A Comparative study of the Behaviour of Biodiesels of Different origins on the Diesel Engine Performance and Emission

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***Abstract*— as the fossil fuels are depleting day by day, there is a need to find out an alternative fuel to fulfill the energy demand of the world. Biodiesel is one of the best available sources to fulfill the energy demand of the world. In the Present investigation a comparative study has been carried out to examine the Performance parameters and exhaust emission of a diesel engine fuelled with Biodiesel of two non edible oil sources. Tests have been carried out in four cylinder direct injection diesel engine with different loading conditions. Performance parameters investigated are Brake thermal efficiency, Brake specific fuel consumption (BSFC) and Brake specific Energy consumption (BSEC), the emission parameters investigated are CO, HC, NOx, and smoke. Results showed almost similar performance and emission behavior of both the Biodiesels irrespective of their origin.**

Keywords- Biodiesel; performance; Emission; Jatropha; Karanja; Transesterification.

I. INTRODUCTION

Increasing concerns have caused an intensified search for alternative sources of energy. These concerns include feedstock availability as related to the security of the supply and using domestic energy sources, price volatility and continuing depletion of the reserves of non-renewable petroleum and greenhouse gas emissions. These concerns have been addressed by a variety of legislative and regulatory mandates and incentives around the world.

Biodiesel is the fuel made up of alcohol esters derived from oils and fats from renewable biological sources. This new fuel emits far less of the most regulated pollutants than standard diesel fuel. Biodiesel is defined as the mono-alkyl esters of vegetable oils or animal fats, obtained by transesterification of an oil or fat with an alcohol. The reason for not using a neat vegetable oil as fuel is its high viscosity, which leads to problems in diesel engine including formation of deposits and injector coking due to poorer atomization upon injection into the combustion chamber. Transesterification of the oil reduces the viscosity of the oil to the range closer to that of Diesel fuel[1].

Some researchers reported that the performance of the diesel engine operated with the Biodiesel fuel is almost similar with that of Diesel fuel. The efficiency is found similar or better compared to the diesel fuel. The carbon monoxide, Hydrocarbon and smoke emission observed with the biodiesel is lesser than the Diesel fuel. The NOx emission is found to be higher for the Biodiesel fuel [2-6].

In the present investigation, biodiesel was prepared from Jatropha and Karanja oils. These oils are widely available in India. Furthermore the use of non-edible vegetable oils is of importance because of the great need for edible oil as food. The main objective of this experimental study is to compare the performance and exhaust emission parameter while using Jatropha and Karanja Biodiesel as a fuel in a DI diesel engine. The results for JOME (Jatropha oil methyl ester) and Karanja oil methyl ester (KOME) were compared with those for diesel fuel.

II. FUEL AND PREPARATION

A. *Jatropha Oil*

The genus name Jatropha derives from the Greek word jatr´os (doctor) and troph´e (food), which implies medicinal uses. The first commercial applications of Jatropha were reported from Lisbon, where the oil imported from Cape Verde was used for soap production and for lamps. Jatropha is a small tree or large shrub, which can reach a height of three to five meters, but under favorable conditions it can attain a height of 8 or 10m. The plant shows articulated growth, with a morphological discontinuity at each increment [7].

Jatropha plant bears fruits from second year of its plantation and the economic yield stabilizers from fourth and fifth year onwards. The plant has an average life with effective yield up to 50 years. Jatropha gives about 2 kg of seed per plant in relatively poor soils. The seed yields have been reported as 0.75–1.00 kg per plants thus the economic yield can be considered to range between 0.75 and 2.00 kg/plant and 4.00 and 6.00 MT per hectare per year depending on agro-climatic zone and agriculture practices. One hectare of plantation on average soil will give 1.6 MT oil [8]

There are several advantages with Jatropha. Firstly, it is easier to harvest than large tree and has much shorter gestation period. Secondly, the seed collection period of Jatropha does not coincide with the rainy season in June–July, when most agricultural activities takes place. This makes it possible for people to generate additional income in the slack agricultural season. Thirdly, it is resistant to common pests and not consumed by the cattle. Fourthly, the by-products of biodiesel are also quite useful as bio fertilizer and glycerin. Fifthly, it require very few nutrients to survive and therefore can be grown on less fertile land. [9]. In addition to being a source of oil, Jatropha also provides a meal that serves as a highly nutritious and economic protein supplement in animal feed, if the toxins are removed [10].

