Brake Specific Fuel Consumption of Diesel Engine by Using Biodiesel from Waste Cooking Oil

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Abstract: In this research, the effects of biodiesel (from waste cooking oil) in fuel mixture (biodiesel and diesel fuel No.2) on BSFC of a diesel engine. The experiments were conducted on a four cylinder direct-injection diesel engine. Results showed that the use of biodiesel BSFC increases 18 to 24% by the using net biodiesel. Also results showed that the reduction in engine load appeared to cause an increase in BSFC which increase up to 15% by reducing the engine load.

Keywords: Engine performance, Biodiesel, Diesel engine, RSM, Engine Operating Conditions.

1. Introduction

Biofuels such as alcohols and biodiesel have been proposed as alternatives for diesel engines (Agarwal, 2007; Demirbas, 2007; Ribeiro et al., 2007). Biodiesel can be produced from various vegetable oils, waste cooking oils and animal fats. The fuel properties of biodiesel may be changed when different feedstocks are used. If the fuel properties of biodiesel are compared to petroleum diesel fuel, it can be seen that biodiesel has higher viscosity, density, pour point, flash point and cetane number, near-zero aromatic compound, and no sulphur link (Canakci and Ozsezen, 2005; Knothe, 1997).

In particular, biodiesel has received wide attention as a replacement for diesel fuel because it is biodegradable, nontoxic and can significantly reduce toxic emissions and overall life cycle emission of CO₂ from the engine when burned as a fuel (Cvengroš and Považanec, 1996; USEPA, 2002). Biodiesel can form blends with petroleum diesel fuel at any ratio and thus have the potential to partially, or even totally, replace diesel fuel in diesel engines.
Biodiesel fuel has many effects on diesel engine performance. There has been a lot of research on the regulated performance characteristics of diesel engines with biodiesel/diesel blends.

Many researches compared the blends with different content biodiesel For BSFC. Most of them (Aydin and Bayindir, 2010; Raheman and Phadatare, 2004; Meng et al., 2008; Ramadhas et al., 2005; Godiganur et al., 2010; Raheman and Ghadge, 2007; Qi et al., 2010) agreed that the fuel consumption of an engine fueled with biodiesel becomes higher. In (Armas et al., 2010; Zhu et al., 2010; Godiganur et al., 2010; Labeckas and Slavinskas, 2006) authors believed that, with increasing the content of biodiesel, engine fuel consumption will increase. Raheman and Phadatare (2004) tested karanja methyl ester (B100) and its blends (B20, B40, B60 and B80) on a single-cylinder, 4-stroke, DI, WC diesel engine, and observed the same trend. Reyes and Sepúlveda (2006) found that B40 has the minimum SFC (specific fuel consumption) of all the blends (B20, B40, B60, B80 and B100) tested on a 6-cylinder, 4-stroke and WC diesel engine. Of course, there are very few researches that showed an opposite trend (Pal et al., 2010; Mahanta et al., 2006).

On the contrary, it was reported in (Mahanta et al., 2006; Ozgünay et al., 2007; Song and Zhang, 2008; Pal et al., 2010) that fuel consumption was decreased for biodiesel compared to diesel. For instance, Ulusoy et al. (2004) observed that the fuel consumption of frying oil biodiesel was 43% less than that of diesel on a 4-cylinder, 4-stroke 46kW diesel engine. And it was observed by Sahoo et al. (2007) that BSEC is slightly higher for B100 at lower loads and remains same at higher loads.

The objective of this research work is to investigate the effects of biodiesel percentage of in fuel mixture (biodiesel and diesel fuel No.2) as fuel parameter on changes in BSFC. In addition, using diagrams, the interaction effects of process parameters on the parameters are analyzed and discussed.

2. Materials and Methods

2.1 Biodiesel preparation and fuel properties

Biodiesel from waste vegetable cooking oil is a more economical source of the fuel, so biodiesel was produced from this source in the present investigation. In the present research, biodiesel was produced by transesterification process TMU biofuels laboratories. The important properties of biodiesel and No. 2 diesel are shown in Table 1.

<table>
<thead>
<tr>
<th>Property</th>
<th>Method</th>
<th>Units</th>
<th>Biodiesel</th>
<th>Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash point</td>
<td>ASTM-D92</td>
<td>°C</td>
<td>150</td>
<td>61</td>
</tr>
<tr>
<td>Pour point</td>
<td>ASTM-D97</td>
<td>°C</td>
<td>-5</td>
<td>0</td>
</tr>
<tr>
<td>Cloud point</td>
<td>ASTM-D2500</td>
<td>°C</td>
<td>-1</td>
<td>3</td>
</tr>
<tr>
<td>Kinematical viscosity, 40°C</td>
<td>ASTM-D445</td>
<td>mm²/s</td>
<td>4.3</td>
<td>4.15</td>
</tr>
<tr>
<td>Density</td>
<td></td>
<td>Kg/m³</td>
<td>875</td>
<td>830</td>
</tr>
</tbody>
</table>
2.2 Test engine experimental setup and procedure

The engine tests were carried out on a 4-cylinder, four-stroke, turbocharged, water cooled and naturally aspirated DI diesel engine. The engine speed was measured by a digital tachometer with a resolution of 1 rpm. The engine was allowed to run for a few times until the exhaust gas temperature, the cooling water temperature, the lubricating oil temperature, have attained steady-state values and then the data were recorded.

