Submission Guidelines for ECN 4 Topic 1: Internal Nozzle Flow for Spray A, B, C and D.

AVAILABLE SUB-TOPICS

I. For Spray A, we would like to reduce the spread in exit temperature predicted in ECN 3 by the various simulations.
II. For Spray B, we want to assess if internal flow features can explain the observed spray angle variability during the injection cycle.
III. For Spray C and D, the objective is to compare cavitation predictions from different simulations with one another and, if available, with lab visualizations.

I. Spray A, revisited

The proposed work might require a new simulation or just the mining of data from existing ones. Previous modeling results were somewhat inconclusive; see Figure 1 and ECN3 presentation **ECNTopic1.1V5Modeling.pptx**. What affects the exit fuel temperature? Some of the competing drivers are:

- The pressure drop experienced by the fuel along the orifice
- The mechanism of turbulent viscous dissipation at the boundary layer
- Wall heat transfer

This sub-topic could be developed in the form of a sensitivity study. For instance, consider your modeling choices:

- What is the sensitivity of your results to the equation of state you chose?
- What is the sensitivity to the parameters used in the turbulent boundary layer model?
- What is the dependence on the wall thermal properties (for instance, assuming a isothermal wall vs. assigning a heat flux)?

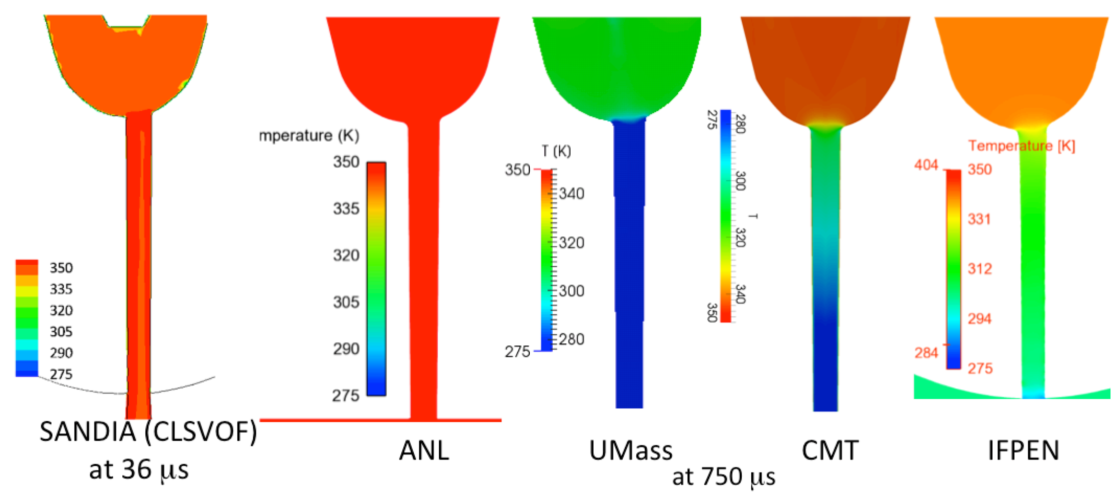

Figure 1. Transverse (x-y) temperature variation of n-dodecane assuming a reservoir temperature of 343 K. From ECN 3 presentation, topic 1.

Tentative list of participants:

Pedro Martí pedmar15@mot.upv.es

II. Spray B's variable spreading angle

Relevant presentations: **ECN2.6 2013-10-01, ECN3Topic 1.1.pdf, ECN3.1 2014-07-03, ECN3.4 2014-11-06, ECN3-Topic1.2-modeling_final.pptx**. Why does Spray B's spreading angle change during the injection cycle? An instance is displayed in Figure 2 for the same spray at two different points in the injection cycle. This variability has been observed in different facilities for the same injector and with in the same test rig for different injectors. This behavior has potentially important effects downstream, for instance with respect to ignition location. Instances of partially recirculating flow ("bubbles") should be expected due to the flow turning angle at the orifice inlet. Can angle variability be explained in terms of internal flow dynamics?

- The full injection cycle (or at lease a representative part) needs to be simulated:
  - Determine whether the angle variation depends on the needle's wobble or if it can be reproduced with symmetric geometry and straight axial needle's motion.
  - Characterize the dynamics of recirculation bubbles near the orifice inlet.
  - Assess if there are conditions for cavitation.
  - Characterize the turbulent layer thickness along the orifice.

