Internship/Master thesis in collaboration with Cenaero

Numerical evaluation of two-phase natural circulation flow in the cooling channel of the external reactor vessel

Cenaero (http://www.cenaero.be) is an applied research center that provides numerical simulation methods and tools to companies involved in a technology innovation process, allowing to invent and design more competitive products. Our ambition is to be internationally recognized as a technology leader in modelling and numerical simulation, to be a strategic partner of large global industries as well as a real support to regional companies including innovative SMEs. We are mainly active in the aerospace, process engineering, energy and building sectors, and provide expertise and engineering services in multidisciplinary simulation, design, and optimization in the fields of mechanics (fluid, structure, thermal and acoustics), manufacturing of metallic and composite structures. Having a solid and recognized experience in numerical simulations and the development of methodologies and tools for turbomachinery applications, Cenaero is an official strategic R&D partner of the Safran group. In addition to providing engineering services and software development, Cenaero operates a Tier-1 supercomputing infrastructure (tier1.cenaero.be). Our headquarters are in Gosselies (Belgium), with a subsidiary office near Paris (France). To support the expanding research activities focusing on energy management, we are looking for an intern student.

Description

In-vessel retention is a severe accident mitigation strategy to contain the molten core debris inside the reactor vessel by cooling its external surface via the natural circulation of cooling water. Once the molten core is relocated to the lower head, massive thermal loading is imposed on the reactor vessel wall, applying a high heat flux to the surrounding cooling water. This causes an upward natural convective flow of the cooling water in the annular channel between the reactor vessel and insulation wall. The natural circulation cooling system has been important technique for nuclear reactors cooling design due to its operational simplicity, safety, and maintenance reduction features. In order to achieve reliable cooling performances, the natural circulation must be designed and operated to avoid some physical phenomena associated to the two-phase instabilities.

Two-phase heat transfer process owns the benefits that heat flux can be dissipated by evaporation, during which the higher heat transfer coefficient can be achieved and the identical fluid temperature result in uniform wall temperature. However, the problems of bubble confinement and local dryout may lead to flow instability and critical heat flux (CHF), which is still underway to be settled.

The objective of this study is to investigate the effects of low thermal resistance, pressure drop and flow distribution inside a natural circulation manifold arrangement, which directly affects the wall temperature uniformity and system safety.

Objective

The different steps of this work are the following:

- Brief state of the art of two-phase natural circulation in in-vessel retention strategy.
- Ability of working with open-source CFD code: OpenFOAM.
- Implementation of the chosen numerical model (two-phase approach and turbulence model).
- Geometry and mesh generations.
- Evaluation on test data.
- Writing the report/dissertation.

Profile

- Master in Nuclear Engineering program.
- Knowledge in Computational Fluid Dynamics (CFD) simulations is a must as well as comprehension of C++ programming.
- Fluent in English and French.
- Real team player, able to work with autonomy.

Contact

Motivated candidates are invited to send their CV and motivation letter to rh@cenaero.be and Pierre.Etienne.Labeau@ulb.be, mentioning the internship offer reference.