Experimental Investigation of Performance Characteristic of Diesel Engine Run on Calophyllum Inophyllum Biodiesel 5% Blend

Rahul Krishnaji Bawane[1] Kiran Vilas Hande[2] Ronak Paresh Hariya[3]
[1]Assistant Professor [2,3]BE Student
[1,2,3]Department of Mechanical Engineering
[1,2,3]Pimpri Chinchwad College of Engineering & Research, Ravet - Pune, Maharashtra State, India

Abstract— An increasing demand of fossil fuels has being a critical problem for us. The natural resources of fossil fuel are dwindling day by day. Biodiesel that may call natural fuel may be a good source or substitute for fossil fuel in future. Biodiesel can be produced from vegetable oils and also from waste fats. Biodiesel is a mono-alkyl-ester of long chain fatty acids derived from renewable feedstock such as vegetable oils by transesterification process. The esterifies cotton seed oil, pungam oil, rice bran oil, and Calophyllum Inophyllum oil are chosen as the alternative fuels. Among these oils, Calophyllum Inophyllum oil is considered as an alternative fuel. An experiment is conducted to obtain the performance characteristics of the diesel engine run by chosen esterifies oils, and the results are compared with esterifies Calophyllum Inophyllum oil. From the comparison of results, it is inferred that the engine performance is nearly matches the diesel fuel without any engine modification. The experimental results obtained in the engine run on 5% biodiesel blend of Calophyllum Inophyllum oil is a promising alternative fuel for direct-injection four-stroke diesel engine.

Key words: Calophylum Inophyllum Oil, Transesterification, Biodiesl, Properties, Performance Characteristics, Diesel Engine Fuel

I. INTRODUCTION

The twenty-first century introduced an era of increased global petroleum demand that has not been met with an increase in oil production. The most practical and least disruptive strategy to achieve the objective of lowering de-pendency on petroleum is to use alternative fuels. Biodiesel is a diesel fuel alternative produced from oil seeds, primarily soy, and can be grown and produced domestically.

Among the many alternative fuels biodiesel are considered as a most desirable fuel extender and fuel additive due to its high oxygen content and renewable in nature. Alternative fuel termed as Biodiesel is obtained from non-edible oil seeds, vegetable oil, and Animal fats. Chemically biodiesel is referred as mono-alkyl esters of long chain fatty acid derived from renewable biological sources. It can be directly used in the compression ignition engine. Bio-diesel fuel is a clean burning alternative fuel that comes from 100% renewable resources. Many people believe that Biodiesel is the fuel of the future. Sometimes it is also known as Bio-fuel. Biodiesel does not contain petroleum, but petroleum can be mixed to produce a biodiesel blend.

In the present work biodiesel is prepared by Transesterification and check the thermo physical properties of the raw oil, biodiesel and neat diesel, and run diesel engine with 5% biodiesel blend and check performance characteristics.

II. OBJECTIVES

There are two main objectives in this work,

- Preparation of a biodiesel 5% blend and run the diesel engine.
- Compared the performance characteristics of the 5% biodiesel blend with diesel.

III. MATERIAL

Calophyllum Inophyllum oil contains 19.58% free fatty acids. The methyl ester is produced by chemically reacting Calophyllum Inophyllum oil with an alcohol (methyl), in the presence of catalyst (Sodium Hydrox-ide). A two stage process is used for the transesterification of Calophyllum Inophyllum oil.

Fig. 1: Setup for making biodiesel

The first stage (acid catalyzed) of the process is to reduce the free fatty acids (FFA) content in oil by esterification with methanol (99% pure) and acid catalyst sulfuric acid (98% pure) in one hour time at 57ºC in a closed reactor vessel. The oil is first heated to 50ºC then 0.7% (by wt. of oil) sulfuric acid is to be added to oil and methyl alcohol about 1:6 molar ratio (by molar mass of oil) is added. Methyl alcohol is added in excess amount to speed up the reaction. This reaction was proceeding with stirring at 650 rpm and temperature was controlled at 55-57ºC for 90 min. The fatty ester is separated after natural cooling.

