Post-Test Calculation of A Feedwater Line Break Experiment performed at ATLAS

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1. Introduction

A feedwater line break test simulating the FLB accident for the APR1400 (Advanced Power Reactor 1400MWe), named FLB-DC-02, was conducted at ATLAS [1]. There are two feedwater injection nozzles for each SG: one on the downcomer and the other on the economizer. A break with a size of 0.18 ft^2 (APR1400-based size) was assumed to occur on the pipe connected to the downcomer. Based on the experimental data, a post-test calculation is performed using the MARS-KS code [2]. This FLB-DC-02 test is characterized with low SG water levels and a superheated critical flow which would be challenges to assessment of the thermal-hydraulic system code.

This post-test calculation of this FLB-DC-02 test using MARS-KS code aims at reproducing the experimental scenario and at assessing the MARS-KS code for the simulation of secondary transients.

2. ATLAS and FLB-DC-02 Experiment

ATLAS is a scaled-down two-loop IET (Integral Effect Test) facility, designed to investigate major design basis accidents and operational transients for a 1400 MWe-class advanced PWR (Pressurized Water Reactor) APR1400. The ATLAS is a 1/2-height and a 1/288-volume scaled IET facility with respect to the APR1400. It has a maximum power capacity of 10% of the scaled nominal core power, and it can simulate full pressure and temperature conditions of the APR1400. Break was simulated using a long break nozzle (Di = 10.23 mm) in line with the feedwater injection pipe connected to the SG downcomer.

In this experiment, very low SG water level 0.74 / 0.77 m for each SG (normally 5.0 m for each SG) was maintained to limit the heat removal rate from primary system to secondary system so that the HPP (High Pressurizer Pressure) tip can be simulated with ATLAS. The HPP can't be reached in the transient if the SG water level at 5.0 m was maintained during steady state (the U-tube heat transfer area with SG water level at 5 m corresponds to the heat transfer area for 100% of scaled core power, whereas, the ATLAS maximum operation core power 2.0 MW can only provide 10% of scaled power).

The measured steady state conditions are shown in **Table 1**. The transients of FLB-DC-02 test are described in the report [3] and will be discussed in comparison with the calculated results in the following.

3. Code Calculation

3.1 Calculation of Steady State

The steady state conditions were obtained in the code calculation by specifying the code model conditions as close to the experimental condition as possible. The calculated steady state conditions are shown in **Table 1** along with the experimental steady state conditions.

Table 1: Calculated and Measured Steady Sate Conditions

Design parameters	FLB-EC-01 test (A)	Calculated (B)	Difference (A - B)/A
Primary System			
Pressurizer pressure (MPa)	15.51	15.5	-0.02%
Pressurizer level (m, Full)	3.27	3.25	-0.61%
Hot leg flow (kg/s)	3.918	3.579	-8.65%
Hot leg temperature (^oC)	324.05	323.66	-0.12%
Cold leg flow (kg/s)	1.929	1.790	-7.22%
Cold leg temperature (^oC)	288.33	284.81	-1.22%
Steam Generator (SG-1, SG-2)			
Steam pressure (MPa)	6.86	6.92	0.87%
Steam temperature (^oC)	286.59	285.95	-0.23%
	294.24	285.04	-3.13%
Steam flow rate (kg/s)	0.398	0.413	3.61%
	0.418	0.413	-1.34%
Feedwater flow rate (kg/s)	0.413	0.413	-0.02%
	0.431	0.413	-4.13%
SG water level (m, WR)	0.741	0.781	5.50%
	0.774	0.776	0.31%

3.2 Transient Results

In the calculation using MARS-KS code, the overall transients of FLB-DC-02 were well reproduced. However, the break flow rate (**Fig. 1** and **Fig. 2**) was overestimated after 80 s, which was responsible for the inconsistent transients of SGs' pressure (**Fig. 3**) and water level (**Fig. 4**). The faster decrease of SGs' water level resulted in earlier reach of Low Steam Generator Level (LSGL) setpoint, and hence earlier injection of auxiliary feedwater (**Fig. 5**) into SG 2. The earlier injection of auxiliary feedwater at 142 s provides more cooling to the primary system, causing the primary pressure (**Fig. 6**) to reach the HPP set point later. From the inconsistence of the transients of break flow and SG water level, it's inferred the MARS-KS code overestimates the critical flow of superheated steam or the modeling of SG lower portion and lower U-tube sections might need to be examined.

