Effect of Karanja oil as fuel on performance and emission characteristics of four stroke single cylinder diesel engine.

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Abstract : In this paper, we performed a test on four-stroke single-cylinder diesel engine with eddy current dynamometer. The exhaustible fossil based fuel and its negative impact on the environment, when used in diesel engine has stimulated to search for an alternative source of energy. In this regard, Karanja oil seems quite viable solution, as it is renewable and environmental benign. From the last three decades scientists and researchers all over the world have contributed methods to utilize efficiently bio-origin resources. Experimental investigation on use of biodiesel prepared from vegetable oil in diesel engine also seemed successful and encouraging. *Index Terms* – Bio-diesel, Vegetable oil, Emission.

I. INTRODUCTION

Today, diesel engines are used worldwide for transportation, manufacturing, power generation, construction, and farming. The types of diesel engines are as varied as their use – from small, high-speed indirect-injection engines to low-speed direct-injection behemoths with cylinders one meter (three feet) in diameter. Their success comes from their efficiency, economy, and reliability.

India is one of the fastest growing economies in the world and will continue to enjoy the demographic dividend for few decades. Energy is a critical input towards raising the standard of living of citizens. As the population increases daily, the demand for energy to meet different lifestyle requirements increase as well. However, conventional or fossil fuel resources are limited, non-renewable, polluting and, therefore, need to be used prudently. These sources are going to deplete in near future and cannot be used for around 10-20 centuries. Diesel is one of the most widely used product of fossil fuel. The crude oil price has been fluctuating in the world market. Such fluctuations are straining various economies the world over, particularly those of the developing countries. Road transport sector accounts for 6.7% of India's Gross Domestic Product (GDP). Currently, diesel alone meets an estimated 72% of transportation fuel demand followed by petrol at 23% and balance by other fuels such as CNG, LPG etc. for which the demand has been steadily rising. Provisional estimates have indicated that crude oil required for indigenous consumption of petroleum products in FY 2017-18 is about 210 MMT. The domestic crude oil production can meet only about 17.9% of the demand, while the rest is met from imported crude. India's energy security will remain vulnerable until alternative fuels to substitute/supplement petro-based fuels are developed based on indigenously produced renewable feedstock.

Experiments study shows that, Navindgi M. C. et al. [2] have carried an investigation with non-edible straight vegetable oils of Neem, Mahua, Linseed and Castor oil on a C.I. Engine and concluded that these neat oils with preheating can be substituted as fuel for diesel engine. Rampure P. B. et al. [3] have tested non-edible Rice bran oil in a diesel engine and found that by using rice bran oil the engine runs on without any problem, the nozzle orifices were not clogged and no major carbon deposits were observed on the combustion chamber. Acharya S. K. et al. [4] have tested Kusum oil as fuel for small horse power diesel engine and concluded that the preheated oil's performance was slightly inferior in efficiency but pollution point of view it can perform well for the unmodified engine for a long period of operation without any ignition problem. The Use of Vegetable oils results in increased volumetric fuel consumption and BSFC [5]-[7]. Some fuels can be used directly to the engine while others need to be formulated to bring it to the relevant properties close to conventional fuels [8], [9].

Avinash Kumar Agrawal and K. Rajamanmohan [13], conducted experimental investigation of performance and emission of karanja oil and its blend(10%,20%,50% and 75%) visa-vis mineral diesel in a single cylinder agricultural diesel engine. In this study physical and thermal properties of karanja oil were evaluated. Author conducted two set of experiment, one set for unheated and second for preheated fuel samples. Without preheating set of experimentation shows higher brake thermal efficiency except B100 and BSFC up to 50% was lower than diesel .pre-heating set of experimentation shows higher brake thermal efficiency and lower BSFC for all blends as compared with diesel fuel. BSFC for unheated and heated karanja oil were lower and exhaust gas temperature was generally higher than diesel for all blends. NOx emission was found to be less as compared with diesel for both set oil.

