Analysis of ATLAS 6-inch cold leg break simulation with MARS-KS code

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1. Introduction

A Domestic Standard Problem (DSP) exercise using ATLAS facility has been organized by KAERI. As the second DSP exercise, the 6-inch cold leg bottom break was determined. This experiment is the counterpart test to the DVI line break to verify the safety performance of the DVI method over the traditional CLI method [1]. Compared with the large break LOCA, the phases of the small break LOCA prior to core recovery occur over a long period. The blowdown, natural circulation, loop seal clearance, boil-off, and core recovery phase should be investigated minutely with relevant models of safety analysis codes in order to predict these thermal hydraulic phenomena correctly. To investigate the ECC bypass phenomena, a finer study on the thermal-hydraulic behavior in upper annulus downcomer was carried out.

2. Analysis Models and Results

2.1 Analysis conditions and methods

For the calculation, the thermo-hydraulic safety analysis code, MARS-KS 3.1 is used [2]. The nodalization diagram of the provided steady-state input deck for ATLAS is depicted in Figure 1.

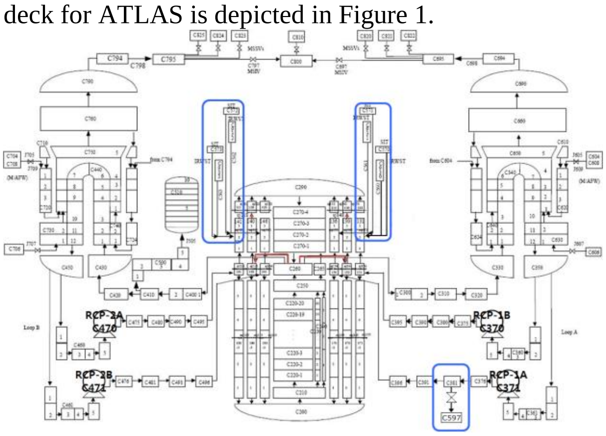

Fig. 1 Nodalization diagram of the ATLAS

To analyze 6-inch cold leg break accident, a break pipe line, SITs, SIP and IRWST were modeled. The provided steady-state model for the 8% power condition of ATLAS facility was adopted and additional safety-related components are modeled according to the given description of test facility tabulated in Table 1. For bypass model, the downcomer to upper head bypass and the downcomer to upper head bypasses were modeled with several pipe components. The break flow simulation is modeled as shown in Figure 2.

Table 1 Summary of the break model

				Area	Length	Volume	Hydraulic di	incl_angle	elevation	k_f	k_r
575	**sngljun**	entrance		0.000E+00	-	-	3.810E-02	-	-	0.5	1.0
576	**pipe**		1	5.067E-04	0.2992	1.516E-04	2.540E-02	**-90.0**	**-0.299**	0.63	0.63
			2	5.067E-04	0.485	2.458E-04	2.540E-02	0.0	0.0		
577	**sngljun**			0.000E+00	-	-	2.540E-02	-	-	AAC	
578	**pipe**	nozzle1		**8.958E-05**	**0.128**	**1.148E-05**	**1.068E-02**	**0.0**	**0.0**		
579	**sngljun**			0.000E+00	-	-	3.810E-02	-	-	AAC	
580	**pipe**		1	**1.140E-03**	**0.466**	**5.311E-04**	**3.810E-02**	0.0	0	0.63	0.63
			2	1.140E-03	0.59	6.727E-04	3.810E-02	**-90.0**	**-0.59**	0.63	0.63
			3	**1.140E-03**	**0.56**	**6.385E-04**	**3.810E-02**	0.0	0		
581	**valve**			0.000E+00	-	-	3.810E-02	-	-	0.54	0.54
597		Containment		**1.598E+00**	**3.38**	**5.400E+00**	**1.426E+00**	-90	-3.38		

