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Adaptive Modelling for Multiphase Flow Through Debris Bed With Boiling

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Abstract: In the event of a severe accident, a large part of the core may collapse and form a debris bed. Debris bed coolability is important to avoid releasing the radioactive materials to the environment. If it is not rapidly cooled, the debris bed will begin to melt and become harder to cool. To stop or slow down the accident evolution, the main approach is to inject water into the reactor core. However, the success of the cooling is not guaranteed depending on the debris bed and the operating condition. This procedure is challenging to understand and model, as it involves the complex multiphase flow, heat transfer, and sometimes, boiling. Establishing a mathematical model and obtaining its numerical solution is not a trivial task. This work aims to offer an efficient computational framework to solve these complex multi- physics phenomena.

We present a three-dimensional multi-fluid macroscopic model for the numerical simulation of multiphase flow through debris bed with phase change. Each phase (liquid water, vapour, and debris bed) is modelled separately, and has its own characteristics, density, velocity, etc. Phases are coupled via the parametrisation equation and the phase change between liquid water and vapour is achieved via Stefan condition. The NBS/NRC steam table is integrated in the code, which provides saturation temperature, density, thermal capacity, etc. The spatial distribution of different phases is modelled using the volume fraction representation. The resulting computer routines is implemented in the adaptive multiphase framework FLUIDITY. Anisotropic mesh adaptivity have been demonstrated through the simulations.

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