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A Review of Performance and Emission Studies in CI Engine Using Biodiesel Obtained from Mixed Feedstock's

Bharat Aher[1], Bhushankumar Manmode[2]
Department of Mechanical Engineering, JSPM Narhe Technical Campus, Pune, India
Corresponding Author: Bharat Aher

Abstract : *Consumption of fossil fuels and petroleum products in India is continuously rising the recent years. The alternative option for conventional vehicular fuels is biodiesel, which can be produced from the feedstock available abundantly in the developing countries due to their agricultural base. Indian National Biodiesel Policy does permit the production of biodiesel from non-edible vegetable oils. Bio-diesels produced from vegetable oils not only provide energy security but also reduces harmful emissions. To contribute to fuel supply, renewable energies such as non-edible oil such as Karanja, Jatropha,Mahua appear to be an attractive resources for biodiesel production in India as it can be grown on waste land and does not need intensive water supply. Moreover, the environmental issues concerned with the exhaust gases emission by the usage of fossil fuels also encourage the usage of alternative fuels such as biodiesel. In this regard, current review work is done on Karanja, Jatropha, palm, simarouba biodiesel to find suitability of combination. As not much focus on the use of combination of different biodiesel and their behavior in diesel engine not yet tested. In this regard, current work done to find suitability of combination of biodiesel as a potential source in near future.*
Keywords : *Biodiesel, Diesel Fuel , Jatropha oil methyl Ester, Karanja oil methyl ester*

I. Introduction

India currently ranks as the worlds 11th greatest energy producer accounting for about 2.4% of the world's total annual energy production, while it ranks as the 6th largest energy consumer accounting for about 3.3 % of the world's total annual energy consumption. About 70% of the total diesel demand is utilized by the transport sector [1]. This demand is going to increase due to the growing economy (8-10 %). Thus the dependency on imported petroleum is rapidly increasing as the domestic production is very less. It is estimated that India has only 0.4% of the world's proven reserves of crude oil .India meets about 70 % of its petroleum requirement through import which are expected to expand in the coming years. In India volume of crude oil imported increased from 11.66 million tons during 1970-71 to 163.59 million tons by 2010 to 2011 [2].

Government of India has recently formulated a biofuel policy with an aim to supplement about 10% of diesel consumption through biodiesel by the end of 2016–2017. This will cause an annual requirement of 835 million tons (Mt) of biodiesel which will be far below the potential estimate of non-edible base biodiesel (100 Mt/yr) [3]. Thus, there is a need to enhance the biodiesel production.

Further, over recent past year's stringent emissions legislations are imposed word wide on NOx, smoke and particulate emitted from diesel engine. CI Engines are also typically characterized for low carbon mono-oxides (CO) emissions, whereas oxides of nitrogen (NOx) emissions still remains high. Recently, many researchers are trying to work out key technology to meet forth-coming emission norms. This advancement in CI Engine comprises of direct injection (DI), turbo-charging, advanced high pressure injection system and electronic management system. However, exhaust gas recirculation (EGR) and after treatments are effective techniques to reduce NOx emissions [4].

Among the various alternative fuels under consideration, Biodiesel derived from Vegetable oil, is the most promising alternative fuel to conventional diesel fuel. In the present paper comparative analysis of various oils are done, because they are easily available in many regions of the country. The rapidly increasing interest of people towards automobile, moving machinery and off-road appliances have put front some serious issues. The continuous hike in fuel prices, demand for high power, economy, efficiency and year after year tightening emissions norms are some major issues.

II. Feedstock's description

Jatropha plant has the botanical name J. curcas, and it is a multipurpose bush/small tree belonging to the family of Euphorbiaceae; it can grow under a wide variety of climatic conditions like severe heat, low rain fall, high rain fall, and is a small deciduous tree (up to 5 m) which originates all over the India.