II. THEORETICAL BACKGROUND

2.1 Karanja Oil:

Karanja oil is derives from the seeds of Pongamia pinnata tree, is common throughout India. Karanja is a legume tree that grown to about 15-25 meters in height with a large canopy which spreads equally wide. Flowering starts generally after 3- 4 years. Cropping of brown seed pods and single almond sized seeds can occur by 4- 6 years. The tree grows wild on sandy and rocky soils withstanding a temperature between 00C up to about 500C with a humid and subtropical climate. Each fruit contains 1-2 red kernels and the yield of kernels per tree is reported between 8 to 24kg. The oil content is 30% to 40%. Karanja oil is toxic and having disagreeable taste and odor due to flavonoid constituents. Oil made from the seeds has been used as lamp oil, in soap making, and as a lubricant.

2.2 Production of Bio-diesel:

Biodiesel covers a variety of materials made from vegetable oils, recycled cooking greases or oils, or animal fats. The definition of the term "biodiesel" is "a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100".

In production of biodiesel main raw material required is feedstock. Common Feed stocks are Canola, Cottonseed, Peanut, Olive, Rice, Bran, Soybean, Sunflower, Palm, Cocoa, Butter, Rapeseed, Mustard, Coconut, Kernel, Jatropha, Pig, Beef, Sheep, Chicken, Turkey, Lard, Tallow, Yellow Grease (Yellow grease is a product from rendering plants, as well as waste oils and greases from restaurants). In this paper, Karanja is considered as raw material.

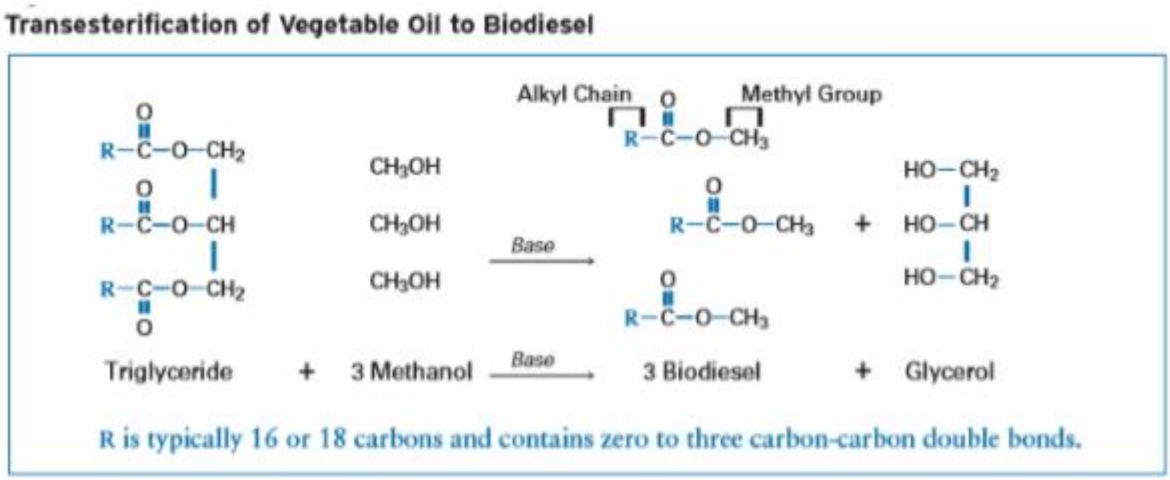

Fig 1. Transesterification of vegetable oil

In a process known as transesterification, triglycerides react in the presence of a base chemical (sodium or potassium hydroxide) with an alcohol, usually methanol, resulting in three fatty acids bonded to the methyl group from methanol. . These chemicals are referred to as fatty acid methyl esters (FAME) with alkyl chain lengths of 12 to 22 carbons. Water, base chemical, unreacted triglycerides and alcohol, and glycerine are by-products of the transesterification reaction and must be removed from biodiesel fuel. The glycerine – also called glycerol – is purified and has uses in the cosmetic, food and other industries, and as an animal feed stock.8, 9 Biodiesel has chemical and physical properties similar to those of conventional diesel fuel. Table 1 represents the comparison of different properties of Karanja vegetable oil with its bio-diesel.

Table 1 Properties of Karanja oil and its bio-diesel

Sr. No.	Property	Unit	Karanja Oil	Bio-diesel
1	Density	Gm/cc	.926	.905
2	Viscosity	Cst	41	9.2
3	Flash Point	ºC	227	130
4	Calorific value	kJ/kg	30000	36000

Table 2 represents the comparison of different properties of diesel with Karanja bio diesel and its blends.

