ECN7 Diesel sprays major objectives

- Predictive plume dispersion
- Predictive rate of injection at start of injection, including initial gas in sac
- Predictive evaporation and vapor-phase mixing
- Archiving of simulations for use as engineering tool model development

Scientific questions for consideration at ECN7:

1. What are the real numerical and physical model barriers towards predictive plume growth and dispersion?
2. Is boundary layer cavitation predicted for Spray D, and does that change plume growth?
3. Does Spray C have partial hydraulic flip, with ambient gas ingestion upstream (and how far)?
4. Can the asymmetry and transients be predicted for Spray C, including lower density at the nozzle centerline for a brief period at injector opening?
5. What is the accuracy of experimental mass rate of injection and momentum rate of injection during the start of injection?
6. How does initial gas in the sac affect ramp-up in rate of injection and spray dispersion?
7. What are best practices for CFD to account for needle elasticity and numerical gap at needle seat for predictive ramp-up in rate of injection?
8. What is the role of fuel temperature transients on internal flow and initial plume dispersion?
9. What is the impact of vaporization on mixing layer and plume growth?
10. How does mixture fraction vary radially and axially for vaporizing vs non-vaporizing sprays? Which is more fuel rich? How is the mass of air entrainmed into the plume affected?
11. Are radial and axial liquid penetration predictive against experiment using projected liquid volume?
12.

Specification of target simulations

Following the diesel combustion session, ECN7 will focus on internal flow and spray mixing dynamics for Spray C and Spray D, rather than Spray A or Spray B.

Case 1: “Cold” Spray C and Spray D

Case 1 make use of data where the injector and ambient were less than 363 K temperature, utilized for some valuable experiments at Argonne National Laboratory

Injector serial numbers: C 037 and D 134

Nozzle geometry and needle motion: Use tables for "Generation 2" STL geometry and needle motion available at https://ecn.sandia.gov/diesel-spray-combustion/target-condition/spray-c-nozzle-geometry/ and https://ecn.sandia.gov/diesel-spray-combustion/target-condition/spray-d-nozzle-geometry/. Follow instructions to reference Argonne National Laboratory.

Injector conditions: 1500 bar (upstream of needle seat), n-dodecane, 328 K wall and fuel temperature. Note that the needle lift data was collected at an injector temperature of 297 K, but spray radiography experiments were conducted using an injector temperature of 328 K. We choose to recommend simulations applicable to spray radiography.

Ambient conditions: 20 bar, nitrogen, 300 K

Injection duration: The needle motion profiles were obtained using 0.795 ms electronic command, which produces needle movement and injection duration of approximately 2.4 ms. While the computational cost may be too high to simulate the entire 2.4 ms (and end of injection to 2.6 ms), a reasonable compromise would be to simulate the opening 0.3 ms, a "steady period", and the closing 0.3 ms with 0.2 ms after the end of injection.

Initial state of sac and hole: The hole should be empty and the sac should be initialized with 30% gas, with the gas towards the hole exit. This initial state is motivated by transparent nozzle research for Spray D (see Yasutomi et al. SAE 2019-01-2279 and Abers et al. SAE 2019-01-2280).

Case 2: "Hot" Spray C and Spray D

Case 2 utilizes the official "Spray A" target conditions (https://ecn.sandia.gov/diesel-spray-combustion/target-condition/spray-ab/) with some alteration for injection duration.

Injector serial numbers: C 037 and D 134

Nozzle geometry and needle motion: Same as Case 1.

Injector conditions: 1500 bar (upstream of needle seat), n-dodecane, 363 K wall and fuel temperature.

Ambient conditions: 60 bar, nitrogen (or inert 0% oxygen mixture), 900 K

Injection duration: For internal flow simulations, same as Case 1. For Lagrangian simulations, use 4.5 ms and the CMT-recommended rate of injection (https://www.cmt.upv.es/ECN03.aspx#sprayCD). Much of the experimental data includes long duration data with quasi-steady liquid penetration (see Westlye SAE 2016-01-0860, Daly SAE 2018-01-0284, and online ECN data search results).

Initial state of sac and hole: Same as Case 1.

Experimental data available

Rate of mass and momentum of injection: CMT has provided data at https://www.cmt.upv.es/ECN05.aspx. Please reference these authors and data.

Spray radiography computed tomography: Argonne has provided 3D fuel density (mass of fuel per unit volume of spray) for Spray D https://anl.app.box.com/v/XRaySpray/folder/34797223647 and Spray C https://anl.app.box.com/v/XRaySpray/folder/52763782169. Please follow instructions for use and reference of these data

Liquid radial and axial penetration: Sandia has made available data on the ECN data search https://ecn.sandia.gov/ecn-data-search/?=&noxycon=0&norif=Spray C&vars=checked-checked-checked-checked-checked-unchecked-unchecked-unchecked-unchecked

CFD submissions

Rather than requesting specific quantities of interest, for this workshop we request that raw data be prepared and submitted in VTK format. Quantities of interest will be extracted and shared with the ECN (with permission of submitters). Please contact the organizers to discuss submission of VTK format files.