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Experimental analysis on performance and emission characteristics of KARANJA oil blends with diethyl ether as additive in diesel engine

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Abstract-India's dependency on fuel import from other countries has highly increasing year by year. The exploration for alternative fuels for diesel engines from the non- conventional energy sources are consistently growing owing to rise of petroleum price, the risk to the environment by toxic fumes, the depletion of natural fuels and the global warming effect. Karanja oil (Pongamia pinnata) is a natural vegetable oil and available in plenty amount in India. Firstly, so as to reduce the viscosity of Karanja oil, Methanol is added with it for transesterification process. The biodiesel (B20) of Karanja Oil Methyl Ester added with diethyl ether is tested in Variable Compression Ratio (VCR) engine. The performance of the engine can be determined by calculating the brake power, brake specific fuel consumption, brake thermal efficiency and the engine's emission characteristics can be analyzed by checking the CO, CH, NOx from exhaust for different compression ratios and constant engine speed. From the obtained results, the brake thermal efficiency and brake specific fuel consumption of B20 is comparable to diesel. Emissions of CO, HC and smoke are reduced and NO_x is increased with increasing blending of KOME with diesel.

Keywords: Karanja, Pongamia, transesterification, Diethyl ether, Variable Compression Ratio, Engine performance

I. INTRODUCTION

The Earth's restricted stores of non-renewable energy sources have involved worldwide concern as these are under risk of diminishment because of overexploitation. The disintegration of environmental situations happens because of burning of non-renewable energy sources and it is the predominant worldwide source of CO_2 emissions. These variables have prompted a creative worldwide scan for the advancement of renewable energy sources. In spite of the fact that it isn't conceivable to run a CI Engine on 100% biodiesel like Jetropha and Pongamia with no significant alterations in the available engines, but when mixed with diesel in different extents it would make the world astonish with its Eco-friendly nature. Biodiesel is just long-chain alkyl esters which are acquired from animal fat and plant seeds. They are viewed as carbon sink as they take 78.5% of carbon in the environment and considered as cleaner than petroleum products.

Pongamia pinnata (Karanja) is deciduous, salt tolerant, dry season safe nitrogen settling leguminous tree. It is an oil seed-bearing tree, local to moist and subtropical conditions and can develop in a wide types of soil. The presence of poisonous flavonoids like karanjin, pongapin and pongaglabrin in the oil, makes it non-consumable with just 6% being used out of 200 million tons delivered every year. The oil substance of the Karanja seed is 30% to 40%. This dull dark colored oil has a horrible smell and shows fungicidal properties. In India the evaluated amount of oil from seeds is around 50,000 tones. The yield from a solitary tree would associate with 25 to 100 kg. This karanja seeds is discovered plentifully in tropical and subtropical zones and furthermore at a less expensive rate. The great seeds are chosen and are taken for oil extraction. The oil can be extricated by mechanical expeller and by soxhlet extraction technique.

The removed oil is artificially unpredictable esters of unsaturated fats. As a result of these high sub-atomic acids, the oil has higher viscosity causing significant issues in CI engines. These atoms must be part into less complex particles which have viscosity and different properties like that of standard diesel. The process of changing over the crude vegetable oil into biodiesel, which is unsaturated fat alkyl ester, is known as Transesterification.

It is the way toward utilizing an alcohol i.e., methanol or ethanol within the sight of catalsts, for example, sodium hydroxide, to break the atoms into methyl ester. The result of this procedure is Karanja Oil Methyl Ester (KOME). Biodiesel mixes are added with added additives to enhance ignition execution. With the expansion of diethyl ether, it appears to bring about the intense change in outflow smoke at higher loads.

The main objective of this present work is to enhance the engine performance and furthermore to lessen the fuel consumption by utilizing an substitute fuel made by Karanja Oil Methyl Ester with diethyl ether as an additive in Variable Compression Ratio (VCR) engine. The evaluation is completed by varying the proportion of Karanja oil to diethyl ether and the performance and emission parameters are investigated.

II. LITERATURE REVIEW

[1] Arun K. Vuppaladadiyam et al, studied about the crude oil extracted from Pongamia pinnata seed was used to synthesize biodiesel by transesterification with methanol in the presence of two different base catalysts namely NaOH and KOH. They considered the fuel properties like density, viscosity and flash point. From the results, they concluded that using of co solvents may improve the yield and quality of biodiesel.

