

Potential of Preheated Karanja Oil Utilization in a Direct-Injection CI Engine**R. R. Khodke¹, Dr. S. C. Kongre²**

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ABSTRACT –

The diesel engine is the most efficient power plant among all known types of internal combustion engines. Heavy trucks, urban buses, and industrial equipment are powered almost exclusively by diesel engines all over the world and diesel powered passenger cars are increasingly popular. Increase in petroleum prices, threat of global warming has generated an interest in developing alternative fuels for engine. Technologies now focusing on development of plant based fuels, plant oils, plant fats as an alternative fuel. Vegetable oils have energy content suitable for use as a fuel in diesel engines. Some of these oils have already been evaluated as substitutes for diesel fuels. However, several operational and durability problems of using straight vegetable oils in diesel, caused by their relatively higher viscosity compared to mineral diesel. This viscosity can be brought into the acceptable range by transesterification, by blending of vegetable oil with diesel, or by preheating the vegetable oil. The reduction in the viscosity by blending or preheating saves the processing cost incurred in the transesterification process involving expensive chemicals. Karanja oil holds special promise in this regard, because it can be produced from the plants grown in rural areas [4]. This paper investigates the potential of Karanja oil utilization in direct ignition CI engine. The different properties of Karanja oil is measured and compared it with the diesel.

Index Terms: Alternative fuel, karanja oil, viscosity, calorific value, preheating of karanja oil.

I. INTRODUCTION

Energy is one of the most significant inputs for growth of all sectors including agricultural, industrial service and transport sectors. Energy has been at the centre stage of national & global economic development from several decades. The demand for energy, around the world is increasing exponentially; specifically the demand for petroleum-based energy [2]. India with the high rate of economic growth and increase in the population is the significant consumer of energy resources. India lacks in sufficient energy reserves and dependent on oil imports, but India has an abundant re-source of vegetable oils. The use of vegetable oil in a diesel engine is not a new concept. In fact early engines were demonstrated with straight vegetable oils (SVO). Vegetable oils were proved to be very costlier during those days. However due to limited reserves of fossil fuels, escalation nature of diesel fuel prices and increase in environmental pollution, created a renewed interest of research in vegetable oil as substitute fuel for diesel engines. Vegetable oil is easily available, renewable and environment friendly. However major disadvantage of vegetable oil is its viscosity, which is much higher than that of diesel. Due to higher viscosity, vegetable oil causes poor fuel atomization, incomplete combustion and carbon deposition on the injector. Karanja is a forest based tree-borne non- edible oil with a, production potential of 135 000 million tonnes [9]. Karanja tree grows all over the country. In parts of India, this tree is also

known as pongamia, belongs to the family of Leguminaceae. It is a medium sized tree that attains a height of about 18 m and a trunk diameter greater than 50 cm. The fresh extracted oil is yellowish orange to brown and rapidly darkens on storage [10].

In this current era if we see the cost of fuel is rising day by day that's why the transportation cost is also raising and it is directly affecting to inflation level of country. To reduce the cost of fuel it is common practice generally in India, for all vehicles, mixing the alternative fuel with main fuel e.g. mixing the kerosene in diesel. It causes some effects on environment as well as engine performance and life of the engine. To reduce the all above effects on vehicle and environment, a person should know the perfect combination of main fuel and blending fuel, like diesel and kerosene, so that the engine gives optimum performance without changing the conventional engine part design and environment will not be adversely affect. As the kerosene having a higher calorific value and low viscosity than the diesel [5], it will be use as a third blending fuel in diesel-Karanja oil blend fuel. This project is concentrate on the perfect combination of diesel-karanja oil and kerosene. It will beneficial for mitigating the cost of diesel fuel especially in the rural areas, because in rural area peoples use to try the improper mixture of diesel and kerosene.

II REVIEW OF LITERATURE

The use of vegetable oils as an alternative fuels has been known for 100yrs when the inventor of the diesel engine Rudolph Diesel first tested peanut oil, in his compression engine.

One possible alternative to fossil fuel is the use of oils of plant origin like vegetable oils & tree borne oils seeds. This fuel can be termed as Biodiesel. This fuel biodegradable & non-toxic & has low emissions profiles as compared to petroleum diesel. Usage of biodiesel will allow a balance to be sought between agriculture economic development & the environment.

Biodiesel is the monoalkyl esters of long chain fatty acids derived from renewable feed stocks, such as vegetable oil or animal fats, for use in compression ignition engine. Biodiesel, which is considered as a substitute for diesel fuel is commonly, composed of fatty acid methyl esters which can be prepared from triglycerides in vegetable oils by transesterification with methanol. The resulting biodiesel is quite similar to diesel fuel in its main characteristics.

