Analysis of ATLAS FLB-EC6 Experiment using SPACE Code

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1. Introduction

The Korean nuclear industry has been developing 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, simulation of ATLAS FLB(Feedwater Line Break) experiment using SPACE code has been performed. The FLB-EC6 experiment is economizer break of a main feedwater line. The calculated results using the SPACE code are compared with those from the experiment.

2. ATLAS FLB 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).

The reference plant of the ATLAS is a 1400 MWe-class evolutionary pressurized water reactor (PWR), APR1400 (Advanced Power Reactor 1400 MWe), which was developed by the Korean nuclear industry. 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 Feedwater Line Break Experiment

The main feedwater line break accident is one of the design basis. For CE type plants, the FLB is a over-pressurization event. In this study, a postulated FLB event of the APR1400 was experimentally investigated with the ATLAS. APR1400 steam generators have two main feedwater supply lines: the economizer line and down comer line. The economizer feedwater line is larger, supplying 90% of feedwater at full power operation. The feedwater lines and break locations are shown in Fig.1. In FLB-EC6 experiment, break of economizer feedwater line is modeled. The size of break nozzle is 15.24mm in diameter. The initial conditions for the experiment are shown in Table 1.

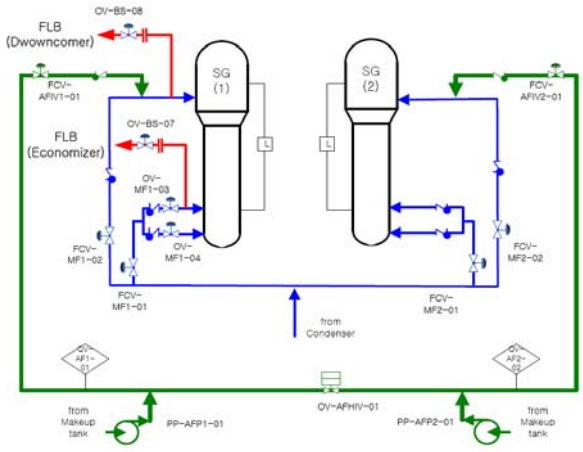

Fig. 1. Main feedwater line for ATLAS FLB

Table 1. Initial conditions for ATLAS FLB-EC6

Description	Initial value
Nominal Power (MWt)	1.631
Pressurizer pressure (MPa)	15.50
Core inlet temperature (^{o}C)	294.24
Core outlet temperature (^{o}C)	298.16
Steam pressure (MPa)	7.85
Steam flow rate (kg/s)	0.418

3. SPACE Calculation

3.1 General 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.

3.2 SPACE Nodalization

The SPACE nodalization of the ATLAS experiment facility is shown in figure 2. 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.

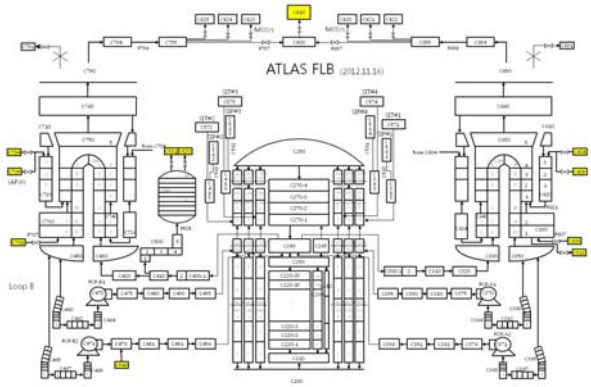

Fig. 2. SPACE nodalization for ATLAS FLB

3.3 Calculation Results

The transient scenario was calculated with the SPACE code and the results were compared with measured results. In the beginning of the transient calculation, a 300sec null transient calculation was performed to stabilize all variables to the initial condition of the experiment. The actual line break occurred at t=303 sec. The major sequence of events for FLB-EC6 is shown in table 2.

Table 2. Major sequence of events

Event	Time [sec]
Break opening	303
Reactor Trip	461
Turbine Trip	461
RCP Trip	461
Main Steam Line Isolation	465

Fig. 3 shows break flow rate through the break area. The break valve opens at t=303sec. The maximum break flow rate predicted by SPACE code is slightly less than the experiment but the overall break flow rate shows good agreement with the experiment. The accumulated break flow also shows good agreement. Fig.4 shows steam generator water level. The level in steam generator 1 falls slightly faster in SPACE result but in general the SPACE code results show good agreement with the experiment.

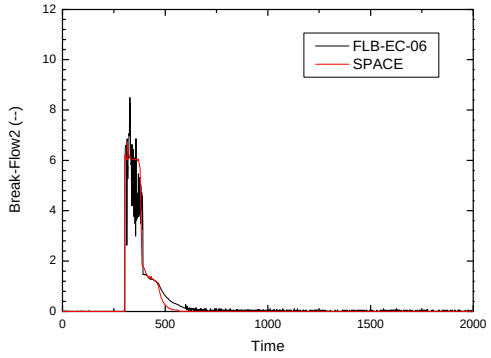

Fig. 3. Break flow rate at break valve

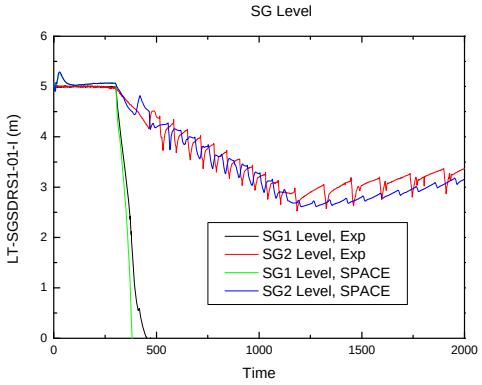

Fig. 4. Steam generator collapsed water level

4. Conclusions

The ATLAS FLB-EC6 experiment, which is economizer feedwater line break, was simulated using the SPACE code. The calculated results were compared with those from the experiment. The comparisons of break flow rate and steam generator water level show good agreement with the experiment. The SPACE code is capable of predicting physical phenomena occurring during ATLAS FLB-EC6 experiment.

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