Thermal-Hydraulic Behavior of the ATLAS Facility during 5% DVI Line Break

Ki-Yong Choi*, Seok Cho, Hyun-Sik Park, Kyoung-Ho Kang, Nam-Hyun Choi, Yeon-Sik Kim, Won-Pil Baek
Korea Atomic Energy Research Institute, (150-1 Deokjin-dong) 1045 Daedeokdaero, Yuseong, Daejeon, 305-353, Korea, Tel:+82-42-868-8928, Fax:+82-42-861-6438, E-mail:kychoi@kaeri.re.kr

1. Introduction

A series of DVI line break tests were performed with the ATLAS facility in order to investigate integral thermal-hydraulic behavior of the APR1400. Tests for four break sizes were completed: 100%, 50%, 25%, and 5% [1, 2]. Among them, this paper presents experimental results of the 5% DVI line break. A post-test calculation was also performed with the MARS 3.1 code in order to evaluate the code's modeling capabilities.

2. Experimental Procedure

The experimental conditions for the DVI line break tests are determined by a pre-test calculation with a best-estimate thermal hydraulic code, MARS3.1. Based on the calculated sequence of events of the DVI line break for the APR1400, the initial and boundary conditions for the present integral effect test are determined. The loss of off-site power simultaneously with the break and the worst single failure as a loss of a diesel generator were assumed, resulting in the minimum safety injection flow to the core. As for the core power, a conservative 1973 ANS decay heat curve with a 1.2 multiplication factor will be used in the transient calculation. The containment back-pressure was maintained at atmospheric conditions. The break nozzle area was scaled down according to the scaling ratio of 1/203.6. The inner diameter of the break nozzle was 3.41mm.

Table 1 Major sequence of events for the present test

Event	Time (sec)	Remarks
Break open	202	
LPP	400	P<10.7214 MPa
Main steam isolation	401	LPP+0.07 sec
Main feed isolation	408	LPP+7.07 sec
Decay power start	380	Table control
SIP	428	LPP+28.28 sec
1^{st} loop seal clearing	8238	Loop 1B only
2^{nd} loop seal clearing	10385	Loop 1B only
SIT	-	Not actuated
Stop	10880	

. 3. Major Test and Analysis Results

3.1 Major sequence of events

The detailed sequence of events observed during the present test is summarized in Table 1. The transient started at 202 seconds. The primary pressure reached a low pressurizer pressure set point (LPP) at 400 seconds. The main steam and feedwater lines were isolated after the LPP signal with specified delay times. The SIP was actuated after the LPP with a time delay of 28.28 seconds. The SITs were not activated during the present test period because the primary pressure did not decrease down to the set point, 4.03MPa.

3.2 Major thermal-hydraulic behavior

Due to small break size, an increase in the PCT was not observed. Figure 1 compares the measured PCT with the calculated one. Overall, the predicted PCT by the MARS code is very close to the measured value.

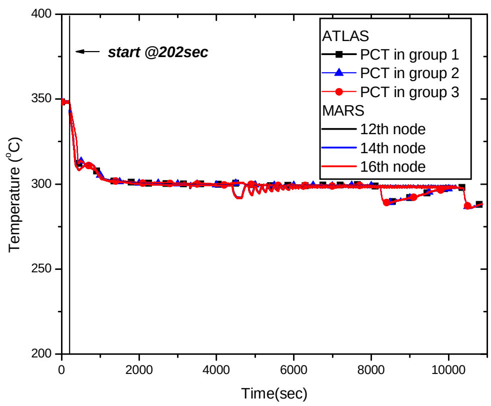

Fig.1 Comparison of the measured PCT behavior

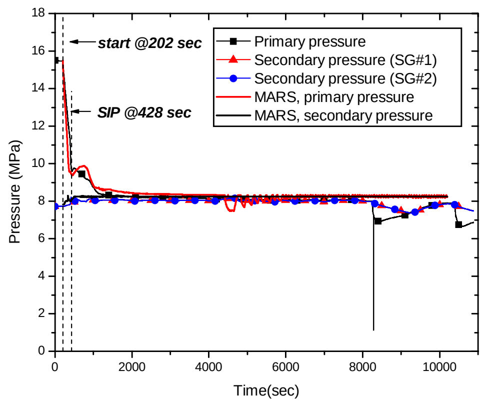

Fig.2 Comparison of the 1^{st} and 2^{nd} pressures

Figure 2 shows the measured primary and secondary pressure during the test. The calculated values are also plotted for comparison. The discharge coefficient of C_d=0.75 at the break nozzle was used because this value resulted in the best agreement with the measured primary pressure. The MARS code predicts the 1^{st} and 2^{nd} pressures with great accuracy.

Comparison of an accumulated mass balance during the present test is plotted in Fig.3. Accumulated break flow and ECC flow are compared with the calculation results. The predicted value of the ECC flow rate shows excellent agreement with the measured one. As for the break flow, the MARS code predicts a higher break flow than the measured one.

