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Performance & Testing of Diesel Engine with Blends of Diesel and Karanja Biodiesel produced by Ultrasonic Technique -Review study

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Abstract: *Due to the limited conventional fossil fuels, it has become necessaryto find alternative clean and renewable energy resources. Biodiesel is a liquid fuel consisting of mono alkyl esters (methyl or ethyl) of long chain fatty acids derived from vegetable oils or animal fats or micro and macro algal oil. It is a kind of bio- energy as a substitute for conventional petrol diesel fuel.Recently, the production of biodiesel has been increased due to some crucial reasons such as the rise in crude oil price, limited resources of fossil oil, and pollution reduction.This paper presents a review of the alternative technological methods that could be used to produce this fuel. Biodiesel from karanga oil was produced by alkali catalyzed transestrification using ultrasonic technique. However, the production process faces many drawbacks related to the immiscible nature of the reactants and the presence of free fatty acids in the desired oil. Several approaches have been proposed but only to a limited success. Heterogeneous catalysts which are more environmental friendly usually subject to a drawback of low catalytic activity. Ultrasonic irradiation has been proven to be successfully used in a meaningful way to enhance the emulsification of the reactants to increase the mass transfer rate during the reaction. This enhancement leads to reductions in reaction time, catalyst amount, alcohol-to-oil ratio and reaction temperature causing a significant decrease in the production economics.*

Keywords— *Biodiesel, karanja, Ultrasonic, Performance*

I. INTRODUCTION.

The resources of petroleum as fuel are dwindling day by day and increasing demand of fuels, as well as increasingly stringent regulations, pose a challenge to science and technology. With the commercialization of bioenergy, it has provided an effective way to fight against the problem of petroleum scarce and the influence on environment.[14]But conventional method of producing biodiesel are transestrification which is take more time and cost whereas ultrasonic method of transestrification has advantage of less reaction time and less in cost. Biodiesel process faces various problems related to immiscible nature of oil and alcohol leads to poor mass transfer rate. This requires long reaction time, higher catalyst consumption, higher methanol-oil molar ratio, high temperature and high stirring rate. This review discusses that the latest advances in ultrasonic assist transesterification reaction with the use of heterogeneous catalysts to produce biodiesel with cost effective. Ultrasonic energy can emulsify the reactants to reduce the catalyst requirement, methanol-oil ratio, reaction time and reaction temperature.[10]

In a country like India it is observed that biodiesel can be viable alternative automotive fuel. Biodiesel is a fastest growing alternative fuel and India has better resources for its production. India has huge potential for biodiesel and it will be the most suitable, if biodiesel is produced from on-edibletype oil seeds, like karanja (Pongamia Pinnata), ratanjyot (Jatropha Curcus). The above oil seeds canbe cultivated in the wasteland. This biodiesel can be used in internal combustion engines in a similar fashion as petro- diesel without any modification.[7]

Researchers are making sincere attempts to find out the suitable alternative to diesel fuel which does not require major engine modifications. In this paper, the results of some of the researchers have been summarized and compared to get the state of the art of biodiesel production, its combustion, emis- sions and performances characteristics as CI engine fuels.

II. PRODUCTION OF BIODIESEL BY ULTRASONIC TECHNIQUE.

The transesterification reaction was carried out in a three- neck glass batch reactor equipped with an ultrasonic transducer and probe, a condenser, a stirrer and a thermocouple thermometer. Fig. 1 shows the schematic diagram of the ultrasonic-assisted biodiesel production system.[4] The ultrasonic-assisted reactions were achieved using a ultrasonic processor that was capable of producing a frequency of 20 kHz with a maximum power of 200 W. Ultrasonic power was varied by varying the amplitudes (represented by % of the full amplitude) and the power dissipated was calculated by the ultrasonic system. Alkali (NaOH, KOH), acid (H2SO4, HCL) or enzymes (lipase) catalyzed reaction. Acid catalyzed transestrification is most commonly used process because it is a reversible reaction. In the transestrification process methanol and ethanol are more common. Methanol is more extensively used due to its low cost and physiochemical advantages with triglycerides and alkali are dissolved in it [2]. The pulse of the ultrasonic (s) was set at different lengths varying between 1 and 9 s. Pulse on was the time that ultrasonic irradiated while pulse off was the interval time between the pulsing periods. The glass reactor vessel was placed in a water bath to control the initial temperature at 40 ◦C.

