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MARS-KS Calculations for ATLAS 6-inch Cold Leg Break Test (DSP-02)

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1. Introduction

An integral effect test on the SBLOCA (Small-Break Loss of Coolant Accident) aiming at 6-inch cold leg bottom break, SB-CL-09, was conducted with the ATLAS on November 13, 2009 by KAERI. The 6-inch cold leg SBLOCA test was selected for the second domestic standard problem (DSP-02) in 2010 to enhance the understanding on the behavior of nuclear reactor systems with the DVI and to assess existing and new thermal-hydraulic analysis codes such as MARS, TRACE, RELAP, and so on. In this study, the calculations and analysis using MARS-KS V1.2 code were conducted for this 6-inch cold leg break test.

2. Modeling Information

The modeling of ATLAS facility was based on the steady state input deck which was provided by KAERI. On the basis of that, some additions and modifications were made.

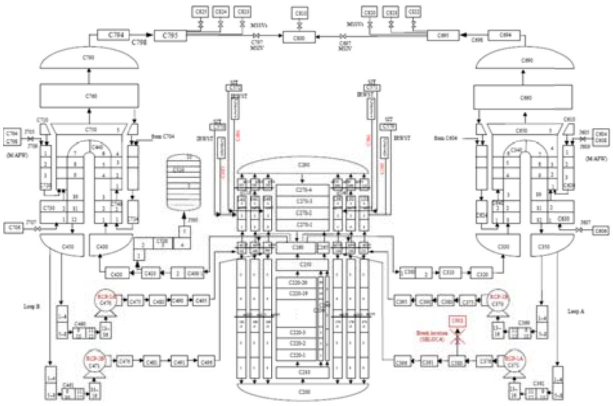

Fig. 1. MARS-KS Nodalization for ATLAS 6-inch cold leg break test

The break system was simply modeled using one SNGLJUN and TMDPVOL component. The default critical flow model of MARS, Henry-Fauske model was employed in SNGLJUN component. Through sensitivity studies, discharge coefficient (Cd) and thermal non-equilibrium factor (Neq) were set to 0.8 and 0.2, respectively as the optimal values. The Final MARS-KS nodalization applying some additions and modifications are shown in Fig. 1.

3. Steady State Analysis Results

The steady state was determined by conducting a null transient calculation and the steady state calculation results which are the initial conditions of 6-inch cold leg break test are shown in Table 1.

Table 1. Steady State Calculation Results

Parameter	Exp.	Cal.	Error (%)
Primary system			
- Core power (MW)	1.633	1.6326	-0.02
- PRZ pressure (MPa)	15.5	15.5	0.0
- Hot leg temp. (K)	597.7/598.7	596.0/596.0	-0.28/-0.45
- Cold leg temp. (K)	565.4/565.5 564.2/565.3	562.9/562.9 562.9/562.9	-0.45/-0.47 -0.23/-0.42
- RCS flow rate (kg/s)	2.02/1.84 1.89/1.97	2.09/2.08 2.08/2.09	3.59/13.0 9.95/6.16
- Pressurizer level (m)	3.83	3.86	0.67
Secondary system			
- Steam-dome pressure (MPa)	7.82/7.82	7.81/7.81	-0.18/-0.18
- FW flow to economizer (kg/s)	0.373/0.382	0.401/0.403	7.39/5.44
- FW flow to downcomer (kg/s)	0.044/0.042	0.044/0.042	0.0/0.0
- Circulation ratio	9.74/9.67	9.49/9.47	-2.59/-2.08
- Heat removal (MW)	0.673/0.752	0.784/0.783	16.49/4.07
ECCS			
- SIT pressure (MPa)	4.24/4.15 4.01/4.17	4.24/4.15 4.01/4.17	0.0/0.0 0.0/0.0
- SIT level (m)	5.28/5.32 5.32/5.32	5.28/5.32 5.32/5.32	0.0/0.0 0.0/0.0

4. Transient Analysis Results

In experiment, after initial steady-state conditions were reached, the test was initiated by opening a break simulation valve at 204 seconds, and transient calculation was also conducted with setting up 204 seconds as an initial time. The predicted sequence of events is compared with that of experiment as shown in Table 2.

