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Study Of Jatropa Based Bio-Diesel as 2-Stroke Engine Lubricant

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ABSTRACT

Lubricants from vegetable oils that are biodegradable in nature represent an attractive alternative to the mineral based products. Bio products are being viewed as having the immense potential for meeting the future energy requirements. Bio-diesel is one such alternative that is extensively being used as fuel blend in diesel engines world over. The inherent lubricity characteristics of biodiesel provide protection for the Fuel Injection (FI) pump in the diesel engines particularly when low sulphur diesels are having problems of lubrication in the FI pumps. An attempt was made in our laboratory to make use of biodiesel as a lubricant in 2-stroke gasoline engines in place of the conventional mineral based 2T oil. Use of bio-diesel as 2-Stroke engine lubricants does not require any diluents as they posses good miscibility with gasoline fuel and do not require any additive for improvement of lubricity as they posses very good in-built lubricity effect. This paper describes the study of performance characteristics of bio-diesel as a lubricant in 2-stroke engines of the Japanese Automobile Standard Organization (JASO) test method. When used as such, the biodiesel as 2T lubricant has shown performance at par with mineral based oils with respect to lubricity and exhaust smoke.

KEYWORDS

Biodiesel, Lubricity, Detergency, Exhaust Smoke and 2-Stroke engine oil.

INTRODUCTION

Increasing demand for petroleum products, rising scarcity of conventional fuels and environmental concerns over the use of fossil fuels worldwide have necessitated the development of alternate fuels and lubricants based on bio origin. Petroleum based energy sources continue to dominate the transportation sector in the foreseeable future but its replacement by bio-based alternatives not only minimize its consumption, but also benefit environment. Biodiesel is one such bio-based energy source, which is defined as the mono alkyl esters of long chain fatty acids derived from vegetable oils. It is considered as a clean fuel since it has no sulphur, no aromatics, and has about 10% built-in oxygen, which helps it to burn fully. Use of biodiesel in conventional diesel engines gives distinct emission benefits both regulated and non-regulated and results in substantial reduction of unburned hydrocarbons, carbon monoxide and particulate matters (1). It was reported that neat biodiesel possesses inherently greater lubricity than petrodiesel due to the presence of alkyl esters, fatty compounds and long chain structure (2, 3). Number of studies has been conducted on soyabean and rapeseed oil derived biodiesel and reported with reduction of exhaust smoke (4,5). Also the higher percentage of biodiesel blends in petroleum diesel tends to decrease the exhaust smoke (6).

India being one of the largest consumer of 2-Stroke engine lubricants in Asia. Replacement of petroleum based 2T lubricants with biobased lubricants, can contribute considerably for the conservation of petroleum products in the Asian Market. Two wheeler being economical mode of transportation catering to the middle class population in India, its population is estimated to be 77% (fig.1) in which the population of two stroke engine powered two/three wheeler alone is estimated to be around 23% (fig.2). The emission levels in the metropolitan and urban areas of India are found to be very high. Vehicular pollution especially from Two-stroke vehicles is an ongoing problem in India, fig.3 shows that around 45% of the total vehicular pollution is contributed by Two-stroke Two-Wheel vehicles (7). Though the 2T lubricants with low smoke levels are being recommended by all the OEMs, biodegradability and environmental issues of lubricants is still a big challenge.

Considering the inherent properties and environmental benefits of using biodiesel as automotive fuel, an attempt

has been made to study on the possibility of using bio-diesel (B100) as a Two-stroke engine lubricant.

