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Numerical Modeling of an In-vessel Flow Limiter Using an Immersed Boundary Approach

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This work is in the context of the mitigation of the consequences of a large-break loss of coolant accident in a Pressurized Water Reactor. To minimize the flow leaving the vessel and prevent or delay the uncovering of the core, CEA has devised a device, named in-vessel flow limiter, limiting the flow of fluid from the vessel to the break. The goal is to interfere as little as possible with the nominal operation flow and maximize the fluid retained in the event of this kind of accident.

In order to quickly perform a series of 3D-CFD simulations to optimize this device, it is imperative to have a simulation tool that provides sufficiently accurate results in a reasonable time. For this goal, an immersed boundary condition approach is retained. The solid obstacles constituted by the fins of the device are not extruded from the fluid domain, but included in the calculation domain itself. Their presence is considered by a first-order in space local Direct Forcing term using a penalty approach.

Through 3D/1D up-scaling of CFD global quantities, local pressure-drop coefficients, induced by the in-vessel flow limiter, can be provided to Thermal-Hydraulic system safety codes. It allows safety studies of the thermal-hydraulic system taking into account the in-vessel flow limiter presence in a more realistic way.

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