Experimental Investigation of Emission Characteristics of Calophyllum Inophyllum Linn (Honne) Oil as Alternative Fuel in CI Engine

Rahul Krishnaji Bawane, Nilima Baliram Gadge, Swapnil Ambhore, Aquib Shaikh

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 called 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 Linn (honne) oil are chosen as the alternative fuels. Among these oils, Calophyllum Inophyllum Linn (honne) oil is considered for the first time as an alternative fuel.

An experiment is conducted to obtain the operating characteristics of the variable compression ratio (VCR) engine run by chosen esterifies oils, and the results are compared with esterifies Calophyllum Inophyllum Linn (honne) oil. From the comparison of results, it is inferred that the engine performance is improved with significant reduction in emissions for the chosen oils without any engine modification. The effective compression ratio can be fixed based on the experimental results obtained in the engine since the findings of the present research work infer that the biodiesel obtained from Calophyllum Inophyllum Linn (honne) oil is a promising alternative fuel for direct-injection four-stroke VCR engine.

Index Terms— Biodiesel, Transesterification, Calophyllum Inophyllum Linn (honne) oil, Compression Ratio, Emission Characteristics.

1 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 dependency 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. Biodiesel 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 Biofuel. Biodiesel does not contain petroleum, but petroleum can be mixed to produce a biodiesel blend that can be used in many different vehicles. Pure biodiesel fuel though, can only be used in diesel engines. Biodiesel is biodegradable and non-toxic.

The main objective of this work is to analyze the engine emission characteristics of diesel engines fuelled with biodiesel produced from 'Calophyllum Inophyllum Linn (honne) Oil' and/or its blends with diesel fuel, which will help in both the direction of reducing emission problems and search of alternative fuel for CI engines.

2 MATERIAL AND METHOD

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

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.

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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 esterified 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.

3 Methodology

As per the present authors' knowledge the use of blends of Calophyllum Inophyllum Methyl Ester – CIME in diesel engine at various load conditions and blend proportion are not reported in the literature. The objective of the present work is to study through experiments on the eimmision characteristics of CIME blends in direct injection (DI) diesel engine at various load.

TABLE I: BIODIESEL BLENDS USED FOR EXPERIMENTATION

Blend Type	*Blend*	*IOP in bars*	*Injection Timing in degree bTDC*	*Compression Ratio*
H00	100% Diesel	210	27	17.5 : 1
H25	25% CIME + 75% Diesel			
H50	50% CIME + 50% Diesel			
H75	75% CIME + 25 Diesel			

The properties of H100 and Diesel and Calophyllum Inophyllum Oil were determined as per the methods approved by Bureau of Indian Standards.

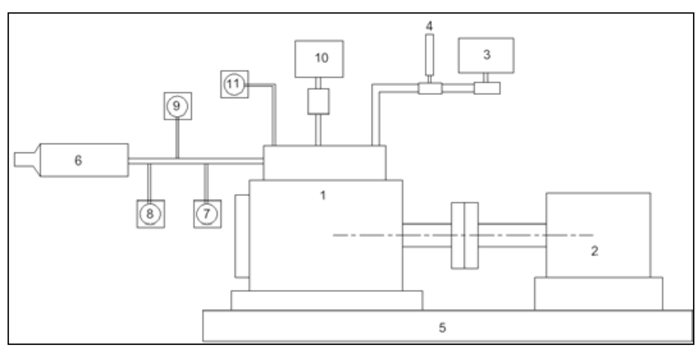
TABLE II: CHARACTERISTICS OF FUEL USED

Parameter	*Test Standard*	*Diesel (H00)*	*CIME (H100)*	*Honne Oil*
Density at 15ºC (gm/cc)	IS 1448 (P16) 2007	0.835	0.8653	0.9363
Kinematic Viscosity at 40ºC (cst)	IS 1448 (P25) 2007	3.5	1.744	51.58
Calorific Value (MJ/Kg)	IS 1448 (P6) 2007	43.00	35.37	40.27
Flash Point (ºC)	IS 1448 (P69) 2013	44	8.5	220