Table 2 Properties of different fuel blends

Fuel blend	Calorific Value (MJ/kg)	Flash Point (ºC)	Fire Point (ºC)	Viscosity (Cst) at 40 ºC	Specific gravity
Diesel	43	64	75	2.9	0.822
Karanja Bio-diesel	36	130	210	10	0.914
5% Karanja blend	42.9	75	85	3.2	0.855
10% Karanja blend	42.8	83	93	4.1	0.869
15% Karanja blend	41.9	92	102	4.5	0.882

III. EXPERIMENTAL SET-UP

This is a single cylinder vertical diesel engine is coupled to a rope pulley break arrangement to absorb the power produced. Necessary weights and spring balances are included to apply load on the break drum. Suitable cooling water arrangement for the break drum is provided. Separate cooling water lines are provided for the engine cooling. Thermocouples are provided for measuring temperature.

Fig 2 Experimental Set-up

A fuel measuring system consists of a fuel tank mounted on a stand, burette, and a 3-way cock. Air consumption is measured by using a M.S. tank, which is fitted with a standard orifice and a U-tube water manometer that measures the pressures inside the tank. Engine specifications are mentioned in following table.

Table 3.1 Engine Specifications

Engine Type	4-Stroke, 1-Cylinder
Fuel	Diesel
Bore	80 mm
Stroke	100 mm
Rated Power	3.7 kW
Rated Speed	1500
Method of loading	Rope brake

IV. RESULTS AND DISCUSSION

4.1 Brake Thermal Efficiency:

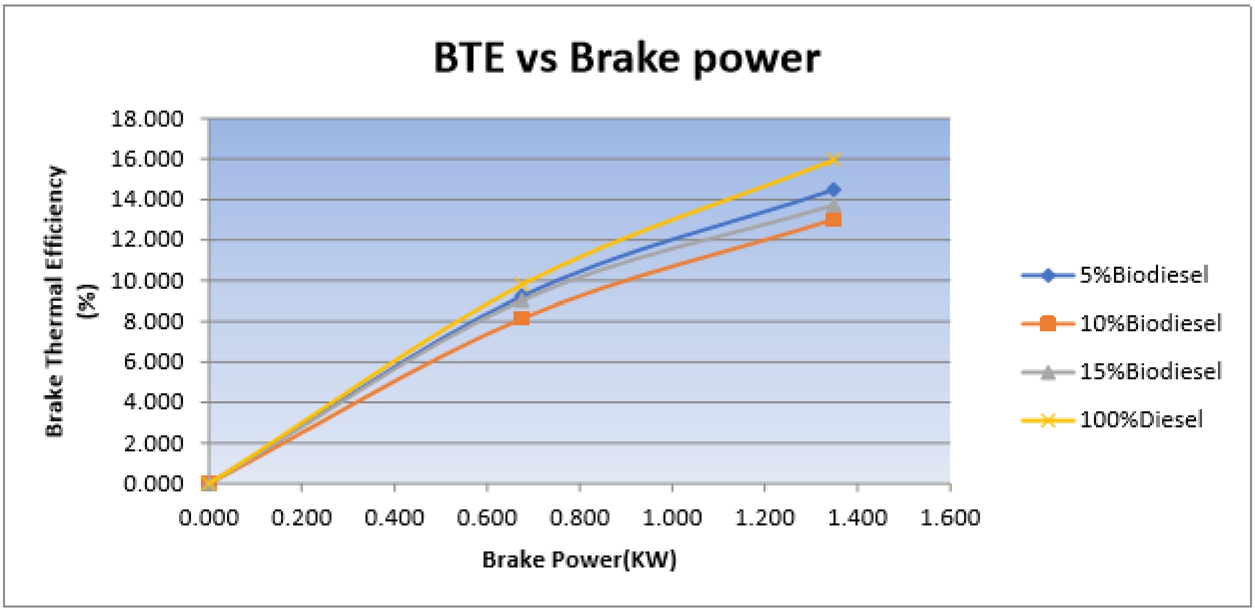

Fig 3 Brake thermal efficiency vs. Brake power

As shown in fig. 4.1, brake thermal efficiency increases with increase in load on the engine as engine has poor part load efficiency. It is also mentioned in the chart that with increase in blending percentage of Karanja oil, brake thermal efficiency of engine decreases. It may be due to lower calorific value of bio-diesel. Decrease in efficiency is negligible at part load condition while at full load condition, decrement may be around 5% for 15% blend compared to pure diesel.

