ECN8 DIESEL SPRAY GUIDELINES

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CONTENTS

- Overall Introduction

- Diesel topics
  1. Internal flow and near field
  2. Vaporizing spray
  3. Ignition
  4. Flame morphology and emissions

OVERALL INTRODUCTION

- General guidelines including different ECN groups working on Diesel sprays
    - From nozzle flow through vaporizing spray, combustion and emissions
    - Improving synergy among groups

- For each topic same structure
    - Motivation
    - Objectives
    - Operating conditions
    - Requested info

OVERALL INTRODUCTION

- As from ECN7
  - Spray D more interesting

- Highlights for ECN8
  - Follow the move towards **large nozzles (Spray C/D)** started at previous workshops

  - Introduction of **chicken-foot Spray D** nozzle (vessel/engine)

  - Comparison of **fuels within each of the Diesel topics/sections**
    - C12, OME3

OVERALL INTRODUCTION

TOPICS
1. INT FLOW NEAR FIELD
2. VAP SPRAY
3. IGNITION
4. FLAME

- Operating conditions

PARAMETRIC VARIABLE		O2 [%]	Ta [K]	Dens [kg/m3]	Pinj [MPa]	Inj Dur [ms]	1	2	3	4
Standard	Ai	0	900	22.8	150	5.0	X	X		
	Ar	15	900	22.8	150	5.0			X	X
Tsweep	T2	0/15	800	22.8	150	5.0	X	X	X	X
	T3	0/15	1000	22.8	150	5.0	X	X	X	X
O2sweep	O2	21	900	22.8	150	5.0				X

  - Reference nozzles
    - Single hole Spray D (SD)
    - Chicken foot Spray D (cfSD)

  - Fuels
    - C12, OME3

OVERALL INTRODUCTION

- Modelling info
  - C12
    - Liquid properties are available in most CFD codes, if needed please contact organizers
    - Recommended chemical mechanism
      - Yao et al (2017). Fuel 191, 339-349 http://dx.doi.org/10.1016/j.fuel.2016.11.083

  - OME3
    - Liquid properties will be shared
    - Recommended chemical mechanism (OME2-3-4)
      - Cai et al (2020). Fuel, 264, 116711. https://doi.org/10.1016/j.fuel.2019.116711

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1. INTERNAL FLOW AND NEAR FIELD (BATTISTONI) 1/2

- **MOTIVATION**
  - Large holes will be used on heavy-duty CI engines with low-sooting fuels
  - Physics of transition from near nozzle to spray in hot conditions is still unknown

- **OBJECTIVES**

  Study:
  - Internal flow and near-field mixing dynamics within ~20 mm for SD and cfSD
  - Cone angle and related flow features of cfSD (multi-hole) vs. SD (single-hole)
  - Cold conditions: diameters PDF, to validate liquid break-up on large holes
  - Hot conditions: vaporization/mixing correlation with primary break-up

  Open questions:
  - Are liquid distribution and mixing fields well predicted in the atomization region?
  - Transcritical paths with new fuels: dense-fluid approach vs. break-up & evap.?
  - How to identify liquid boundary?

1. INTERNAL FLOW AND NEAR FIELD (BATTISTONI) 2/2

- **OPERATING CONDITIONS**
  - Cold: 1500 bar, 328 K wall and fuel temperature, into nitrogen 22.8 kg/m^3, 300 K
    (for transient simulation effects: sac initialized with 30% gas)
  - Hot: 1500 bar, 363 K wall and fuel temperature, into nitrogen 22.8 kg/m^3, 900 K
    (temperature sweeps: 800 K and 1000 K, at 22.8 kg/m^3)
  - Nozzle geometries: “Generation 2” STL files and needle motion

- **REQUESTED INFO** *(both Experiments and Simulations)*
  - Mass & momentum flow rates, tip penetration, near nozzle cone angle vs. time
  - Transverse integrated mass (TIM) vs. axial distance
  - 2D contours of liquid volume fraction (LVF) and on cross-sections *for sim.*
  - 2D contours of projected liquid density and projected liquid volume (PLV)
  - Mean droplet size (SMD) and PDF of liquid drop diameters
  - Liquid and vapor mass fractions (either as projected quantities or as cut-plane values *for sim.*)
  - Entrainment vs. axial distance
  - In addition: raw data from simulations in VTK format are accepted as well. 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.

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2. VAPORIZING SPRAYS (MAES) 1/2

- **MOTIVATION**
  - Main interest for future CI engines: HD with larger nozzles & renewable fuels
  - Improve understanding of mixing physics & validation of mixing assumptions
  - Asses mixing field predictions for Spray D – LES while matching spray pen.

- **OBJECTIVES**
  - Study mixing differences when moving to new fuels & large orifices
  - Identify differences between Spray D & chicken-foot-Spray D (cfSD)
  - Evaluate liquid spray temperature during evaporation

- **OPERATING CONDITIONS**
  - Standard non-reacting Spray A + Temperature sweep for liquid spray

2. VAPORIZING SPRAYS (MAES) 2/2

- **REQUESTED INFO**

  Experiments:
  - Tip & liquid penetration under inert conditions
  - Projected liquid volume fraction maps
  - Mixing measurements (Rayleigh, tracer LIF, etc.)
  - Liquid spray temperature measurements

  Simulations:
  - RANS & LES simulations both welcome (to compare mixing fields)
  - Tip & liquid penetration under inert conditions
  - Projected liquid volume fraction (and associated temperature) maps
  - Time resolved mixing fields