[2] Balajee. D et al, had studied performance and combustion characteristics of CI engine withvariable compression ratio fuelled withpongamia and jatropha and its blendswith diesel. The performance and combustion characteristics of B10, B20 and B30 blends of jatropha and pongamia with diesel for various compression ratios (13, 14, 15, 16, 17.5) have been studied and it is found out that the blends of biodiesel like jatropha and pongamia with diesel could substitute in the place of pure diesel and be used as an alternate source of fuel in the near future, thus saving the natural resources for the future generation.

[3] Bobade S.N.and Khyade V.B. had conducted the experiments to find out the properties of Pongamia pinnata i.e., Karanja oil. This detailed study intends to explain about all the advantages and disadvantages of Karanja oil as a sustainable feedstock for theproduction of Biodiesel equivalent to fossil fuel.

[4]MookanRengasamy et al, made an analysis on using synthesized Iron catalyst for production of biodiesel from Karanja oil and concluded that the resulting biodiesel properties agrees well with the specifications of biodiesel standards ASTM D6751. The compatibility of physical and chemical properties of resulting fatty acid methyl ester was evaluated with the existing conventional diesel fuel.

[5] NanthaGopal K, ThundilKarupparaj R et al, studied about the production of biodiesel from Pongamia oil is tested for different blends and comparison is made with the standards of conventional diesel. They conclude that the diesel engine can perform satisfactorily with the biodiesel and their blends without any modifications of the engine.

III. MATERIALS AND METHODS

3.1 Karanja oil:

Karanja oil is produced from the seeds of Karanja plant and by extruding them in a seed expeller and pressed hardly to extract only the oil. Finally, the byproducts are oil and Karanja cake.

3.2 Transesterification:

In transesterification process, Karanja oil was made to react with Methanol in the presence of sodium hydroxide as a catalyst to obtain glycerol and fatty acid ester. 200ml of methanol and 8 grams of NaOH were taken in a round base flask and the byproduct is sodium methoxide. This is mixed with 1l of Karanja oil and the mixture is heated to 65°C and constant stirring is done for two hours to form ester. Then it is allowed to cool and after 12 hours it settles down in a separating flask. After the separation of glycerol and methyl ester, the methyl ester was washed with distilled water to remove the excess methanol. After the process, the fuel properties like specific gravity, viscosity and flash point undergone a drastic improvement.

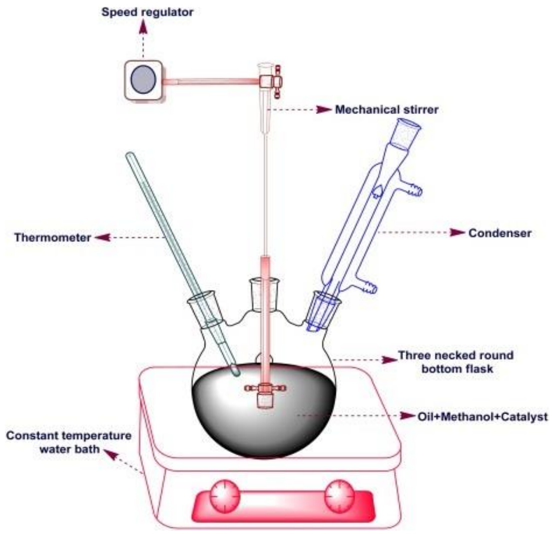

Fig.1: Transesterification setup

3.3 Comparison of properties of Diesel, Raw Karanja oil and Biodiesel:

The properties of Karanja oil before transesterification, Karanja oil after transesterification and Diesel are compared in the table below:

Table.1: Comparison of properties

PROPERTIES	RAW OIL	DIESEL	BIODIESEL
Density(kg/m^3)	924	832	860
Calorific value(KJ/kg)	34000	42800	37270
Viscosity at 40°C (cSt)	69.6	3.8	5.6
Flash point(°C)	241	74	120
Fire point(°C)	253	63	130

