POLITECNICO MILANO 1863

Politecnico di Torino

Master Thesis

RANS simulations of forced convection to a liquid metal flowing in a non-uniformly heated tube

Description

For numerical simulation of nuclear engineering applications, such as rod bundles or gyrotrons, a RANS approach is predominantly adopted. At present, a variety of turbulence models are present in the literature and implemented in fluid dynamic calculation codes. There is no universal turbulence model that provides the most accurate results regardless of the application. For this reason, it is appropriate to evaluate which model to use, through proper validation and comparison with experimental data or numerical data obtained through LES or DNS simulations. In this regard, it is good practice to adopt accepted standards to quantify the degree of accuracy inferred from the comparison of a numerical solution and the available reference data.
Liquid metals are excellent cooling fluids, adopted in both nuclear and solar thermodynamic applications. Given the difficulty of experimental investigations of liquid metals, it would be advantageous to replace them with numerical simulations. These must be able to span a wide range of Reynolds numbers in addition to providing sufficiently accurate results with an acceptable computational cost. Therefore the Reynolds-Averaged Navier Stokes (RANS) approach is preferred over more time consuming LES/DNS simulations.

In this thesis the candidate will perform RANS simulations of the turbulent forced convection to a liquid metal flowing in a uniformly and non-uniformly heated tube. Both the heat transfer in the fluid as well as in the solid wall (Conjugate Heat Transfer - CHT) will be considered. The geometry is the same as the test section used by [1], for which accurate experimental data are available for a comparison. Moreover, the RANS results will be also compared with available accurate LES data. Different turbulence models should be investigated through simulations done with OpenFOAM. The models not already available within the OpenFOAM distribution should be first implemented. The model error will be estimated according to the V&V 20-2009 Standard [2].

Tasks

- Implementation of the Lag EB $k-\epsilon$ and Lag EB $k-\omega$ turbulence models in OpenFOAM;
- RANS simulations at different Reynolds numbers and heat flux boundary conditions with OpenFOAM;
- Model error abalysis according to V&V 20-2009 Standard.

Start date and duration

As soon as possible / 6 months.

Skills

Basic knowledge of CFD. Prior experience with OpenFOAM, Linux and C++ is a plus.

References

[1] T. Laube *et al.* "Turbulent heat transfer in a liquid metal tube flow with azimuthally inhomogeneous heat flux", Int. J. Heat Mass Transf., 189 (2022), p. 122734

[2] ASME V&V 20-2009 (R2016), "Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer", ASME, New York

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