Performance and Emission Characteristics of Mahua Biodiesel blends

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Abstract: The performance and emission characteristics of an engine that burns with Mahua biodiesel of 10%, 20% and 30% blends with diesel (on a volume basis) per unit area is investigated and compared with normal diesel fuel. The investigation is carried out to enhance the efficiency of the diesel fuel using biodiesel blends. The engine utilizes a direct injection system with a variable compression ratio. Also, the experiment was allotted with explicit injection temporal arrangement at 120° before the top dead center (BTDC) with the various compression ratios (air-fuel ratio) per unit area as 15:1, 16:1 and 17:1. Experiments were carried out at a constant speed of 1500 revolutions per minute. The results of the compression ratio relationship on brake thermal efficiency, specific fuel consumption, and emission characteristics have been investigated and associated. The mix blend 10 (B10) and the Compression ratio (CR) 17 are found to offer most mechanical efficiency at higher compression magnitude relations and it turns out to be 27.32%. Conjointly the Specific Fuel consumption (SFC) of mix B10 is found to be reduced in comparison to that of plain diesel. Emission parameters per unit area were analyzed with different various blends and different compression ratio relationships and compared with diesel fuel. The emission of Carbon monoxide oxides (CO), Hydrocarbons (HC) were generated with a rise in mixing magnitude relation and compression magnitude relations of most loads. Conjointly carbon dioxide emissions were found to be more than in diesel. The engine performance was found to be optimal once persecution of B10 as fuel at a compression magnitude relation of 17:1 throughout full load condition is when made.

1. Introduction

The Mahua Oil is not used to full potential not fit to be eaten and cooking purpose oil, Mahua is out there in massive amounts in and around the Tamilnadu. The petroleum belongings of the Mahua biofuel were initiate to be within the confines of biodiesel conditions of various countries. The Mahua tree grows up to twenty meters tall and it belongs to the Sapotaceae family. The two major species of genus Madhuca found in India are MadhucaIndica (syn. Bassialatifolia) and Madhucalogifolia (syn. Bassialongifolia). Mahua is widely accepted by neighborhood names such as Illupei in Tamil, Butter tree in English, Mauwa in Hindi, Ponnam in Kerala. [1] The oil from the Seeds is employed as an ointment, in rheumatism. It is also used for toiletry, illumination, and keeps body shiny when applied. The flower juice is engaged within the treatment of the Expansion of axillary majestic, neurotic disorder and brought with cow's milk as AN aphrodisiac, in cough and respiratory disorder. The derived alcohol from the fermentation of flowers is taken into account to be a tonic and wholesome. Fuel belongings of normal fuel, Mahua fuel are equivalent in the unit area. The hot price of Mahua fuel was found at 94.30% on a (vol) of normal diesel. It is absolutely initiate that Mahua can be simply replaced up to 20 % in diesel with no vital distinction in output, BSFC, and BTE. Supported this experimental, it's been ascertained that esters of Mahua oil can be used as extra fuel for diesel. [2]
2. Literature Review

Senthil Ramalingam, et al delineated that A20 offers improved performance and reduction emissions per unit area earned. These studies were administrated completely using different sorts of CI engines with biofuel ordered from various oil backgrounds. To complete the outcomes of these experimental, an accumulative experimental considering all the constraints at a time in one kind of engine continues to be missing. To fill this gap, the experiment on the complete associated independent of finding the optimum engine style limitations like compression quantitative relation for higher performance of diesel with bio-fuel (A20) attained from Annona oil was carried out. The purpose was to determine the changes needed in little, constant speed, DI diesel engines used for farming applications in order that these are often created to run on diesel and biofuel mix with higher performance and comparable time improve the emissions. It is initiate that the lesser concentrations of biofuel progress the thermal efficiency. Decrease the pollutant and the brake specific fuel consumption is also detected whereas using B10 [3]. In the meantime, the starter of normal fuels, the growth of compression ignition (CI) engines is being the belongings of diesel fuel. The existing designs and working constraints of existing engines are homogenous for this fuel. For all additional fuels, the operating constraints must be optimized the exact fuel properties. [4]

R. Anand investigated the waste cooking oil and its mixtures with normal fuel is selected as fuel for variable compression ratio (VCR) engine. The several mixtures of waste cooking oil (WCO) and standard fuel were arranged and the subsequent research carried out. The performance and emission characteristics of the VCR engine using several mixtures at different compression ratios from 18:1 to 22:1 at unit interval for half of half the engine load and its evaluation were compared to the standard fuel. The hydrocarbon pollution of several mixtures is greater at high compression ratios. The rise of the compression ratio has increased the HC pollution for mixture of 40%. The pollution of oxides of nitrogen (NOx) from the waste cooking oil mixture of 40% is greater than that of normal fuel. The CO pollution of the mixture of 40% is nearer to the normal fuel and it was maximum at compression ratio 21. [5]

