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Blind Calculation Result of DSP-05 Activity

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1. Introduction

A domestic collaboration program utilizing ATLAS [1] was first started in 2009 and it was named as domestic standard problem exercise, DSP. The DSP activities have contributed to improve the technical methodology utilizing safety analysis code and to establish a human network among nuclear safety experts in Korea.

The 5th DSP was launched in 2018 with the experimental scenario of multiple steam generator tube rupture (MSGTR) accident under the passive auxiliary feedwater system (PAFS) operation condition.

14 organizations have participated in the 5th DSP as listed in Table-1 utilizing independently selected safety analysis code. Up to now, only the blind calculations have been made by each participant. In the blind calculation phase, only initial and boundary conditions of selected experimental scenario were provided by the operating organization, KAERI. After finalizing the blind calculation step, the test data was provided to participants and they are now processing the open calculation.

In this paper, the blind analysis result of participants will be discussed with brief explanation of the experimental scenario. Considering the confidential problem of test data, all of the test results in this paper were normalized by an arbitrary value including the time frame.

Table I: Participants of DSP-05 with codes they used

Participants	Code used
DOOSAN	RELAP5 MOD3.3 Patch4
EN2T-A	MARS-KS 1.5
EN2T-B	TRACE V5 patch4 / SNAP 2.4.1
FNC	SPACE 3.2
INU	MARS-KS 1.5
KAIST	MARS-KS 1.5
KAERI	SPACE 3.2
KHNP-A	SPACE 3.2
KHNP-B	MARS-KS 1.4
KINS	MARS-KS 1.5
KNF	SPACE 3.12
PNU	MARS-KS 1.5
SENTECH	MARS-KS 1.4
UNIST	MARS-KS 1.5

2. Test Scenario and Conditions

The target scenario of DSP-05 is the experimental scenario of multiple steam generator tube rupture (MSGTR) accident under the passive auxiliary feedwater system (PAFS) operation condition. The sequence of major event is shown in Table-2. The initial and boundary conditions for the present test were obtained by applying the scaling ratios to the MARS-KS calculation results for APR1400.

Table II: Sequence of events

Description	Remark(Set-point)
SGTR initiation	OV-BS-04 Open
RCP trip	Coincidence with break
PRZ heater off	LT-PZR-01 < 1.2 m
HSGL signal	SG-1 level > 5.05 m
Reactor trip	Coincidence with HSGL
Decay Power	Reactor trip + 12.07 sec delay
MSCV close	Coincidence with HSGL
MFIV close	Coincidence with HSGL
MSIV1/2 close	Coincidence with HSGL
MSSV operation	7.7 MPa < PT-SGSD1/2-01 < 8.1 MPa
SIP injection	PT-PZR-01 < 10.72 MPa + 28.28 s delay
PAFS actuation	SG-2 wide level<25 % (2.78 m)
SIT injection	PT-PZR-01 < 4.03 MPa

The detailed description of the test condition, procedure and results can be found in literature. [2]

3. Evaluation of Blind Calculation result

14 participants submitted their blind calculation results to KAERI and they were compared each other quantitatively. A total of 58 thermal-hydraulic parameters were requested as submission data.

The whole test period were divided into three phases. They are initial steady state, transient after break valve opening and before PAFS operation, transient after PAFS operation.

3.1 Steady State Calculation Result Evaluation

Steady state results can be quantified by using the quantification of Q_A. At first, the acceptable errors (AE) for the quantification process were determined. Taking into account the measurement uncertainties, different AEs from 0.25% to 30% were used depending on parameters. The percentile error, E was defined as the ratio

$$E = \frac{|(\exp value \pm \exp error) - calc\ value|}{|(\exp value \pm \exp error)|}$$

Then, the single acceptability factor, Qi was obtained by the following formula:

$$Q_i = \frac{E}{AE} \cdot W_i$$

And, finally, the global acceptability factor, Q_B can be obtained by summing the whole single acceptability factors,

$$Q_B = \sum_i Q_i$$

The 17 parameters among submitted blind calculation results are evaluated according this method and the total Q_B is compared between participants as shown in Figure 1. Most of participants had result that showed good agreement with the experiment initial steady state condition. Two participants of KAERI and KHNP-A showed higher primary system coolant temperature than the experimental result.

