A REVIEW ON NON-EDIBLE KARANJA OIL- A SUSTAINABLE FUEL FOR C.I. ENGINE

R. R. Khodke[1], Dr. S. C. Kongre[2]

[1]Student-MTech (HPE), Department of Mechanical Engineering, Shri Shankarprasad Agnihotri College of Engineering, Wardha, [2]I/C HOD, Department of Mechanical Engineering, Acharaya Shriman Narayan Tantraniketan, Pipri, Wardha, Maharashtra, India

[1]roshan.khodke2010@gmail.com,[2]suhas_kongre@rediffmail.com

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ABSTRACT

The diesel engine is the most efficient power plant among all known types of internal combustion engines. Heavy trucks, urban buses, and industrial equipment are powered almost exclusively by diesel engines all over the world and diesel powered passenger cars are increasingly popular. Increase in petroleum prices, threat of global warming has generated an interest in developing alternative fuels for engine. Technologies now focusing on development of plant based fuels, plant oils, plant fats as an alternative fuel. This article is a literature review of investigation of the potential to use karanja oil in a four stroke, DI diesel engine under different load conditions. Karanja based bio-diesel is a non-edible, biodegradable fuel suitable for diesel engines. Karanja biodiesel has been prepared by transesterification method. Biodiesel-diesel blends have been prepared on volume basis. Physical properties of Karanja biodiesel, diesel and its blends have been determined.

Index Terms: Alternative fuel, Karanja oil, Biodiesel, Esterification and Transesterification, etc.

1. INTRODUCTION

Energy is one of the most significant inputs for growth of all sectors including agricultural, industrial service and transport sectors. Energy has been at the centre stage of national & global economic development from several decades. The demand for energy, around the world is increasing exponentially; specifically the demand for petroleum-based energy [2]. Global warming is related with the greenhouse gases which are mostly emitted from the combustion of petroleum based fuels. Fast depletion of fossil fuels is demanding an urgent need to carry out research work to find out the viable alternative fuels. Diesel fuel is largely consumed by the transportation sector. India with the high rate of economic growth and increase in the population is the significant consumer of energy resources. India lacks in sufficient energy reserves and dependent on oil imports, but India has an abundant re-source of vegetable oils. The use of vegetable oil in a diesel engine is not a new concept. In fact early engines were demonstrated with straight vegetable oils (SVO). Vegetable oils were proved to be very costlier during those days. However due to limited reserves of fossil fuels, escalation nature of diesel fuel prices and increase in environmental pollution, created a renewed interest of research in vegetable oil as substitute fuel for diesel engines. Vegetable oil is easily available, renewable and environment friendly. Vegetable oils have energy content suitable for use as a fuel in diesel engines. Some of these oils have already been evaluated as substitutes for diesel fuels.

Karanja is non-edible oil and holds special promise in this regard, because it can be produced from the plants grown in almost all part of India. Several operational and durability problems of using karanja oil in diesel engine directly, caused by their relatively higher viscosity compared to mineral diesel. This viscosity can be brought into the acceptable range by transesterification i.e. by producing biodiesel from karanja oil.

2. ADVANTAGES OF NON-EDIBLE OIL

Preliminary evaluation of several non-edible oilseed crops for their growth, feedstock and adaptability show that these feed-stocks have the following advantages [3]:

1. The adaptability of cultivating non-edible oil feedstock in marginal land and non-agricultural areas with low fertility and moisture demand.

2. They can be grown in arid zones (20 cm rainfall) as well as in higher rainfall zones and even on land with their soil cover. Moreover, they can be propagated through seed or cuttings.

3. They do not compete with existing agricultural resources.

4. They eliminate competition for food and feed. Non-edible oils are not suitable for human food due to the presence of some toxic components in the oils.

5. They are more efficient and more environmentally friendly than the first generation feedstocks. Conversion of non-edible oil into biodiesel is comparable to conversion of edible oils in terms of production and quality.

