Performance Emission and Combustion Characteristics of Honne Oil Biodiesel Blends in Diesel Engine

Varathan R
PG scholar, M E Thermal engineering
Regional Centre of Anna University
Tirunelveli, India
varathan5818@gmail.com

Karuppasamy K
Assistant Professor, Department of Mechanical Engineering
Regional Centre of Anna University
Tirunelveli, India

***Abstract*—Recently, non-edible oil resources are gaining worldwide attention because they can be found easily in many parts of the world especially wastelands that are not appropriate for cultivating food crops, eliminate competition for food, more efficient, more environmentally friendly, produce useful byproducts and they are more economical compared to edible oils. In this present work, non-edible calophyllum inophyllum (Honne) oil is selected as an source for biodiesel production. The catalytic transesterification method is used to produce honne oil biodiesel, in view of this method produces maximum biodiesel yield. In this work honne oil biodiesel, blending with diesel and the biodiesel blends are prepared. It was tested in single cylinder Kirloskar engine and the performance, combustion and emission characteristics were studied. In these results B25 biodiesel blend has produced maximum performance and minimum emission characteristics and it is also nearer to the diesel results.**

***Key words*—IC engines, Alternate fuels, Biodiesel.**

I. INTRODUCTION

The large increase in number of automobiles in recent years has resulted in great demand for petroleum products. With crude oil reserves estimated to last only for few decades, there has been an active search for alternate fuels. The depletion of crude oil would cause a major impact on the transportation sector**.** Of the various alternate fuels under consideration, biodiesel, derived from vegetable oils, is the most promising alternative fuel to conventional diesel fuel. A lot of research work has been carried out using vegetable oil both in its neat form and modified form. Studies have shown that the usage of vegetable oils in neat form is possible but not preferable. The high viscosity of vegetable oils and the low volatility affects the atomization and spray pattern of fuel, leading to incomplete combustion and severe carbon deposits, injector choking and piston ring sticking. Non-edible oils have several advantages over edible oils. Non edible oils possess toxic components that make them unsuitable. The use of non-edible oils for biodiesel production solves the food-versus-fuel concern and other issues. Moreover, unproductive lands, degraded forests, cultivator's fallow lands, irrigation canals, and boundaries of roads and fields can be used for the plantation of non-edible oil crops. Many researchers have recommended non-edible oils to be a sustainable alternative to edible oils for biodiesel production. Methods such as blending with diesel, emulsification, pyrolysis and transesterification are used to reduce the viscosity of vegetable oils. Among these, the transesterification is the most commonly used commercial process to produce clean and environmentally friendly fuel.

II. EXPERIMENTATION

The acid value of vegetable oil is defined as the number of milligrams of potassium hydroxide required to neutralize the free acid present in 1 g of the oil sample. From literature, it was found that the acid values of crude Calophyllum inophyllum oil were 41.74 mg KOH/g oil. The transesterification procedure cannot be successful when the acid value is more than 4 mg KOH/g oil. Therefore, to produce biodiesel, the FFA must be converted to esters using acid catalytic esterification before attempting alkaline catalytic esterification. For the single step esterification process there is no biodiesel separation from the oil. So that I am using two step esterification process.

A. Pre-treatment process

In this process, crude Calophyllum inophyllum oil (CCIO) was entered in a rotary evaporator and heated to remove moisture for 1 h at 95^0C under vacuum.

B. Esterification process

In this process, 8:1 M ratio of methanol to honne oil and 1% of sulfuric acid (H_2SO_4) were added to the preheated oil at 60^0C for 3 h and 400 rpm stirring speed in a glass reactor. On completion of this reaction, the products were poured into a separating funnel to separate the excess alcohol, sulfuric acid and impurities presented in the upper layer. The lower layer was separated and entered into a rotary evaporator and heated at 95^0C under vacuum conditions for 1 h to remove methanol and water from the esterified oil.

C. Transesterification process

In this process, the esterified Calophyllum inophyllum oil from the previous step was reacted with 25% of methanol and 1% of alkaline catalyst potassium hydroxide (KOH) and maintained at 60^0C for 2 h and 400 rpm stirring speed. In this process, triglyceride was converted to methyl ester and glycerol was formed as a byproduct. After completion of the reaction, the produced biodiesel was deposited in a separation funnel for 12 h to separate the glycerol from biodiesel. The lower layer containing impurities and glycerol was drawn off.

