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# Effect of Bio Lubricant Using Jatropha Biodiesel on Engine Vital Parts Life Cycle

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**ABSTRACT:** The combustion related properties of vegetable oils are somewhat similar to diesel oil. Neat vegetable oils or their blends with diesel, however, pose various long-term problems in compression ignition engines, e.g., poor atomization characteristics, ring-sticking, injector coking, injector deposits, injector pump failure, and lube oil dilution by crank-case polymerization. For large-scale and dependable implementation of biodiesel in transportation engines, its results on engine put on and engine sturdiness upon extended utilization wishes to be experimentally investigated. In experiment, engines were run by blend of 20 percent jatropha biodiesel was selected as optimum biodiesel blend as fuel for 512 hours. Aim of this experiment is to evaluate the wear effect on engine vital parts due to use of bio lubricant at the end of endurance test formulated from jatropha bio diesel. Diesel engines were completely disassembled and subjected to dimensioning of various vital moving parts and then subjected to long-term endurance tests. After completion of the test, both the engines were dismantled once more to measure wear on various important sections and perform physical inspections. Ring sticking, injector coking, carbon deposits on pistons, and physical wear of several important elements were all found to be significantly reduced in case of bio lubricant blend lubricating oil engine.

**KEYWORDS:** Diesel Engine, Endurance Test, Lubricating oil, Wear.

## I. INTRODUCTION

Internal combustion engines have been firmly established as essential to the modern way of life. They are essential to both modern mechanized agriculture and transportation. Vegetable oils have been tested as a diesel fuel substitute ever since the introduction of IC engines. In 1885, the diesel engine founder Rudolf Diesel used diesel fuel in form of peanut oil in a demonstration at the 1900 Paris World's Fair. In 1912, Diesel said when addressing the Engineering Society of St. Louis, Missouri that “Although the use of vegetable oils as engine fuels may appear insignificant at the moment, these oils may eventually overtake petroleum and the coal tar products of the present day in importance.’’ (Sinthupinyo et al., 2010)

There are also a lot of forest resources that can be used to extract oil and refine it to have combustion-related properties similar to those of diesel oil. Malaysia is engaged in research and development initiatives addressing the use of engine fuels derived from palm oil. In the Indian context, only non-edible vegetable oils may be treated seriously as a fuel for CI engines since edible oils are now in high demand and quite expensive. Without a doubt, oil seed production can be improved once they are adopted for regular use in diesel engines. Given the current high rates of petroleum fuel consumption, it is clear that vegetable oils can only, at most, partially replace them. (*Srinivasa, Rao P., and Gopalkrishnan, K. V. , 1991, ‘“Vegetable Oils and Their Methyl Esters as Fuels for Diesel Engines,”’ Indian J. Technol., 29, Pp. 292– 297.*, 1991). The international energy group has recognized biodiesel as an alternative fuel for the transportation sector. The European Commission predicted that biofuels would have a market share of 12 percent by 2020 (Körbitz, 1999).

By assessing engine performance, emissions, and combustion properties of biodiesel and its mixes in brief experimental investigations, numerous studies have shown encouraging prospects for using biodiesel in conventional diesel engines. But in long-term engine tests, biodiesel is observed to contribute to the development of engine deposits, the breakdown of lubricating oils, and the clogging of fuel filters, primarily depending on the degradability of lubricating oil and fuel, the impurity content of bio-diesel, the cold flow properties, etc (Fazal et al., 2011; Lapuerta et al., 2008; Pandhare et al.,

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2012).

## II. LITERATURE SURVEY

Many researchers worked on evaluation of wear on engine vital parts due to usage of biodiesel blended fuel in diesel engine. For both static engine tests as well as field testing, Fazal et al. suggested that biodiesel/biodiesel blend fuelled engines will exhibit either reduced or similar wear to mineral diesel fuelled engines (Fazal et al., 2011). According to Agarwal et al endurance test of 512 hours on a single-cylinder engine using a 20% blend of linseed oil methyl ester, biodiesel had no appreciable negative impact on the wear of different important moving parts of the engine (A. K. Agarwal & Das, 2001). Verhaeven et al. stated that even after a 100,000 km field trial using vegetable oil methyl ester (UVOME) and rapeseed oil methyl ester (RME) as alternative fuels, there was no discernible change in the wear of the fuel injectors and fuel injection equipment (Verhaeven et al., 2005). In a 7500 km field test conducted in winter conditions, Etinkaya et al. detected the same quantity of carbon deposits on the fuel injectors of the two vehicles running on mineral diesel and used cooking oil-based biodiesel (Çetinkaya et al., 2005). Sinha et al. reported except for the big end bearing, which showed slightly higher wear for B20-fueled compression ignition direct injection (CIDI) engines, physical evaluations of several important engine components revealed lower wear for B20-fueled engines compared to mineral diesel (Sinha & Agarwal, 2010). In a long-term endurance test, Agarwal et al. found that warmed Karanja oil and its blends-fueled engines had more carbon deposits on the piston than mineral diesel-fueled engines (Avinash Kumar Agarwal & Dhar, 2012) (A. K. Agarwal & Dhar, 2010). Similar carbon deposits have been seen in the combustion chambers of engines powered by biodiesel and diesel, according to Pehan et al (Pehan et al., 2009).