6. Less farmland is required and a mixture of crops can be used. Non-edible oil crops can be grown in poor and wastelands that are not suitable for food crops.

7. Most of non-edible oils are highly pest and disease resistant.

8. The main advantages of non-edible oil are their liquid nature portability, ready availability, renewability, higher heat content, lower sulfur content, lower aromatic content and biodegradability.

3. KARANJA OIL

Karanja is an oil seed-bearing tree, which is non-edible and does not find any suitable application with only 6% being utilized of 200 million tons per annum. The oil is also used as a lubricant, water-paint binder, and pesticide. Karanja tree grows all over the country. Karanja oil belongs to the family leguminaceae, commonly known as Pongamia Pinnata. Other name of karanja oils are pongam oil or honge oil. Pongamia is widely distributed in tropical Asia. The tree is hardy, reasonably drought resistant and tolerant to salinity. It is attractive because it grows naturally throughout the India, having very deep roots to reach water, and is one of the few crops well-suited to commercialization by India’s large population of rural poor. [5]

The karanja tree is of medium size, reaching a height of 15-25 feet. The tree bears green pods which after some 10 months change to a tan color. The pods are flat to elliptic, 5-7 cm long and contain 1 or 2 kidney shaped brownish red kernels. The yield of kernels per tree is reported between 8 and 24 kg. The composition of typical air dried kernels is: Moisture 19%, Oil 27.5%, and Protein 17.4%. The oil content varies from 27%-39%.

The most common method to extract oil involves in collecting the pods. The pods are kept in water for 2 to 3 hours followed by drying in hot atmospheric condition. The dried pods are stuck with hammers and sticks to open them after which the seeds are winnowed out. Oil extraction is carried out in Ghanis and small expellers. The fresh extracted oil is yellowish orange to brown and rapidly darkens on storage

4. BIODIESEL

Transesterification technique to convert high free fatty acids (FFA) and high viscous fluid to low FFA and low viscous fuel, namely karanja biodiesel. Since the crude karanja oil acid value was found to be more than 6, so acid esterification and transesterification techniques is used to form biodiesel. [6]

4.1 Acid Esterification

Oil feed stocks containing more than 6% free fatty acids go through an acid esterification process to increase the yield of biodiesel. Five liters of karanja oil were filtered and preprocessed to remove water and contaminations, and then fed to the acid esterification process. The acid catalyst i.e. sulfuric acid (H2SO4) (0.5% V/V), was dissolved in methanol (6% molar ratio of methanol/oil) and then mixed with the preheated oil. The mixture was heated up to 600C and stirred at a speed of 1600 r.p.m. for 2 hours resulting in decrease the acid value 8.42 shown in Table No.1. As the acid value label was higher before going for trasesterification process once again acid esterification process was repeated to reduce the acid value. After 2nd acid esterification the acid value reduced to 6.16 shown in Table No.1. The top layer methanol was separated out by decantation process and the oil layer was taken for transesterification. Once the reaction was completed, it was dewatered by passing over a hydrous sodium sulphate (Na2SO4) and then fed to the transesterification process.[7]

4.2 Transesterification

Oil feed stocks containing less than 4% free fatty acids are filtered and pre-processed to remove water and contaminants and then fed directly to the transesterification process along with any products of the acid esterification process. The catalyst KOH is dissolved in methanol and then mixed with the pretreated (650C) oil. Once the reaction is complete, the major co-products, biodiesel and glycerine are separated into two layers.

The product is allowed to stand overnight to separate the biodiesel and glycerol layer. The upper biodiesel layer is separated from the glycerol layer and washed with hot distilled water to remove the excess methanol, catalyst and traces of glycerol. The washed ester layer is dried under the vacuum to remove the moisture and methanol and again passed over a hydrous Na2SO4. The biodiesel obtained is termed as Karanja oil methyl ester (KOME). Acid value after transesterification is 1.12 shown in Table No.1. The various properties of karanja biodiesel as shown in Table No.2. [7]

Table-1: Acid Value of Karanja oil.

