Experimental Investigation on the Gas Jet Behaviour for a Hollow Cone Piezo Injector

Zaira Künsch
Outline

- Motivation
- Objective
- Experimental Setup
- PLIF Measurements
- Post-Processing
- Results
  - Gas Jet Evolution
  - Penetration Length
  - Maximal Jet Width
  - Average Jet Concentration
- Conclusions and Future Work
**Motivation**

**PROBLEMS**
- Depletion of fossil fuel reserves
- Negative impact of engines emission on the atmosphere

**CONSEQUENCES**
- Low fuel consumption
- Alternative fuels
- Low emission

**SOLUTION**
- Compressed natural gas direct-injected engines
  - CNG-DI
Objective

Provide first information on the gas jet behaviour for a hollow cone piezo injector
Experimental Setup

Ambient conditions:
\[ p_\infty = 1 \text{ bar} \]
\[ T_\infty = 293 \text{ K} \]
## PLIF Measurements

<table>
<thead>
<tr>
<th>Case</th>
<th>Injection Pressure [bar]</th>
<th>Needle Lift [μm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>52</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>52</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>52</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>52</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>62</td>
</tr>
</tbody>
</table>

$\Delta t_{\text{inj}} : 0.08, 0.10, 0.20, 0.30, 0.40, 0.50, 0.75, 1.00, 1.25, 1.50, 2.00, 2.50, 3.00, 3.50$ ms
Post-Processing

Macroscopic jet quantities

- Penetration length
- Maximal jet width
- Jet Area
- Jet Volume

\[ V = 2 \cdot \pi \cdot A \cdot x_c \]
Results: Gas Jet Evolution

\( p_{\text{inj}} = 5 \text{ bar} \)

\( p_{\text{inj}} = 30 \text{ bar} \)
Results: Gas Jet Evolution

\[ p_{\text{inj}} = 5 \text{ bar} \]

\[ p_{\text{inj}} = 30 \text{ bar} \]
Results: Penetration Length

- Influence of injection pressure
Results: Penetration Length

- Influence of needle lift

![Graph showing penetration length as a function of time after energizing the injector with different needle lifts](image-url)

- $NL = 25 \, \mu m$
- $NL = 52 \, \mu m$
- $NL = 62 \, \mu m$
Results: Maximal Jet Width

- Influence of injection pressure

![Graph showing the effect of injection pressure on maximal jet width.](image)
Results: Average Jet Concentration

- Influence of injection pressure
Conclusions

• Injection pressure and needle lift have a greater influence on jet width than on penetration length.
• Injection pressure and needle lift affect on gas jet collapsing tendency.
• Penetration length shows 0.8-power-law time dependency.
• Jet volume is a useful quantity for quantifying spatial distribution and thus jet mixing ability.
Future Work

- PLIF as qualitative validation tool for computational mixture formation investigations
- Study engine effects on hollow cone gas jets (influence of backpressure, moving piston)

Publication in Progress
Keskinen K., Kaario O., Nuutinen M., Vuorinen V., Künsch Z. and Larmi M.  
Simulation of methane-air mixture formation in axisymmetric direct injection configurations for a medium-speed gas engine
Thanks

• Prof. Martti Larmi and whole Thermodynamics and Combustion Technology Research Group at Aalto University

• Prof. Konstantinos Boulouchos and whole Aerothermochemistry and Combustion Systems Laboratory at Swiss Federal Institute of Technology

• Henry Fordin Säätiö
Results: Collapsing Tendency

\[ p_{\text{inj}} = 5 \text{ bar} \]

\[ p_{\text{inj}} = 30 \text{ bar} \]