Preliminary Analysis on the Characteristics of the SISTA using MARS-KS

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1. Introduction

System-integrated Modular Advanced ReacTor (SMART) is a Small Modular Reactor (SMR) developed by Korea Atomic Energy Research Institute (KAERI) [1]. It is equipped with passive systems to improve safety. SMART Passive Containment Cooling System (PCCS) [2] is one of the major passive safety systems. It can lower the pressure and temperature of containment during accident and prevent the release of radioactive material to atmosphere by condensing steam and dissolving radioactivity into an In-containment Refueling Water Storage Tank (IRWST). In order to identify safety function of the SMART PCCS concept, SMART IRWST Separated Test Apparatus (SISTA) was installed in SMART-ITL[3]. It is a simplified simulator of the SMART PCCS. Fig. 1 shows schematic of SISTA which is consisted of two major components, drywell and IRWST. Additionally, a pressurizer and related pipe line are installed to provide high pressure steam into the drywell. The main propose of SISTA is to identify the thermal-hydraulic behavior of IRWST and drywell by injecting break mass flow using the pressurizer. To fulfill it, the thermal-hydraulic relationship between the pressurizer and drywell should be analyzed and it depends on the characteristics of the pipe line. Hence, in this paper, the characteristics of pipe line and mass flow rate will be analyzed using the results of the preliminary tests and simulations with MARS-KS code [4]. In addition, thermal-hydraulic behavior of main components will be simulated for main tests using MARS-KS code.

2. Preliminary Tests and Method

2.1 Preliminary Tests Using By-pass Line

4 cases of preliminary tests were performed to define loss coefficient of pipe line with different pressurizer pressure condition using the by-pass line. Table I shows initial conditions of the tests. The containment is connected to the atmosphere and pressurizer maintains a steady pressure using heater. High flow rate was measured using QM-1 and low flow rate was measured by QM-2. PT-1 and PT-2 measured pressures at the inlet of QM-2 and outlet of QM-2, respectively. Using a differential pressure between pressurizer and PT-1, loss coefficient of pipe line including QM-1 was calculated. Using a differential pressure between PT-1 and PT-2, the loss coefficient of pipe line including QM-2 was estimated. In the result of serial calculations, it was found that the loss coefficients of the pipe line from 4 test cases were almost the same.

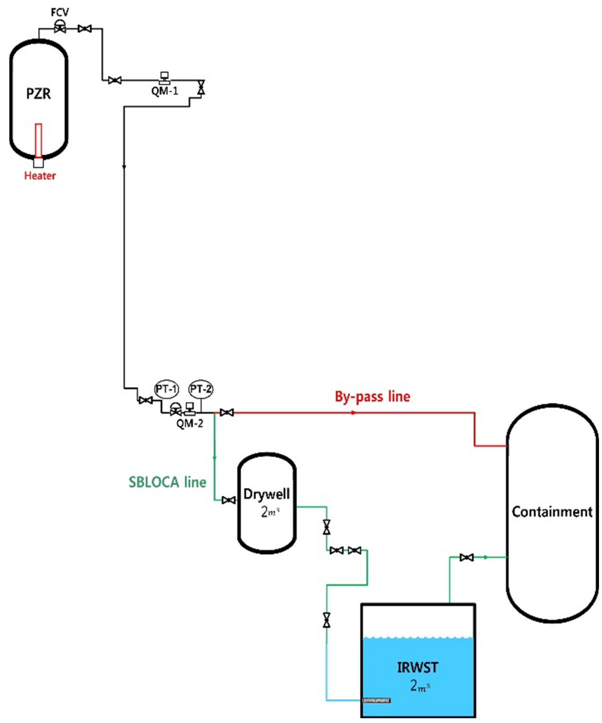

Fig. 1. Schematic diagram of SISTA

Table I. Initial condition of preliminary tests using SISTA-bypass line

	Pressurizer Pressure (MPa)	FCV (%)	Heater Output (kW)
Case1	15	10	170
Case2	10	10	127
Case3	5	10	73
Case4	3	10	50

2.2 Computational Analysis with MARS-KS

The MARS-KS code was used to calculate friction factors of the pipe line by comparing to the results of preliminary tests. It predict the mass flow rates and pressures of major components in the SISTA. First of all, the MARS input of the SISTA-bypass line was prepared by reflecting loss coefficient of pipe line. And the validation calculations were performed as the 4 cases of preliminary tests. Then the MARS input of the SISTA-SBLOCA line was also prepared, and the simulations were performed under constant pressure conditions. Fig. 2 shows the nodalization result of SISTA SBLOCA line.

It includes most of the instruments and is very similar with the real geometric conditions of SISTA. Using these input data, the mass flow and pressure of SISTA SBLOCA line were predicted.

