Components Effects for the Performance of the Passive Residual Heat Removal System of an Advanced Integral Type Reactor

Hyun-Sik Park, Ki-Yong Choi, Sung-Jae Yi, and Moon-Ki Chung
Korea Atomic Energy Research Institute, Thermal Hydraulics Safety Research Team, P.O.Box 105, Yuseong, Daejeon, 305-600, Korea, hspark@kaeri.re.kr

1. Introduction

A set of experiments has been performed to investigate the effects of several components on the performance of the passive residual heat removal system (PRHRS) for an advanced integral type reactor, SMART-P [1], by using a high temperature and high pressure thermal-hydraulic test facility, the VISTA facility [2]. Previously Park et al. [3,4] performed experiments on the thermal-hydraulic characteristics of the PRHRS for the SMART-P. In this paper the effects of several components are tested for the gas cylinder system, the PRHRS compensation tank, the initial filling of the PRHRS loop, and the heat loss compensation of the primary system.

2. VISTA PRHRS

The VISTA PRHRS is described by Park et al. [4] in detail. The PRHRS of the VISTA facility is composed of a train for the cooling subsystem, which includes an emergency cooldown tank (ECT), a heat exchanger (HX), a compensating tank (CT), several valves and related piping. It is designed to have the same pressure drop and heat transfer characteristics and is arranged to have the same elevation and position as those of the reference system, SMART-P.

3. Test Matrix

The experimental test matrix includes PRHRS-P-R1, PRHRS-P-R1-noGCS, PRHRS-P-R1-noCT, PRHRS-P-R1-noFILL, and PRHRS-P-R1-noHLC. Four tests are different from the reference test in that they have not used the gas cylinder system, the PRHRS compensation tank, the initial filling of the PRHRS loop, and the heat loss compensation of the primary system.

The scaled 100% flow rates of the primary system are 19.6 m^3/hr at the pressure and temperature of 147 bar and 310°C, respectively, and the scaled 100% flow rates of the secondary system are 0.25 kg/s. In the reference test of PRHRS-P-R1 both the PRHRS bypass valves and the secondary system isolation valves were operated simultaneously, the initial water level of the CT was 80% of the full level, and the initial pressure of the CT was 4.5 MPa.

4. Results and Discussions

The test results are compared with the reference test results which are described in detail by Park et al. [4].

4.1 Effect of the Gas Cylinder System

For the PRHRS tests without a gas cylinder system, the gas space allocated to the primary loop is limited to three pressurizers and the system pressure in the primary loop decreases very rapidly when compared with the reference test. However, the temperatures in the primary loop decrease more slowly than those of the reference test. It is because the pressure and temperatures are higher in the secondary system than those of the reference test, which is due to a lower natural circulation flow rate and heat removal capacity. One interesting phenomena is that the unsteady flow instability, which occurred during the reference test, does not occur in the present test. Figure 1 shows the variation of the primary system pressure during the PRHRS operation of PRHRS-P-R1-noGCS.

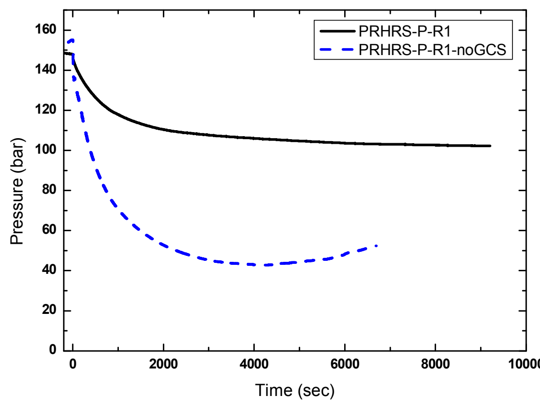

Figure 1. Variation of the Primary System Pressure during the PRHRS Operation (PRHRS-P-R1-noGCS)

4.2 Effect of the PRHRS Compensation Tank

For the PRHRS tests without a PRHRS compensation tank, the gas space allocated to the secondary loop is smaller than that of the reference test. The natural circulation flow rate is similar at the initial stages but its decreasing rate is higher than the reference test at the later stages. The decrease of the pressure and temperatures in the secondary loop is faster in the present test and the decreases of the pressure and temperatures in the primary loop are also slightly faster. Figure 2 shows the variation of the natural circulation flow rate during the PRHRS operation of PRHRS-P-R1-noCT.