TABLE III: ENGINE SPECIFICATIONS

Sr. No.	*Description*	*Specification*
1	Make	Rocket Engineering Model VRC-1
2	Bore	80 mm
3	Stroke	110 mm
4	Swept Volume	553 mm
5	RPM	1500
6	Brake Horse Power	5 HP
7	Compression Ratio	17.5 : 1
8	Fuel Oil	High Speed Diesel
9	Coefficient of Discharge	0.65
10	Water Flow Transmitter	0 to 10 lit./min.
11	Air Flow Transmitter	0 to 250 wc
12	Piezo Sensor	0 to 5000 psi with low noise cable
13	Software	Labview

FIGUREI: ENGINE SETUP



1. Test Engine, 2. Electrical Dynamometer, 3. Fuel Tank, 4. Fuel Burette, 5. Test Bed, 6. Silencer, 7. Smoke Meter, 8. HC/CO/NOx/CO2/O2 Analyzer, 9. Exhaust Temperature Sensor, 10. Air Flow Meter, 11. Stop Watch

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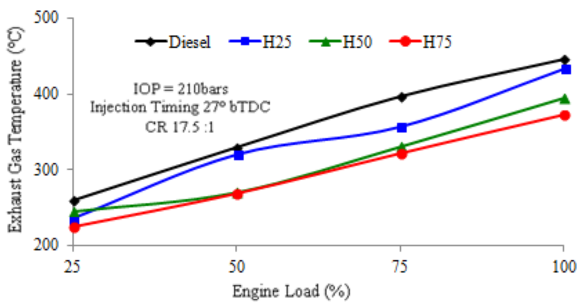
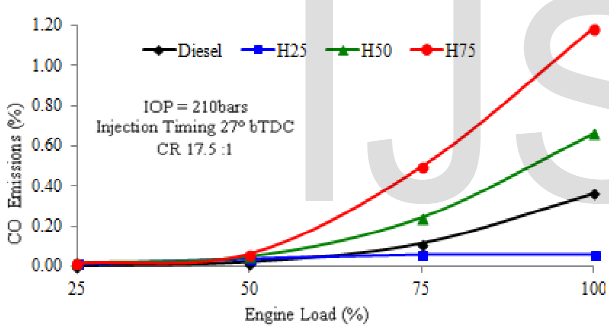
4 REULTS AND DISCUSSION

4.1 Variation of Exhaust Gas Temperature



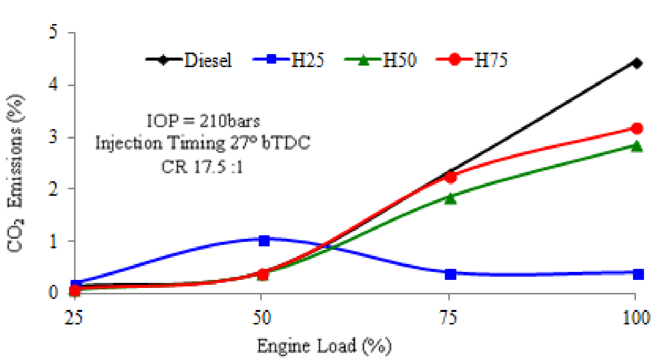
Exhaust Gas Temperature is shown trend to be reduced with the increase of blend proportion at each load condition. It shows greatest value of exhaust gas temperature with diesel and followed by blends H25, H50 and H75. This could be due to oxygen content of honne oil, which assists complete combustion of fuel in combustion chamber itself, and also due to lower calorific value, overall heat release is less than that of diesel fuel.

4.2 Variation of CO Emission



The CO emission increased with the increase of engine load, at partial load upto 50% emissions are less, however, it increased at higher engine load. This is due to relatively less oxygen available for the reaction when more fuel is injected into the engine cylinder at higher engine load. CO emission with H25 is closer to that of diesel as compared to all other blends and highest with H75.