At second level, the separated oil from the separating funnel has to undergo transesterification. Methoxide (methanol + sodium hydroxide) is added with the above ester and heated to 65°C. The same temperature is maintained for 2 hr. with continuous stirring, and then, it undergoes natural cooling for 8 hr. Glycerol will deposit at the bottom of the flask, and it is separated out by a separating funnel. The remnants in the flask are the esterifies vegetable oil (biodiesel).

The separated biodiesel from the above-mentioned method contains various impurities like traces of glycerol, unused methanol, soap particles, etc. Water washing is carried out to remove all impurities. Air bubble wash is one of the methods normally recommended in the laboratory level. In this method, the impure biodiesel is placed in a

beaker initially. Water is added slowly through the side wall of the beaker (both are immiscible). It is ensured that the equal amount of water is added above the level of biodiesel. Air is made to pass through the biodiesel and the water from the bottom of the beaker with the help of a bubbler (electrically operated).

The air will then take away all impurities from the biodiesel; they will move up as the bubbles move up, and they are added in the water. The unused methanol will be diluted in water. The traces of glycerol and soap particles make the water to become like soap water. Once the water becomes like soap water, the bubbler is stopped. After allowing some time for impurities to settle, the biodiesel is drained from the separating funnel, and pure biodiesel will be directly used, with or without blending, in the engine.

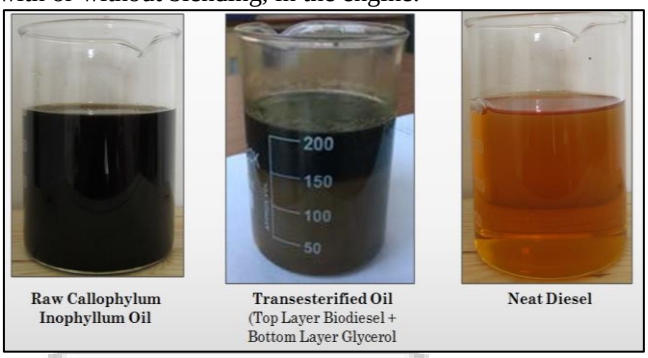

Fig. 2: Oil Samples

Thermo-physical properties of Raw Calophyllum Inophyllum Oil and its Biodiesel are tested in Chem-Tech Laboratories, Pune, according to American Society for Testing and Materials (ASTM) as tabulated below and the Neat Diesel parameters are taken from references.

Parameters	Test Method	Neat diesel	Raw Calophylum Inophylum Oil	Calophylum Inophylum Biodiesel
Density at 15°C (Kg/m^3)	ASTM D4052 2016	835	941.9	893.9
Kinemaric Viscosity at 40°C (Cst)	ASTM D7042 2016	3.5	57.60	9.231
Gross Calorific Value (MJ/Kg)	ASTM D240 2017	44	37.76	23.43

Table 1: Thermo-Physical Properties

IV. METHODOLOGY

The objective of the present work is to study through experiments on the performance characteristics of Calophyllum Inophyllum Oil Biodiesel blends in direct injection (DI) diesel engine at various loads.

Load Kg	Fuel	Injection Pressure Bars	Injection Timing °bTDC	CR
0.0	C0 : Neat Diesel	210	27	18
3.0				
6.0	C5 : 5% Biodiesel Blend			
9.0				

Table 2: Experimental Conditions

V. EXPERIMENTATION

For the experimentation diesel engine used is located in IC Engine Laboratory of Pimpri Chinchwad College of Engineering and Research, Laxminagar Ravet, Pune - 412101, Maharashtra State, India. It is a single cylinder variable compression diesel engine with the following specifications,

