SPACE Code Simulation of ATLAS DVI Line Break Accident Test (SB-DVI-08 Test)

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1. Introduction

APR1400 has adopted new safety design features which are 4 mechanically independent DVI (Direct Vessel Injection) systems and fluidic device in the safety injection tanks (SITs). Hence, DVI line break accident has to be evaluated as one of the small break LOCA (SBLOCA) to ensure the safety of APR1400.

KAERI has been performed for DVI line break test (SB-DVI-08) using ATLAS (Advanced Thermal-Hydraulic Test Loop for Accident Simulation) facility which is an integral effect test facility for APR1400. The test result shows that the core collapsed water level decreased before a loop seal clearance, so that a core uncover occurred. At this time, the peak cladding temperature (PCT) is rapidly increased even though the emergency core cooling (ECC) water is injected from safety injection pump (SIP). This test result is useful for supporting safety analysis using thermal hydraulic safety analysis code and increases the understanding of SBLOCA phenomena in APR1400.

The SBLOCA evaluation methodology for APR1400 is now being developed using SPACE code. The object of the development of this methodology is to set up a conservative evaluation methodology in accordance with appendix K of 10 CFR 50. ATLAS SB-DVI-08 test is selected for the evaluation of SBLOCA methodology using SPACE code. Before applying the conservative models and correlations, benchmark calculation of the test is performed with the best-estimate models and correlations to verify SPACE code capability. This paper deals with benchmark calculations results of ATLAS SB-DVI-08 test. Calculation results of the major hydraulics variables are compared with measured data. Finally, this paper carries out the SPACE code performances for simulating the integral effect test of SBLOCA.

2. Calculation Summary

2.1 Major Models and Correlations

One of the major models for simulating the LOCA phenomena is the critical flow model. SPACE code of version 1.41 provides four critical flow models such as Ransom-Trapp (RT) model, Henry-Fauske Moody (HFM) model, homogeneous equilibrium model (HEM) and Henry-Fauske HEM model. One of them, RT model is the best-estimate model for critical flow. In this version of SPACE, however, RT model has a problem when two phase flow is discharged in the break location. Therefore, HFM model is applied in this study. The wall heat transfer correlations, which are provided as the default options are applied in the active core regions.

2.2 Nodalizations

To simulate the SB-DVI-08 test, the nodalization of ATLAS is established based on the RELAP5 input, which is verified in the domestic standard problem (DSP). The nodalization of primary and secondary system is similar to APR1400 plant nodalization. The primary system has 6 downcomer, 2 active cores, 4 cold leg and 2 hot leg. The secondary system has 2 steam generator and 2 steam line. Turbine and main feedwater systems are treated as boundary conditions. The safety system has 3 SIT and 1 SIP considering the single failure assumption. 4 DVI pipe lines are modeled and connected with the upper downcomer. The break system is modeled by TFBC and connected with 1 DVI pipe line.

3. Calculation Results and Discussion

The primary pressure is well predicted with experimental data using the discharge coefficient is 0.85 and Henry-Fauske Moody critical flow model based on the discharge coefficient sensitivity analysis as shown in Fig. 2. Before the loop seal clearance, the decrease of core level is under-predicted with experimental data and RELAP result. In the test, peak cladding temperature (PCT) was observed in this time but SPACE and RELAP cannot predict the PCT at the time.