3. Transesterification of vegetable oils

Transesterification is the most significant step in biodiesel manufacture. It is a kind of organic reaction where an alcohol group in ester is replaced. It can also be the response of the vegetable oil with an alcohol content to give ester and glycerol. It is the progression by means of alcohol in the catalyst of Potassium hydroxide which breaks the molecule of vegetable oil into methyl ester and glycerol. The transesterification reaction process is represented by the following equation [6].

\[ \text{Oils (triglycerides)} + \text{Methanol} \rightarrow \text{Biodiesel} + \text{Glycerol} \]

3.1 Process

To reduces the free fatty acid value of Mahua oil upto 2% by means of an acid catalyst. The raw Mahua oil had an initial acid value of 24.26 mg KOH for gram mille, consistent to a free fatty acid near to 14.71 %, it has to 1% above the limit. Transesterification process has used to reduce the free fatty acid by alkaline catalyst. [4] The process of transesterification is complex if oil covers a large amount of free fatty acid content that will form soap. The soap can avoid the separation of the biofuel to the glycerin fraction [7]. So free fatty acid was transformed to esters in a pre-treatment method by means of an acid catalyst (H₂SO₄) to decrease the acid value of Mahua oil to lower than 2mg KOH/gm. and finished transesterification with an alkaline catalyst to biofuel [8]. In this method, Mahua oil feedstock, and concerted sulphuric acid were used in quantities conventional for each experimentation. A recognized amount of Mahua oil was transferred into the flask and heated to the required temperature. The Mahua oil was mixed with methanol and sulphuric acid (H₂SO₄) the temperature has sustained at 60 °C. Throughout the process, the combination was stirred continuously.
by a magnetic stirrer at a speed of 600-700 revolution per minute. The mixture was transferred into a
discrete funnel and kept for 4 hours. The additional methanol with sulphuric acid and layers form in
the top surface then it has been removed. The free fatty acid were formed in the bottom part of
the funnel. The additional methanol was removed from the funnel by heating up to 70°C and the mixture
was washed with distilled water. The investigation was carried out by the five combinations 10%
Mahua Biofuel and 80% Diesel (B10), 20% Mahua Biofuel and 80% Diesel (B20), 30% Mahua
Biofuel and 70% Diesel (B30).[9]

4. Experimental setup

4.1 Commercial Software – Engine softLV
The experimental were conducted on Engine Soft LV for engine testing application. The software
assesses the engine thermal power, efficiencies of thermal and volumetric, consumption of fuel during
the loading conditions.

4.2 Arrangements
The measurements of all operating parameters are fully equipped within the CI engine. In this
experimental, the diesel engine was run with a various Mahua biofuel mixtures and diesel in Table 1.
In the experiments were conducted in more numbers and the average value were noted. The technical
terms of the engine are given in Table 2. The outcomes of the engine result were compared to the
normal fuel data as well as for various compression ratio.

| Table 1. Properties of Mahua Biofuel mixtures and Diesel fuel |
|---------------------------------------------------------------|
| Properties               | Units   | Diesel | B10  | B20  | B30  |
|----------------------------|---------|--------|------|------|------|
| Density                   | 15°C kg/m³ | 840    | 830.9 | 831.4 | 843.6 |
| Calorific Value           | KJ/kg   | 43340  | 45.52 | 43.64 | 43.29 |
| Kinematic Viscosity       | cst @ 40°C | 3.12   | 2.86  | 3.07  | 3.26  |
| Cetane number             |         | 48     | 59    | 58    | 57    |
| Flash Point               | 0°C     | 52     | 58    | 56    | 55    |
| Fire Point                | 0°C     | 60     | 68    | 66    | 65    |

| Table 2. Specifications of the apparatus |
|------------------------------------------|
| Engine Type                        | Kirloskar                                      |
| Engine type                         | Four-stroke, Vertical, Compression ignition   |
| No. Cylinder                        | single cylinder                                |
| Engine IS rating at 1500 rpm         | 4.41 kW                                        |
| Bore                                | 87.5 mm                                        |
| Engine type                         | Four-stroke, Vertical, Compression ignition   |
| No. Cylinder                        | single cylinder                                |

5. Experimental Results

5.1 Effect on Brake Thermal Efficiency (BTE)
Figure 1 shows the variation of the brake thermal efficiency with the different compression ratio. The
biofuel mixture of 10 % in diesel fuel has slightly increased. The compression ratio 17 is indicated the
24.32 % for the normal fuel and the mixture of 10 % of Mahau fuel has shown 27.32 % of the brake thermal efficiency. This is due to the fact that the calorific content of the B10 Mahau blend is much higher compared to other combinations. The mixture of 20 % of Mahau biofuel has slight nearer to the compression ratio 17 for the B10 results. The graph shown the difference of the energy content has play the major role on the thermal efficiency of the engine. The low energy content present in the higher biofuel mixtures so the graph has shown the bottom curves of the higher mixtures in the diesel fuel.

