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MARS Assessment on Gravity Reflood Behavior in FLECHT-SEASET 33338 Test

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1. Introduction

A thermal-hydraulic system code, MARS (Multi-dimensional Analysis of Reactor Safety) has been developed for realistic thermal-hydraulic system analysis of light water reactor transients. MARS is assessed against various experimental data to qualify whether its performance is adequate for its specified applications.

The test data for FLECHT-SEASET 33338 are selected to assess MARS capability of predicting reflood thermal-hydraulics under a simulated loss-of-coolant accident condition. The test section is connected to the upper and lower plenums, and the downcomer at the bottom of which the injection line is installed is linked with the lower plenum. The arrangement of the heater rods within the core is typical of a Westinghouse 17 x 17 rod bundle design. Among the 161 heater rods which are contained within the core, 52 heater rods were designed to provide relatively higher power. The water of 325K enters the system through the injection line at the flooding rate of 5.9kg/s during 15 second from the start of the flooding and at the flooding rate of 0.807kg/s after 15 second. The initial pressure of upper plenum is 0.28MPa.

2. System Modeling

The core is one-dimensionally modeled using 20 uniform cells, as shown in Fig. 1. The downcomer is modeled as a pipe with 10 cells to predict the correct water level and connecting pipes and valve are also modeled.

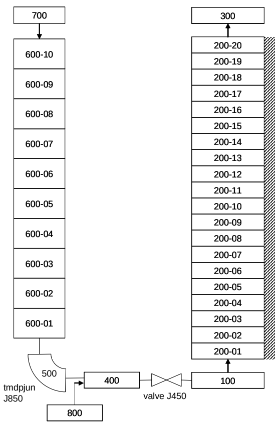

Fig. 1. Schematic of input model for FLECHT-SEASET 33338 test

The flooding rate is defined at the Time Dependent Junction connected to the bottom of the downcomer. If a grid spacer is located within a computational cell, the junction flow area is defined by subtracting the spacer grid blockage area from the normal junction area. For the heat structures, the radial power distribution is considered by modeling the hot/cold channels.

Because the measured locations do not match the centers of the computational cells, where the volume-averaged variables are defined, an interpolation scheme for calculated results is used for valid comparison between calculation and experimental data.

3. Results and Discussion

For initial heater rod cladding temperature, the calculated values at each node elevation are compared with experimental data in Fig. 2, where "MARS(hot)," and "MARS(cold)" denote the results for hot and cold channel within the core respectively.

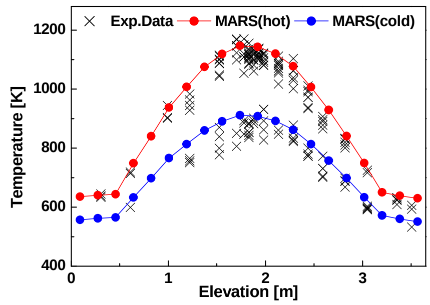

Fig. 2. Comparison of calculated and experimental initial cladding temperature

Figure 3 through 5 show comparisons of predicted and measured cladding temperatures at the low, middle and high elevations respectively; where two experimental data are averaged values measured in hot channel (HOT) and cold channel (COLD) respectively. Because 33338 test has very high reflooding rate, cladding temperatures begin to decrease right after coolant injection. At the low elevation, the predicted values are in good agreement with test data. At the middle and high elevations, cladding temperatures are reasonably predicted during the initial coolant injection time of 15 second. After the reduction of reflood rate, experimental data in the hot channel show a slight increase and delayed quenching, while MARS predict continuous cladding temperature decrease and early quenching. The trend of early quenching shows larger deviations as the elevation increases.

Figure 6 shows comparison of calculated and measured steam temperatures at the middle elevation. For the heat-up phase, steam temperature is reasonably predicted. However, for the reflood phase, the calculated steam temperature is predicted lower than the measured.