Sr. No.	Description	Specification
01	Number of cylinder	1
02	No. of strokes	4
03	Fuel	H.S Diesel
04	Rated power	3.5 Kw @1500 rpm
05	Cylinder diameter	87.5mm
06	Stroke length	110mm
07	Connecting rod length	234mm
08	Compression ratio vary	12 to 18:1
09	Orifice diameter	20mm
10	Dynamometer arm length	185mm

Table 3: Engine Specifications

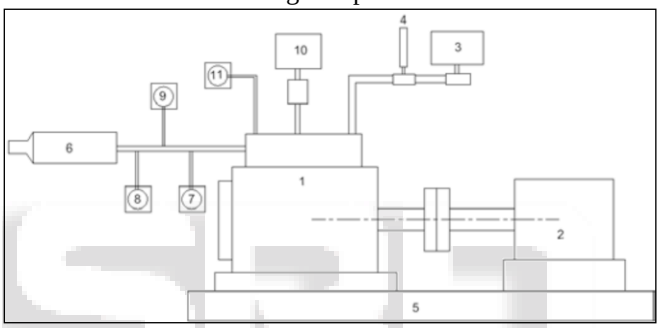

Fig. 3: Engine Setup
1. Test Engine, 2. Electrical Dynamometer, 3. Fuel Tank, 4. Fuel Burette, 5. Test Bed, 6. Silencer, 7. Smoke Meter, 8. Gas Analyzer, 9. Exhaust Temperature Sensor, 10. Air Flow Meter, 11. Stop Watch

VI. RESULTS & DISCUSSION

A. *Exhaust Gas Temperature*

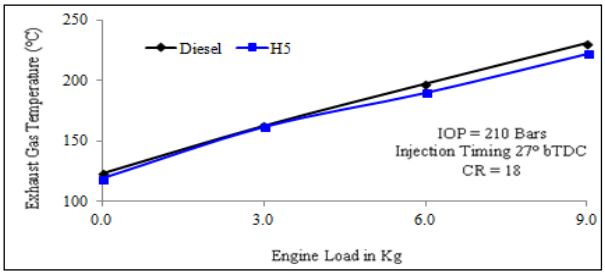

Fig. 4: Exhaust Gas Temperature

The variation of exhaust gas temperature with engine load is represented for neat diesel and 5% blend of biodiesel. As engine goes on increasing exhaust gas temperature is also increasing for both diesel and Biodiesel. As calorific value of neat diesel is higher than the value for Biodiesel, it gives more burning effect results in high exhaust gas temperature.

B. *Brake Power*

As there is increase in engine load, there is rise in brake power for both neat diesel and biodiesel. There is slight reduction in brake power if neat diesel goes on blending with Calophyllum

Inophyllum oil. The above graph compares brake power of 5% biodiesel blend with neat diesel.

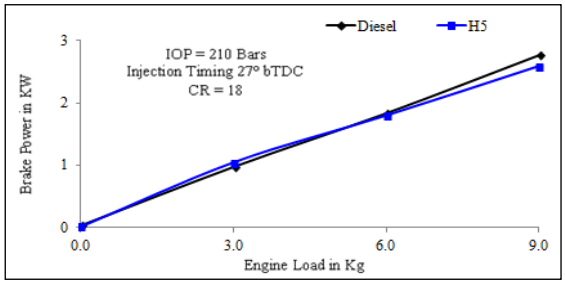

Fig. 5: Brake power

C. *Brake Thermal Efficiency*

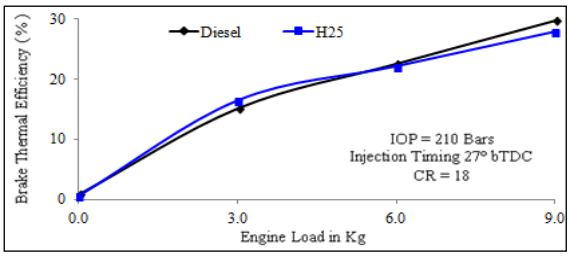

Fig. 6: BTE

It is clearly observed from the chart that the BTE for both of fuels increases with increase in load. This is due to higher percentage increase in break power with load as compared to increase in the fuel consumption.

