Simulation of OECD-ATLAS A5.1 Test with MARS-KS Code

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1. Introduction

The OECD/NEA ATLAS (phase 1) project started from April 2014, with a three-year project period. This joint project focused on key LWR thermal-hydraulic safety issues related to multiple high risk failures highlighted from the Fukushima Daiichi accident utilizing the ATLAS facility [1].

In the frame of project, as a counterpart test of the Large Scale Test Facility (LSTF) SB-CL-32 test [2], the A5.1 test was performed to investigate the thermal-hydraulic phenomena during a cold-leg SBLOCA such as core heat-up, loop seal clearing (LSC), the effect of accident management (AM) actions, and scaling issue [3]. In this study, we assess the MARS-KS V1.5 against OECD/NEA ATLAS A5.1 test.

2. Description of OECD/ATLAS A5.1 Test

The target scenario of the A5.1 test is a 1% horizontal small break loss of coolant accident (SBLOCA) at the cold leg with the secondary side depressurization as an accident management (AM) action. The initial and boundary conditions were determined by the scaling analysis from the LSTF SB-CL-32 test. The power per rod of heater group of G-1 was about 1.77 times higher than that of heater groups of G-2 and G-3.

Figure 1 shows the location of the break unit and emergency core cooling (ECC) injection point at A5.1 test. The break unit was installed at the downstream of RCP-1A. The orifice of 5.41 mm inner diameter with sharp-edge shape was installed on the break unit. The ECC water injection points were located downstream of the RCP-1A and RCP-2A. The total failure of high-pressure injection system was assumed. The AM action was taken by the manual operation of two automatic depressurization valves (ADV).

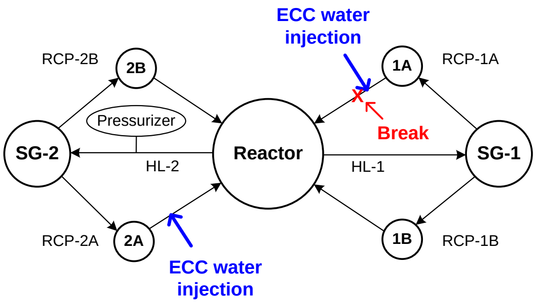

Fig. 1. Location of break unit and ECC injection point [3]

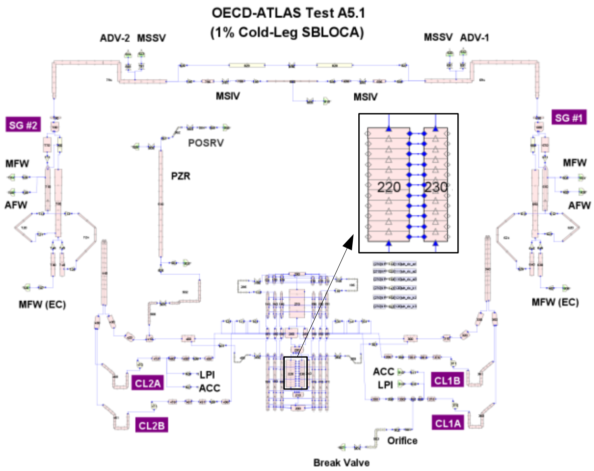

Fig. 2. MARS-KS nodalization of A5.1 test.

The transient was initiated by opening the break valve. Loss of off-site power concurrent with the scram of reactor was assumed. The turbine tripped and the main feedwater isolation valves and main steam isolation valves were closed with their actuation signals after some delay from the scram signal. The initiation of the AM action started with some delay after the break valve opening. The auxiliary feedwater injection was actuated with some delay after the initiation of AM action. The ACC and LPI injections were initiated when the primary pressure was reduced to the set points [3].

3. Description of MARS-KS Input Model

Figure 2 shows the MARS-KS nodalization of A5.1 test. The input model was developed using SNAP 3.1.1 with emphasis on increasing the geometrical fidelity to the ATLAS facility. The core consists of two channels with 11 axial node, and two channels are connected to each other with multiple junction component. The PIPE-220 component corresponds to the channel of heater groups of G-2 and G-3, and the PIPE-230 component corresponds to the channel of heater group of G-1.

The heat losses from primary and secondary systems to atmosphere are modeled. All heat losses of the primary side are assumed to occur only on the outer surface of the reactor vessel. The counter-current flow limitation options are activated on the fuel alignment plate, the hot-leg riser, the steam generator (SG) u-tube inlet, and the intermediate leg outlet

The break unit from the cold leg outer wall to the break valve is modeled.

