Chapter 4

Performance of Engine Fuelled With Eco Friendly Fuel

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Abstract

In the present world it is essential to find an alternate fuel source due to the increased industrialization and depletion in natural resources. The method of obtainingbiodieselfromvarioussourcesandblendingthemwithdieselisadopted in many economically developed and developing countries around the world. This paper investigates the utilization of Jatropha Methyl Ester (JME) and Mahua Methyl Ester (MME) blends with diesel in Variable Compression ratio (VCR) CI engine. The experiments has been carried out on a direct injection, single cylinder, constant speed, water cooling system VCR engine at injection pressures 200, 210 bar and compression ratio of 17.5 using various blends. Performance and emission characteristics of B20 blends of Jatropha Methyl Ester (JME) and Mahua Methyl Ester (MME) is a appropriate alternative fuel for pure diesel and minimized air pollution in the atmosphere. The blends of bio diesel like Jatropha Methyl Ester (JME) and Mahua Methyl Ester (MME) with diesel could substitute in the place of pure diesel and be used as an alternate source of fuel in the near future, thus saving the natural resources for the future generation.

Keywords: IC engine, bio diesel, analysis, Jatropha, Mahua oil.

1. Introduction

In the context of fast depletion of fossil fuels and ever increasing diesel vehicle population, use of renewable fuels like vegetable oils has become pertinent steady with the estimation the International Energy Agency, by 2025 global energy utilization will increase by about 42%. Many research works are going on to

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substitute the diesel fuel with appropriate alternative fuel such as bio diesel. Probably in this century, it is believed that crude oil and petroleum products will become very scarce and costly to find and produce [1]. Although fuel economy of engines is greatly improved, increase in the number of automobiles alone dictates that there will be a great demand for fuel in the near future. Alternative fuel technology, availability, and use must and will become more common in the coming decades. Another reason motivating the development of alternative fuels for the IC engine is concerned over the emission problems of gasoline engines [2]. A third reason for alternative fuel development is the fact that a large percentage of crude oil must be imported from other countries which control the larger oil fields. Adaptation of bio-origin unconventional fuels can address these issues. These fuels are basically non-petroleum and result in energy security and environmental benefits. They are available either in one form or other for more than one hundred years.

The energy plays an important role in everyday life. Growth of an economy is largely dependent on adequate supply of energy. Energy available in its original form in nature such as crude oil, natural gas, coal, solar heat, etc. is called primary energy sources. Many of these sources are not directly usable and can be used only after processing of or conversion. Crude oil is refined in a petroleum refinery and resulting petroleum products include petrol are termed as secondary energy sources. Present demand and supply World energy future in present trend countries, the world in the next 50 years will be more crowded than that of today. The world population may reach 10 billion. The conventional sources of energy are depleting and may be exhausted by the end of the century or at the beginning of the next century [3-5]. The various alternative fuel options researched for diesel are mainly bio- gas, producer gas, methanol, ethanol, and vegetable oils. Out of all these vegetable oils offer an advantage because of its comparable fuel properties with diesel. The various edible vegetable oils like sunflower, soya bean, peanut, cotton seed etc. have been tested successfully in diesel engine. Research in this direction with edible oils yielded encouraging results. But as India still imports huge quantity

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of edible oils, therefore, the use of non-edible oils of minor oil seeds like mahua (madhuca indica) oil has been tested as a diesel fuel extender. Several studies around the world revel that if biomass energy is used instead of fossil fuels, there will be a net reduction in CO emissions and CO2 emissions. SO2 emissions from using biomass energy tend to be considerably lower because relevant plants and trees contain only trace quantities of sulphur compared to the considerably higher emissions from coal, gasoline, and even some natural gas [6-8].

1.1 Problems Associating with Vegetable Oil fuel

- Viscosity of vegetable oils is much higher than that of diesel. It can cause problems in fuel handling, pumping, atomization and fuel injection, incomplete combustion, poor cold start-up, deposit formation and ring sticking.
- Slower burning rate: vegetable oil gives rise to exhaust smoke, fuel impingements of oil on cylinder walls and lubricant oil contamination.
- Volatility of vegetable oils is very less which preclude their use in spark ignition engine.
- Flow properties of the vegetable oils are poor which limit their utilization during cold weather in moderate temperature climates.

2. Methodology

Two species of the genus madhuca indica and madhuca longifolia are found in India. Mahua is known as Illupai maram in Tamil and Hippi in Kannada, which can be successfully grown in the wastelands and dry lands [9]. The seeds of the tree, popularly known as Indian butter tree. The specific gravity of mahua oil was 9.11% higher than that of diesel [10]. The kinematic viscosity of mahua oil was 15.23times more than that of diesel at temperature of 40ºC. The kinematic viscosity of mahua oil reduced considerably with increase in temperature to 80ºC and by increasing the proportion of diesel in fuel blends.

