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CFD and system code modelling of passive safety system performance

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Abstract

Apros system code model and the OPenFOAM CFD model were created and the preliminary simulations were conducted for the planned arrangement of the Panda facility PCCS experiment P1A4. The Apros model consisted of the whole system including the containment vessel, the PCC pipe, the PCCS water circulation loop and the water pool. The OpenFOAM model included only the containment vessel, the PCC pipe and the steam injection lines inside the vessel.

Quasi-steady conditions of the whole test apparatus were calculated with Apros varying the steam injection rate. The vessel pressure, gas temperatures, steam mole fractions, water mass flow rate in the PCCS circulation loop and water inlet temperature of the PCC pipe were given as boundary conditions for the CFD simulation. The purpose of the work was to learn and prepare the Apros and CFD model capabilities for future simulation of the Panda test P1A4 to be conducted in the OECD/NEA benchmark exercise.

The Apros results showed that the system model works as expected and the results are qualitatively reasonable. Steam injection rate of 0.01 kg/s seemed to produce quasi-steady conditions during 55 hours simulation.

The CFD simulation exceeded 1720 s until finalisation of this report. The preliminary CFD simulation results were promising.

Some model improvements should be done for the future work. More suitable heat transfer correlation for a single-pipe PCCS should be implemented in Apros. Also a multi-node pool model should be developed.

What comes to the CFD model, an investigation regarding the numerical schemes is recommended. Furthermore, a denser mesh should be developed by refining the regions close to the PCCS pipe and the vessel walls where condensation occurs.

Key words

SMR, BWRX-300, passive safety system, modelling, Apros, OpenFOAM

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