CFD-based multiscale and multiphysics tools for nuclear applications and needs for high fidelity experimental data

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ABSTRACT

Due to the complexity and multidimensionality of thermal-hydraulic phenomena taking place within nuclear reactor pressure vessel and in power plant components, computational fluid dynamics (CFD) has become a key element in the tools chain being used in the nuclear field for equipment design as well as for operational and safety analysis of nuclear power plants.. In the present article we will illustrate several nuclear relevant applications of CFD as standalone computational tool and as part of a high fidelity multiphysics, multiscale framework.

In particular, we will report about our experience in the development and application of a CFD-based multiphysics simulation tool involving fluid-dynamics, heat transfer, neutron transport and 3D chemistry for the high fidelity prediction of crud deposition on PWR fuel rods, and the development of a multiscale coupling between CFD and the US NRC 1D best estimate-thermal hydraulic code TRACE. Other applications to be discussed in the paper include 3D mixing phenomena during a PWR boron dilution transient, thermal fatigue in power plants isolated branch lines and subcooled boiling in heated channels.

The need for high resolution CFD-grade experimental data will be discussed, and the experimental efforts carried out at the Experimental and Computational Multiphase (ECMF) Laboratory of the University of Michigan will be summarized.