Experimental Investigation on Performance of a Compression Ignition Engine Fuelled With Linseed and Rice Bran Methyl Esters

Y N V Mani Sandeep Kumar, R. Leela Prakash, A. Siva Durga Mahesh, A. Aditya, T. Ram Ganesh

Abstract: ***Increase in depletion of fossil fuels and increase in environmental consciousness leads industry to evolve alternative energy sources. Biodiesel is one among such evolutions. Alternate fuels are acceptable as they shows the characteristics that are nearly equal to the Petroleum products. In this study Linseed oil and Rice Bran oil is used for the production of biodiesel. These oils are edible and serves as the potential alternatives since consists the properties like density, calorific value, volatility etc. similar to the diesel properties up on some chemical processing Transesterification. Here these oils are Transesterified and made it as a biodiesel and blended with diesel in various proportions like B5, B10, B20, B30. Where B5 represents that the blend consists of 5% biodiesel and 95% diesel. Here the Linseed oil and Rice bran oil is available in larger quantity and these oils are trans-esterified and then blended with diesel. In the process of Transesterification the oil is processed with chemical agents and removal of glycerol from it leaving alkyl esters where this can be used as a biodiesel. The blends that are made using biodiesel and diesel were tested using IC engine test rig where, it gives the performance characteristics like Brake power (BP), Brake specific fuel consumption (BSFC), Brake Thermal Efficiency (BTHE), Indicated Thermal Efficiency (ITHE), Mechanical Efficiency and volumetric efficiency etc. The performance characteristics of various Blends were compared. Upon considering results the best suitable blends were shown further in this study.***

Index Terms: ***Biodiesel, Transesterification, Linseed oil, Rice bran oil, Performance characteristics.***

I. INTRODUCTION

Biodiesels are the alternative fuels that are indistinguishable to Conventional Diesel fuel. The biodiesels can be made from vegetable oils, oil or fats of Animals, waste cooking oil and tallow etc. Transesterification is the process where it converts the oil in to biodiesel. Apart from this the CI engine needs some minor modifications as it runs with biodiesel as a fuel, whose characteristics are slightly differ from the diesel characteristics. Practically, vegetable oils are promising fuels that can be used for production of biodiesel for diesel engines. Rice Bran oil and Linseed oil are non-conventional, Edible, inexpensive vegetable oils where it properties like calorific value and their specific gravity are nearly equal to that of diesel so these oils can be used as Biodiesel.

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Mr. Y N V MANI SANDEEP KUMAR, Assistant Professor, Mechanical Engineering department, KLEF, Vadeswaram, India.

R. LEELA PRAKASH, Student, Mechanical Engineering department, KLEF, Vadeswaram, India.

A. SIVA DURGA MAHESH, Student, Mechanical Engineering department, KLEF, Vadeswaram, India.

A. ADITYA Mechanical Engineering department, KLEF, Vadeswaram, India.

T. RAM GANEH, Student, Mechanical Engineering department, KLEF, Vadeswaram, India.

Rice bran oil is generally extracted from inner husk of a rice grain and it has high smoke point of 254^0 C and its lenient flavour makes it suitable for higher temperature cooking and for deep frying. Generally, it is used widely in Asian countries. This oil contains a high range of fats, where 47% of fats are Mono-unsaturated, 33% of fats are Poly-unsaturated, and 20 % of its fats are saturated and it has the calorific value of 38,200 KJ/Kg. Linseed oil or Flaxseed oil is obtained by pressing ripened flax seeds, sometimes pressing is followed by the process of Solvent extraction. It is a drying oil where it easily polymerizes to solid form. Due to its polymer forming characteristic it can be used for its own or blended with other combination of oils. Linseed oil is edible for its nutritional values as origin of Alpha- Linolenic acid and it has a calorific value of 40,000 KJ/Kg.

S.no	Properties	Linseed oil	Rice bran oil	Diesel
1.	Density (gm/cc)	0.921	0.913	0.83
2.	Auto-Ignition Temperature(^{0}C)	343	323.8	256
3.	Calorific value (KJ/Kg)	40,000	38,200	44,600
4.	Viscosity (cSt)	9.84	6.41	3.21

Table 1 Comparison of properties of oils with diesel

1.2. TRANSESTERIFICATION

Transesterification is the process in which it removes the high free fatty acids and glycerol from the vegetable oils and leaves out methyl esters which is known as the Biodiesel. Here in this process both the Linseed oil and Rice bran oil were reacted with CH_3OH (Methanol) with in the presence of KOH acid catalyst in which the vegetable oil breaks in to biodiesel and fatty acids.

$$\begin{array}{lcccr} CH_2 - OOC - R & & & & CH_2 - OH \\ | & & & & | \\ CH - OOC - R' & + 3\,CH_3OH & \overset{KOH}{\longleftrightarrow} & 3\,CH_3 - O - COR & + \; CH - OH \\ | & & & & | \\ CH_2 - OOC - R'' & & & & CH_2 - OH \\ \text{Triglyceride} & \text{Methanol} & & \text{Biodiesel} & \text{Glycerol} \end{array}$$

Fig 1.1 Transesterification Process.

