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Multi-dimensional Analysis about UPI during the LBLOCA of KORI Unit 1

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1. Introduction

A multi-dimensional transient analysis during the LBLOCA of the Kori Unit 1 has been performed by using the MARS code. Kori Unit 1 has upper plenum injection type ECCS for the low pressure safety system. Up to now, the analysis of Kori Unit 1 LBLOCA has been conducted by using KREM based upon the WCOBRA/TRAC-SECY-UPI method[1]. This method has been approved for the Westinghouse 3 loop reactor type which uses the cold leg injection. This paper suggests the analysis results obtained by the multi-dimensional reactor vessel modeling. The results are focused on the hydraulic behavior at the upper plenum and core region multi-dimensional analysis method by using the MARS

2. MARS Model

40 percent break at the cold leg and single failure of one ECC pump train is assumed. It is assumed that the broken cold leg and failed ECCS are located in vicinity for the conservation concept. Based on 1-D nodalization of the Kori Unit 1, the reactor vessel nodalizations have been replaced by the multi-dimensional component, as shown in **Fig. 1**. The multi-dimensional component for the reactor vessel is designed as 5 radial, 8 peripheral, and 21 vertical grids. Reactor core region possesses 4 radial and 12 vertical grids. But it is assumed that the fuel assemblies are homogeneously distributed only in inner 3 radial grids. The outer 1 radial grid region is modeled as the core bypass. The outer-most 1 radial grid is used for the downcomer region. Finally, total 840 volumes are generated for the nodalization of the reactor vessel part. The corresponding heat structures and fuels are modified to fit for the multi-dimensional reactor vessel model.

3. Form Drag Modeling

The form drag coefficients for the upper plenum and the core have been designated as 0.6 and 9.39, respectively[2]. The form drag coefficients for the radial and peripheral directions are assigned to the same on the assumption of homogeneous distribution of the flow obstacles. **Fig. 2** shows the chart of the form drag for the cross flow across the rod bundles.

4. Results

After obtaining the 102 % power steady operation condition, cold leg LOCA simulation is performed during 400 second period. The multi-dimensional steady run results show no severe differences compared to the traditional 1-D nodalization results. After 30 second elapsed from the LOCA, a liquid pool is maintained at the upper plenum because the ECCS water can not overcome the upward gas flow that comes from the reactor core through the upper tie plate. The depth of ECCS water pool is predicted as about 20 % of the total height from the upper tie plate and the center line of the hot leg pipe. At the vicinity region of the active ECCS show higher depth of liquid pool. The accumulated water flow rate passing the upper tie plate is calculated by the transient result. Much downward water flow is obtained at the outer-most region of upper plenum space, as shown in **Fig. 3**. The downward flow dominant region is about 32.3 % of the total upper tie plate area. The accumulated ECCS bypass ratio is predicted as 27.64 % at 300 second, as shown in **Fig. 4**. It is calculated by the ratio of the integrated ECCS water flow to the integrated two hot leg flows. The peak cladding temperature is predicted as 1236.32 K and the location is 7 ft from the bottom of fuel at the inner radial region of reactor core nodalization, as shown in **Fig. 5**. The peripheral location is the opposite against the active ECCS.

It can be concluded that the multi-dimensional analysis about the ECCS behaviors in the upper plenum space during the LBLOCA of Kori Unit 1 shows a meaningful agreement in the phenomenological validity.

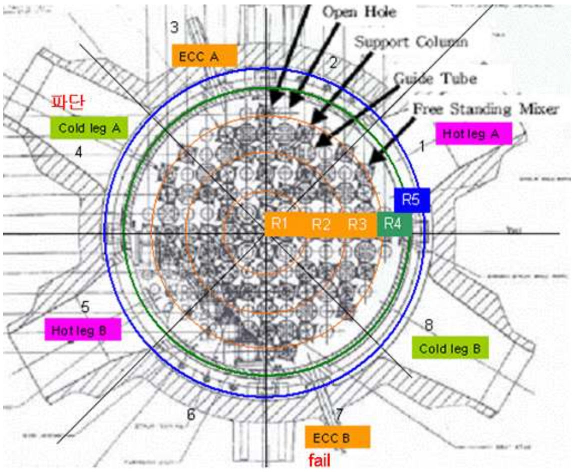

Fig. 1. Schematic plane view of the multi-dimensional grid of Kori Unit 1 reactor core.