3. Analysis and Results

The experiments at design matrix (Table 3) were performed and the experimental data for BSCF of the diesel engine are shown in Table 4.

Table 4. The experimental and predicted data for the three responses

<table>
<thead>
<tr>
<th>Experiment number</th>
<th>BSFC(gr/(Kw.hr))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>230.6</td>
</tr>
<tr>
<td>2</td>
<td>258.7</td>
</tr>
<tr>
<td>3</td>
<td>248.8</td>
</tr>
<tr>
<td>4</td>
<td>288.5</td>
</tr>
<tr>
<td>5</td>
<td>217</td>
</tr>
<tr>
<td>6</td>
<td>236.3</td>
</tr>
<tr>
<td>7</td>
<td>235.2</td>
</tr>
<tr>
<td>8</td>
<td>266</td>
</tr>
<tr>
<td>9</td>
<td>213.1</td>
</tr>
<tr>
<td>10</td>
<td>262.7</td>
</tr>
<tr>
<td>11</td>
<td>242.7</td>
</tr>
<tr>
<td>12</td>
<td>283</td>
</tr>
<tr>
<td>13</td>
<td>256.4</td>
</tr>
<tr>
<td>14</td>
<td>226</td>
</tr>
<tr>
<td>15</td>
<td>241.2</td>
</tr>
</tbody>
</table>

3.1. Brake specific fuel consumption

Figures (10 to 13) show the effects of biodiesel percentage and engine speed on the predicted brake specific fuel consumption of the engine at various load condition. As the Figures show the maximum brake specific fuel consumption is more than 330 (gr/Kw.hr) for fuel blends included more than 95%
biodiesel at 25% engine load and engine speed between 2700 to 2800 rpm. Also the minimum brake specific fuel consumption (less than 208 (gr/Kw.hr)) happens at full engine load and engine speed between 1500 to 1700 rpm for fuel blends included less than 10% biodiesel.

According to the results, the BSFC initially decreased with increase in speed up to 1300 rpm and then BSFC remains approximately constant between 1300 rpm and 1900 rpm. For the range more than 1900 rpm, the BSFC increased sharply with speed (Xue et al., 2011).

The predicted values for the brake specific fuel consumption increase with the increasing amount of biodiesel in the fuel blend. The heating value of the biodiesel is lower than that of diesel fuel No.2. Therefore, if the engine was fueled with biodiesel or its blends, the BSFC will increase due to the produced lower brake power caused by the lower energy content of the biodiesel (Aydin and Bayindir, 2010; Ozsezen et al., 2009; Karabektas, 2009; Murillo et al., 2007; Kaplan et al., 2006; Choi and Oh, 2006; Ramadhas et al., 2005; Canakci et al., 2009). At the same time, for the same volume, more biodiesel fuel based on the mass flow was injected into the combustion chamber than diesel fuel No.2 due to its higher density. In addition to these parameters, viscosity, the atomization ratio and injection pressure should be considered since they have some effects on the BSFC and brake power values (Lin et al., 2009; Song and Zhang, 2008).

As the figures show with increase in load, the BSFC of biodiesel decreases. One possible explanation for this trend could be the higher percentage of increase in brake power with load as compared to fuel consumption (Raheman and Phadatare, 2004; Meng et al., 2008; Ramadhas et al., 2005; Godiganur et al., 2010; Raheman and Ghadge, 2007; Qi et al., 2010).

Fig 10. Effect of Percentage of biodiesel in fuel mixture and engine speed on BSFC at 25% engine load.
Fig 11. Effect of Percentage of biodiesel in fuel mixture and engine speed on BSFC at 50% engine load.

Fig 12. Effect of Percentage of biodiesel in fuel mixture and engine speed on BSFC at 75% engine load.
4. Conclusions

1- The brake specific fuel consumption increases with the increase of biodiesel in the blends, due to the lower heating value of biodiesel. Results showed that the brake specific fuel consumption of diesel No.2 fuel is 18 to 24% more than the brake specific fuel consumption of net biodiesel at various engine loads.

2- The brake specific fuel consumption at 25% engine load was around 15% more than this characteristic at full engine load for all fuel blends.

3- These results are similar to those found in the literature and support that waste cooking oil methyl esters have similar properties with diesel fuel.

4- Also the results of the study show that use of biodiesel blends with diesel had not significant change on performance of the diesel engine.

5. References


-USEPA. A comprehensive analysis of biodiesel impacts on exhaust emissions; 2002; EPA420-P-02-001.