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2.1 Edible oil

The seeds contain 30-40 percent fatty oil called mahua oil, which is edible and is also used in the manufacture of various products such as soap and glycerin. The oil cake is used as bio fertilizer, organic manure and as feed for fish and cattle. The leaves are used as fodder and as green manure. The flowers are used for extracting ethanol, which is used in making country liquor.

2.2 Propagation technique

Elaborating on the technique for propagating the trees, he said the variety can be propagated through seeds and transplanted seedlings. Seeds are sown at a depth of 1.5-2.5 cm on raised beds. The seeds germinate in about ten days. One-month-old seedlings are transplanted in plastic containers of 15 x 25 cm. Six to twelvemonth old-seedlings are used for planting in the main field.

3. Transesterification

Transesterification is the process of using an alcohol (methanol, ethanol, proponol, or butanol) in the presence of catalyst to chemically break the molecule of the raw renewable oil into methyl or ethyl esters of the renewable oils with glycerol as by-product. The transesterification reaction proceeds with catalyst or without catalyst by using primary or secondary monohydric aliphatic alcohols having 1-8 carbon atoms as follows:

Triglycerides + monohydric alcohol ↔ glycerin + mono-alkyl esters

Transesterification means taking a triglyceride molecule or a complex fatty acid, neutralizing the free fatty acids, removing the glycerin, and creating an alcohol ester. Theoretically, transesterification reaction is an equilibrium reaction. In this reaction, however more amount of methanol was used to shift the reaction equilibrium to the right side and produce more methyl esters as the proposed product. A catalyst is usually used to improve the reaction rate and yield. Alcohols are primary or secondary monohydric aliphatic alcohols having 1-8carbon atoms. Among the

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alcohols that can be used in the transesterification reactions are Methanol, ethanol, proponol, or butanol or amyl alcohol. Methanol and ethanol are most frequently used. Ethanol is a preferred alcohol compared to methanol because it is derived from agricultural products and is biologically less objectionable in the environment. However methanol is preferable because if it's low cost and its physical and chemical advantages (polar and shortest chain alcohol). The transesterification can also be catalyzed by alkalis, free fatty acids and water always produce negative effects, since the presence of free fatty acids and water causes soap formation, consumes catalyst and reduces catalyst effectiveness, all of which resulting in a low conversion.

3.1 Reaction mechanism of transesterification

Tranesterification consists of a number of consecutive, reversible reactions. Triglyceride is converted stepwise to diglyceride, monoglyceride and finally glycerol. The formation of alkyl esters form monoglycerides is believed as a step which determines the reaction rate, since monoglycerides are the most stable intermediate compound. Several aspects, including the type of catalyst (alkaline, acid or enzyme), alcohol/vegetable oil molar ratio, temperature, water content and free fatty acid content have an influence on the course of the tranesterification.In the tranesterification of vegetable oils and fats for bio-diesel production, free fatty acids and water always produce negative effects, since the presence of fatty acids and water causes soap formation, consumes catalyst and reduces catalyst effectiveness, all of which result in a low conversion. When the original ester is reacted with an alcohol, the transesterification process is called alcoholysis. The transesterification is an equilibrium reaction and the transformation occurs essentially by mixing the reactants. In the transesterification of vegetable oils, a triglyceride reacts with an alcohol in the presence of a strong acid or a base, producing a mixture of fatty acids alkyl esters and glycerol. The stoichiometric reaction requires 1mol of a triglyceride and 3mol of the alcohol. However an excess alcohol is used to increase the yield of the alkyl esters and to allow its phase separation from the glycerol formed.

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3.2 Jatropha oil

Jatropha Curcas is a large shrub or tree native to the American tropics but commonly found and utilized throughout most of the tropical and subtropical regions of the world. Several properties of the plant, including its hardness, rapid growth, easy propagation and wide ranging usefulness have resulted in its spread far beyond its original distribution. The fatty acid composition of Jatropha classifies it as a linoleic or oleic acid type, which are unsaturated fatty acids. The fatty acid composition of jatropha oil consists of myristic, palmitic, strearic, arachidic,oleic and lioleic acids.

The seeds and oil are toxic due to the presence of cursive and curcasive. However, from the properties of this oil it is envisaged that the oil would be suitable as fuel oil.

3.3 Mahuaoil

The biodiesel fuel is prepared by mixing the titanium dioxide nano-particles in the mahua methyl ester with the aid of an ultrasonicator.

