Depressurization Accident Analysis of MPBR by PBR_SIM with Chemical Reaction Model

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Abstract

The simple model for natural circulation is implemented into PBR_SIM to provide air inlet velocity from the containment air space. For the friction and form loss only the pebble region is considered conservatively modeling laminar flow through a packed bed. For the chemical reaction model of PBR_SIM the oxidation rate is determined as the minimum value of three mechanisms estimated at each time step: oxygen mass flow rate entering the bottom of the reflector, oxidation rate by kinetics, and oxygen mass flow rate arriving at the graphite surface by diffusion. Oxygen mass flux arriving at the graphite surface by diffusion is estimated based on energy-mass analogy. Two types of exothermic chemical reaction are considered: ($C + zO_2 \rightarrow xCO + yCO_2$) and ($2CO + O_2 \rightarrow 2CO_2$). The heterogeneous and homogeneous chemical reaction rates by kinetics are determined by INEEL and Bruno correlations, respectively.

The instantaneous depressurization accident of MPBR is simulated using PBR_SIM with chemical model. The air inlet velocity is initially rapidly dropped within 10 hr and reaches a saturation value of about 1.5cm/s. The oxidation rate by the diffusion process becomes lower than that by the chemical kinetics above 600K. The maximum pebble bed temperatures without and with chemical reaction reach the peak values of 1560 and 1617 ^{0}C at 80 hr and 92 hr, respectively. As the averaged temperatures in the bottom reflector and the pebble bed regions increase with time, ($C+1/2O_2->CO$) reaction becomes dominant over ($C+O_2->CO_2$) reaction. Also, the CO generated by ($C+1/2O_2->CO$) reaction will be consumed by ($2CO+O_2->2CO_2$) reaction and the energy homogeneously generated by this CO depletion reaction becomes dominant over the heterogeneous reaction.