B. *Karnja Oil*

Karanja is amongst the number of non edible seed sources available for the production of Biodiesel. Karanja is believed to be originated in India and distributed throughout the country from the Ravi river eastward in the hills of south India up to the elevation of about 1200 meters and in the Himalayas up to about 610 meters. It is widely grown from tropical dry to sub tropical dry forest life zones. It is a widely adaptable tree that grows under the wide range of temperature from 5^0 C to 50^0 C and average rainfall of 600 to 2500 mm [11]. The production potential of Karanja is 70000 metric tons annually [12].

C. *Production of Biodiesel*

The production of Biodiesel from Jatropha and Karanja oils involves the heating the 10 liters oil at 60 degree in a reactor with a capacity of 10 liters. A mixture of 40 percent methanol and 0.75 percent potassium hydroxide is added to the oil and stir for 1.3 hours. It than allowed to settle the two distinct layers of Biodiesel (Jatropha/Karanja oil Methyl ester) and Glycerol. Once the heavy black glycerol layer was settled down, the methyl ester layer formed at the upper part of the reactor. Glycerol followed by JOME/KOME separated from the bottom part of the reactor through a valve. After that, a gentle washing process was carried out to remove some un reacted remainder of methanol and catalyst using heated distilled water, which if not removed can react, and damage storing and fuel carrying parts. After washing two distinct layer formed with bottom layer having water and impurities settled down and removed. The upper layer is of biodiesel. A heating process at about 60^0C was applied for removing water contained in the Biodiesel and finally, left to cool down.

D. *Fuel Properties*

The Fuel properties were determined and listed in the table-1.

TABLE I. FUEL PROPERTIES

Properties	Test Method	Diesel	JOME	KOME
Kinematic viscosity @40^0 C, cSt	D445	2.4	5.8	5.5
Density@15^0c, kg/m3	D1298	822.4	893.2	891.8
Flash Point, ^{0}C	D93	67	167	136
Net Calorific Value, MJ/kg	D240	42.7	38.92	37.58
Water &sediments % volume	D2709	0.01	0.02	0.02
Sulfer, %wt	D4294	0.28	Nil	Nil

TABLE II. ENGINE SPECIFICATION

Make	Force motors
Cylinder Number and Type	Four and Four Stroke
Rated Power (H.P.)	27
Rated speed	2200 rpm.
Bore(mm)	78
Stroke(mm)	95
Compression Ratio	18.65:1

III. EXPERIMENTAL SET UP AND TEST METHODOLOGY

The experimental setup shown in Figure 1 consists of a four cylinders, four stroke, naturally aspirated diesel engine, an engine test bed with hydraulic dynamometer. The specifications of the test engine are given in Table 2. The test bed contains instruments for measuring various parameters such as engine load, air flow by anemometer, gas temperatures by K type thermocouples. The fuel consumption was determined by weighing the fuel on an electronic scale. For the analysis of the exhaust gases, Eurotron green line gas analyzer and AVL 437 smoke meter was used.

The engine was allowed to reach its steady state by running it for about 10 minutes. The engine was sufficiently warmed up and stabilized before taking all readings. After the engine reached the stabilized working condition, the load applied, fuel consumption, brake power and exhaust temperature were measured, the values were recorded thrice and a mean of these was taken for comparison. The engine performance and Exhaust emissions were studied at different loads. The brake specific fuel consumption, brake specific energy consumption and thermal efficiency were calculated. The emissions such as CO, HC, and NOx were measured using exhaust gas analyzer and smoke with smoke meter. These performance and emission characteristics for different fuels are compared with the result of baseline diesel.

