PBR_SIM for Depressurization Accident Analysis of Pebble Bed Reactor

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Abstract

The PBR_SIM (Pebble Bed Reactor_ SIMulation) code is developed for thermal-hydraulic system dynamic analysis for system control, operational transients, and depressurization accident with/without passive or active concrete cooling system. The primary system including the containment and soil is divided into 12 axial divisions and 20 radial divisions. Radial and axial conduction including radiation, and axial He convection are considered in the core region. In and through the air gap region we consider axial convection and wall convective heat transfer by combination of both air natural convection and forced convection, and radial radiation transport between the reactor vessel and the containment. Radial radiation transport between solid walls is considered through the He gap regions between the core barrel and the inner surface of the reactor vessel, and between the outer surfaces of the reflectors to the inner surface of the reactor vessel. In the containment and soil region only radial conduction heat transfer is considered.

The predictions by PBR_SIM for MPBR at 100% power are compared with those by VSOP. It turns out that the temperature in the upper region in the second channel predicted by PBR_SIM is higher than that by VSOP while that in the lower region is pretty close to each other. The transient capability of PBR_SIM is validated through HEATING-7 analyzing the in stantaneous depressurization accident. The fuel temperature reaches a maximum one of 1679 C at 108 hrs, while the reactor vessel and containment temperatures continue to increase up to 200 hrs.

The effect of the air velocity in the gap region on thermal response during the depressurization accident is investigated. While its effect on the maximum fuel temperature is very small, the maximum reactor vessel and containment temperatures are very significantly affected by the air velocity. For 6m/s, the maximum containment temperature drops below the containment limiting temperature, while the reactor vessel temperature is slightly above the reactor vessel limiting temperature.