containmentFOAM

JÜLICH Forschungszentrum

Coupled containmentFOAM-Modelica modeling of the passive safety systems of small modular reactors

Currently, various reactor concepts are being developed in the category of small modular reactors. The reduced power and, consequently, size of these reactors opens the doors to safety concepts not feasible to traditional designs and of high interest from a modelling perspective. For example, the Westinghouse IRIS reactor, a so-called integrated pressurized water reactor (iPWR) shown in Fig. 1, relies on the equalization of the pressure of the reactor vessel and the surrounding containment to stop the release of the cooling water before the reactor core is uncovered. To control the pressure in the containment within the target values, pressure suppression systems are connected to the containment atmosphere. These essentially consist of a water pool into which the vapor-containing atmosphere is injected at overpressure and vapor is condensed.

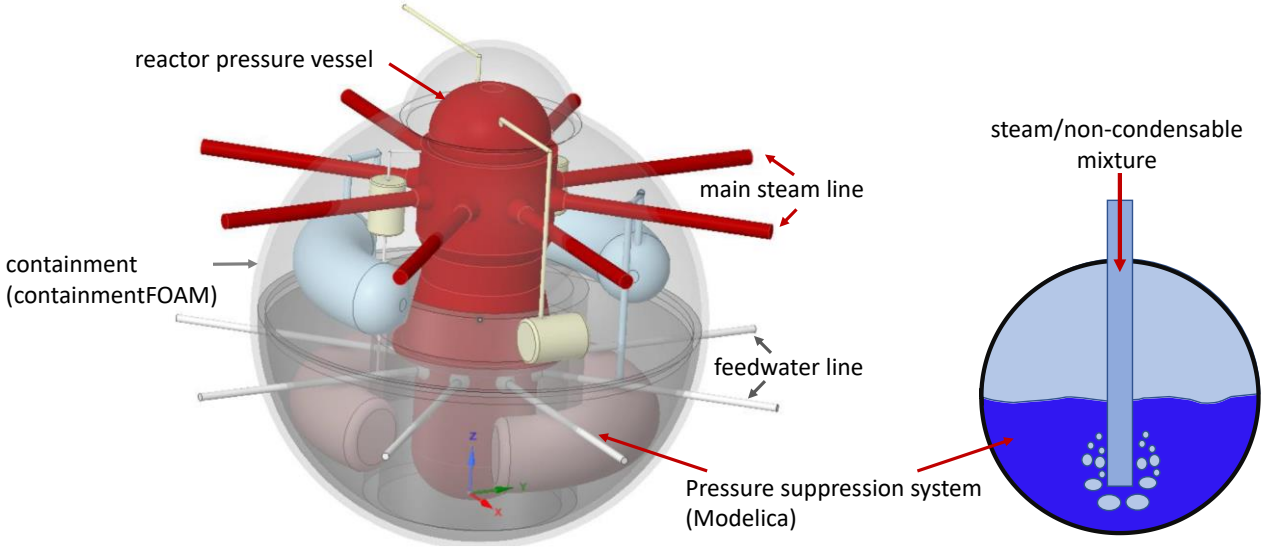

Figure 1. Structure of the IRIS reactor (left), pressure reduction system (schematic) (right).

For the simulation of the pressure build-up in the containment, a program coupling between containmentFOAM (based on OpenFOAM®) and (Open)Modelica is currently being developed. While the gas and steam distribution in the containment is calculated with containmentFOAM, Modelica uses a simplified formulation of the system dynamics to take over the mapping of the pressure reduction system as a 'dynamic pressure boundary condition'. The work will continue a previous project, which completed a prototypic implementation of the program coupling using the Functional Mockup Interface (FMI-2.0) and developed a simplified model of the pressure reduction system in OpenModelica. This approach requires further developments in the coupling scheme and/or the physical modeling (heat and mass transfer phenomena) included in the Modelica model. The specific tasks can be weighted according to the previous experience of the person working on the project. A containmentFOAM model for the final application (simulation of experiments or simplified reactor sequence) will be provided.

Schedule (6 months):

2 weeks: Literature review on coupling strategies or modeling of pressure decay systems.
6 weeks: Familiarization OpenModelica and containmentFOAM
8 weeks: Implementation of new developments for the Modelica models (coupling scheme and/or heat and mass transfer phenomenology)
6 weeks: Execution of coupled simulations, test of the robustness of the coupling and implementation of improvements if necessary. Application-oriented validation.
4 weeks: Preparation of the final documentation.

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