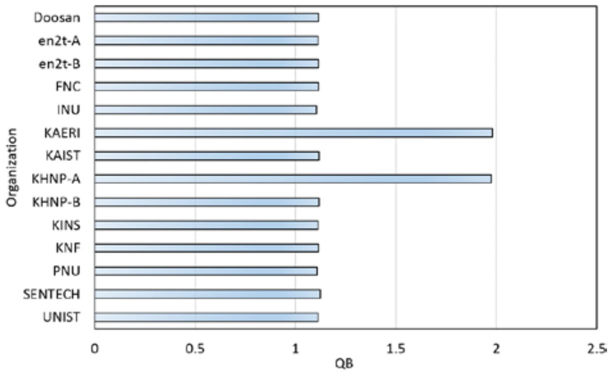

Fig. 1. Steady state quantification results

2.2 Transient Calculation Result Evaluation

The transient calculation result was evaluated in the three kinds of time period. They are the whole transient period, the time interval from break valve opening to PAFS operation, and the time after PAFS operation.

To quantitatively evaluate the accuracy of transient calculation result, the Fast Fourier Transform Based Method (FFTBM) which was proposed by Prof. F. D'Auria [3] was utilized. The overall accuracy of a code calculation result can be obtained by defining average performance indices, total weighted AA and total WF. The accuracy of a calculation result can be characterized by the following criteria:

AA < 0.3	: very good prediction
0.3 < AA < 0.5	: good prediction
0.5 < AA < 0.7	: poor prediction
AA > 0.7	: very poor prediction

A total of 58 thermal-hydraulic parameters were evaluated and the result is shown in Table IV.

The thermal hydraulic phenomena in the system before and after PAFS operation is significantly different. Because all participants could not predict properly the PAFS actuation time, the AA values for the whole transient were relatively large.

Table IV: AA values from FFTBM analysis

Participant	From transient start to PAFS operation	After PAFS operation	Whole transient
DOOSAN	1.634	0.287	0.751
EN2T-A	0.341	0.246	0.341
EN2T-B	0.739	0.493	0.487
FNC	0.325	0.292	0.452
INU	1.042	0.253	0.365
KAIST	0.3	0.242	0.291
KAERI	2.561	0.718	0.797
KHNP-A	0.21	0.266	0.43
KHNP-B	1.1	0.19	0.521
KINS	0.644	0.271	0.47
KNF	0.53	0.253	0.469
PNU	0.277	19.996	8.166
SENTECH	5.119	0.246	0.481
UNIST	0.656	0.244	0.647

The primary system behavior, which is shown in Figure 2, showed fairly good prediction results from all participants with smaller than 0.3 of AA value. However, calculation results of the secondary system pressure of SG-2 which is connected with PAFS had large AA values in the viewpoint of the whole transient periods. Poor predictions of the PAFS actuation time is the main reason for the large AA values, as shown in Figure 3.

Calculation results of the integrated mass of SGTR break flow are compared to the corresponding measurement in Figure 4. The figure shows there were large discrepancies between predictions and experimental result. Note that most participants could not predict either the core collapsed level.

