PERFORMANCE ANALYSIS OF BLENDS OF KARANJA METHYL ESTER IN A COMPRESSION IGNITION ENGINE

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Abstract- On the face of the upcoming energy crisis, vegetable oils have come up as a promising source of fuel. They are being studied widely because of their abundant availability, renewable nature and better performance when used in engines. Many vegetable oils have been investigated in compression ignition engine by fuel modification or engine modification. The vegetable oils have very high density and viscosity, so we have used the methyl ester of the oil to overcome these problems. Their use in form of methyl esters in non modified engines has given encouraging results.

Karanja oil (Pongamia Pinnata) is non edible in nature is available abundantly in India. An experimental investigation was made to evaluate the performance, emission and combustion characteristics of a diesel engine using different blends of methyl ester of karanja with mineral diesel. Karanja methyl ester was blended with diesel in proportions of 5%, 10%, 15%, 20%, 30%, 40%, 50% and 100% by mass and studied under various load conditions in a compression ignition (diesel) engine. The performance parameters were found to be very close to that of mineral diesel. The brake thermal efficiency and mechanical efficiency were better than mineral diesel for some specific blending ratios under certain load.

Keywords- Karanja methyl ester, transesterification, biodiesel, engine performance

I. INTRODUCTION

Fossil fuels are one of the major sources of energy in the world today. Their popularity can be accounted to easy usability, availability and cost effectiveness. But the limited reserves of fossil fuels are a great concern owing to fast depletion of the reserves due to increase in worldwide demand. Fossil fuels are the major source of atmospheric pollution in today's world. So efforts are on to find alternative sources for this depleting energy source. Even though new technologies have come up which have made solar, wind or tidal energy sources easily usable but still they are not so popular due to problems in integration with existing technology and processes. So, efforts are being directed towards finding energy sources which are similar to the present day fuels so that they can be used as direct substitutes. Diesel fuel serves as a major source of energy, mainly in the transport sector. During the World Exhibition in Paris in 1900, Rudolf Diesel was running his engine on 100% peanut oil. In 1911 he stated ''the diesel engine can be fed with vegetable oils and would help considerably in the development of agriculture of the countries, which use it'' [1]. Studies have shown that vegetable oils can be used in diesel engines as they are found to have properties closer to diesel fuel [2]. It is being considered a breakthrough because of availability of various types of oil seeds in huge quantities [3]. Vegetable oils are renewable in nature and may generate opportunities for rural employment when used on large scale [4]. Vegetable oils from crops such as soya bean, peanut, sunflower, rape, coconut, karanja, neem, cotton, mustard, jatropha, linseed and castor have been evaluated in many parts of the world. Non edible oils have been preferred because they don't compete with food reserves. Karanja (pongamia) is an oil seed-bearing tree, which is non-edible and does not find any other suitable application due to its dark colour and odour [5]. In this work, different proportions of karanja methyl ester, viz, 5%, 10%, 15%, 20%, 30%, 40% and 50% are mixed with 95%, 90%, 85%, 80%, 70%, 60% and 50% respectively with diesel fuel on mass basis.

II. MATERIALS AND METHODS

Biodiesel can be produced by a variety of esterification technologies. The oils and fats are filtered and pre-processed to remove water and contaminants. If, free fatty acids are present, they can be removed or transformed into biodiesel using special pre-treatment technologies. Non-edible oil like karanja oils having acid values more than 3.0 were esterified followed by transesterified. Esterification is the reaction of an acid with an alcohol in the presence of a catalyst to form an ester. Transesterification on the other hand is the displacement of the alcohol from an ester by another alcohol in a process similar to hydrolysis, except that an alcohol is used instead of water. This reaction cleavage of an ester by an alcohol is more specifically called alcoholysis. In case of esterification processes, the karanja oil is preheated at different temperature and then the solution of sulfuric acid and methanol is added to the oil and stirred continuously at different temperature. Esterification is continued till the acid value was lowered and remained constant. (This should be between 0.1 and 0.5) Then the heating was stopped and the products were cooled. The un-reacted methanol was separated by distillation. The remaining product was further used for transesterification to obtain methyl esters. The karanja oil was converted to methyl ester by transesterification. The fatty acid composition of karanja oil is given in Table 1. Karanja oil contains 10-20% saturated acids (palmitic, stearic and lignoceric) and 55-90% unsaturated acids (oleic and linoleic). As the viscosity of karanja oil is higher than that of diesel fuel, it is necessary to use a viscosity reduction technique to evaluate its performance and emission in a diesel engine. Therefore, it is required to modify the fuel. So certain approaches are used to modify vegetable oils to better usable forms. Blending is a simple method of modification in which another liquid with a certain character is mixed to get the average required parameter. But the problems of separation of the mixture components and coking occur. So a chemical process called transesterification is preferred [6]. This process produces uniform quality of the alkyl esters and reduces viscosity and increases cetane number [7].

