A simple in-surge pressure analysis using the SPACE code

Bum Soo, Youn [a*], Yo Han, Kim [a], Dong-Hyuk, Lee [a], Chang Keun, Yang [a], Se-Yun, Kim [a], Sang Jun, Ha [a]
[a] *Korea Electric Power Research Institute, 103-16 Munji-Dong, Yuseong-Gu, Daejeon, 305-380, Korea*
[*] *Corresponding author: bsyoun@kepri.re.kr*

1. Introduction

Currently, nuclear safety analysis codes used in Korea are developed by all the overseas. These codes are paying huge fee and permission must be obtained for use in the country. In addition, orders for nuclear power plants must ensure the safety analysis code for independent domestic technology. Therefore, Korea Electric Power Research Institute(KEPRI) is developing the domestic nuclear power safety analysis, SPACE(Safety and Performance Analysis CodE for nuclear power plants). To determine the computational power of pressurizer model in development SPACE code, it was compared with existing commercial nuclear power safety analysis code, RETRAN.

2. Methods and Results

The calculation uses the revised Solver. Solver name is the SPACE_0.10_20100514a.

2.1 Problem Introduction

The pressurizer tests have various interpretations depending on conditions[1-5] but this analysis chooses the pressure by simple in-surge to run the verification SPACE code. The Pressure interpretation by simple in-surge is an analysis about pressurizer which is high pressure state initially by partially saturated liquid. The vapor condensation phenomenon to occur within the pressure vessel by injecting the supercooled liquid state of saturation has been added vessel partially is main target of a predicted calculation. Using this analysis SPACE code verify the accuracy of steam condensation heat transfer model which generated injecting a supercooled liquid and the interface heat transfer model by the stratified flow. The result compare to the results of the RETRAN code. The reference RETRAN rum is an u34clof003 which is DNBR case and safety valve not operating.

2.2 Analysis Method

Figure 1 shows a nodding diagram of SPACE code. There did not model the pressureizer safety valve, water spray, heater and the amount of supercooled liquid injected into the pressurizer model using the TFBC(Temporal face boundary condition – Hydraulic component) component. The total length of pressurizer, which is composed of ten cells, is 3.892m. The area of pipe is 46.543m^2. The bottom entrance is connected to surge line. Originally, internal pressurizer maintains saturation 16MPa and 1 to 5 cells are liquid state. Top space of the pressurizer, 6 to 10 cells, is the state of saturated vapor. A surface roughness in the pressurizer has not been entered.

The total length of surge line, which is composed of two cells, is 76.33m. The area of pipe is 0.5595m^2. The bottom entrance is connected to hotleg. Originally, internal surgeline maintain saturation 16MPa, which corresponds to the saturation temperature of 610.5K.

The total length of hotleg, which is composed of five cells, is 14.3883m. The area of pipe is 9.6211m^2. The side entrance and exit are connected to flow and pressure boundary conditions. Originally, internal hotleg maintain saturation 16MPa, which corresponds to the saturation temperature of 610.5K.

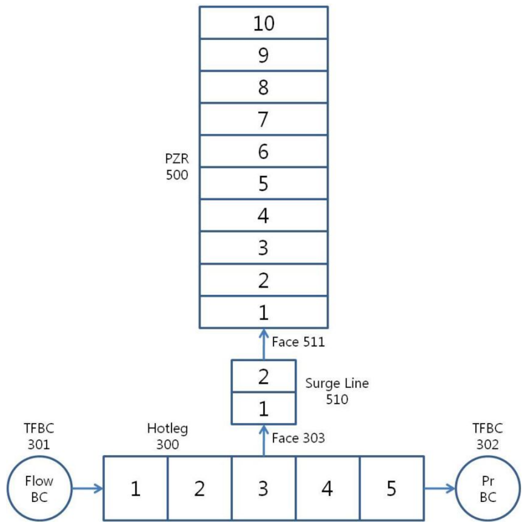

Fig. 1. Nodding diagram of simple in-surge pressurizer.

