Analysis of ATLAS Cold Leg SBLOCA Using SPACE Code

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1. Introduction

SPACE Code has been developed to predict the thermal-hydraulic responses of nuclear steam supply system to the anticipated transients and postulated accidents and adopted advanced physical modeling of two-phase flows, mainly two-fluid, three-field models that comprise gas, continuous liquid, and droplet fields and has the capability to simulate 3D effects by the use of structured and/or non-structured meshes [1].

In this paper, a cold-leg SBLOCA which is the experiment, SB-CL-09, of the ATLAS integral effect test facility during the second domestic stand problem (DSP-02) was analyzed. The results were compared with those of MARS-KS code simulations. The SPACE code with a 1.0 version was released by KHNP in 2012. The analysis has been performed in a desktop PC with Windows 7 environment.

2. Modeling and Results

2.1 ATLAS SPACE Code Model

Figure 1 shows a nodalization diagram of SPACE for ATLAS facility. As shown in the figure, the nodalization diagram is almost identical to the MARS-KS modeling. Some modifications are as follows.

1. The time dependent volume, time dependent junction, single junction, valve components of MARS-KS code are converted the TFBC components in SPACE code.

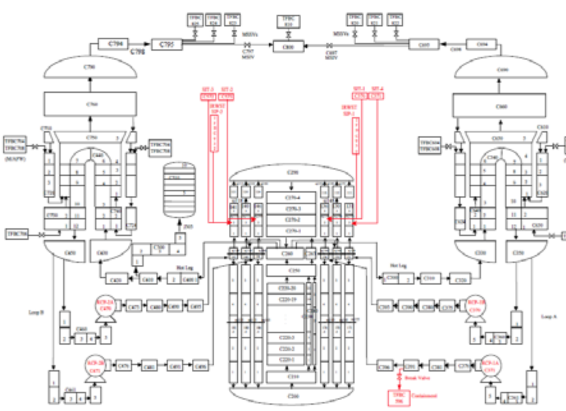

Fig. 1. ATLAS SPACE Nodalization

The SPACE code input deck of ATLAS has been prepared using the steady state MARS-KS input deck provided by KAERI. All initial and boundary conditions as well as the analysis assumptions were determined according to the DSP-02 specifications [2]. The core power used a steady state calculation was applied 8% of the scaled core power of the APR1400. The heat losses were not considered in a code calculation. The core power consists of average channel power and hot channel power. Total core power is produced about a 1.566 MW. As for the conservative core power condition, the ANS73 decay heat curve with a 1.2 multiplication factor was used in the transient calculation. The break system was modeled using a 596 TFBC component and connected to the 391 CELL component which are located in a cold leg 1A. The critical flow model has been selected a Henry-Fauske critical flow model and the discharge coefficient was set to 1.0. Four train Safety Injection Tanks (SITs) and two train Safety Injection Pumps (SIPs) have been modeled using the TFBC and SIT components.

2.2 Steady State Analysis Results

Figure 2 shows the results of a comparison of initial conditions between the SPACE values and the MARS-KS values. The SPACE calculated initial conditions are close to the MARS-KS calculated values for the major parameters.

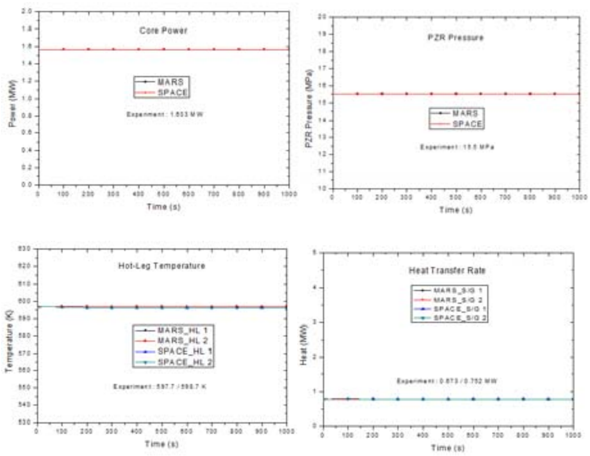

Fig. 2. Comparison of steady state results of SPACE and MARS-KS code

2.3 Transient Analysis Results

A cold-leg 1A SBLOCA was initiated by opening the break valve at 0.0 s after a steady state condition. When the pressurizer pressure decreased and reached to a low pressurizer set pressure of 10.72 MPa, a LPP signal was generated at 26 s. The main steam lines were isolated with a delay of 0.07 seconds. The core power was tripped at 27 with a delay of 0.35 seconds after the LPP signal. The core power was reduced starting from 27 s according to decay power curve. RCP was tripped with the same time. The main feed water was stopped with a 7.07 seconds delay after the LPP signal. The SI pump was started with a 28.28 seconds delay of the LPP signal. When the down-comer pressure became lower than 4.03 MPa, the SIT started to deliver a SI flow through the DVI lines.