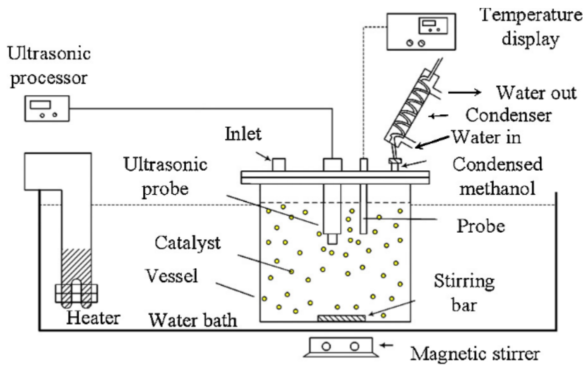

Figure 1. Schematicdiagramoftheultrasonic-assistedreactionsystemused[11]

The catalyst was first dispersed in the oil and placed in the water bath to reach the desired initial temperature. Then, the required amount of methanol was added to the mixture and ultrasonification was immediately started. The ultrasonic irradiation was introduced in an intermitted mode under varying conditions. After the desired reaction time, excess methanol was distilled off under vacuum. The mixture was then centrifuged in an Eppendorf centrifuge at 2500 rpm for 20 min. The biodiesel layer was then collected for GC analysis. All the experiments were carried out at atmospheric pressure.

III. MATERIALS

3.1) Karanja (Pongamia Pinnate)

It is available in Western Ghats of India. The average life of Karanja tree is 80-100 years and grows a height of 40 feet. It can grow in humid and subtropical environment within sustainable temperature of 5-50 0C and an average rainfall of 600-2500 mm. The average yield of kernel per tree is about 9-90 Kg per year and the oil production is approximately 1, 35,000 metric tons per year in India [2]

Table1. Fatty acid composition in Karanja oil (PongamiaPinnate)

Sr.No	Fatty acid	Structure	Weight (%)
1	Palmitic	C16:0	11.6
2	Stearic	C18:0	7.5
3	Arachidic	C20:0	1.7
4	Oleic	C18:1	51.5
5	Linoleic	C18:2	16.0
6	Linolenic	C18:3	2.6
7	Lignoceric	C24:0	1.0

3.2) Karanja fuel Properties:

Table2. The comparison of chemical properties of karanja oil methyl esters (KOME) and Diesel is as [2]

Sr.No	Properties	KOME	Rawkaranja oil	Diesel
1	Specific Gravityengine	0.860	0.912	0.840
2	FlashPoint	144	241	74
3	Kinematic Viscosity Cst@40°C	4.78	29.65	2.98

IV. PERFORMANCE CHARACTERISTICS.

Brake power is higher for the dual fuel combustions from B50 to B30 than Diesel. In case of B40, the B.P. is more or less equal to that of Diesel. For the dual fuel combinations from B50 to B100, the B.P. is less than that of Diesel. As the load increases, BSFC decreases to the minimum of at 70% load and then increases for all the fuel samples tested. This can be correlated that B.P. increases as the load increases. As the load increases, brake thermal efficiency increases up to 70% load and then decreases for all the fuel samples tested. The low brake thermal efficiency for B60, B80 and B100 may be due to the lower HHV and the increase in fuel consumption. [1]

The engine performance of biodiesel is similar to that of diesel with nearly same thermal effiency, but with higher fuel consumption due to lower calorific value and biodiesel produce lower co emission 20-30% that of diesel fuel at all load engine conditions. Also the unburnt carbon and NOx emission are reduced. [6]

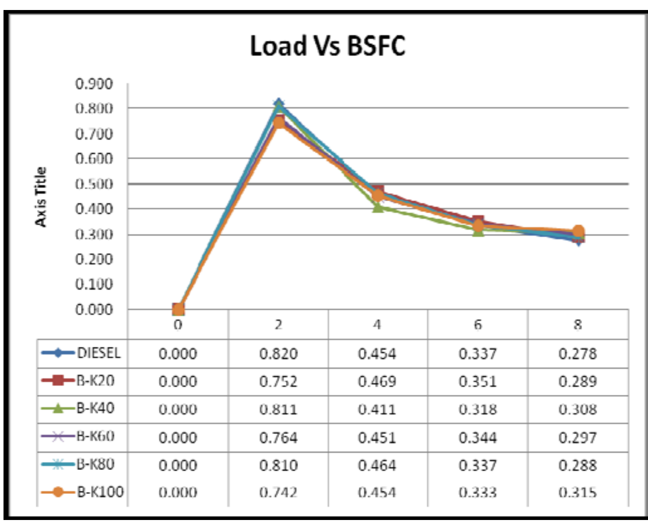

Figure 2.BSFC (kg/kW.hr) Vs Load on Engine [6]

