher ITE with 56.64%when compared to other blends at full load conditions. B30 blends display a different increase and decline across the entire experiment. In practically all loads, B20 displays the same ITE between 51%to 55%.
- ISFC has been observed and concluded that it increased with an increase in load with diesel as fuel, alternatively it decreased with load in biodiesel blends. Diesel shows the peak of ISFC with 0.444 Kg/kw-hr at full load conditions. We can notice that B10 shows a continuous decline in ISFC with the increase in loads.
- At full load conditions, B10 shows the least BSFC with 0.236 Kg/Kw-hr and diesel shows the peak BSFC at this load. B20 shows a constant BSFC at all load conditions, in contrast, diesel shows a constant decrease with the increase in loads.
- When it comes to air-fuel ratio B30 gives the highest ratio when compared with other blends at almost all load conditions except at full load conditions. We can see that B10 shows the lowest Air fuel ratio at full load of 24.54 % and B30 shows the highest at no load condition with almost near to 60%
- The current experimental analysis shows that when the B10 biodiesel mix is operated at full load condition, there are appreciable decreases in NOx, CO_2, HC, and smoke emissions. In comparison to other blends (B20, B30) and diesel at peak load, the NOx, CO_2, HC, and smoke emissions dropped.

From the analysis above, the blend B10 performs better than other blends (B20, B30,) in terms of performance metrics like brake thermal efficiency, mechanical efficiency, indicated thermal efficiency, brake-specific fuel consumption, indicated power, and emission metrics like unburned hydrocarbons, carbon monoxide, carbon dioxide, and oxides of nitrogen. B10 is therefore considered to be the ideal blend due to its improved performance. Overall, biodiesel showed increased engine performance with reduced emissions, and this has the potential to satisfy substantial future emission limits with the right exhaust post-treatment technology to offset the disadvantage of higher HC and NOx emissions without modifying engine hardware.

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