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Bio Diesel from Karanja oil as an Alternative Fuel for Diesel Engine

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Abstract: *The world is getting modernized and industrialized day by day. The awareness about the environment rose among general civic to search for an alternative fuel that could burn with not as much of the pollution. But energy sources used in these engines are limited and decreasing gradually. This situation leads to seek an alternative fuel for diesel engine. Biodiesel is an alternative fuel for C I engine. The esters of vegetables oil animal fats are known as Biodiesel. This paper investigates the prospect of making of biodiesel from Karanja oil. It is botanical name* Pongamia pinnata *is a renewable non-edible plant. Karanja is a wildly growing hardy plant in all regions of the country on degraded soil having low fertility and moisture. Hence, it is seen that 950ml biodiesel is Produced from 1 liter of Karanja oil. The seeds of Karanja contain 70-75% oil. In this study the oil has been converted to biodiesel by the well-known Transesterification process and used it to diesel engine for performance evaluation. Finally after drying the found methyl ester is converted to the required biodiesel.*

Keywords: *Bio-diesel, Karanja Oil, Transesterification Process.*

1. Introduction

Petroleum-based fuels are used in almost all sectors of transportation used world. As the demand of these fuels increases, the price of the fuel also keeps on increasing day by day. It is becoming increasingly important to develop sustainable solutions to our energy needs. As fossil fuels are depleting at a faster rate and global warming more heavily affects our lives, the urgency of finding a solution to these problems is more obvious. Energy is essential for existence, economic growth and improving quality of life of people. Fossil fuels have been used as an important conventional energy source for years since their exploration. Energy demand around the world is increasing at a faster pace as a result of increasing trends in industrialization and modernization. Most of the developing countries import fossil fuels for satisfying their energy demand. This necessitates the search for alternative of oil as energy source. Biodiesel is an alternative fuel for C I engine. The esters of vegetable oils and animal fats are known collectively as biodiesel. It is a domestic, renewable fuel for diesel engine derived from natural oil like Karanja oil. Biodiesel has an energy content of about 10% less than petroleum-based diesel fuel on a mass basis. It has a higher molecular weight, viscosity, density, and flash point than diesel fuel. Pongamia pinnata is unusual among tree crops is a renewable non-edible plant. From Karanja seeds Karanja oil can be extracted which have similar properties as diesel but some properties such as kinematic viscosity, solidifying point, flash point and ignition point is very high in Karanja oil. Finally after drying the found methyl ester is converted to the required biodiesel. Hence, it is seen that 950ml biodiesel is Produced from 1 liter of Karanja oil.By some chemical reactions, Karanja oil can be converted into biodiesel. Karanja oil can also be used directly by blending with Bio-diesel. Some benefits of Karanja oil are as follows: The oil is being extensively used for making soap in some countries because it has a very high saponification value B. The oil is used an illuminants as it burns without emitting smoke. C. From the bark of Pongamia Pinnata a dark blue dye is produced which is used for coloring cloth, fishing nets etc. D. The byproduct of Jatropha seeds contain high nitrogen, phosphorous and potassium which is used for fish foods, domestic animals food and in lands as fertilizer. Alternative fuels, other than being renewable, are also required to serve to decrease the net production of carbon dioxide (CO_2), oxides of nitrogen (NOx), particulate matter etc. from combustion sources. The production of biodiesel is limited by land area but Pongamia pinnata trees can be cultivated in any kinds of land. Karanja is a wildly growing hardy plant, in arid and semiarid regions of the country on degraded soils having low fertility and moisture. It can be cultivated successfully in the regions having scanty to heavy rainfall even it can be cultivated even on fallow and barren lands. The seeds of Karanja contain 70-75 % oil. The compression ignition engines are widely used in the transport sector, a standby power unit in industries and in agricultural fields mainly because of their long life, reliability and economy. The global energy crisis of the 1970's prompted world countries to search for alternative energy sources, after being vulnerable to crude oil embargoes and shortages. For the past few decades, a lot of effort has been made to reduce the dependency on petroleum fuels for power generation and transportation all over the world. The climate changes occurring due to increased Carbon Dioxide (CO_2) emissions and global warming, increasing air pollution and depletion of fossil fuels are the major problems of today. The researchers have focused on the bio-fuels as environment friendly energy source to reduce dependence on fossil fuels and to reduce air pollution. The bio-fuels can play an important role towards the transition to a lower carbon economy and also combine the benefits of low green house emissions with the reduce of oil import. The use of biodiesel, a renewable resource, has several advantages. Bio-fuels are ideal alternative to dwindling fossil resources. In preparation for a future petroleum crisis, the United state recently made a commitment to triple the bio-fuel account for at least 2 % of the petroleum- based fuels market by the end of 2005 and a minimum of 5.75 % of the market by the end of 2010 (MacDonald, et al; 2004 and Biomass Research and Development Initiative. In Biomass Research and Development Technical Advisory Committee Recommendations to the Secretaries of Energy and Agricultural Newsletter, March 2002). Since 19th Century, ethanol has been used as fuel for diesel engines Ethanol is used as an alternative fuel, a fuel extender, oxygenates and an octane enhancer. It is a low cost oxygenated compound with high oxygen content (34.8%). Ethanol is most often chosen because of the ease of production, can be obtained from various kinds of biomass such as maize, sugarcane, sugar beet, corn, cassava, red seaweed, etc., relatively low-cost and low toxicity Lapuerta et al. (2010) studied the stabilities, lubricity, viscosity, and could filter plugging point (CFPP) to increase the knowledge about the implications of the use of short-and long-chain alcohol/ diesel fuel blend in diesel engine. Blend of methanol, ethanol, propanol, butanol, and pentanol with diesel fuel have analyzed at 1, 2.5, 7.7, 17, 50 and 90 5 in volume (including 95 % (v/v in the case of CFPP). Results have that short- chain alcohols depict poor blending stability and low viscosity (mainly for concentration of ethanol and propanol in diesel fuel blend beyond 22 and 45 %, respectively). A systematic effect was observed in viscosity when moderate concentration of butanol and pentanol were mixed with diesel. It can be concluded that alcohols can be blended with diesel fuel under low and high concentration, although to improve the blending stability of short- chain alcohols in medium concentration, the use of additives or fatty acid esters would be necessary. Nagarhalli (2010) conducted experimental work to analyze the emission and performance characteristics of a single cylinder 3.67 kW, compression ignition engine fuelled with mineral diesel and diesel-biodiesel blends at an injection pressure of 200 bars. The performance parameters evaluated were break thermal efficiency, break specific energy consumption (BSFC) and the emissions measured were carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC), and oxides of nitrogen (NOx). The results of experimental investigation with biodiesel blends were compared with that of baseline diesel. The results indicate that the co emissions were slightly higher, HC emissions decreased from 12.8 % for B-20 and 2.85 % for B-40, NOx emissions decreased up to 39 % for B-20 and 28 % for B-40. The efficiency decreased slightly for blends in comparison with diesel. The basic was slightly more for B-20 and B-40. From the investigation it can be concluded that biodiesel can be used as an alternative to diesel in a compression ignition engine without any engine modifications. Lokesh (2011) estimated that by 2011, 20 % of bio-energy needs of India should be met by biodiesel. To meet these expectations it would require 12 to 13 million hectares of biodiesel feed stock plantations. Currently biodiesel is produced using non-edible oil. From tree like Jatropha Curcas. This strategy of propagating Jatropha Curcas as primary bio diesel feed stock has certain drawbacks. This paper addresses the shortcomings in the present strategy and suggests few alternatives, i.e. Farmers can be encouraged to grow short duration annual crops like Ricinus Comunis (castor), which can be used to produce biodiesel. Alternate plantation in wasteland with trees like Calophyllum Inophyllum (Undi) with 50-73% oil, Diploknema (Aisandra) with 60% oil and Simarouba Glauca (Lakshmi Tharu) with

