System Code Analysis of ATLAS Facility Including Heat Loss Evaluation

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1. Introduction

KAERI has been operating an integral effect test facility, the Advanced Thermal-Hydraulic Test Loop for Accident Simulation (ATLAS) for transient and accident simulations of advanced pressurized water reactors (PWRs) as shown in Figure 1 [1]. By using the ATLAS, a high-quality integral effect test database has been established for major design basis accidents of the APR1400.

There have been many efforts to improve the prediction capability of the system codes such as RELAP5, MARS-KS, and SPACE using ATLAS experimental data. However, since the heat loss of the ATLAS has not been reflected correctly in the code input model, there have been differences between the experimental data and the code prediction results. This difference can induce a distortion in maximum cladding temperature, natural circulation flow rate in primary system, cooling and de-pressurizing rate of the system.

To improve the prediction capability of the system code input model for the ATLAS, this study performed followings: 1) evaluation of the ATLAS heat loss using the experimental data, 2) modeling/application of the local heat loss quantification to the ATLAS input model, 3) transient simulation with heat loss, and 4) comparison with the experimental data.

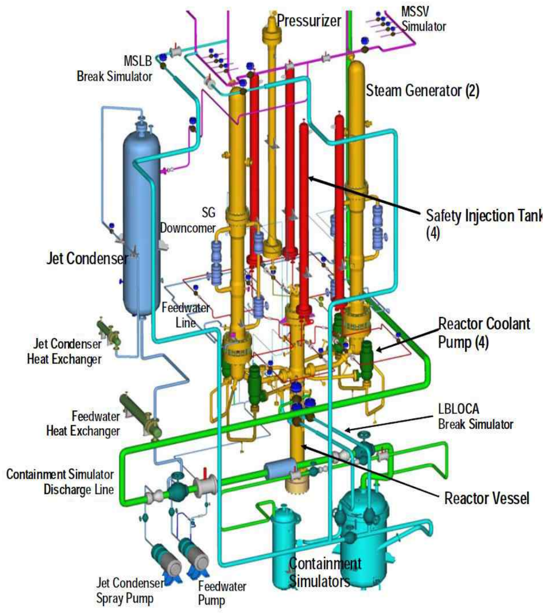

Fig. 1. Schematic diagram of ATLAS Facility

2. Evaluation of Heat Loss

The ATLAS heat loss test was performed to evaluate the heat loss of the primary-side of the ATLAS. Secondary side of steam generators (SGs) was isolated and empty. It enabled to exclude the heat transfer at the U-tubes. The heat losses were determined in two separate and different ways as follows [2].

2.1 Integral Approach

In the integral approach, the heat loss was evaluated by adjusting the core heater power to maintain constant temperature, with running four reactor coolant pumps (RCPs). Since the heat transfer to the SG is ignored, the primary-side heat loss is almost same with the sum of the core heater power and the pump heat output. This approach has the merit to easily grasp the total heat loss of the entire system according to the fluid temperature.

2.2 Differential Approach

In the differential approach, the individual heat loss of primary-side components was derived from temperature evolution during a cool-down transient by using Equation (1). This approach has the merit to grasp approximately the local heat loss of the component according to the fluid temperature.

$$\dot{Q}=\left(mc_{p,fluid}\frac{\partial T}{\partial t}\right)_{fluid}+\left(mc_{p}\frac{\partial T}{\partial t}\right)_{structure} \quad (1)$$

2.3 Experimental Data

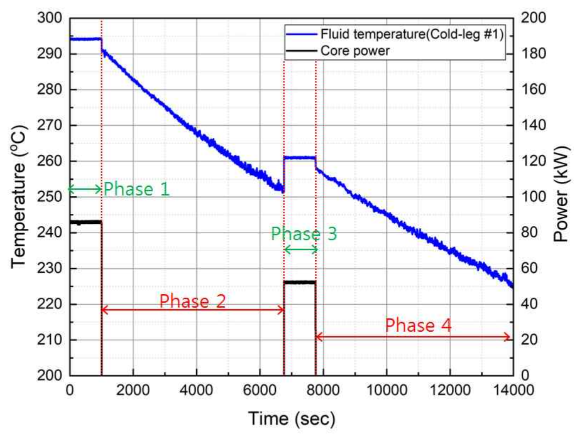

Fig. 2. Experimental data of ATLAS heat loss test

Fig. 2 shows the experimental data for the heat loss test. In the phases 1 and 3, for the integral approach, the core heater power was on, with RCPs running. In these periods, the fluid temperature and the total heat loss are kept constant. In the phases 2 and 4, for the differential approach, the core heater power and the RCPs were off. The local fluid temperature decreases due to the heat loss. Using this temperature data and Equation (1), the local heat loss can be determined according to the fluid temperature as shown in Figure 3. It is found that the local heat loss increases with the fluid temperature.