The plant oil usually contains free fatty acids, phospholipids, water, odourants & other impurities. Because of these, the oil cannot be used as fuel directly. To overcome these problems the oil requires slight chemical modification mainly transesterification. Transesterification is the key & the foremost important step to produce the clear & environmentally safe fuel from vegetable oils. Chemically the oils/fats consists of triglycerides molecules of three long chain fatty acids. They differ by the length of carbon chains, orientation & position of double bond in these chains. Thus biodiesel refers to lower alkyl esters of long chain fatty acids which are synthesized either by transesterification with lower alcohols or by esterification of fatty acids.

Vegetable oils occupy an important position in the development of alternative fuels although there have been many problems associated with using it directly in engine. These include:

1. Carbon deposits.
2. Oil ring sticking.
3. Thickening or gelling of the lubricating oil as a result of contamination by vegetable oils,&
4. Lubricating problems.

Other disadvantages to the use of vegetable oils & especially animal fats are the high viscosity (about 11-17 times higher than diesel fuel), lower volatilities causes the formation of deposits in engine due to incomplete combustion. These problems are associated with large triglyceride molecules and its higher molecular mass and avoided by modifying the engine [1].

The investigation of the performance and combustion characteristic of single cylinder, naturally aspirated, water cooled, DI diesel engine running on karanja oil (K100) and blends with diesel K10, K15, and K20 and the experimental results were compared with that of diesel. The results showed that the fuel properties of K100, density, viscosity, flash point and carbon residue were found to be higher than that of diesel and calorific value is lower than that of diesel. Based on the fuel properties of K100, the higher amount of carbon residue may lead to carbon deposits on the combustion chamber and viscosity was found to be higher, the high flash point enables the safe storage and transportation. Based on the investigations, the specific fuel consumption to develop the same amount of engine output power was found to be more this may be due to low calorific value of all the blends. The thermal efficiency of K15 was well comparable with that of diesel. Engine ran successfully even on K100 fuel without any engine modifications. Finally based on performance and combustion characteristics it can be seen that K15 was found to be optimum blend. Further investigations are to be carried out at varying IOP and injection timing [2].

Karanja based bio-diesel is a non-edible, biodegradable fuel suitable for diesel engines. Karanja biodiesel has been prepared by transesterification method. Biodiesel-diesel blends have been prepared on volume basis. Physical properties of Karanja biodiesel, diesel and its blends have been determined. An experimental investigation has been carried out to analyze combustion characteristics of a single cylinder, VCR diesel engine fuelled with Karanja biodiesel and its blends (10%, 20%, 30%, 50% and 75%) with neat diesel. A series of engine tests, with CR 16.5, 17.5 and 18.5 have been conducted using each of the above blends for comparative evaluation. Combustion parameters such as ignition delay, peak pressure development, heat release rate analysis of engine have been studied. The results of the experiment in each case have been compared with baseline data of neat diesel. Ignition delays of bio-diesel blends are lower than that of diesel; peak pressure takes place definitely after TDC for safe and efficient operation. Comparable rate of pressure rise obtained is indicative of stable and noise free operation of CI engines with karanja biodiesel blends. B10 is suitable alternative fuel for diesel at slightly higher CR can be used without any engine modifications [5]. The combustion characteristics of 3.5 kW, DI, VCR diesel engine fuelled with karanja biodiesel (produced by transesterification process) blends have been analyzed and compared to those with diesel fuel. The conclusions of present work are summarized as (1) Transesterification process improved the fuel properties of the Karanja oil with respect to density, CV, viscosity, flash point. Higher flash point of karanja biodiesel and its blends with diesel made for safe storage and handling of these fuel. (2) It is observed that the ignition delays of bio-diesel blends are lower than that of diesel and are decreasing with an increase in the biodiesel in the blend. The peak pressure takes place definitely after TDC for safe and efficient operation. Otherwise, a peak pressure occurring

very close to TDC or before that causes severe engine knock, and thus affects engine durability. (3) Comparable rate of pressure rise obtained is indicative of stable and noise free operation of compression ignition engines with karanja biodiesel blends. The maximum heat release rate of biodiesel and their blends is lower compared to that of diesel, possibly because of the lower heating value of the biodiesel blends and shorter ignition delay. But B10 gives comparable heat release rate. (4) The B10 is best alternative fuel for diesel at slightly higher CR can be used safely. No hardware modifications are required for handling these fuels (Karanja biodiesel and their blends) in the existing engine [5]

Test results shows that calculated Cetane Index is within permissible limits up to minimum of 51.8. Density and kinematic viscosity of the samples are decreasing continuously. Sulphur test also shows the decreasing trend in result. Chemical analysis is done for testing in small CI engine to evaluate the performance and exhaust emissions at different load conditions [6].

