Simulation of OECD-ATLAS B2.1 Test using MARS-KS Code

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1. Introduction

The OECD/NEA ATLAS (phase 2) project started from October 2017, with a three-year project period. The objective of this joint project is to address thermal-hydraulic safety issues and accident management issues relevant for water reactors using the ATLAS test facility.

In the frame of project, the B2.1 test was performed to investigate the operational performance of the hybrid safety injection tank (HSIT) and to provide the best guidelines for accident management. In this study, we assess the predictable capability of MARS-KS V1.5 using the OECD/NEA ATLAS B2.1 test.

2. Description of OECD/ATLAS B2.1 Test

The target scenario of the B2.1 test is a prolonged station blackout (SBO) along with the availability of HSITs as a passive safety feature.

In the test, the uniform radial power distribution is applied. The active components such as safety injection pumps are assumed to be unavailable. The top of each HSIT is connected to the top of the pressurizer (PZR) by the pressure balance line (PBL). The bottom of each HSIT is connected to the direct vessel injection nozzles with injection valve. The isolation valve installed at the PBL is kept open during the entire test. Therefore, the initial pressure of each HSIT is the same as that of PZR.

The HSITs and PBLs were filled with subcooled water. The HSIT-1 and HSIT-2 actuate coincident with the first opening of the pilot-operated safety relief valve (POSRV) installed at the top of the PZR. The HSIT-3 and HSIT-4 actuate when the maximum cladding temperature (MCT) reaches the set-point. When the bottom fluid temperature exceeds the preset value, the injection from each HSIT is terminated by closing the injection valve [1].

3. Description of MARS-KS Input Model

Figure 1 shows the MARS-KS nodalization of B2.1 test. The input model was developed using SNAP 3.1.1. The core consists of two channels with eleven axial nodes. The 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. The PIPE-230 component corresponds to the channel of heater group of G-1. The HSITs are modeled as the vertical PIPE components with seven volumes. The thermal front tracking model is applied to each volume.

The heat losses from primary and secondary systems to atmosphere are modeled using the general table type of heat transfer coefficient versus temperature. Total heat loss of the primary side is assumed to occur only on the outer surface of the reactor vessel and PZR.

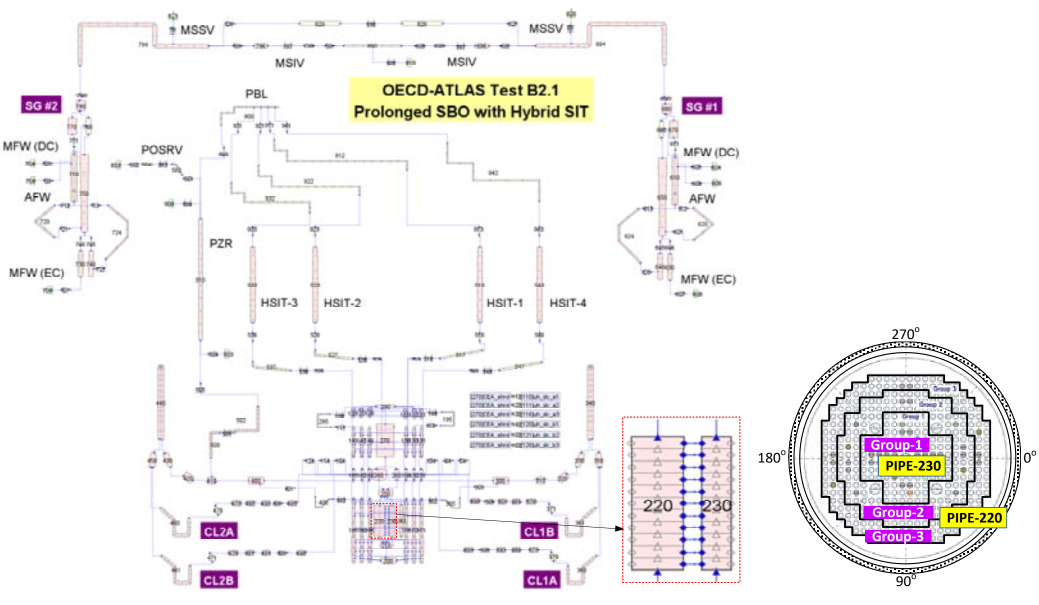

Fig. 1. MARS-KS nodalization of B2.1 test.

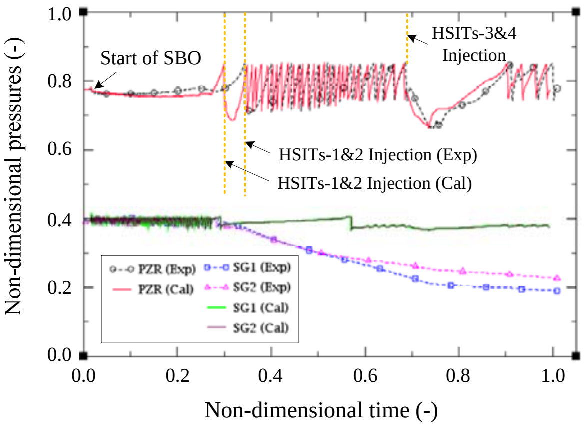

Fig. 2. Primary and secondary system pressures.

