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Rewetting of vertical hot surface in a 6x6 rod bundle during reflood phase : Part II, One-dimensional analysis by MARS PIPE

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1. Introduction

A 6x6 reflood test facility, ATHER (facility for **A**dvanced **T**hermal **H**ydraulic **E**valuation of **R**eflood phenomena) has been constructed and operated by KAERI in order to investigate the reflooding phenomena and evaluate the effect of the spacer grid on heat transfer enhancement during the reflood period. The 6x6 reflood test results would contribute to enhance the understanding on the thermal hydraulic behavior in the reactor core during the reflood phase, to assess the reflood models of the thermal-hydraulic system codes, such as TRAC, COBRA-TF, MARS, RELAP5, and CATHARE. Recently, a series of bottom reflood tests were carried out and the experimental data are now available for the assessment. The detailed descriptions on ATHER can be found elsewhere [1]. In this paper, assessment of the one dimensional reflood model in the MARS code was performed based on the experimental data.

2. Modeling Methods and Results

2.1 Reference test case

Table 1 shows typical test cases carried out using AHTER facility. In the present work, the "EP52-50030" case was selected as a reference case for MARS analysis.

Table 1 Reference test cases

Parameter	Unit	EP52-50030	EP82-50030	EP82-70030
Flooding velocity (U_F)	cm/s	2		
Inlet coolant temperature (T_{in})	^oC	30		
Initial max. wall temperature (T_w)	^oC	500		700
System pressure (P_{sys})	MPa	0.5	0.8	

2.2 One-dimensional analysis method

Figure 1 shows a nodalization scheme in the 1-D PIPE model. The test section is simulated by the pipe component 150 with 17 axial nodes. The time-dependent volume 120 simulates the steam supplier, which provides an initial steam flow in order to maintain the system at the predefined system pressure by removing the heat from the heater surface. The generated steam is injected into test section component 150 of which a separator is on the top. The separated droplet is drained to the time-dependent volume 190. System pressure is maintained at a predefined value by controlling the opening of the valve component 175. Four heat structures were modeled; heater rods, a guide tube, unheated rods, a cold wall of the test section. The heater has a chopped cosine profile.

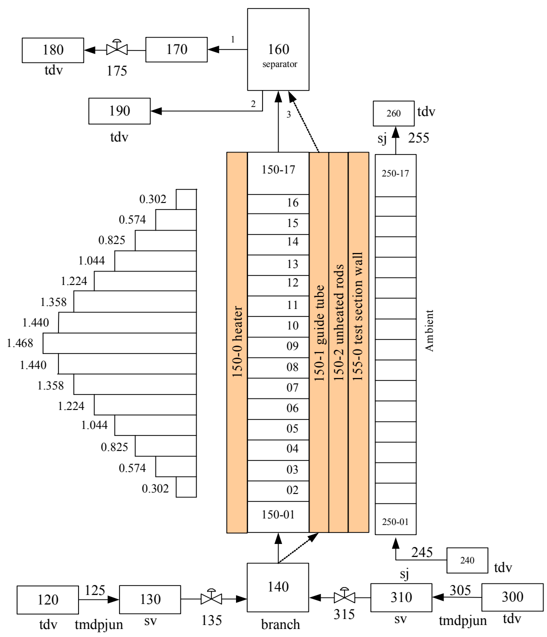

Figure 1. PIPE module nodalization for the 6x6 reflood test section

The internal detailed geometry of the heater rods was modeled. A guide tube which is installed in the center of the test section was modeled. Two unheated rods in the corner of the test section were also modeled. Finally, the outer rectangular cold walls were modeled with a free-convective boundary condition.

Initially, the flooding water isolation valve 315 is closed and a steam of 0.02kg/s is injected into the test section. The power of the heater rods are controlled until the heater surface temperature at the 13^{th} node from the bottom is heated up to 500^oC. During the heat-up process, the system pressure, which is defined by the pressure at component 170, is controlled to maintain 4 bar. After the system reaches a steady state condition, valve 135 is closed, concurrently with an opening of valve 315 to initiate a transient calculation. Figures 2 through 4 show the axial wall temperature profiles, depending on the flooding velocity. As the flooding velocity increases, a rewetting occurs more rapidly. The detailed modeling method can be found elsewhere [2].

2.3 Analysis results and discussions

Figure 2 compares a measured axial temperature profile on the heater surface with a calculated one at a steady state condition. The calculated temperature profile agrees well with the measured temperature profile. The same boundary conditions, including a heat loss, are used to get the same temperature profile with the measurements.

