MARS Code Simulation of A Cold Leg Intermediate Break LOCA at ROSA-2/LSTF

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1. Introduction

The simulated experiment is a cold leg IBLOCA (Intermediate Break LOCA) experiment due to guillotine break of an ECCS (Emergency Core Cooling System) piping connected to cold leg performed with ROSA-V/LSTF (Rig-Of-Safety-Assessment V/Large Scale Test Facility) by JAEA (Japan Atomic Energy Agency) [1]. In this research, post-calculation of this experiment is performed using MARS (Multi-D Analysis of Reactor Safety) code with three-dimensional model for the RPV (Reactor Pressure Vessel) [2]. In conducting the code calculation, many mistakes made by the author were fixed by comparing the calculated results with experimental results. Finally, quite good calculation results are obtained and are compared with experimental results herein.

2. LSTF and LOCA Experiment

ROSA-V/LSTF [3] is a two-loop IET (Integral Effect Test) facility to simulate a typical 3423 MWt four-loop Westinghouse-type PWR with full height and 1/48 in volume. Break was simulated using a long break nozzle (Di = 41 mm). The measured steady state conditions are shown in **Table 1**. Details of this experiment are described in [1].

3. Code Calculation

3.1 Calculation of Steady State

The steady state conditions are 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

Parameters	Measured	Calculated
	(Loops with / w/o PZR)	
Hot leg fluid temp. (K)	598.7 / 597.6	599.7/599.8
Cold leg fluid temp. (K)	563.3 / 563.2	564.2/564.2
Loop mass flow rate (kg/s)	24.59 / 24.43	25.21/24.91
DC-to-hot leg bypass (kg/s)	0.048 / 0.043	0.046/0.046
Pressurizer pressure (MPa)	15.53	15.58
Pressurizer liquid level (m)	7.27	7.52
SG pressure (MPa)	7.30 / 7.36	7.332/7.33
SG liquid level (m)	10.26 / 10.22	9.59/9.63
Steam flow rate (kg/s)	2.65 / 2.61	2.86/2.86

3.2 Transient Results and Discussion

The break is easily implemented in the code simulation by specifying a single junction with inner diameter 41 mm connecting the volume at break location in the primary system with a time-dependent atmospheric volume. Various trips as given in **Table 1** are implemented according to the safety setpoints. In addition, Three ECCSs, HPI system, Accumulator system and LPI system, are activated to inject the SI (Safety Injection) water into the primary system according to the experimental data as given in **Eq.1** and **Eq. 2**. Through implementing these transient boundary conditions in the code calculation, the transient results are calculated. The code calculated results are compared with the experimental results and are discussed in the following.

As shown in **Fig. 1**, the ECCSs are well simulated in the code except that the accumulator injection is a little delayed in the simulation than in the experiment.

Fig. 2 and **Fig. 3** show the break flow and accumulated break flow, respectively. It shows the break flow transient is well simulated by the code, except that the break flow is slightly overestimated between 50 s and 250 s when critical flow is experiencing transition from two-phase critical flow to vapor flow, and is somewhat underestimated from 300 s to 500 s. From 300 s, the LPI system begins to inject cooling water into primary system. Primary-system pressure is also underestimated at around 350 s, which might contribute to the underestimation of break flow.

As seen from **Fig. 4**, the primary-system pressure is well predicted except some minor deviations at around 200 s and 350 s. As shown in **Fig. 5**, SG A's pressure transient is well predicted by the code, whereas SG B's pressure transient is not well simulated. It indicates that input deck for SG B does not reflect the real conditions of the experiment. This kind of not exactly interpreting the test facility and test conditions is always encountered in the thermal hydraulic code simulation, due to the text description of test facility and test conditions which is not user friendly and needs to be improved.

MARS code predicts the pressurizer and SGs' pressure transients and break flow with good accuracy, but inaccurately predicts the core and downcomer water level transients as shown in **Fig. 6** and **Fig. 7**. The inaccurate prediction might be because MARS code simplifies the numerical solutions of the governing equations (1-D governing equation representing the 3-D flow in reality) and adopts many empirical thermal-hydraulic models, which is an approximation to the real.