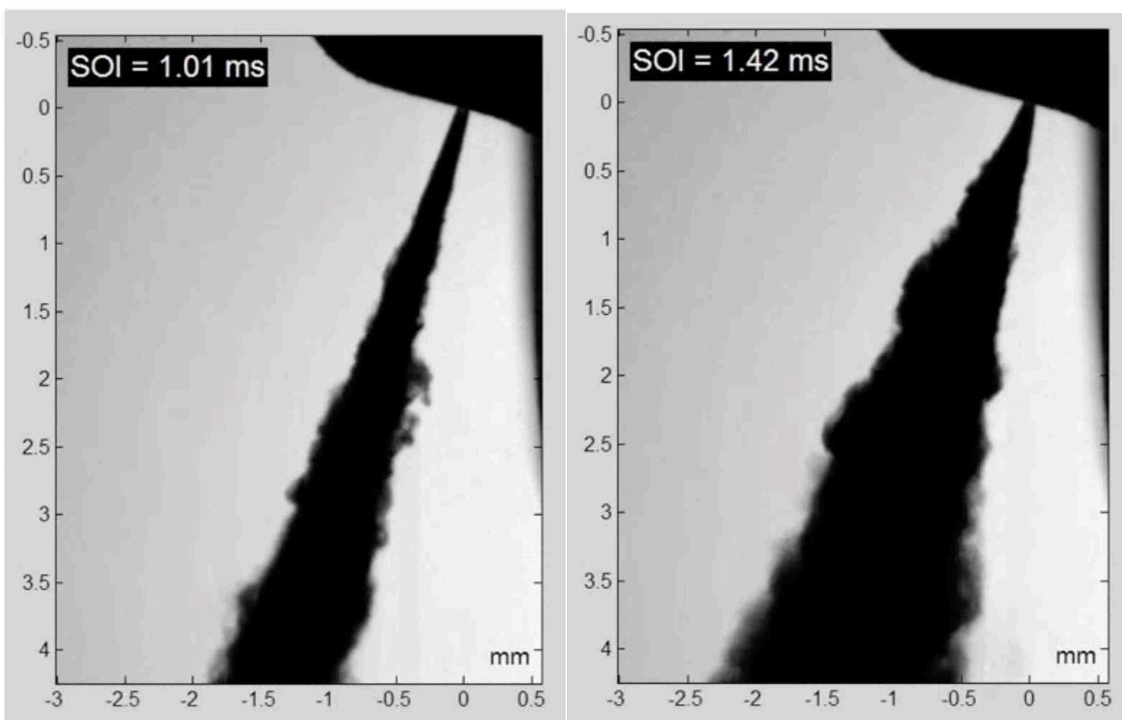

Figure 2. Spray B exhibits different spreading angles at different points in the injection cycle.

Injector 201 is the target injector. The injector tomography and a CFD-ready mesh are available: http://www.sandia.gov/ecn/cvdata/targetCondition/SpBNozGeo.php

III. Spray C and D

Relevant presentations: **ECN3.1 2014-07-03, ECN3.2 2014-09-01**, **ECN3.5 2014-12-04.** Spray C and D are single-orifice Diesel injectors, like Spray A, but are essentially more symmetrical and less affected by manufacturing irregularities, see Figure 3.

Based on the orifice shape and the injection pressure, Spray D, and particularly spray C, are expected to be more prone to cavitation than spray A. Their larger size (the nominal orifice diameter is 0.186 mm) could make it more feasible to fabricate a transparent nozzle. Thus the proposed objective for this sub-topic is the characterization of the cavitation region if observed in experiments or simulations.

The injector geometry description (in stl format) is available, but it may be too noisy for a viable CFD mesh. Based on the injector's scanning, an axis-symmetric "idealization" of the geometry, in preparation at Sandia, is recommended.

The fuel is n-dodecane. The injection pressure is 150 MPa and the "reservoir" temperature (before entering the sac) is 70 degrees C.

Deliverables:

1. From the stationary operation of the injector, and for the cross-sections at the orifice exit and along the injector's axis, generate data for the following quantities and their fluctuations:
    1. Velocity
    2. Density
    3. Temperature
    4. Void fraction
    5. Turbulent kinetic energy and viscosity

2. If the simulation covers the opening and closing transients, please also provide the time-dependent variation of the quantities above.

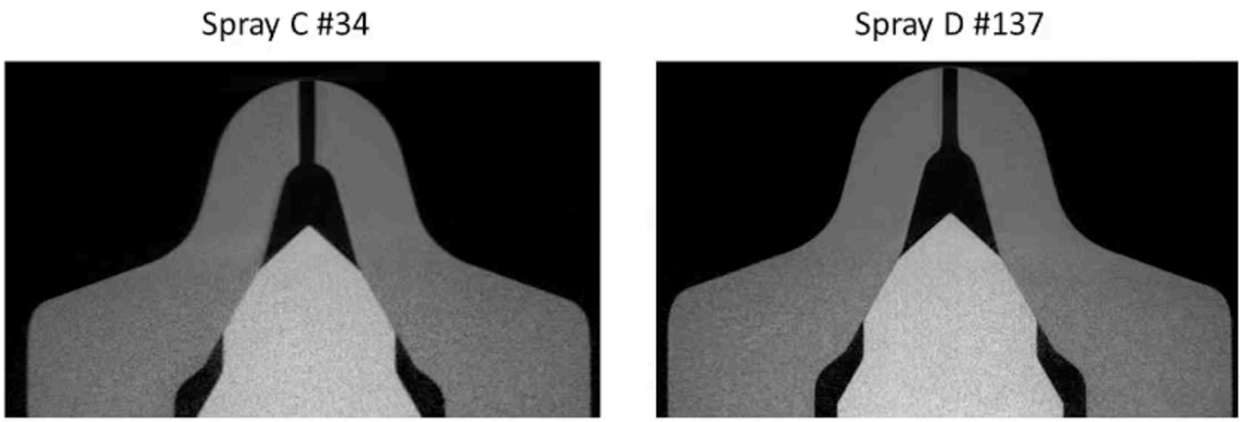

Figure 3. Spray C (left) and spray D (right). The diverging orifice is a distinguished feature of spray C.

Tentative list of participants:

Ehsanallah Tahmasebi ehsanallah.tahmasebi@polimi.it
Gianluca D'Errico gianluca.derrico@polimi.it
Tommaso Lucchini tommaso.lucchini@polimi.it

Michele Battistoni michele.battistoni@unipg.it

NOTES

- Jun 1st, 2015 is the Deadline for modeling/experimental submissions to ECN4
- As we strive to compare results from potentially very different calculations, please provide the data files in ASCII format. Always give dimensions for all quantities.