Investigation of emission and performance analysis of honne oil in VCR diesel engine

B V Subhanandh1*, N Abilash1, P Saji Raveendran2

1Department of Mechanical Engineering, Department, Noorul Islam Centre for Higher Education, Kumaracoil-629 180, Tamil Nadu, India
2Department of Mechanical Engineering, Kongu Engineering College, Perundurai-638 060, Tamil Nadu, India

*Email: bvanandh@yahoo.com

Abstract: The world is facing two serious problems: energy crises and pollution. The daily increase in industrialization and the number of automobiles is the reason for these two problems. This work focus on to analyse the performance characteristics and emission parameters of the diesel engine for the blend of calophyllum inophyllum (Honne oil) Biodiesel blend (B10, B20 and B30) and Also find out how they affect the performance of the I.C Engine. While testing, the compression ratio of the engine was in the range of 15 to 18. Then speed of the engine is constant (1500 rpm). In conventional diesel engines and exhaust gases such as carbon monoxide (CO), oxides of nitrogen (Nox), hydrocarbons (HC) has been reduced. Considering that, by using this hybrid system, the thermal performance and the emission system must be investigated.

Keywords: Biodiesel, Engine, Cetane number, Thermal efficiency

1. INTRODUCTION

Biodiesel is a clean alternative to diesel, biodegradable, renewable, nontoxic and more environment friendly oil. It’s easy and effective blending with pure diesel and better quality of exhaust emission [1-2]. Bio-diesel can be extracted from edible oil and inedible oil. The need for edible oil from food crops is restricted in countries such as India, the need is more for domestic purpose. It can be determined without problems in many factors of the world, particularly in wasteland, friendly nature and more economical in comparison with edible oil [3]. An effective stunning source of inedible oil is extracted from the seeds of Calophyllum Inophyllum which is very often called as Honne oil in India. Viscosity of Honne oil is more in comparison with Diesel. The calophyllum seed has enriched oil content compared to other seeds [4-5]. In addition, it very well might be noticed that, it has certain notable qualities which as high oxygen content, high flash point and high cetane number; and despite the aspect has the high viscosity, high pour point, low calorific value and low oxidation stability, when compared to diesel [6]. For viscosity in honne oil is to regulate by using the glycerol transesterification process. Transesterification is a chemical process in which triglycerides react with methanol and sodium hydroxide as a catalyst [7]. Purification process acquired or eliminate methanol, while warming of biodiesel at 75°C during around 30 min and to be eliminate methanol. The yield of biodiesel is found at 80% of transesterification process. Biodiesel produced from transesterification processed Honne oil is called Honne oil Methylester [8-9].

The various chemical properties of calophyllum methylester has evaluated and matched with diesel. Thermal efficiency and emission characteristics of Honne oil esterified to variable compression ratios of the CI engine are not reported in literature review [10-11]. Several research studies have been
conducted to assess fuel efficiency and emission properties of CI engines by using alternatives biofuels and diesel. As far as engine efficiency is concerned, most studies have shown most investigations have shown that biofuel-diesel mixture decline the BP and incremental biofuel utilization was contrasted with diesel [12]. The incremental level of biofuel in the blend resulted to decrease the BP. The use of biofuel-diesel blends in IC engines results in lower emissions of CO, HC and PM are exhausted from combustion process. From the above literature assessments behind to investigating the Honne oil biofuel.

