Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Rewetting of vertical hot surface in a 6x6 rod bundle during reflood phase
Part I: Discussions on the preliminary experimental results

S. Cho, S.-K. Moon, K.-Y. Choi, B.-D. Kim, J.-K. Park, and W.-P. Baek
Korea Atomic Energy Research Institute, 150 Deokjin-Dong, Yuseong, Deajeon, 305-353, Korea
Phone: +82-42-868-2719, Fax: +82-42-868-8362, E-mail: scho@kaeri.re.kr

1. Introduction

A series of bottom reflood tests were carried out to investigate thermal-hydraulic characteristics during the reflood phase. This paper includes descriptions of 6x6 rod bundle reflood test with the comparison of the single rod reflood test carried out by KAERI. The ranges of experimental parameters are 2~8 cm/s of flooding velocity, 20~80 ^oC of inlet subcooling temperature, 0.1 ~ 0.8 MPa of system pressure and 500~700 ^oC of initial wall temperature. In the single rod annular flow channel reflood test, quench front behavior can be easily observed through the visualizing window and a dominant flow regime near downstream of quench front is inverted annular film boiling regardless of the flooding velocity. For the case of the 6x6 rod bundle experiments, on the other hand, the dominant flow regime is dispersed flow film boiling (DFFB), and therefore the thermal hydraulic behavior becomes more complicated and chaotic due to the interaction between liquid and vapor phase.

2. Descriptions on the test facility

2.1 6x6 reflood test facility

Figure 1 shows a schematic diagram of the 6x6 rod bundle test facility, ATHER (facility for **A**dvanced **T**hermal **H**ydraulic **E**valuation of **R**eflood phenomena), which consists of a test section, separating system for measuring the amount of entrained liquid droplet, pressure oscillation damping system to control the system pressure during preparation and testing period, coolant supply system and steam supply system. The function of the steam supply and pressure oscillation damping system is to increase and control the system pressure and temperature at the specified pressure level. The detailed descriptions on ATHER can be found in Ref. [1].

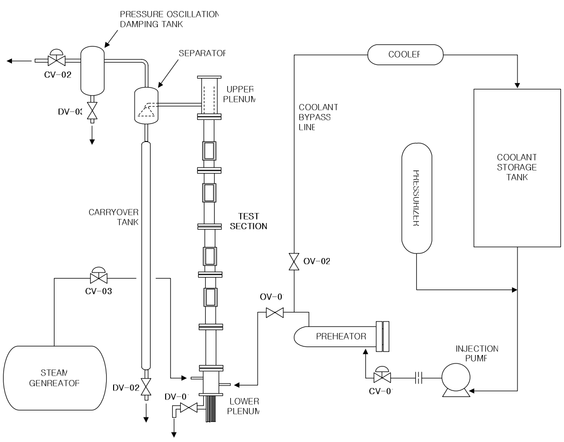

Fig. 1 Schematic diagram of ATHER

2.2 Test methods

In the present study the following experimental procedure was adopted. To obtain the desired test condition, firstly, the coolant mass flow rate through the test section was adjusted at the presetting value. The coolant temperature could be controlled by the preheater at a desired test condition. After adjusting the coolant mass flow rate and temperature, the flow was diverted from the test section to the bypass line in order to drain the water in the test section. The power to the test section was applied and the wall temperature was brought up to the desired value. After the test parameters such as inlet water temperature, coolant flow rate, and initial wall temperature of heater rod reached desired level, the experiment was initiated by diverting the coolant flow from the bypass line to the test section. The start of reflood was defined as the instant when the collapsed water level is just passing through the bottom of heated section of the rod bundle. After the top end of heated section had been quenched, the experiment was finished. For the higher-than atmospheric-pressure test, steam from the steam generator injects into the lower plenum of the test section to maintain desired system pressure controlled by the CV-02 in Fig. 1. The system pressure will be accurately controlled by CV-02 and CV-03.

3. Discussions on the experimental results

Presently, the performance tests of ATHER have been finished. Among these tests, three test items will be discussed in this section.