60-75% oil may be explored. In addition, microalgae, which have much faster growth-rate than terrestrial crops and yield oil between 4.6 to 18.4 l/m^2 per year may be a prospective feed stock for bio diesel production. There is a need for developing alternate, multipurpose crop plantation strategies and methods for producing bio-fuels. Nevertheless, without affecting the farmer's needs of food, fodder and fuel wood for cooking.

2. METHODOLOGY

The use of biodiesel is an effective way of substituting diesel fuel in the long run. One important conclusion that can be drawn from the work done earlier is that the vegetables oils can't be used directly in the C I engine. Several problems crop up if unmodified fuel is used and viscosity is the major factor. It has been found that transesterification is the most effective way to reduce the viscosity of vegetable oils and to make them fit for their use in the present C I engines without any modification. Transesterification is the process by which biodiesel is produced. In this process an ester reacts with an alcohol to form another ester and another alcohol. The catalyst for this reaction is KOH or NaOH. Three mol methanol's react with one mol triglyceride which produces mixture of fatty esters and glycerin. The industrial-scale processes for transesterification of vegetable oils were initially developed in the early 1940s to improve the separation of glycerin during soap production. The primary input is assumed to be oil that has previously been extracted from Karanja oil seed. To accomplish the transesterification reaction described above, the oil, methanol, and catalyst are mixed together in a stirred reactor one hour. 45º-55º C temperatures will cause the reaction to reach equilibrium more rapidly; in most cases the temperature is kept below the normal boiling point of the methanol (65ºC) so the reactor does not need to be pressurized. As shown in the reaction equation below, three moles of methanol react with one mole of triglyceride. In practice, most producers will use at least 100% excess methanol to force the reaction equilibrium towards a complete conversion of the oil to biodiesel. The reaction is slowed by mass transfer limitations since at the start of the reaction the methanol is only slightly soluble in the oil and later on, the glycerin is not soluble in the methyl esters.

