Contribution ID: **59** Type: **Oral**

Numerical investigation of subcritical and supercritical spray dynamics in cryogenic refuelling processes

Wednesday 29 October 2025 12:00 (15 minutes)

The transition to cleaner energy carriers is essential for reducing greenhouse gas emissions. As the market share of cryogenic fuels such as liquefied natural gas (LNG) and liquid hydrogen (LH_2) increases, cryogenic fluid transportation and storage systems are becoming increasingly important. The unique thermophysical properties of cryogenic fluids pose significant challenges for the injection, storage, and transportation, requiring accurate modelling tools for cryogenic fluid management.
As an application case, subcooled liquid hydrogen (sLH_2) refuelling sprays are examined in the context of heavy-duty truck operations. Compared with gaseous hydrogen or low-pressure liquid hydrogen storage, sLH_2 offers benefits due to its high energy density, low storage pressure, and suitability for long-haul operations. In sLH_2 refuelling systems, the target tank pressure typically exceeds the critical pressure of hydrogen (Pc = 12.964 bar, Tc = 33.145 K). As a result, the injected sprays conditions range across multiple thermophysical regimes. Such transitions require the development of a unified numerical framework that can consistently capture the cryogenic spray dynamics.
A newly developed numerical solver, CoolFoam, is employed to simulate cryogenic spray behavior under varying thermodynamic conditions. The solver is developed on the OpenFOAM platform, specifically tailored for compressible, non-isothermal, multi-fluid, and cryogenic flows. The influence of tank pressure, temperature, and refuelling mass flow rate on spray development is systematically assessed. Results highlight the influences of key operational parameters in determining spray penetration, evaporation rate, and heat transfer, which directly affect the efficiency, safety, and reliability of hydrogen refuelling for vehicle tanks.
The validated framework therefore offers a novel tool for evaluating cryogenic spray and optimizing refuelling strategies across both subcritical and supercritical regimes. These insights contribute to the development of safer and more energy-efficient cryogenic refuelling protocols, thereby supporting a wider adoption of cleaner cryogenic fuel applications.

Submitters Country

united kingdom

Are you a student?

Yes

Author Affiliations & Email Addresses

I confirm that valid email addresses and affiliations have been added for all co-authors.

Co-Author Affirmation

By clicking here, I, the submitting author, affirm that all co-authors know of and concur with the submission of this abstract.

Author: LIU, Yuzhao (university of oxford)

Co-author: Prof. VOGIATZAKI, Konstantina (university of oxford)

Presenter: LIU, Yuzhao (university of oxford)

Track Classification: Liquid Hydrogen Technologies