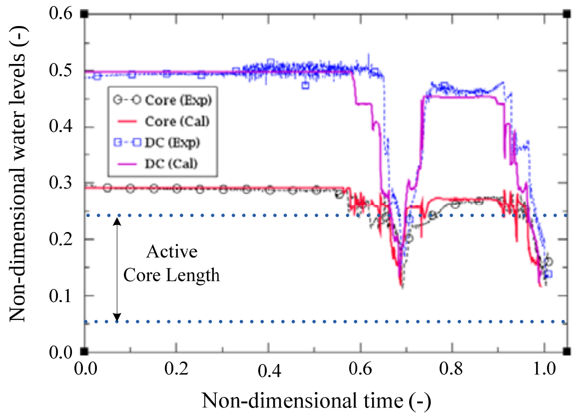

Fig. 4. Collapsed water levels of core and downcomer.

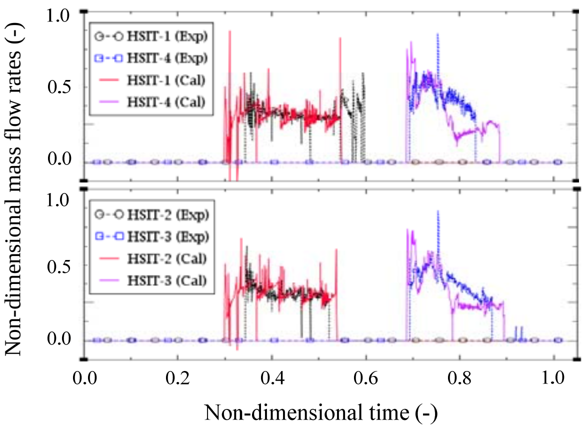

Fig. 3. Injection flow rates of HSITs.

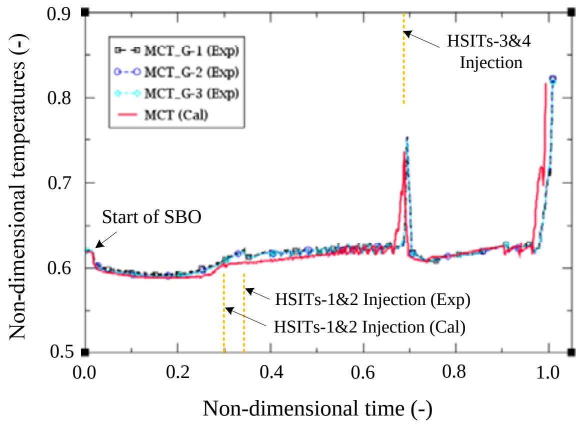

Fig. 5. Maximum cladding temperatures.

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.

With the occurrence of SBO signal, all active components were tripped, the secondary system was completely isolated. The secondary side water inventory was gradually decreased and finally depleted by the open-close hysteresis of main steam safety valves. After the depletion of secondary side water inventory, the primary system pressure increased to the set-points of the opening of POSRV and the injection of HSITs-1&2. After the termination of HSITs-1&2 injection, the continuous decrease in the primary side water inventory induced partial exposure of active core, which results in the safety injection of HSITs-3&4 [1].

Figure 2 compares the predicted primary and secondary pressures with experimental data. The code predicts the primary pressure well except that the rise of primary pressure after the depletion of the secondary side water inventory is faster in the calculation than in the experiment. The code fails to capture the gradual decrease in the secondary pressure by heat loss after non-dimensional time of about 0.3.

Figures 3 shows the injected mass flow rates from the HSITs. The calculation well reproduces the amount of mass flow rates and injection duration. This result shows that the current modeling method can adequately simulate the HSIT behavior.

Figure 4 and 5 show the results of collapsed water level and the maximum cladding temperature (MCT). The core water level was maintained at above the top of the active core during the entire period of HSITs-1&2 injection. The cladding temperature increases sharply with the water level decrease in the core region, and decreases rapidly with the injection of HSITs-3&4. The MTC profile and the level changes at core and downcomer (DC) are well predicted by the code.

5. Conclusions

We assessed the predictable capability of MARS-KS V1.5 using OECD-ATLAS B2.1 test. It is found that the MARS-KS code is able to predict adequately the main thermal-hydraulic phenomena, especially the cool-down performance of HSIT, during the SBO transient.

REFERENCES

[1] S. Cho et al., Test Report on the OECD-ATLAS B2.1 Test: Simulation of a Prolonged Station Blackout (SBO) Transient with Hybrid-SITs of ATLAS32). Rev.00., OECD-ATLAS2-TR-19-01, KAERI, 2019.