2.4 Analysis Results

In case of not considering heater in pressurizer, predictions of RETRAN code and SPACE code are shown in Figure 2. Compared with the RETRAN analytical results without include the heat structure, it appears pressure increase for the duration of the injection supercooled liquid. This is seen generally at RETRAN code results also, but there is a very small pressure difference. Even after pressure behavior of supercooled liquid injection, RETRAN code and SPACE code are showing a sustained decline. Discontinuous behavior of the pressure is the main cause node by node to change to flow range of pressurizer that is configured vertically.

Supercooled liquid, continue to flow from the pressurizer bottom, has constant temperature and very low flow rate. So, actual behavior is maintained stratified flow around the interface. However, if liquid phase inflow to the node flow range of each node transition to stratified flow region in early single-phase vapor form for RETRAN and SPACE code that performs the calculation modeled node unit, and change liquid phase cause continues to liquid flow. Interfacial heat transfer coefficient, which is set in relation to fit the flow area of each node. Thus, there is displayed discontinuous pressure because the value is calculated in different ways on node that present the interface by single-phase vapor – stratification – single-phase liquid region.

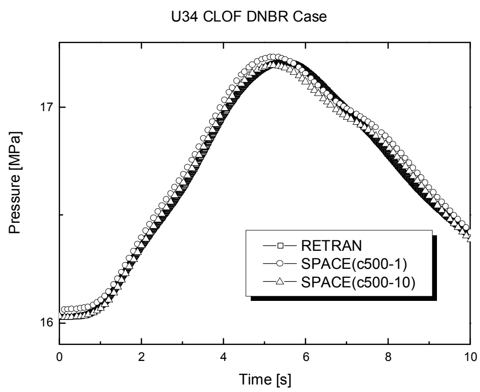

Fig. 2. Calculation results of RETRAN and SPACE code.

Figure 3 shows the mass flow rate at surgeline face. After 4seconds, the flow begins to decline, can be found the pressure falls in figure 2.

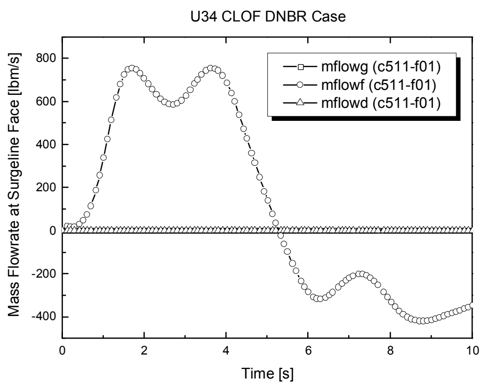

Fig. 3. Mass flow rate at surgeline face.

3. Conclusions

In case of pressure by simple in-surge, SPACE code and RETRAN code results can be presented to confirm the same trend. However, RETRAN is not calculated the momentum flux term at surge line entrance-exit junction. Even if you calculate, RETRAN not change the result. Meanwhile, SPACE cannot be removed the momentum flux term.

In addition, in case of SPACE, initial pressure assuming that uniform at 0.0second. Null transient must be considered.

Acknowledgement

This study is being funded by the Ministry of Knowledge Economy and Korea Electric Power Corporation(KEPCO).

REFERENCES

[1] Kim, S. N. (1984). An experimental and analytical model of PWR pressurizer during transients. Ph.D. Thesis in NE, MIT.

[2] Kang, S. W. (1984). Pool heat transfer in a simulated PWR pressurizer. Trans. Am. Nucl. Soc., 46, p. 845.

[3] Bake, S. M., No, H. C. & Park, I. N. (1986). A non-equilibrium three-region model for transient analysis of pressurized water reactor pressurizer. Nuclear Technology, 74.

[4] Nahavandi, A. N. & Makkenchery, S. (1970). An improved pressurizer model with bubble rise and condensate drop dynamics. Nuclear Engineering and Design, 12, 135-147.

[5] Robinson, J. T. (1981). Benchmark of RETRAN pressurizer model. NE-81-R-488.