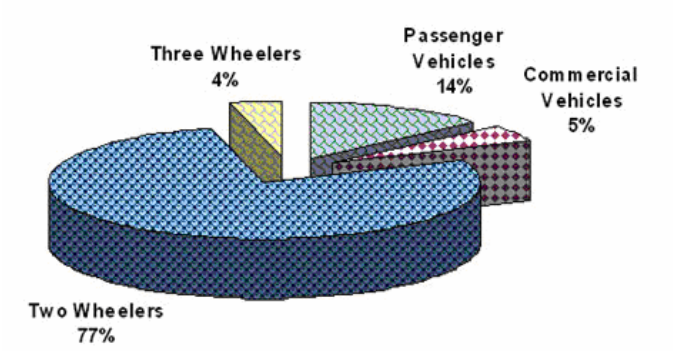


Fig. 1 Domestic Market Share - 2006-07
Source - SIAM Industry Statistics

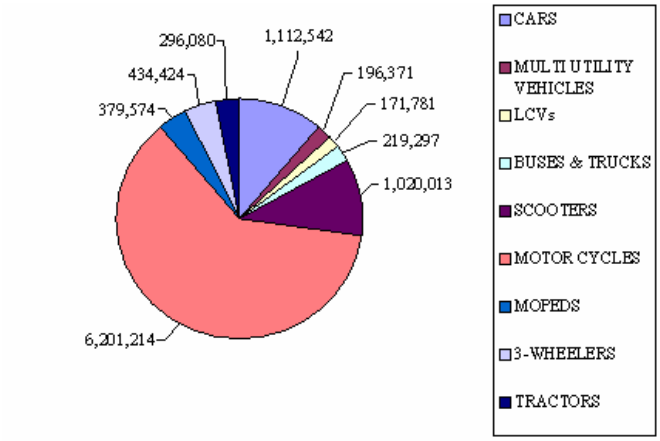


Fig. 2 Vehicle Population in India (2007-08)
Source - ACMA 2007

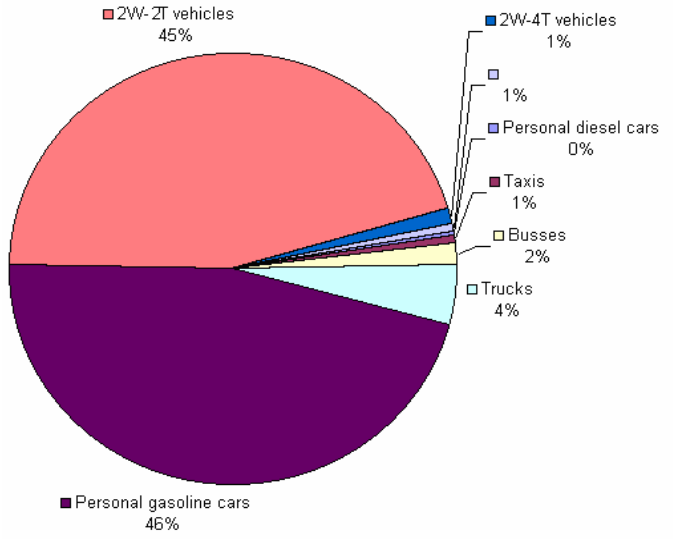


Fig. 3 Percentage Pollution Load in Delhi
Source - www.cleanairnet.org

EXPERIMENTAL INVESTIGATION

TEST METHOD AND INSTRUMENTS

In our study, the test oils were evaluated for its performance as a 2-Stroke engine lubricant using the Japanese Automotive Standards Organisation (JASO) Test Methods. The JASO test method describes performance evaluation of 2T oils with respect to Lubricity (JASO M340-92), Detergency (JASO 341-92 and Exhaust Smoke (JASO 342-92). The test engines Honda AF-27 and Suzuki SX-800R generator engine, which are the standard testing tools described in this method were used for the study. The details of the test engines are given in Table-1. The performance of biodiesel is compared with the additive treated mineral based 2T oil, which is already being used commercially. In all these test methods, the specified reference oil i.e Jatre-1 as prescribed in the JASO test method is used as base line for determining the performance indeces.

The exhaust smoke is measured using USPHS full-flow light extinction type smoke meter fitted to the exhaust sub muffler at a distance of about 150-mm. The smoke level was recorded as the percentage of light beam absorbed by the exhaust smoke from the engine through muffler and sub muffler, indicated directly by the voltmeter calibrated by the scale from 0 to 100%, where Zero and 100 indicate complete transmission and complete extinction of light, respectively.

Table-1 Description of test engines

Model	Honda AF27 type (SK50MM)	Suzuki generator: SX-800R
Number of cylinder and cooling system	Single cylinder forced air-cooled	Single cylinder forced air-cooled.
Bore X Stroke	39.0X41.4	46.0 X 42.0
Displacement	49	69 CC
Compression ratio	7.0	5.6

TEST OILS AND FUEL

Transesterified biodiesel (B100) was used as 2-Stroke engine lubricant for our study and compared their performance with an additive treated mineral based 2T oils (MBO) and Reference oil (RO). The formulation details and physico-chemical properties of the oils are given in table-2 and the fatty acid constitution of biodiesel is given in Table-3. The commercial unleaded premium gasoline of 93 Octane number (RON) is used as fuel as recommended in the test method. The specifications of test fuel are given in Table-4.

