Development of a multi-physics coupling algorithm for the FRENETIC code

Introduction

The design process and safety assessment of the Advanced Lead-cooled Fast Reactor European Demonstrator (ALFRED) require suitable computational tools to correctly represent the peculiar characteristics of the system in the different operating and accidental conditions. In this perspective, Politecnico di Torino has been developing the Fast Reactor Neutronics/Thermal-hydraulICs (FRENETIC) code, a multiphysics neutronic/thermalhydraulics (NE/TH) tool for full-core analyses of fast systems with hexagonal grid, which has been already validated against experimental data and reference codes [1].

The code has been tested in various conditions, performing both code-to-code comparisons and validation against experimental results. In particular, in the frame of an IAEA coordinated research project on the shutdown heat removal tests performed on the Experimental Breeder Reactor-II (EBR-II), FRENETIC has been adopted to reproduce the EBR-II transient behaviour [2].

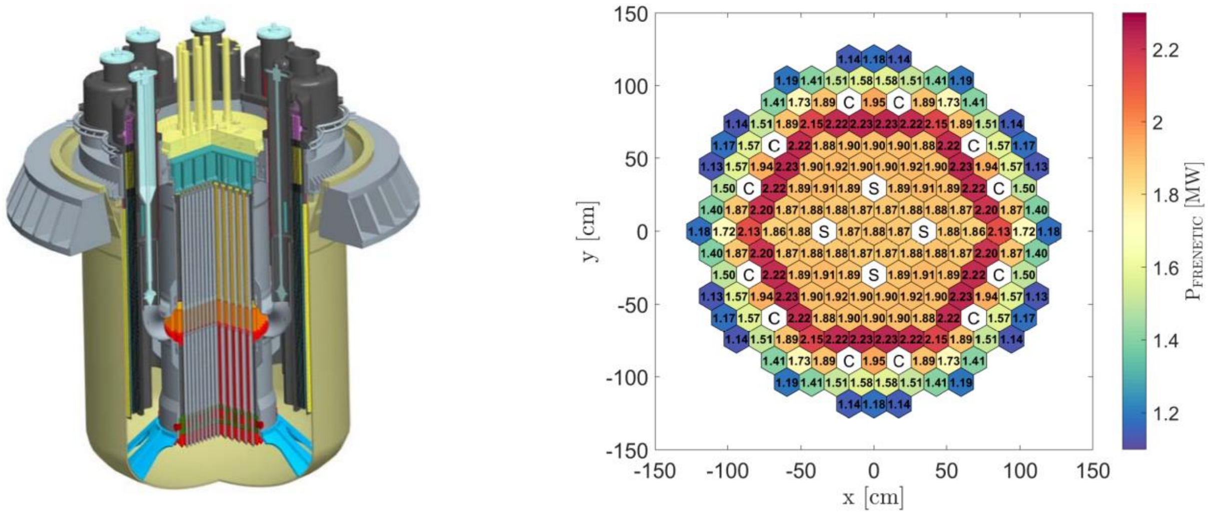

Figure 1: ALFRED 3D sketch [3] (left) and computed full-core fission power map in MW per fuel assembly for ALFRED in HFP conditions [4].

Aim of the work

In the framework of the continuous testing and improvement of the FRENETIC code, the multiphysics coupling algorithm between the TH and NE modules has been identified as one of the most promising aspects for improving the code computational efficiency and robustness. In particular, the present proposal involves the development and implementation of an adaptive selection of the under-relaxation factors for the physical quantities (temperatures, power density) exchanged between the NE and TH modules of the code, as suggested in [5].

The student will first become familiar with the models and methods employed by FRENETIC, as well as with the code itself. He will then develop and implement a method for the adaptive selection of the under-relaxation factors in the code. The correct implementation of the method will be verified by comparing the code results with suitable analytic solutions and/or benchmark cases, both in steady-state and in transient conditions. Finally, the performance improvement arising from the code modification will be assessed by running a full-core simulation of the ALFRED reactor.

Keywords: IV generation fission reactor, lead-cooled reactor, multiphysics, coupling

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