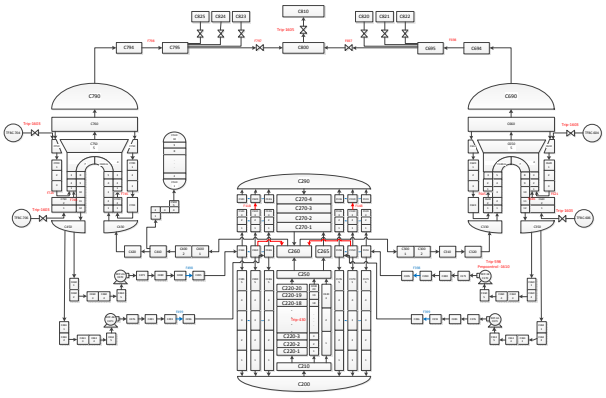

Fig. 1. Nodalization for ATLAS SB-DVI-08 test

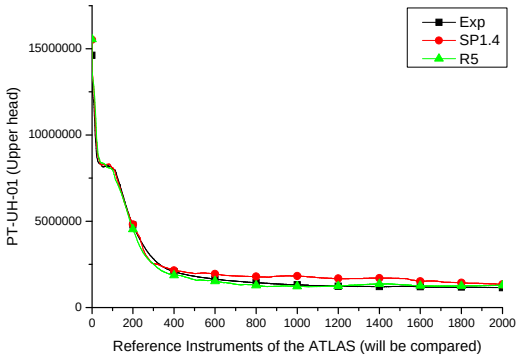

Fig. 2. Comparison of PZR pressure between test data, RELAP and SPACE calculation result

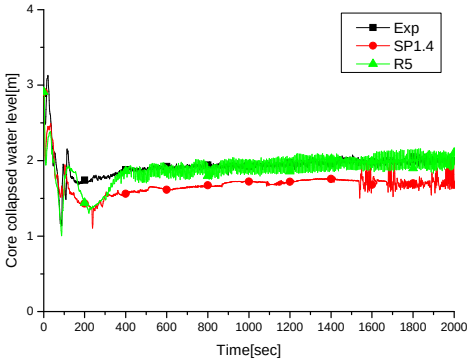

Fig. 3. Comparison of core collapsed water level between test data, RELAP and SPACE calculation result

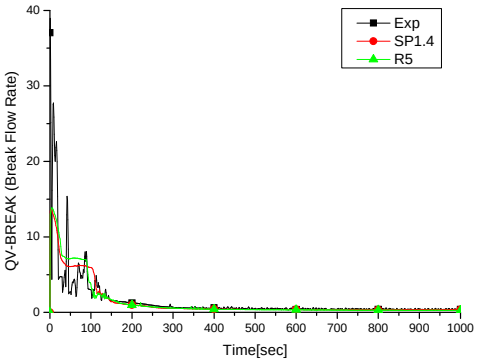

Fig. 4.Comparison of break flow rate between test data, RELAP and SPACE calculation results

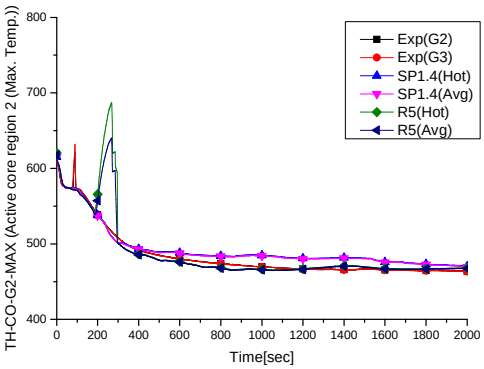

Fig. 5.Comparison of PCT between test data, RELAP and SPACE calculation results

After loop seal clearance, the core pressure starts to decrease because the steam in the U-tubes vents out through the loop seals. At this time, the core level is recovered up to the top of active core. Until the injection of SITs, the core water level is boiled off and decreased. After the initiation of SITs, the core level is recovered again as shown in Fig. 3. In the RELAP calculation, the PCT is predicted in the boil off phase when the active core has a minimum level as shown in Fig. 5. However, SPACE cannot predict the PCT at the boil off phase although SPACE shows a same core level.

3. Conclusions

SPACE code calculation is performed to evaluate the ATLAS DVI line break test using best-estimate methodology with Henry-Fauske Moody critical flow model. SPACE well predicts the major hydraulics variables. However, the tendency of core collapsed water level should be improved during the loop seal clearance and boil off phase. Also, the time step sensitivity analysis and the use of conservative heat transfer correlations have to be considered in future works. In conclusion, this results based on using the best-estimate methodology is useful for developing the conservative evaluation methodology for SBLOCA phenomena of APR1400.

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