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Commissioning of an Integral Effect Test Loop for SMART

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1. Introduction

An integral-effect test loop for SMART [1], SMART-ITL (or FESTA) [2], has been constructed at KAERI. Its height was preserved and its flow area and volume were scaled down to 1/49 compared with the prototype plant, SMART. The ratio of the hydraulic diameter is 1/7. The SMART is a 330 MW thermal power reactor, and its core exit temperature and PZR pressure are 323℃ and 15 MPa during a normal working condition, respectively. The maximum power of the core heater in the SMART-ITL is 30% of the scaled full power. As shown in Fig. 1, the SMART-ITL consists of a primary system including a reactor pressure vessel with a pressurizer, four steam generators and four main coolant pumps, a secondary system, a safety system, and an auxiliary system.

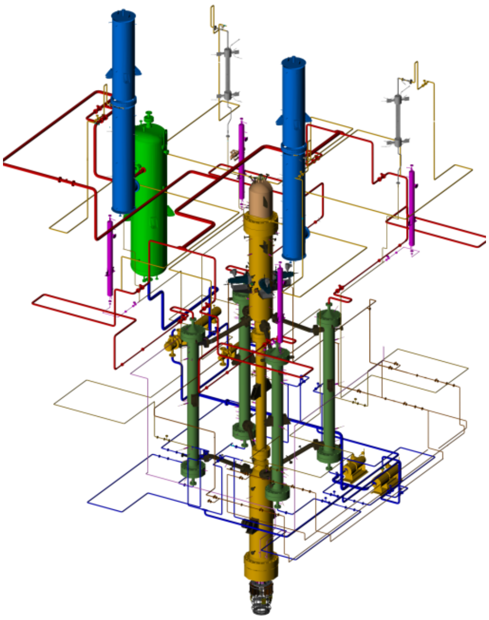

Fig. 1 Schematics of the SMART-ITL.

The SMART-ITL facility will be used to investigate the integral performance of the inter-connected components and possible thermal-hydraulic phenomena occurring in the SMART design, to validate its safety for various design basis events and broad transient scenarios, and to validate the related thermal-hydraulic models of the safety analysis codes. The scenarios include small-break loss-of coolant accident (SBLOCA) scenarios, complete loss of RCS flowrate (CLOF), steam generator tube rupture (SGTR), feedwater line break (FLB), and main steam line break (MSLB).

The role of SMART-ITL will be extended to examine and verify the normal, abnormal, and emergency operating procedures required during the construction and export phases of SMART.

After an extensive series of commissioning tests in 2012, the SMART-ITL facility is now in operation. In this paper, the major test results acquired during the commissioning tests will be discussed.

2. Major Commissioning Activities

After the installation of the test facility, the commissioning activities began during 2012. They include pipe cleaning, hydro and leak tests, component-wise performance tests, system-wise performance tests, and integrated performance tests. All the commissioning activities were performed with the appropriate check sheet following the prepared test procedure.

Component-wise performance tests were performed for each pump, heater, control valve, flowmeter, pressure vessel, etc. System-wise performance tests were performed for all fluid systems, power supply system, control and monitoring systems and data acquisition system. The integrated commissioning tests include preparation, heat-up, steady-state operation, accident scenario, and cooldown.

2.1 Pipe Cleaning, and Hydro & Leak Tests

Each unit component is cleaned before it is installed in SMART-ITL. However, the inter-connecting pipe could be contaminated during the installation works including welding. The pipe cleaning follows the fluid flow using the demi-water supplied from KAERI.

The hydro and leak test results are summarized in Table 1. The leak rate was proved to be acceptable for primary, secondary, and PRHR systems.

Table 1: Hydro and leak test results

System	Test	Design Pressure (MPa)	Test Pressure (MPa)	Test Duration (hr)
Primary System	Hydro	18	27	1
	Leak	18	17	12
Secondary System	Hydro	10	8	1
	Leak	10	8	12
PRHRS	Hydro	18	17	1
	Leak	18	8	12

2.2 Component- and System-Wise Performance Tests

For the pumps and heaters, insulation resistance, inverter setpoints, breaker, and voltage mismatch, etc, was checked. For the valves, the operation performance of the on/off valve and the opening of control valve were checked.

