Development of MPS Method for Analysing Convection and Solidification of Multi-Component Corium in Severe Accident of a Light Water Reactor

Takanari Fukuda[1]*, Akifumi Yamaji[1], Xin Li[1], Jean-François Haquet[2] and Anne Boulin[2]

[1] Waseda University, Shinjuku 3-4-1, Tokyo, Japan
E-mail: sun-village@akane.waseda.jp

[2] CEA, DES, IRESNE, DTN, SMTA, Severe Accident Modeling Laboratory,
Cadarache F-13108 Saint-Paul-Lez-Durance, France

ABSTRACT

In a severe accident of a light water reactor, involving core degradation and failure of the reactor pressure vessel, molten core materials (or "corium"), mainly comprised of (U, Zr)O_2 (oxidic phase) and Fe, Zr (metallic phase), may be released to the concrete containment floor. Consequently, Molten Core-Concrete Interaction (MCCI) might occur. Facing the necessity to retrieve the "fuel debris" from the Fukushima Daiichi nuclear power plant, the importance to deepen our understanding of the post-MCCI debris internal status, especially the distribution of the oxidic and metallic phases, has been newly recognized. In the meantime, an MCCI experiment, VULCANO VF-U1, has shown that the simulant corium finally solidified with a characteristic distribution of metallic phase, which could not be fully explained with the simplified understanding of stratification by density difference between the metallic and oxidic phases [1]. Understanding of multi-component convection with consideration of heat transfer, thermal decomposition and ablation of the concrete wall with gas release, interface tension, and solidification of the corium during convection may be important. Thus, we have aimed to show the mechanism of such characteristic distribution of the metallic phase in VULCANO VF-U1, by developing Moving Particle Semi-implicit (MPS) method for analyzing multi-component convection with solidification.

To improve the accuracy of analyzing multi-component convection with solidification, a new semi-implicit algorithm and a solidification model developed by Duan et al. have been adopted [2]. Moreover, to consider the influence of the concrete decomposition gas bubbles on the metallic corium phase dispersion, an effective gas model by Chai et. al. has been incorporated [3]. The possible mechanisms, which governed the solidified metallic phase distribution are discussed using the developed method.

REFERENCES

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