Assessment of MULTID Component of MARS-KS using RBHT Tests

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1. Introduction

The MARS-KS has the multi-dimensional (MULTID) component to get more flexible 3-D capabilities, and to allow the user to model accurately the multi-dimensional hydrodynamic feature of reactor application, primarily in the vessel and steam generator [1].

This study aims at assessing the predictive capability of MULTID component of MARS-KS V1.6 for the reflood phenomena using the RBHT tests performed in the framework of OECD/NEA RBHT project [2, 3]. We investigated how much the result of MULTID component differs from that of 1-D PIPE component for two parameters, the rod surface temperature and the quench profile.

2. Description of MARS-KS Input Model

The test section of RBHBT facility consists of 7 x 7 full-length rods having a diameter of 9.5 mm with a pitch of 12.6 mm placed in a square flow housing of 90.2 mm. There are 45 electrically heated rods and 4 unheated support rods in the corners. The bundle has a top-skewed axial linear power profile having a peak power at 2.74 m elevation [2, 3].

Figure 1 shows the MARS-KS nodalization for 1-D PIPE, cylindrical MULTID, and Cartesian MULTID input models, respectively. All three input models have a total of 34 axial nodes with varying lengths from 0.05 m to 0.1392 m. The node lengths are relatively short in the vicinity of peak power. The heat loss from the housing wall to the environment is modeled [4].

The cylindrical MULTID component is nodalized with two cells (i.e., r1 and r2) in radial direction so that the inner cell has 16 heated rods. The Cartesian MULTID component is nodalized with four square cells (i.e., two cells in x-direction and two cells in y-direction).

The lower and upper plenums are modeled with BRANCH components. Each plenum is connected to the test section using one junction in 1-D PIPE input model, two junctions in cylindrical MULTID input model, and four junctions in the Cartesian MULTID input model.

The form loss coefficients for the cross flow are calculated from the correlation proposed by Zukauskas [5]. The heated and unheated rods in each cell are assumed to be arranged in in-line square array. By assuming that Reynolds number is greater than 10^6, the form loss coefficients becomes independent of Reynolds number.

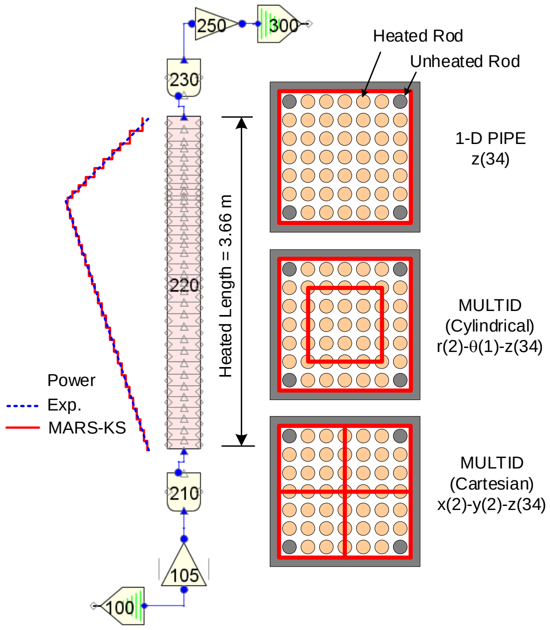

Fig. 1. MARS-KS nodalization.

3. Results and Discussion

The predictive capability of 1-D PIPE model was assessed using the 11 tests performed in the framework of OECD/NEA RBHT project in our previous study [4]. In this study, the two tests are selected for the assessment of MULTID component. Table 1 shows the test conditions of selected cases. While Test O-1 was conducted under low flooding rate, low power, and low inlet water subcooling, Test O-4 was conducted under high flooding rate, high power, and high inlet water subcooling [2, 3].

Figures 2 and 3 show the results of rod surface temperature at 2.69 m elevation, just below the peak power elevation. The results of inner cell of cylindrical MULTID model and one quadrant of Cartesian MULTID model are compared with the test data and the result of 1-D PIPE model.