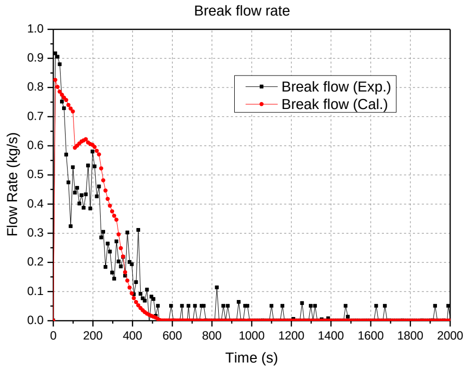

Fig. 1. Break flow rate

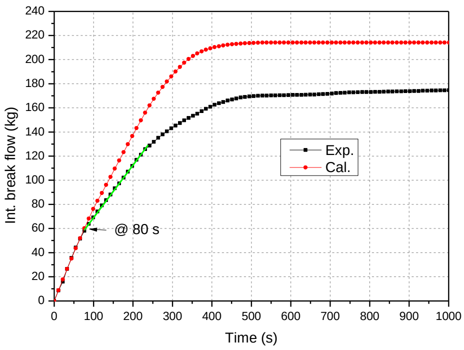

Fig. 2. Accumulated break flow

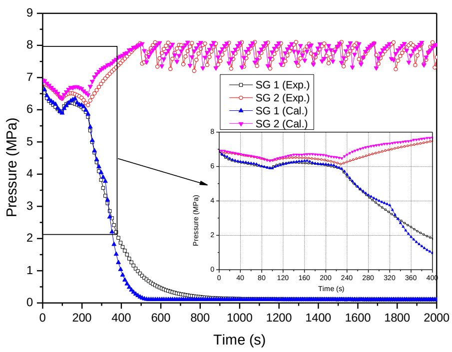

Fig. 3. SGs' pressure

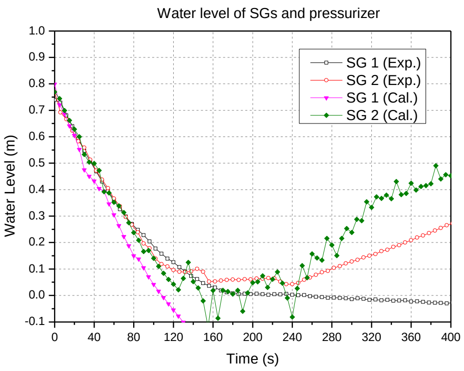

Fig. 4. SGs' water levels

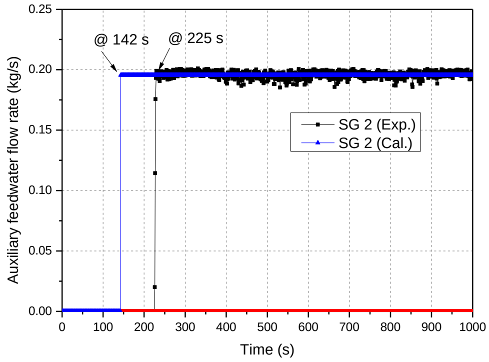

Fig. 5. Auxliary feedwater flow rate

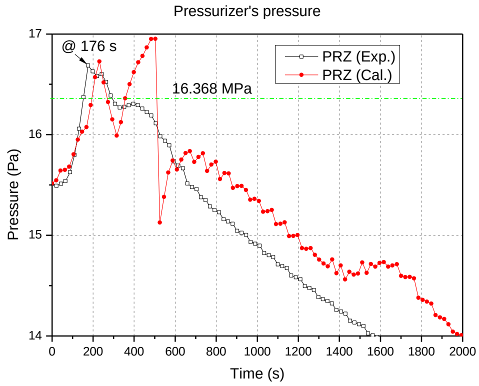

Fig. 6. Pressurizer' pressures

4. Conclusion

The FLB-DC-02 test was featured with lower SG water level 0.77 m compared with the scaled value (5.0 m) and superheated steam flow through the break. In general, the overall transients of the FLB-DC-02 were well produced by the MARS-KS code. However, the critical flow of superheated steam was overestimated by the MARS-KS code. Provided that the critical break flow was accurately modeled, the transients of this FLB-DC-02 would be reproduced better.

REFERENCES

[1] Kyoung-Ho Kang et al., *ATLAS Facility and Instrumentation Description Report*, KAERI/TR-3779/2009, KAERI, Daejeon, South Korea, 2009.

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[3] H. S. Park et al, "*Quick look report on the feedwater line break test (FLB-DC-02) with the ATLAS"*, S06NX08-A-1-TR-18 Rev. 00, KAERI, Daejeon, 2012.