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Coupling 1D thermohydraulics with 3D CFD via preCICE

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Nuclear reactor safety relies on the simulation of the complex reactor cooling systems under a broad range of operation and accident conditions. Established codes, such as ATHLET, provide extensively validated 1D models of the involved devices and connecting pipelines. Developing and validating new such models is a very rigorous process, making coupling to external implementations a natural next step. Such a synergy across simulation codes and communities could greatly improve our understanding of the complex flow phenomena leading to stable or unsafe operation and could accelerate the development of successful Gen-IV reactor designs.

GRS, the reactor safety institute developing ATHLET, has already implemented a plethora of coupling interfaces between ATHLET and different codes, including ANSYS Fluent, OpenFOAM, and the GRS code COCOSYS. However, developing and maintaining these interfaces requires significant time and development effort, with technical requirements that may differ across interfaces. In the ATHLET-preCICE project, we are developing an ATHLET adapter for preCICE, with the goal to enable ATHLET to be coupled with any of the several codes that preCICE officially or via its community already supports. At the same time, we are also researching methods for geometric multi-scale mapping and extending the preCICE library to allow black-box coupling of solvers of different dimensionality. Such a feature would have natural extensions to other simulation fields, such as simulations of blood flow, floods, or helicopter fluid-structure interaction.

In this talk, we will present multi-model flow and CHT simulations, coupling ATHLET with OpenFOAM and an FEM heat transfer code (preCICE currently officially supports CalculiX, code_aster, and FEniCS for this part). We will present the ATHLET-preCICE adapter, an adapter based on the PyAFFE interface of ATHLET and using the Python bindings of preCICE. We will continue with supporting validation cases and project updates, before concluding with an overview of further application studies.

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