Karlsruhe Institute of Technology

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master thesis – numerical

LES of liquid metal flow in a non-uniformly heated pipe

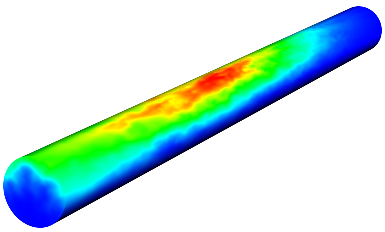
Background

Liquid metals, like sodium, lead and its alloys, gallium and its alloys, are excellent heat transfer fluids which remain in the liquid phase up to high temperatures. Therefore they are attractive when the size and weight of the heat exchange devices should be limited and when high thermal loads are present. However, there remain some challenges in the physical understanding of macroscopic heat transfer properties, as the molecular thermal conduction is of the same order as turbulent conduction.

Recently, liquid metals have been proposed as heat transfer fluids for Concentrated Solar Plants (CSP). Here, only one half of the receiver's surface is irradiated by the concentrated sunlight, thus resulting in a strongly non-uniform heat flux on the outer wall. As a consequence, the tube walls are subjected to high thermal stresses. A proper thermo-hydraulic, as well as mechanical design of the solar receiver requires then a good knowledge of the local wall temperatures and convective heat transfer coefficients.

Content of the Thesis

There is high fidelity experimental data for this setup available. In this thesis, the gap between experiment and simulations will be addressed. The candidate will perform Large Eddy Simulations (LES) of the turbulent forced convection to a liquid metal flowing in a uniformly and non-uniformly heated tube. The different velocity and temperature scales in low Prandtl number fluids - such as liquid metals - allow performing an LES for the flow field and a DNS for the temperature field with the same grid. In particular, the effects of heat transfer in the wall of the pipe shall be investigated.



Instantaneous flow field in a non-uniformly heated pipe (Straub, 2020)

LES simulations at different Re numbers and heat flux boundary conditions will be conducted with OpenFOAM, the results will be post-processed in detail and the obtained results will be evaluated and interpreted, including a comparison with experimental data.

The thesis will be jointly supervised by Prof. Luca Marocco, Politecnico di Milano.

Requirements

knowledge in fluid mechanics
numerical methods / programming

Beneficial Skills

OpenFoam, C++, theory of turbulent flows

Start: immediately

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