The seeds contain 30–35% oil by weight, which can easily be converted into bio-diesel meeting the standards. Recently Jatropha is being considered as one of the most promising potential oil source to produce biodiesel all over the world. The seeds and oil are not edible due to the presence of toxins as phorbol esters, trypsin inhibitors, lectins and phytates. The oil of Jatropha curcas consists of both saturated (14.2% palmitic acid and 7.0% stearic acid) and unsaturated fatty acids (44.7% oleic acid and 32.8% linoleic acid). In developing countries like India it has been identified as the major source of biodiesel [5].

Fig. 1 Jatropha seed and Karanja seed

Pongamia oil is non-edible oil extracted from seeds of Pongamia pinnata (L.), family Fabaceae commonly known as 'Karach', 'Karanja' in Assam. In India the plant is distributed in Andhra Pradesh, Orissa, Bihar, Jharkhand, Chhatisgarh, Madhya Pradesh, Karnataka, Kerala, West Bengal and Maharashtra. Karanja is medium sized fast-growing ever green tree, 12–15 m height, branches spread into hemispherical crown of dense green leaves. The yield of kernels per tree is between 8 and 24 kg. The karanja seed kernel contains 27–39 wt% oil. The oil is extracted from the kernel by traditional expeller, which yields 24–26% oil.

Among the non-edible oilseeds karanja is one of the potential plants having annual production of 2 lakh tons of oilseed or 60,000 tons of oil, while only 6% is being utilized presently [5].

Palm is one of the most productive and economically suitable as an alternative biodiesel source. Average oil yield from a palm tree is 3-4 times higher than any other conventional biodiesel feedstock like rapeseed or sunflower. Besides, palm oil production needs less N-fertilizers and the energy needed in palm mills is provided by the combustion of palm fibres and shells, which reduces the carbon footprint [6].

Simarouba's seed contain about 40 % kernel and kernels content 55 -65% oil. The amount of oil would be 1000 – 2000 kg/ha/year for a plant spacing of 5m x5m. It was used for industrial purposes in the manufacture of soaps, detergents and lubricants etc [7].

Comparative characteristics of jatropha and karanja biodiesel are given in table 1.

Table 1 : **Comparison of properties for Jatropha, Karanja [5]**

Sr. No.	Property	Biodiesel	
		Jatropha	Karanja
1	Cetane no.	52.31	44.25
2.	Iodine value	93	128
3	Saponification no.	202.6	202.5
4	Density @ 15^{o}C,[kg/m^{3}]	890	867
5	Acid value, [mg KOH/gm]of oil	0.4	0.002
6	Kinematic Viscosity, [mm^{2}/s]	4.84	5.57
7	Flash point,[^{o}C]	175	183
8	Calorific value,[MJ/kg]	39.58	36.06

Performance and emission characteristic of combination of various mixed feedstocks

G.Shirsath and M.S.Tandale et al. (2011) have studied the emission of Karanja and Jatropha biodiesel and its blend for diesel engine applications in which they reports on the use of combination of biodiesels derived from jatropha and karanja oils. Jatropha oil methyl ester [JOME] and Honge oil methyl ester [HOME] represents the respective biodiesels derived from these non edible oils. They conducted experiments on a four stroke single cylinder diesel engine using these biodiesel combinations in order to check their feasibility as alternative fuels to diesel. Advancing the injection timing improved the overall performance of the engine fuelled with JOME while retarding the injection timing favored the HOME. For biodiesel blends of HOME and JOME engine operation,

KJB20 performs better compared to other combination of biodiesel blends. It was observed that increasing the JOME content in the biodiesels blend improved the performance with reduced emissions of smoke, HC, CO emissions. However NOx emission increased. Smoke, CO and HC emissions increased with increased percentage of HOME in HOME and JOME blends while the NOx values decreases. Overall, it is observed that the KJB 20 gives the better results than the other combination such as KJB40, KJB60and KJB80 [8].