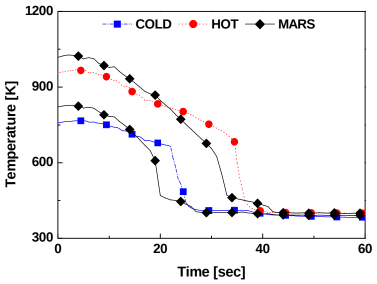

Fig. 3. Comparison of calculated and experimental cladding temperatures at the low elevation (48in)

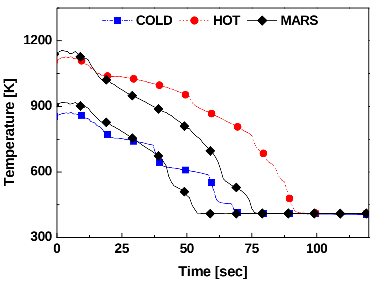

Fig. 4. Comparison of calculated and experimental cladding temperatures at the middle elevation (72in)

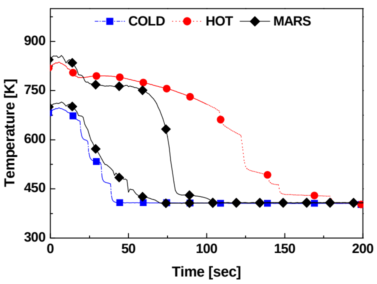

Fig. 5. Comparison of calculated and experimental cladding temperatures at the high elevation (111in)

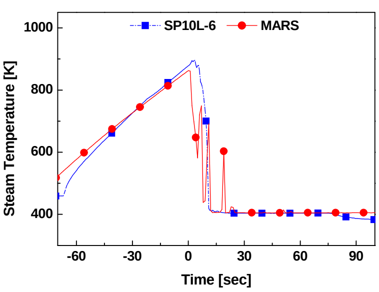

Fig. 6. Comparison of calculated and experimental steam temperatures at the middle elevation (72in)

Additionally, sensitivity studies for the effect of the size of the cells have been performed. The core is one-dimensionally modeled using 40 uniform cells. Figure 7 shows the effect of the node number for prediction of the cladding temperature at the elevation of 90in. "MARS" and "MARS_NODE" denote the results for the core modeled by 20 and 40 cells respectively. The quenching for the 40 cells model is made earlier than that for the 20cells model for all elevations.

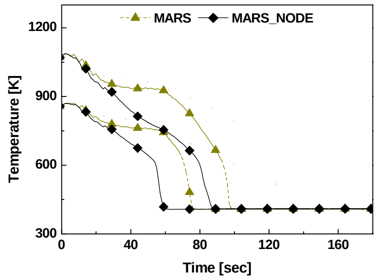

Fig. 7. The effect of the node number for prediction of the cladding temperature at the elevation of 90in

4. Conclusions

The assessment for MARS code using FLECHT-SEASET 33338 gravity reflood test has been performed. For the cladding temperature, the quenching is predicted much earlier than experimental results. The increase of the number of the cells modeling the core does not improve the calculation results. Therefore, the MARS reflood model should be improved to assure accurate prediction of the reflood thermal hydraulic phenomena.

Acknowledgement

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REFERENCES

[1] F. Odar, Assessment of the TRAC-M Codes Using Flecht-Seaset Reflood and Steam Cooling Data, NUREG-1744, U.S. Nuclear Regulatory Commission, 2001.
[2] Chung, B.D. et al., Improvements to the RELAP5/MOD3 Reflood Model and Uncertainty Quantification of Reflood Peak Clad Temperature, NUREG/IA-0132 CAMP001, U.S. Nuclear Regulatory Commission, 1996.
[3] KAERI, MARS Code Manual: Input Requirements, KAERI/TR-2811, Korea Atomic Energy Research Institute, 2007.
[4] KAERI, MARS Code Manual: Developmental Assessment Report, KAERI/TR-3042, Korea Atomic Energy Research Institute, 2007.
[5] KANG, D.G. et al., Assessment of the MARS-KS Code Using FLECHT-SEASET 31504 Forced Reflood Test, Proceedings of the 7th Thermal-Fluid Engineering Conference, Oct. 13-16, 2008, Sapporo, Japan.