5.2 Effect on Specific Fuel consumption (SFC)

Figure 2 shows the variation of the Specific Fuel consumption with the different compression ratio. The CI engines has low energy content, density and viscosity are the major characteristics that the impacts on the specific fuel consumption. The diesel fuel have the low brake thermal efficiency has compared to the 10 % mixture of Mahau biofuel so the consumption of the fuel at the different compression ratio of the process the diesel has 0.345 kg/Kwh at the compression ratio of 17. The Mahau biofuel has low consumption of the diesel fuel is 0.320 kg/kWh. The other mixture of biofuel has shown more amount of fuel is consumption due to the less energy content present in the mixture similar the compression ratio 17 has given the better results compared to the other ratios.
5.3 Effect on Carbon monoxide oxides (CO) emission

Figure 3 shows the variation of the carbon monoxide emission with the different compression ratio. The reason for the CO emission due to the incomplete combustion of the combustion process. The oxygen content of the diesel fuel is very low so the emission of the CO is high compared to the Mahua biofuel. The Mahua biofuel has high oxygen present in the fuel. Figure 2 shows the variation of the Specific Fuel consumption with the different compression ratio. The CO content is converted into the carbon dioxide. The 10% of the Mahua biofuel has less emission compared to the higher mixture of the Mahua biofuel. The incomplete combustion of the fuel leads to the formation of CO and can be transformed to CO$_2$ if complete burning is provided. In the case of biodiesel mixtures, CO emission is very much lower than diesel fuel. The Decrease of Compression ratio plays the main role in reducing the CO emission. And from Figure 3 the B10 blend gives less emission.

5.4 Effect on Hydrocarbon (HC) emission
Figure 4 shows the variation of the hydrocarbon emission with the different compression ratio. The hydrocarbon pollution is the byproduct of the uneven burning of the fuel in the combustion chamber. The Mahua fuel of 10% mixture produced the lowest emission for the other fuel mixture. Mahua fuel has higher latent heat of vaporization so the result of the direct ignition due to the low burning temperature of the combustion chamber at the compression ratio of 17. The graph shown the high amount of the HC emission has produced for the normal diesel fuel at the maximum loading conditions.

![Hydrocarbon Emission Graph](image1)

**Figure 4.** The Variation of the Hydrocarbons (HC)

### 5.5 Effect on Carbon Dioxide Oxides (CO₂) emission

Figure 5 shows the variation of the carbon dioxides emission with the different compression ratio. It should be seen that the blend B10 and the decreasing compression ratios offer the highest greenhouse emission compared to other blends. The share increase in greenhouse emission is compared to static 17. The readings are for Diesel, B10, B20 and B30 area unit 0.8%, 1.1%, 0.7%, and 1.5% severally. Among all the blends, the B10 offers highest greenhouse emission of 1.1% in terms of share increase in greenhouse emission at full load.

![Carbon Dioxide Oxides Emission Graph](image2)
5.6 Effect on Nitrogen Oxides (NO\textsubscript{x}) emission

Figure 6 shows the variation of the nitrogen oxides emission with the different compression ratio. It's seen that increasing the compression ratio provides the highest NO\textsubscript{x} (parts per million) as compared to static compression ratio 17. As compared to blends B10 provides lower emission when compared to other blends like diesel, B20, and B30 in compression ratio 17. From the analysis NO\textsubscript{x} for static compression ratio order of B10 for Diesel, B10, B20, and B30 are 50, 41, 63 and 46 respectively. The biodiesel manufacture perpetually high emission of NO\textsubscript{x}. Compared to different biodiesel blends B10 manufacture fewer NO\textsubscript{x} emissions.

6. Conclusion

The Experiment was done with injection timing arrangement particularly at 12 °BTDC with the various compression ratios as 15:1, 16:1 and 17:1 with an increasing compression ratio relation. A VCR engine with various bio fuel mixtures and different CR relationship was utilized to obtain the subsequent results.

The experimental results shown that at a higher compression ratio, the thermal efficiency of the B10 mixture was higher than that of normal fuel and different blends when augmented at maximum engine conditions. This leads to the higher thermal efficiency of the engine. Also, the result expressed that the engine specific fuel consumption of B10 mixture increased at a compression ratio 17 when compared to the other biofuel mixtures tested from a compression ratio 15 to compression ratio 17 relationships.

This could point out the 17:1 and B10 mixture to be minimum in specific fuel consumption. There's a big reduction in CO and change of state within the organic compound for all fuel mixtures of Mahua biodiesel at maximum compression ratio relationship tested at maximum engine condition. Additionally, carbon dioxide quantity was maximum for the normal fuel has compared to the all tested bio fuels from a compression ratio 15 to compression ratio 17 relationship. In these experimental results shown that the 10 % of the Mahua biofuel mixed with normal fuel gives better performances and good emissions characteristics and hence Mahua biofuel can very much be used as alternatives fuel for the diesel fuels.
Acknowledgment

The authors sincerely thank the Management and the Principal of Sri Ramakrishna Institute of Technology, Coimbatore for the continuous encouragement and support rendered towards the completion of this research work.

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