Karlsruher Institut für Technologie

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Master Work Proposal

Topic: Coupling of TwoPorFlow and KANECS based on the preCICE platform

Motivation

Multi-physics coupling is inherent in nuclear reactors, where thermal-hydraulics, neutron kinetics, and other physical processes interact and jointly determine reactor behavior. These interactions have a direct impact on key quantities such as power distribution, temperature fields, and safety margins, making multi-physics simulations essential for accurate analysis under both normal and transient conditions. Our group has extensive experience in developing coupled codes and performing multi-physics analyses using various coupling strategies and techniques. Building on this background, it is valuable to explore whether a general-purpose coupling platform can provide improved flexibility and sustainability. In this context, preCICE, an open-source library for partitioned multi-physics simulations, offers a modular approach to coupling existing solvers and is therefore a promising candidate for integrating and advancing in-house nuclear simulation tools.

Research Content

This thesis focuses on developing a modular coupling framework between the thermal-hydraulic code TwoPorFlow and the reactor-physics code KANECS using preCICE. TwoPorFlow is a porous-media-based thermal-hydraulic code for reactor applications, while KANECS is a deterministic neutronic solver based on the SPN transport approximation. Both of the two codes are developed by our group (KIT-INR-RPD). The coupling between these two codes represents a typical reactor multi-physics problem, in which the thermal-hydraulic state affects neutronic feedback, and the power distribution calculated by the neutronic solver provides the heat source for the thermal-hydraulic analysis.

The main scientific and technical content of the thesis is to identify a suitable coupling strategy for these two in-house solvers within the preCICE framework. This includes defining the exchanged physical quantities, the data-transfer structure, and the coupling sequence between the thermal-hydraulic and neutronic calculations. The expected outcome is not only a working coupled program, but also a clear assessment of how preCICE can be applied to in-house nuclear simulation tools. Therefore, this Master's work will provide both a practical software implementation and useful experience for future extensions toward more general multi-physics coupling applications.

Work Plan (6 months, flexible)

1) Familiarization with the usage of TwoPorFlow and KANECS.
2) Understanding of the source code (main numerical solution steps) of the two codes.
3) Study of the preCICE coupling framework and development of the adapters for the two codes.
4) Coupled calculation and verification.

Skill Requirements

- Basic knowledge of reactor thermal-hydraulics and reactor physics.
- Familiarity with numerical solution methods.
- Experience with scientific programming with Fortran and Python.

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