Experimental Investigation on Performance and Emission Characteristics of Diesel Engine Fueled with Blends of Karanja Oil Methyl Ester

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Abstract— Biodiesel are becoming popular as alternative eco-friendly fuel now days. The petroleum product requirement is going on increasing day by day in India with limited resources in the oil pool. Crisis of petroleum fuel and import of fossil fuel is giving a high impact on the economy and development. Besides the economy and development, fossil fuel also leads to a major problem like global warming and climatic change. The emission of harmful gasses like CO, NOx, CO_2, and smoke density causes acid rain, health hazard and also global warming. The high oil price, environmental concern and supply instability put many researchers to go for alternative fuel i.e. biodiesel. Biodiesel is part of the solution which reduced many of the problems. The objectives of this study are the production process, fuel properties, oil content, engines testing and performance analysis of biodiesel from karanja oil which is known as Karanja oil methyl ester (KOME). Engine tests have been carried out in a water cooled four stroke diesel engine and experimental investigation have been carried out to examine properties, performance and emission of different blends of KOME. The study reveals that the emission parameters are better for biodiesel blends fuel compared to diesel. Whereas, brake thermal efficiency and brake specific fuel consumption parameters are inferior compared to diesel.

Keywords: KOME, Biodiesel, Karanja Oil

I. INTRODUCTION

Biodiesel is a clean burning alternative fuel produced from domestic, renewable resources such as plant oils, animal fats, used cooking oil and even from algae. Biodiesel contains no petroleum, but can be blended at any level with petroleum diesel to create a biodiesel blend. Biodiesel blends can be used in compression ignition engines with little or no modifications. Among the vegetable oils edible and non-edible oils are used to produce biodiesel. The use of edible is a great concern with food materials. So it is justified to use non edible for the production of biodiesel. Non edible trees can grow in inhospitable condition of heat, low water, rocky and sandy soils. So non-edible oil plants like karanja, jatropha, mahua, neem will be the best choice for the source of biodiesel production. The use of Karanja biodiesel in conventional diesel engines when used alone or with blends with petroleum diesel substantially reduces exhaust emission such as the overall life cycle of carbon dioxide (CO_2), particulate matter (PM), carbon monoxide (CO), sulfur oxides (SOx) and unburned hydrocarbons(HC) with reducing the green house emission also. To investigate the fuel properties of Pongamia pinnata, commonly known as karanja and its potential to use as a bio diesel and finally a comparative study of different proportionate blends of bio diesel and diesel is driven by an electrical motor. A thermometer is put through a second opening for continuous monitoring of the temperature of the reaction. Methanol being volatile vaporizes during the reaction, hence the condenser is put in the third opening to collect the vapor back to the reactor for preventing any reactant loss. A fourth opening through the flask is meant for supplying reactant into the reactor. The bottom of the flask is conical in shape use for settling of oil after transesterification

Regarding the power is same to that of diesel engine. The specific fuel consumption is more or less the same. The brake thermal efficiency is slightly on higher side. The aim of the present study is to experimentally investigate the effect of different blends of KOME on the performance of diesel engine. The results were compared with petroleum diesel.

In recent years several researches have been made to use vegetable oil, animal fats as a source of renewable energy known as bio diesel that can be used as fuel in CI engines. Vegetable oils are the most promising alternative fuels for CI engines as they are renewable, biodegradable, non-toxic, environmentally friendly, a lower emission profile compared to diesel fuel and most of the situation where conventional petroleum diesel is used. Even though “diesel” is part of its name there is no petroleum or other fossil fuels in bio diesel. It is 100% vegetable oil based, that can be blended at any level with petroleum diesel to create a bio diesel blend or can be used in its pure form. Non edible vegetable oils are the most significant to use as a fuel compared to edible vegetable oils as it has a tremendous demand for using as a food and also the high expense for production. Therefore, many researchers are experimenting on non-edible vegetable oils.

In India the feasibility of producing bio diesel as diesel substitute can be significantly thought as there is a large junk of degraded forest land, unutilized public land, and fallow lands of farmers, even rural areas that will be beneficial for overall economic growth. There are many tree species that bear seeds rich in non-edible vegetable oils. Some of the promising tree species are Pongamia pinnata (karanja), Meliazadirachta (neem), Jatropha curcas (Ratanjyot)etc. But most surprisingly as per their potential only a maximum of 6% is used. Major problems encountered with vegetable oil as bio diesel used in CIengine are

II. KARANJA OIL

It 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 through much of arid 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.