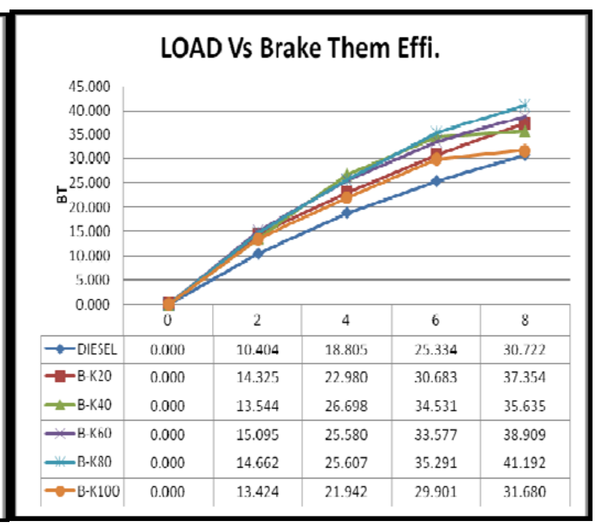

Figure 3.Thermal Efficiency Vs Load on Engine [6]

V. REVIEW OF VARIOUS LITERATURES.

The literature reviews in with this topic is in below table with chronological order.

Table 3. Review of Various Literatures

Author	**Year of paper published**	**Parameter**	**Objective of the research paper**	**Outcomes**
N. Stalin and H. J. Prabhu	ARPN Journal of Engineering and Applied Sciences 2007	Performance test of IC engine using Karanja biodiesel blending with diesel	To study the alternative technological methods thatcould be used to produce this fuel..Performance of IC engine using karanja biodiesel blending with diesel and with various blending ratios has been evaluated.	From Testing torque, brake power and brake thermal efficiency reach maximum values at 70% load. B40 can be recommended for use in the diesel engine without making any engine modifications. The cost (B40) can be considerably reduced than pure diesel.
Venkata Ramesh Mamilla, M. V. Mallikarjun and Dr.G.LakshmiNarayanaRao	IJEOE 2008	Preparation of biodiesel from karanja oil	Biodiesel waspreparedfromthenon-edibleoilof Karanja bytransesterification of thecrudeoil with methanolin thepresenceofNaOHascatalyst.	Karanja oil wastransesterified using NaOHas catalystandmethanoltoformbiodiesel. Thefuelpropertieslike viscosity,density,flash pointfire pointand calorific valueof thetransesterified product (biodiesel)comparewell withaccepted biodiesel standardsi.e.ASTMandGermanbiodieselstandards.The viscosity of biodiesel oilis nearertothat of dieselandthe calorificvalueisabout12%lessthanthatofdiesel.
Dahai Yu Li Tian, Hao Wu, Song Wang, Ye Wang, Dongxiao Ma, Xuexun Fang	Renewable and sustainable Energy reviews Elsevier Journal 2009	Ultrasonic irradiation with vibration for biodiesel production from soybean oil by Novozym 435	The production of biodiesel with soybean oil and methanol through transesterification by Novozym 435 were conducted under two different conditions ultrasonic irradiation and vibration to compare their overall effects. Compared with vibration, ultrasonic irradiation significantly enhanced the activity of Novozym 435.	It was observed ultrasonic irradiation with vibration was proved to be an efficient method for enzymatic biodiesel production. Under ultrasonic irradiation, enzyme activity of Novozym 435 was enhanced in transesterification reaction of soybean oil and methanol. The ultrasonic assisted reaction generated equivalent yield of FAME in relatively shorter time compared with that of vibration. When ultrasonic irradiation and vibration were used together, biodiesel production rate was further enhanced

