Assessment on Heat Transfer Prediction Capability of SPACE Code for PASCAL

Seong-Su Jeon [a*], Kyung-Jin Lee[a], Soon-Joon Hong[a], Jong Cheon[b], Han-Gon Kim[b]
[a]*FNC Tech., Heungdeok IT Valley, Heungdeok 1-ro, Giheung-gu, Yongin-si, Gyeonggi-do, 446-908, S. Korea*
[b]*KHNP, 508 Keumbyeong-ro, Yuseong-gu, Daejeon, 305-343, S. Korea*
[*]*Corresponding author: ssjeon@fnctech.com*

1. Introduction

In South Korea, advanced power reactor plus (APR+) is currently under development for the export strategy. In APR+, a passive auxiliary feedwater system (PAFS) was adopted as an improved safety design concept; and then there have been many efforts to develop the PAFS.

In order to perform the safety analysis of APR+, it is required to assess the heat transfer prediction capability of thermal hydraulic analysis code for PAFS. For this purpose, this study performed followings using SPACE 2.14, safety analysis code developed in South Korea: 1) SPACE modeling for PAFS Condensing heat removal Assessment Loop (PASCAL) [1], 2) the comparison of main heat transfer parameters between PASCAL data and SPACE results.

2. SPACE modeling for PASCAL

Figure 1 shows the SPACE nodalization for PASCAL. All systems were modeled including the steam generator. Using this nodalization, SPACE code simulations were performed.

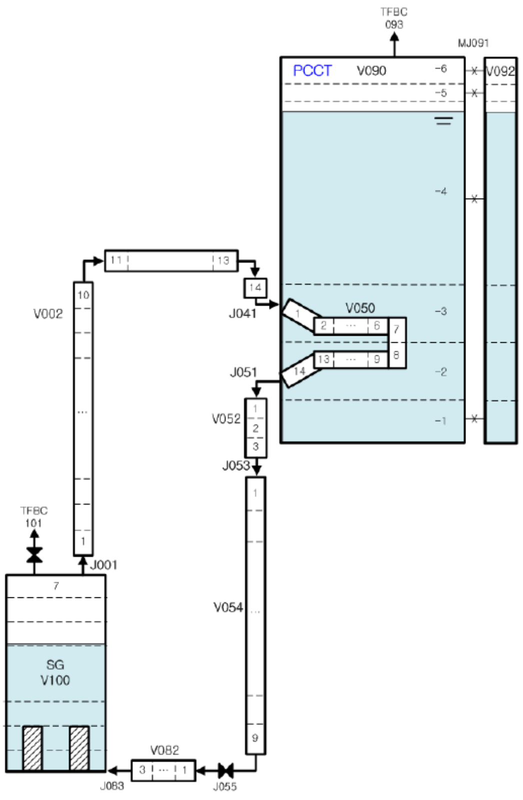

Fig. 1. SPACE nodalization for PASCAL

3. Assessment on heat transfer prediction capability of SPACE code for PASCAL

3.1 Quasi-Steady State System Pressure

Figure 2 shows the system pressure behavior with time. For all cases, SPACE code over-predicted the quasi-steady state system pressure compared with the experimental data (see Table I). This means that SPACE code under-predicted the heat removal rate of the heat exchanger in PASCAL.

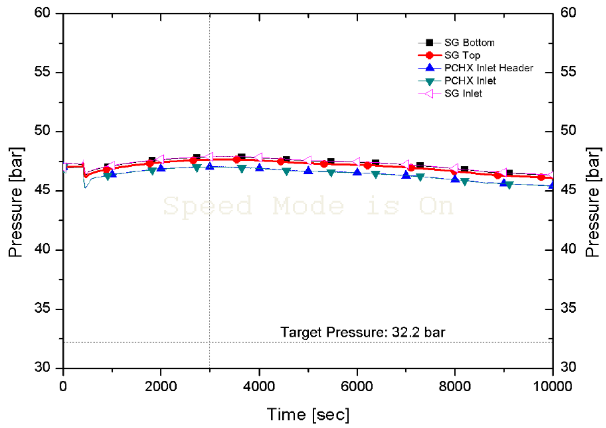

Fig. 2. SPACE results - system pressure (SS/PL-540-P1)

Table I: Quasi-Steady State System Pressure

	SS/PL-300-P1	SS/PL-540-P1	SS/PL-750-P1
Exp.	13.42 bar	32.2 bar	67.36 bar
SPACE	20.22 bar	47.7 bar	90.10 bar
Error	50.67 %	48.14 %	33.76 %

3.2 Overall Removal Heat

Since it is difficult to assess the overall removal heat of the heat exchanger in PASCAL with the nodalization of Fig. 1 quantitatively, the nodalization was modified as followings (see Fig. 3): 1) deletion of S/G, 2) modification of FACE 001 to velocity-TFBC 001, and 3) modification of FACE 083 to pressure-TFBC 083.

Figure 4 shows the overall removal heat of the heat exchanger in PAFS. For all cases, SPACE code under-predicted the overall removal heat compared with the experimental data (see Table II). Average error is about 12 %. This means that the condensation models or the boiling models in SPACE under-predicted the condensation heat transfer rate or the boiling heat transfer rate, respectively.

