PERFORMANCE & EMISSION CHARACTERSTICS OF KARANJA BIODIESEL

Swarup Chandran

Student, Dept. of Mechanical Engineering, SRM University, Tamil nadu, India

---

ABSTRACT: *Fuels derived from crops popularly known as 'BIODIESEL' are renewable and better alternative to petroleum fuels. They are mono alkyl esters of long chain fatty acids derived from vegetable oils and animals fats. They are produced by transesterification in which oil or fat is reacted with an alcohol in presence of catalyst.In this review paper, the performance and emission characteristics of Karanja oil has been discussed. Diesel and Karanja oil blends of different proportions were used to conduct short term engine performance and emission test. Specific fuel consumption, brake thermal efficiency and emissions were measured to evaluate and compute the behaviour of the engine running on Karanja oil. In this investigation, the viscosity of Karanja oil for the CI engine was decreased by blending with diesel. Significant improvement in the engine performance was observed compared to neat Karanja oil as a fuel.*

1. INTRODUCTION

The Earth's limited reserves of fossil fuel have been a matter of global concern as these are under threat of depletion due to over-exploitation. Currently, the combustion of fossil fuels is the dominant global source of CO_2 emissions. These factors have led to the global search of renewable resources. Although majority of the renewable energy technologies are more eco-friendly than conventional energy options, their adoption is very slow.

The advantages of fossil fuels are:

1. **Easily available -** The easy availability of fossil fuels is the major advantage of its usage.
2. **Produce large amount of energy-** Fossil fuels are easily combustible. Most combustion engines are powered with little amount of fuel and they can produce large amount of energy.
3. **High Calorific Value-** Fossil fuels are the highest producers of calorific value in terms of energy.
4. **Low cost**– Fossil fuels are easily available all over the world and the methods to extract energy from them are not that expensive.

The major drawbacks of fossil fuels are:

1. **Environmental Hazards-** Environmental pollution is one of the major disadvantage of fossil fuels. When fossil fuels are burnt, carbon dioxide gas is released , which is a primary gas responsible for global warming.
2. **Acid Rain-** Sulphur dioxide is one of the pollutant that is released when fossil fuels are burnt and it is the main cause of acid rain.
3. **Effect on human health-** Pollution due to combustion of fossil fuels can cause serious health hazards. Pollution related diseases range from mild to severe such as asthama, chronic obstructive pulmonary disorder(COPD) and lung cancer.
4. **Non-renewable-** Since fossil fuels are being extracted at an alarming rate, it is estimated that the fossil fuels will get depleted in the next 30-40 years.

Hence, in order to curb the effects of the above mentioned drawbacks, renewable energy sources are used. According to the recent trend, straight vegetable oils(SVOs) have been tested in diesel engines. These oils are blended with diesel in different proportions(20%,40%,60%,80% of diesel content) and its performance charactersitics are studied. The relatively high viscosities of these oils cause problems such as choking of injectors, oil ring sticking and thickening of lubricating oil. Due to incomplete combustion, partially burnt vegetable oil runs down the cylinder walls and dilutes the lubricating oil. Despite the above mentioned limitations of SVOs,it could be possible to use them for low-end applications such as energizing the single cylinder diesel engines[1]. Experiments conducted at various institutes have concluded that engines running on neat SVOs with the integration of above mentioned additional sub system could perform effectively for around 250 hr. It has been reported that when direct injection engines are run with neat vegetable oil as fuel injectors get choked-up after few hours and lead to poor fuel atomization, less efficient combustion and dilution lubricating oil by partially burnt vegetable oil.[2]

2. PRODUCTION OF KARANJA BIODIESEL

Biodiesel is derived from vegetable oils which are renewable and can be produced locally. Although vegetable oil has a high calorific value compared to a diesel fuel, its high viscosity and low volatility prohibits it to have a complete combustion process and hence produces various atmospheric emissions. Different ways to reduce viscosity includes dilution, microemulsion, pyrolysis, catalytic cracking and transestrification. Because of its simplicity and the importance of glycerol which is a byproduct obtained, transestrification is the most preferred[3]. Transestrification reduces the viscosity of the oil without affecting the calorific value of the original fuel. It consists of series of reversible reactions[4]. In its initial step the triglycerides are converted to dilyceridesand in the subsequent step the diglyceride is converted to monoglyceride and then to glycerol. Transestrification ,also called as alcoholysis, is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis. In present condition the Karanja oil has been used as a raw material for the production of biodiesel and in the first step oil was extracted from the seeds of Karanja tree by a mechanical expeller at room temperature. The molecular weight has been found out to be 892.7. The viscosity of raw oil was measured to be 27.84cSt at 313K. By the process of acid esterification the acidic value of the oil is reduced in order to have a better yield[1,4]. This process consists of heating of the oil with 1ml H_2SO_4 at 318K for half an hour. After this the product is transferred to a separating funnel where the excess alcohol and impurities are removed since they get accumulated at the top. Acid esterification is followed by alkaline esterification where the product of the latter esterification is preheated to temperature of 318K. NaOH is added as a catalyst in methanol and then heated for about half an hour. The product is poured into a separating funnel and allowed to settle overnight. The Karanja oil methyl ester floats at the top and the impurities along with glycerol settles down which can be drained off easily. The oil is then washed thoroughly with hot distilled water thrice to remove the catalyst and obtain the pure oil.

