Performance of a CI Engine using Karanja Biodiesel Blend: A Review

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Abstract:- Nowdays as we know that energy is basic need of every life. Basic sources of energy are fossil fuel such as natural gas, coal and petroleum products such as diesel and gasoline. Increasing demand of petrol, depleting reserves of oil, concerns about environmental and governmental policies. Also the increasing fuel rate has make it essential to search for alternate fuel .Thus producing an efficient alternative renewable fuel for power generation can be proved as a good substitute and environmental friendly for today's power crisis. As the oil prices are increasing day- by-day and the fossil fuels are depleting, to overcome such situations one of the alternative fuels is bio-fuel such as bio-diesel which can be produced using resources available locally within the country. One of the economical source for biodiesel production is by the use of non edible oil. The present research work aims to carry investigation on performance, energy and exergy analysis of Compression Ignition (CI) Engine by using non edible Karanja oil. The thermal efficiency of any thermal system and its energy losses in are calculated from the 1st law of thermodynamics, while the exergy or maximum work output is calculated from the 2nd law of thermodynamics. Exergy analysis helps us to find out availability which cannot be possible with the use of energy analysis. Extension of Exergy is thermoeconomics that provides system designer not available through conventional energy and economic evaluation but crucial to design and for cost -effective system .

Key Words: karanja biodiesel, exergy, energy, CI engine, performance analysis

1. INTRODUCTION

In day today life energy has became one of the important necessity of life. From Urban to rural life everyone is dependent upon energy. Petroleum is found to be one the dominant energy source in fulfilling human basic needs.

Biodiesel is found to have such similar physical characteristics like diesel. It is renewable, cleaner-burning, alternative for petroleum based diesel fuel. It is safe to handle and transport because it is biodegradable as sugar. Also when mixed with petroleum diesel, biodiesel is compatible with unmodified engines. Biodiesel is the most common biofuel and since it is primarily derived from plants and animals, the supply can be replenished by means of farming and recycling. With that byproduct of bio fuel can be used as manure, fertilizers and pharmaceutical and cosmetic industries. Methanol and free fatty acids (soaps) are the two major impurities contained in crude glycerol obtained as byproduct during biodiesel production. The two most widely used bio fuel are ethanol and biodiesel. Others include butane, methanol, Fischer-Tropsch diesel and gasoline. Gaseous biofuel are hydrogen and methane.

1.1 Classification of biofuel

According to their source.

Derived from the forest, agricultural or fishery products or municipal wastes, including by-products and wastes originated from agro-industry, food processing, and food industrial services.

According to their type.

- Soilid pellets i.e. fuelwood, charcoal, and wood pellets.
- Liquid such as ethanol, biodiesel and pyrolysis oils
- Gaseous such as biogas.

The United States and Brazil listed among the largest biodiesel producers in the world, totaling some six and 4.3 billion liters, respectively, in 2017. The United States has planned to reach production levels of over 1 billion gallons of biodiesel by 2025. After the implementation of the Energy Policy Act 2005 which provided tax incentives for certain types of energy, biodiesel production in the U.S began to increase [2]. SpiceJet flew India's first biofuel flight, from Dehradun to Delhi with blended biojet fuel in the present year 2018 ,which can be said to be an encouraging step towards use of alternative fuels for transportation and aviation sector. The National Policy on Biofuels 2018 expect a target of 20% blending of ethanol in petrol by 2030 [1].

2. DETAILS OF NON EDIBLE KARANJA OIL

Biodiesel is produced mainly from vegetable oils by transesterification of triglycerols. But From economic and social reasons, edible oils should be replaced by lower-cost and reliable feedstocks for biodiesel production such as non-edible plant oils. Karanja also called as Pongamia pinnata is among one of those non edible oils. It is a species of family Leguminasae, native in tropical and temperate Asia including part of India, China, Japan, Malaysia, Australia. It is drought resistant, semi-deciduous, nitrogen fixing leguminous family tree. It's height is about 15-20 m with a large canopy spreads equally wide [14].