Compared to short-term research on engine performance, emissions, and combustion that have been published in open literature, there are very few studies (Fazal et al., 2011) (A. K. Agarwal & Das, 2001) (Verhaeven et al., 2005) (Sinha & Agarwal, 2010) (Haseeb et al., 2011) (Armas et al., 2011) on the long-term effects of biodiesel on engine wear and engine deposits. Before biodiesel is widely implemented as an alternative fuel throughout the nation, it must be evaluated for material compatibility with diesel engines during long-term engine operation due to differences in the chemical composition of biodiesel and mineral diesel. In South Asia, where this tree species is frequently found, jatropha biodiesel oil represents a viable non-edible feedstock for making biodiesel. Because it is abundantly available throughout the entirety of South Asia and is well adapted to local climatic conditions, jatropha biodiesel oil is viewed as a feedstock with the potential to produce biodiesel on a big scale (Avinash Kumar Agarwal & Dhar, 2012) (Dhar & Agarwal, 2014).

Even though bio lubricant have lots of advantages over petroleum based lubricant, the attempt to formulate the bio-lubricant and its applications are very few. In this article, we aimed to present our research and test the tribological properties and compatibility of a bio-lubricant based on non-edible Jatropha oil for automotive use. Jatropha oil was chosen as a feedstock because it can be farmed on marginal terrain and does not compete with food. In this study, long-term endurance test was carried out to find out effect of 10% blend of jatropha biodiesel with commercial lubricant oil 15W40 on wear of engine vital components was investigated with comparison to 15W40 lubricating oil using a constant speed medium duty diesel engine.

## III. WEAR ANALYSIS OF ENGINE VITAL PARTS

### A. EXPERIMENTAL SETUP

For comparative study, two - single cylinder, four strokes, water cooled, direct fuel injection diesel engines were selected. Both the engines were coupled with an electrical brake dynamometer for loading conditions. Provision for load variation arrangement is also equipped. Table 1 shows the technical specifications of diesel engine used in current research work.

TABLE 1. Technical Specifications of the Test Engine

| | |
|---|---|
| Manufacturer | Field marshal |
| Engine | Water cooled, diesel engine |
| Number of strokes | 4 |
| Number of cylinders | 1 |
| Bore | 76 mm |
| Stroke | 110 mm |

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| | |
|---|---|
| Rated Speed | 1500 rpm |
| Maximum Speed | 2000 rpm |
| Engine Power | 3.75 kW |
| Compression Ratio | 17 |
| Nozzle Pressure | 200 bar |

Graduated burette was used to measure the fuel consumption rate with a resolution of 1 ml and an accuracy of ±1%. Speed of engine kept constant 1500 rpm, but may vary slightly with respect to applied load value. For the present investigation, load cycle is selected as per table 2, as per long-term endurance test specified by Indian Standards Code as per IS 10000, part VIII-1980, "Methods of tests for internal combustion engines: Part VIII Performance tests" (*IS 10000 P9-1980_Endurance Test.Pdf*, n.d.). Engine was run for the same operating parameters and loading cycles for both the trial run. The engines were used for 512 hours at their rated speed (32 cycles every 16 hours of continuous operation) (*IS 10000 P9-1980_Endurance Test.Pdf*, n.d.).