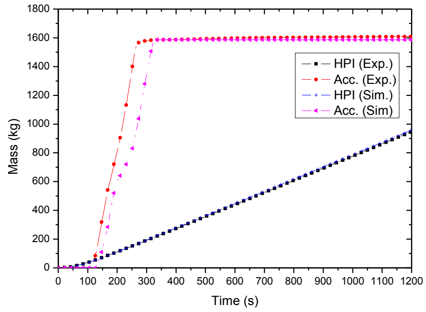

Fig. 1. Accumulated safety injection flow of each ECCS

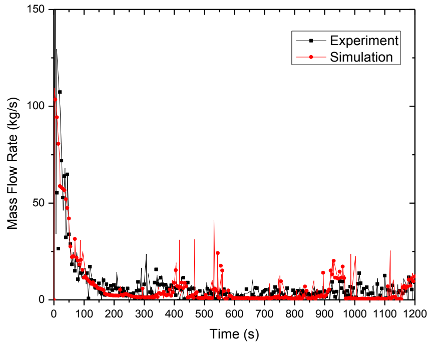

Fig. 2. Break flow rate

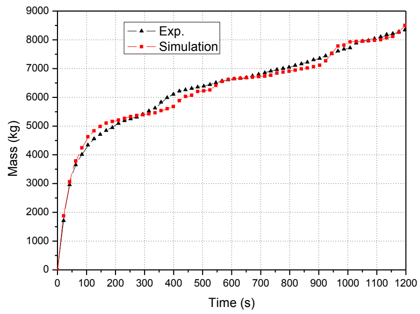

Fig. 3. Accumulated break flow

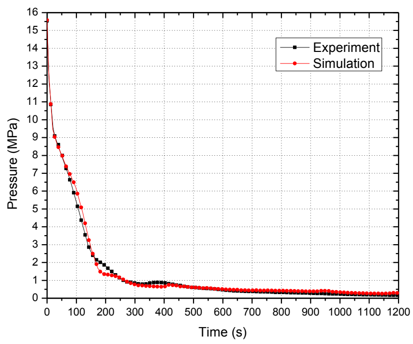

Fig. 4. Pressurizer pressure

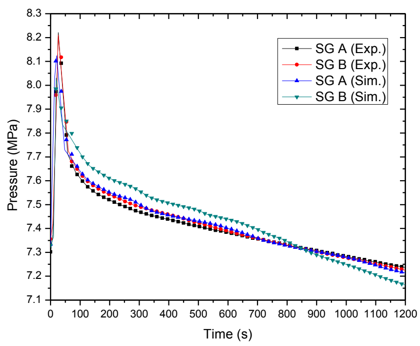

Fig. 5. SGs' pressures

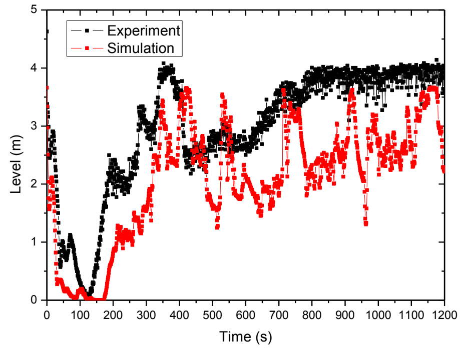

Fig. 6. Core water levels

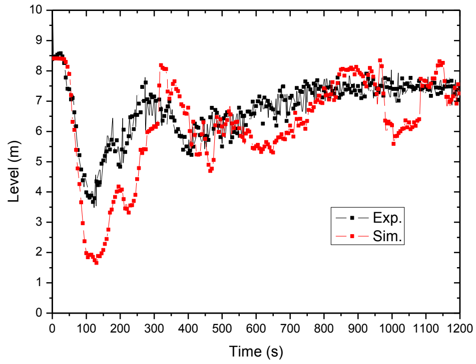

Fig. 7. Downcomer water levels

4. Conclusion

The IBLOCA experiment is well modeled with MARS code. The code calculated results are compared with the experimental results and discussed. Transients of some general parameters such as pressurizer pressure, SGs's pressure and break flow rate are well predicted by the MARS code, which shows the prediction capability of MARS code. However, MARS code predicts the steady state with some biases, which results from the inexact interpretation of test facility and test conditions due to the unfriendly user interface (text input) of describing the test conditions. It indicates the necessity of developing more friendly user interface (such as graphic input) to reduce the possibility of user-made mistakes in simulation. In addition, the core and downcomer water levels are also not well predicted, which indicates that the simplified numerical solutions of governing equations or the thermal-hydraulic models might need to be improved.

REFERENCES

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[3] The ROSA-V Group, ROSA-V Large Scale Test Facility (LSTF) System Description for the Third and Fourth Simulated Fuel Assemblies, JAERI, 2003.