The production potential per hectare is 900 to 9000 Kg/hectare. Infact, Pongamia oil has got a potential of 135000 million tones per annum and only 6% is being utilized. The tree stands best for intense heat and sunlight and its dense network of lateral thick roots make it drought tolerant. Karanja has a potential to be used as a main feedstock for the production of biodiesel. These trees can grown with minimum care like on sides of roads, canal and boundary portion of agricultural lands. Its seeds contain 27 - 39% of the oil .

The 20% blend of KOME with diesel (B20) is the most optimized blend for a diesel engine. The Brake thermal efficiency (BTE) and Brake specific fuel consumption (BSFC) of B20 is much comparable to diesel. Emissions of exhaust gases CO, HC and smoke are reduced and NOx is increased with increasing blending of KOME with diesel. It is also found that in increase in injection pressure results in improvement in performance with esters and blends with Karanji oil. The yield of 97% of Karanja oil methyl ester (KOME) was obtained from Karanja oil (KO) by transesterification process at 65 °C using 1 wt% of KOH, 6:1 M ratio of methanol to oil in 2 h [9].

2.1 Different methods of Preparation of Karanja Biodiesel

Before Direct use /Blending

Vegetable oil can be directly used as diesel fuel without any changes to engine.The very first engine (by Rudolf Diesel) was tested was tested using vegetable oil as fuel. The primary concerns with vegetable oil as fuel is high viscosity which makes atomization of vegetable oil difficult which leads to problem in long run.

Preheating

This is another way to improve the viscosity of the oil. The viscosity of the oil decreased with increased its temperature. The kinematic viscosity of oil was 29.65, 10.23 and 5.23 cSt and density was 938, 870 and 850.2 kg/m3 at 30 °C, 70 °C and 100 °C respectively. The Viscosity and density of Karanja oil found very close to diesel at 100 °C [9].

Degumming

This is a simple and economical technique to reduce the viscosity of the oil. This process also improves cetane number and removes gummy material like phosphatides, protein, carotene and colorants of the oil. In this process, oil is stir and heated in the presence of the certain acid for 10–15 min and then the mixture kept 6–7 days to complete the reaction. Gummy materials settled at the bottom portion. Degummed oil is washed by water for two to three times to remove the acid concentration.

Micro emulsification

This is a simple and economical technique to reduce the viscosity of the oil. This process also improves cetane number and removes gummy material like phosphatides, protein, carotene and colorants of the oil. In this process, oil is stir and heated in the presence of the certain acid for 10–15 min and then the mixture kept 6–7 days to complete the reaction. Gummy materials settled at the bottom portion. Degummed oil is washed by water for two to three times to remove the acid concentration because of lower viscosity.

Pyrolysis

This is a process in which chemical change occur in oil due to heating. This process carried out in the absence of air or oxygen. It is possible to produce biodiesel from edible, non-edible oil and animal fats by this process. Properties of biodiesel produced by this method are close to diesel fuel. The viscosity of soybean oil was reduce to 10.2 cSt by this approach.

Transesterification

In this process, the chemical reaction occurs between triglyceride and alcohol (methanol is widely used due to its lower cost and effectiveness). The mixture is stird and heated near to boiling temperature of methanol in the presence of a catalyst. At the end of the process, biodiesel and glycerol are produce. The presence of catalyst improves the reaction rate and yield. Catalysts like NaOH, KOH etc. are used for transesterification [23].

The reaction equations of this process are shown below.