Karanja Oil	Acid Value
Before esterification	25.76
After 1st esterification	8.42
After 2nd esterification	6.16
After transesterification	1.12

Table-2: Fuel Properties of Karanja oil, KOME and Diesel

Properties	Diesel	Karanja oil	KOME
Specific gravity	0.84	0.91	0.88
Calorific Value (MJ/kg)	45.34	34	36.12
Clould Point (^{0}C)	-12	7	6
Fire Point (^{0}C)	68	250	22.5
Flash Point (^{0}C)	63	240	218
Kinematic Viscosity @ 40(^{0}C) (cSt)	2.44	32.1	6.88

Table-3: Properties of KOME and its blend

Blends of KOME	Calorific Value (MJ/kg)	Specific gravity	Kinematic Viscosity @ 40(^{0}C) (cSt)	Flash Point (^{0}C)
B20	39.00	0.843	3.25	75
B40	37.95	0.856	4.40	83
B60	37.25	0.867	5.65	86
B80	36.25	0.876	6.55	92
B100	36.12	0.880	6.88	218

The fuel properties of different bends of KOME like B20 (20% KOME and 80% diesel), B40 (40% KOME and 60% diesel), B60 (60% KOME and 40% diesel), B80 (80% KOME and 20% diesel), and B100 (100% KOME) are mentioned in Table-3. [7]

4.3 Effect of different parameters on production of biodiesel.

- **Effect of free fatty acids**

Free fatty acids (FFAs) content after acid esterification should be minimal or otherwise less than 2% FFAs. These FFAs react with the alkaline catalyst to produce soaps instead of esters. There is a significant drop in the ester conversion when the free fatty acids are beyond 2% [8].

- **Effect of temperature**

  The temperature maintained by the researchers during different steps range between 45^{0}C and 65^{0}C. The boiling point of methanol is 60.7^{0}C. Temperature higher than this will burn the alcohol and will result in much lesser yield. A study by Leung and Guo [9] showed that temperature higher than 50^{0}C had a negative impact on the product yield for neat oil, but had a positive effect for waste oil with higher viscosities.

- **Effect of stirring**

Stirring can play an important role in the yield of biodie-sel production. Meher et al. [10] conducted the transesteri-fication reaction with 180, 360 and 600 revolutions per minute (rpm) and reported incomplete reaction with 180 rpm. The yield of methyl ester was same with 360 and 600 rpm. Sharma and Singh [11] reported that mode of stirring too plays a vital role in the transesterification reaction. The yield of biodiesel increased from 85% to 89.5% when magnetic stirrer (1000 rpm) was replaced with mechanical stirrer (1100 rpm). A possible explanation may be a thorough mixing of the reactants by mechanical stirrer.

5. TESTING

Many author tested karanja biodiesel and its blend with diesel on 4-stroke CI engine. H. A. Phadtare [14] reported that the B10 is best alternative fuel for diesel at slightly higher CR can be used safely. No hardware modifications are required for handling these fuels (Karanja biodiesel and their blends) in the existing engine.

N. Panigrahi [19] reported that the specific gravity, Kinematic viscosity of B20 and B40 blends is much closer to diesel. At higher load maximum brake power was observed for B20 blend. Brake specific fuel consumption (BSFC) reduces with increase in load.

6. CONCLUSION

As discussed karanja oil has a great potential to be use as a alternative fuel in CI engine. To reduce the viscosity of karanja oil transesterification method is used, which gives the biodiesel from karanja oil. Several published articles shows the different properties of pure karanja oil, karanja biodiesel. Many researchers reported that the blending of biodiesel of karanja oil with diesel in different proportions, reduce the viscosity problem of pure karanja oil.

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