2. PROPERTIES

Table 1. Fuel properties of diesel and various calophyllum inophyllum biodiesel blends

| Properties             | Standard Ranges | Diesel | B10 | B20 | B30 |
|------------------------|-----------------|--------|-----|-----|-----|
| Density (kg/m³)        | 860-900         | 830    | 836 | 840 | 852 |
| Viscosity at 40°C (cSt)| 1.9-6.0         | 3.556  | 4.1 | 4.2 | 4.4 |
| Cetane Number          | 47 min          | 47     | 49.5| 51.5| 51.8|
| Calorific value (MJ/kg)| 34-45           | 42.5   | 42  | 41.18| 40.1 |
| Ash Content (%)        | 0.1 max         | 0.10   | -   | -   | -   |
| Flashpoint (°C)        | 120-170         | 65     | 72  | 78  | 96  |
| Fire Point (°C)        | 130-185         | 78     | 99  | 105 | 136 |
| Cloud point (°C)       | 3 to 12         | 8      | -   | -   | -   |

To begin with, biofuel-diesel mixture was prepared with various quantity rate (5-30%). The magnetic stirrer and shaker machine at 2000 rpm and 600rpm were used for 30 min to form the blend [13-14]. The biodiesel blend is made by mixing definite ratio of diesel under suitable conditions. The usage of this biodiesel blend such as B10, B20 and B30 were used in the conventional engine. Figure 1 & 2 shows that the preparation of biodiesel. Table 1 & 2 shows that the properties of the biodiesel blends and composition respectively.

Table 2. Biodiesel blends used for the experiment

| Blend Type | Description          | Compression Ratio | RPM |
|------------|----------------------|-------------------|-----|
| B00        | 100% Diesel          | 15:1, 18:1        | 1500|
| B10        | 10% Honne oil + 90% diesel | 15:1, 18:1        | 1500|
| B20        | 20% Honne oil + 90% diesel | 15:1, 18:1        | 1500|
| B30        | 30% Honne oil + 90% diesel | 15:1, 18:1        | 1500|
3. EXPERIMENTAL SETUP

The analysis was performed on engine it consist of single cylinder, water cooled, four stroke type conventional engine is used. Although the compression ratio is adjustable in this engine. The complete experimental setup shown in figure 1 is different CR of 15:1 to 18:1. Piezo Sensor & Crank angle sensor are attached to the engine to analyze combustion process & the sensor with degree resolution respectively. Thermocouples of type RTD K are used to measure temperatures of intake, exhaust, and cooling water. The computer received several data taken from the signal. Rotameters, strain gauge type load sensor are used for cooling the water. The experiment is carried out on a different range of compression ratio in diesel engine [15-16]. The fuels used in the experiment are B10, B20 and B30. While conducting the experiment, the lubricating oil level and water supply need to be taken before starting the engine. The values of current, intensity, air depletion, velocity, exhaust smoke condition and exhaust smoke emissions are reported at different load conditions (25%, 50%, 75%, 100%) by varying compression ratios. The accurate value is obtained by taking the average of the above values. Figure 3 shows that the schematic representation of engine test bed. Table 3. Shws the specification of engine.

Table 3. Details of the Engine Specification.

| Parameters          | Specification                             |
|---------------------|------------------------------------------|
| No. of cylinder,    | Single cylinder, Four                    |
| Cycle of operation  | stroke direct injection                  |
| Bore and,           | 87.5 mm                                  |
| Stroke              | 110 mm                                   |
| Rated Power         | 4.4 kW                                   |
| RPM                 | 1500                                     |
| Compression ratio   | 17.5: 1, Modified to work               |
| Type                | Water cooled                             |
|                     | in range of 15 to 18                     |

4. EXPERIMENTAL PROCEDURE

The major factors taken in to consideration are BP, Torque, BTE and Emissions. The BP and Torque can be evaluated by using the eddy current dynamometer. Start the engine at no load for 5 minutes then switch on the computer and run the software to take the readings. The engine load has
been gradually increased as 0%, 25%, 50%, 75% and 100%. The change in CR by angling the cylinder cut-off consist of six allen bolts. The compression ratio is adjusting with the help of allen bolts [17-18]. The tested are conducted at the speed of 1500rpm. For all test the BTE and exhaust emission such as CO, CO2, NOx are measured. At any operating circumstance, the data are controlled and saved in the PC to plots the execution. The similar technique is continual for the biodiesel mixture and the results are plotted.