TABLE 1. VALUES OF PROPERTIES OF KARANJA OIL

PROPERTY	UNIT	VALUE
Colour	-	Yellow
Density	gm/cc	0.860
Viscosity	mm^2/sec	40.2
Boiling Point	^0C	316
Calorific value	Kcal/KG	3700
Cetane number	Number	41.7

Thus the final product which is obtained can be termed as the freshly prepared biodiesel. With variations in the catalyst used we can obtain various concentrations of oil. KOH is also used as a catalyst but the yield obtained is less. When the product of alkaline esterification is washed the Na+ ions forms soap with water molecules and settles at the base of the separating funnel so that they can be removed easily. Hence the biodiesel so formed is free of catalyst and pure diesel oil is obtained. This result is in accordance with work done by Leung and Guo.[5].

Sometimes the extent of esterification is to a target cetane number according to the correlation:

Cetane number after esterification =
(cetane number of the unprocessed fuel) + Zx(%esters)
Where Z is a constant

TABLE 2. FATTY ACID COMPOSITION OF KARANJA OIL

Karanja oil is found to have the following fatty acid composition: [6]

Fatty Acids	Composition(Percentage)
Palmitic Acid (Hexadecanoic)- C16	3.7 – 7.9
Stearic Acid (n-octadecanoic) – C18	2.4 – 8.9
Oleic acid (C18:1)	44.5 - 71.3
Linoleic acid (C18:2)	10.8 – 18.3
Arachidic acid (C 20)	2.2 – 4.7
Any special fatty acid	Behenic acid: 4.2 – 5.3

3. ANALYSIS OF PERFORMANCE AND EMISSION CHARACTERISTICS

Brake Thermal Efficiency-

Brake Thermal Efficiency is defined as the ratio of the heat equivalent of the brake output to the heat supplied to the engine.

It is observed that as the load increases, brake thermal efficiency increases upto 70% load and then decreases . The brake thermal efficiency decreases with decrease in diesel blend due to low HHV (higher heating values) and increase in fuel consumption. Further it was noted that the brake thermal efficiency for B40 was almost equal to that of diesel.

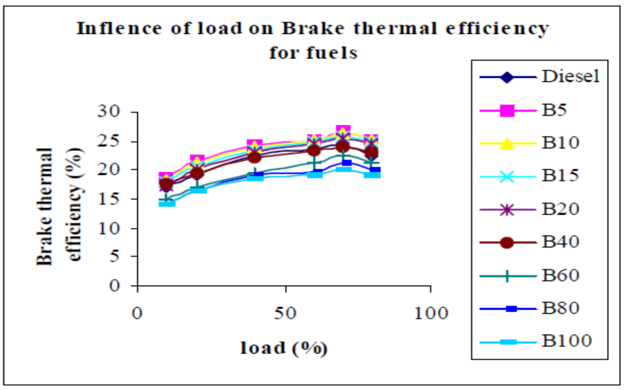

CHART 1 : Brake Thermal Efficiency for different diesel blends

Brake Specific Fuel Consumption-

Brake Specific Fuel Consumption is a measure of the fuel efficiency of any prime mover that burns fuel and produces power. It is the rate of fuel consumption divided by the power produced. BSFC decreases to minimum till 70% load and then increases. The BSFC continuously increases as the amount of Karanja oil in the fuel blend increases. However, the specific fuel consumption for biodiesel is less than the SFC for diesel. The specific fuel consumption for B5, B10, B15 and B20 are almost equal to that of diesel.

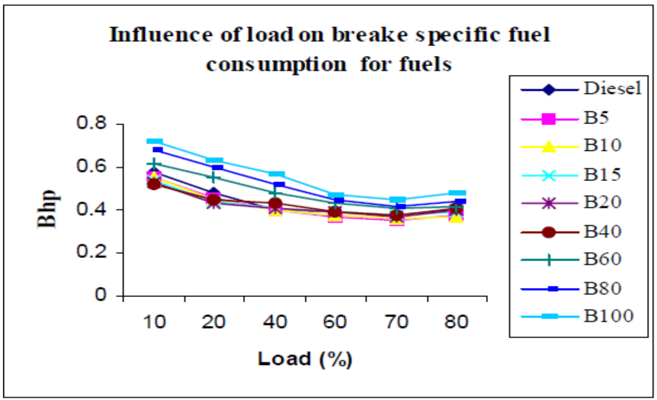

CHART 2 : Brake specific fuel consumption for different diesel blends

CO Emission-

It is observed that the CO emission of diesel at full load is 0.11%, whereas that of biodiesel is 0.16%. However, the emissions are lower for blends as compared to biodiesel. The emission decreases with increase in the diesel content in the blend. Moreover, CO emissions are increased with increase in engine load.

CO_2 Emission-

It is observed that the CO_2 emission increases with the increase of load conditions. Moreover, the amount of CO_2 emitted decreases with increase in the diesel content in the fuel blend.