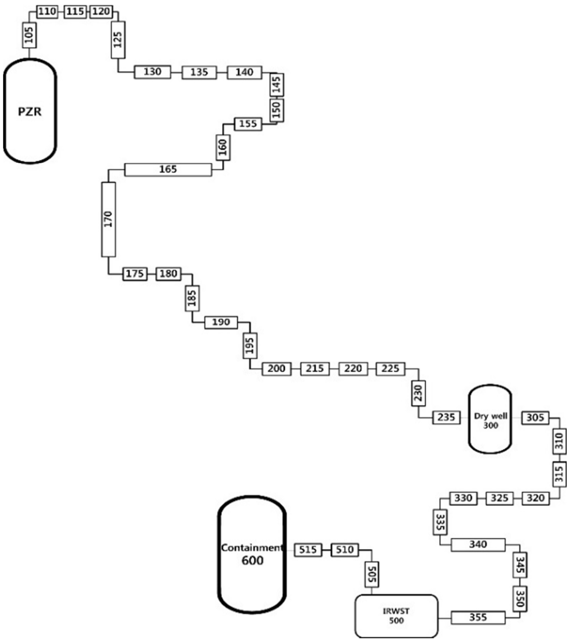

Fig. 2. Nodalization result of SISTA SBLOCA line using the MARS-KS code

3. Result

Figure. 3 shows the comparison results of mass flow rates between preliminary tests and the MARS-KS simulations using the by-pass line. The pressure of PT-1 correspond to the values acquired from different steady pressure condition as shown in Figure. 4. Comparison results show that the obtained pipe characteristics was well suited for the test mass flowrate range.

Figure. 5 represents the mass flowrate of the SISTA SBLOCA line on the QM-1 and Drywell under different constant pressure conditions. After inserting steam in pipe, the initially injected mass flowrate showed a different behavior. It was caused by the long pipe line between QM-1 and Drywell. For simulating initial break mass flowrate, the difference between the measured mass flowrate on QM-1 and the injected mass flowrate on drywell will be considered in the test. Figure. 6 shows the pressure of drywell and IRWST with the pressurizer pressure of 15 MPa. It is found that the pressure change at 20 s and increases steadily afterward. At 20 s, the pressure of drywell is 1.16 bar, which is hydraulic pressure of IRWST. It means that the steam is injected from drywell to IRWST when the pressure of drywell becomes higher than the hydraulic pressure of IRWST.

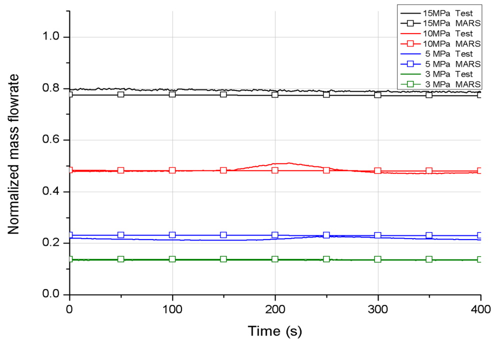

Fig. 3. Comparison of mass flowrate using the bypass line between the steady-state test and the MARS-KS calculation

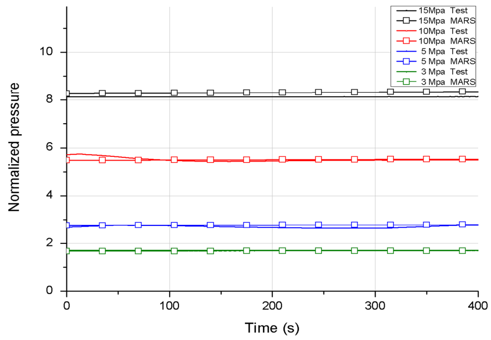

Fig. 4. Comparison of pressure at PT-101 between steady-state test and the MARS-KS calculation

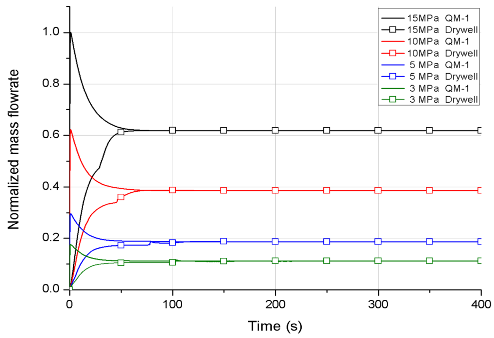

Fig.5. Comparison of mass flowrate between QM-1 and Drywell using the MARS-KS calculation

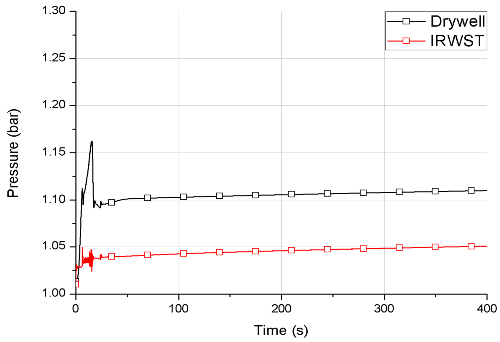

Fig. 6. Pressure of drywell and IRWST with the pressurizer pressure of 15 MPa using the MARS-KS calculation

4. Conclusion

SISTA was built for the verification of SMART PCCS concept. Before the main test using the SBLOCA line, some preliminary tests were performed and analyzed. Comparison of the preliminary test and the MARS code demonstrated that the obtained value was reasonable. In addition, the SBLOCA line test was simulated using the MARS-KS code. More tests are necessary to provide data to verify the code calculation results. The present results are expected to be used as basic data for main tests.

REFERENCES

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