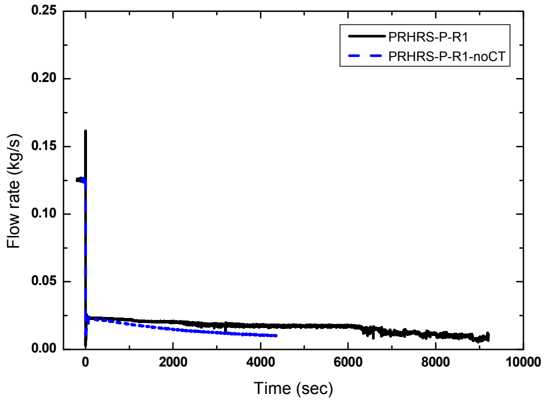

Figure 2. Variation of the Natural Circulation Flowrate during the PRHRS Operation (PRHRS-P-R1-noGCS)

4.3 Effect of the Initial Filling of PRHRS

For the PRHRS tests without an initial filling of the PRHRS lines, the gas space allocated to the secondary loop is larger than that of the reference test. The natural circulation flow rate is similar to the reference test throughout the tests. The peak pressure and the initial temperature drop in the secondary loop are lower and higher, respectively, than those of the reference test. Figure 3 shows the variation of the secondary system pressure during the PRHRS operation of PRHRS-P-R1-noFILL.

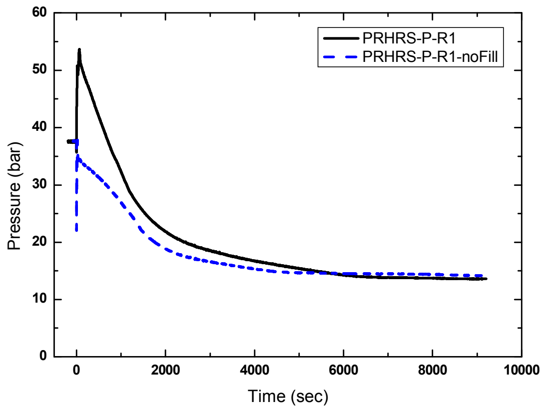

Figure 3. Variation of the Secondary System Pressure during the PRHRS Operation (PRHRS-P-R1-noFILL)

4.4 Effect of the Heat Loss Compensation

For the PRHRS tests without a heat loss compensation, the overall PRHRS performance is better than the reference test. The decreases of the pressure and temperatures both in the primary and secondary loops are faster than those of the reference test. Figure 4 shows the variation of the primary system temperatures during the PRHRS operation of PRHRS-P-R1-noFILL.

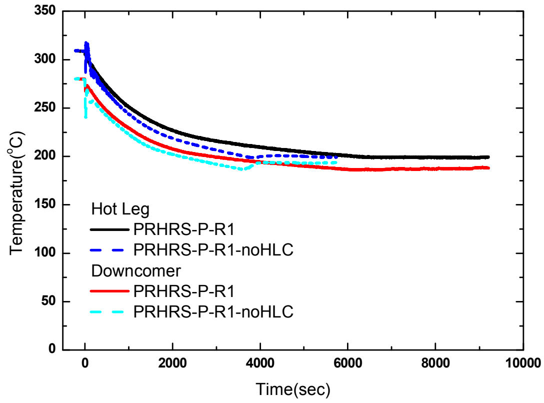

Figure 4. Variation of the Primary System Temperatures during the PRHRS Operation (PRHRS-P-R1-noHLC)

5. Conclusion

A set of experiments has been performed to investigate the effects of several components on the PRHRS performance by using the VISTA facility which simulates the SMART-P. For all the cases a stable flow occurs in a natural circulation loop which is composed of a steam generator secondary side, a secondary system, and a PRHRS, which shows a similar trend to the reference case. Especially for cases without a gas cylinder system and without an initial filling of the PRHRS loop the unsteady flow instability, which occurred during the reference test, does not occur. The experimental results show that the overall performance of PRHRS is enhanced without a PRHRS compensation tank, without an initial filling of PRHRS loop, and without a heat loss compensation.

REFERENCES

[1] M.H. Chang, et al., *Basic Design Report of SMART*, KAERI/TR-2142/2002, KAERI, Daejeon, Korea, 2002.

[2] S.J. Lee, et al., *Basic Design of the High Temperature/High Pressure Thermal-Hydraulic Test Facility*, KAERI internal report, KAERI, 2001.

[3] H.S. Park, et al., *Experiments on the Heat Transfer and Natural Circulation Characteristics of the Passive Residual Heat Removal System for the Advanced Integral Type Reactor*, Proceedings of ICAPP '04, Pittsburgh, PA USA, June 13-17, 2004.

[4] H.S. Park, et al., *A Preliminary Experimental Study on the Performance of the Passive Residual Heat Removal System for the SMART-P*, Proceedings of the Korea Nuclear Spring Meeting, Gyeongju, Korea, 2004.