Figure 1. Experimental set up

IV. RESULT AND DISCUSSION

The test fuels used during this study were Jatropha Biodiesel, Karanja Biodiesel and neat diesel fuel. Experiments were conducted at a constant speed of 2000 rpm and by varying the loads.

A. Brake specific fuel consumption

The percentage change of Brake specific fuel consumption (BSFC) of the two biodiesels in comparison to neat diesel fuel with BMEP is presented in the Fig. 2. Both the Biodiesel showed increased fuel consumption compared to diesel fuel. JOME and KOME showed an average 21.1 and 27.7 percent increased fuel consumption while compared with the BSFC of neat Diesel fuel. This may be attributed to the lower calorific value of the Biodiesels.

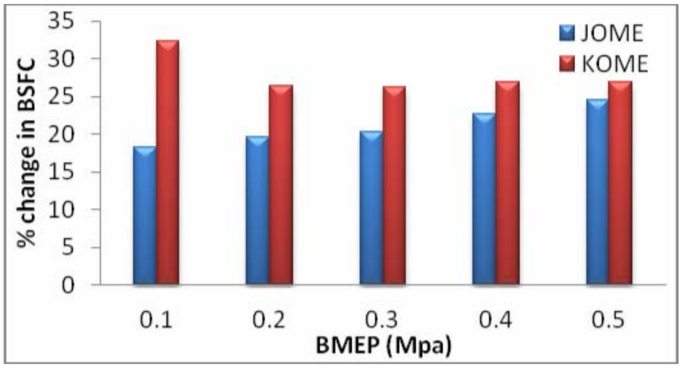

Figure 2. Percentage change of BSFC with Diesel Fuel

B. Brake specificEnergy consumption

The percentage change of Brake specific Energy Consumption (BSEC) of the two biodiesels in comparison to neat diesel fuel with BMEP is presented in the Fig. 3. Both the Biodiesel showed approximately same energy consumption, and increased energy consumption compared to diesel fuel. JOME and KOME showed an average 10.4 and 12.4 percent increased energy consumption compared to the neat Diesel fuel.

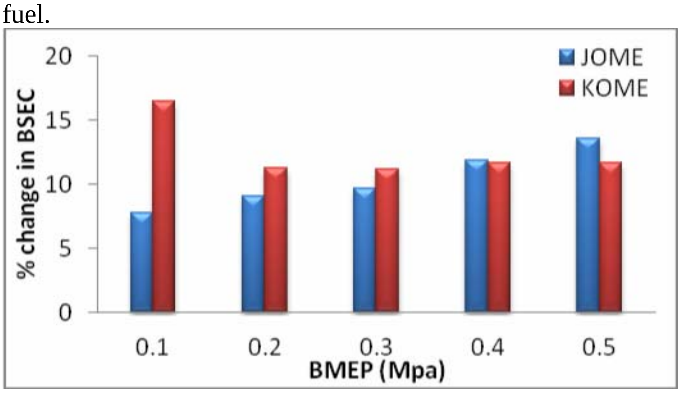

Figure 3. Percentage change of BSEC with Diesel Fuel

C. Brake Thermal efficiency

Figure 4 shows the percentage change of Brake thermal efficiency (BTE) of biodiesels compared to diesel with the BMEP. JOME and KOME both showed reduced thermal efficiency compared to diesel fuel. JOME showed an average 9.4 percent and KOME showed an average 11 percent reduced thermal efficiency.