The catalyst tends to concentrate in the glycerin; it can become unavailable for the reaction without agitation. A common approach to overcome this issue is to conduct the transesterification in two stages. First, the oil is combined with 80% to 90% of the methanol and catalyst and this mixture is allowed to react to equilibrium. Then, the glycerin that has formed is separated by gravity separation and the remaining 10% to 25% of the methanol and catalyst is added for a second reaction period. At the conclusion of this second reaction period, the remaining glycerin is separated and the biodiesel is ready for further processing. After the biodiesel is separated from the glycerol, it contains 3% to 6% methanol and usually some soap. If the soap level is low enough (300 to 500 ppm), the methanol can be removed by vaporization and this methanol will usually be dry enough to directly recycle back to the reaction. Methanol tends to act as a co-solvent for soap in the biodiesel, so at higher soap levels the soap will precipitate as a viscous sludge when the methanol is removed.

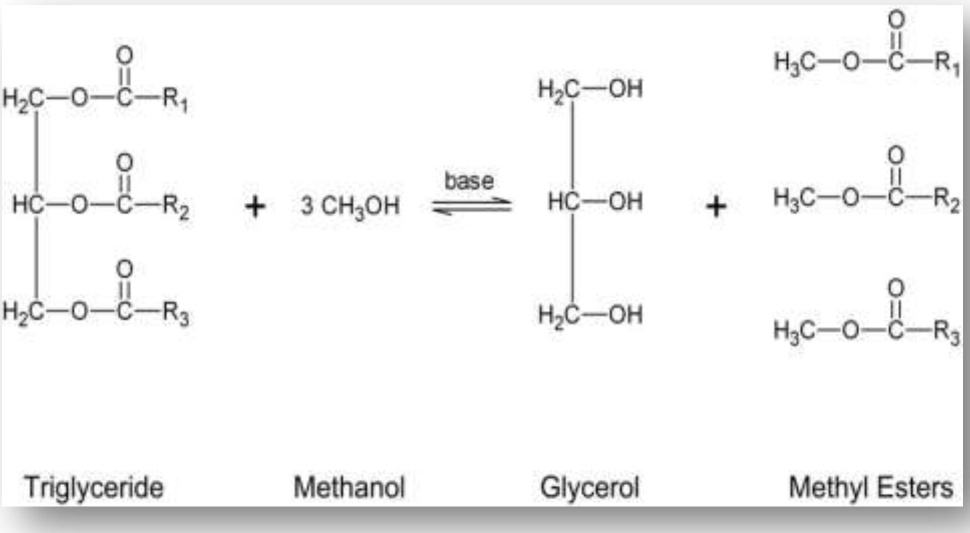

Figure1.*The reaction Process*

After the methanol has been removed, the biodiesel needs to be washed to remove residual free glycerin, methanol, soaps, and catalyst. The washing process is usually done multiple times until the wash water no longer picks up soap. Although the gray water from later washes can be used as the supply water for the earlier wash steps, the total amount of water will typically be one to two times the volume flow rate of the biodiesel. Sometimes reduce the amount of water required; producers will add acid to the wash water. Weaker organic acids, such as citric acid, will neutralize the catalyst and produce a soluble salt.