Table 1 - Fatty and unsaturated acids in karanja oil [8]

Acid	Percentage
Palmitic acid $C_{16:0}$	3.7-7.9
Stearic acid $C_{18:0}$	2.4-8.9
Lignoceric acid $C_{24:0}$	1.1-3.5
Oleic acid $C_{18:1}$	44.5-71.3
Linoleic acid $C_{18:2}$	10.8-18.3

The physical properties of karanja oil, karanja methyl ester are compared with diesel fuel and are given in Table 2.

Table 2: Comparison of Karanja Methyl Ester with Diesel [7]

Property	Karanja Oil	KME	Diesel
Specific Gravity	0.933	0.936	0.85
Viscosity (cst) at 40^{O}C	41.8	20.5	2.87
Flash point (^{O}C)	232	204	76
Calorific Value (MJ/Kg)	-	35.94	44.02
Cloud Point (^{O}C)	-	10	6.5
Pour Point (^{O}C)	6	6	3.1

III. EXPERIMENTAL SETUP

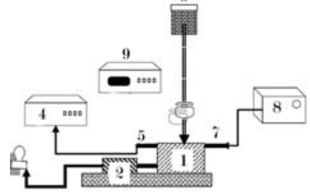

Figure 1 - Experimental setup

1. Single Cylinder 4S Diesel Engine	6. Fuel Tank
2. Dynamometer	7. Inlet Manifold
3. Resistance Load	8. Air Drum
4. Gas Analyser	9. Control System (Computer)
5. Exhaust Manifold	

Figure 1. Shows schematic diagram of the experimental setup. The specification of the engine is given in the Table 3.

Table 3: Test Engine Specifications

Make	Kirloskar
Type of Engine	Four stroke, single cylinder, DI diesel engine
Speed	1500 rpm
Bore	87.5 mm
Stroke	110 mm
Compression ratio	17.5
Method of cooling	Air cooled with radial fan

The engine was coupled to a dynamometer to provide load to the engine. A sensor is connected near the flywheel to measure the speed. Air intake was measured by air flow sensor that is fitted in an air box. A burette was used to measure fuel flow to the engine via fuel pump. A thermocouple with a temperature indicator measures the exhaust gas temperature. Emissions such as unburnt hydrocarbon (HC), carbon monoxide (CO) and nitric oxide (NO) were measured by an AVL 444 exhaust gas analyser. Combustion diagnosis was carried out by means of a Kistler make quartz piezoelectric pressure transducer (Model Type 5395A) mounted on the cylinder head in the standard position. Kistler pressure transducer has the advantage of good frequency response and linear operating range. A continuous circulation of air was maintained for cooling the transducer by using fins to maintain the required temperature. Combustion parameters such as cylinder peak pressure, ignition delay, maximum rate of heat release and rate of pressure rise were evaluated. The experiments were carried out by using diesel-2 and their various blends of karanja methyl ester (KME5,10,15,20,30,40,50,100) with diesel at different load conditions on the engine keeping all the independent variables same.

IV. *RESULTS & DISCUSSION*

Performance Parameters

A. Brake Thermal Efficiency (BTE)

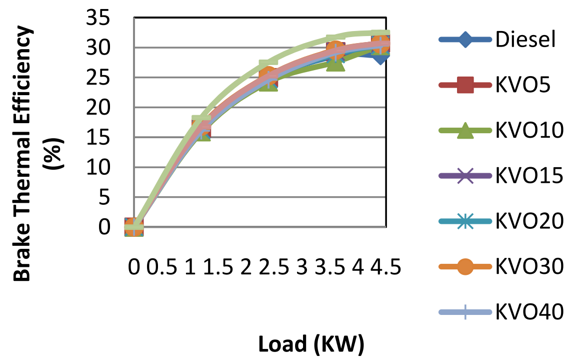

Figure 2 – Variation of brake thermal efficiency with load

Figure 2 shows the variation of the brake thermal efficiency with respect to load for diesel fuel and karanja methyl ester-diesel fuel blends. It can be observed from the figure that, KME100 shows higher brake thermal efficiencies at all load conditions compared to that of diesel fuel. Almost all blends show slightly better BTE than diesel at higher load conditions. The higher thermal efficiencies may be due to the additional lubricity provided by the fuel blends [9].