NO_x Emission-

The NO_x values as parts per million for different blends of diesel and biodiesel in exhaust emission are plotted as function of load. It is observed that the increasing portion of biodiesel (Karanja oil)in the blend increases NO_x emissions by 5-10 % as compared with that of pure diesel. It is due to the increased exhaust temperatures and the presence of oxygen content which facilitates NO_xformation.

Hydrocarbon Emissions(HC)-

At higher engine speeds and loads,it was observed that total hydrocarbon emissions of Karanja biodiesel blends were found to be lower than mineral diesel.This may be due to better combustion of Karanja oil ,with better mixture formation of air and it,due to improved swirl motion of air and it was about 6% reduction in THC. Total hydrocarbon emissions for all tests fuels were higher at lower engine loads and quantity of THC emissions decreased with increasing engine load.

Smoke Emission-

Smoke content in exhaust is a qualitative indicator of amount of larger diameter particulates, which are large enough to scatter the incident light. It was observed that at lower engine loads for all tests fuels, smoke capacity was almost identical at all engines speeds . At higher engine loads, smoke capacity decreased with concertration of Karanja biodiesel in the test fuel, indicating that Karanja biodiesel was helpful in reducing particulate emissions.The significant reduction in smoke may be due to the presence of oxygen in biodiesel blend.

4. COMPARATIVE ANALYSIS OF KARANJA AND JATROPHA BIODISEL

To conduct the comparative analysis of Karanja and jatropha biodiesel, tests were performed in a single cylinder diesel engine at different engine loads.

Brake thermal efficiency-

It was found that the trend of variation of BTE of JB50 and KB50 blends was similar to that of D100. The BTE of the blends was found to be lower than that of mineral diesel. The BTE for KB50 was found to be lower than JB50 due to poor atomisation and combustion quality as a result of low volatility, higher viscosity and higher density of Karanja biodiesel.

Brake specific fuel consumption-

Test blends of JB50 and KB50 exhibit slightly higher BSFCs compared to D100 due to lower density and calorific value. Out of the tested fuels, KB50 shows lowest BSFC due to its lower calorific value and density.

Hydrocarbon emission-

All fuels exhibit higher emissions at higher engine load due to less oxygen available for reaction during injection of fuel at higher engine load. Of the biodiesels tested, HC emission values were 62 and 54 ppm for JB50 and KB50 respectively, as compared to 42.3 ppm with D100 at 80% load.

Carbon monoxide emission-

CO emission indicates incomplete combustion of fuel inside the engine cylinder, which occurs when the flame front approaches fissure volume and a relatively cool cylinder liner. It was observed that the Carbon monoxide values were 0.418% and 0.153% for JB50 and KB50 respectively as compared to 0.1138% for D100 at 80% load.

NO emissions-

NO emission is high due to high temperature and equivalent ratio. Lower NO emissions were observed for JB50 and KB50 as compared to D100. During the premixed combustion phase, heat release rates of biodiesel were lower which would lead to lower peak temperature. NO emissions were found to be 935 and 952 ppm for JB50 and KB50 respectively, compared to 972 ppm for D100 at 80% engine load.

4. CONCLUSION

The study conducted by P.K. Srivastava and Madhumita Verma [9] shows that methyl ester of Karanja oil have slightly lower thermal efficiency compared to diesel. The brake specific fuel consumption of methyl ester of Karanja oil is slightly higher compared to diesel. The exhaust gas temperature of methyl ester is higher than diesel. HC, CO and NO emissions of the Karanja oil methyl ester are higher than diesel. It appears that the properties of Karanja biodiesel are very close to that of diesel. Hence, it can be concluded that methyl ester of Karanja oil can be used as an alternative fuel.

Moreover, the study conducted by Singh, Y and Singla, A [8] concludes the following facts-

1. The brake thermal efficiency of JB50 and KB50 was lower than D100.

2. The HC and CO emissions of JB50 and KB50 was found to be higher than that of D100.

3. NO emissions of KB50 and JB50 was found to be lower than D100.

5. REFERENCES

[1]. S. Bajpai, P.K. Sahoo, L.M. Das; Feasibility of blending Karanja vegetable oil in petrol-diesel and utilization in a direct injection diesel engine.

[2]. Ma F. Hanna MA. Biodiesel Production: a review. Bioresource Technol 1999;70:1-15.

[3]. Y.C. Sharma, B. Singh; Development of Biodiesel from Karanja2007

[4]. Canacki M. Erdil A. Arcaklioglu E. Appl Energy 2006;83:59

[5]. Leung DYC, Guo Y. Fuel Process Technol 2006;87:883

[6]. www.chempro.in/fattyacid.htm.

[7] N. Stalin and H. J. Prabhu; Performance Test Of IC Engine Using Karanja Biodiesel Blending With Diesel.

[8] Singh,Y. and Singla, A.; Comparative analysis of jatropha and based biodiesel properties, performance and exhaust emission characteristics in an unmodified diesel engine.

[9] P.K. Srivastava and Madhumita Verma; Methyl ester of Karanja oil as an alternative renewable source energy.