MARS Code Assessment of Main Steam Line Break Accident in ATLAS

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1. Introduction

At the end of last year, as Main Steam Line Break (MSLB) accident was postulated at Domestic Standard Problem-03 (DSP-03) using Advanced Thermal-Hydraulic Test Loop for Accident Simulation (ATLAS) whose reference reactor is APR1400, SLB-GB-02T test which is the experiment for the MSLB accident was carried out by Korea Atomic Energy Research Institute (KAERI) in the ATLAS [1]. By the experimental data obtained, the verification for thermal-hydraulic safety of the ARP1400 is being required in cooperation with the appropriate code. Accordingly, in this study, one-dimensional analysis was performed using MARS KS 1.2 code to assess the accuracy of the code comparison with the measured data and to contribute to establishing the safety analysis methodology for the MSLB accident.

1.1 MSLB accident

MSLB is a double-ended guillotine break accident of the main steam line between head of the steam generator and Main Steam Isolation Valve (MSIV). When the MSLB accident occurs, the pressure of the secondary side decreases rapidly. Sudden pressure drop leads to excessive heat transfer from primary side to secondary side related with instantaneous increased flow rate of Main Feed Water (MFW). As a result, temperature and pressure of the primary side decrease sharply so then reactivity of core increase due to negative moderator temperature coefficient. But the reactivity effect was not considered in this experiment because once shutdown of the ATLAS occurs after a few seconds following the MSLB, then decay heat starts.

2. Transient Modeling

All initial conditions of the experiment are made up on the base of 8% power of APR1400 and scaled down except for core temperature rise. Furthermore, the experiment allows some conservative conditions including Reactor Cooling Pump (RCP) trip and only two operable Safety Injection Pump (SIP) numbered 1 and 3. Main initial conditions are shown in the table 1.

Table 1. Main initial conditions [1]

Design parameter	Exp.	Code
Primary system		
Normal Power (MW)	1.56	1.56
Pressurizer Pressure (MPa)	15.5	15.5133
Pressurizer Level (m)	3.8	3.5883
Core Inlet Temp. (℃)	290.1	293.49
Core outlet Temp. (℃)	293.9	297.78
Cold leg flow rate (kg/s)	16.4	17.261
Secondary system		
Steam Flow Rate (kg/s)	0.444	0.44384
Feed Water Flow Rate (kg/s)	0.444	0.44384
Steam Pressure (MPa)	7.335	7.828
Steam Temp. (℃)	288.8	293.61

After MSLB accident occurs, under the assumption that the fracture area is maintained in the same way from beginning to end, trip type valve was used as alternative for the fracture area. As shown in the table 2, to retain validity about the experiment, all accident sequences have been set to have passive connection except for MLSB and MFIS which occurs at the same time with MLSB. In additional, Auxiliary Feed Water Actuation Signal (AFAS) occurs when the water level of the steam generator is lower than 2.78 m.

3. Results

Table 2. The accident sequence

Event	Exp.	Code	Remarks
	Time (sec)		
Break Open	303	303	
LSGP (Rx trip)	310	311	Steam dome < 6.11MPa
RCP trip	311	312	LSGP trip + 1.0s
MSIS	315	314	LSGP trip +3.54
MFIS	303	303	Coincident with the break
Decay power start	322	323	LSGP trip + 12.07s
LPP	476	548	Pressurizer < 10.7244 MPa
SIP	505	576	LPP + 28.28s
LSGWL	320 / 317	310 / 310	SGRSWL < 2.78 m
AF injection start	364 / 361	353 / 353	LSGWL + 43.45s

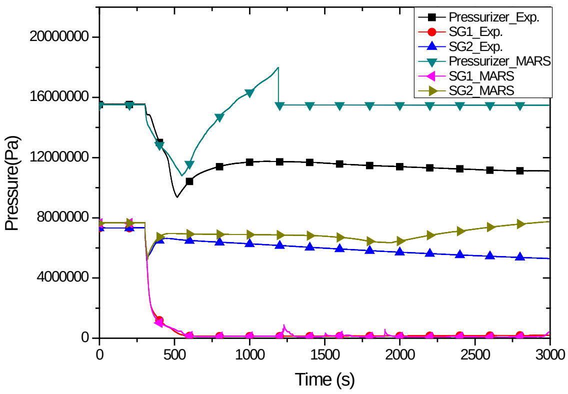

Fig. 1 Pressure of Pressurizer, SG1 and SG2

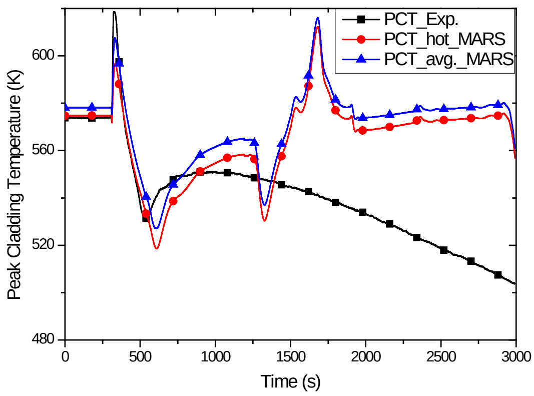

Fig. 2 Peak Cladding Temperature

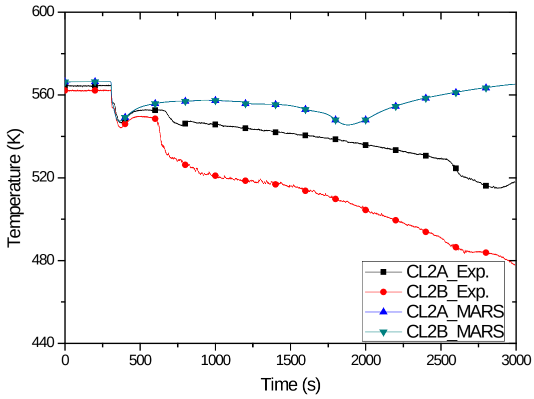

Fig. 3 Cold Leg Temperature of Intact SG

The time sequence of each event for the MARS code comparison with the experiment is shown in the Table 2. Totally, the time sequence of the MARS code accords with the experiment except for LPP and LSGWL.

First of all, LPP occurred about 72 seconds later than the time of the experiment. Also, considerable difference of pressure occurred at the pressurizer due to failure for pressure control after safety injection. It is shown that the pressure change as the water level change is not considered in this modeling. (Fig. 1)

Secondly, LSGWL occurred about 10 seconds faster than the time of the experiment because more flow rate loss had existed in MARS code after the MSLB accident.

Thirdly, Peak Cladding Temperature (PCT) was lower than the experimental value of about 6 K and 3 K in case of the averaged channel and the hot channel respectively. It shows that the PCT was underestimated in the MARS code. (Fig. 2)

Lastly, the temperature difference between the cold legs (CL2A, CL2B) of the intact steam generator shown in the experiment does not appear in the code. It is considered that three-dimensional effect by DVI nozzles which have the difference position in azimuth of 90 degrees in each does not affect in one-dimensional modeling. (Fig. 3)

4. Conclusions

In this study, MARS code assessment was done by using the experimental data for the MSLB accident in ATLAS. Even though approximate trend was consistent, on the whole, it shows low quality from a quantitative point of view. In additional, no temperature discrepancy of the cold leg along the direction of the safety injection was not shown in the MARS code because of limitation of the one-dimensional modeling.

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