Figure.1: Jatropha oil

The ultrasonicator technique is the best suited method to disperse the nano-particles in base fuel (mahua methyl ester), as it facilitates possible agglomerate nano-particles back to nanometer range. Nanoparticles are generally having higher surface

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area and hence surface energy will be high and it will tend to agglomerate to form a micro molecule and starts to sediment. In order to make nanoparticle to be stable in a base fluid, it should be evolved to surface modification. Cetyl Trimethyl Ammonium Bromide (CTAB) is a cationic surfactant and it forms an envelope on the surface of the particle and makes the surface as a negative charge. Hence the particle sedimentation was controlled. In order to disperse the nano particle to base fluid ultrasonication procedure was followed. A known quantity of (say 100 mg) additive and of CTAB (100 mg) were weighed and poured in the bio diesel and ultrasonicated for 1 hour.

Figure. 2: Plain mahua oil bio diesel

3.4 Bio diesel Blend Preparation

Blends were prepared in different proportions of Jatropha Methyl Ester (JME), Mahua Methyl Ester (MME) oils and diesel JME15MME5, JME10MME10 and JME5MME15 maintaining constant blend ratio B20. The various properties of tested fuels like density, viscosity, calorific value, flash and fire point were determined by using ASTM methods. The mixed blends appearances presented that viscosity of the mixed blends increases with dual biodiesel proportions. The dual bio diesel and diesel description is given below in Table 3.1. The viscosity was higher for dual bio diesels and lower for diesel. The density of the mixed blends (i.e., JME15MME5, JME10MME10 and JME5MME15) showed a commonly in relation to an increase in

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blends proportion. It was described that lower calorific value of mixed dual bio diesels is due to longer oxygen content than compare to diesel. Density and higher viscosity of blends are due to their complicated chemical structure and higher molecular weight.

4. Experimental setup

A 5HP (3.5 kW) 4-Stroke direct injection research diesel engine was chosen to investigate the performance and combustion characteristics. The air flow rate into the engine was measured by mass flow sensor and the fuel consumption was measured by burette method. Loading was applied on the engine with the help of eddy current dynamometer. The experiment was carried at different loads. Various sensors were utilized during the experiment to collect, store and analyze the data by computerized data acquisition system(IC engines). An exhaust gas analyzer (AIRREX HG-540, 4Gas analyzer) was employed to measure HC, CO, CO_2 and NOx emissions.

Figure.3: Experimental Setup

5. Results and Discussion

5.1 Performance Characteristics

The experimental data from tests on VCR engine has been systematically studied. The effect of blend ratio and fuel injection pressure at compression ratio of 17.5 has

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been presented by varying loads. Three blends characteristics have been compared with diesel to understand the effect of each parameter. The operation of the VCR (Variable Compression Ratio) diesel engine was found to be smooth all over the full load condition at different injection pressures, Compression ratio (CR17.5:1) without any operational difficulties for the dual bio diesel blends diesel fuel (i.e. JME15MME5, JME10MME10 and JME5MME15). The IC engine brake thermal efficiency is the ratio of the thermal energy in the fuel to the energy delivered by the engine at the crankshaft. It importantly depends on the manner in which the energy is converted as the efficiency is normalized respect to the fuel calorific value. The brake thermal efficiency indicates the ability of the combustion system to receive the experimental fuel and offers comparable means of assessing how efficient the energy in the fuel can be transformed into mechanical output.

5.2 Brake thermal efficiency for various blends

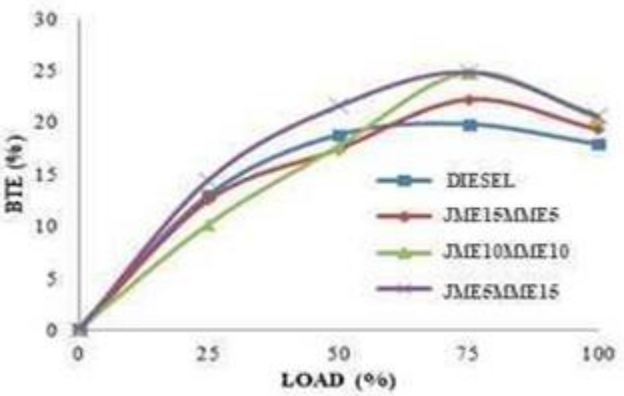

Figure.4: Variation of brake thermal efficiency with load

The nature of change of brake thermal efficiency (BTE) with percentage load for various mixed blends is shown in above figure. The brake thermal efficiency of bio diesel is higher than compare to diesel especially at full load condition. From the graph it is evident that the brake thermal efficiency has increased with increase in blend ratio of Mahua Methyl Ester(MME) bio diesel. From the brake thermal efficiency of mixed blends for JME15MME5, JME10MME10 and JME5MME15 are 19.33 (7.8%),20.37 (12%) and 20.62(14%) respectively higher than diesel (17.93). Even

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the calorific value of bio diesel blends is lower than compare to diesel; proper fuel mixing provides quality combustion. This proves that dual bio diesel provides better brake thermal efficiency than diesel.