4.2 Brake Specific Fuel Consumption:

It is clear from the fig. 4.2 that, with increase in load the brake specific fuel consumption decreases. The BSFC may increase for overloading condition. The minimum BSFC is at 80% loading condition with pure diesel. BSFC is increased around 12% at 15% bio-diesel blend.

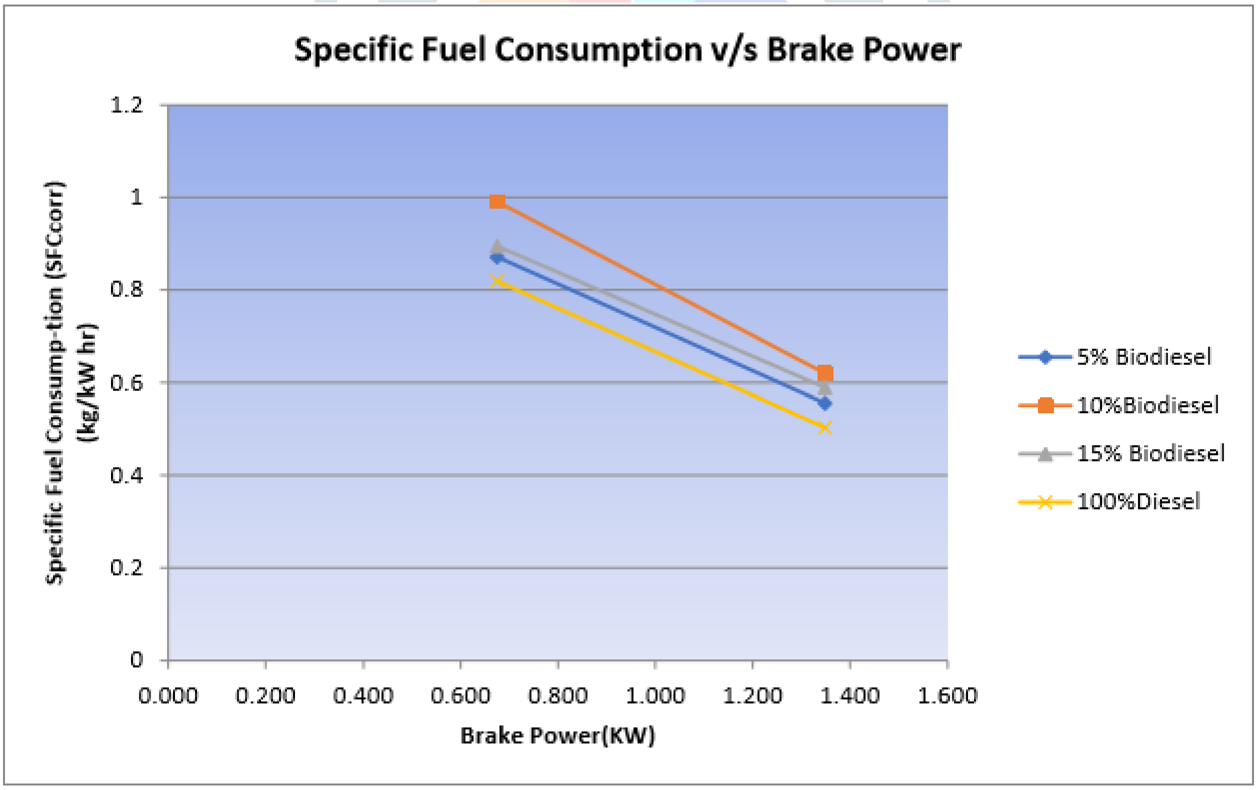

Fig 4 Specific fuel consumption vs brake power

4.3 Exhaust gas temperature:

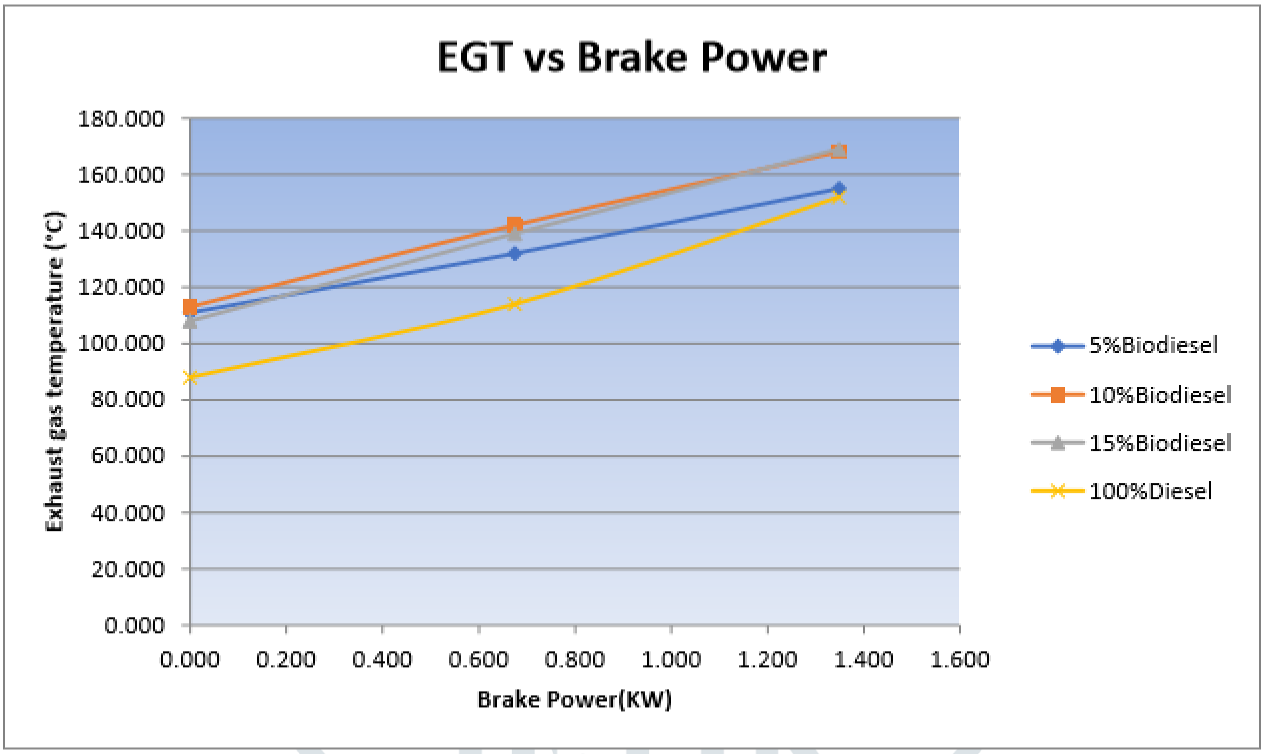

Fig 5 Exhaust gas temperature with brake power

From fig. 4.3, it is seen that with rise in loading condition EGT increases. It is also seen that there is significant change in EGT for blending condition compared to pure diesel fuel.

V. CONCLUSION

After study about Diesel and Biodiesel, we came to know that properties such as volatility, viscosity, centane number, heating value (energy content), density and low-temperature operability has major impact on performance of fuel. Whereas, properties such as flash point, water sediment, ash, sulphur, copper strip corrosion, cloud point and pour point, carbon residue, stability, water separability have minor impact on performance of fuel. From graphs we can conclude that:

- Initially diesel engines take more fuel consumption due to low temperature of the combustion. At higher brake power Specific fuel consumption decreases.
- As load applied to the engine increases brake thermal efficiency of the fuel blends also increases. The maximum brake thermal efficiency is 14.49% for B5 at 6kg load, which is 1.473% lesser than standard diesel. As the load increases specific fuel consumption of the engine decreases gradually. At 6kg load conditions the specific fuel consumption for the blends B5, B10 and B15 are 0.556 kg/ kWh, 0.620 kg/ kWh and 0.589 kg/ kWh respectively whereas for standard diesel it is 0.503 kg/ kWh.
- As load applied increases exhaust gas temperature increases. At 6kg load conditions the exhaust gas temperature for the blends B5, B10 and B15 are 155 (°C), 168 (°C) and 169 (°C) respectively whereas for standard diesel it is 152(°C).
- Due to lack of equipment we were not able to calculate the emissions from the fuel, but it was clearly noticeable that emissions from blends were much lesser than standard diesel fuel.

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