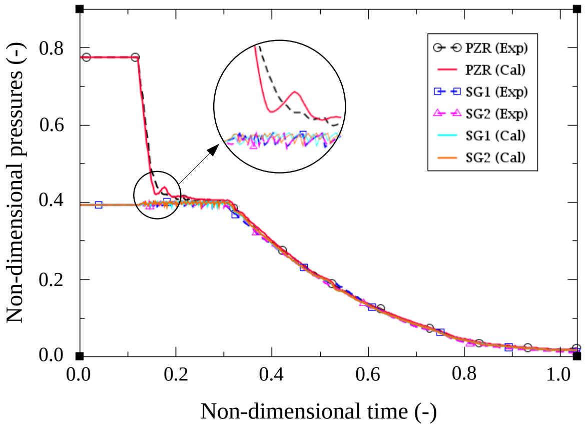

Fig. 3. Primary and secondary system pressures.

4. Results and Discussion

The main results of MARS-KS V1.5 are compared with the experimental data. All data are plotted with dimensionless values on the figures.

Figure 3 shows the comparison of the predicted primary and secondary pressures with experimental data. After the initiation of the break, a rapid depressurization of the primary system caused the core to trip. After the initiation of AM action, the operation of MSSVs stopped and the system pressures gradually decreased. The primary and secondary system pressures are well predicted by the code except that there is small fluctuation in the calculated primary pressure at around non-dimensional time of 0.16 which was not observed during the test.

Figure 4 depicts the collapsed water levels of the core and downcomer (DC). The collapsed water level of the reactor core decreased rapidly in the early stage of the transient. After the initiation of AM action, the collapsed water level of the core increased by the occurrence of LSC. The collapsed water levels in the core and DC increased with the initiation of ACC injection and LPI injection [3].

The calculation well reproduces the collapsed water levels of the core and DC. The increase in the core level by LSC is well captured by the simulation. However, a momentary LSC that was not observed in the test occurred in the calculation. After the LSC occurrence, the calculation shows a significant decrease in the PRV water level, while the experimental results show little change in the water level.

Figure 5 shows the maximum cladding temperatures (MCT). The core heat-up is not observed in both calculation and test. This indicates that the most part of active core was submerged in the coolant during the transient. The maximum cladding temperatures of each heater groups are well predicted by the code.

5. Conclusions

We assessed the capability of MARS-KS V1.5 using OECD/NEA ATLAS A5.1 test. It was found that the MARS-KS code was able to predict adequately the main thermal-hydraulic phenomena observed in 1% cold-leg SBLOCA with AM action and total failure of HPI.

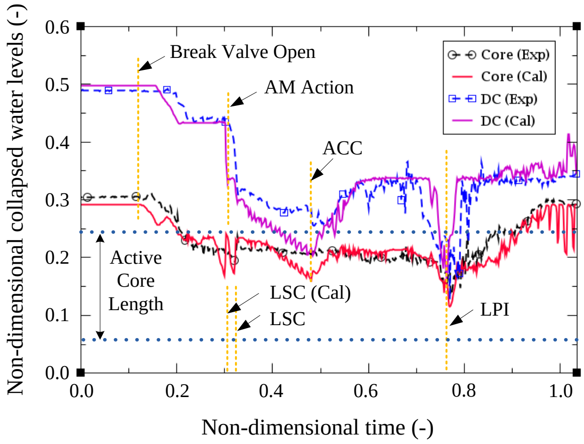

Fig. 4. Collapsed water levels of core and downcomer.

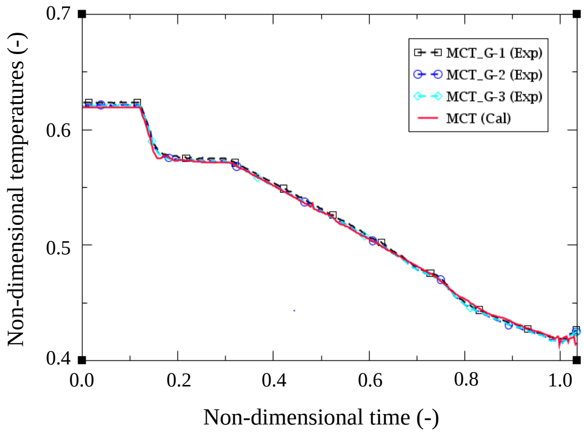

Fig. 5. Maximum cladding temperatures.

Acknowledgements

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