Table 2. Sequence of Events

Event	Exp. (sec)	Cal.(sec)
Break	204	204
Low PRZ Pressure Trip	228	227 (-1)
Core Power Decay	236	236
Main Steam Isolation	228	227 (-1)
Main Feedwater Isolation	238	235 (-3)
Safety Injection Pump	257	256 (-1)
Loop Seal Clearing (time)	398	398
LSC (location)	1A, 2B	1A
Safety Injection Tank	649	680 (+31)
Peak Clad. Temp.	204	204

The predicted pressurizer pressure agrees relatively well with the experimental data as shown in Fig. 2. However, in 400~700 seconds, the calculated value is slightly higher than measured. This is the reason that SIT injection time is quite different from that of test as shown in Table 2.

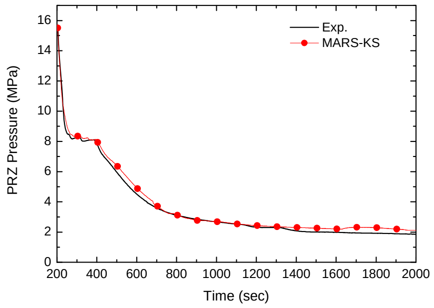

Fig. 2. Pressurizer Pressure

Figure 3 shows the break flow rate of the experiment and MARS-KS calculation. As mentioned previously, sensitivity studies were performed to find the optimal discharge coefficient and thermal non-equilibrium factor. The predicted break flow rate is in good agreement with experiment. However, code slightly under-estimates the break flow rate from 700 to 1200 seconds.

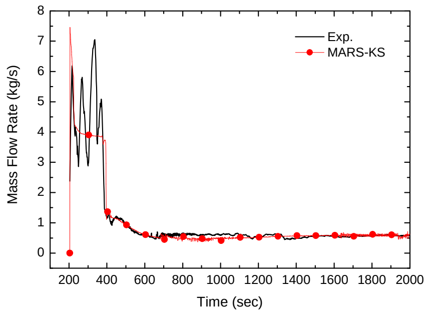

Fig. 3. Break Flow Rate

The predicted core collapsed liquid level is compared with the experiment as shown in Fig. 4. In MARS-KS calculation, the decrease of collapsed water level is predicted well in blowdown phase, but just before LSC, water level is higher than experiment. However, the sudden decrease and increase of water level at the LSC are predicted qualitatively. After LSC, there is another water level dip at SIT injection time which is not in experiment. And then, it maintains the certain level which is higher than experiment.

Figure 5 shows the measured heater rod surface temperature and predicted one. Peak cladding temperature occurs at the beginning of the transient both experiment and calculation. Predicted cladding temperature generally agrees well with the experiment, while there is peak at SIT injection time in calculation which is not in experiment. This peak prediction of cladding temperature is directly related to core collapsed water level at SIT injection time. The core collapsed liquid level decreases up to 1.2 m at SIT injection time and then, core is rapidly recovered with water as shown in Fig. 4.

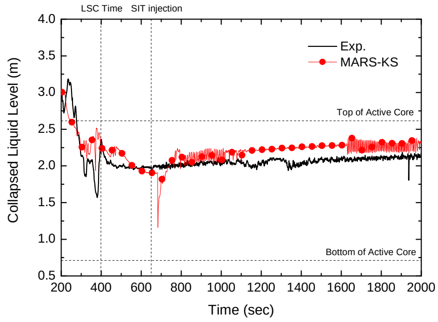

Fig. 4. Core Collapsed Liquid Level

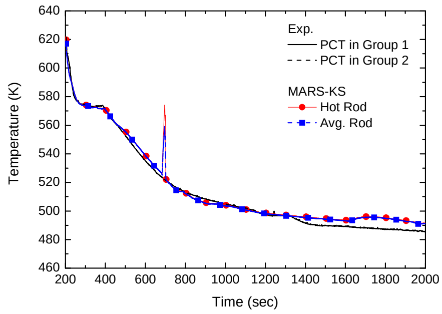

Fig. 5. Heater Rod Surface Temperature

5. Conclusion

In this study, the calculations and analysis using MARS-KS V1.2 code were performed for ATLAS 6-inch cold leg break test, DSP-02. ATLAS facility was adequately modeled, and the steady state results obtained by conducting a null transient calculation were in good agreement with experimental data. For transient calculation, while the prediction of core water level and location of loop seal clearing shows some discrepancies, MARS-KS could predict the sequence of events and the major thermal-hydraulic parameters of the test with a reasonable agreement.

Acknowledgement

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REFERENCES

[1] KAERI, 6 inch Cold Leg SBLOCA Simulation Test (SB-CL-09) Report using the ATLAS, 2010.
[2] KAERI, Detailed Description Report of ATLAS Facility and Instrumentation, KAERI/TR-4184, 2010.