D. Post-treatment process

Methyl ester formed in the upper layer from the previous process was washed to remove the entrained impurities and glycerol. In this process, 50% of distilled water at 60^0C was sprayed over the surface of the ester and stirred gently. The lower layer was discarded and upper layer was entered into a flask and it is dried using rotary evaporator to make sure that biodiesel is free from methanol and water.

III. BIODIESEL PROPERTIES

The important properties like kinematic viscosity, density, heating value, flash point, fire point, specific gravity of each biodiesel blends are determined and it is tabulated below

Table.1. Properties of biodiesel blends and diesel

Properties	Diesel	B25	B50	B75	B100
Kinematic viscosity at 40^0 C (mm^2/s)	3.233	3.705	4.541	4.977	5.749
Density at 40^0 C (kg/m^3)	834.9	845.2	855.8	866.7	877.4
Heating value (MJ/kg)	45.304	43.671	41.787	40.618	39.273
Flash point (^{0}C)	72	85	110	131	142
Fire point (^{0}C)	81	93	118	139	148
Specific gravity	0.834	0.845	0.855	0.866	0.877

IV. EXPERIMENTAL SETUP

Experiments were performed in the thermal laboratory, Department of mechanical engineering, Government College of Technology, Coimbatore. The experimental setup consists of single cylinder, four strokes, diesel engine connected to eddy current dynamometer for variable loading. The set as stand-alone type independent panel box consisting of air box, fuel tank, manometer etc. The set up enables study of engine for brake power, BMEP, brake thermal efficiency, mechanical efficiency, specific fuel consumption, volumetric efficiency, A/F ratio, and emission characteristics CO, CO_2, HC and NO_X and combustion characteristics heat release rate, cylinder gas pressure.

The important components of the system are,The engine, Dynamometer, Exhaust emission testing machine, Calorimeter, Fuel measuring unit, Pressure sensor, Temperatur sensor, Rotameter, Software.

Table.2. Technical specifications of the engine

Manufacturer	Kirloskar Oil Engines Ltd., India
Model	TV–SR II, naturally Aspirated
Engine	Single cylinder, DI, 4 strokes
Bore/stroke	80mm/110mm
Compression ratio	16.5:1
Speed	1500 rpm/min, constant
Rated power	3.5kW
Injection pressure	240 bar/23° BTDC
Type of sensor	Piezo electric
Crank angle sensor	1-degree crank angle

The emissions test is done with I3sys smoke meter EDM 1601 Exhaust Gas Analyzer. It is designed with sophisticated measurement modules. It is used measuring the emission characteristics like CO, CO_2, HC and NO_X, SO_X, O_2.

V. RESULTS AND DISCUSSION

A. Performance characteristics

Brake thermal efficiency is increasing with increasing brake power for all multi-blends of biodiesel and diesel. It may be due to reduction in heat loss and increase in power with increase in load. Brake thermal efficiency of 25% biodiesel is very close to diesel for entire range of operation.

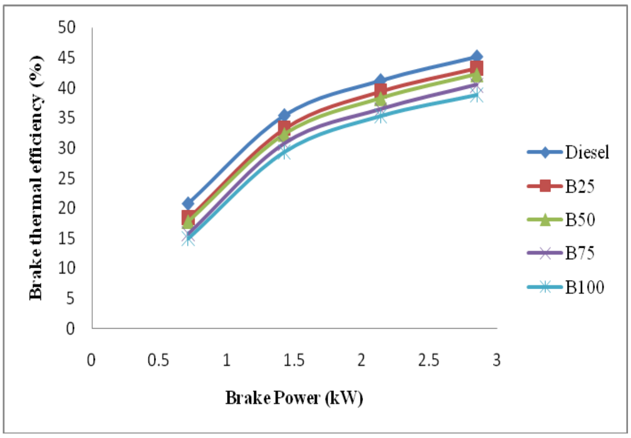

Fig.1. Brake power Vs Brake thermal efficiency

Maximum brake thermal efficiency of 25% blend is 43.22% against, 45.19% of diesel oil, which is lower by 1.97%.I can say that brake thermal efficiency of 25% biodiesel is very well comparable with diesel. The maximum brake thermal efficiency of 50%, 75% and 100% blends are 42.22%, 40.46% and 38.86 against 45.19% of diesel.

