Combustion Heat Release Models of Biodiesel

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Format of Presentation:

- Aims and Objectives of the Study
- Experimental Setup
- Fuel Manufacture Process
- Results and discussions
- Conclusions and Recommendation for Future Work
Aims of the Study:

- To investigate the viability of using biodiesel as an alternative, or additive, to basic diesel fuel.
- To be evaluated the engine performance along with emission characteristics for an engine running with biodiesel and traditional fuels.
Objectives of the Study

To find an immediate alternative energy solution through an investigation of combustion heat release processes of different biodiesel blends, which does not involve a drastic overhaul of the world's engine structure.

Obtaining one of solutions, which can reduce the global green house gas emissions over the petroleum, while a similar output in performance and efficiency.
Biofuels

1\textsuperscript{st} generation: bio-diesel and bio-ethanol

Transesterification or reforming of vegetable oils

2\textsuperscript{nd} generation: from lignin and cellulose

Wood, straw etc - hydrolysis to liquid fuel - not yet viable

Sugars/starch fermentation
Experimental setup

- Biodiesel production process
- Testing fuel properties
- Engine testing
Fuel Pod - Basic Unit for Manufacture of Bio-Diesel - Transesterification Process

- Vegetable oil
- Mixture of Methanol and NaOH
- Glycerol
- Bio-Diesel

Oil, M, and NaOH
Conversion of vegetable oils to bio-diesel

Major process: triglyceride to methyl esters

\[ \text{KOH or NaOH} \]

\[
\begin{align*}
\text{Triglyceride} & \quad \text{+} \quad 3 \text{ CH}_3\text{OH} \quad \xrightarrow{\text{KOH or NaOH}} \quad \text{Fatty acid methyl ester (FAME) - Bio-diesel} \\
\end{align*}
\]

KOH + Free Fatty Acids = Soap
U-tube viscometer is used to measure kinematic viscosity.

A bomb calorimeter is used to test calorific values samples.

Hydrometer is used to measure density.

U-tube viscometer is used to measure kinematic viscosity.
Steady State Engine Test Rig – Schenk dynamometer fitted with JCB 444 TCA 74 kW engine
The average yield of biodiesel was found to be 49 L, which is about 98% by volume from the vegetable oils. The average amount of glycerol obtained as a by-product from 50 L of vegetable oils was 8 L.

### Results and Discussions

The table below presents the results of kinematic viscosity, calorific value, cloud point, pour point, flash point, and density for various vegetable oils, biodiesel fuels, and standard diesel.