**Figure 3.** Schematic representation of engine test bed.

5. RESULT AND DISCUSSION

The experimental study below shows the variation seen that the adjusted compression ratio for biodiesel blends. The analysis were recorded at various load conditions.

In the Figure 4 &5, it’s clearly seen that when load increases there is change in CO value. CO is formed when fuel ignition is incomplete. It’s seen that at various compression ratios. The CO impurity is reduced for all the blends when the CR is increased. The explanation is better burning of fuels at higher CR due to the cylinder consist of high air temperature. It’s likewise noticed that CO discharges are greater at low CR, and smaller at higher CR. It is observed that when load upturns the CO production is increased. It is discovered that the lowest CO emission is found for B30 when compared to diesel at higher CR of 18.

**Figure 4.** Carbon monoxide with Load at CR 15
As shown in Figure 6 & 7 it’s clearly seen the deviation of CO$_2$ with load. The outcome noticed that CO$_2$ gases increments with the increment in load for all type of fuels. Diesel has the lowest CO$_2$ emission. Most of the blend, CO$_2$ decreases with growing percent of bio diesel because of increase in oxygen content. The Honne biodiesel and its blends releases lesser ratio of CO$_2$ as related to diesel at greater CR. At lower CR, incomplete burning of soaring carbon content conventional fuel causes less CO$_2$ emission as compared to bio diesel and its blends, but in the existent work CO$_2$ emission of B30 shows highest CO$_2$. 

Figure 5. Carbon monoxide with Load at CR 18

Figure 6. Carbon dioxide with Load at CR 15
Figure 7. Carbon dioxide with Load at CR 18

Figure 8 & 9 shows that when CR increases the NOx emission reduced for fossil fuel. At a CR 15 NOx emission of diesel is higher then CR 18 NOx emission of diesel is lower for compared between Honne oil blends. For CR 18 NOx emission of biofuel blends is high for compared with diesel due to high temperature in combustion chamber and presence of oxygen content in biofuel. For the fully loaded condition, the highest NOx emission obtained for diesel at CR 18 when compared to biodiesel blend.

Figure 8. Nitrogen oxides with Load at CR 15
Brake Thermal Efficiency (BTE) is the heat input of an energy is converted into mechanical energy. The Figure 10 & 11 shows the different blend of biodiesel. The BTE of honne biodiesel is less than diesel by reason of the lower warming value and increased viscosity of biodiesel. BTE of biofuel decrease with rise in the percent of biofuel-diesel blends. However, when the increment in CR, BTE rises for honne biodiesel mixtures and attain utmost value at the CR of 18.
6. CONCLUSION

The emission characteristics and the performance of various blend of Honne oil bio diesel (B10, B20 and B30) are correlated to diesel. The carbon monoxide emission minimized as amount of the biodiesel percentage increased. CO₂ emission for diesel is least and highest for biodiesel blend. CO₂ emission increased with rising percent of biodiesel. NOx emission rising with increasing percent of biodiesel mixtures. The BTE is greater for diesel when related to Honne biodiesel. The increase of percent of biodiesel blends reduce BTE of the engine.

