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Experiments on injection performance of SMART ECC facility using SWAT

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1. Introduction

SMART (System-integrated Modular Advanced ReacTor), an advanced integrated PWR is now in the under developing stages by KAERI. Such integral PWR excludes large-size piping of the primary system of conventional PWR and incorporates the SGs into RPV, which means no LBLOCA could occur in SMART. Therefore, the SBLOCA is considered as a major DBA (Design Basis Accident) in SMART and it is mainly analyzed by using TASS/SMR computer code. The TASS/SMR code should be validated using experimental data from both Integral Effect Test and Separate Effect Test facilities. To investigate injection performance of the ECC system, on SET facility, named as SWAT (SMART ECC Water Asymmetric Two-phase choking test facility), has been constructed at KAERI. The SWAT simulates the geometric configurations of the SG-side upper downcomer annulus and ECCSs of those of SMART. It is designed based on the modified linear scaling method with a scaling ratio of 1/5, to preserve the geometrical similarity and minimize gravitational distortion. The purpose of the SWAT tests is to investigate the safety injection performance, such as the ECC bypass in the downcomer and the penetration rate in the core during the SBLOCA, and hence to produce experimental data to validate and the prediction capability of safety analysis codes, TASS/SMR.

2. Experimental apparatus and procedure

SWAT was designed using a 1/5 scaling ratio applying the modified linear scaling method. The design features of the SMART is such that the elevation of RCP suction nozzles is the same with that of the ECC injection nozzles are maintained to reduce a distortion caused by the gravitational effect. SWAT consists of a main test section, safe injection system, saturated steam and saturated water supply system and recirculation water supply systems and break simulation system. In order to remove the uncertainty of the experiment, the pressurizer, stop cooling system, chemical, volume control system, SG system, and core region is excluded from the experiment simulated target. The main part of the test section is the SG-side upper downcomer. The boundary conditions are saturated steam and water flow condition and drain flow rate to control the collapsed water level in the down-comer. As shown Fig. 1, the schematic diagram and the loop arrangement of main test section respectively were installed. The 4 saturated steam pipes and 4 saturated water pipes were connected to the upper unit in order to inject main test section. The safety injection pipe excluding the break safety injection pipe was installed in 3 places. The thermocouples, pressure transmitters, vortex type flow meters were installed to measure temperature, pressure and flow. The experimental data measured by various instruments and so on separate PC' hard disks were respectively stored. In vapor pressure of about 2.5MPa, the test was performed by controlled flow of saturated steam, saturated water and downcomer level.

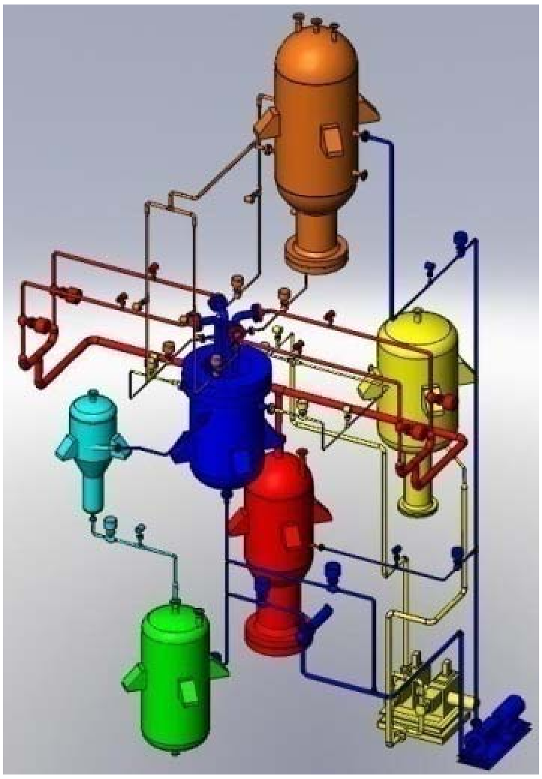

Fig. 1. Schematics of test section and loop arrangement

3. Test Results and Discussion

3.1. Test matrix

This test was performed with about 2.5MPa vapor pressure, 312℃ temperature, a flow rate of saturated vapor, saturated flow and a level of down-comer. As the downcomer maintained the critical flow status at the break nozzle, a down stream of break nozzle does not affect pressure boundary condition in down-comer. As shown table II, tests carried out 7 conditions.