The karanja tree is of medium size, reaching a height of 15-25 meters. 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%, 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 oil is dark in color with a disagreeable odor.

Sl.No.	Fatty acid	Value (%)
1	Palmitic	3.7-7.9
2	Stearic	2.4-8.9
3	Oleic	44.5-71.3
4	Linoleic	10.8-18.3
5	Lignocerc	1.1-3.5

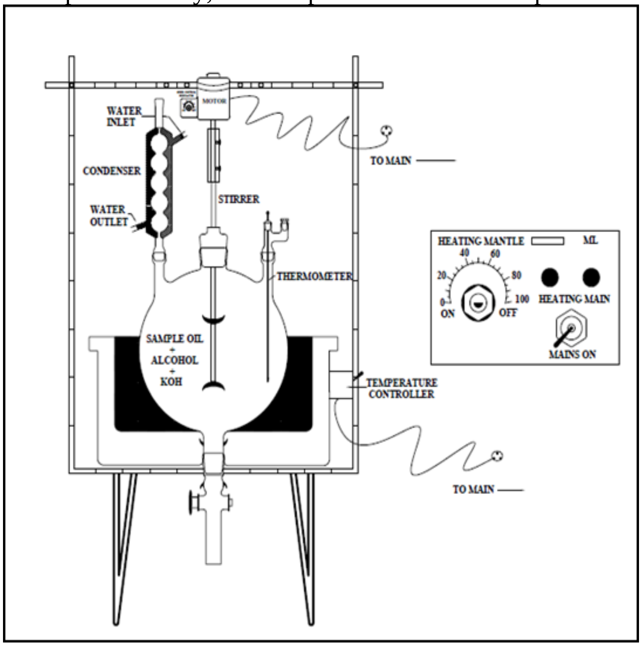
Table 1: Characteristics of fatty acids in karanja oil

III. Experimental Setup

The experimental setup for carrying out the transesterification reaction of esterified Karanja oil is shown in fig.4. The transesterification reactor consists of a round bottomed flask with conical shape opening at the bottom flask of 2.0 liter capacity which is kept inside a heating mantle. The electrical heater consists of a thermostat which maintains the temperature of oil inside the flask at a desired value i.e. below 65oC. The round bottomed spherical flask contained four openings. The centre one is used for putting the electrical stirrer into the reactor. The stirrer is driven by an electrical motor. A thermometer is put through a second opening for continuous monitoring of the temperature of the reaction. Methanol being volatile vaporizes during the reaction, hence the condenser is put in the third opening to collect the vapor back to the reactor for preventing any reactant loss. A fourth opening through the flask is meant for supplying reactant into the reactor. The bottom of the flask is conical in shape use for settling of oil after transesterification. which was indicated in smoke opacity curve.

- Exhaust gas temp is higher compare to diesel.
- CO_2 & NOx emissions are found to be more for KOME blends while HC, CO and smoke emissions are lowered as compared to diesel. From the above observation it can be concluded that besides considering the economy part blends of B20 and B10 of Karanja biodiesel can be considered as a sustainable fuel. It can be used as an environment friendly alternative fuel without major engine modification. its low volatility and high viscosity due to long chain structure. The common problems faced are excessive pumping power, improper combustion and poor atomization of fuel particles. The conversion of the vegetable oil as a CI engine fuel can be done any of the four methods; pyrolysis, micro emulsification, dilution/blending and transesterification.

In the present study, some experiments have been performed



IV. Results and Discussion

A. Seed Characterization:

Moisture content = 0%
Oil content =34.87%

B. Physico -chemical properties of oil:

The physicochemical properties of karanja oil are shown in the table-3 given below:

Properties	Value
Density at 25ºc(kg/m^3)	910
Kinematic viscosity at 40ºc(cSt.)	34.78
Acid value(mg KOH/g)	30.64
FFA(mgKOH/g)	15.4
Calorific value(Mj/kg)	36.4
Cetane number	32.22
Flash point(ºc)	219
Fire point(ºc)	229
Cloud point(ºc)	9
Pour point(ºc)	3

Table 3: Physico-chemical Properties of Karanja oil

V. Experimental Procedure

A. Extraction of Karanja oil

The Karanja oil was mechanically extracted from the seeds using a screw press, and then allowed to settle until the impurities are precipitated. The extracted oil was then filtered with a suction filter by using nylon mesh filter cloth with mesh opening of 5 microns. 100 kg of Karanja seeds provided on average of 25liters of extracted oil which was clear, viscous, and dark brown in color.

