MARS Assessment of RBHT Experimental Data

Gwang Hyeok Seo [a*], Gyoo Dong Jeun [a] , Yong Jin Cho [b], Seung Hoon Ahn [b]
[a] *Department of Nuclear Engineering, Hanyang University, 17,Haengdang-dong, Seongdong-Gu, Seoul, 133-791, Republic of Korea*
[b] *Korea Institute of Nuclear Safety, P.O. Box 114, Yusong, Daejeon, Korea*
[*] *Corresponding author : seokh3@hanyang.ac.kr*

1. Introduction

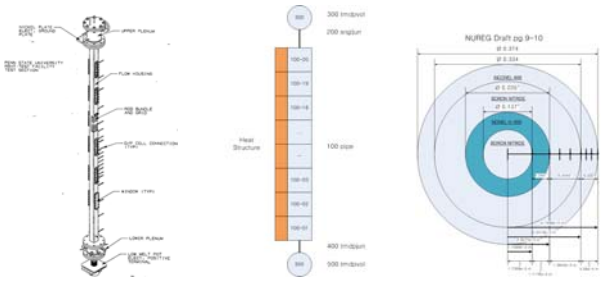
There are few reflood experiments which has instrumentation systems and local data for investigation of reflood phenomena. However, the Rod Bundle Heat Transfer (RBHT) program, focusing on reflood model development and validation, has total 512 instrumentations providing detailed data on local conditions [1].

In this study, data of test 0945, 1383 and 1389 from the RBHT experiments were used to assess the MARS-KS-002 code. The facility was modeled as 1-D, and the experimental data were compared with the results of the MARS code.

2. RBHT Facility Description and Modeling

The RBHT test facility is designed for systematic separate effects test to generate fundamental rod bundle heat transfer data. A test section of the facility consists of the heater rod bundle, the flow housing, and the lower and upper plenums [2].

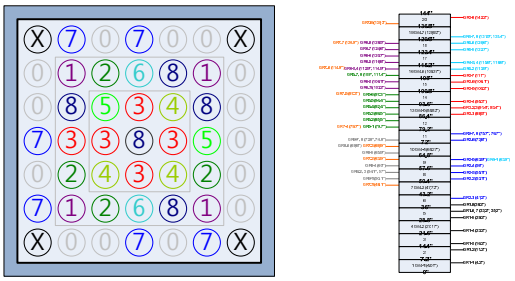
In the modeling process, the test section was composed of three parts, which are the rod bundle part, and the lower and upper plenum parts. Flow rate was defined at the time-dependent junction in the lower plenum part. Figure 1 shows test section (a), modeling of hydraulic part (b) and modeling of the heated rod (c).



a) Test Section b) Modeling c) Modeling

Fig. 1. Test Section and Modeling

The rods in the test section are classified by ten groups, which are eight heated rod groups (1-8), one unheated rod group (X) and one un-instrumentated group (0) as shown in Fig. 2a). Locations of all thermocouples to measure cladding temperatures are marked in Fig. 2b).



a) Rod Groups b) Thermocouples

Fig. 2. Locations of Rod Groups and Thermocouples

The axial power distribution of the RBHT experiments forms top skewed shape as shown in Fig. 3. The radial power distribution is uniform.

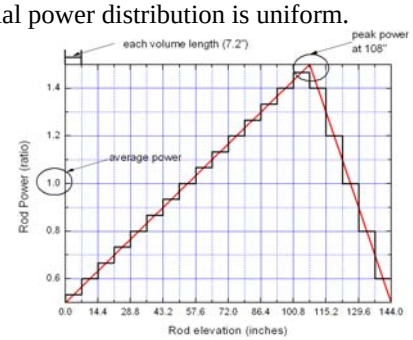


Fig. 3. Axial Power Distribution

3. Results and Discussions

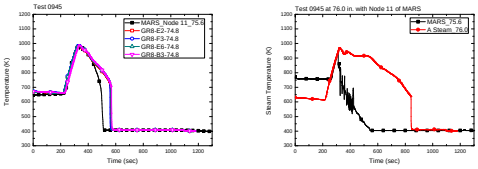
The experimental data in the three tests as described in Table 1 were compared with the results of the MARS code for each test. The calculated temperatures at the moment of coolant injection were adjusted in the range of the experimental data.