The power developed increases the specific fuel consumption decreases for all the tested fuels. The specific fuel consumption of blends is more than that of diesel, this is due to lower calorific value of the fuel, and engine consumes more amount of the fuel in order to produce the same output power. Brake thermal efficiency for B25 fuel is very close to that of diesel. At full load, the maximum Brake thermal efficiency for diesel is 0.17 kg/kWh for B25 the value is 0.19 kg/kWh, B50 is 0.20 kg/kWh, B75 is 0.21 kg/kWh and B100 is 0.23 kg/kWh.

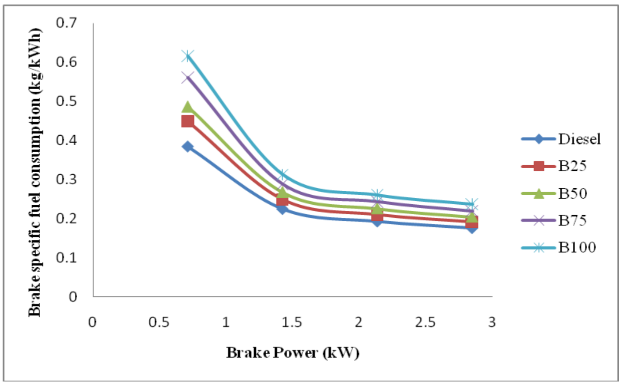

Fig.2. Brake power Vs Brake specific fuel consumption

B. Emission characteristics

The CO emission depends solely depends upon the strength of the mixture, availability of oxygen and viscosity of fuel.

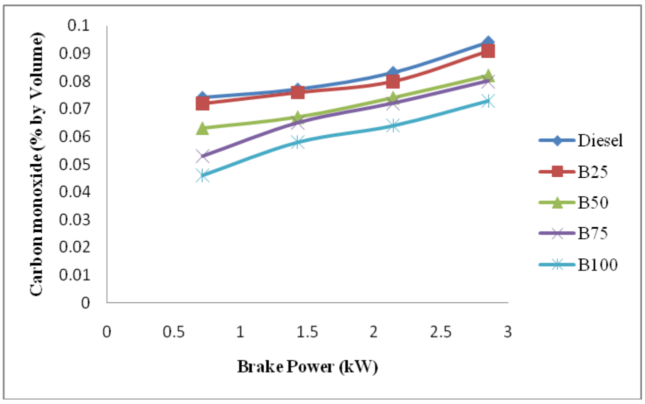

Fig.3. Brake power Vs carbon monoxide

From fig it is observed that the CO emission decreases at lower loads sharply increases for all test fuels. This is due to incomplete combustion at very high loads which results in higher CO emissions. CO emission is found highest for Diesel if we compare with biodiesel. Lowest for pure biodiesel B100 at all loads.

Lower CO_2 emission was observed with biodiesel compared to diesel. This is due to the lower carbon content of biodiesel. CO_2 emissions is higher for lower loads when compared to higher loads this is because of oxygen demand in the lower loads is low. For the higher loads oxygen requirement is high so that CO_2 level is decreased for the higher loads.

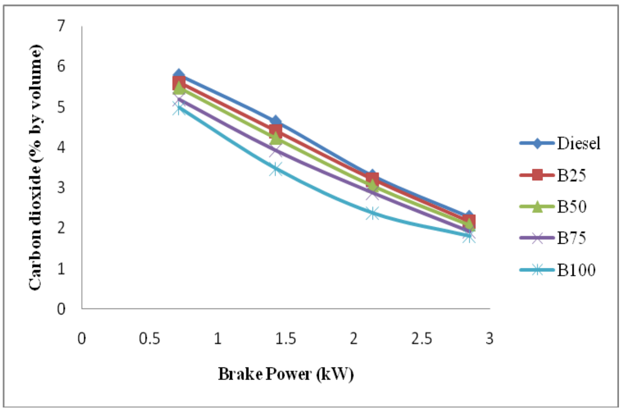

Fig.4. Brake power Vs Carbon dioxide

The emission of HC is decreasing with increase of loads. HC of pure biodiesel (B100) has lower emission compared with all other blends. The minimum value of HC at pure biodiesel is 17 ppm against 30 ppm of diesel. For higher loads combustion improvement and try it for a complete buring so that HC level is decreased.