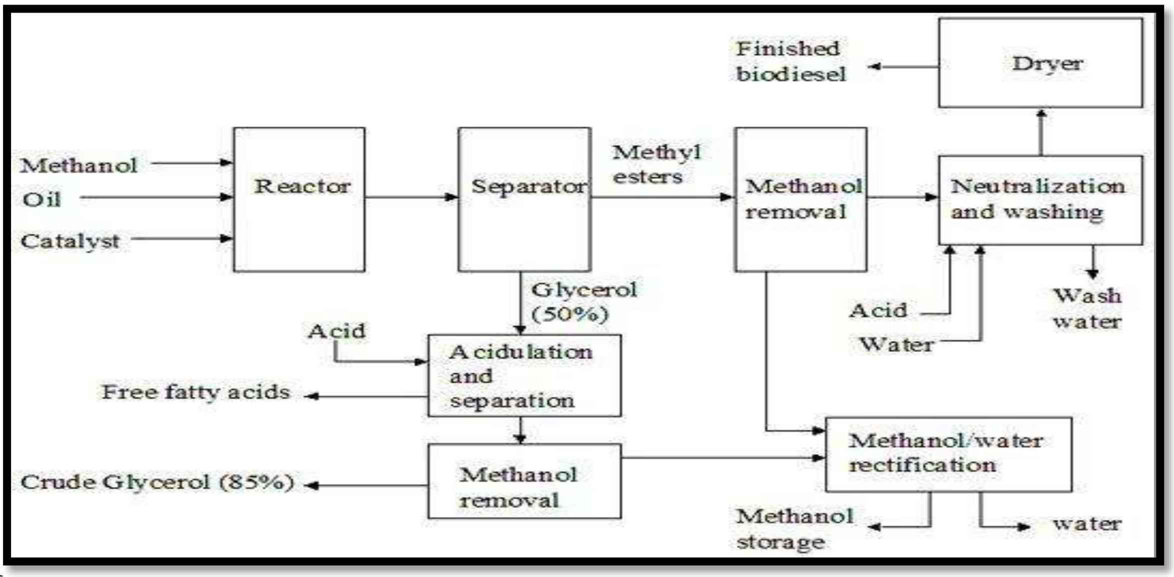

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Figure2.*Schematic of Biodiesel Processing*

The glycerin that is separated from the biodiesel will contain a substantial amount of methanol, most of the catalyst, soaps that have been formed during the reaction and many of the polar contaminants that were originally present in the oil. These contaminants contribute to a dark brown or black color for the glycerin in spite of it being clear when present as a pure compound. The raw glycerin has very little value and must be upgrade to raise its purity before it can be sold. The usual practice is to add strong hydrochloric acid to the glycerin to neutralize the catalyst and split the soap. The reactions are given below,

Soap + Hydrochloric Acid → Fatty acid + Salt

Fatty acid + NaOH → Soap + Water

The soaps split into free fatty acids and salt, as shown in the equation. The fatty acid is not soluble in the glycerin and can be separated with a centrifuge. The methanol can be removed by vaporization leaving a crude glycerol that is 80% to 90% pure. Most of the impurities will be salts. The fatty acids are not soluble in the glycerin and can be separated with a centrifuge. These high free fatty acid oils present special challenges when used for biodiesel production. When an alkali catalyst is added to these feed stocks, the free fatty acid reacts with the catalyst to form soap and water as shown in the above reaction. This reaction makes the catalyst unavailable for catalyzing the reaction and if enough soap is produced it can inhibit the separation of the methyl esters and glycerin. When oils and fats with high free fatty acids are to be used for biodiesel production, an acid catalyst such as sulfuric acid can be used to esterify the free fatty acids to methyl esters. Then, the Methanol with the fatty acid are converted to methyl esters, a conventional alkali-catalyzed process can be used to transesterify the triglycerides in the feedstock. While acids can be used to catalyze the transesterification reaction, the reaction is very slow at the 50° to 0°C reaction temperature the two-step approach of acid-catalyzed esterification followed by base-catalyzed transesterification gives a complete reaction at moderate temperatures. A problem with this approach is that the water produced by the esterification reaction should be removed before the base catalyzed process begins so that soap formation is not excessive. This can be done by settling or centrifuging the methanol-water-acid layer that separates after the esterification has reached equilibrium. Finally after drying the found methyl ester is converted to the required biodiesel. Hence, it is seen that 950ml biodiesel is Produced from 1 liter of Karanja oil.

