Paralelization of thermalhydraulic sub-channel code COBRA-TF using Krylov methods of the PETSc toolkit

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Abstract

In order to reduce the computing time when simulating large nuclear reactors in detail, we have developed a parallel version of the thermalhydraulic sub-channel code COBRA-TF (CTF), with standard message passing technology (MPI). The parallelization is oriented to reactor cells, so it is best suited for models consisting of many hexahedral cells in a structured mesh. The generation of the Jacobian is parallelized, in such a way that each processor is in charge of generating the data associated to a subset of cells. Also, the solution of the linear system of equations is done in parallel. For the latter step, we have used the PETSc toolkit, which offers a number of iterative linear solvers as well as preconditioners. The Bi-CGStab solver combined with a block Jacobi (with incomplete LU in each subdomain) represents a significant reduction of simulation time compared to the previous implementation that makes use of SPARSKIT package.

With the objective of validating the parallel implementation of COBRA-TF, a whole Pressurized Water Nuclear Reactor core (PWR) has been modeled and applied to a flow injection transient simulation. A set of simulations with different number of computer cores validate the parallel version of the CTF solver against the standard CTF simulation as a reference.