ISSN 2278-3091

International Journal of Advanced Trends in Computer Science and Engineering, Vol.2 , No.6, Pages : 91-95 (2013)

Special Issue of ICETEM 2013 - Held on 29-30 November, 2013 in Sree Visvesvaraya Institute of Technology and Science, Mahabubnagar – 204, AP, India

Development and Use of Karanja or Jatropha as better option for Alternative Fuels on C.I Engines

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Abstract:- Bio-diesel is an alternative to petroleum-based fuel, derived from vegetable oils, animal fats and used waste cooking oils. Since the petroleum crises in 1970s, the rapidly increasing prices and uncertainties concerning petroleum availability a growing concern of the environment and the effect of green house gases during the last decades, has revived more and more interests in the use of vegetable oil as a substitute of fossil fuel. Due to the fact that the vegetable oils are produced from plants, their burning lead, to the complete recyclable Carbondioxide Co_2.

The high energy demand in the industrial world, as much in the domestic sector, and the derived problems of the widespread use of fossil fuels, make increasingly necessary the development of renewable energy source. Recent development in green segment transfer and modification techniques suggest an alternative route for the development of diesel fuel from plant sources, especially non-edible oilseeds. In this work the transformation process of jatropha and karanja oil in order to obtain bio-diesel by means of transesterification, as prepared in the laboratory, will be discussed. In the laboratory experiment, jatropha and karanja methyl esters were characterized to test their properties as fuel in diesel engines, such as viscosity, density, flash point, and cetane number. The blends of varying proportions of the jatropha and karanja with diesel were prepared, analysed, and compared with diesel oil. The engine performance and emission characteristics were evaluated in a single cylinder CI engine and a comparison was made to suggest the better option among the bio-diesel under study.

Keywords: Non-edible oils – Karanja – Jatropha – Diesel Engine – Comparision with Bio-diesels – Better options as Bio-diesel.

INTRODUCTION

The consumption of diesel is much higher than that of petrol. In India, the demand of HSD (High Speed Diesel) is projected to grow from 39.81 million metric tones to 52.32 million metric tones at the rates of 5.5% per annum. Also due to gradual epletion of the world petroleum reserve, rising petroleum prices increasing threat to the environment from exhaust emission, and global warming have "'generated an intense intern international interest in developing alternative, non-petroleum fuels for fall or partial replacement. In recent years, systematic efforts have been undertaken by many researchers to determine the suitability of vegetable oil, animal fats and their derivatives as fuel or additives to diesel. Blending by dilution, microemulsification, thermal cracking, and transesterification are the common methods to convert oil as fuel in CI.

There are many tree species, bearing seeds available in India, which are rich in non-edible vegetable oils. But surprisingly, they are not used as per their potential. Therefore, in India the feasibility of producing bio-diesel, as a diesel substitute, can be considered, along with the unutilization of the available potential of non-edible oil sources. There is a large junk of degraded forest land, unutilized public land, fallow lands of farmers, and lands in the rural areas, which will be beneficial for overall economic growth.

For the present study, the transformation process of jatropha and karanja oil, in order to obtain biodiesel by means of transesterification, was studied in the laboratory. The blends of varying proportions of jatropha and karanja with diesel were prepared, analysed, and compared with diesel oil.

The engine performance and emission characteristics were evaluated in a single cylinder CI engine and a comparison was made to come up with the best alternative.

EXPERIMENTAL PROGRAMME

The experimental investigations on karanja and jatropha oil are as follows.

Preparation of laboratory samples

Untreated vegetable oils, karanja and jatropha, under study were mixed with a mixture of anhydrous methanol and a catalyst, NaOH, in proper proportion. The mixtures were maintained at a temperature little below 65 °C (being the boiling point of methanol) and were continuously stirred for around three hours. After the stirring

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process, the mixture was allowed to settle down for 24 hours. The layer of glycerol, settled at the bottom was carefully taken out and the upper layer, the ester of karanja oil, was tapped separately. The washing of the transesterified vegetable oils were done for the removal of additional ester, followed by the evaporation for the removal of water particles and alcohol.