Test Results: -

(i) Density: - Density is the mass of liquid per unit volume reported at 15°C.

Significance:-It is used for calculating the mass when volume of the bulk is known (volume x density=weight).

(ii) Cetane Number:-Cetane number of diesel fuel is determined in a single cylinder CFR engine by comparing the ignition delay characteristics of the fuel with that of reference blends of known cetane number. The reference fuels used for this purpose are normal cetane or hexa decane (100CN).

Significance:-Cetane number is the index of ignition quality of a Diesel fuel. High cetane number fuel will facilitate easy starting of compression ignition engines and lessens engine roughness. In the absence of the engine, the diesel Index or the calculated cetane Index will give an approximate idea of the ignition quality of the fuel. It can also be roughly calculated by the formulae for fuels not containing ignition improvers. $CN = 0.72 \text{ Diesel Index} + 10$.

(iii) Sulphur content:- This is determined by several methods like lamp combustion method or wick bold procedure for volatile petroleum products and by bomb calorimeter for several products. Sulphur in the sample is oxidised by combustion and is estimated volumetrically after absorption in H_2O_2 or gravimetric methods after converting to Barium sulphate. Total sulphur in low levels is also determined by XRM (WD& ED), oxidative micro coulometer and UV- fluorescence.

Significance:- Sulphur in any form creates corrosion problem and hence its tolerance is limited. Currently being brought down has to very low levels, in view of the environmental safety. Approximately 98% of sulphur present in fuel is converted to sulphur Di-oxide leading to the formation of acidic aerosols harmful for environmental balance is converted to sulphates, which are emitted and unburnt carbon as particulate matter.

(iv) Calorific Value:- A weighted quantity of sample is burnt in presence of oxygen in a bomb calorimeter under control condition. The calorific value is calculated from the weight of the sample and the rise in temperature. It can also be calculated from the formulae

$Q_v = 12400 - 2100d^2$ where Q_v = calorific value, Gross, cal/gm and d = density at 15°C **Significance:** - It is a measure of the heat producing ability of the fuel.

(v)**Viscosity**:-Viscosity of a liquid fuel is a measure of its resistance to flow. It is expressed either in Redwood and Saybolt seconds or in centistokes (kinematic viscosity).

Significance:-Viscosity is an important characteristic of petroleum products and it is used for the pump design. Pump clearances are adjusted according to viscosity and if it is out of range, it may lead to pump seizure.

(vi)**Distillation**:-The distillation (volatility) characterisations of hydro-carbon have important effects on their safety and performance, especially in the case of fuels and solvents. The boiling range gives important information on composition and behaviour during storage and use, and the rate of evaporation is an important factor in the application of many solvents. Limiting values to specified distillation characteristic are applied to most distillate petroleum product specifications in order to control end use performance and to regulate the formation of vapours which may form explosive mixture with air, or otherwise escape into the atmosphere are emissions (VOC). **Significance**:-Significance of this test varies from product to product in case of crude oil the ASTM distillation data gives some idea of fractions that could be collected below 300⁰C. If it is a True Boiling Point (TBP) distillation, the TBP curve reveals a lot of characteristics that are useful for the design of refinery. The 10% volume of distillation for motor spirit is an indication of the ease with which the engine can be started. Too high TBP will cause crank case oil dilution [6].

The techno-economic effects of diesel-kerosene blends on the operation of a direct ignition (DI) diesel engine were investigated using a stationary LD 20-D! Issan diesel engine. Standard experimental procedures were adopted. The values of pressure data of all petroleum fuel blends were higher when compared with that obtained when the engine was run on diesel fuel. However, due to the deterioration of combustion process caused by too much kerosene at 40% kerosene mixing, pressure data for 30% kerosene blend were higher than that at 40% kerosene blend from about 80 degrees after top dead centre. The exhaust gas temperature at 100% rated load was 16.7% higher at 30% kerosene blend as compared with that obtained with diesel fuel. Brake power increased with rated load for all the fuel blends. The brake power at 100% rated load was 19.8% higher at 30% kerosene blend than that obtained when the engine was run on diesel fuel. Specific fuel consumption at 100% rated load was 7.5% lower at 30% kerosene blend than that obtained when compared with diesel fuel. It was deduced that the use of 30% kerosene along with diesel fuel will result in 10% saving on fuel cost [7]. The exhaust gas temperature also increased with percentage of kerosene in the test fuel. This may be due to the oxygen content of kerosene, which improves combustion and thus increase exhaust gas temperature. Brake power increased with rated load for all the fuel blends. Mixing kerosene with diesel fuel pumps up the diesel fuel cetane number, giving it a more combustible effect. Specific fuel consumption decreased with increase in engine load. This decrease in specific fuel consumption rate is attributable to higher calorific value of kerosene as compared with diesel fuel. The use of 30% kerosene along with diesel fuel brings about 10% savings on the fuel cost [7].