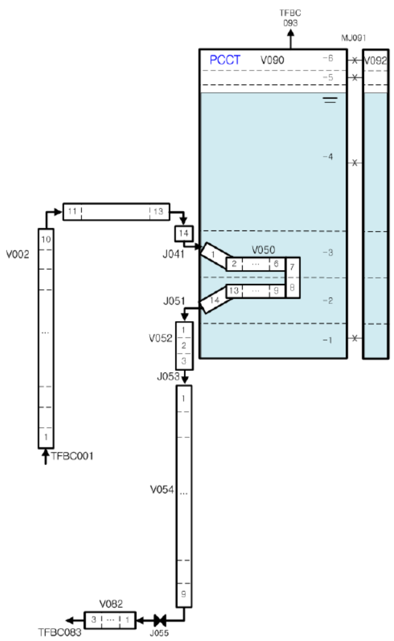

Fig. 3. Modified SPACE nodalization for PASCAL

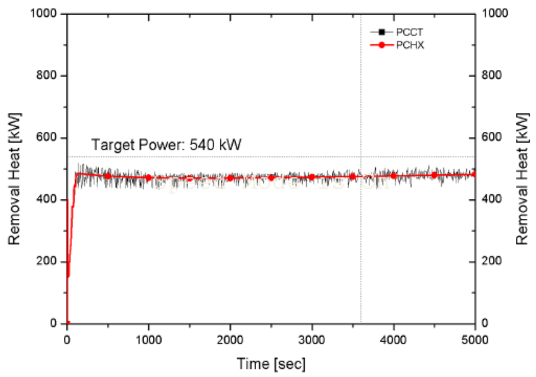

Fig. 4. Removal heat of heat exchanger (SS/PL-540-P1)

Table II: Overall Removal Heat

	SS/PL-300-P1	SS/PL-540-P1	SS/PL-750-P1
Exp.	300 kW	540 kW	750 kW
SPACE	269 kW	475 kW	650 kW
Error	-10.3 %	-12.0 %	-13.3 %

3.3 Local Heat Transfer Coefficients

Using the modified nodalization of Fig. 3, the local heat transfer coefficients (HTCs) were assessed. Test conditions are shown in Table III.

Table III: Test Conditions

	SS/PL-300-P1	SS/PL-540-P1	SS/PL-750-P1
PCHX flowrate	0.15 kg/s	0.2955 kg/s	0.43 kg/s
PCHX pressure	13.42 bar	32.2 bar	67.36 bar

Figure 5 shows the local condensation HTCs for SS/PL-540-P1 case. For all tube positions, SPACE code under-predicted the condensation heat transfer rate. This means that the condensation models of Shah and Chato in SPACE are required to be improved.

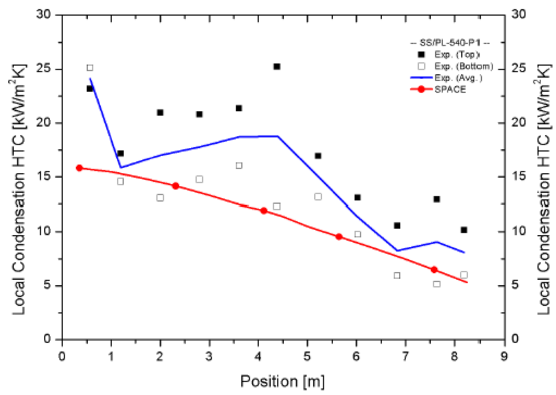

Fig. 5. Local condensation HTC (SS/PL-540-P1)

Figure 6 shows the local boiling HTCs for SS/PL-540-P1 case. For upper tube, SPACE code under-predicted the boiling heat transfer rate. This means that the boiling model of Chen in SPACE is required to be improved.

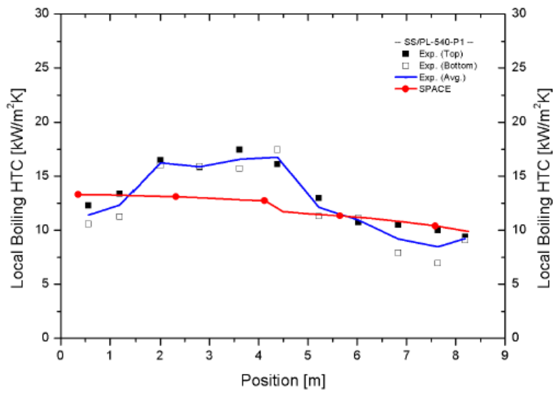

Fig. 6. Local boiling HTC (SS/PL-540-P1)

3. Conclusions

In this study, assessments on heat transfer prediction capability of SPACE code for PASCAL were performed. It was found that the both the condensation models of Shah and Chato and the boiling model of Chen under-predicted the PASCAL data. It is necessary to improve the condensation and boiling heat transfer models in SPACE code for the optimal safety analysis of PAFS.

ACKNOWLEDGMENTS

This work was supported by the Nuclear Research & Development of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Knowledge Economy (No. R-2007-1-005-02).

REFERENCES

[1] K. H. Kang, S. Kim, B. U. Bae, Y. J. Cho, Y. S. Park and B. J. Yun, "Separate and Integral Effect Tests for Validation of Cooling and Operational Performance of the APR+ Passive Auxiliary Feedwater System," Nuclear Engineering and Technology, vol. 44, no. 6, pp. 597-610 (2012).