Fuel property measurement

The improvement in the performance of the CI engines, over the past century, has resulted from the complimentary refinement of the engine design and fuel properties Replacement of the existing fuels with new fuels call for an understanding of critical fuel properties to ensure that the new fuels can be used. Major problems encountered with vegetable oil, as bio diesel used in CI engine, is its low volatility and high viscosity due to its long-chain structure. The common problems faced are excessive pumping power, improper combustion, and poor atomization of fuel particles, discussed in this section are some key fuel properties as well as a comparison with, the standard diesel fuel.

Specific gravity

Specific gravity is the relative measure of the density of a substance. It is defined as the ratio of the density of the substance, ρ, to a reference density, ρεφ. The specific gravity of conventional diesel fuel is about 0.835, while for transesterified karanja oil it is 0.882 and for transesterified jatropha the value is 0.876, which means that the bio-diesel Under study is denser than conventional diesel fuel.

Viscosity

The resistance to flow, exhibited by fuel blends, is expressed in various units of viscosity. It is a major factor of consequence in exhibiting their suitability for mass transfer and metering requirements of engine operation. High value of viscosity reduces volatility and gives poor atomization of oil during injection of the CI engine. This results in incomplete combustion and ultimately carbon deposits on the injector nozzle as well as in the combustion chamber. The viscosities of karanja, jatropha oil, and their derived biodiesel are measured by Red Wood Viscometer (ASTM D445). A comparative study of viscosity dependencies are made at different temperatures (Table 1) and plotted in Figure 1.

Table 1 Viscosity dependency on temperature variation

	Viscosity of Karanja oil (cSt)		*Viscosity of Jatropha oil (cSt)*	
Temp (°C)	*Raw*	*Derived biodiesel*	*Raw*	*Derived bio-diesel*
30	29.65	8.73	53.79	7.20
45	17.34	7.44	35.20	5.37
60	14.62	5.97	24.85	4.14
75	11.74	5.34	14.55	3.32
90	10.63	4.62	8.23	2.96

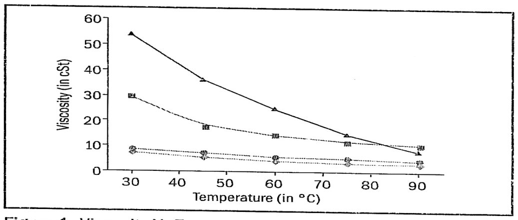

Figure 1 Viscosity Vs Temperature

Flash and Fire point

A key property, determining the flammability of a fuel, is the flash point. The flash point is the lowest temperature at which an applied ignition source causes the vapours of a sample to ignite.

The 'fire point' is sometimes used to designate the fuel temperature, producing sufficient vapour to maintain a continuous flame. These two parameters have great importance while determining the fire hazard (temperature at which fuel will give off inflammable vapour).

Cloud point and pour point

The cloud point is the temperature at which a cloud of wax crystals first appears in a fuel sample that is cooled under conditions described by ASTM D2500.The pour point is the lowest temperature at which movement of the fuel sample can be determined when the sample container is tilted under conditions described by ASTM D97. These two temperatures are of great importance in knowing the behaviour of fuels in cold weather.

Calorific value

The calorific value of a fuel is the thermal energy released per unit quantity of fuel when the fuel is burned completely and the products of combustion are cooled back to the initial temperature of the combustible mixture. It measures the energy content in a fuel. This is an important property of bio-diesel that determines the suitability of the material as alternative to diesel fuels.

Cetane number

Perhaps the most important characteristic of the ignition of diesel and or bio-diesel fuels is the cetane number, since it directly pertains to ignition within compression ignition engines. The cetane number is the primary specification measurement used to match fuels and engines. The cetane number of a diesel fuel is related to the ID (ignition delay) time, that is, the time that passes between injection of the fuel into the cylinder and the onset

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of ignition. The shorter the ID time, the higher the cetane number and vice versa. A fuel of higher cetane number gives lower delay period and provides smoother engine operation. The API (American Petroleum Institute) and the NBS (National Bureau of Standards) have jointly devised an arbitrary scale, expressing the gravity or density of liquid petroleum product in terms of degree API. For karanja it is found to be 28.93 (degree API) and 47.79 (diesel index). The cetane number is calculated as 56.64. For jatropha, the corresponding values are 30.03, 50.15, and 57.12, respectively. These values prove the suitability of the fuel under study as a diesel fuel.