Figs. 2 and 3 show typical behavior of the collapsed water level and corresponding quenching front locations of the single rod tests [2] and the 6x6 rod bundle tests with cold hydrostatic head. As shown in Fig. 2, during initial stage of reflood, the collapsed water level shows a little bit higher values than the corresponding cold hydrostatic head due to the presence of an additional acceleration term. After this initial stage, when gravity term becomes dominant, the collapsed water level becomes lower than the cold

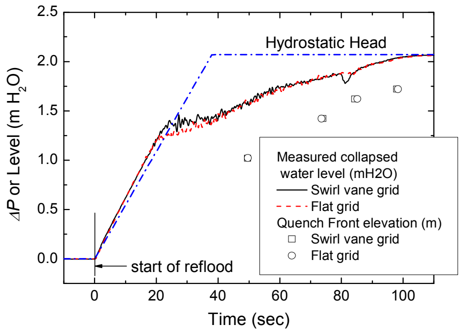

Fig. 2 Differential pressure transients of two spacer grids for the single rod test (U_F = 5 cm/s, T_{wall} = 600 °C, T_{in} = 20 °C, Group-A test)

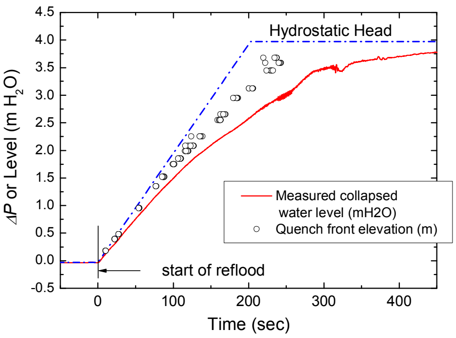

Fig. 3 Behavior of measured collapsed water level for the 6x6 rod bundle test (P_{sys} = 0.5 MPa, U_F = 2 cm/s, T_{wall} = 500 °C, T_{in} = 20 °C, Group-C tests)

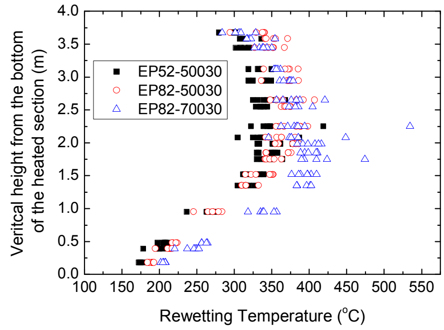

Fig. 4 Behavior of the rewetting temperature along vertical height of the 6x6 rod bundle with the variation of test parameters

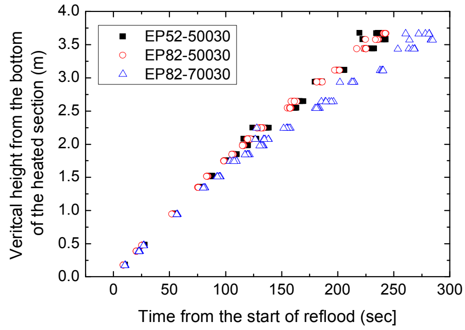

Fig. 5 Behavior of the rewetting time along vertical height of the 6x6 rod bundle with the variation of test parameters

hydrostatic head level.

The behavior of the collapsed water level in Fig. 3, however, shows a different trend from that of the single rod tests. The reason why the collapsed water level shows a different behavior can be easily understood when we think about the locations of the quench front. The elevation of the quench front in case of the single rod tests is lower than the measured collapsed water level, which indicates that the dominant flow regimes around the quench front is inverted annular film boiling. For the case of 6x6 rod bundle tests, on the other hand, the location of the quench front is always higher than the collapsed water level, which means that the dispersed flow film boiling is dominant in the flow channel. This difference in the flow pattern is mainly due to the cold wall effects.

Figures 4 and 5 show the rewetting temperature and time variation with respect to the vertical height of the test section of ATHER. The test conditions can be found in Table 1. As can be observed in these figures, the effect of the system pressure on the rewetting temperature is negligibly small in the half-lower part of the test section, but in the half-upper part the differences of the rewetting temperature between EP52-50030 and EP82-50030 increase noticeably. The effect of the initial wall temperature of heater rod on the rewetting temperature and rewetting time is more significant than that of the system pressure. The additional 6x6 rod bundle test will be made in a near future.

Table 2 Test conditions of the case in Figures 14 and 15

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

4. Conclusions

In the single rod annular flow channel the dominant flow regime near the quench front is inverted annular film boiling. However, in the 6x6 rod bundle system, the dispersed flow film boiling is the dominant flow pattern.

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] Cho, S., Chun, S.-Y., Baek, W.-P., Chung, M.-K., 2005, "Spacer grid effect during reflood in ana annulus flow channel," 11th International Topical Meeting on Nuclear Reactor Thermal-Hydraulics (NURETH-11), paper: 287, Avignon, France.