WP3 – Release and mixing: UU update

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Pre-normative REsearch for Safe use of Liquid HYdrogen

UU - WP3 activities plan

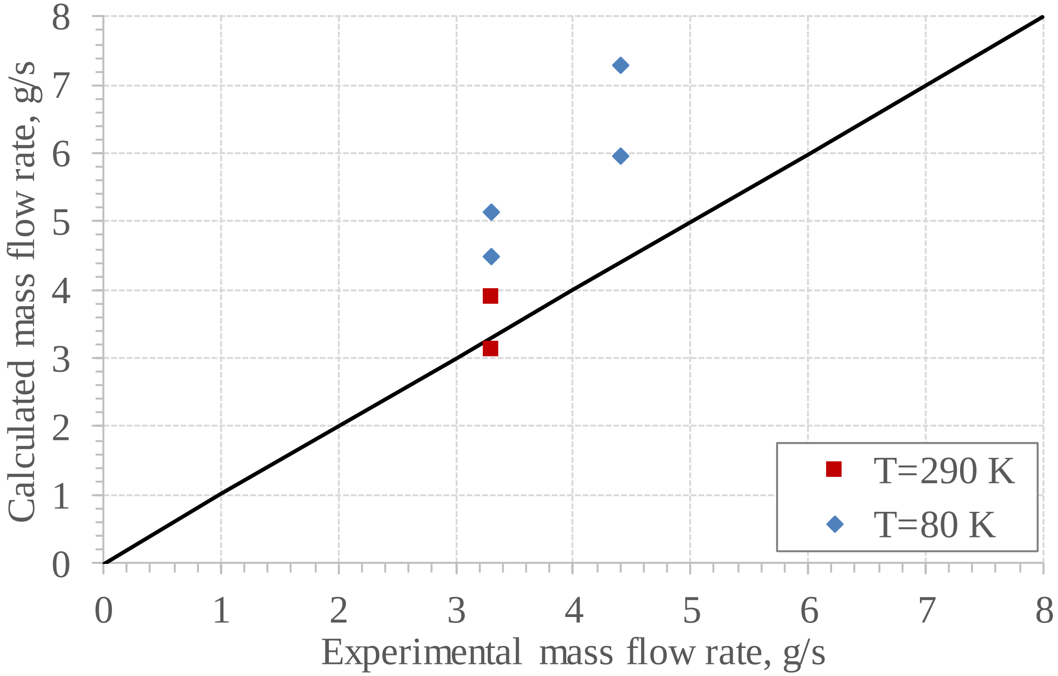
- ✓ Analysis of the similarity law for momentum dominated cryogenic jets for use in calculation of hazard distances: validation against SNL tests
- Analysis of the applicability of notional nozzle theory and volumetric release source concept for prediction of concentration decay in cryogenic under-expanded jets:
  - ✓ Low pressure releases (P < 10 bar): validation against SNL tests
  - High pressure releases (P > 10 bar): validation against ICESAFE and PRESLHY experiments performed by KIT (E3.1)
- Perform simulations of experiments on multi-phase releases:
  - Contemporary engineering tool for evaluation of mass flow rate from LH2 tank with inclusion of conjugate heat transfer: HSE experiments (E3.5)
- Studies on formation of cryogenic mixtures of H2/O2 and H2/air (connected to WP4-Ignition)

Release source modelling

Jet fire tests performed at KIT - ICEFUEL

The under-expanded jet theory developed at Ulster was employed to model cryogenic and warm hydrogen releases by KIT at ICEFUEL facility (Breitung et al., 2009).

Release conditions	
Temperature, K	80, 290
Pressure, bar	3 – 20
Diameter, mm	2, 4

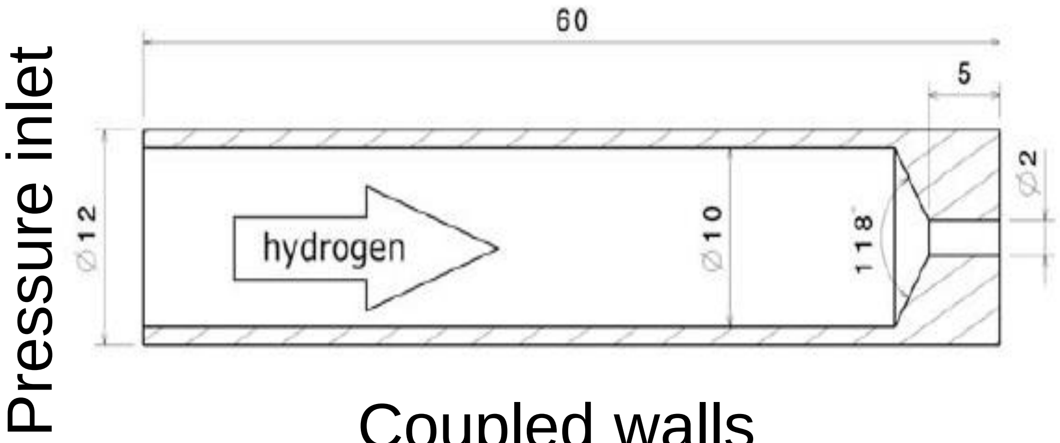


CFD simulations to investigate reasons for mass flow rate deviation:

- Losses and heat transfer in the release pipe
- Effect of cryogenic release temperature
- Calculate notional nozzle conditions for jet fires simulations (WP5)

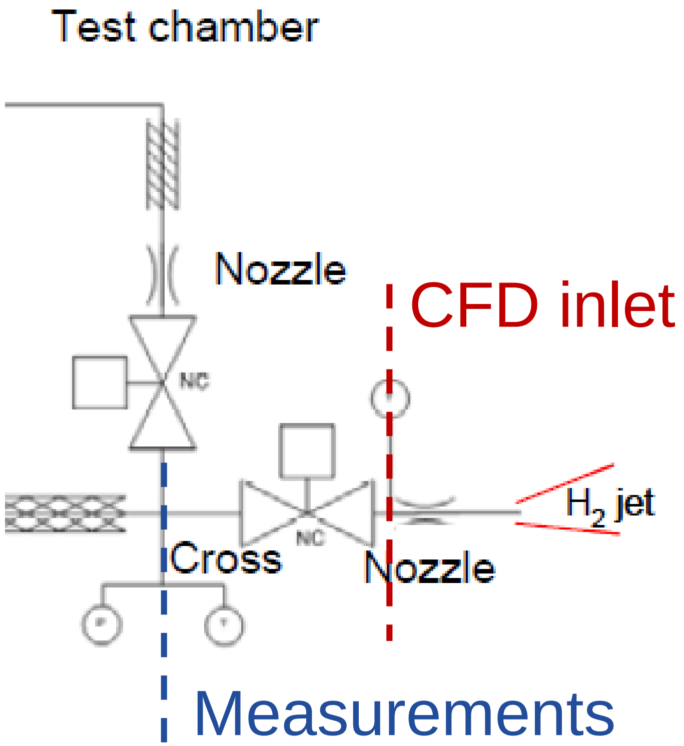
Release source: CFD modelling

Problem formulation



Pressure inlet

Coupled walls



CFD inlet

Measurements

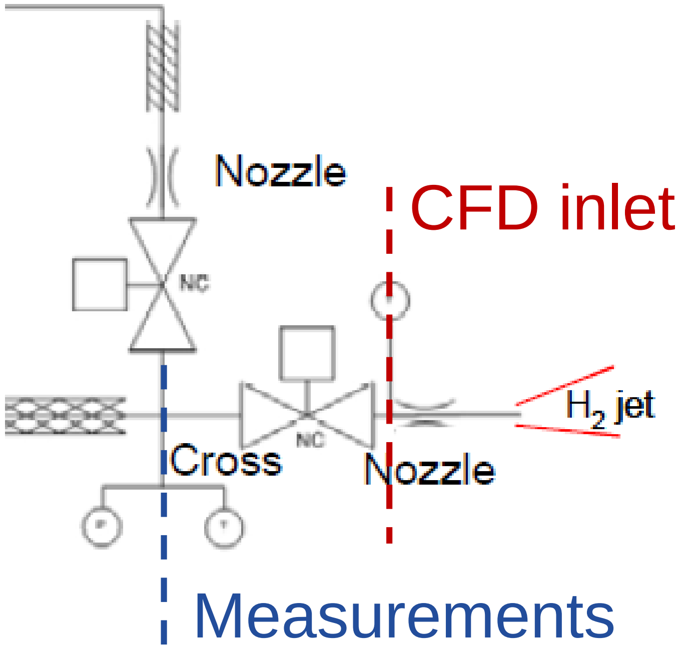
- Density based compressible explicit solver
- LES dynamic Smagorinsky-Lilly model
- Cylindrical domain with dimensions 7 cm (radius) x 18 cm (length)
- Hexahedral mesh with ~500 thousands CVs
- Inclusion of conjugate heat transfer in simulations

Effect of inlet temperature on $\dot{m}$

Simulation results

Test with T=80 K P=14 bar measured at the cross.

Case	Mass flow rate, g/s
CFD – Tin=80K	4.3
CFD – Tin=100K	3.8
CFD – Tin=120K	3.5
CFD – Tin=150K	3.2
Experiment	**3.3**



- Heat transfer causes a 9% difference on the calculated mass flow rate
- Important: location of temperature sensor!

Thank you for your attention!

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