Table 2 Comparative studies of fuel properties of diesel and biodiesel

Properties	*Karanja oil*		*Jatropha oil*		*Diesel*
	Raw	*Derived biodiesel*	*Raw*	*Derived biodiesel*	
Viscosity (cST) at 30 °C	29.65	8.73	53.79	7.2	2.5
Calorific value (kj/kg)	–	35879	–	42640	43500
Flash point (°C)	241	217	261	248	52
Fire point (°C)	253	223	302	295	63
Cloud point (°C)	7	6	7	6	5
Pour point (°C)	3	3	4	4	4
Specific gravity (at 30 °C)	0.912	0.882	0.902	0.876	0.835

As shown in Table 2, the viscosity and specific gravity of biodiesel obtained are very high compared to the suitability in the CI engine, therefore and it is evident that dilution or blending of biodiesel with other fuels, like diesel, fuel would bring the viscosity and density close to a specification range. Therefore, biodiesel obtained from karanja and jatropha were blended with diesel oil, in varying proportions, to achieve the required viscosity and density, close to that of diesel fuel (Table 3).

Table 3 Variation of viscosity and density for different blends

Karanja blend with diesel		*B5*	*B10*	*B15*	*B20*	*B25*	*B100*
	Viscosity (cSt)	2.78	2.89	3.06	3.64	3.98	8.73
	Density (kg/m^3)	837	840	842	844	847	882
Jatropha Blend with diesel		B10	B20	B30	B40	B50	B60
	Viscosity (cSt)	2.99	3.5	3.81	4.31	4.51	5.34
	Density (kg/m^3)	839	843	847	851	855	859

STUDIES OF DIFFERENT BLENDS OF BIO-DIESEL

To study engine performance and emission, the experiments were done in Kirloskar make vertical single cylinder, direct injected compression ignition diesel engine (Engine model-AVI).The power output of the engine was 5 HP (horsepower) at the rate of 1500 rpm (revolutions per minute), having a compression ratio 16.5:1.The emission as well as engine performance was studied at different engine loads (25, 50, 75, and 100% of the load corresponding to load at maximum power).

Brake thermal efficiency

The variation of brake thermal efficiency with load for different fuel blends are shown in Figure 2 and Figure 3. In all the cases, brake thermal efficiency was increased due to reduced heat loss with increase in load. The maximum efficiency for transesterified karanja oil, obtained in this experiment, is 33.74% (B25) and 33.54% (B20). However, considering the viscosity, B20 is the better option and this value is comparable with the maximum brake thermal efficiency for diesel (34.45%). For transesterified jatropha oil, considering the viscosity, B50 is the better option and the maximum brake thermal efficiency is 36.9%. From Figure 2 and Figure 3, it can seen that brake thermal efficiency for bio-diesel, under investigations in comparison to diesel engine, is a better option for part load on which most engine runs.

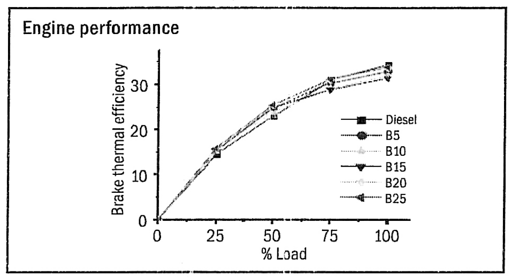

Figure 2 Variation of thermal efficiency for karanja blended with diesel

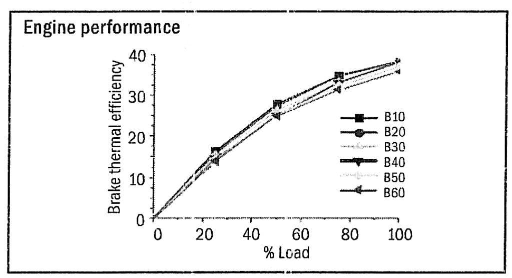

Figure 3 Variation of thermal efficiency for jatropha blended with diesel

Brake specific fuel consumption

The variation of BSFC (brake specific fuel consumption) at different load for jatropha and karanja, blended with diesel, is shown in Figure 4 and Figure 5. For all cases, BSFC reduces with increase in load. The reverse trend in the BSFC may be due to increase in biodiesel percentage, ensuring lower calorific value of fuel. Another reason for the change in BSFC in biodiesel in comparison to petro-diesel may be due to a change in the combustion timing caused by the biodiesel's higher cetane number as well as injection timing.