3.4 Blending of biodiesel:

After the transesterification of the oil, the biodiesel is blended with diesel and the additive Diethyl ether in various proportions. At first, 20% of biodiesel is blended with 80% of diesel to B20 i.e, 200ml of biodiesel is added with 800ml of diesel. Diethyl ether (DEE) is mixed in various proportions with the B20 blend of biodiesel. Firstly, 5% of DEE is added and the biodiesel is made and then 10% of DEE is blended with B20. The various blends of the biodiesel are mentioned below:

Table.2: Blending of biodiesel

BLENDS	COMPOSITION
Blend 1	Diesel
Blend 2 (B20)	80%Diesel + 20%Biodiesel
Blend 3	B20 + 5% Diethyl ether
Blend 4	B20 + 10% Diethyl ether
Blend 5	B20 + 15% Diethyl ether

IV. EXPERIMENTAL SETUP

4.1 Variable Compression Ratio engine:

The performance characteristics of the engine can be analyzed by carrying out a load test on the engine. The load can be varied continuously at regular intervals of time. The loading is done on a variable compression ratio engine manufactured by Kirloskar which is a largest producer of portable multi-fuel engines. The cylinder we used is a single cylinder four stroke diesel engine and it is an air cooled engine. A fuel tank with a measuring burette is present which helps to measure the fuel consumed. It is coupled with a 3 phase loading rheostat. It is coupled by means of rigid coupling without any misalignment between axes which enables to damp-out all kind of vibrations during transmission. The compression ratio of an engine can be varied by number of ways. Here, it is altered by head tilting method. During the tilting process, the clearance volume of the cylinder is also varied. If the piston is farther to the deck, then the clearance volume is increased and thus the compression ratio is decreased. If the piston deck is closer to the deck, then the clearance volume decreases and hence the compression ratio increases. The specifications of Variable compression ratio engine are tabulated as:

Table.3: Specifications of VCR engine

SPECIFICATIONS	
General details	4- stroke Kirloskar Water cooled Single cylinder
Power	3.5kW at 1500 rpm
Speed	1500rpm
Compression ratio	17.5:1(variable from 12 to 18)
Bore	87.5 mm
Stroke	110mm
Combustion principle	Compression ignition

4.2 Exhaust Gas Analyzer:

The exhaust gas analyzer is used to analyze the chemical composition of exhaust gas released by the engine. The instrument measures theconcentrations of Carbon monoxide (CO in % & ppm), Carbon Dioxide (CO2) andOxygen (O2) in percentage, Hydrocarbons (HC), Nitric Oxide (NOx) and Oxides ofSulphur (SOx) in ppm in the engine exhaust gas.

V. RESULTS AND DISCUSSIONS

5.1 Performance characteristics:

5.1.1Effect on Brake Specific Fuel Consumption:

The results of Brake Specific Fuel Consumption are evaluated with the help of various loading conditions like 0%, 25%, 50%, 75%, and 100% by running the engine with different blends prepared. From the graph, it can be concluded that the specific fuel consumption of the engine increases with increase in loads when the blend 2 (B20) is used and when addition of diethyl ether increases, the brake specific fuel consumption also increases.

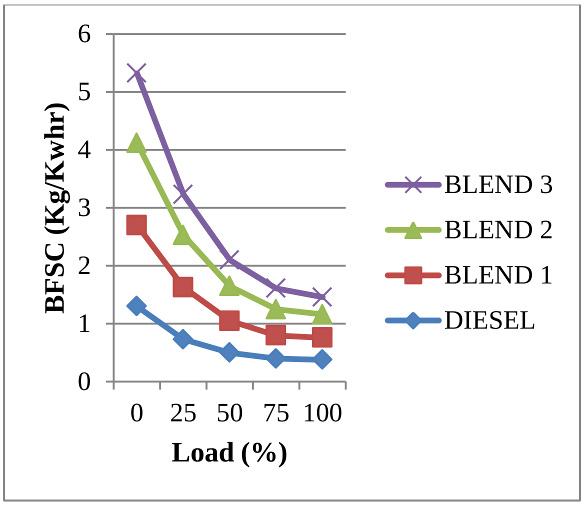

Fig.2: Engine load vs Brake specific fuel consumption

5.1.2 Effect on Brake Thermal Efficiency:

The results of Brake Thermal Efficiency are evaluated with the help of various loading conditions like 0%, 25%, 50%, 75%, and 100% by running the engine with different blends prepared. From the graph, it can be concluded that the brake thermal efficiency of the engine increases with increase in loads when the blend 2 (B20) is used.