Table I: Test Conditions of SWAT

Test-ID	***Flow per nozzle***	***Initial level of Down-comer***	***ECC injection location***
I-3-R1	100%	0.7 m	SI-3
I-3-R2	0%	0.7 m	SI-3
I-3-3	100%	Increasing from 0.7 m	SI-3
I-5-1	75%	0.7 m	SI-3
I-7-1	50%	0.7 m	SI-3
I-8-1	70%	0.7 m	SI-1, 2
I-10-1	33%	0.7 m	SI-1, 2, 3

3.2. Results and Discussion

The steam condensation rate is the rate of total steam injected into the main test section and a steam emitted in a break line of the main test section. The rate of steam condensation was calculated using Equation (1). The results are shown in Fig. 2. Test results show that the steam condensation rate is increased with increasing safety injection water (compared with 50% ~ 100%). Although the safety injection water is injected into different side, a steam condensation rate is similar to the total same injection water amount. Furthermore as maximum standard deviation is 3.5%, standard deviation is very good. Therefore, the main experimental data are considered within the acceptable standard deviation.

$$Cond\_Rate = 1 - \frac{QM_{(BK-01)}}{\sum QM_{(SS-01,02,03,04)}} \qquad (1)$$

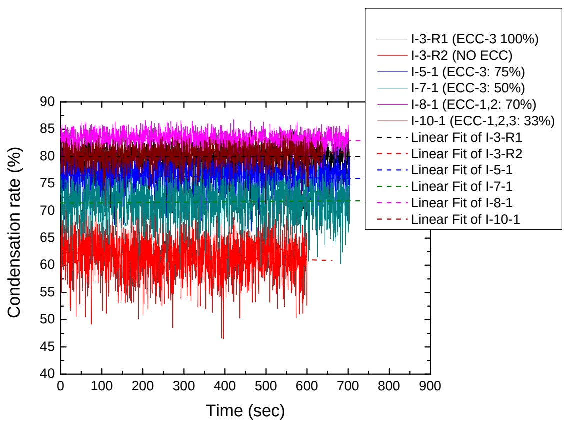

Fig. 2. Comparison of steam condensation rate

In Fig. 3, safety injection bypass rates compared with values which are calculated by Equation (2). Here, regardless of the amount of safety injection water, the safety injection bypass rate slightly appeared. However, the bypass rate of test I-3-3 is higher than other tests. Due to the water level elevation is located in the break nozzle height, safety injection bypass sweeps out with increasing down-comer level on the break nozzle.

$$Bypass\_Faction = 1 - DC\_Penetraion\_Faction$$
$$= \left[1 - \frac{QM_{(DCD-01)}}{\sum QM_{(ECC)} + \sum QM_{(SW)} + \sum QM_{(SS)} - QM_{(BK-01)}}\right] \qquad (2)$$

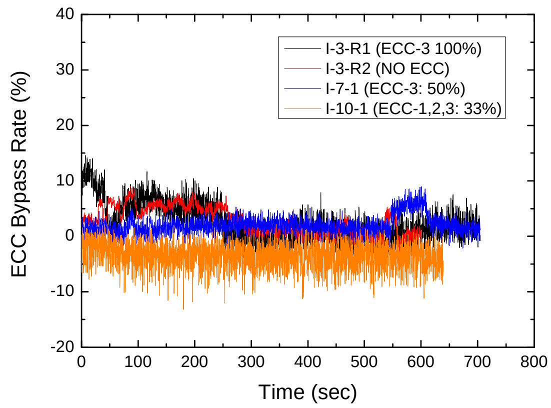

Fig. 3. Comparison of safety injection bypass rate

4. Conclusions

The condensation rate is increased with a increasing of the safety injection flow rate. Although the safety injection water is injected into different side, a steam condensation rate is similar to the total same injection water amount. Regardless of the amount of safety injection water, the safety injection bypass rate slightly appeared. However the bypass rate of test I-3 is higher than other tests. Due to the water level elevation being located in the break nozzle height, safety injection bypass sweeps out with increasing downcomer level to the break nozzle.

The experimental data which was obtained from these tests will be used for verification data on results of code analysis and offer information about safety injection performance using significant reactor analysis including thermal hydraulic phenomenon.

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