(1) Triglyceride + ROH ↔ Diglyceride + RCOOR1

(2) Diglyceride + ROH ↔ Monoglyceride + RCOOR2

(3) Monoglyceride + ROH ↔ Glycerol + RCOOR3

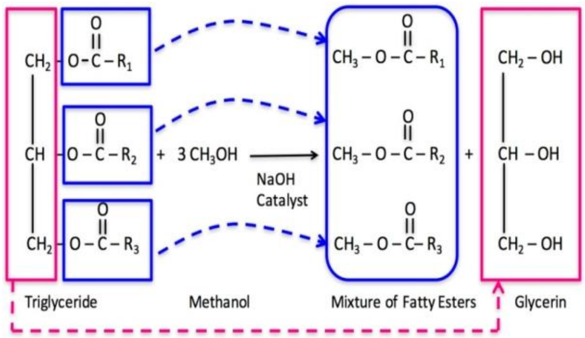

Fig -1: **Chemestry of biodiesel production**

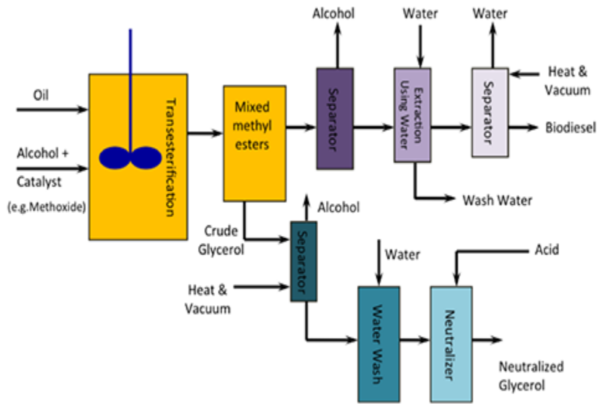

Fig -2: **Schematic of Biodiesel production using transesterification**

2.2 Local rate for domestic and non edible oils

Oil	(Rs/kg)
Groundnut oil	100
Rapeseed oil	83.5
Sunflower oil	60.5
Linseed oil	78
Sesame oil	78
Washed cottonseed oil	59
Castor oil	82.5
Karanja oil	60

3. LITERATURE REVIEW

T.Pushparaj et al (2012) had carried out performance tests on single cylinder, direct injection, water cooled diesel engine with neat diesel fuel & biodiesel 30% blend (B30) with ethanol in various percentage as additive. Biodiesel was made by transesterification process. Karanja oil was selected for biodiesel production. The effects of test on the engine power, engine torque, BSFCs and exhaust gases temperature were found and the experimental results showed that the use of biodiesel with ethanol additive improves the performance parameters and decrease the CO and HC emission as compared to diesel fuel. 10% ethanol as additive would give beneficial effects [3].

H.Raheman &, A.G. Phadatare (2004)have carried out emissions and performance of diesel engine using 20%, 40%, 60% and 80% blends of KOME with diesel and by pure KOME. Increase in torque, brake power, brake thermal effciency and reduction in brake-specific fuel consumption was found. Brake thermal efficiency of B20 and B40 was 26.79% and 26.19%, which was higher than pure diesel (24.62%). For B60, B80 and B100, efficiency was lower than pure diesel. For all blends, reduction in exhaust emissions CO, NOx and smoke observed as compared to diesel. The 40% blend of KOME with diesel was recommended to use as fuel without any hardware modification in the conventional engine [4].

G. Vidyasagar Reddy et al.(2004) carried out experiment of two bio diesels from jatropha oil (B20J),Mahua oil (B20M) and Dual biodiesel(B10M+B10J) blended with diesel. The effects of dual biodiesel and exhaust emissions were observed in a single cylinder, direct injection, air cooled and high speed diesel engine at various engine loads with constant engine speed of 1500 rpm. Results showed that at full load conditions the brake thermal efficiency B20J is higher than other blends. BSFC lowest for diesel compare to other blends. The emissions of CO and HC of dual biodiesel are lower than that of diesel. But NOx is higher in dual biodiesel compare diesel[5].

Rupesh L. Patel & C. D. Sankhavara (2017) obtained that 20% blend of KOME with diesel (B20) is the most optimized blend for a diesel engine. The Brake thermal efficiency (BTE) and Brake specific fuel consumption (BSFC) of B20 is comparable to diesel. Emissions of CO, HC and smoke are reduced and NOx is increased with increasing blending of KOME with diesel [6].