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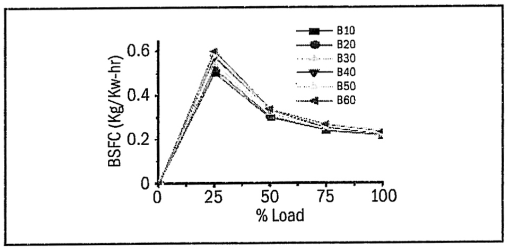

Figure 4 Variation of BSFC for jatropha blended with diesel

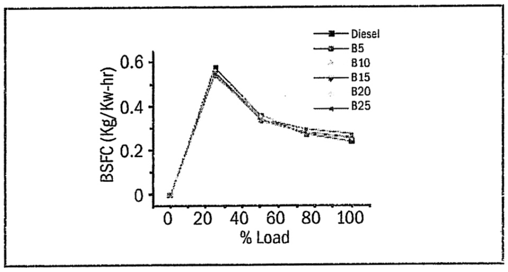

Figure 5 Variation of BSFC for karanja blended with diesel

Carbon monoxide emission

The variation of CO (carbon monoxide), produced with diesel and diesel blends (karanja and jatropha), are presented in Figure 6 and Figure 7. The amount of CO produced, whether for a B20 karanja blend or a B50 jatropha blend, is much less than the CO produced from the diesel that indicates the complete combustion of the biodiesel being an oxygenated fuel. For B20 karanja blend, at maximum load, the amount of CO produced is 1.42 gm/kW-hr and for jatropha B50, it is 0.756 gm/Kw-hr, which are less than that mentioned in EURO-IV norms (max 1.5 gm/Kw-hr).

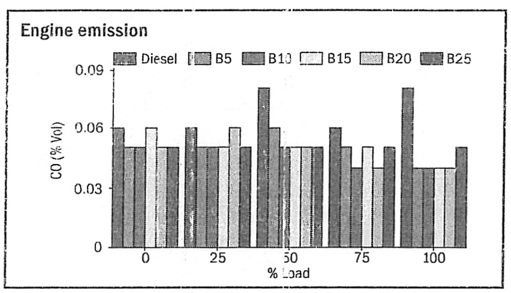

Figure 6 Variation of CO for karanja blends

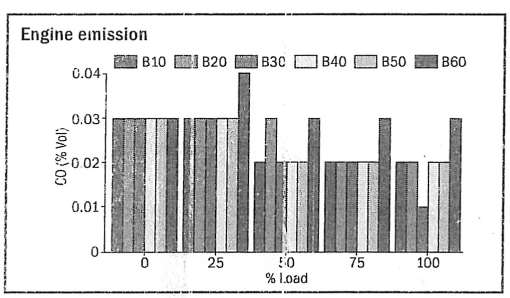

Figure 7 Variation of CO for jatropha blends

Nitrogenoxide emission

The variations of NO_X (oxides of nitrogen), at different engine load for the fuel under study, is presented in Figure 8 and Figure 5. The cetane numbers of die biodiesel obtained are generally higher than that of diesel fuel associated with lower NO_X emissions. For B20 karanja blend, the maximum and minimum NC_X produced is 0.12 gm/Kw-hr and 0.06 gm/ Kw-hr, whereas the value for jatropha (B50) is 0.11 gm/Kw-hr and 0.04 gm/Kw-hr, which is much less than that mentioned in EURO-TV norms (max 3.5 gm/ Kw-hr).