Where R, R’, R” are alkyl groups of various carbon chain links varies from 12 to 18 and —OOC— represents carboxyl group. Where the various vegetable oils have totally different chemical structure.

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II. EXPERIMENTAL PROCEDURE

2.1. Transesterification

- Initially the crude vegetable oils of Linseed oil and Rice bran oil of 1 kg each which are required for the process of esterification.
- Take 400 ml of Linseed oil and Rice bran oil in two different beakers and add 100 ml of methanol (alcohol) in each beaker and later add KOH pallets (catalyst) of 20 grams in each beaker and heat it for 45-60 minutes at the temperature of 70^0C to 100^0C. After, heating stir the mixture for 30 to 45 minutes using a stirrer around 1200 rpm.

Fig 2.1 Transesterification of Linseed oil with Methanol

Fig 2.2 Transesterification Rice bran oil with Methanol

- After all these process pour the Linseed oil and rice bran oil mixture in to a two separating funnel and keep aside for the nearly 20 hours so as to separate fatty acids from methyl esters.

Fig 2.3 Separating funnels with Linseed oil and rice bran oil mixture.

- After 20 hours we can see the formation of three layers namely biodiesel, fatty acids and glycerol from top to bottom in a separating funnel. Now that biodiesel is washed with warm water need to heated for 20 minutes and wash that corresponding oil for multiple times so as to remove the fatty acids and glycerol and leaving behind the biodiesel.

Fig 2.4 Washing of Linseed oil and Rice bran oil with hot water

- Repeat the process until it get the required amount of biodiesels for both the oils and pour that biodiesels separately in two different bottles.

Fig 2.5 Esterified Linseed oil and Rice bran oil.

- Now take the 300 ml of esterified oils of equal amounts in to a beaker and heat it for 45-60 minutes at the temperature of 70^0C to 100^0C. After, heating stir the mixture for 30 to 45 minutes using a stirrer around 1200 rpm. After, all these process pour this mixture of Dual biodiesel (esterified linseed oil and Rice bran oil) in to a bottle.

Fig 2.6 Heating of Hybrid biodiesel

Fig 2.7 Stirring of Hybrid biodiesel

Fig 2.8 Hybrid Biodiesel

1.3. Preparation of Blends.

Finally made the blends with diesel of B5, B10, B20, and B30 by mixing the biodiesel with diesel in various proportions so as to meet the corresponding blends i.e. this study have taken 4 samples of blends each of 700 ml in quantity. For the first blend B5 the corresponding sample consists of 35 ml of mixed biodiesel and 665 ml of diesel, for B10 blend the sample consists of 70 ml of biodiesel and 630 ml of diesel, for B20 blend the sample consists of 140 ml of biodiesel and 560 ml of diesel and for the blend B30 the sample consists of 280 ml of biodiesel and 420 ml of diesel.

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Fig 2.9 Blends of various proportions.

III. IC ENGINE TESTING

IC engine testing is the major aspect for this study as it is the only way to check the performance characteristics of blends that are processed by biodiesels and based up on the characteristics this study able to conclude that this blends are suitable or not and which blend shows the maximum efficiency in all aspects as compared with conventional diesel.This study utilizes the Kirloskar made four stroke single cylinder diesel engine which is water cooled engine. Generally, it is used for agricultural aspects and for the regular household purpose for generation of electricity. This is a fuel injection into compressed air type. The engine flywheel is connected to an electrical alternator for loading the engine. The brake power from the engine can be calculated by wattmeter and all the other characteristics can be provided for completenessof the test rig. Here, all the measurements instrumentations are provided on an independent panel separated from the engine.

Fig 3.1 I.C. engine test rig.

Make	Kirloskar
No. of Cylinders	1
No. of Strokes	4
Rated speed	1500 rpm
Rated Power	5 bhp/ 3.5 Kw
Type of Cooling	Water cooled
Dynamometer	Eddy current
Bore diameter	0.82 meters
Stroke length	0.110 meters
Compression ratio	16:1

Table 2 I.C. engine specifications.

3.1. Operational Procedure:

Initially fill the fuel tank with diesel and check the lubrication and water circulation before cranking the engine. Connect the control panel to 230 V electrical mains now start the engine by cranking and increase the load of the engine by knob adjustment. Take the reading for diesel at various load capacities. Here, all the results were stored in the software in a computer in which it is connected to the test rig by com port provided at RS – 232. Where it is used as converter to the computer through the data cable provided. Here the process of operation starts by the computer by clicking the start icon in software (NI based software) and after that run icon is essential for starting the operational procedure and then the results were saved in the excel format in the software. After, taking all the readings results documents must be saved after taking all the results from the diesel engine must be shut off and the oil must be changed and repeat the process. This process is continued for all the blends and the results of the individual blends were saved in the computer.