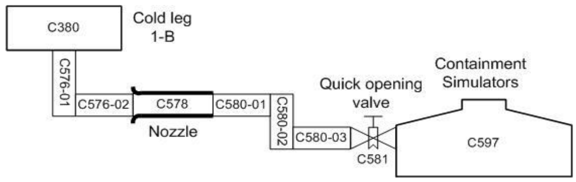

Fig. 2 Schematics of model of break simulation system

The transient behavior of the RCS pressure was simulated with MARS as depicted in Figure 3. The RCS primary side rapidly depressurized until the hot coolant began to flash into steam. The reactor and the RCP trips and SG secondary isolation were initiated at 236s. As a result, the SG secondary side pressure increased up to the main steam safety valve set-point, and steam was released through the MSSV. The rapid depressurization ended when the pressure decrease to just above the saturation pressure of the SG secondary side.

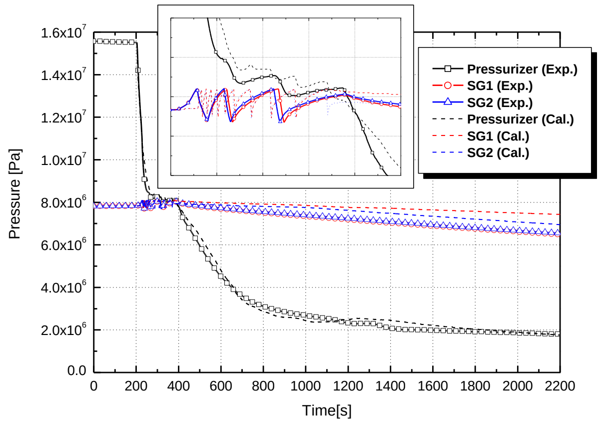

Fig. 3 Transient pressure behavior in reactor coolant system

The initial peak of the break mass flowrate is overestimated in calculation when compared to the measured data. However, the general trends of mass flowrate of break agree well with measured data as shown in Figure 4. When compared to the experimental data, the PCT behavior is well predicted in the simulation except two slight peaks (380, 560 s) as presented in Figure 5.