Mistral engines, a Swiss Aeronautical Company wishes to be able to have operating Wankel engines on kerosene fuel because of its market availability. Kerosene is a fuel with lower cetane number than diesel fuel, thus it should give a longer ignition delay. This makes it viable for lower emissions since the longer ignition delay means longer time for the fuel to mix with the in-cylinder gas prior to combustion onset. With the cooperation of the Industrial Energy System Laboratory of the Swiss Federal Institute of Technology in

Lausanne, a study on the combustion of kerosene in an internal combustion engine (ICE) is here presented. This study is performed in a mono cylinder ICE with variable Compression Ratio (CR) and Variable Valve Timing (VVT). Different strategies, such as Homogeneous Charge Compression Ignition (HCCI), Homogeneous Charge Spark Ignition (HCSI), Controlled Auto Ignition (CAI) and a combustion pre-chamber concept are considered [8]. To understand the behavior of kerosene combustion in an ICE several parameters were investigated. The influence of the fuel temperature, the timing of the pre-injection and the richness of the mixture. Furthermore, SI and CI were investigated and HCCI was attempted to be achieved with a new concept of combustion pre-chamber. The experiments allow to draw the conclusions are, (1) Higher thermodynamic efficiency, earlier start of combustion, faster combustion process and higher cylinder pressure happens for higher kerosene temperature. Vaporization process becomes easier with increased fuel temperature once the surface tension of the drops is lowered. Hence homogenization of mixture is improved. (2) Start of combustion is sensitive to excess of air ratio in SI and CI mode, presenting a large delay when the mixture is very rich. (3) Engine start is difficult on CI mode when engine is cold. (4) Too late pre-injections lead to IHR instability at the end of HTHR. Fuel stratification may take place and auto-ignition of small clouds of rich mixture happens. (5) The pre-chamber leads to larger ignition. In fact, the ignition is not controlled as in SI mode. (6) The use of pre-chamber leads to overall better efficiencies (combustion and indicated), thus better engine performance. (7) The use of pre-chamber and HCCI approach leads to improved combustion stability. (8) The long ignition delay, which can partly lead to low soot emissions, could be beneficial for expanding the HCCI operation area. In combination with the market availability of kerosene, it has the possibility to be a suitable HCCI fuel [8].

3.75 kW diesel engine AV1 Single Cylinder water cooled, Kirloskar Make was used to test blends of diesel with kerosene and Ethanol. Engine test setup was developed to carry the trials using these blends. This paper presents a study report on the performance of IC engine using blends of kerosene and ethanol with diesel with various blending ratio. The engine performance studies were conducted with rope break dynamometer setup. Parameters like speed of engine, fuel consumption and torque were measured at different loads for pure diesel and various combination of dual fuel. Break Power, BSFC, BTE and heat balance were calculated. Paper represents the test results for blends 5% to 20% [9]. Exhaust gas temperature for kerosene blend from 5% to 20% was observed as highest compare with any of the other blends. Highest gas temperature for all fuel blends were recorded as in the range of 200 to 225 Degree Celsius. Minimum exhaust gas temperature was observed for pure diesel [9]. For 20% mixture of ethanol blend with diesel has a very good efficiency compared with pure diesel and blend of kerosene. Also it is observed that the 20% ethanol blend is having higher volumetric efficiency compare with diesel and kerosene blend. Exhaust gas temperature for ethanol blend has not shown any substantial increase compare with pure diesel. Hence blending of ethanol at about 20% can lead to a better performance of engine compare with pure diesel [9]

Due to the continuous consumption of energy resources, the price of conventional fossil fuel is increasing too fast and lead to additional burden on the economy of the importing nations. The scarcity and depletion of conventional petrol sources are cause of great concern worldwide and has promoted research into alternate energy sources for IC engine [10].

Spark Ignition Engine is widely used prime mover due to its smooth operation & low maintenance. The Blending of alternative fuel with the conventional fuel may be the solution of scarcity of conventional fuel for the spark ignition engine [10].