The seeds were grinded into fine particles & 50gms of the grinded seed was taken and a thimble was made. The soxhlet apparatus was set up as shown below.300ml of hexane was added to thimble from above.

B. Working of the Apparatus:

A Soxhlet extractor is a piece of laboratory apparatus invented in 1879 by Franz Von Soxhlet. Typically, a Soxhlet extraction is only required where the desired compound has a limited solubility in a solvent, and the impurity is insoluble in that solvent. Normally a solid material containing some of the desired compound is placed inside a thimble made from thick filter paper, which is loaded into the main chamber of the Soxhlet extractor. The Soxhlet extractor is placed onto a flask containing the extraction solvent. The Soxhlet is then equipped with a condenser.

The solvent is then heated to reflux. The solvent vapour travels up a distillation arm and floods into the chamber housing the thimble of solid. The condenser ensures that any solvent vapours cools, and drips back down into the chamber housing the solid material. The chamber containing the solid material is slowly filled with warm solvent. Some of the desired compounds then get dissolved in the warm solvent. When Soxhlet chamber is almost full, the 16 chamber is automatically emptied by a siphon side arm, with the solvent running back down to the distillation flask. This cycle is allowed to repeat several times within 8hrs of extraction.

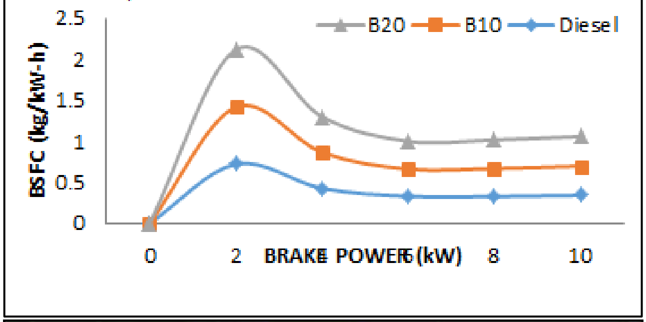
During each cycle, a portion of the non-volatile compound dissolves in the solvent. After many cycles the desired compound is concentrated in the distillation flask. After extraction the solvent is removed, typically by means of a rotary evaporator at 40-50ºC, yielding the extracted compound i.e. oil. The non-soluble portion of the extracted solid remains in the thimble, which is discarded.

C. Preparation and studies of different blends of biodiesel:

To study engine performance and emission, the experiments were done in Prakash make vertical single cylinder, direct injected compression ignition diesel engine (Engine model – AVI). The power output of the engine is 5HP @ 1500rpmhaving compression ratio 16.5:1. The emission as well as engine performance was studied at different engine loads (0,2,4,6,8,10 kw) and 100% of the load corresponding to load at maximum power.

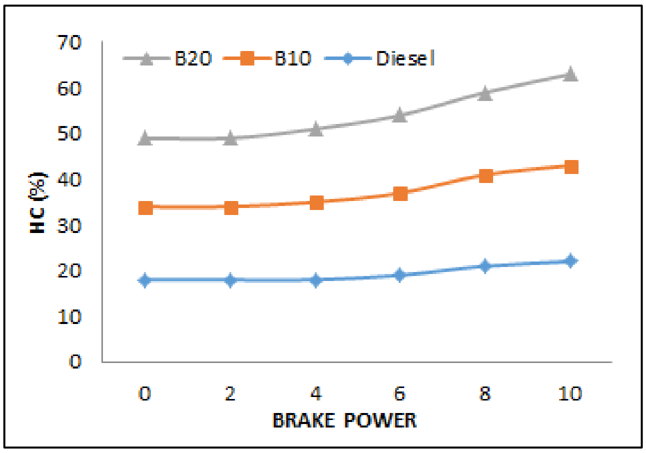
D. Brake Specific Fuel consumption:

The variation of BSFC at different load is shown in figure 11. For all cases BSFC reduces with increase in load. But at full load this value increases for all fuel. The increase in the BSFC for different blend maybe due to increase in biodiesel percentage ensuring lower calorific value of fuel. Another reason for the increase in BSFC in biodiesel in comparison to petrol diesel may be due to a change in the combustion timing caused by the biodiesel's higher cetane number as well as injection timing. At quarter load BSFC reduces a minimum of 0.34kg/kwh (B20) and. But for full load BSFC increases up to a maximum value



E. Hydrocarbons:

The variations of un-burnt hydrocarbon at different engine load for different diesel blends are shown in fig: 14. The shorter ignition delay associated with biodiesel higher cetane number could also reduce the emission of HC in compare to diesel. For B20 the maximum and minimum HC produced is which is around same as that is mentioned in EURO – IV Norms. At higher loads the emission of HC is more due to rich mixture with incomplete combustion of fuel.