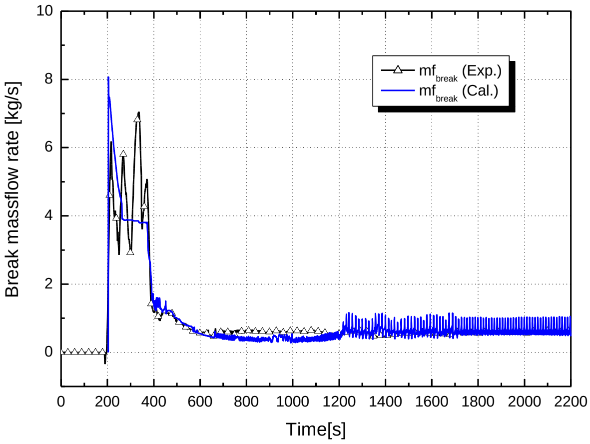

Fig. 4 Mass flowrate at break pipe

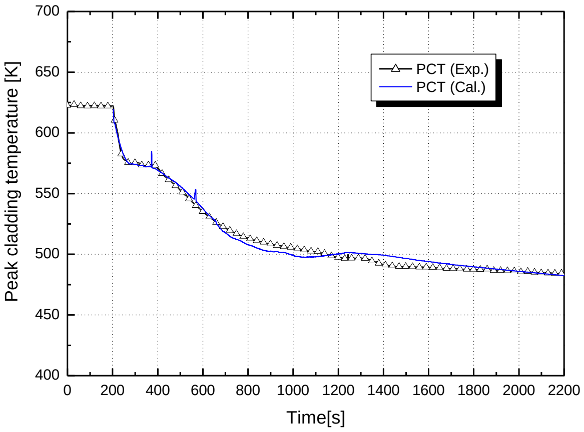

Fig. 5 Comparison of peak cladding temperature

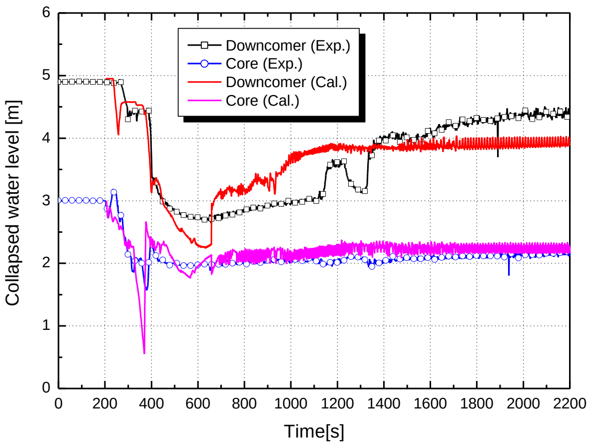

Fig. 6 Collapsed water levels in core and downcomer

The peaks of PCT are mainly due to the core uncovery as one can note in the figure of core collapsed water level of Figure 6. The loop seal clearing phenomena are shown in Figure 7. In the broken leg and its opposite-positioned leg, loop seal is cleared in calculation while loop seal cleared in the broken and its neighbored leg in the measurement. After the loop seal clearing, a continuous decrease of collapsed water level in downcomer and a recover of core collapsed level are found similarly in calculation and measurement.

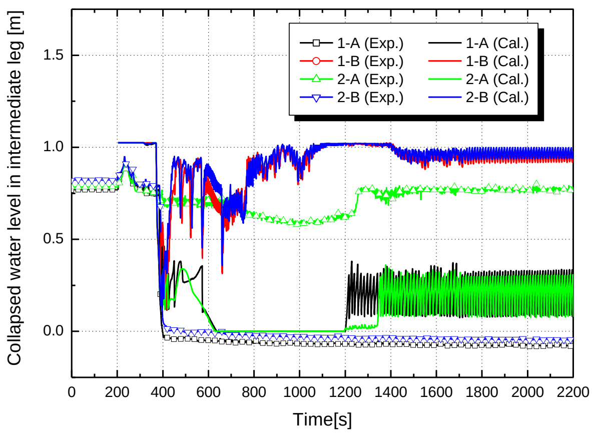

Fig. 7 Loop seal clearing phenomena in intermediate leg

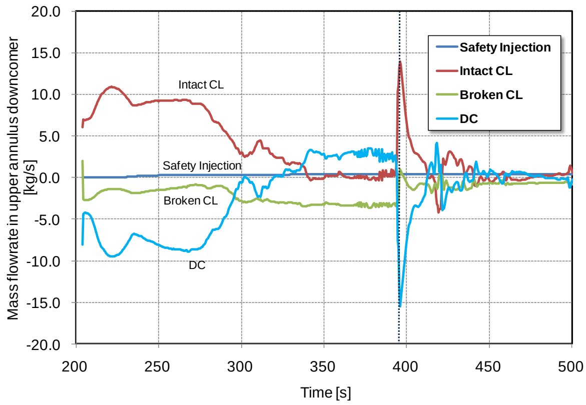

Fig. 8 Transient mass flow behavior in upper DC

Before the occurrence of loop seal clearing, the ECC bypass to the broken cold leg is negligible as depicted in Figure 8.

3. Conclusions

The transient analyses for 6-inch cold leg break were carried out with MARS-KS code. The general behaviors of the major thermo-hydraulic parameters show good agreement with the measured data. However, the sequence of the loop seal clearance should be reconsidered. The ECC bypass isn't considered the critical phenomena. An investigation on the inventory redistribution in DC and core is needed for a future work.

ACKNOWLEDGEMENT

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REFERENCES

[1] 6 inch Cold Leg SBLOCA Simulation Test (SB-CL-09) Report using the ATLAS, KAERI, 2010
[2] Korea Institute of Nuclear Safety, Expert training course for the regulatory auditing safety analysis, KINS/TR-143, 2007