Srivastava and Verma (2008) have tested various blends of KOME in the single cylinder diesel engine.and observed lower thermal efficiency, higher BSFC and higher exhaust gas temperature for all blends as compared to diesel. Also, HC, CO and NOx emissions were found slightly higher for all blends than diesel [7].

P.K.Sahoo.et.al. (2009) had used jatropha, karanja, and polanga oil based methyl ester and blended with conventional diesel having sulphur content less than 10mg/kg. Ten fuel blends (diesel,B20,B50,B100) were tested for their use as substitute fuel for a water – cooled 3 cylinder tractor engine .Test data were generated based on engine speed (1200,1800&2200 rev/min) change in exhaust emission (smoke, CO,HC,NOx,&PM) were also analysed for determining the optimum test fuel at various operating conditions.The maximum increase in power was observed for 50% Jatropha biodiesel and diesel blend at rated speed. BSFC for all the biodiesel blends with diesel, increasesd with blends and decreased with speed. Reduction in smoke was also found with all biodiesel and their blends compared with diesel [8].

Padmanabhan S. et al. (2009) have derived performance and emission analysis on CI engine using soapnut oil as biodiesel. It have derived the result diesel has a lower specific fuel oil consumption because of high calorific value, with blended fuel B10 the equivalent SFC was very closer but higher than that of the diesel. The CO, HC and CO2 emission are reduced as compared to the pure diesel [9] .

Likita Bwonsi et al. (2017) have carried out the energy and exergy analysis on 4-stroke, single cylinder, air cooled, diesel engine fuelled with biodiesel fuel from palm kernel oil and its blends with petroleum diesel. It has concluded that the both thermal and exergy efficiencies reduce with increasing load and increase with increasing speed. Exergy efficiency maximum values range from 28.18% to 38.12%, B60 is the least efficient. It has also concluded that the diesel100 is more efficient than the biodiesel derived from palm kernel oil [10].

Perihan Sekmen & Zeki Yılbaşi (2011) analyzed the quantity and quality of energy in a four-cylinder, direct injection diesel engine using petroleum diesel fuel and biodiesel fuel.And found that use of biodiesel fuel have the similar energetic performance values with that of diesel fuel. Likewise, the use of biodiesel develops similar exergetic performance values with that of diesel fuel. The most reasonable factor of the system inefficiency is the destruction of exergy by irreversible processes. This mainly occured by the combustion. Exergy losses due to the exhaust gas and heat transfer are other minor contributors in exergy destruction. In addition to these results, this study reveals that a combined energy and exergy analysis provides a much better and more realistic answer [11].

4. CONCLUSIONS

- Using 10%, 20%,30% and 40% fuel blends of karanja biodiesel with diesel KB20 have an overall better performance with regards to both engine performance and emission characteristics with varying load.
- Karanja as the most potential species to produce biodiesel in India, which could generate rural employment.
- The increment of NOx emission result in higher temperature can cause the loss of heat in convection hence increased unaccountable losses .
- The unaccounted losses were around 10% more in case of diesel than B20.
- Both thermal and exergy efficiency reduces with increase in load and increases with increase in speed. B60 is the least efficient.
- For waste heat recovery potentiality of that engine. Focus should be made on waste heat availability at low speed and low load condition whereas at high speed high load condition focus should be done on cooling water .
- Irreversibility caused due to combustion, exhaust gases and other contributors should be analysed and reduced, as exergy is destructed by irreversible process.
- The high exergy destruction is also due to the high value of the chemical exergy of the reactants and reaction which causes irreversibility so focus should also be made on transesterification reactor.
- Mostly all types of biodiesel blended with diesel with an increment proportion of 10-20% i.e (10%, 20%, 30%, ...100%) or (20%, 40%, 60%...100%) , so focus can be made on changing the blend mixture proportion for more accurate and unique results.

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