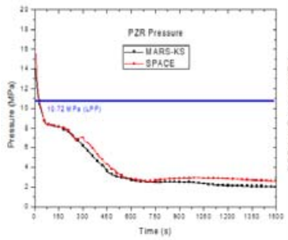

Fig. 3. PZR pressure

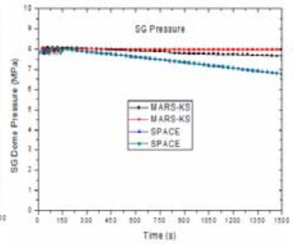

Fig. 4. SG pressure

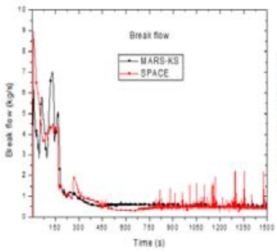

Fig. 5. Break flow

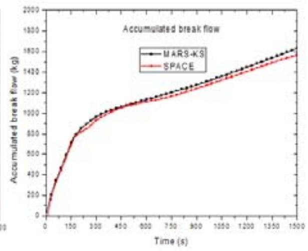

Fig. 6. Accumulated break flow

Figure 3 shows the pressurizer pressure during the transient. After break is occurred, the primary pressure decreases rapidly. And, the decreasing rate of the primary pressure becomes small during the period about from 50 seconds to 200 seconds. Because the loop seal is cleared around 200 seconds in the calculation, the primary pressure is started to decrease after loop seal clearing phenomena is occurred. Figure 4 shows the secondary pressure. The results of SPACE are good predicted compared with those of MARS-KS. The secondary pressure in the MARS-KS calculation decreases slowly than the results of the SPACE code. Overall, the secondary pressure is over-predicted in the MARS-KS calculation during the transient.

Figure 5 shows the comparison of the break flow rates. Before 150 seconds, the results of the SPACE and MARS-KS code do not show good agreement. In the MARS-KS code, the break flow rate shows oscillation but the increment of the accumulated break flow before 150 seconds shows a similarity as shown in Figure 6. After 150 seconds, the accumulated break flow is over-predicted in the MARS-KS calculation compared with that of SPACE calculation during the transient.

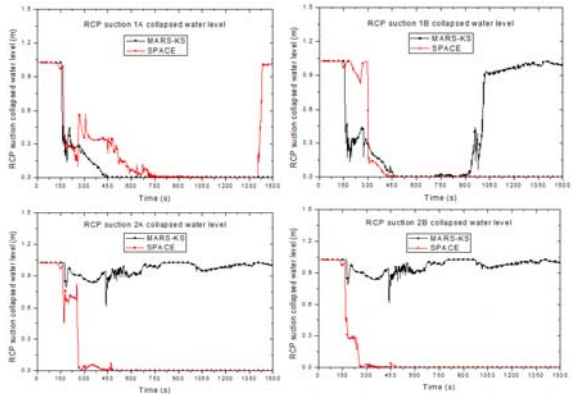

Fig. 7. Loop seal clearing

Figure 7 shows the variation of the collapsed water level of the vertical intermediate legs, which is indicative of the occurrence of a loop seal clearing. Four loop seals of loop 1A, 1B, 2A and 2B are cleared simultaneously at around 200 seconds in the SPACE code. However, in the MARS-KS analysis, two loop seals of loop 1A and 1B are cleared at around 200 seconds at the same time, the other two loop seals of 2A and 2B are maintained with collapsed water level.

3. Conclusions

In this paper, ATLAS 6 inch cold-leg SBLOCA test has been analyzed using the SPACE code. The results of SPACE code calculation were compared with the MARS-KS calculated values. According to the analysis results, the SPACE code predicts the results of MARS-KS calculation reasonably well. However, the several results were different. The secondary pressure by MARS-KS code shows the over-prediction compared with SPACE calculation values. The core water level was affected by the down-comer water level and differential pressure between the core and the down-comer. The PCT shows a different trend.

Acknowledgement

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REFERENCES

[1] Sang-Jun Ha, chan-eok Park, Kyung-doo Kim, Chang-Hwan Ban, Development of the SPACE Code for Nuclear Power Plants, Nuclear Engineering and Technology, Sep. 10, 2010.
[2] ATLAS Domestic Standard Problem (DSP-02) Specifications, KAERI, 2010.