**TABLE 2. Long Term Endurance Test Cycle**

| Load (% rated Load) | Running Time (Hr) |
|---|---|
| 100 | 4 (Inc. warm-up 0.5 hrs) |
| 50 | 4 |
| 110 | 1 |
| No Load (Idling) | 0.5 |
| 100 | 3 |
| 50 | 3.5 |

### B. Fuel Selection

The best engine performance was demonstrated by several researchers using a 20% jatropha biodiesel blend with diesel fuel (Liaquat et al., 2014; Roy et al., 2021; Shahabuddin et al., 2013; Sharma & Murugan, 2017). Use of oxygenated additive also improves the engine performance. Patel et al. (Patel et al., 2017) reveals the performance and emission analysis with optimized blend of jatropha biodiesel (B20) with mineral diesel was identified for the best performance and least emission. They also investigated that use of 4% addition of DEE in B20 blend reduces $NO_x$ and HC emission drastically (Patel et al., 2017). So, on the basis of their investigation a blend of 20% jatropha biodiesel with 4% DEE additives and 76% diesel fuel on volume basis was selected as fuel for both the trial run. The diesel fuel is the ultra-low sulphur diesel obtained from the local petrol station near institute, whereas the biodiesel was directly received from a supplier.

### C. Lubricant Selection

Shahabuddin et al. (Shahabuddin et al., 2013) performed experiment using four ball tribo tester with various percentage blends of jatropha biodiesel with commercial lubricant SAE 40 to investigate effect on Tribological properties of lubricating oil. They reveal that with respect to wear rate and rise in temperature during the entire operation time, the JBL 10 bio-lubricant showed the best performance in terms of its ability to withstand its properties. To investigate the effect of same lubricant oil on engine after endurance test, in this work use of formulate bio lubricant having 10 percentages of Jatropha biodiesel was mixed with the commercial lubricant SAE 15W-40 API CF-4 as alternate bio-lubricant oil for comparison purpose. The jatropha biodiesel were mixed with the base lubricant by a homogeneous mixture machine to make bio lubricant

### D. Long Term Endurance Test

Before the endurance test began, both engines were completely disassembled for comparative research and physically inspected for the status of the many important parts. In this experimental work some selected parts such as liner, piston, piston rings, gudgeon pin, connecting rod both ends and valves selected for comparative wear analysis (*IS 10000 P5-1980_wear.Pdf*, n.d.). The engines selected vital parts dimensions were noted down as per specified by Indian Standards Code as per IS 10000, part V-1980, "Preparation of Tests And Measurement For Wear (*IS 10000 P5-1980_wear.Pdf*, n.d.). After physical examination and note down the dimensions of selected parts, the engine was assembled as per guideline of manufacturer.

The engines were prepared for the long-term endurance test by draining the lubricating oil from the oil sump and replacing it with new SAE 15W-40 API CF-4 grade lubricating oil per the manufacturer's specifications. The second engine was using 10 percent jatropha biodiesel blend with 15W40 lubricating oil. The lubricating oil samples were collected from the engines after every 128 hours as per standard sampling methods (Fitch & Troyer, 2004) for conducting various comparative studies. 100 ml of oil was drawn at each 128 hours of trial run and same quantity of oil was added to oil bath for maintain a constant oil level.

## IV. RESULT AND DISCUSSION

Long-term engine running led to the wear of numerous moving parts. Both engines were run under the same circumstances, and they went through similar loading cycles. The only difference in the operation was that both engines were run with two different lubricating oils, allowing a direct comparison of how different lubricating oils affected the lifespan of the engine hardware. This was viewed as a litmus test to compare the alternative lubricating oil to standard 15W40 lubricating oil in terms of material compatibility. Before and after the long-term endurance test, measurements of the body's vital organs and physical state were recorded. The wear of these parts throughout the specified period of engine running was determined by the difference between these two dimensions. By precisely measuring the dimensions of different important engine components before and after the long-term endurance test, wear was calculated. These wear observations helped compare the effectiveness of bio lubricant to 15W40 lubricant oil on the wear of the essential engine parts. The table clearly shows that the 10 percent jatropha biodiesel mixed lubricating oil operated engine had significantly less wear on critical moving parts than the neat lubricating oil operated engine. The values in table 3 represent the percentage benefit in wear of engine vital parts due to use of bio lubricant.

At five different locations, the cylinder liner's wear was measured parallel to and perpendicular to the crank shaft axis. Wear was reported to be greater in the direction perpendicular to the crank shaft axis during both phases. The active thrust on the piston and piston tilt during the stroke may be to blame for this. When an engine is running on bio-lubricant, there is less liner wear. By adopting bio-lubricant, comparative linear wear was minimised by 10.14 percent.

