Preliminary Measurement of Diesel Spray Impingement by Refractive Index Matching Method

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Project Objective

- Fuel spray impingement on the cylinder wall and piston surface is an important problem for direct-injection diesel engines because it is a possible source for hydrocarbon emission and soot emissions.
- Fuel spray propagation has been studied extensively, however, spray impingement on a surface and the resulting fuel film thickness and mass adhered to the wall are still not understood well.
- The fuel film spatial distribution, fuel film thickness, and adhered mass will be measured using the refractive index matching method.
- Fuel is injected to a flat surface inside a pressurized chamber at an ambient temperature of 500 K, and 2.3 MPa pressure. A selection of six injectors, with nozzle diameter from 75 μm to 349 μm, are investigated to study the influence of injector nozzle on the formation of the fuel film.

Theoretical Analysis

- Variation of light reflection intensity through the quartz window:
  \[ \Delta T(x, y) = 1 - \frac{I_{\text{inj}}(x, y)}{I_{\text{ref}}(x, y)} \]
  \(\Delta T\): variation of reflection intensity.
  \(I_{\text{inj}}\): local intensities of the fueled images.
  \(I_{\text{ref}}\): local intensities of the references images.
- Correlation between fuel film thickness and reflection variation:
  \[ \Delta T(x, y) = f[h(x, y)] \]
  \(h(x, y)\): fuel film thickness

Calibration Experiment

- A set of experimental instruments and procedures were setup in our lab to implement the refractive index matching method, and the refractive index matching method was investigated and found to be able to obtain the local fuel film thickness.
- Injection condition for measuring the diesel fuel film thickness was determined, and the injection rate shapes of the six injectors have been obtained.
- Injection in the hot chamber will be first photographed. Spray parameters will be then analyzed. Next, diesel fuel film thickness will be measured.

Acknowledgement:

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Spray Injection Conditions

<table>
<thead>
<tr>
<th>Injector nozzle diameter (HEUI 300B)</th>
<th>0.349 mm</th>
<th>0.206 mm</th>
<th>0.18 mm</th>
<th>0.12 mm</th>
<th>0.1 mm</th>
<th>0.075 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Engine running speed</td>
<td>1200 rpm</td>
<td>1200 rpm</td>
<td>1200 rpm</td>
<td>1200 rpm</td>
<td>1200 rpm</td>
<td>1200 rpm</td>
</tr>
<tr>
<td>Injection amount per cycle</td>
<td>33.0 ±1.0 mm³/cycle</td>
<td>33.0 ±1.0 mm³/cycle</td>
<td>33.0 ±1.0 mm³/cycle</td>
<td>4.5 ±1.0 mm³/cycle</td>
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<tr>
<td>Injection pressure (oil rail pressure)</td>
<td>140 MPa (23.3 MPa)</td>
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<tr>
<td>Injection main duration</td>
<td>3.05 ms (measured)</td>
<td>4.4 ms (measured)</td>
<td>6.7 ms (measured)</td>
<td>2.9 ms (measured)</td>
<td>7.2 ms (measured)</td>
<td>9.5 ms (measured)</td>
</tr>
</tbody>
</table>

Spray Impingement Instruments

- After the calibration of refractive index matching method was done, similar optical setup is installed inside an high pressure chamber with 2.3 MPa pressure, 25 kg/m³ density, and 500K temperature conditions.
- Impingement distance studied will be 20, 40, 60, 80, 100 and 120 mm.
- Impingement angles studied will be 0, 30, 45, and 60 degree.