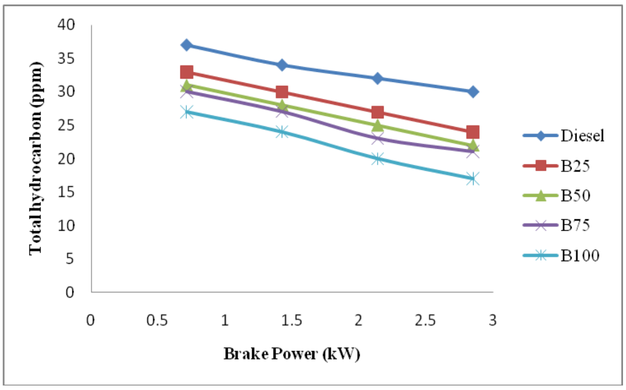

Fig.5. Brake power Vs Total hydrocarbon

The NOx emission depends upon the oxidation of nitrogen at high temperature. The results obtained in Fig. 14 show that NOx emission increases with engine load for all test fuels. It is found highest for pure biodiesel and lowest for diesel at all loads. Higher NOx emission in case of biodiesel is due to the fact that it contains higher oxygen which results in higher combustion temperature.

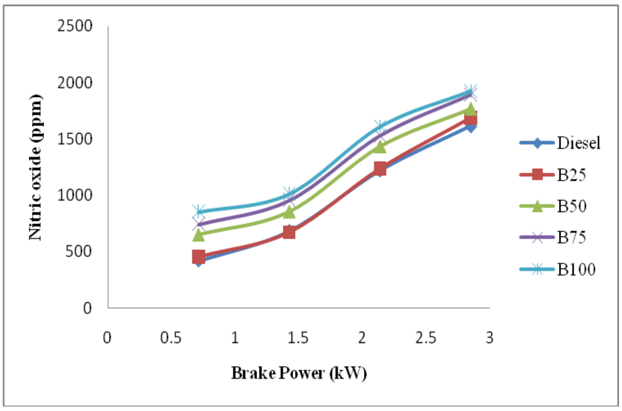

Fig.6. Brake power Vs Nitric oxide

C. Combustion characteristics

The heat release rate for all other tested fuel was slightly less than that of diesel this may be attributed to low vaporization, high viscosity and low peak pressure of blends as compared to that of diesel. It can be observed that heat release rate is high for diesel. This is due to premixed and uncontrolled combustion phase.

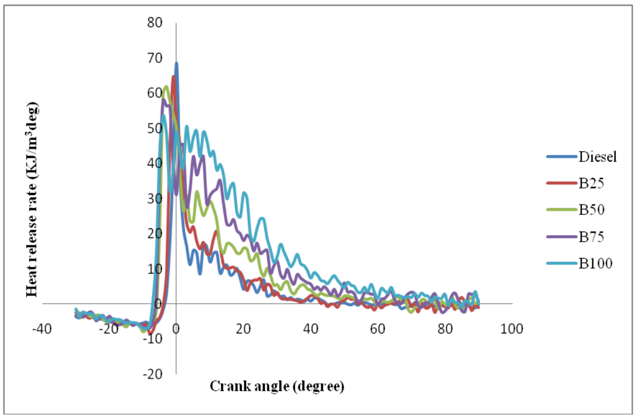

Fig.7. Crank angle Vs Heat release rate

In a CI engine the cylinder pressure is depends on fuel burning rate during the premixed burning phase, which in turn leads better combustion and heat release. It can be seen from Fig the maximum pressure is for diesel when it is compared to the biodiesel.