The three locations each had a piston measurement measured. For engines running on both lubricating oils, wearon the piston was determined to be between 0.13 and 0.17 millimeters. Engines running on bio-lubricant showed relatively less wear. By adopting bio-lubricant, comparative piston wear was minimised by 10.35 percent

Measurements of the connecting rod bearing bore for the bio-lubricant-lubricating engine and the commercial 15W40 lubricating oil were recorded before and after the endurance test. Measurements indicate that an engine running with 15W40 lubricating oil will wear out more quickly. Comparative Connecting rod bearing bore wear was reduced by 10.60 percent by using bio-lubricant.

For both sets of experiments, gudgeon pin, pin bore, and small end bush wear are comparable. When using a bio-lubricant engine configuration, the wear rate is lower than when using conventional lubrication oil. By using bio-lubricant, the comparative rate of wear decrease in all three important parts was reduced by 9 to 10%.

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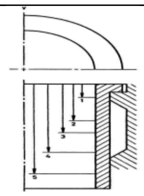
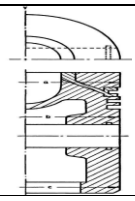
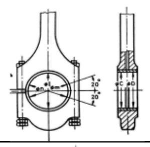
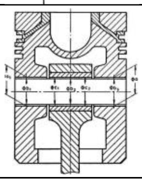
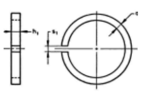
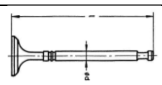
**TABLE 3. Comparative Performances of Bio Lubricant with 15W40 Lubricant Oil with Respect to The Wear of the Vital Engine Components**

<table>
<tr><th>Sketch of Vital Parts</th><th>Name of Vital Parts</th><th colspan="2">Wear Difference (%)</th></tr>
<tr><td></td><td>Liner Wear Comparative Difference</td><td colspan="2">10.14</td></tr>
<tr><td></td><td>Piston Wear Comparative Difference</td><td colspan="2">10.35</td></tr>
<tr><td></td><td>Connecting Rod Big End (Bearing Bush) Comparative difference</td><td colspan="2">10.60</td></tr>
<tr><td rowspan="3"></td><td>Connecting Rod Small End Wear Difference</td><td colspan="2">10.28</td></tr>
<tr><td>Gudgeon Pin Bore Wear Difference</td><td colspan="2">10.03</td></tr>
<tr><td>Gudgeon Pin Diameter Wear Difference</td><td colspan="2">8.93</td></tr>
<tr><td rowspan="6"></td><td rowspan="3">Piston Ring Radial Wall Thickness Wear Difference</td><td>Ring 1</td><td>7.80</td></tr>
<tr><td>Ring 2</td><td>8.03</td></tr>
<tr><td>Ring 3</td><td>8.24</td></tr>
<tr><td rowspan="3">Piston Ring Axial Width Wear Difference</td><td>Ring 1</td><td>3.49</td></tr>
<tr><td>Ring 2</td><td>5.43</td></tr>
<tr><td>Ring 3</td><td>3.29</td></tr>
<tr><td rowspan="4"></td><td rowspan="2">Valve Stem Diameter Wear difference</td><td>Inlet</td><td>4.35</td></tr>
<tr><td>Exhaust</td><td>5.88</td></tr>
<tr><td rowspan="2">Valve Length Wear difference</td><td>Inlet</td><td>5.97</td></tr>
<tr><td>Exhaust</td><td>6.25</td></tr>
</table>

Combustion gases place a significant thrust on piston rings. The piston ring pack already in use is made up of four rings: three compression rings and one oil control ring. The entire ring face was operating under intense pressure and heat. The axial width and radial wall thickness of the piston rings were measured to determine how well they were wearing. On the whole, the engine running on biolubricant showed less wear. Using bio-lubricant oil reduced piston ring wear by around 8% in comparison.

A decrease in the distance between the valve head and mounting flange face serves as a gauge for valve seat wear. In the instance of an engine using bio lubricant, less wear (4%) was seen.

## V. CONCLUSION

In the long-term endurance test, the comparative effect on various engine parts due use of bio lubricant vis-a`-vis 15W40 lubricating oil was evaluated. The assessment of wear of various parts of biodiesel blend diesel-fuelled engines with biolubricant and commercial lubricant was made. It was found that the wear of the engine vital parts run on bio lubricant is substantially lower than that of the commercial lubricating oil. It can be concluded that bio lubricant formulated with blends of jatropha biodiesel in 15W40 lubricating oil can be safely used as a substitute for conventional lubricating oil considering the wear rate advantage.

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