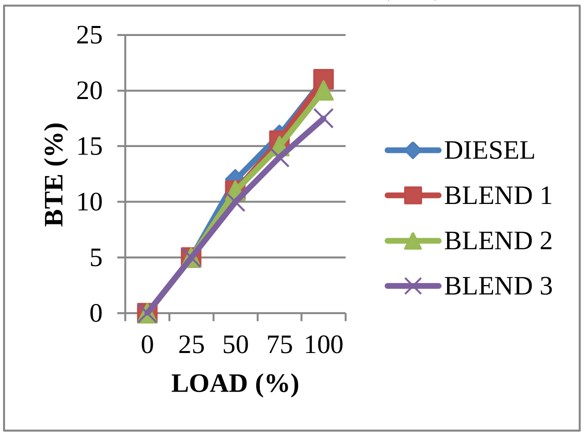

Fig.3: Engine load vs Brake Thermal Efficiency

5.1.3 Effect on Indicated Thermal Efficiency:

The results of Indicated Thermal Efficiency are evaluated with the help of various loading conditions like 0%, 25%, 50%, 75%, and 100% by running the engine with different blends prepared. From the graph, it can be concluded that the indicated thermal efficiency of the engine increases with increase in loads when the blend 2 (B20) is used.

5.1.5 Effect on Volumetric Efficiency:

The results of Volumetric efficiency are evaluated with the help of various loading conditions like 0%, 25%, 50%, 75%, and 100% by running the engine with different blends prepared. From the graph, it can be concluded that the volumetric efficiency of the engine increases with increase in loads when the blend 2 (B20) is used.

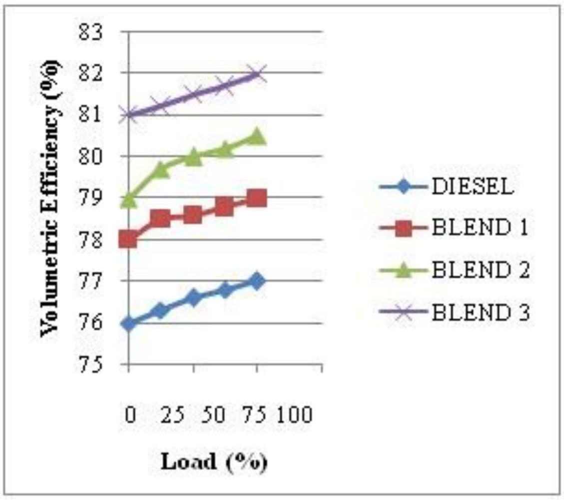

Fig.4: Engine load vs Volumetric Efficiency

5.2 Emission Characteristics:

5.2.1 Effect on Carbon Monoxide:

It has been observed that CO emission was found to decrease with the increase in proportion of biodiesel in the blends. CO emissions are increased with increase in engine load. The lower CO emission of biodiesel compared to diesel is due to the presence of biodiesel which helps in complete oxidation of fuel.

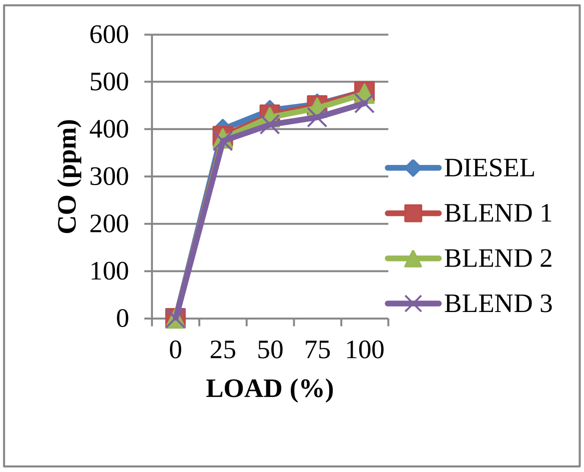

Fig.5: Engine load vs Carbon Monoxide

5.2.2 Effect on Hydrocarbon Emission:

Hydrocarbons in exhaust are due to incomplete combustion of carbon compounds in the blends. The HC emission decrease with increase in proportion of biodiesel in the fuel blends. The possible reason for decrease in unburnt HC may behigher cetane number and increased gas temperature.