CONCLUSION-:

By transesterification method karanja crude oil was converted to KOME. Major of the fuel properties were tested. Performance and emission tests were conducted by using a four stroke diesel engine. Respective graphs were plotted and results were analyzed and compared with diesel. The major conclusions were drawn based on the tests.

- Lower calorific value indicates more oil consumption.
- The specific gravity, Kinematic viscosity of B20 and B10 blends is much closer to diesel.
- BSFC reduces with increase in load but at full load increases.
- BTE shows better result for diesel.
- Incomplete combustion of KOME is much lower than diesel which was indicated in smoke opacity curve.
- Exhaust gas temp is higher compare to diesel.
- CO_2 & NOx emissions are found to be more for KOME blends while HC, CO and smoke emissions are lowered as compared to diesel.

From the above observation it can be concluded that besides considering the economy part blends of B20 and B10 of Karanja biodiesel can be considered as a sustainable fuel. It can be used as an environment friendly alternative fuel without major engine modification.

VI. Scope of Future Work

Further study of low volatility of karanja oil need to be investigated to know the effect on engine. The properties of blend may be further improved to make use of higher percentage of karanja oil in the blend by preheating the blend.

References

[1] Nagarhalli M.V. et al., 1997. Effects of Biodiesel BlendedFuels and Multiple Injections on D.I. Diesel Engine, SAE Paper No. 970218: 388-407.
[2] H.Raheman and A.G. Phadatare et al.2000. Triglycerides-based diesel fuels. Renewable and Sustainable Energy Reviews, Vol. 4:111-133.
[3] Nitin Shrivastava et al. Long-range on road test with twenty percent rapeseed biodiesel. Applied Engineering in Agriculture, ASAE Vol. 15(2): 91-101.
[4] Ramchandra S. Jahagidar Chemical and physical properties of vegetable oil esters and their effect on diesel fuel performance. Biomass 1986; 9:1–17.
[5] Meher et. al. Biofuel as diesel fuel alternative: an overview. J. Energy Heat Mass Transfer 1993; 15:293–304.16
[6] Krawcyzk (1996) Survey of seed oils for use as diesel fuels. J.Am. Oil Chem.Soc. 1996;71(4):471–7.
[7] A.S. Ramadhas et.al Vegetable oils verses diesel fuel: development and use of biodiesel in a compression ignition engine. TIDE 1998;8(3):191–204.
[8] A.S. Ramadhas et.al Diesel fuel alternative from vegetable oils. Chem. EngngWorld 1997;32(10):77–80.
[9] V.S. Hariharan et.al The effects of vegetable oil properties on Injection and combustion in two different diesel engines. J. Am. Oil Chem. Soc.1984; 61(10):1610–9.
[10] B. Premanand et.al Laboratory endurance test of a sunflower oil blend in a diesel engine.J. Am. Oil Chem. Soc. 1983;60(8):1567–73. Sudipta
[11] N Usta.et al. 2010 Emission and Performance Characteristics of Karanja Biodiesel and its blends in C.I. Engine and it's economics. Vol.5 No2 Feb.2010, ARPN Journal of Engineering and Applied Sciences.
[12] H.Raheman and A.G. Phadatareet al., Emissions and Performance of Diesel Engine from Blends of Karaja Methyl Ester) Biodiesel and Diesel.
[13] Nitin Shrivastavaet al., 2012, A comparative study of the behavior of biodiesels of different origins on the diesel engine performance and emission. IRACST Vol-2 No.4 August 2012 Page 766-770
[14] Subramanian, K.A., Singal, S.K., Saxena, M., Singhal, S., Utilization of liquid biofuels in automotive diesel engines, Biomass and Bioenergy, 2005; 29:65-72.
[15] Azam A.M., and Nahar N. M., Prospects and potential of fatty acid methyl esters of some non-traditional seed ois for use as biodiesel in India. Biomass and Bioenergy. 2005; 29:293-302.
[16] Saucedo E. Biodiesel. Ingeniera Quimica 2001; 20:19-29.
[17] TiwariS, Saxena M, Tiwari SK "Mahua oil based resins for the high-temperature curing of fly ash coatings". Journal of applied polymer Science. 2003; 87(2):110-120.
[18] Germplasm Resources Information Network. United States Department of Agriculture. 2006-01-31. Australia: Commonwealth Scientific