D. *Mechanical Efficiency*

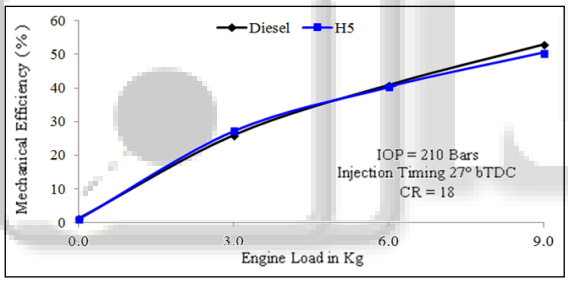

Fig. 7: Mechanical efficiency

Mechanical efficiency can be defined as the ratio of brake thermal efficiency to the indicated thermal efficiency. As there is percentage increase in brake power, mechanical efficiency goes on increasing for both neat diesel and biodiesel. Mechanical efficiency of diesel engine at different load is slightly more than the biodiesel.

E. *Volumetric Efficiency*

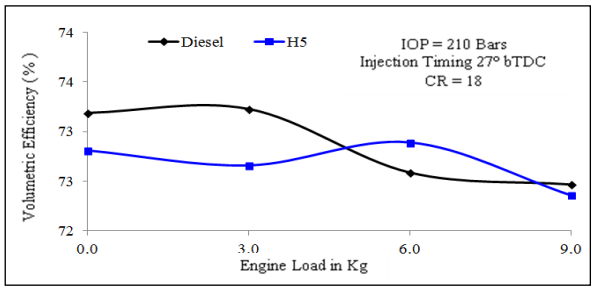

Fig. 8: Volumetric efficiency

As there is decrease in volumetric efficiency of diesel engine with respect to engine load, the graph shows that the volumetric efficiency at engine load of 6 Kg the diesel curve is below the 5% biodiesel curve that shows biodiesel 5% blend gives better volumetric efficiency at engine load 6 Kg.

F. *Specific Fuel Consumption*

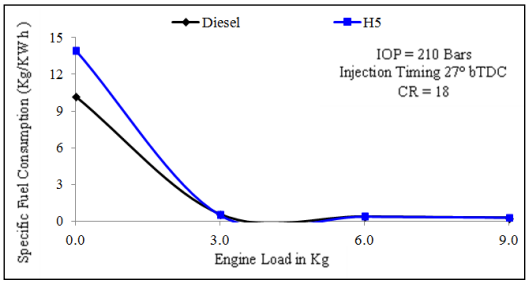

Fig. 9: Specific Fuel Consumption

It is clearly observed from graph that specific fuel consumption at no load condition (Idler time) is maximum than the load condition which is as expected. While at high engine load the combustion is improved due to higher in-cylinder temperature after successive working of engine at this load that is would improve fuel atomization and evaporation processes and partially improve fuel air mixing process. Specific fuel consumption for biodiesel is more than that of neat diesel at different load conditions.

VII. CONCLUSIONS

The present work is done to study the production of Calophyllum Inophyllum biodiesel and the effect of engine load on the engine performance when run on 5 % biodiesel blend. Based on the results of the present work, following conclusions are drawn:

1) Calophyllum Inophyllum oil Biodiesel is prepared by Transesterification process and diesel engine is run on 5% blend successfully.
2) Performance characteristics show that 5 % blend is satisfying to use as alternative fuel for diesel engine without any modifications.

VIII. FUTURE SCOPE

1) Engine performance needed to be conducted on various blend proportions like C10, C15 and on.
2) Engine performance is needed to be check for the various Compression Ratio.
3) Engine is needed to be optimized on the basis of comparing experimental results based on varying engine load, blend proportion and compression ratio.

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