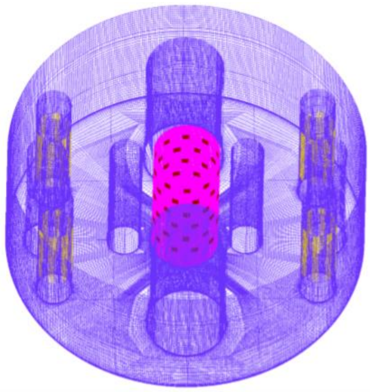
Project FORTE - Nuclear Thermal Hydraulics R&D for BEIS

Thermal Hydraulics of Liquid Metal Fast Reactors

THE CHALLENGE

The heat transfer characteristics of liquid metal are markedly different from that of conventional fluids (air and water). Notably, the Prandtl number is several orders of magnitude smaller than that of the water because of their high thermal conductivity. As a result, conventional turbulence models are not valid and new models are needed. Model development is however hindered by the lack of experimental data for validation because of the particular difficulties involved in working with, and instrumenting, liquid metals.

In addition, the pool-type design typical of Liquid Metal Fast Reactors (LMFRs) involves thermal hydraulic phenomena which are unique for such reactors, including thermal stratification, thermal stripping and unstable thermal interfaces causing thermal fatigue. All of the above have made the advancement of numerical modelling a critical step in the development of LMFR technology.



Geometry and mesh of the E-SCAPE upper plenum simulation

OUR SOLUTION

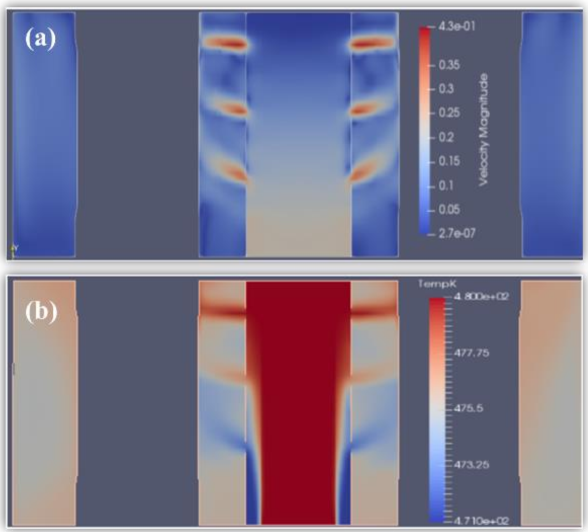
The ultimate goal of this research is to carry out high fidelity numerical simulations using Large Eddy Simulation (LES) of a major experimental facility to validate the numerical schemes that have been developed. In addition, it provides detailed, experimentally-unattainable information to develop a better understanding of the physics of liquid metal heat transfer.

The facility chosen is the E-SCAPE (European SCAled Pool Experiment) test facility, which is a 1/6th model of the MYRRHA research reactor under design at SCK•CEN. RANS simulations have been carried out using the general-purpose open source software Code_Saturne developed by EDF R&D for: (i) the upper plenum thermal hydraulics model and (ii) the above-core jetting and structures model. In the future, LES models will be created and validated against experimental data.

OUR INNOVATION

Once validated, our high-fidelity computer models based on Large Eddy Simulation will serve as numerical experiments to create a database for engineering models developed for LMFRs.

We also aim to test and improve turbulent heat transfer models for low Prandtl number fluids and advance the understanding of multiple jets mixing and their interactions with solid structures.



(a) Velocity and (b) temperature contours in a vertical cross-section of the E-SCAPE upper plenum

THE BENEFITS

This study will provide a better understanding of the physics and empirical and mathematical models of the hot plenum and the above-core jet mixing of LMFRs. The developed model supports LMFR designs and bridges the knowledge gap in low Prandtl fluids heat transfer.

The modelling of a major experimental facility in Europe provides opportunities for collaboration with experimentalists in Europe and worldwide.

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