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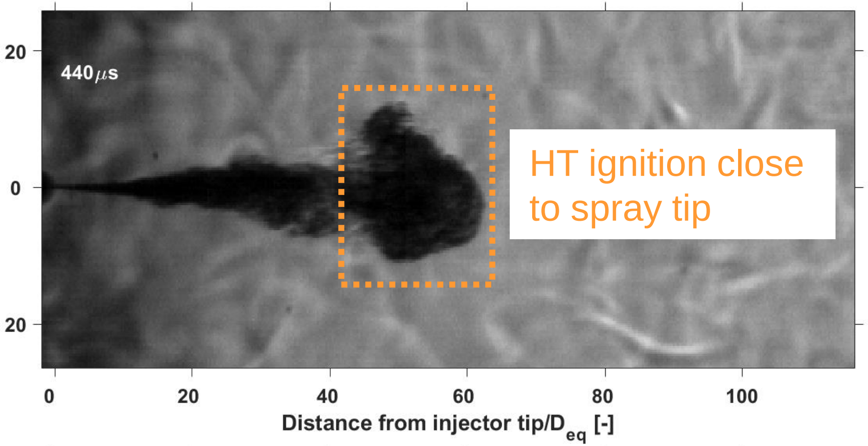
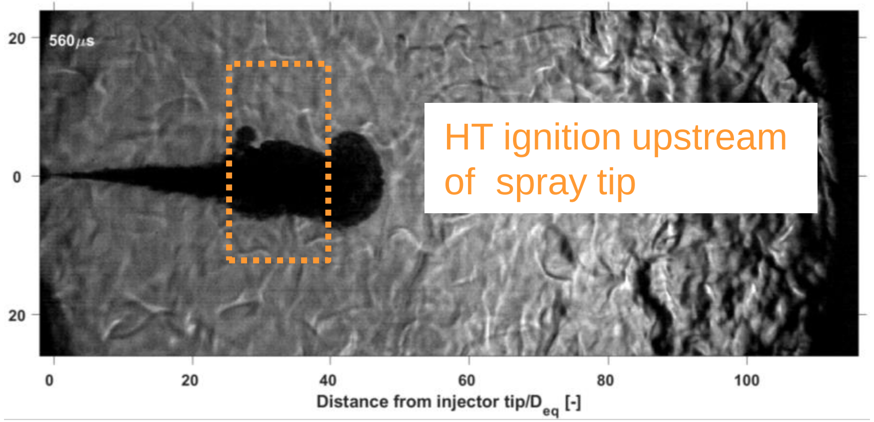
3. IGNITION (GARCIA/PEI) 1/3

Spray A



HT ignition close to spray tip

Spray D



HT ignition upstream of spray tip

3. IGNITION (GARCIA/PEI) 2/3

- **MOTIVATION**
  - Evaluation of the ignition sequence for large nozzles
  - Comparison of fuel effects

- **OBJECTIVES**
  - Experiments
    - Determination of ignition sequence of SD vs SA with time- and space-resolved techniques
    - Can the mixture fraction at ignition site be resolved?
  - Modelling
    - Evaluation of ignition sequence
    - Capturing ignition differences between SD and SA
    - Reference mechs: Yao (C12), Cai et al (OME3)

3. IGNITION (GARCIA/PEI) 3/3

- **REQUESTED INFO**
  - Experiments
    - Planar techniques for SD (e.g. formaldehyde LIF)
    - Rayleigh scattering under inert conditions to derive mixture fraction at ignition location as well as to evaluate mixing predictions before start of combustion

  - Modelling
    - Usual combustion metrics
      - Ignition delay
      - Field variables: Time- and spatially resolved species from SOI (Start of Injection) to slightly after SOC (start of combustion)
    - Approach
      - Each group at least a well-mixed (WM) combustion model
      - LES preferred, RANS accepted
      - Mixture fraction validation before ignition

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4. FLAME MORPHOLOGY AND EMISSIONS (MANIN) 1/3

- **MOTIVATION**
  - Detailed look into combustion and pollutant formation
  - Heavy duty is the main driver for CI (diesel) research

- **OBJECTIVES**
  - Gather information about flame morphology (lift-off length, flame length, flame structure, etc.)
  - Quantitative data (if possible) about pollutants:
    - PAHs and Soot (including detailed aspects of PM such as optical, size, etc.)
    - NO (if available - qualitative or quantitative)

4. FLAME MORPHOLOGY AND EMISSIONS (MANIN) 2/3

- **OPERATING CONDITIONS**
  - Conditions: Typical Spray A and relevant temperature sweep
    - Additional oxygen concentrations welcome
    - Fuel pyrolysis conditions may also be interesting for soot modeling

- **REQUESTED INFO**
  - Experiments (when applicable/available):
    - Lift-off length (OH* or OH LIF, schlieren, etc.)
    - Flame structure (dissipative structures possibly from inert Rayleigh)
    - PAH LIF measurements
    - Soot measurements (DBI, LII, spectroscopy, two-color, etc.)

4. FLAME MORPHOLOGY AND EMISSIONS (MANIN) 3/3

- **REQUESTED INFO**
  - Experiments continued... (when applicable/available):
    - NO measurements via LIF or other method
    - Speciation measurements (quantitative – OH, PAHs, NO, etc.)

  - Simulations:
    - Lift-off length (OH mass fraction)
    - Squared gradients or scalar dissipation rate maps
    - Temporal maps and volume integrated masses for C2H2, C3H3 and PAHs from A1 to A4
    - Temporal maps and volume integrated soot mass
      - Soot mass for the different processes (inception, surface growth, condensation, etc.)
    - Temporal maps and volume integrated NO mass