The core heater is composed of 2 groups with the outputs of 1,440 and 1,600 kW, respectively. The linearity was checked between the input power given and the output power measured. Similarly the linearity of two pressurizer heaters was checked to show good performance.

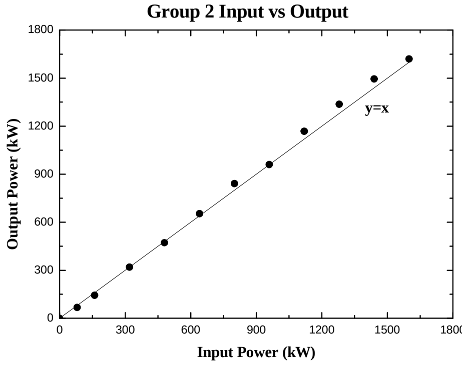

Fig. 2 Performance test results of core heater (group #2).

The reactor coolant pump (RCP) was also characterized for the rotation speed, head and efficiency, which are provided from the vendor, and the coastdown characteristics and homologous curve were also checked.

The performance of steam generator (SG) depends on the characteristics of both the fluid flow and heat transfer, which show a differential pressure distribution and heat transfer through primary and secondary systems, respectively. Both the primary-side and secondary-side performance tests were performed.

The performance of the safety injection system was also checked for the safety injection pump. To simulate the flowrate for the given pressure, the correlations of the flowrate versus RPM and RPM versus pressure, which is shown in Fig. 3, were produced for a pre-determined pump stroke.

2.3 Integrated Commissioning Tests

The integrated commissioning tests include the preparation, heat-up, steady-state operation, accident scenario (natural circulation tests, preliminary SBLOCA test) and cooldown. The system is heated up below the acceptable speed of 55^{o}C/hr and within the thermal margin of 30^{o}C compared with the core exit temperature. The system could be similarly cooled down. The natural circulation tests are performed both for the RCS loop and the PRHRS loop. The steady-state condition was maintained for 600 seconds before simulating the natural circulation tests. The steady-state test results show that most of the thermal-hydraulic parameters agree well with the target values. As shown in Fig. 4, the pressure trend of secondary system shows the typical results expected.

The test results for the steady-state operation and SMART are discussed in a separate paper [3].

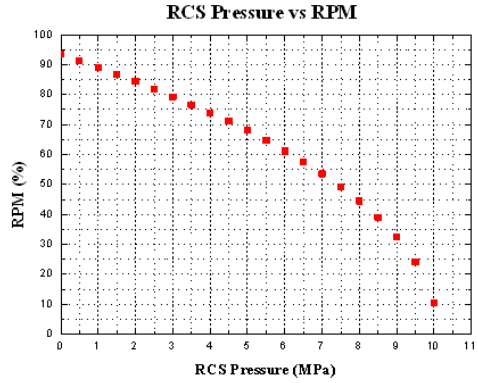

Fig.3 RPM versus pressure curve of SIP.

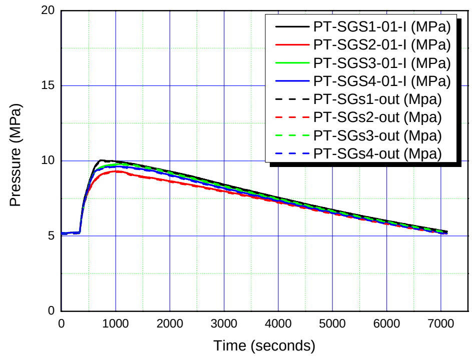

Fig.4 Pressure trends of secondary system during PRHRS natural circulation test.

3. Conclusions

SMART-ITL was constructed at KAERI and recently finished its commissioning. A series of commission tests of pipe cleaning, hydro and leak tests of primary, secondary and PRHR loops, component-wise performance tests, system-wise performance tests, and integrated performance tests were successfully performed to make the SMART-ITL be ready for an accident simulation of the SMART design.

ACKNOWLEDGEMENT

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