The present work is mainly concerned with an experimental investigation to study the petrol engine performance, combustion, noise and emission characteristics using blends of petrol & kerosene. The performance characteristics for different blends are evolved in running the engine under steady state conditions [10].

It is observed that 80 % Petrol and 20 % Kerosene provides the lesser NO_x and emission of HC compared to other blends. 20 % and 40 % petrol give higher value of CO at lower load but as the load increases, the concentration of CO by volume decreases, and the 20 % kerosene can be preferred at higher load as it will give less CO emission. With the overall results of engine performance and emission characteristics the optimum percentage of blend of petrol and kerosene is found out to be 80:20 (80% petrol and 20% kerosene) [10].

III. POTENTIAL OF KARANJA OIL

Increase in petroleum prices, threat of global warming has generated an interest in developing alternative fuels for engine. Technologies now focusing on development of plant based fuels, plant oils, plant fats as an alternative fuel.

It has been found that karanja oil hold special promise in this regard, because it can be produced from the plants grown in rural areas.

The different properties of karanja oil and diesel are shown in Table No.1

Table-1: Properties of Karanja oil & Diesel.

Sr. No.	Property	Unit	Diesel	Karanja Oil
1	Density	g/cc	0.833	0.945
2	Kinematic Viscosity	Cst	7.92	41.50
3	Calorific Value	KJ/kg	43843	38477
4	Cetane Number	-	49.38	38.10

The use of pure karanja oil as a fuel in diesel engine is restricted by unfavorable physical properties, particularly viscosity. Due to higher viscosity, karanja oil causes poor fuel atomization, incomplete combustion and carbon

deposition on the injector. One possible method to overcome the problem of higher viscosity is preheating and blending of karanja oil with diesel in proper proportion [4].

Siddalingappa R. Hotti, Omprakash Hebbal, In diesel-karanja oil blending, due to the lower calorific value of karanja oil the specific fuel consumption is increased and engine consumes more amount of the fuel in order to produce the same out-put power as compare with the case of pure diesel. The brake thermal efficiency of engine fuelled with diesel-karanja oil are lower than that of the engine fuelled with pure diesel [2].

O. Obodeh and F.O. Isaac, in diesel-kerosene blending, due to the higher calorific value of kerosene the specific fuel consumption is reduced compare with the case of pure diesel. Brake thermal efficiency of engine fuelled with diesel-kerosene is higher than the pure diesel [7]. The studies of changes in kinematic viscosity of karanja oil by preheating are as follows. In first part the karanja oil is preheated at different temperatures like A-1 (Preheating @ 40⁰C), A-2 (Preheating @ 60⁰C), A-3 (Preheating @ 80⁰C), A-4 (Preheating @ 100⁰C) and A-5 (Preheating @ 120⁰C) and stored for two weeks, after that changes in kinematic viscosity are found as shown in Table No. 2.

Table-2: Kinematic viscosity of Preheated & Stored Karanja oil.

Sr. No.	Sample Code	Kinematic Viscosity (cst)
1	A-1 (Preheating @ 40 ⁰ C)	66.69
2	A-2 (Preheating @ 60 ⁰ C)	64.22
3	A-3 (Preheating @ 80 ⁰ C)	60.76
4	A-4 (Preheating @ 100 ⁰ C)	60.51
5	A-5 (Preheating @ 120 ⁰ C)	55.57

In second part, the karanja oil is preheated at different temperatures like B-1 (Preheating @ 40⁰C), B-2 (Preheating @ 60⁰C), B-3 (Preheating @ 80⁰C), B-4 (Preheating @ 100⁰C) and B-5 (Preheating @ 120⁰C) and measured the changes in kinematic viscosity without storing as shown in Table No. 3.

Table-3: Kinematic viscosity of Preheated Karanja oil without storing.

Sr. No.	Sample Code	Kinematic Viscosity (cst)
1	B-1 (Preheating @ 40 ⁰ C)	33.09
2	B-2 (Preheating @ 60 ⁰ C)	20.06
3	B-3 (Preheating @ 80 ⁰ C)	15.57
4	B-4 (Preheating @ 100 ⁰ C)	12.40
5	B-5 (Preheating @ 120 ⁰ C)	10.03

IV. CONCLUSION

Based on the above results of properties, it is clearly seen that, in first part kinematic viscosity of karanja oil slowly regain its original value as the storing days increases. In second part, kinematic viscosity of karanja oil decreases with increasing temperature, if it is directly use (without storing).

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