IV. RESULTS

This study has performed the testing of bio-fuels on IC engine test rig at various loads. The results for the resultant blends were shown below. This study gives out which blend shows the performance characteristics that are nearly equal to that of diesel performance characteristics. The performance of the bio-fuels is calculated based upon the parameters like Indicated power, Brake power, Brake thermal efficiency, Indicated thermal efficiency, Brake specific fuel consumption, Volumetric efficiency, Mechanical efficiency. Graphs were plotted between these parameters for diesel as well as the bio-blends. Based up on these graphs this study will say which blend is more efficient for commercial usage.

4.1 Brake Specific Fuel Consumption

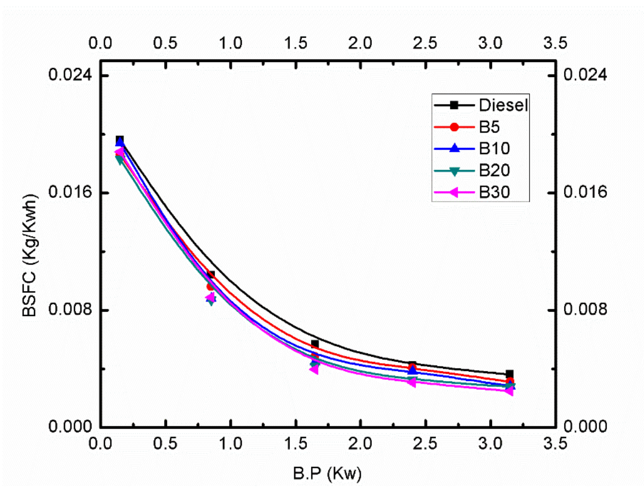

Fig 4.1 Comparison of Brake specific fuel consumption of various blends with respect to Brake power.

Brake specific consumption of fuel (BSFC) represents the fuel efficiency of an engine while working under load conditions.

Here in the above Fig 4.1. It is noticed that Diesel has high fuel consumption of 0.020 Kg/Kwh at low load and 0.003625 Kg/Kwh at maximum load when compared with other blends whereas B20, B30 has least fuel consumption as compared to diesel and other blends. B5 and B10 have the moderate fuel consumption which lies between diesel and B30 blends fuel consumption. However, all these blends shows nearly equal performance in Brake specific fuel consumption.

4.2. Brake Thermal Efficiency

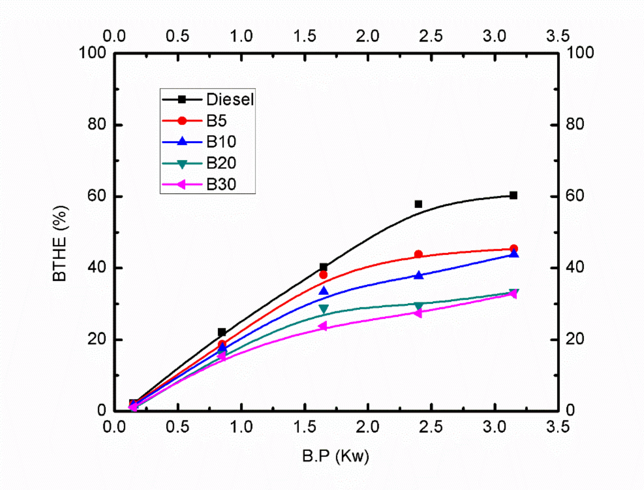

Fig 4.2 Comparison of Brake thermal efficiency of various blends with respect to Brake power

Brake thermal efficiency (BTHE) states that how effective the engine converts the heat energy from the conventional fuel to that of mechanical energy. In the above Fig 4.2. it is clear that diesel have high break thermal efficiency of 60.26% as compared with all the blends. B5 and B10 blends shows the reasonable results of 45.38% and 43.85% which shows nearly results. Finally, B20 and B30 blends shows the less performance as compared with other blends and fuel. This graph indicated that all other blends shows subservient results as compared with diesel in terms of Brake thermal efficiency.