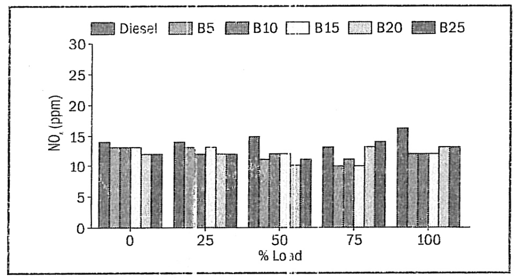

Figure 8 Variation of NO_x for karanja blends

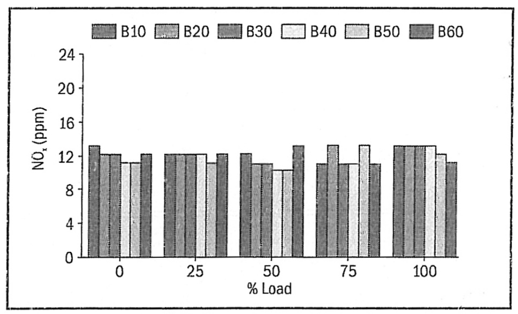

Figure 9 Variation of NO_x for jatropha blends

The variations of un-burnt hydrocarbon, at different engine load for different diesel blends with karanja and jatropha, are shown in Figure 10 and Figure 1 1.The shorter ignition delay, associated with biodiesei higher cetane number, could also reduce the over mixed fuel, which is the primary source of un-burnt hydrocarbons. For B20 karanja blend, the maximum and minimum hydrocarbon produced is 0.35 gm/Kw-hr and 0.18 gm/Kw-hr, whereas for the B50 jatropha blend, it is 0.09 gm/Kw-hr and 0.07 gm/Kw-hr, which are much less than the HC produced from diesel emission.

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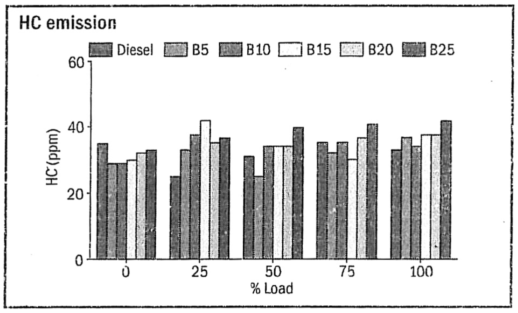

Figure 10 Variation of NO_x for karanja blends

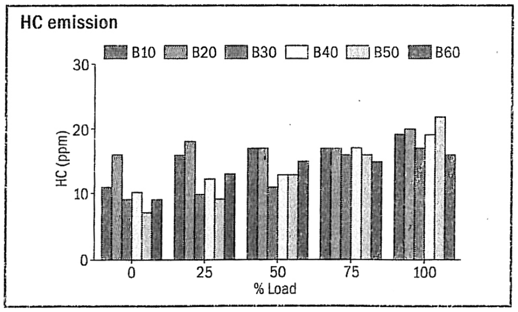

Figure 11 Variation of NO_x for jatropha blends

CONCLUSION

Based on the result of this study, that is, the physical and chemical properties of karanja or jatropha oil, it can be suggested that fuel produced from plants cannot be used directly as CI engine fuel due to higher viscosity and density as this, will result in low volatility and poor atomization of oil during oil injection in the combustion chamber, causing incomplete combustion and carbon deposits in the combustion chamber.

Based on engine emission, studies, that is, CO, NO_X and hydrocarbon, it can be said that all the parameters are within the maximum limits that conclude safer use as an alternate fuel.

The physical and chemical properties results of all blends show that blends of upto 20% straight karanja and upto 50% straight jatropha have a value of viscosity and density equivalent to specified range for CI engine fuel and therefore it can be concluded that upto 20% blend for karanja and 50% blend for jatropha can be used to run the stationary CI engine on a short-term basis. In overall perspective, the B50 jatropha is a better choice as it can partially replace more amounts of diesel in comparison to karanja.

The combustion process essentially results in deposition inside the cylinder walls and more importantly on the cylinder head. With continued use of the engine, these depositions may eventually lead to hotspots, creating possibilities of untimely ignition. While the last aspects have been investigated in detail in CI engines using diesel, the same is wanting in the proposed biodiesel under investigation for long-term purposes.

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