Wear and tear analysis of a single cylinder diesel engine using karanja biodiesel (B20) after 512 hours

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This study presents effects of biodiesel blends namely B20K fuel (80% diesel + 20% Karanja biodiesel) on single cylinder diesel engine performance and lubricating oil under two long duration endurance tests of 512 h. SAE grade 15W 40 engine oil was used for both the tests. Experimental results indicated that engine can be safely operated with B20 fuel, without significant changes in engine power, fuel economy and lubricating oil properties.

Keywords: B20K, Long term endurance test, Lubricating oil

Introduction

India imports nearly 70% of fossil fuel, which by 2010 is likely to increase to 82%. India has great potential for production of biodiesel from non-edible oilseeds. In India, 80 million ha of wastelands, available in rural and economically underdeveloped region, has large scale biodiesel production and enormous potential for employment and development of these areas. India is producing $6.7\times10^6$ tonnes of non-edible oils\(^2\)-\(^6\) (Madhuca indica, Mesua ferrea L., Linum usitatissimum, Pongmia pinnata, Oryza sativa, Shorea robusta, Calophyllum inophyllum, Gossypium herbaceum, Jatropha curcas, Azadirachta indica, Schleichera trijuga, Ficus elastica). Biodiesel results in substantial reductions of unburned hydrocarbons (UBHC), carbon monoxide (CO), and particulate matter (PM). It is considered a clean fuel since it has almost no sulphur, no aromatics and has 11% built in oxygen, which helps in complete combustion. Its higher cetane number improves ignition quality even when blended with diesel fuel\(^7\)-\(^8\). Neat methyl esters (B100) of rapeseed, soybean, sunflower, tallow and other fats and oils can be used as diesel fuel with little or no modifications of existing diesel engine.

This study presents wear and tear analysis of a single cylinder diesel engine using B20K fuel (80% diesel and 20% karanja biodiesel) under two endurance tests of 512 h.

Experimental Section

Two diesel engines were used to assess engine and oil performances using B20K fuel. Engines [Kirloskar single cylinder (DAF 8), four stroke, vertical, air cooled, direct injection] had following specifications: bore, 87.5 mm; stroke, 110 mm; compression ratio, 17.5:1; speed, 1500 rpm; brake power, 8/5.9 bhp/kw; displacement volume, 779.704 cc; and injector opening pressure, 200 bar. Engines were operated for 512 h with test fuels to inspect effect of long term engine operation on engine wear, both by physical dimensioning and lubricating oil analysis. Two similar new engines were completely disassembled and subjected to dimensioning of various parts and then subjected to long term endurance test on 20% biodiesel blends and petroleum diesel respectively. During this test, each engine was run for 32 cycles (each of 16 h continuous running) at rated speed as per IS: 10000, part viii, 1980\(^9\). SAE grade 15W 40 engine oil was used for both tests. Lubricating oil samples were collected from engines after every 150 h and immediately analyzed to obtain wear result. Test cycle for long-term endurance test used load (% of rated load) and running time (h), respectively, as follows: 100, 4; 50, 4; 10, 1; 100, 3; 50, 3.5. Test cycle used for load idling was zero and running time, 0.5 h.

Results and Discussion

A comparative study was done on performance of engine oil using both diesel and B20K as a fuel on the basis of results obtained in the tests. Physico-chemical
<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Properties</th>
<th>Biodiesel (B100K)</th>
<th>Biodiesel blend (B20K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cloud point, °C</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Pour point, °C</td>
<td>0</td>
<td>-3</td>
</tr>
<tr>
<td>3</td>
<td>Flash point, °C</td>
<td>145</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>Kinematic viscosity(40^\circ\mathrm{C}), cSt</td>
<td>4.08</td>
<td>3.534</td>
</tr>
<tr>
<td>5</td>
<td>Relative density(15^\circ\mathrm{C})</td>
<td>0.891</td>
<td>0.8544</td>
</tr>
<tr>
<td>6</td>
<td>Carbon residue, %wt</td>
<td>0.016</td>
<td>0.014</td>
</tr>
<tr>
<td>7</td>
<td>Ash content, %wt</td>
<td>0.004</td>
<td>&lt; 0.01</td>
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<tr>
<td>8</td>
<td>Copper strip corrosion(100^\circ\mathrm{C}), 3 h</td>
<td>No 1</td>
<td>No 1</td>
</tr>
<tr>
<td>9</td>
<td>Moisture, %wt</td>
<td>0.005</td>
<td>Nil</td>
</tr>
<tr>
<td>10</td>
<td>Cetane no.</td>
<td>57.6</td>
<td>50.3 (Cetane index)</td>
</tr>
</tbody>
</table>

Fig. 1—Variation of brake specific fuel consumption with time

Fig. 2—Variation of smoke opacity with time
properties of karanja oil methyl ester (B100K) and its blend (B20K) were determined (Table 1).

Brake specific fuel consumption (BSFC) trend (Fig. 1) indicates performance of engine for both fuels. BSFC in case of B20K is slightly higher than diesel due to lower calorific value of B20K than diesel. Smoke density from engine fueled by B20K is lower than engine fueled by diesel at 512 h of running (Fig 2), may be due to presence of oxygen molecule in biodiesel chain, which enhanced its complete burning as compared to diesel. Viscosity at 100°C indicated that extent of lowering of viscosity of lubricating oil is less in case of B20K fuelled engine compared to diesel fuelled engine, may be because of lower fuel dilution (Fig. 3). At the start of test, viscosity value for all fuels was 13.5 cSt, whereas for 512 h engine operation, viscosity for B20K was 12.2 cSt followed by diesel (12.022 cSt). However, viscosity variation did not exceed the limits (lower limit, 12.5 cSt; upper limit, 16.3 cSt) for 15W40 lube oil during engine operation on B20K blend as well as diesel. Iron in wear debris may be due to wear of cylinder liner, piston, rings, valves, valve guides, gears, shafts, bearing, rust and crankshaft. It was monitored that lubricants from 20% biodiesel fueled engine indicated a lower increase in iron content (Fig. 4).

**Conclusions**

BSFC for B20K is found slightly higher than diesel due to lower calorific value of B20K than diesel. Difference in change in viscosity of lubricating oil using diesel and B20K as fuel is found negligible and B20K does not affect oil viscosity and is able to maintain its viscosity throughout the test. Lower levels of iron concentration indicate low rate of engine wear in case
of B20K fuel. Thus, by mixing 20% biodiesel in diesel, no adverse effect was observed on engine components, lubricating oil and emission performance of engine.

References
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