Development of a LW-SMR dry containment model with containmentFOAM

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ABSTRACT

In line with the growing interest in Europe for the deployment of Small Modular Reactors (SMRs), the Horizon Euratom SASPAM-SA Project launched in 2022 aims to investigate the applicability of the know-how for large-LWRs to water-cooled SMR (LW-SMR). More specifically, the project investigates potential Severe Accident (SA) sequences for two different "generic" SMRs, Design-I with a submerged containment and Design-II with a dry containment and several passive safety features, based on information available in the open literature. On this basis, the ability of different codes widely used in Europe to analyse the identified SA sequences are evaluated.

This paper presents the up-to-date status of the 'Design-II' LW-SMR dry containment model development using containmentFOAM, a CFD package tailored for containment safety analyses based on OpenFOAM-9, which is developed at Forschungszentrum Jülich (FZJ). The use of the code in SASPAM-SA aims to complement the calculations performed with lumped parameter codes, such as MELCOR, ASTEC, or AC2. Due to the close coupling of the containment and the reactor cooling phenomena, the additional insights of containmentFOAM for the buoyancy-driven transport processes and the condensation in presence of non-condensable gases are relevant for the system response. However, the new safety concepts that are feasible due to the reduced size of SMR containments come with novel challenges for the code.

The first priority of the modelling process is to ensure a consistent definition of the model geometry, as it is based on a database conceived for lumped parameter models. The evaluation of the thermal-hydraulic conditions predicted by the lumped parameter codes motivates a review of the applicability of the code to the expected higher pressures and steam concentrations (fluid properties, condensation regimes, etc.). Besides, the liquid released from the reactor vessel occupies a significantly larger fraction of the smaller containment volume. Therefore, two-phase models are currently being tested to consider the more prominent role of the liquid for the containment behaviour. Last, an OpenModelica-containmentFOAM coupling scheme is under implementation to represent the specific safety features of Design-II, such as the pressure suppression system.

KEYWORDS
SMR, CFD, containmentFOAM, two-phase flow, system code coupling