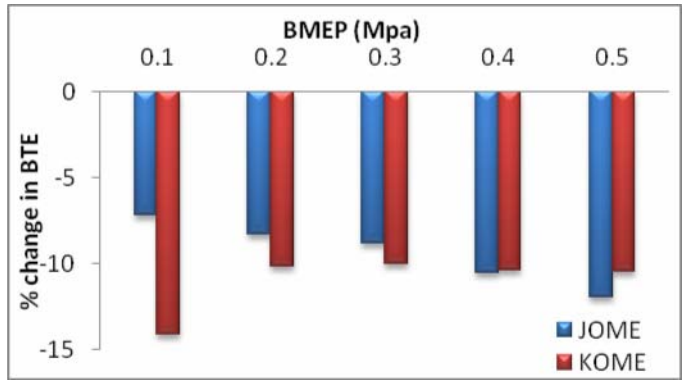

Figure 4. Percentage change of BTE with Diesel Fuel

D. Exhaust gas temperature

Figure 5 presents the change in the exhaust gas temperature of the Biodiesel in comparison to Diesel fuel. JOME and KOME showed an average 16.4 and 15.2 percent increase in temperature compared to Diesel fuel. This may be attributed to the oxygen molecules present in the Biodiesel increasing the combustion chamber temperature.

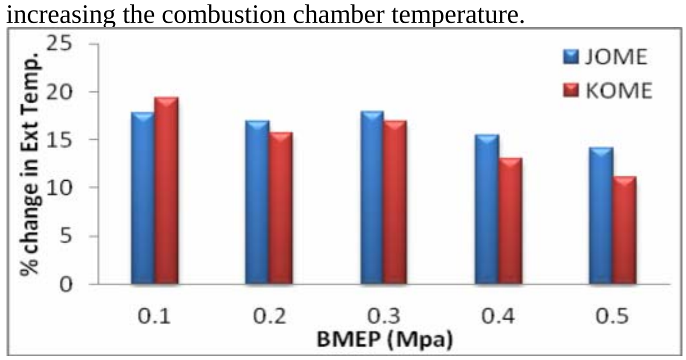

Figure 5. Percentage change of Exhaust gas Temperature with Diesel Fuel

E. Carbon monoxide Emission

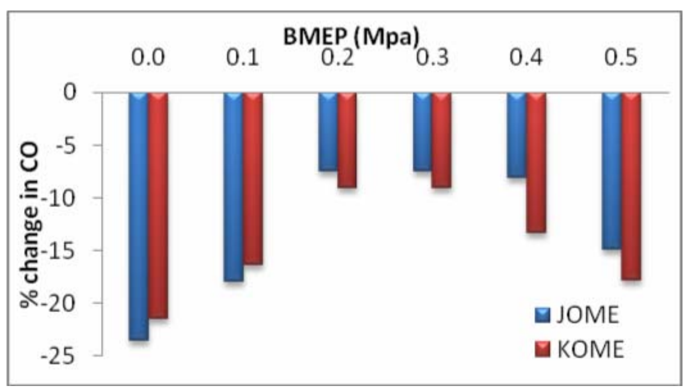

Figure 6. Percentage change of CO Emission with Diesel Fuel

The percentage change of Carbon monoxide (CO) Emission of the two biodiesels in comparison to neat diesel fuel with the BMEP is shown in the Fig. 6. CO Emission of Biodiesel was found to reduce with the Biodiesel. this may be due to the oxygen molecules of Biodiesel promoting the complete combustion. The JOME and KOME showed an average 13.2 and 14.5 percent reduction in CO Emission in comparison to neat Diesel fuel.

F. *Unburned Hydrocarbon Emission*

Figure 7 shows the percentage change of unburned hydrocarbon (HC) emission of biodiesels compared to diesel with the BMEP. JOME and KOME both showed reduced CO emission compared to diesel fuel. JOME showed an average 16.9 percent and KOME showed an average 14.8 percent reduced thermal efficiency. The lower HC emission of Biodiesel is the indicator of clean combustion which may be the result of increased Exhaust gas temperature.