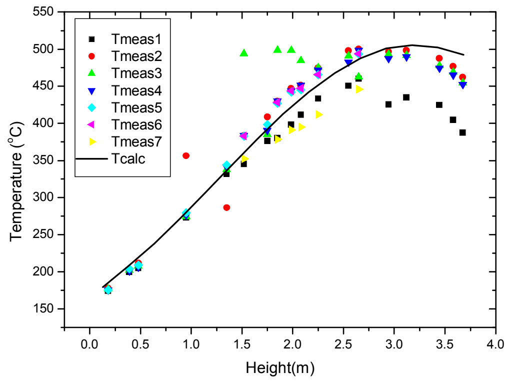

Figure 2. Comparison of initial temperature distribution (EP52-50030)

The heater rod power and the flooding velocity are shown in Figure 3. The power maintained at a constant value about 3.0 kW during the transient. The flooding velocity was also controlled to have the same value of 2cm/s to measurements.

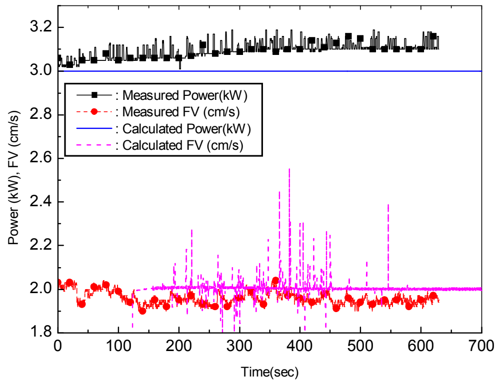

Figure 3. Comparison of power and flooding velocity (EP52-50030)

Figure 4 shows a comparison of the reflooding process. The reflooding starts when a collapsed water level starts to increase at about 123sec. In the MARS calculation, the reflooding starts when the liquid fraction at the node 15002 changes from 0.0 to 1.0. As shown in Figure 4, agreement of the reflooding process between measurement and calculation is excellent.

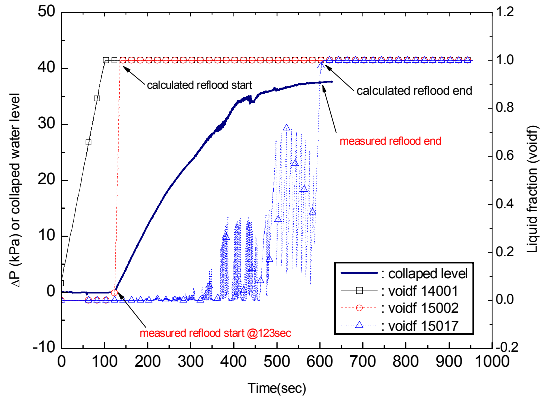

Figure 4. Comparison of reflooding process (EP52-50030)

Figure 5 shows a comparison of the rewetting temperature. It can be found that the agreement between measument and calculation is excellent.

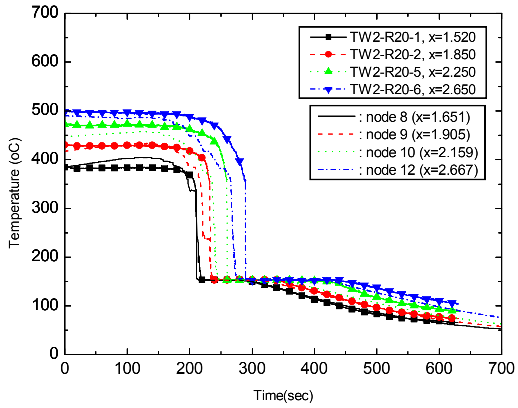

Figure 5. Comparison of rewetting temperature (EP52-50030)

3. Conclusions

A 6x6 rod bundle reflood test has been simulated by MARS3.1 with the one-dimensional pipe modeling. It was found that the one-dimensional pipe modeling method predicts experimental data with great accuracy.

References

[1] Cho, S., Moon, S.-K., Chun, S.-Y., Kim, B.-D., Park, J.-K., and Baek, W.-P., 2005, “Preliminary descriptions on the 6 x 6 reflood test of KAERI, - Part I: Overview of the test facility and matrix,” KNS 2005 fall Meeting, Busan, Korea.

[2] K.Y.Choi, et al., Preliminary Descriptions on the 6×6 reflood test of KAERI-Part Ⅱ: System and vessel module analysis with MARS 3.0 and COBRA-TF, Proceeding of KNS meeting, 2005.