<table>
<thead>
<tr>
<th>Fuels</th>
<th>Kinematic Viscosity At 40°C (mm²/s)</th>
<th>Calorific Value (MJ/kg)</th>
<th>Cloud Point (°C)</th>
<th>Pour Point (°C)</th>
<th>Flash Point (°C)</th>
<th>Density (kg/m³) At 15°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn oil</td>
<td>39.3</td>
<td>37.37</td>
<td>-1.1</td>
<td>-40.0</td>
<td>277</td>
<td>920</td>
</tr>
<tr>
<td>Rapeseed oil</td>
<td>37.98</td>
<td>37.37</td>
<td>-3.9</td>
<td>-6.7</td>
<td>246</td>
<td>910</td>
</tr>
<tr>
<td>Soybean oil</td>
<td>35.28</td>
<td>36.75</td>
<td>-3.9</td>
<td>-12.2</td>
<td>254</td>
<td>915</td>
</tr>
<tr>
<td>Sunflower oil</td>
<td>33.72</td>
<td>37.26</td>
<td>7.2</td>
<td>-15.0</td>
<td>274</td>
<td>920</td>
</tr>
<tr>
<td>Waste oil</td>
<td>41.7</td>
<td>37.16</td>
<td>0</td>
<td>-39.7</td>
<td>279</td>
<td>910</td>
</tr>
<tr>
<td>Corn Biodiesel</td>
<td>4.78</td>
<td>37.45</td>
<td>0</td>
<td>-10</td>
<td>167</td>
<td>880</td>
</tr>
<tr>
<td>Rapeseed Biodiesel</td>
<td>4.47</td>
<td>37.70</td>
<td>-1</td>
<td>-11</td>
<td>163</td>
<td>880</td>
</tr>
<tr>
<td>Soybean Biodiesel</td>
<td>5.23</td>
<td>37.34</td>
<td>1</td>
<td>-7</td>
<td>178</td>
<td>885</td>
</tr>
<tr>
<td>Sunflower Biodiesel</td>
<td>4.53</td>
<td>37.00</td>
<td>1</td>
<td>-6</td>
<td>173</td>
<td>885</td>
</tr>
<tr>
<td>Waste oil Biodiesel</td>
<td>5.58</td>
<td>37.90</td>
<td>2</td>
<td>-7</td>
<td>179</td>
<td>885</td>
</tr>
<tr>
<td>Diesel</td>
<td>2.4</td>
<td>42.54</td>
<td>-5</td>
<td>-17</td>
<td>76</td>
<td>845</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property</th>
<th>Diesel</th>
<th>Bio-diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>ASTM D975</td>
<td>ASTM D6751</td>
</tr>
<tr>
<td>Composition</td>
<td>HC\textsuperscript{a} (C10-C21)</td>
<td>FAME\textsuperscript{b} (C12-C22)</td>
</tr>
<tr>
<td>Kinematic viscosity (mm\textsuperscript{2}/s) at 40 °C</td>
<td>1.9-4.1</td>
<td>1.9-6.0</td>
</tr>
<tr>
<td>Boiling point (°C)</td>
<td>188-343</td>
<td>182-338</td>
</tr>
<tr>
<td>Flash point (°C)</td>
<td>60-80</td>
<td>100-170</td>
</tr>
<tr>
<td>Cloud point (°C)</td>
<td>-15 to 5</td>
<td>-3 to 12</td>
</tr>
<tr>
<td>Pour point (°C)</td>
<td>-35 to -15</td>
<td>-15 to 16</td>
</tr>
<tr>
<td>Water (vol %)</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Carbon (wt %)</td>
<td>87</td>
<td>77</td>
</tr>
<tr>
<td>Hydrogen (wt %)</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Oxygen (wt %)</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Sulphur (wt %)</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Cetane number (ignition quality)</td>
<td>40-55</td>
<td>48-60</td>
</tr>
<tr>
<td>Stoichiometric air/fuel ratio (AFR)</td>
<td>15</td>
<td>13.8</td>
</tr>
<tr>
<td>HFRR\textsuperscript{c} (µm)</td>
<td>685</td>
<td>314</td>
</tr>
<tr>
<td>BOCLE\textsuperscript{d} scuff (g)</td>
<td>3600</td>
<td>&gt;7000</td>
</tr>
</tbody>
</table>

\textsuperscript{a}HC = hydrocarbon, \textsuperscript{b}FAME = fatty acid methyl ester, \textsuperscript{c}HFRR = Hard Face Ring and Pin, \textsuperscript{d}BOCLE = Bore OD Loss.
Variation of Engine performance with the engine speed, at full load
Variation of the brake power and the brake torque with the different biodiesel blends percentage, at full load.
Variation of different gas emissions with biodiesel blends percentage.
Cylinder pressure profile comparisons

Variation of in-cylinder pressure for different fuels at different engine speeds and loads
Comparison of the rate of Cylinder pressure rise

![Graphs showing the rate of cylinder pressure rise at different engine speeds and loads, with lines representing different fuel blends: Diesel, B10, B20, B30, B40, and B100.](image)
Comparison of heat release rate
Comparison of Cumulative heat release

- Diesel
- B10
- B20
- B30
- B40
- B100

Graphs for different RPM and torques showing pressure vs. angle.
Conclusions:

The “Fulpod” processor was used for the production of biodiesel from vegetable oils by using the transesterification process.

After esterification of vegetable oils, the kinematic viscosity was reduced from 40 mm²/s to 5 mm²/s.

Thus, any type of vegetable oils biodiesel can be used as an alternate and nonconventional fuel to run all types of CI engine.

By running biodiesel fuel, the experiential data shown, decreased in almost all of the emissions (CO, THC and CO₂) except for NOx.

The study has shown that no matter what type of feedstock is used there will be very similar decreases in emissions and performance of the engine.

The combustion profile for biodiesel fuel that is very similar to that of the baseline diesel fuel, and a similar torque is demanded from the engine.
Recommendation for Future Work

Future work should be conducted on actual road vehicles, to see the impact of driving a car in varying weather conditions, how the driver affects the emissions, efficiency and performance of the oil.

Investigation and characterization of combustion for mixture of biodiesel with ethanol or methanol and evaluate the engine performance and exhaust gas emissions.

Studies to optimize and characterize biodiesel production from canola oil and jatropha oil.
Thank you very much for your attention ...
Any questions?