5.3 Specific fuel consumption for various blends

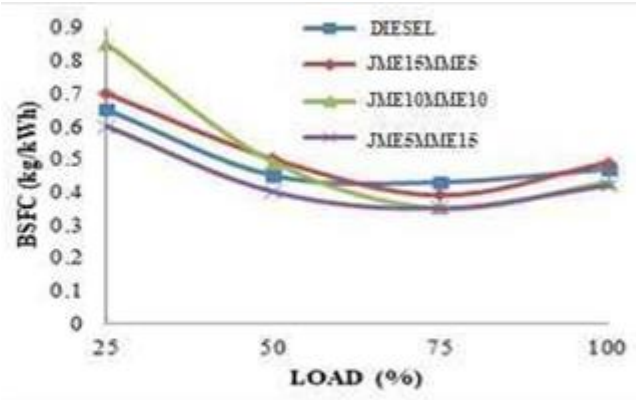

Figure.5: Variation of brake specific fuel consumption with load

The variation of brake specific fuel consumption (BSFC) with percentage load is shown in above figure. As load increases the brake specific fuel consumption reduces for the dual bio diesels mixed blends. For the maximum full load condition in compression ratio17.5 (CR17.5:1), the value of brake specific fuel consumption of mixed blends ratio B20 in JME15MME5,JME10MME10 and JME5MME15 showed for 0.49, 0.43 and 0.42 kg/kW h whereas diesel have 0.47 kg/kWh.

5.4 Emission Characteristics

5.4.1 Carbon monoxide for various blends

The variation of carbon monoxide with percentage load is shown in above figure. From the plot it was observed that as the load increase the carbon monoxide also increased. The carbon monoxide of dual bio diesels mixed blends ratio B20 (i.e.JME15MME5, JME10MME10 and JME5MME15) decreases when compared to the diesel at compression ratio17.5 for full load condition (CR17.5:1), The value of carbon monoxide (CO) of mixed Blends ratio B20 in JME15MME5 is 3.78%, JME10MME10 is 3.79%and JME5MME15 is 3.74% whereas diesel have4.74%.

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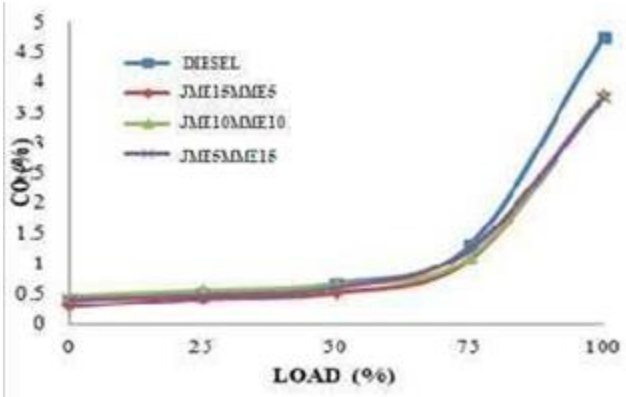

Figure.6: Variation of carbon monoxide with load

6. Conclusion

Effects of blends on a single cylinder VCR diesel engine characteristics run by dual bio diesels blend B20 mixed ratios (i.e.JME15MME5, JME10MME10 and JME5MME15) were systematically studied. The following are the conclusions from this study. Dual Bio diesel blends with 5% Jatropha Methyl Ester (JME) oil, 15% Mahua Methyl Ester(MME) oil and 80 % Diesel with high injection pressure can be selected as an alternative fuel. This study provides the reliable data for researchers to choose suitable bio diesel combination. This study furnishes qualitative and quantitative information about the performance of engine with dual bio diesels. Higher BTE, lower BSFC, lower emissions are the superior qualities of the selected dual bio diesel combination. However, the NOx intensity to be reduced by choosing the suitable technology. Comparison of properties of the bio diesels such as Viscosity, calorific value, helps the engineers to choose the various combinations of blends. Performance comparison of blends with diesel engine proved that the bio diesel blends are good renewable source to meet energy crisis and to address the eco-friendly societal problem. This study augments the data base pertaining to bio diesels.

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