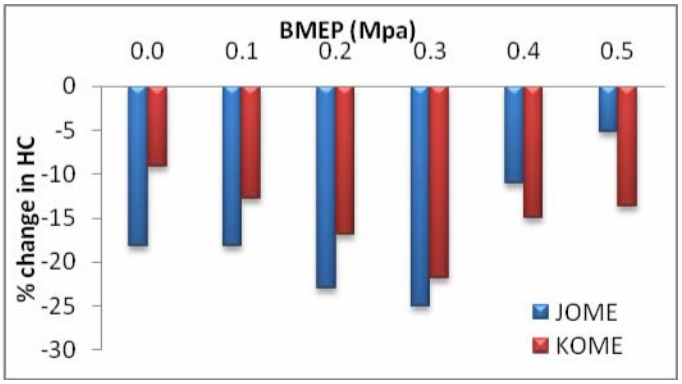

Figure 7. Percentage change of HC Emission with Diesel Fuel

G. *Nitrogen oxide Emission*

The result of percentage change in Nitrogen Oxides (NOx) emission of Biodiesel in comparison to neat Diesel fuel is presented in Fig, 8. The NOx emission of Both the Biodiesel were found to higher than the Diesel fuel. JOME and KOME reported an average 19.6 and 18.1 percent increased emission compared to diesel fuel. This may be attributed to the higher exhaust gas temperature resulting in increasing thermal NOx.

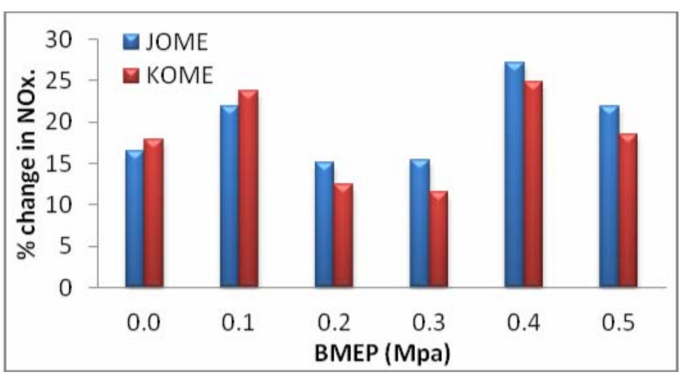

Figure 8. Percentage change of NOx Emission with Diesel Fuel

H. *Smoke Emission*

Figure 9 present the percentage change of Smoke emission of the biodiesels studied compared to diesel fuel. Smoke emission was found initially higher at no load condition and reduced when load is applied. Both the biodiesel JOME and KOME reported an average 9.8 and 11.8 percent reduced smoke emission compared to neat diesel fuel. This may be due to the oxygen content of the biodiesel molecules, which enables more complete combustion even in regions of the combustion chamber with fuel-rich diffusion flames, and promotes the oxidation of the already formed soot [13-15].

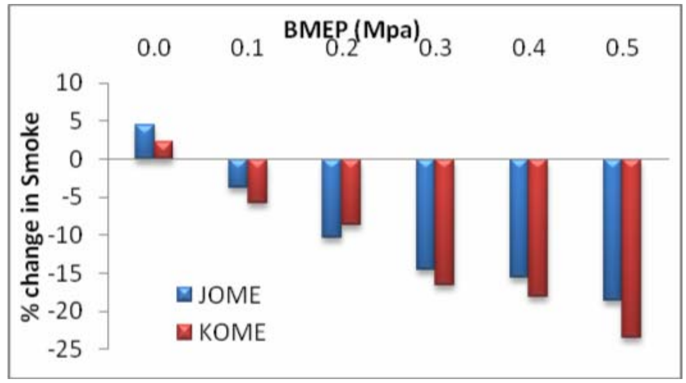

Figure 9. Percentage change of Smoke Emission with Diesel Fuel

V. CONCLUSION

Based on the study on the two Biodiesels JOME and KOME, the main result of performance and emission parameters are summarized as follows.

- Biodiesels of different origin reported almost similar performance in the Diesel engine.
- Higher BSFC, BSEC and lower thermal efficiency was found for both the biodiesels.
- Thermal efficiency was lower
- The emission of both the Biodiesels showed reduction in Co, HC and smoke emissions where as NOx emission was found higher compared to diesel.

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