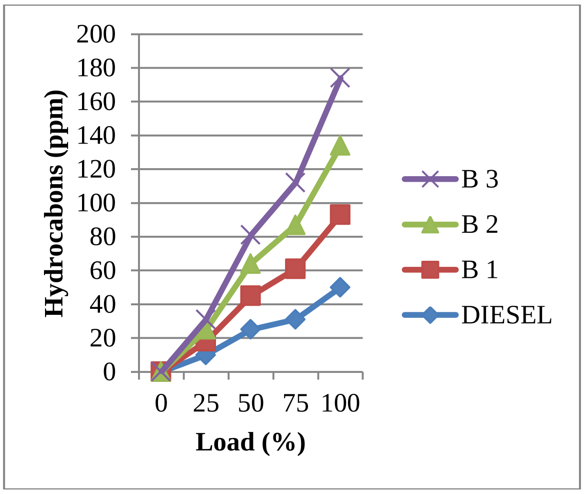

Fig.6: Engine load vs Hydrocarbons

5.2.3 Effect on Carbon Dioxide:

Carbon Dioxide in exhaust is due to incomplete combustion of carbon compounds in the blends. The CO_2 emission decrease with increase in proportion of biodiesel in the fuel blends. The possible reason for decrease in CO_2 may be higher cetane number and increased gas temperature.

5.2.4 Effect on Oxygen:

Oxygen in exhaust is due to incomplete combustion of carbon compounds in the blends. The O_2 emission decrease with increase in proportion of biodiesel in the fuel blends. The possible reason for decrease in O_2 may be higher cetane number and increased gas temperature.

5.2.5 Effect on NOx Emission:

The slower burning character of the fuel causes a slight delay in the energy release, which results in higher temperature in later part of power stroke and exhaust stroke. Increased exhaust gas temperature is due lower heat transfer and the fact that biodiesel has some oxygen content in it which facilitate NOx formation.

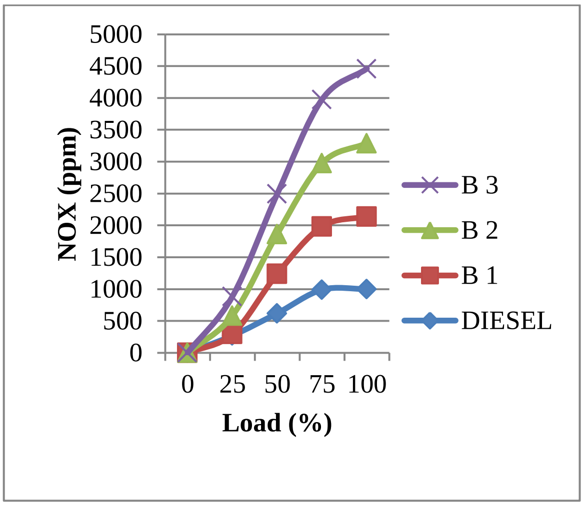

Fig.7: Engine load vsNOx

VI. CONCLUSION

The performance and combustion characteristics of biodiesel derived from Karanja oil and its blends are compared with the characteristics of standard diesel. It shows that the diesel engine can perform effectively with Karanja oil and its blends without any modifications of the standard diesel.

The performance characteristics of Karanja oil are better when compared to conventional diesel. While using Blend 3, the brake power, brake thermal efficiency and mechanical efficiency are maximum compared to that of other blends. At the same time, on using Blend 4, maximum indicated power and minimum specific fuel consumption are obtained.

The emission characteristics of Karanja oil are better when compared to conventional diesel. The emission from the Karanja biodiesel satisfies the Bharat Stage-4 standard emission conditions. It is noticed that there is a significant reduction in emission of CO, unburned HC and smoke emission in Karanja biodiesel when compared to that of diesel. The NOx emission is marginally higher in Karanja biodiesel compared to diesel.

Thus the results show that the Karanja Oil Methyl ester with diesel in various proportions can be used as an alternative fuel source and it is also environment friendly fuel for a diesel engine. Further, detailed analysis of various more blends will definitely enable us to find a perfect suitable blend which can overcome all the disadvantages of petroleum diesel.

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