Project FORTE - Nuclear Thermal Hydraulics R&D for BEIS

Two-Phase Flow and Heat Transfer

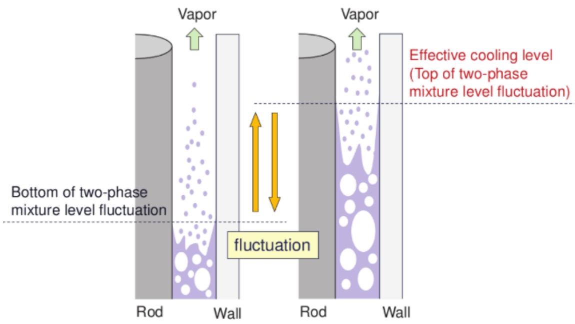
THE CHALLENGE

Two-phase flows feature extensively in the context of nuclear thermal hydraulics and they present a significant increase in complexity over their single-phase counterparts. The development of accurate, robust, and widely applicable two-phase computational models is thus one of the most significant challenges facing the nuclear thermal hydraulics modelling community today. Current modelling approaches are heavily reliant on empirical correlations that offer only limited applicability, and the fidelity of the data produced in the majority of experimental work is, unfortunately, too coarse to be useful for model development. In order to assess current modelling practice, help drive model development and foster collaboration across the community, there is a need to produce high quality ‘CFD grade’ experimental data.

OUR SOLUTION

We aim to address these issues by conducting a series of simultaneous experimental and numerical investigations into one of the most important and relevant aspects of nuclear thermal hydraulic two-phase flows: boiling. Specifically, two cases have been selected: subcooled flow boiling and rod bundle boil-off. In the latter a lack of flow in a rod-bundle style LWR fuel assembly leads to bulk phase change and eventual dry-out. The approach can be summarised as:

- Current numerical modelling capability has been assessed through simulations of subcooled flow boiling against a number of prominent experimental datasets.
- A series of novel experiments in rod-bundle boil-off have been designed, developed and executed in order to provide high-quality, high-fidelity, experimental data.
- A number of recent and novel numerical wall boiling models identified in the capability assessment will then be validated against the rod-bundle boil-off data to identify model deficiencies and provide the insight required to drive model development.



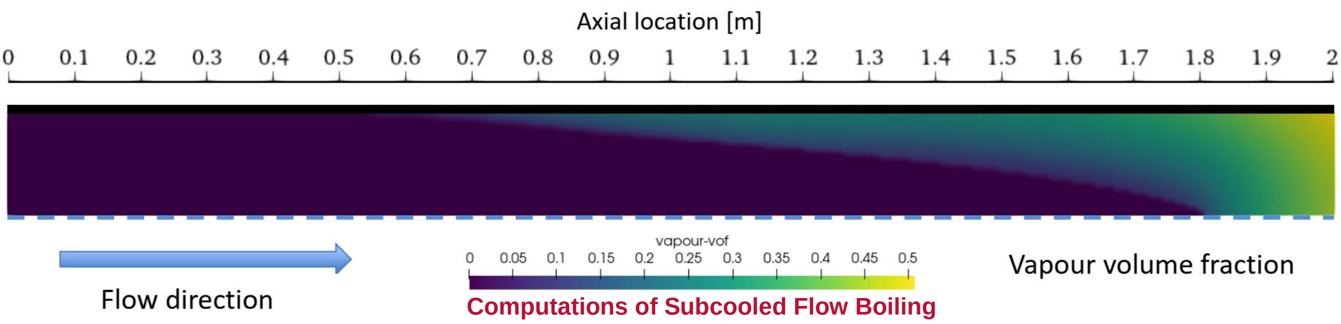
Rod-bundle boil-off illustration

OUR INNOVATION

By utilizing a simple test piece configuration and advanced high-speed imaging techniques we are able to acquire test data to a level of measurement fidelity not currently available and better discern and understand the distinct physical mechanisms that govern the overall boiling process. This will allow the better identification of areas for model development, provide a more valuable model assessment and provide valuable model validation data.

THE BENEFITS

The novel experimentation constitutes a significant and valuable contribution to the international nuclear thermal hydraulics modelling community and is expected to be disseminated through a number of journal publications and conference presentations. The high-fidelity data, together with the insight and understanding gained from the numerical modelling assessment, will assist in beginning to move nuclear thermal hydraulics modelling away from its reliance on empirical correlations and towards the development of more mechanistic, better performing and more widely applicable models.



Computations of Subcooled Flow Boiling

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