M. Nagarhalli et al., (2012) have studied the emission of Karanja and Jatropha biodiesel and its blend for diesel engine applications in which they reports on the use of combination of biodiesels derived from jatropha and karanja oils. They use blends of two biodiesel oils to run a single cylinder, 4 stroke, constant speed, D.I. diesel engine. Blends of transesterified jatropha and karanja have been used in different proportions (10% to 90%) and neat biodiesel were tested for performance, brake thermal efficiency, brake specific energy consumption (bsec) and their emissions CO, HC, NOx. at an injection pressure of 200 bar and 210 bar. The results are compared with that of neat diesel. The results indicate that HC and CO emissions were lower at 200 bar and K20-J80 blend. NOx emissions were higher at blends than diesel. The brake thermal efficiency was higher than diesel at both the injection pressures used. Hence, blends of jatropha and karanja can be used in existing diesel engines without any engine modifications [9].

A. Sanjid et al., (2013) have studied the emission of jatropha and palm biodiesel and its blends for diesel engine .Experimental results of the research carried out to evaluate the BSFC, engine power, exhaust and noise emission characteristics of a combined palm and jatropha blend in a single-cylinder diesel engine at different engine speeds ranging from 1400 to 2200 rpm.

In their work, the engine performance, emissions and noise of PBJB5 and PBJB10 palm and jatropha combined biodiesel diesel blends were investigated and compared with B0, palm and jatropha biodiesel blends. At the expense of a slight increase in BSFC and NO emissions, the PBJB5 and PBJB10 biodiesels showed better emission characteristics than B0.

The calorific value of PBJB5 was found to be 45.8 MJ/kg, which was close to B0. Besides, PBJB5 and PBJB10 both have advantages over B0 in terms of transport and handling as their flash points were found to be higher.

NO emission was increased for all the tested biodiesels compared with B0. However, NO emissions of PBJB5 and PBJB10 were found to be slightly lower than the PB10 and PB20 blends respectively, and almost the same for the JB10 and JB20 blends [10].

Raheman et al. (2013) have studied the performance of mixed biodiesel feedstock from mahua and simarouba. The fuel properties of biodiesel obtained from the mixture, MSO, were found to be within the limits specified by the biodiesel standards ASTM D 6751– 03, DIN EN 14214, and BIS 15607. The fuel properties of biodiesel blends approached those of HSD with a decrease in concentration of biodiesel in the blends. They found the following conclusions –

With an increase in engine load, the BSFC decreased, whereas both EGT and BTE increased for all the fuels tested. However, BTE for all biodiesel blends as compared with HSD was reduced on average by 2.09% at full load, and it was further reduced to 3.41% at 20% engine loading due to higher losses.

The CO and HC emissions of the diesel engine when operated with biodiesel blends as compared with HSD were reduced by 10.97% to 21.16% and 38.76% to 47.6%, whereas NOx emissions increased by 5.57% to 11.45% [11].

III. Conclusions

Effective, environmental friendly and economical substitute for conventional diesel fuel is need of time. The search for cost-effective feedstock and processes to produce quality biodiesel must not only consider economical factor but also focus on long term environmental issues. EGR for biodiesel was reported more efficient because trade-off between smoke and NO_x. In order to control NO_x emission, EGR technique can be used. There is an opportunity to study the performance and emission characteristics of engine on JOME and KOME, to find out optimum operating parameters. Also, the experimental work can be undertaken to study the effect of EGR on engine characteristics. The following conclusion could be drawn according to the analysis and summary of massive related literature in this work

- Thermal efficiency with biodiesel mixture was slightly lower than that of neat diesel fuel due to lower heating value of the mixtures. However, volatility, higher viscosity, higher density may be additional reason for efficiency reduction with biodiesel mixtures.
- It was noticed that, not much work has been done on combination of mixed biodiesel feedstocks by changing various parameters such as injection timing, injection pressure, nozzle hole geometry etc. So there is scope for research in this direction.
- Vegetable oils could not be directly used in engine due to its higher viscosities, low volality and polyunsaturated characteristics. Therefore, these problems can be overcome by four methods: pyrolysis, dilution with hydrocarbons, micro-emulsion and transesterification. Biodiesel was prepared from transesterification process which is best method among all.
- KJB20 performs better compared to other combination of biodiesel blends and it can be used CI engine without any engine modification.

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