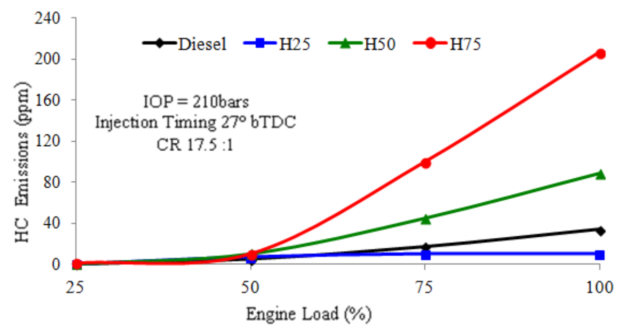
4.3 Variation of CO_2 Emission



Data shows that CO2 emissions decreased significantly as compared to that of diesel for all load conditions. This result due to content of oxygen in the honne oil itself, so the carbon content is relatively lower in the same volume of fuel consumed.

In the present work CO2 emission is lower most with blend H25 as compared to other blends, even though their content of CIME is more that H25, this requires further investigations.

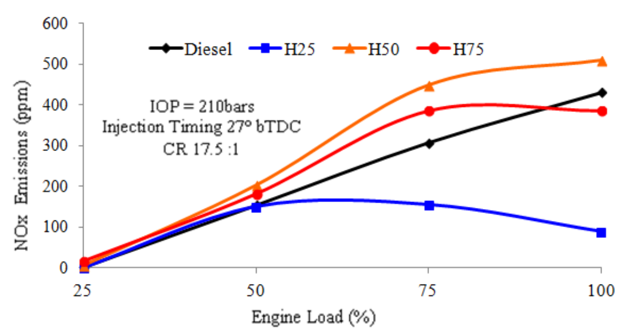
4.4 Variation of HC Emission



HC emissions increased with the increase of engine load. With partial load upto 50% there are HC emission upto to 10ppm, but on increasing load towards full load condition, it increases continuously.

HC emission for H25 is lower most and for other blends are shows increasing with blends proportion above the diesel HC emission level.

4.5 Variation of NO_x Emission

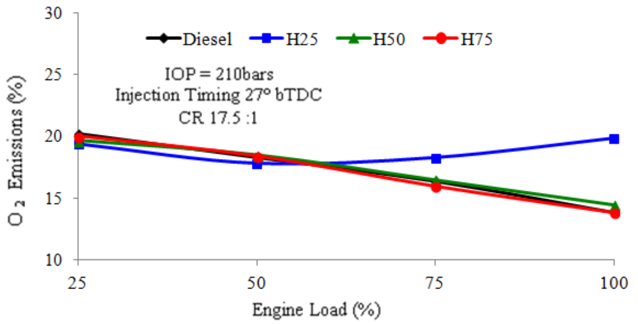


The NOx emission increased as the engine load increased, due to combustion temperature increased. This proves that the emission of NOx is significantly influenced by the cylinder gas temperature and the availability of oxygen during combustion.

It is observed that H25 produces lower NOx compared to diesel and other blends over the entire load range. The reduction in NOx emission is due to reduced premixed burning rate (low heat release rate) leads to lower cylinder temperature.

At the same time with higher blend proportions, the content of oxygen of honne oil, result in more oxygen availability in combustion chamber, hence shows increasing trend in NOx formation.

4.6 Variation of O_2 Emission



Graph shows that O2 emission decreased continuously with increases in load, this is due to increases in fuel quantity consumed more oxygen, thus residual oxygen content in exhaust gases are decreases with increase in engine load.

H25 shows higher oxygen emission at higher load as compared to other blends and diesel fuel, because of less amount of oxygen is consumed for CO2, NOx and CO emission with blend H25, hence more residual oxygen found in exhaust gas emission.

5 Conclusions

A non-edible Calophyllum Inophyllum Methyl Ester is considered as a new possible source of alternative fuel for diesel engine. No difficulty was faced at the time of starting the engine and the engine ran smoothly over the range of engine speed. Based on the experimental work with H25, at maximum load, the following conclusions are drawn.

- EGT of H75 is 373ºC compared to 446ºC with diesel.
- CO emission of H25 is 0.06% (by volume) compared to 0.365% (by volume) with diesel.
- CO2 emission of H25 is 0.4% (by volume) compared to 4.475% (by volume) with diesel.
- HC emission of H25 is 10 ppm compared to 34 ppm with diesel.
- O2 emission of H25 is 19.87 % (by volume) compared to 13.86 % (by volume) with diesel.
- NOx emission of H25 is 89 ppm compared to 430 ppm with diesel.

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