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Simulations and experiments of severe accident transients in a generic SMR containment: Expanding the THAI+ test facility with a new vessel

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This study focuses on enhancing safety validation methods for small modular reactors (SMRs) by investigating the behavior of passive containment cooling systems (PCCS) during severe accidents. Many SMR designs rely on a containment-water pool coupling, which acts as a final heat sink during events like loss-of-coolant accidents (LOCA). The thermal-hydraulic behavior inside the containment—such as gas stratification, temperature distribution, and natural convection—is influenced by complex interactions between steam, hydrogen, and the cooling pool.

To better understand these dynamics, researchers are using both numerical simulations and technical-scale experiments. In this work, the GOTHIC code is applied to simulate SMR-relevant accident scenarios, which are then validated through experiments at the THAI+ test facility. The facility includes interconnected pressure vessels, and it is being expanded to incorporate a new SMR-type vessel capable of simulating various containment geometries and conditions. This vessel can operate at pressures up to 64 bar and can be fully or partially submerged in water.

Extensive instrumentation, including thermocouples and flow meters, enables high-fidelity monitoring of key parameters like temperature, pressure, and condensation. In test scenarios, steam is injected into the vessel, initially condensing on the inner walls before reaching steady conditions. Hydrogen is later added to study gas stratification and condensation dynamics.

Preliminary simulations show the formation of distinct stratified layers—steam, hydrogen, and condensate—within the containment, offering crucial data for validating thermal-hydraulic models. The facility supports a “double-blind benchmark” environment, providing unprecedented experimental conditions for testing and validating LP and CFD simulations of next-generation reactor safety systems.

Technical Track

Safety and Severe Accidents

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