3. Results and Discussion

3.1. Experimental Set-Up and Procedure

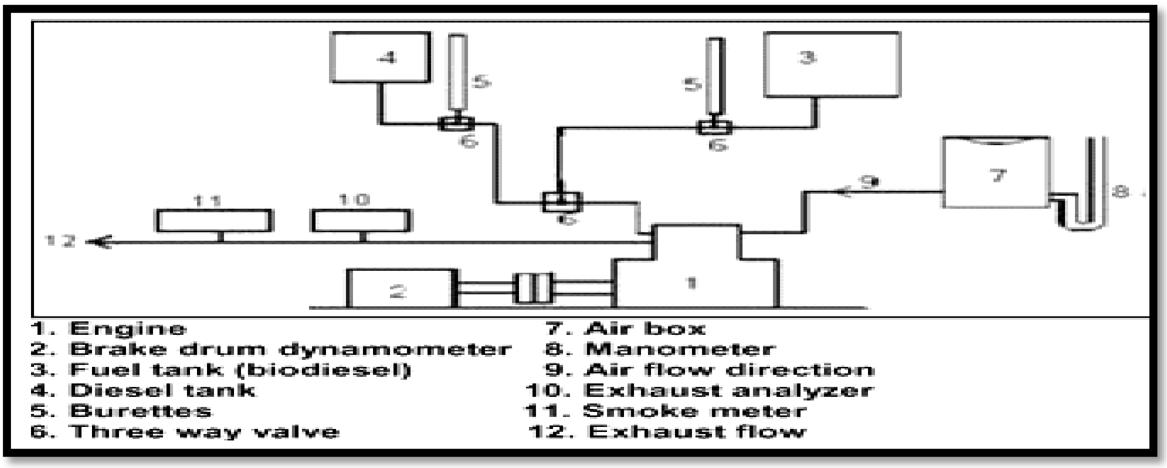

Figure3. *Experimental Set-Up*

The final product of biodiesel from Karanja oil is used as an alternative fuel to operate C I engine in the CIAE Bio-fuel Laboratory. The engine has been run using biodiesel and required data are collected to calculate the engine performance parameters. The tested engine specification is shown in Table-1 & 2.

Table1. *The properties of Karanja oil, Biodiesel and different substitute fuel*

Sl. No.	Fuel Notation	Relative Density	Kinematic viscosity at 30°C	API Gravity	Flash point (^{0}c)	Fire point (^{0}c)
1.	Karanja oil	0.9200	52.3	22.31	-	-
1.	Bio-diesel	0.8888	25.7	27.7	164	169.2
2.	Ethyl Acetate	0.9062	24.9	24.6	-0.5	5.0
Ethanol proof						
3.	Ethanol 200^0	0.7923	27.6	47.1	16.7	21.5
4.	Ethanol 190^0	0.8113	27.9	42.9	18.2	23.8
5.	Ethanol 180^0	0.8265	27.9	39.7	20.2	26.3
6.	Ethanol 170^0	0.8416	28.2	36.6	20.8	26.7
Substitute fuel						
7.	200^0-10/0/90	0.8820	12.7	28.9	38.0	43.5
8.	200^0-15/5/80	0.8750	11.0	30.2	25.4	30.8
9.	200^0-20/10/70	0.8740	6.6	30.3	22.5	27.3

Table2. *Observed Value of Different Parameters at Full Load*

Parameter	Substitute Fuel		
	200^0-10/0/90	**200^0-15/5/80**	**200^0-20/10/70**
Brake power (kW)	3.674	3.684	3.676
Fuel consumption (l/h)	2.037	2.002	2.071
BSFC (kg/kW-h)	365	357	369
Emission of O_2 (%)	3.1	4.0	4.0
Emission of CO_2 (%)	5.5	4.0	4.1
Emission of NO_2 (ppm)	613	625	607
Emission of NO (ppm)	681	625	607

4. Conclusion

Biodiesel is a viable substitute for petroleum-based diesel fuel. Its advantages are improved lubricity, higher cetane number, reduced global warming, and enhanced rural development. Karanja oil has potential as an alternative energy source. However, this oil alone will not solve our dependence on foreign oil within any practical time frame. Use of this and other alternative energy sources could contribute to a more stable supply of energy. Major production centers on the level of modern petroleum refineries have not been developed. The economics of biodiesel fuels compared to traditional petroleum resources are marginal; public policy needs to be revised to encourage development. Increased Karanja oil production would require a significant commitment of resources. Land for production would need to be contracted, crushing and biodiesel production plants need to be built, distribution and storage facilities constructed, and monitoring of users for detection of problems in large scale use are all needed to encourage development of the industry. To meet the challenges of excessive import, we have to strengthen our oilseed sector and lay special emphasis on harnessing the existing and augmenting future potential source of green fuel. The organized plantation and systematic collection of Karanja oil, being potential bio-diesel substitutes will reduce the import burden of crude petroleum substantially. The emphasis should be made to invest in agriculture sector for exploitation of existing potential by establishing model seed procurement centers, installing preprocessing and processing facilities, oil extraction unit, trans-esterification units etc. There is also need to augment the future potential by investing largely on compact organized plantation of Karanja on the available wastelands of the country. This will enable our country to become independent in the fuel sector by promoting and adopting bio-fuel as an alternative to petroleum fuels

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