Spectroscopy Study of Partially Premixed Combustion in a Light-Duty optical Engine

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Background
The partially premixed combustion (PPC) concept has shown high efficiency and has proven its potential to achieve simultaneous reduction of soot and NOx emissions. The low NOx emissions are resulting from the low combustion temperature. The low soot emissions is a result of increased premixing with respect to conventional CI engines. However, the in-cylinder phenomena are still needed to be investigated for further practical implementations. Spectroscopy is an important research tool for the identification of chemical species during the combustion phenomena.

Approach
The origin of the emitted photons are analyzed by means of high-speed spectroscopic measurements in a light-duty optical engine (Figure 1).

Operating Conditions:
Table 1. Single injection strategies. Total injected fuel is approximately 17 mg/cycle.

<table>
<thead>
<tr>
<th>Case</th>
<th>Injection timing</th>
<th>CA50</th>
<th>Intake temperature</th>
<th>Oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-200 CAD</td>
<td>8 CAD</td>
<td>323 K</td>
<td>19.0 %</td>
</tr>
<tr>
<td>B</td>
<td>-50 CAD</td>
<td>9 CAD</td>
<td>348 K</td>
<td>19.0 %</td>
</tr>
<tr>
<td>C</td>
<td>-25 CAD</td>
<td>9 CAD</td>
<td>348 K</td>
<td>18.8 %</td>
</tr>
<tr>
<td>D</td>
<td>-20 CAD</td>
<td>10 CAD</td>
<td>343 K</td>
<td>19.0 %</td>
</tr>
<tr>
<td>E</td>
<td>-15 CAD</td>
<td>10 CAD</td>
<td>413 K</td>
<td>18.8 %</td>
</tr>
</tbody>
</table>

Results
Effect of SOI (Stratification):

![Figure 2: Planck's law fitted to the spectrum.](image)

![Figure 3: Smooth spline fitted to the spectrum.](image)

Conclusions
- Broadband chemiluminescence, a collective name for CO2*, HCO* and CH2O* chemiluminescence, makes up the majority of the spectrum for HCCI combustion. For decreasing ID, OH*, CH* and C2* chemiluminescence increase.
- Analyzing the in-cylinder combustion by means of optical filters should be done with care, since a significant broadband chemiluminescence signal is transmitted as well for both PPC and HCCI regimes.
- Broadband chemiluminescence can also be used as a measure for the heat release rate. This implies that, although OH* chemiluminescence is absent in HCCI combustion, OH* broadband filters can be used to map the local rate of heat release in the combustion chamber. However, further fundamental investigation is required for validation when different combustion parameters are used.