4.3. Indicated Thermal Efficiency

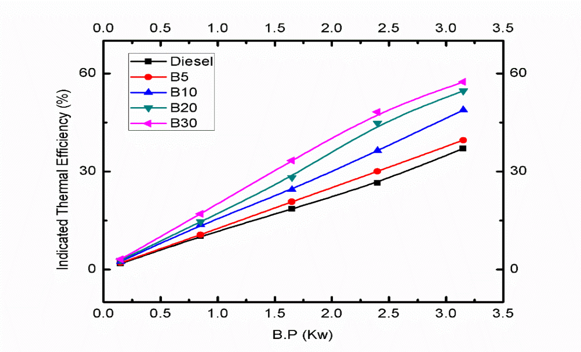

Fig 4.3 Comparison of Indicated thermal efficiency of various blends with respect to Brake power

Indicated thermal efficiency (ITHE) is defined as the proportion of the heat developed from the fuel converted in to indicate work to that of heat energy given by the fuel, at certain time. In the above Fig 4.3. It is clear that B30, B20 blends has the higher performance for ITHE i.e 57.41% and 54.64%. B10 has the moderate efficiency of 48.79% as compared with B20 and B30 whereas the Diesel, B5 blend has nearly equal performance of 37% and 39.56% that are less efficient as compared to other blends. By this graph it is stated that blends of biodiesel shows the good results as compared with diesel for Indicated thermal efficiency.

4.4. Volumetric Efficiency

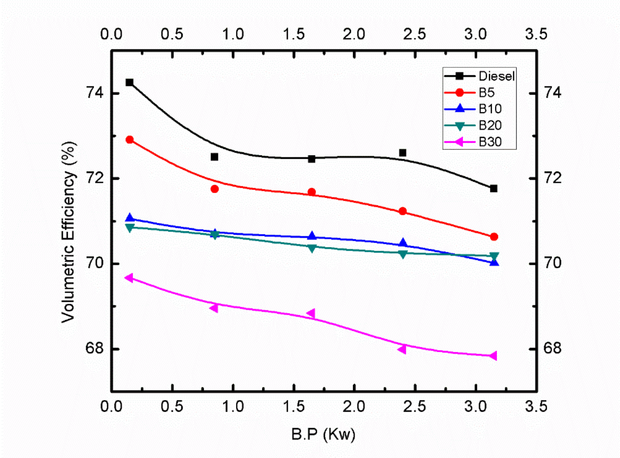

Fig 4.4 Comparison of Volumetric efficiency of various blends with respect to Brake power.

Volumetric efficiency (VE) defined as the ratio of the volume of the fuel that is displaced by a piston to that of Swept volume of an engine. In the above Fig 4.4. It is observed that Diesel has maximum volumetric efficiency of 74.25 % at low load and 71.76% at maximum load condition and B5 blend shows the characteristics that are nearly equal to diesel i.e 70.63% at maximum load. B10 and B20 blends shows the moderate performance as compared with other blends whereas B30 shows the least volumetric efficiency as compared with others fuels. This graph indicated that all other blends shows subservient results as compared with diesel in terms of Volumetric efficiency.

4.5. Mechanical Efficiency

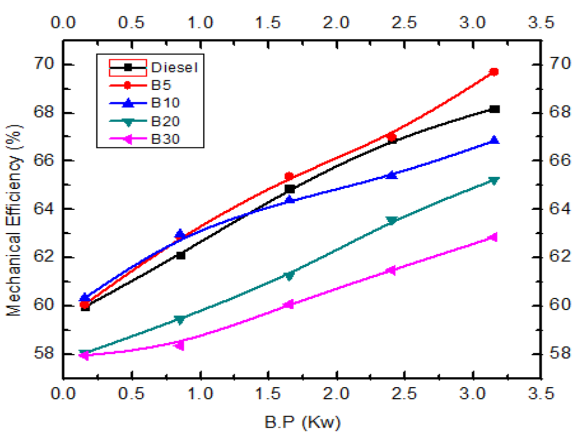

Fig 4.5 Comparison of Mechanical efficiency of various blends with respect to Brake power.

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Mechanical efficiency is defined as the ratio of Brake power to that of Indicated power. In the above Fig 4.5. It is clear that B5 has the maximum efficiency of 69.86% as compared with diesel efficiency of 68.29% and B10 efficiency slightly lesser than diesel efficiency i.e around 67%. B20 has moderate efficiency as compared with other blends whereas B30 blend has least efficiency among all the fuels at various load conditions. This graph indicated that biodiesels of B5 and B10 shows good performance characteristics with respect to diesel for Mechanical efficiency.

V. CONCLUSION

From the above results this study concludes that the performance characteristics of Hybrid biodiesel blends are slightly subservient than conventional diesel. However, the B5 and B10 blends show sustainable performance characteristics that are nearly equal to the conventional diesel fuel as per the plotted graphs. The other blends haven't given the effective outputs when compared with the conventional diesel fuel. So as to use the higher proportional blends like B20, B30, B40 etc. minor modifications to be done for the conventional I.C. engine like fuel pump, air to fuel ratio and advanced injection timing etc. which makes feasible for higher blends. Thus, the results from this study recommend that Hybrid biodiesel is prospectively good replacement for conventional I.C. engine.

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