Estimation of the In-Depth Debris Status of Fukushima Unit-2 and Unit-3 with Multi-Physics Modeling
(7) Preliminary evaluation of debris relocation and interaction with pedestal structures in Fukushima Unit-3 with MPS method

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As a part of the Nuclear Energy Science & Technology and Human Resource Development Project (JFY2019-2021), we have been developing the Moving Particle Semi-implicit (MPS) method to simulate multi-component liquid/solid relocations with solid-liquid phase changes. The paper addresses the model developments to demonstrate the debris relocation and distribution in the Fukushima Daiichi Unit-3 pedestal region.

Keywords: severe accident, MPS method, decommissioning of Fukushima Daiichi reactors, numerical simulation

1. Introduction

In decommissioning of Fukushima Daiichi (1F) Nuclear Power Plants, knowledge of the in-depth debris status within the pedestals must be gained. The Moving Particle Semi-implicit (MPS) method [1] is being developed for the simulation of multi-component liquid/solid relocation with solid-liquid phase changes.

2. MPS method and developed models

Fig. 1 summarizes the improved MPS methods with new models and techniques. The MPS results have demonstrated improved numerical stability and calculation efficiency.

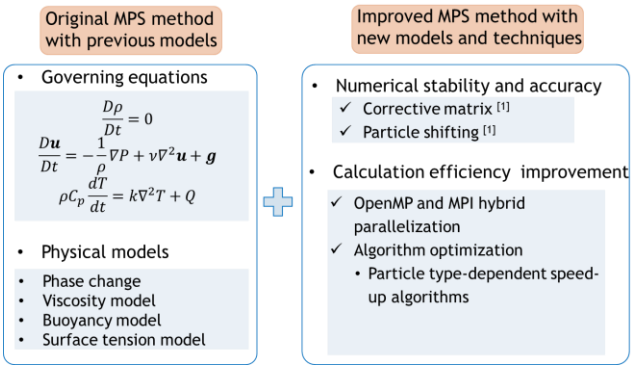

Fig. 1 MPS method and improved models

3. Simulation of debris relocation and distribution in the Fukushima Daiichi Unit-3 pedestal region

The debris relocation and distribution in the Fukushima Daiichi Unit-3 pedestal region are simulated in 1/10 scaled dimensions in the developed MPS code domain. In a case study, 56% of the total fuel debris at 2500 K in Unit-3 was assumed to relocate from the RPV to the pedestal region during the major relocation period (i.e. for 1 h 15 min from ca. 5:20 to 6:35 on March 14th, 2011) according to the pressure histories measured in RPV and PCV of Unit-3. In order to reduce the computation cost, the debris was assumed to have relocated entirely to the pedestal in 45 seconds and then to have remained for the rest of the time where the debris was cooled by conduction and convective heat transfer to the surrounding vapor. The simulation results show that only 12 wt% of the structures set in the pedestal region were melted down and nearly 40 wt% of the debris suspended on the middle-height-level work platform. This is because these structures and the debris have been cooled by the strong natural convection flow of vapor.

4. Acknowledgement

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References

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