Babak Salamatinia, Hamed Mootabadi, Subhash Bhatia, Ahmad Zuhairi Abdullah	Fuel Processing Technology Elsevier Journal 2009	Optimization of ultrasonic-assisted heterogeneous biodiesel production from palm oil: A response surface methodology approach	Use of ultrasonic processor in the heterogeneous transesterification of palm oil for biodiesel production has been investigated. Response surface methodology was employed to statistically evaluate and optimize the biodiesel production process catalyzed by two alkaline earth metal oxide catalysts i.e. BaO and SrO.	This study proved the effectiveness of ultrasonic irradiation in improving the transesterification process towards biodiesel production. The optimization of the process for BaO and SrO catalysts using ultrasonic energy was successfully conducted by fitting the experimental data into a historical design and a response surface methodology was then performed. Two mathematical models were developed by the software and they were able to accurately predict the biodiesel yield at any point in the range of the variables with a high level of significance (N 99.99%). The coefficients of determination for the BaO and SrO catalysts were found to be 93.62 and 92.65%, respectively.
Siriporn Larpkiattaworn, Chalermchai Jeerapan and Rattikan Tongpan	7thBiomass Asia Workshop ,November29-December 01,2010, Jakarta,Indonesia	Ultrasonic Transesterification Reaction for biodiesel	Inthiswork,theeffectofultrasonicconthetransesterification reactionofjatrophaoiltobiodieselwas studiedinbothhomogeneous andheterogeneous catalystsystems.Allreactionswereoperatedat9:1 methanoltooilratio	Ultrasonicirradiationcanprovide thepropertiesof biodieselsuchasviscosityand mono-,di-,tri-glyceridecontentswhichare withinthelimitofEN standard. Moreoverthismethodcouldreducethe transesterification reactiontimeto 20secfor homogeneoussystem,andto1hforheterogeneoussystemwithusing15%K/Al_2O_3catalyst.
Ramchandra S. Jahagidar, Eknath R. Deore, Milind S. Patil, Purushottam S. Desale	Proceedings of the World Congress on Engineering 2011 Vol III WCE 2011, July 6 - 8, 2011,	Performance characterization of single cylinder diesel engine fueled with karanja biodiesel	To make an experimental investigation on single cylinder diesel engine fuelled with the blends of Karanja and Diesel. Engine performance is also evaluated using pure Karanja fuel without any modification in a present engine.	Result shows that the break power of the engine was almost same for all the loads &break thermal efficiency of the Karanja biodiesel where improved by 3 to 8%, Volumetric efficiency is also improved with reduction in exhaust gas temperature. The Karanja biodiesel can itself directly used in the engine without any major

	London, U.K.			modification.
Ambarish Datta and Bijan Kumar Mandal	IJSER 2012	Biodiesel Production and its Emissions and Performance: A Review	To study the feasibility of biodiesel in current engine and its performance and emission characteristics	Biodiesel can be prepared from different renewable feedstocks like vegetable oil, waste cooking oil, animal tallow and algae. In India, the potential non- edible feedstocks are Karanja, jatropa, polanga. The engine performances of biodiesel are comparable to that of mineraldiesel. Emission characteristics of biodiesel are better than diesel fuel except NOX emission. The carbon monoxide, un- burned hydrocarbon and particulate matter are found to be less in the tail pipe emissions. But and oxides of nitrogen are found to be slightly greater in exhaust in case of biodiesel compared to mineral diesel. The higher viscosity also enhances the lubricating property and excess oxygen content results better combustion for biodiesel.
Ali Sabri Badday, Ahmad Zuhairi Abdullah Keat Teong Lee , Muataz Sh. Khayoon	Renewable and sustainable Energy reviews Elsevier Journal 2012	Intensificationof biodiesel production via ultrasonic-assisted process: A critical review on fundamentals and recent development	This paper highlights recent development in the production of biodiesel under ultrasonic irradiation conditions. It handles the drawback of poor immiscibility between reactants as ultrasonic energy can emulsify the reactants to reduce the catalyst requirement, reactiontime and reaction temperature.	Ultrasonic irradiation has been proven to be successfully used in a meaningful way to enhance the emulsification of the reactants to increase the mass transfer rate during the reaction. This enhancement leads to reductions in reaction time, catalyst amount, alcohol-to-oil ratio and reaction temperature causing a significant decrease in the production economics. Ultrasonic irradiation was tested for wide range of homogenous and heterogeneous catalysts and showed promising results on the reaction variables compared with the results of conventional process.
BobadeS.N.andKh	RJCES	Preparation of	To propose	The Karanja biodiesel from