Table-2 Physico-chemical properties of test oils

Description	Reference Oil Jatre-1	Mineral Based Oil	Bio-Diesel

	(RO)	(MBO)	(B100)
Base	Mineral	Mineral	Vegetable
Density @ 15°C, gm/cc	0.8641	0.882	884.9
Visc. @ 40°C	58.01	59.19	4.65
Visc. @ 100° C	8.54	8.59	--
Visc. Index.	120	118	--
Pour point, °C	-24	-3	--
Flash point, °C	98	116	169
Sul Ash, % wt.	0.08	0.196	0.006

Table-3 Fatty acid constitutions of vegetable oils

Component	Jatropa carcus fraction,%	Name of fatty acids
Palmitic acid (C16:0)	14.7	Saturated
Oleic acid (C18:1)	42.4	Mono Unsaturated
Stearic acid (C18:0)	6.7	Saturated
Linoleic acid (C18:2)	35.2	Poly Unsaturated

Table-4 Specification of test fuel

Properties	Results
Density, @ 15 °C, gm/ml	0.7563
RVP at 38 °C Kpa	48
Existing gum, mg/100 ml	2
Distillation IBP deg. C Recovery up to 70 °C, % vol. Recovery up to 100 °C, % vol. Recovery up to 180 °C, % vol. FBP deg. C Residue, % vol.	 38 10.5 46.5 98.5 169 1.0
Aromatics Saturates Olefins	36.6 32.4 31.0
Octane number, RON	93.2

RESULTS AND DISCUSSION

LUBRICITY AND PISTON SEIZURE

Lubricity is the ability of oils to prevent piston seizure. Piston seizure is caused by the breakage of lubricant film between sliding surfaces due to temperature rise around piston and cylinder liner area. Lubricity Index of the test oils was evaluated as per JASO test method with 2% oil to fuel ratio. The details of results are given in table-5.

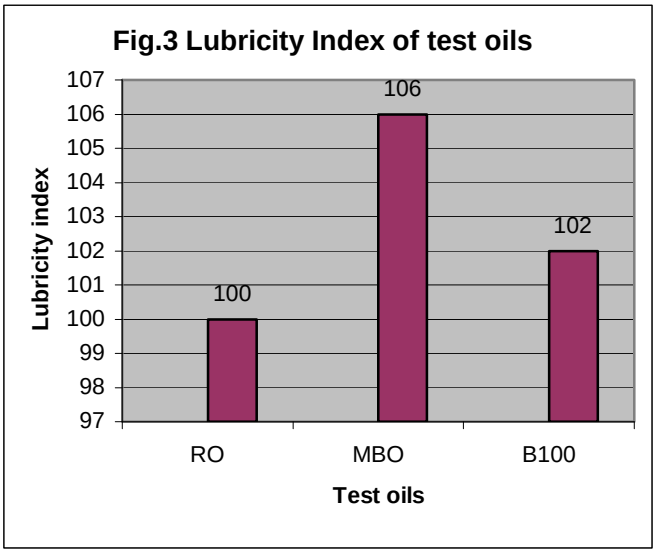
It is clear from fig.3 that the lubricity index (LIX) of biodiesel is at par with mineral based oil meeting the JASO FC quality. The better lubricity performance of the biodiesel may be due to the inherent properties of biodiesel, which help in preserving the matting surfaces in an internal combustion engine (2, 8).

DETERGENCY AND RING STICKING

Detergency Index (DIX) of the oil determines the degree of deposit cleaning tendency of 2T oils to keep the engine parts clean. The detergency index of the oil was evaluated as per JASO Test method with 1% oil to fuel ratio. The results showed that the detergency index of the biodiesel is not meeting the JASO FC requirement. The engine run with biodiesel showed thin layer carbon deposit on the piston with scuffing mark on thrust and antithrust area (Annexure-1). Also the second ring was cold struck.

