Influence of in-cylinder soot formation and oxidation on engine-out soot emission in operation with 1st and 2nd generation biofuels

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MOTIVATION

Challenges for developers of future diesel engines:
1. Reduction of particulate matter (PM) – nitrogen oxide (NOx) trade-off [1,2]
2. Replacement of fossil fuel [3,4]

Potential solutions:
1. Alternative combustion concepts, HCCI (at best, P0 = λMax)
2. Biofuels (1st and 2nd generation)

→ Development of biogenic fuels gives further degree to achieve HCCI operation mode

Target of the experiments:
Analyzing in-cylinder soot formation and oxidation process as well as engine-out soot emissions of a 1st and 2nd generation biogenic fuel in comparison to a reference diesel fuel

DIESEL FUELS
Summary of physical and chemical fuel properties

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Density at 15 °C [kg/dm³]</th>
<th>Cetane number</th>
<th>Lower heating value [MJ/kg]</th>
<th>High heating value [MJ/kg]</th>
<th>Surface tension at 30 °C [mN/m]</th>
<th>Oxygen / Sulphur content [weight %]</th>
<th>Initial / Final boiling point [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference diesel fuel (B0)</td>
<td>824</td>
<td>53</td>
<td>42.5</td>
<td>46.1</td>
<td>2.2</td>
<td>28.6</td>
<td>0 / &lt; 5</td>
</tr>
<tr>
<td>Rapeseed oil methyl ester (RME, B100)</td>
<td>860</td>
<td>53</td>
<td>37.5</td>
<td>41.0</td>
<td>3.5</td>
<td>31.0</td>
<td>11 / &lt; 5</td>
</tr>
<tr>
<td>Di-n-butyl ether (DNBE)</td>
<td>787</td>
<td>100</td>
<td>38.0</td>
<td>42.5</td>
<td>0.5</td>
<td>23.1</td>
<td>12 / &lt; 5</td>
</tr>
</tbody>
</table>

RESULTS

• Analyzing the in-cylinder soot formation and oxidation process by simultaneous imaging of OH* and soot

  ▪ Reference diesel fuel (B0):
    - B0: p0 = 1.05 bar, ρ0 = 300 bar
    - B0: p0 = 1.05 bar, ρ0 = 1000 bar
    - B100: p0 = 1.05 bar, ρ0 = 300 bar
  ▪ Rapeseed oil methyl ester (B100)
    - B100: p0 = 1.05 bar, ρ0 = 1000 bar
  ▪ Di-n-butyl ether (DNBE)
    - DNBE: ρ0 = 1.05 bar, ρ0 = 300 bar
    - DNBE: ρ0 = 1.05 bar, ρ0 = 1000 bar

CONCLUSIONS

• Analyzing in-cylinder soot formation and oxidation process of 1st and 2nd generation biofuels by optical measurement techniques.
• Examining engine-out particle size distribution by a SMPS.
• New 2nd generation biofuels (e.g. DNBE) for soot free in-cylinder combustion.
• New 2nd generation biofuels support to achieve HCCI.
• Reduction of raw PM emissions during in-cylinder combustion.

FUTURE WORK

• Further engine operating points (injection, boost pressure, start of injection exhaust gas recirculation).
• Further fuels (synthetic, 2nd generation).
• Optical measurement technique for local temperature and soot fraction determination.
• Optical examination of fuel injection and mixture formation.

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References