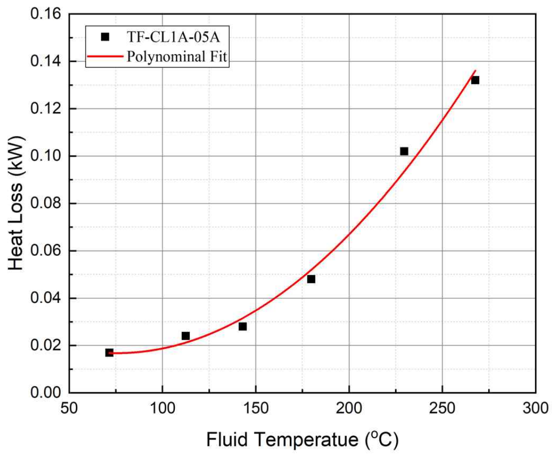

Fig. 3. Sample of local heat loss in ATLAS

3. Modeling of ATLAS Facility Heat Loss

For the heat loss analysis, this study used the MARS-KS1.4 code [3]. Figure 4 illustrates the MARS-KS nodalization of ATLAS facility. The red lines indicate the primary-side heat structures except the U-tubes. To simulate the heat loss of the ATLAS facility, this study applied the local heat loss data (see Fig. 3) from various locations to each heat structure considering the measurement point. The heat loss is modeled with the heat transfer coefficient boundary condition according to the wall temperature.

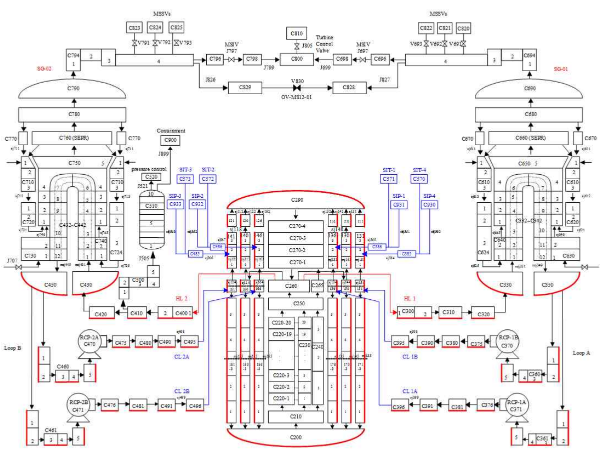

Fig. 4. Schematic diagram of ATLAS Facility

4. ATLAS Simulation Including Heat Loss

Using the modified ATLAS input model, transient simulation for the heat loss was performed. In this simulation, the core heater power and RCP power were off, or zero. Figure 5 depicts the MARS simulation result for the fluid temperature with the experimental data. In the case that the heat loss modeling is not applied, the fluid temperature remained constant. When the heat loss modeling was applied, the fluid temperature decreased with time due to heat loss to the atmosphere. There is still difference between the system code result and the experimental data. However, it is expected that more accurate results will be obtained in the future because the heat loss quantification is currently underway.

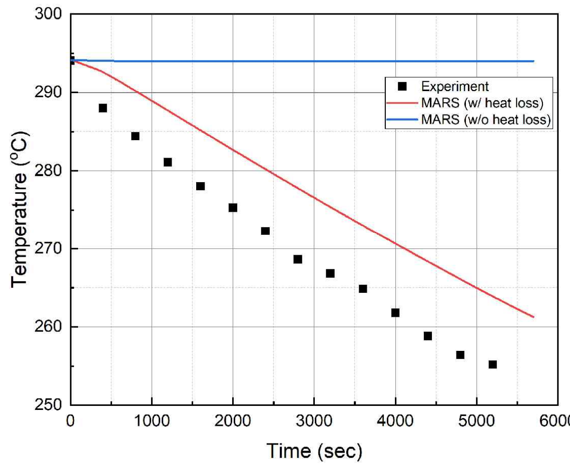

Fig. 5. Heat loss simulation result

5. Conclusions

To improve the prediction capability of the system code for ATLAS, this study evaluated the heat losses for the ATLAS facility and applied them to the MARS-KS input model. Currently, the detailed evaluation and review process of the heat losses are ongoing. In the future, the station blackout test will be simulated. It is expected that the result of this study greatly improve the prediction capability of the system code for the ATLAS.

ACKNOWLEDGMENTS

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