Numerical analysis of the eutectic melting and relocation of the B$_4$C control rod materials by the MPFI-MPS method

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ABSTRACT

Eutectic melting and subsequent relocation of the B$_4$C control rod materials were simulated by a particle method. In the past, it was difficult to simulate the eutectic melting by a particle method [1, 2] because the melting starts at the interface between two different materials, which leads to the instability of the particle motion due to the small amount of fluid particles and lack of the thermodynamic consistency of the particle system. For this simulation, the novel method, the MPFI-MPS method, was developed in the current study. Specifically, the Moving Particle Full Implicit (MPFI) method [3] was introduced for the momentum transfer calculation, and the Moving Particle Semi-implicit (MPS) method [4] was introduced for the heat and mass transfer calculation. The MPFI method suppresses the instability of the particle motion because it assures thermodynamic consistency of the particle system after discretization. Moreover, it conserves angular momentum and makes it possible to simulation rotational motion of fluid. Meanwhile, the heat and mass transfer calculation by the MPS method offers rapid calculation and produces smooth distribution of physical values. The MPFI-MPS method realized the simulation of the eutectic melting and subsequent relocation behaviour. The numerical analysis of the specimen which simulates the partial length of the B$_4$C control rod suggested that eutectic melting interfaces changes before and after the eutectic melting reaches the specimen surface.

REFERENCES