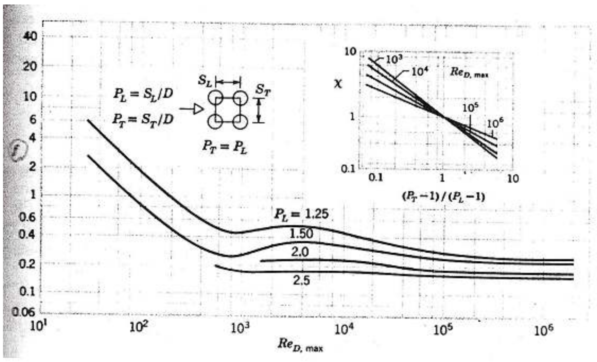

Fig. 2. Chart of the form drag for the cross flow around the rod bundles.

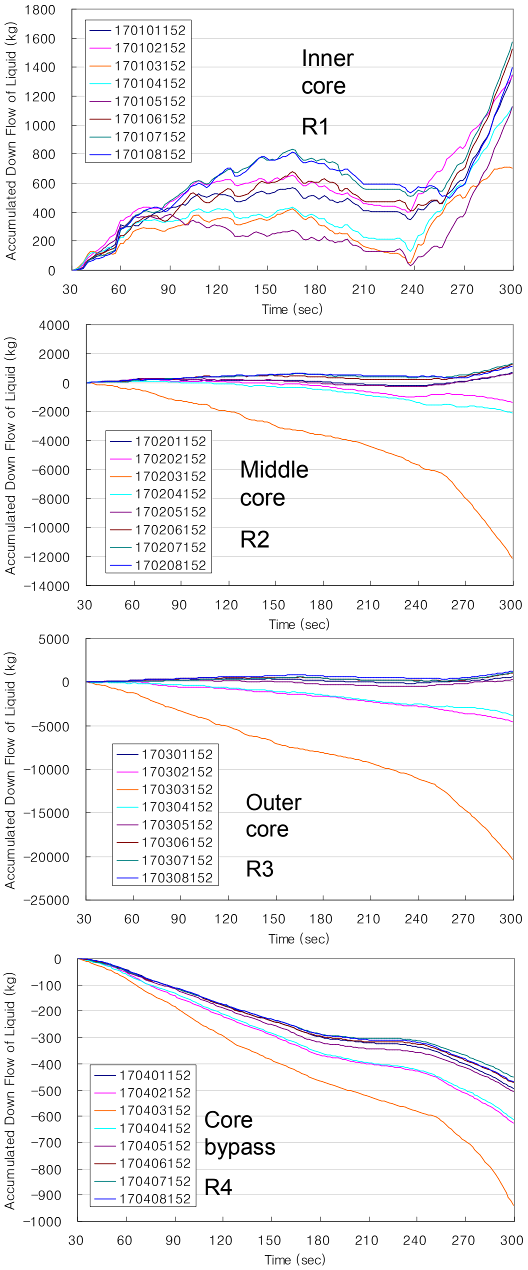

Fig. 3. Accumulated liquid flow across the upper support plate of Kori Unit 1 core.

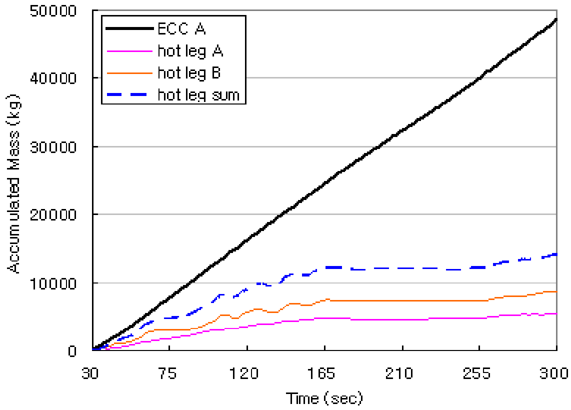

Fig. 4. Accumulated mass of ECC injection and hot leg flow

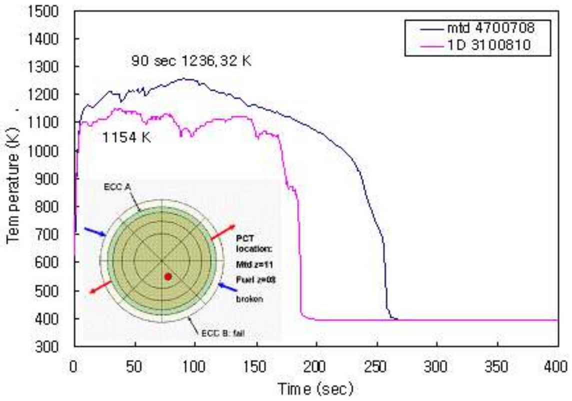

Fig. 5. Location of the peak cladding temperature at the multi-dimensional reactor vessel grid.

Acknowledgements

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REFERENCES

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[2] Fundamentals of Heat Transfer, Frank P. Incropera and David P. De Witt, p.357, 1981.