yadeV.B	2012	methyl ester (biodiesel)from Karanja oil	giveshighlevelofconversionoftriglyceridestotheircorrespondingmethylester inashortduration	refined vegetable oils meets the Indian requirementsof high speed dieseloil.Buttheproduction ofbiodieselfromedibleoilis currently muchmore expensive than diesel fuelsdue to relativelyhighcost ofedibleoil. Thereisaneed toexplorenon-edibleoilsasalternativefeedstockfortheproduction of biodieselnon-edible oillikekaranja.
K.Ramachandran,,T.Suganya, N.NagendraGandhi, S.Renganathan	Renewable and sustainable Energy reviews Elsevier Journal 2013	Recent developments For biodiesel production by ultrasonic assist transestrification using different heterogeneous catalyst	To check the different heterogeneous catalysts used in transesterification reaction for reducing process stages and cost effective.	Ultrasonic irradiation has been confirmed to be successfully used in a significant way to improve the emulsification of the reactants to increase the mass transfer rate during the transesterification reaction. This improvement leads to reductions in reaction temperature, reaction time, alcohol to oil ratio and catalyst amount causing a significant decrease in the biodiesel production cost.
Babak Salamatinia, Hamed Mootabadi Iman Hashemizadeh	Chemical Engineering and Processing: Process Intensification Elsevier Journal 2013	Intensification of biodiesel production from vegetable oils using ultrasonic-assisted process: Optimization and kinetic	Intensification of biodiesel production process using low frequency ultrasonic irradiation (20 kHz, 200 W) is elucidated in this study.	This study proved the effectiveness of ultrasonic irradiation in improving the transesterification process towards biodiesel production.. As a conclusion, there is a high potential of ultrasonic waves to be used in the accelerated production of biodiesel using heterogeneous catalysts.
Swarup Kumar Nayak1 , Sibakanta Sahu1, Saipad Sahu1, Pallavi Chaudhry	IJSER 2013	Experimental Investigation On Performance And Emission Characteristics Of A Diesel Engine Fuelled With Karanja Oil Methyl Ester Using additive	To study the Karanja oil used as a source for biodiesel production via base catalyzed transesterification and biodiesel produced in the process is mixed with an additive (Dimethyl Carbonate) in varying volume proportions to prepare a number of test fuels for engine application	The result shown that brake thermal efficiency increases with increase in additive percentage in biodiesel and it is lower in case of pure biodiesel.BSFC is highest for pure biodiesel and decreases with increase in additive % in biodiesel.Exhaust gas temperature is found highest for pure biodiesel and tends to decrease with increase in additive % in biodiesel.CO and HC emission are found highest for diesel and decrease with increase in additive

				percentage in biodiesel.Smoke and NOx emissions are found highest for pure biodiesel and decrease with increase in additive % in biodiesel.
RahulSaha Vaibhav V.Goud	Biomass Cony. Biroef DOI 10.1007/s13399-014-0133-7 June 2014	Ultrasound assisted transesterification of high free fatty acids karanja oil using heterogeneousbasecatalysts	Production of fuel-quality biodiesel from high free fatty acid (FFA) feed stock, such as karanja oil, was investigated by ultrasonic assisted technique using dual step process. The initial acid value of oil was found to be33mg KOH/g corresponding to FFA level of 18 %, which was far above 1 % limit for satisfactory transesterification reaction using alkali catalyst.	The amount of acid catalyst used for esterification process also affects the acid value. During esterification, sulphuric acid loading was varied from 0.25 to 1.5 wt% with constant reaction temperature (30 °C) and molar ratio 1:9 (oil: methanol). It can be seen that the reduction in acid value (33 to 4.8 mg KOH/g) was significant for increase in the catalyst loading from 0.25 to 0.5 wt%, as compared to further increase in the catalyst concentration from 1 to 1.5 wt%. It was observed that maximum conversion attained was around 84 % at room temperature. The results obtained during this study indicate that at lower temperature using ultrasonic irradiation the extent of methyl ester conversion was higher and when the temperature was increased the ester conversion decreased. The physical properties of karanja oil and its methyl ester were estimated using ASTM standards as shown in Table 2. The specific gravity of karanja oil methyl ester was found to be0.891, which is within the range of ASTM biodiesel standards.

VI. CONCLUSION

From above literature reviews following conclusions are derived

1) Production of biodiesel with conventional transesterification takes almost 24 hours,whereas using ultrasonic assistedtransesterification in only one hour so it is time saving process.
2) Ultrasonic assistedtransesterification produces biodiesel more economically than conventional method. The cost of biodiesel blends (B40) can be considerably reduced than pure diesel.

3) Biodiesel produce lower CO emission 20-30% that of diesel fuel at all load engine conditions. Also the unburnt carbon and NOx emission are reduced. As the load increases, brake thermal efficiency increases up to 70% load and then decreases for biodiesel blends.
4) The Biodiesel blends of B40 can be recommended for use in the diesel engines without making any engine modifications.

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