In the Test O-1, when compared to the experimental data, the results of MARS-KS show higher maximum

Table 1 Test Conditions

Test ID (Test No.)	Flooding Rate (cm/s)	Power (KW)	ΔT_{sub} (K)	Pressure (MPa)
O-1 (9021)	2.5	144	10	0.276
O-4 (9014)	15	252	80	0.276

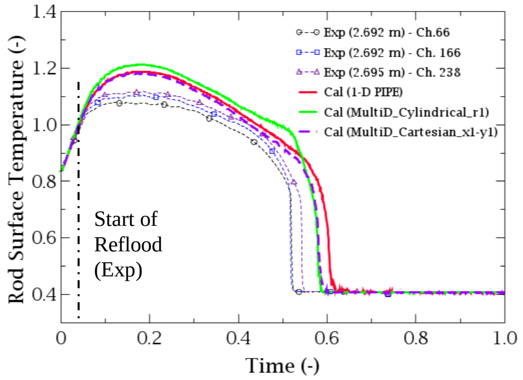

Fig. 2. Rod surface temperature at 2.69m for Test O-1.

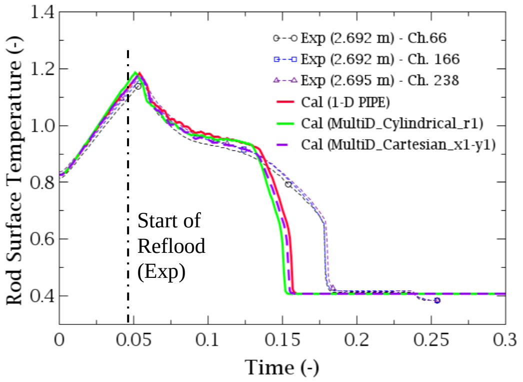

Fig. 3. Rod surface temperature at 2.69m for Test O-4.

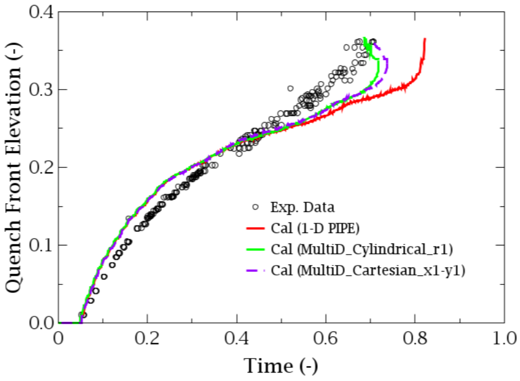

Fig. 4. Quench profile for Test O-1.

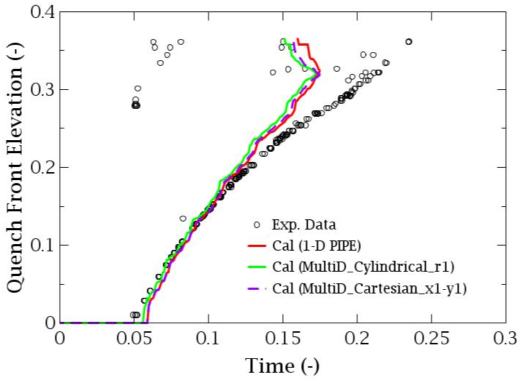

Fig. 5. Quench profile for Test O-4.

rod temperature and slower quenching time. The result of two MULTID components is similar to that of 1-D PIPE component. The maximum temperature is slightly higher in the cylindrical geometry than in the Cartesian geometry. This result is because of the relatively large number of heated rods for the same flow area and relatively small heat loss in the inner cell of the cylindrical MULTID input model. In the Test O-4, when compared to the experimental data, the results of MARS-KS show good prediction for the maximum temperature and faster quenching time. There is little difference between the results of MARS-KS simulation.

Figures 4 and 5 compare the results of quench profile. In the Test O-1, the quenching at the upper elevation occurs faster in the MULTID models than in the 1-D PIPE model, which results in a better prediction for the experimental data. In the Test O-4, the quenching at upper elevation is faster in the simulation than in the experiment. The result of MULTID components is similar to that of 1-D PIPE component. The quenching at the upper elevation occurs faster in the MULTID models than in the 1-D PIPE model, however the difference is insignificant.

4. Conclusion

We assessed the predictive capability of MULTID component of MARS-KS code using RBHT tests. It was found that the result of MULTID components was similar to that of 1-D PIPE component. However, the quenching at the upper elevation occurs faster in the MULTID models than in the 1-D PIPE model. The difference was greater in the Test O-1 than in the Test O-4.

Acknowledgements

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