References

[1] Bhuiya MMK Rasul MG Khan MMK Ashwath N Azad AK and Hazrat MA 2014 Second-generation biodiesel: potential alternative to-edible oil-derived biodiesel. Energy Procedia Vol. 61, pp.1969-1972.
[2] Channapattana SV Kantharaj C Shinde VS Abhay Pawar A and Prashant G Kamble 2015 Emissions and Performance Evaluation of DI CI - VCR Engine Fuelled with Honne oil Methyl Ester / Diesel Blends. Energy Procedia Vol. 74, pp.281-288.
[3] Muhammad Bhuiyaa Mohammad Rasula Mohammad Khana and Nanjappa Ashwath 2019 Performance and emission characteristics of a compression ignition (CI) engine operated with beauty leaf biodiesel. Energy Procedia Vol. 160, pp. 641-647.
[4] Nanthagopal K Ashok B and Raj TR 2016 Influence of fuel injection pressure on Calophyllum inophyllum methyl ester fuelled direct injection diesel engine. Journal of Energy Conversion and Management Vol.116, pp.165-173.
[5] Ong HC Masjuki HH Mahila TMI Silitonga AS Chong WT and Leong KY 2014 Optimization of biodiesel production and engine performance from high free fatty acid Calophyllum inophyllum oil in CI diesel engine. Energy Conversion and Management Vol.81, pp.30-40.
[6] Rahman SMA Masjuki HH Kalam MA Abedin MJ Sanjid A and Sajjad H 2013 Production of palm and Calophyllum inophyllum based biodiesel and investigation of blend performance and exhaust emission in an unmodified diesel engine at high idling conditions. Energy Conversion and Management Vol. 76, pp.362-367.
[7] Magin Lapuerta Octavio Armas and Jose Rodriguez Fernandez 2008 Effect of biodiesel fuels on diesel engine emissions. Progress in Energy and Combustion Science, Vol. 34, pp. 198-223.
[8] Sivaramakrishnan K and Ravikumar P 2013 Investigation on performance and emissions of a biodiesel engine through optimization techniques. Thermal Science Vol. 17, pp. 179-193.
[9] Sejal Narendra Patel and Ravindra Kirar 2012 An Experimental Analysis of Diesel Engine Using Biofuel at Varying Compression Ratio. International Journal of Emerging Technology and Advanced Engineering Vol. 2, pp.385-391.
[10] Mofijur M Maasuki HH Kalam MA Atabani AE Fattah IMR and Mobarak HM 2014 Comparative evaluation of performance and emission characteristics of Moringa oleifera and Palm oil based biodiesel in a diesel engine. Industrial Crops and Products Vol. 53, pp.78-84.
[11] Gad MS El-Araby R Abed KA El-Ibiari NN El Morsi AK and El-Diwani GI 2018 Performance and emissions characteristics of C.I. engine fueled with palm oil/palm oil methyl ester blended with diesel fuel. Egyptian Journal of Petroleum Vol. 27, pp.215–219.
[12] Pankaj S Tikendra N and Arivalagan P 2019 An experimental evaluation of engine performance and emisssion characteristics of CI engine operated with Roselle and Karanja biodiesel. Fuel Vol. 254, 115652.
[13] Tamilselvan P Nallusamy N and Rajkumar S 2017 A comprehensive review on performance, combustion and emission characteristics of biodiesel fuelled diesel engines. Renewable and Sustainable Energy Reviews Vol. 79, pp. 1134-1159.
[14] Venkata Sundar Rao K Kurbet SN Vinay V and Kuppast 2018 A Review on Performance of the IC Engine Using Alternative Fuels Materials Today: Proceedings Vol. 5, pp. 1989-1996.
[15] QixinMa, QuanchangZhang, JichaoLiang and ChaoYang 2021 The performance and emissions characteristics of diesel/biodiesel/alcohol blends in a diesel engine. Energy Reports Vol. 7, pp. 1016-1024.
[16] Saravanan A Murugan Sreenivasa Reddy M and Satyajeet P 2020 Performance and emission characteristics of variable compression ratio CI engine fueled with dual biodiesel blends of Rapeseed and Mahua. Fuel Vol. 263, 116751.
[17] Vijayakumar M Mukesh Kumar P C 2019 Performance and emission characteristics of compression-ignition engine handling biodiesel blends with electronic fumigation. Heliyon Vol. 5, 01480.
[18] HiregoudarYerrenagoudaru Manjunatha Ahmad Raza K Kantharaj B R and Abdul Mujahed K Irshad 2018 Analysis and comparison of performance and emissions of compression ignition engine fuelled with diesel and different bio-fuels blended with Methanol. Materials Today Proceedings Vol. 5, pp.5175-5185