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Analysis of the ATLAS SGTR-HL-05 Experiment using SPACE Code

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1. Introduction

The Korean nuclear industry developed a thermal-hydraulic analysis code for the safety analysis of PWRs(pressurized water reactors). The new code is named SPACE(Safety and Performance Analysis Code for Nuclear Power Plant). As a part of code validation effort, an analysis of the ATLAS SGTR(Steam Generator Tube Rupture) experiment using SPACE code has been performed. The SGTR-HL-05 experiment is a multiple U-tube SGTR. The calculated results using the SPACE code are compared with those from the experiment.

2. ATLAS SGTR Experiment

2.1 Description of ATLAS Test Facility

The ATLAS (Advanced Thermal-Hydraulic Test Loop for Accident Simulation) is a thermal-hydraulic integral test facility for advanced pressurized water reactors. It is located within Korea Atomic Energy Research Institute (KAERI)[1].

The reference plant for the ATLAS is a 1400 MWe-class evolutionary pressurized water reactor (PWR), APR1400 (Advanced Power Reactor 1400 MWe). The ATLAS also incorporates some specific design characteristics of a 1000 MWe-class Korean standard nuclear power plant, OPR1000 (Optimized Power Reactor 1000 MWe), such as the cold leg injection (CLI) mode of the safety injection and low pressure safety injection pumps.

The ATLAS facility has the following characteristics: (a) 1/2-height and length, 1/288-volume, and full pressure simulation of APR1400, (b) maintaining a geometrical similarity with APR1400 including 2(hot legs) and 4(cold legs) reactor coolant loops, direct vessel injection (DVI) of emergency core cooling water, integrated annular downcomer, (c) incorporation of specific design characteristics of OPR1000 such as cold leg injection and low-pressure safety injection pumps, (d) maximum 10% of the scaled nominal core power. The ATLAS can simulate broad scenarios of design-basis accidents (DBAs) including the reflood phase of a large-break loss-of-coolant accident (LBLOCA), small-break LOCA(SBLOCA) scenarios including DVI line breaks, steam generator tube rupture, main steam line break, feed line break, mid-loop operation, etc.

2.2 Description of SGTR-HL-05Experiment

The SGTR accident is one of the design basis accidents having a significant impact on safety in a viewpoint of radiological release. In this study, a postulated SGTR event of the APR1400 was experimentally investigated with the ATLAS. As one of the most limiting SGTR accidents, a break flow equivalent to a double-ended rupture of five U-tubes was simulated in the present SGTR-HL-05 test[1]. Separate piping for the broke U-tube was installed, which connects the primary side and secondary side. The break size was determined by the break nozzle section. The break nozzle section has 5 tubes and 5 orifice holes with inner diameter of 1.68mm each. The initial conditions for the experiment are shown in Table 1.

Table 1. Initial conditions for ATLAS SGTR-HL-05

Description	Initial value
Nominal Power (MWt)	1.623
Pressurizer pressure (MPa)	15.61
Coldleg temperature (^{o}C)	292.3
Hotleg temperature (^{o}C)	325.6
Cold leg flow rate (kg/s)	2.19
Steam pressure (MPa)	7.85
Steam flow rate (kg/s)	0.417

3. SPACE Calculation

3.1 Description of the SPACE Code

The SPACE code is an advanced thermal hydraulic analysis code capable of two-fluid, three-field analysis. The SPACE code can be used in LBLOCA, SBLOCA and in Non-LOCA analysis of PWRs[2,3]. SPACE 2.16 was used for this analysis.

3.2 SPACE Nodalization

The SPACE nodalization of the ATLAS experiment facility is shown in Fig. 1. Two hot legs, four cold legs, two steam generators are modeled. The core power is taken from the experiment results and entered using table. The break flow is calculated using Ransom-Trapp choking model. The heat loss to the environment is modeled using heat structures.

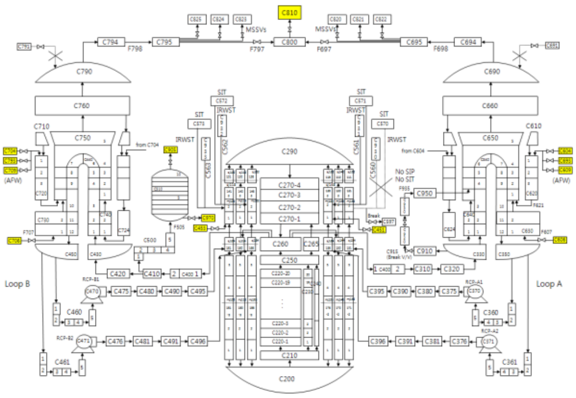

Fig. 1. SPACE nodalization for ATLAS SGTR

3.3 Calculation Results

The transient scenario was calculated with the SPACE code and the results were compared with measured results. Before the transient calculation, a 2000sec steady state calculation was performed to stabilize all variables to the initial condition of the experiment. The transient calculated was restarted at t=0sec, and the actual tube break occurred at t=202 sec. The major sequence of events for SGTR-HL-05 is shown in Table 2.

Table 2. Major sequence of events

Event	Time [sec]
Break opening	202
Main feedwater isolation	215
Main steam line isolation	215
Safety injection start	451

Fig. 2 shows break flow rate through the break tube. The break valve opens at t=202sec. The SPACE code shows good agreement with experiment. Fig.3 shows accumulated break flow through the broken tube. The SPACE code results show good agreement with the experiment.

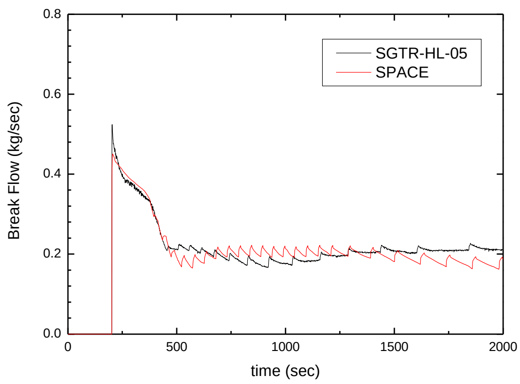

Fig. 2. Break flow rate at broken U-tube

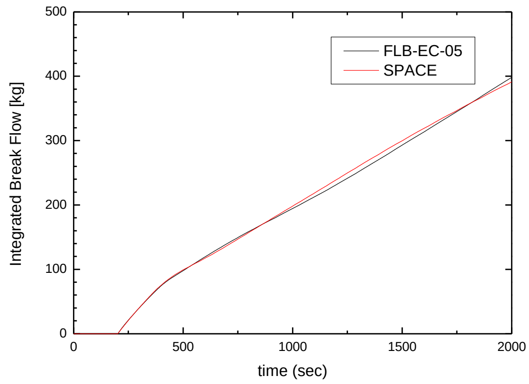

Fig. 3. Accumulated break flow

4. Conclusions

The ATLAS SGTR-HL-05 experiment, which is five U-tube rupture test, was simulated using the SPACE code. The calculated results were compared with those from the experiment. The comparisons of break flow rate and accumulated break flow mass show good agreement with the experiment. The SPACE code is capable of predicting physical phenomena occurred during ATLAS SGTR-HL-05 experiment.

Acknowledgement

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