Table 1. Experimental Conditions

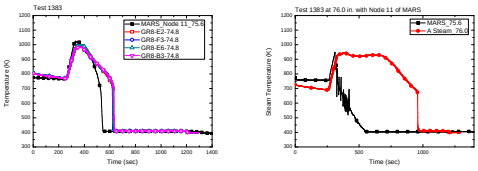
Test ID	Press. (psia)	Flooding Rate (lbm/sec)	Power (kW)	Heating Start (sec)	Heating End (sec)	Injection Start (sec)
0945	40	0.272	135.1	227	1095	296.5
1383	40	0.274	143.8	259.5	1210.5	312
1389	40	0.274	144.1	97.25	1526.5	140

3.1 Trends in Experiments

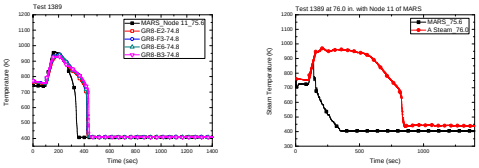
The MARS code predicted peak temperatures and quenching times resulting in similar data from the experiments in general. Fast quenching effect, however, was observed to be slightly different results. The calculated steam temperatures were quenched quickly after the temperatures reached the peak points. In Fig. 4, the comparison of the experimental data and the code results shows good agreement in terms of the cladding temperatures.



a) Test 0945 - Cladding Temp. b) Test 0945 - Steam Temp.



c) Test 1383 - Cladding Temp. d) Test 1389 - Steam Temp.



e) Test 1389 - Cladding Temp. f) Test 1389 - Steam Temp.

Fig. 4. Cladding and Steam Temperature Trends

3.2 Grid Effect

The test section consists of seven grids. The additional quenching effect was observed near the grids. While the temperatures were locally dropped near the grids in the experiments, the calculated temperatures did not show this effect as shown in Fig. 5. In other words, the calculated temperatures were higher than the experimental data near the grids. It seems to be substantial effect of grid on the temperature decrease, not considered in the current MARS model. Figure 6 shows the effect at 60 to 80 inches in detail.

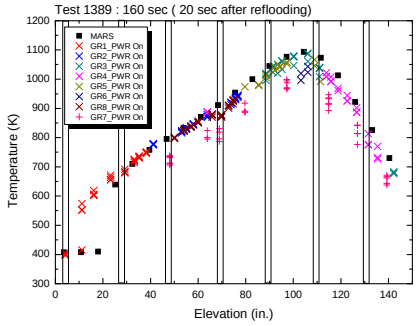


Fig. 5. Temperature Distribution with Elevation (Vertical bars mean ranges of the grid locations.)

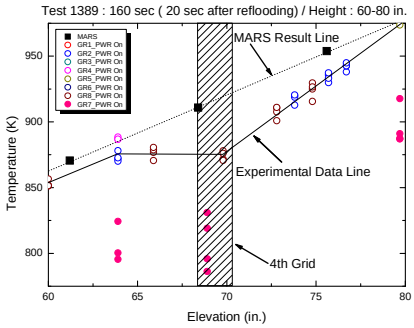


Fig. 6. Temperature at 60-80 in. (Near the 4th grid, the MARS calculations are higher than the experimental data.)

3.3 Multi-dimensional Effects

In the experiments, temperatures of the group 7 were lower than those of the other groups. As shown in Fig. 2a), the group 7 is located at each side of the test section where heat loss was expected. The calculation modeled as 1-D did not reflect this effect. In Fig. 6, only the data of the group 7 marked as '+' symbols are distributed below the temperature curve made of the experimental data and the results of the MARS code.

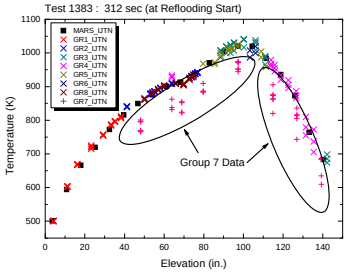
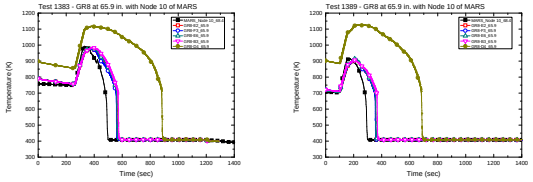


Fig. 6. Test 1383 - Temperatures with Elevation

Moreover, the temperatures in the center rod of the test section showed remarkably higher than those of the other rods which are at the same group and elevation in Fig. 7.



a) Test 1383 at 65.9 in. b) Test 1389 at 65.9 in.

Fig. 7. Temperatures of Group 8 with MARS Calculations

4. Conclusions

The MARS code shows reasonable prediction of the data of test 0945, 1383, 1389. However, the under-predicted steam temperatures resulted in fast quenching while the temperatures near the grids were over-predicted. Furthermore, the 1-D modeling was not enough to describe the multi-dimensional temperature distribution. Therefore, for better simulation, suitable grid and steam quenching models need to be improved in the MARS code. In addition, multi-dimensional modeling is recommended for further study.

REFERENCES

[1] L.E. Hochreiter, "Dispersed Flow Heat Transfer Under Reflood Conditions in a 49 Rod Bundle: Test Plan and Design-Results From Tasks 1-10 NUREG Draft CR6671, The Pennsylvania State University, 2000.

[2] L. E. Hochreiter, "RBHT Data and Analysis Report Reflood Heat Transfer Experiments", The Pennsylvania State University, 2007.

[3] MARS Code Manual, Korea Atomic Energy Research Institute, 2007.