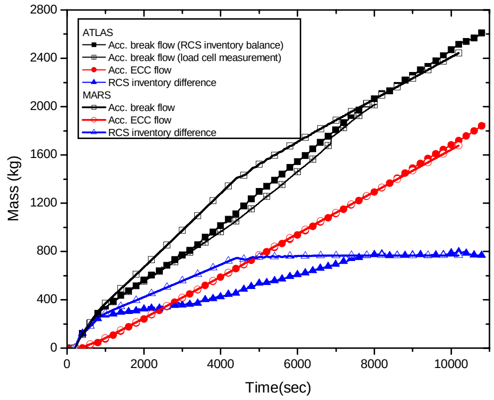

Fig.3 Comparison of the accumulated mass balance

A comparison of the collapsed water level of the core and downcomer with the calculation results are shown in Figs.4 and 5, respectively. Overall, the agreements are reasonable, but the MARS code shows an oscillatory behavior after about 4500 seconds.

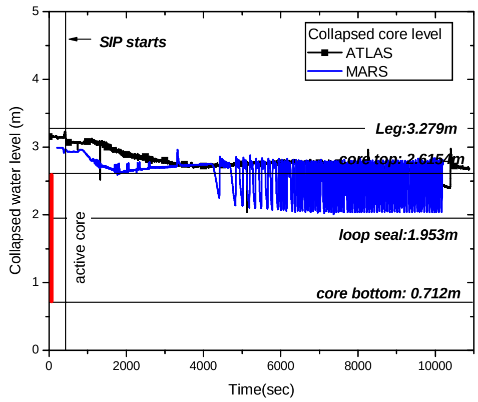

Fig.4 Comparison of the collapsed core level

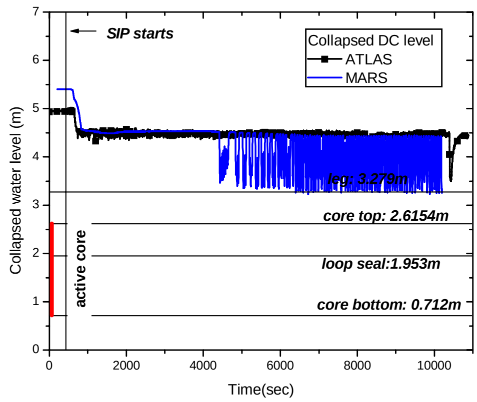

Fig.5 Comparison of the collapsed downcomer level

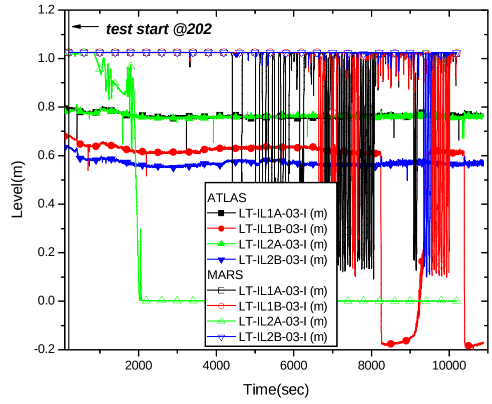

Fig.6 Comparison of the collapsed water level in the vertical intermediate legs

As summarized in Table 1, the loop seal clearing was observed two times only at the loop 1B during the present test. After the intermediate loop was cleared, it was filled again with water inventory repeatedly. However the code predicts much earlier loop seal clearing than measured value. Once the loop 2A is cleared, it remains at the cleared condition. Whereas, the other loop seals shows great oscillations during the remaining test period, which is the main cause of the oscillation in the collapsed water level in the core and the downcomer. In conclusion, the MARS code predicts the overall thermal hydraulic phenomena with reasonable accuracy, but its prediction of the loop seal clearing phenomena needs more improvement.

4. Conclusions

This paper describes the experimental results of the 5% DVI line break test with the ATLAS. An entire scenario of the postulated scenario was simulated successfully. The MARS code revealed reasonable prediction results for the present data. However, it predicted much earlier loop seal clearing and oscillatory behavior in the vertical loop seal piping in the other un-cleared loop seal. It resulted in the oscillation in the collapsed water level in the core and downcomer. This obtained integral effect data will be used for extending our physical understanding for the small break at the DVI nozzle and for verifying safety analysis codes.

REFERENCES

[1] K.Y. Choi et al., "Integral Effect Simulation of a 25% Direct Vessel Injection Line Break with the ATLAS," 6th Japan-Korea Symposium on Nuclear Thermal Hydraulics and Safety, Okinawa, Japan, Nov. 24-27, 2008.

[2] K.Y. Choi et al., "Experimental Simulation of a Direct Vessel Injection Line Break of the APR1400 with the ATLAS," Nuclear Engineering and Technology, V.41, No.5, 2009.