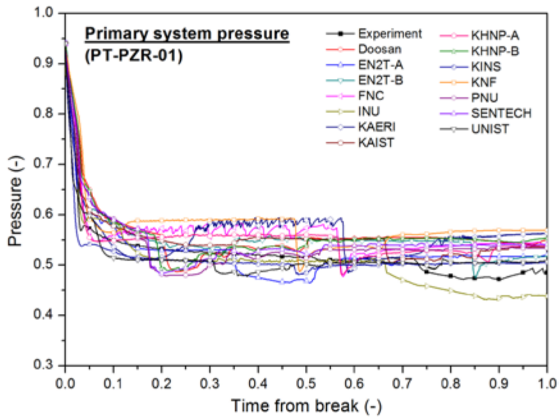

Fig. 2 Calculation results of the primary system pressure

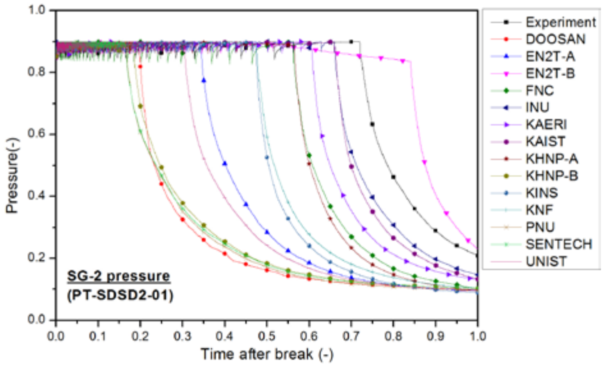

Fig. 3 Calculation results of the SG-2 pressure

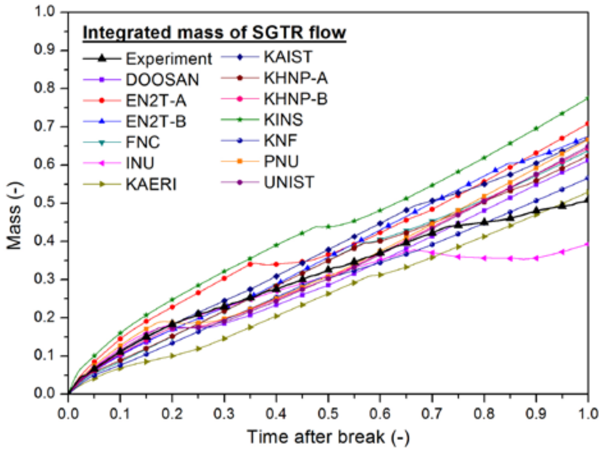

Fig. 4 Integrated mass of SGTR flow

The flow rates of PAFS system after PAFS actuation showed good agreement with experimental result for all participants. However, the fluid temperature of water return line of the PAFS was predicted much higher temperature than the experimental result from all participant, as shown in Figure 5. It can be inferred that the performance of PAFS was significantly under-estimated in all code calculations.

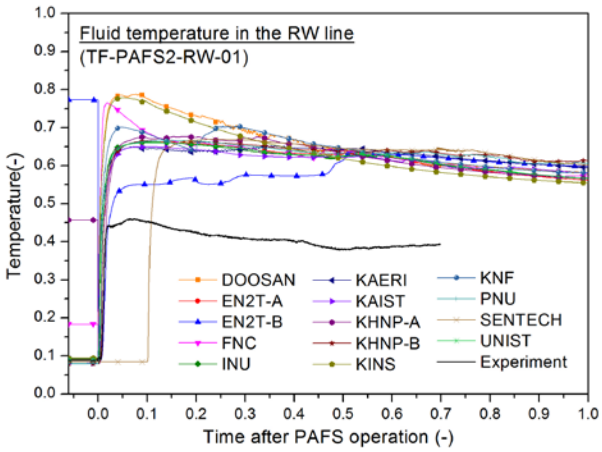

Fig. 5 Fluid temperature in the RW line

3. Conclusions

The 5th domestic standard problem was launched and the ATAS test for DSP-05 was successfully conducted as the scenario of the multiple steam generator tube rupture (MSGTR) accident under the passive auxiliary feedwater system (PAFS) operation condition.

Total 14 institutions participated in DSP-05 and they have conducted blind calculations with given initial and boundary conditions.

The prediction accuracy of blind calculation results from participants were evaluated quantitatively. As the result, prediction accuracy from participants showed relatively inaccurate result in the view point of the whole transient period. However, in each time interval before and after PAFS actuation, prediction accuracy of calculation results were fairly good with AA value around 0.3.

It seems that the PAFS actuation time, which is governed by the collapsed water level in SG-2, should be predicted very well to get better predictions. Thus, it is believed that more effort should be made in the open calculation phase to model the primary to secondary heat transfer and the MSSV operations more appropriately.

REFERENCES

[1] J. B. Lee et al., "Description Report of ATLAS Facility and Instrumentation (Second Revision)," KAERI/TR-7218/2018, Korea Atomic Energy Research Institute (2018).

[2] Yusun Park et al., "Quick Look Report on the Multiple Steam Generator Tube Rupture with Passive Auxiliary Feedwater System Operation", ATLAS-QLR-19-01 (2019)

[3] Andrej Proso et al. "Review of quantitative accuracy assessments with fast Fourier transform based method (FFTBM)", Nuclear Engineering and Design. 217 (2002) 179–206.