B. Brake Specific Energy Consumption (BSEC)

Figure 3 shows the variation of the brake specific energy consumption with load. When two different fuels of different heating values are blended together, the fuel consumption may not be reliable, since the heating value and density of the two fuels are different. In such cases, the brake specific energy consumption (BSEC) will give more reliable value [10]. The brake specific energy consumption was determined for karanja methyl ester-diesel fuel blends as the product of the specific fuel consumption and the calorific value. It can be observed from the figure that the BSEC for KME30 is lower as compared to that of diesel fuel. The availability of the oxygen in the karanja methyl ester-diesel fuel blend may be the reason for the lower BSEC.

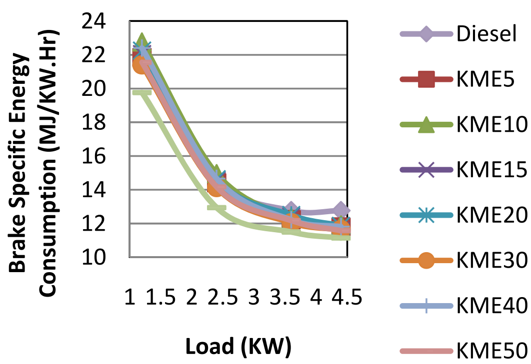

Figure 3 – Variation of brake specific energy consumption with load

In the case of lower load conditions, the incomplete mixture of high viscosity KME may lead to incomplete combustion and require additional fuel air mixture to produce the same power output as that of diesel fuel.

C. *Exhaust Gas temperature (EGT)*

The exhaust gas temperature of an engine is an indication of the conversion of heat into work. Figure 4 shows the variation of the exhaust gas temperature with load for the fuel blends. Exhaust gas temperature for KME100 is highest. For the diesel fuel, the exhaust gas temperature is the lowest among all the tested fuels. The exhaust gas temperature rises from 135 ^{o}C at no load to 347 ^{o}C at full load for KME100, while for KME20 the exhaust gas temperature rises from 136 ^{o}C at no load to 339 ^{o}C at full load.

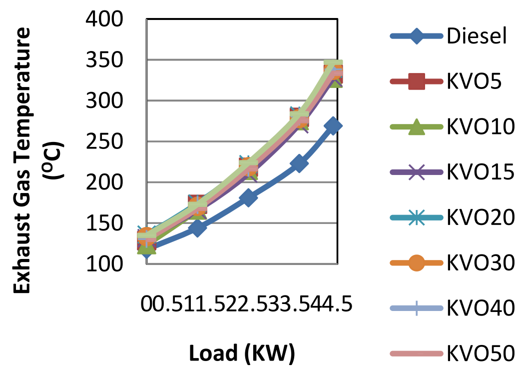

Figure 4 – Variation of exhaust gas temperature with load

In the case of karanja methyl ester-diesel fuel blends, the heat release may occur in the later part of the power stroke. So this may result in lower time for heat dissipation and higher exhaust gas temperatures.

D. *Mechanical Efficiency*

The mechanical efficiency of the fuel mixtures is plotted in figure 5. It can be seen that the mechanical efficiency for KME30 is better than diesel fuel at lower load conditions.

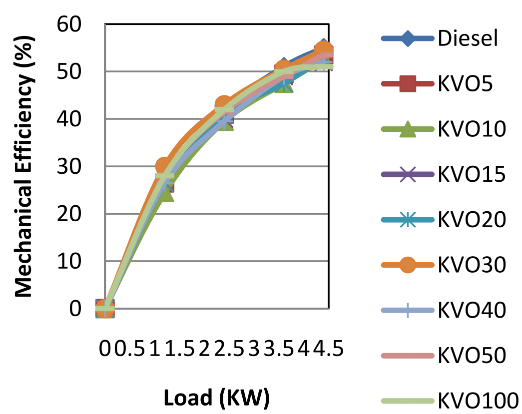

Figure 5 – Variation of mechanical efficiency with load

V. Conclusions

Karanja methyl ester seems to have a potential to use as alternative fuel in diesel engines.

Blending with diesel decreases the viscosity considerably. The following results are made from the experimental study-

- The brake thermal efficiency of the engine with karanja methyl ester-diesel blend was marginally better than with neat diesel fuel.
- Brake specific energy consumption is lower for karanja methyl ester-diesel blends than diesel at all loading.
- The exhaust gas temperature is found to increase with concentration of karanja methyl ester in the fuel blend due to coarse fuel spray formation and delayed combustion.
- The mechanical efficiency achieved with KME30 is higher than diesel at lower loading conditions. At higher loads, the mechanical efficiency of certain blends is almost equal to that of diesel.

VI. REFERENCES

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