Table-5 JASO test results of 2T oils

Description	JASO FC requirement	RO	MBO	B100
LIX	95	100	106	102
DIX	95	100	99.7	78.6
SIX	85	100	103	89

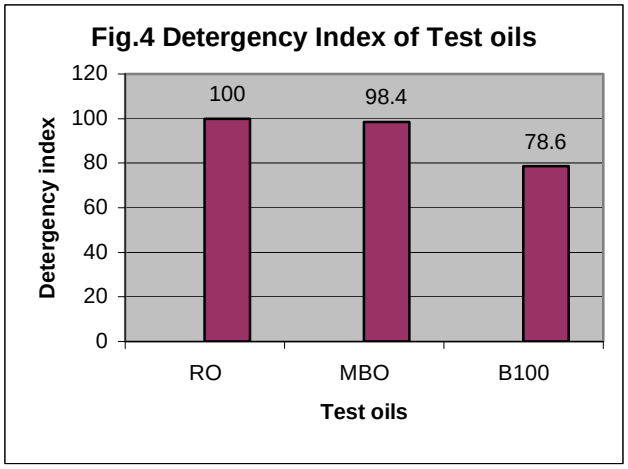


Reason for the deposit built-up of biodiesel as compared to mineral based 2T oils was due to poor oxidation stability as it contains higher percentage of unsaturated fatty acids. Vegetable oil that has higher percentage of un-saturated fatty acids shows poor oxidation stability, whereas the vegetable oil with high percentage of

saturated fatty acids shows better oxidation stability (9, 10).

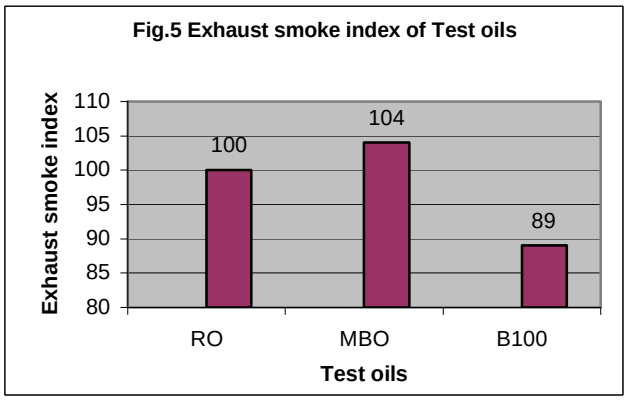
The results of the detergency test as shown in fig.4 indicate that the detergency index of biodiesel is poor as compared to that of additive treated mineral based 2T oils and doest not meet the JASO FC requirement. Also the 2nd piston ring was cold stuck when biodiesel was used.

Earlier study with coconut oil which contains more than 90% of saturated fatty acids has shown better performance with the detergency index very close to that of additive treated mineral based 2Toil (11).



EXHAUST SMOKE

The exhaust visible smoke level of the oils were studied as per JASO test method using 10% oil to fuel ratio as recommended by the procedure. From the fig.5, it is seen that the exhaust smoke performance of transesterified biodiesel is meeting the JASO FC requirement of minimum smoke index value of 85. This performance of biodiesel meeting JASO FC quality may be due to the absence of aromatics and the presence of inbuilt oxygen molecule. Aromatics are known to contribute to soot formation while the presence of oxygen molecules can aid for complete combustion, combination of both these factors could have resulted in lower smoke index (12).



FUTURE WORK

Future work can be taken-up to formulate 2T Oils based on biodiesel with suitable additive packages meeting all the performance characteristics of JASO FC requirement. Also the emission characteristics both regulated and unregulated need to be investigated while formulating biodiesel as 2-Stroke engine lubricants. Long duration field trial study can also be taken-up to evaluate the fuel economy and power performance.

CONCLUSIONS

The performance of biodiesel as a 2-Stroke engine lubricant is meeting the minimum requirement of JASO FC quality with respect to Lubricity and Exhaust smoke.

The detergency performance of the biodiesel is not meeting the JASO FC requirement, this may be due to presence of major part of unsaturated fatty acids in the biodiesel, however the detergency index number of biodiesel is in considerable range and it can be further improved with suitable additive treatment.

In order to meet all the performance requirements of two stroke engines, biodiesel as such cannot be used and need to be modified with suitable additive treatment.

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