Development of a reduced order model for multi-physics safety analyses with FRENETIC code

Introduction

The liquid-lead cooled fast reactor concept is, among the GEN-IV designs, the research focus of the joint Italian effort of both national research centers, led by ENEA, and Italian universities involved in the nuclear education members of the Intra-University Consortium for Nuclear Technology Research (CIRTEN).

The Advanced Lead-cooled Fast Reactor European Demonstrator (ALFRED) design development started within the European project LEADER [1], it has been subsequently revised and it is now planned to be constructed in a site in Pitesti, Romania. The design process and related safety assessment analyses require the development of suitable computational tools, able to correctly represent the peculiar characteristics of these systems in the different operating and accidental conditions. In this perspective, the NEMO group at Politecnico di Torino has been developing the Fast Reactor Neutronics/Thermal-hydraulICs (FRENETIC) code, a multiphysics neutronic/thermalhydraulics tool for full-core analyses of fast systems with hexagonal closed fuel assemblies [2]. The code has undergone various phases of benchmarking and validation against reference solution (Monte Carlo, system codes, …) and experimental data.

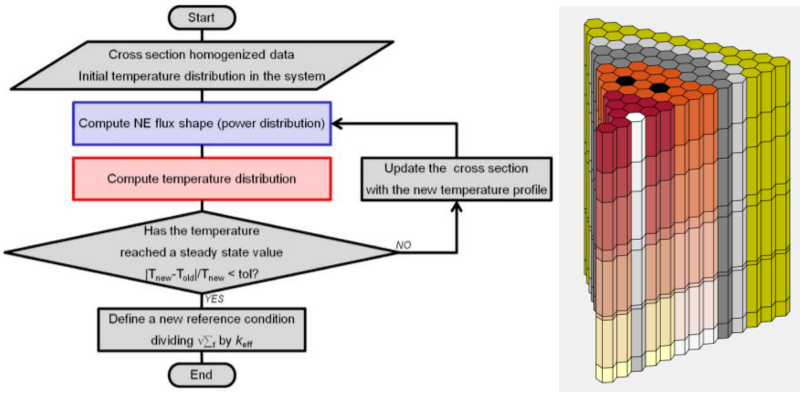

Figure 1: FRENETIC flowchart and ALFRED reactor 3D view.

Aim of the work

In spite of the relatively low computational burden associated to FRENETIC coupled simulations, a thorough evaluation of the full-core transient behavior for a sufficiently wide spectrum of accidental conditions may not be feasible in a time scale compatible with the ALFRED reactor design and its safety assessment.

A possible strategy to reduce the computational load associated to these calculations could be the development of a non-intrusive reduced order model trying to mimic the FRENETIC code response within a certain confidence bound [3]. After an adequate selection of the most important core operating parameters, FRENETIC multi-physics simulations should be run for the most significant parameter combinations, the so-called *training sets*, in order to “train” the reduced order model to reproduce the code response also for unexplored points. Due to its non-intrusiveness, this approach does not require to modify the code, which is thus considered as a *black-box*, allowing to build a fast-running tool for accidental scenarios analysis [4].

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