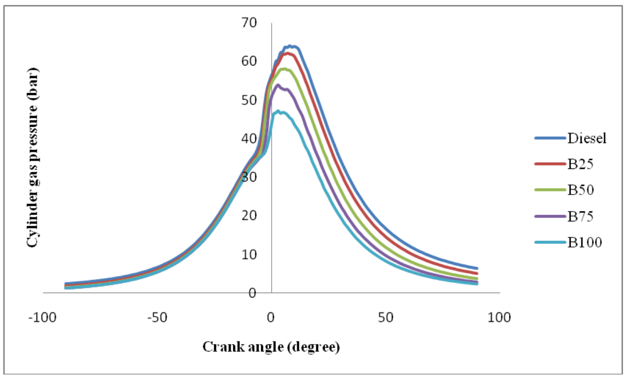

Fig.8. Crank angle Vs Cylinder gas pressure

VI. CONCLUSION

The experimental work carried out on a single cylinder diesel engine using biodiesel derived from honne oil biodiesel as an alternate fuel. The performance, emission and combustion characteristics of blends are evaluated and compared with diesel. No difficulty was faced at the time of starting the engine and the engine ran smoothly over the range of engine speed. From the above investigation, the following conclusions are drawn.

- The properties viz; density, viscosity, flash point and fire point of Calophyllum Inophyllum biodiesel is higher and calorific value is nearer to the diesel.
- The maximum brake thermal efficiency of Calophyllum Inophyllum biodiesel is 38.86% against 45.16% of diesel. The minimum BSFC of Calophyllum Inophyllum biodiesel (B100) is 0.065 kg/kWh higher compared with diesel.
- From results biodiesel has low CO, CO_2 and Total hydrocarbon when it is compared to the diesel. For the biodiesel NO_X emissions only higher than the diesel this is due to the long duration of higher temperature combustion.
- Diesel has the higher heat release rate and cylinder gas pressure when it is compared to biodiesel blends because of efficient combustion in the cylinder.
- Performance, combustion and emission characteristics of 25% blend are better than other blends and it is also close to diesel results, so it is recommended.

VII. *References*

1. Atabani, Aldara da Silva Cesar, AE 2014, ‘Calophyllum inophyllum L. – A prospective non-edible biodiesel feedstock. Study of biodiesel production, properties, fatty acid composition, blending and engine performance’, Renewable and Sustainable Energy Reviews 37, PP 644–655.
2. Chavan, Kumbhar R.R, and Deshmukh R.B, SB 2013, ‘Callophyllum Inophyllum linn (“honne”) oil, A source for biodiesel production’, Research Journal of chemical sciences, ISSN 2231-606X, Vol. 3(11), PP 24-31.
3. Fattah, H.H. Masjuki, M.A. Kalam, M.A. Wakil, A.M. Ashraful, S.A. Shahir, IMR 2014, ‘Experimental investigation of performance and regulated emissions of a diesel engine with Calophyllum inophyllum biodiesel blends accompanied by oxidation inhibitors’, Energy Conversion and Management 83, PP 232–240.
4. Gill P, S.K.Soni, K.Kundu, P 2011, ‘Comparative study of Hemp and Jatropha oil blends used as an alternative fuel in diesel engine’, CIGR Journal, Vol. 13, No. 3.

5. Jaichandar and K. Annamalai, SK 2011, 'The Status of Biodiesel as an Alternative Fuel for Diesel Engine – An Overview' , Journal of Sustainable Energy & Environment, PP 71-75.

6. Leung D.Y.C, Xuan Wu, M.K.H. Leung, DYC 2010, 'A review on biodiesel production using catalyzed transesterfication', Applied Energy 87, PP 1083–1095.

7. Rao S.M, Anand R. B, SM 2014, 'Techniques To Improve The Performance While Reducing The Pollutants Level In The Exhaust Gases Of Compression Ignition Engines', ARPN Journal of Engineering and Applied Sciences, ISSN 1819-6608, VOL. 9, NO. 5.

8. Vyas, Jaswant L. Verma, Nandula Subrahmanyam, AP 2011, 'Effects of Molar Ratio, Alkali Catalyst Concentration and Temperature on Transesterification of Jatropha Oil with Methanol under Ultrasonic Irradiation', Advances in Chemical Engineering and Science, PP 45-50.