1.- Objectives

- Internal nozzle flow characterization. Analysis of the flow structure and the phenomena during the injection process.
- External flow analysis. Eulerian-Lagrangian approach focus on mixing and atomization.

2.- CFD Methodology

**Internal Flow Analysis**
- CFD software used: CONVERGE, ANSYS CFX
- Homogeneous Relaxation Model (HRM). Phase change (cavitation and flash boiling).
- Rate of change of local vapor quality: \( \frac{Dx}{Dt} = x - x_0 \)
- Time scale: \( \theta = \frac{x}{x_0} = 0.54 \sqrt{\frac{1}{\theta}} \leq 7.66 \)
- : 3.84 e-07 s
- \( \alpha \) : fuel void fraction
- \( \Psi \) : dimensionless pressure

**External Flow Analysis**
- Discrete Droplet Model (DDM)
  - Primary Atomization: Huh Model
  - Secondary Atomization: KH-RT

**X-Ray geometry**

Geometry A

Geometry B

Example of employed mesh

1.1 millions + AMR
1.6 millions of cells

3.- Internal Nozzle Flow Results

**Transient Needle Lift Simulation**

**Penetration Calculation**

**Spray Cone Angle & Plume Direction**

4.- External Flow Results

**Eulerian-Lagrangian Approach**

**Error calculations**

\[ \varepsilon = \frac{(S_{exp} \cdot Scf/d)}{S_{exp}} \]

DDM experimental inputs: [9.7% ; 27.5%]
DDM computational inputs: [7.5% ; 15.7%]

5.- Conclusions & Future Work

- The plume direction is well captured by the in-house post-processing code. The spray direction differs from the geometrical axis of the hole. The lack of experimental measurements does not allow to validate the spray cone angle results.
- Eulerian approximations adequately predict the liquid penetration in the first millimeters of the injector exit. The simulation with a fixed needle lift has a faster response than the transient simulations.
- There is an overestimation of about 5% in the internal nozzle flow calculations. This overrating compensates the deficiencies in the Eulerian-Lagrangian approach and reduces the errors. More experimental and numerical investigation is needed to understand the spray behavior.

Finished publications

[3] Payri, R. et al. GDI nozzle Lift Transient Simulations. (under revision to be submitted to Energy Conversion and Management)