Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 24-25, 2013

Analysis of SGTR of Hanul Unit 4 using the SPACE code

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1. Introduction

The Korea nuclear industry has developed a best-estimated two-phase three-field thermal-hydraulic analysis code, SPACE (Safety and Performance Analysis Code for Nuclear Power Plants), for safety analysis and design of a PWR (Pressurized Water Reactor). As the first phase, the demo version of the SPACE code was released in March 2010. The code has been verified and improved according to the Verification and Validation (V&V) matrix prepared for the SPACE code as the second phase of the development.

In this study, SGTR event of Hanul Unit 4 occurred in 2002 has been analyzed using the SPACE code as one aspect of the V&V work. The results from this work were compared with simulation of the SPACE codes.

2. SGTR Event Description

Hanul Unit 4, pressurized light water reactor of 1000 MW electric power, began commercial operation since 1999. SG(steam generator) type is system 80 of CE type which has 8214 tubes per SG. Design pressures of primary and secondary side are 175.8 kg/cm^2 and 89.3 kg/cm^2 respectively.

Hanul Unit 4 was stopped for overhaul at 0:10, 5 April. SGTR event has been occurred under cooling operation at 18:33, 5 April. Plant was under the hot-standby mode during the time of the event and pressure of reactor coolant system and main steam system indicates 158.2 kg/cm^2 and 76.4 kg/cm^2 respectively. After event occurrence, operator of Hanul Unit 4 had recovered pressurizer water level throughout isolation of failed SG and manual SI(Safety Injection). Leakage from failed SG was terminated by pressure equilibrium between primary and secondary side.

3. SPACE code Modeling

When SGTR event was occurred, SPACE code for SGTR accident of Hanul Unit 4 was analyzed to estimate behavior of plant thermal-hydraulic using the plant geometry data, plant operation conditions. Table 1 shows Hanul Unit 4 initial conditions of SPACE code. Basically, all initial conditions and assumptions used in the SPACE code were driven from plant data and RELAP5 simulation report.

Table 1. Initial Conditions for SGTR event

Parameter	Plant Data	RELAP5	SPACE	Remarks
Decay Heat	-	8.445 MWth	8.445 MWth	0.3% of FP
Break Size	-	2.247cm^2	2.247cm^2	
RCS Pressure	158.2 kg/cm^2	158.2 kg/cm^2	158.2 kg/cm^2	
RCS Hot Leg Temp.	290.9 ℃	289.9 ℃	291.0 ℃	
RCS Cold Leg Temp.	291.2 ℃	290.0 ℃	291.0 ℃	
RCS Flow Rate	665,000 lpm	665,000 lpm	656,700 lpm	
Pressurizer Level	35.6 %	35.5 %	35.7 %	
S/G Pressure	74.9 kg/cm^2	74.9 kg/cm^2	76.0 kg/cm^2	
S/G Level(WR)	76.2%	76.0%	76.4%	

SPACE code input deck for Hanul Unit 4 is composed of 148 thermal COMPONENTs and 163 FACEs. 169 heat structures are modeled for thermal characteristic of nuclear fuel, SG tube and pipe.

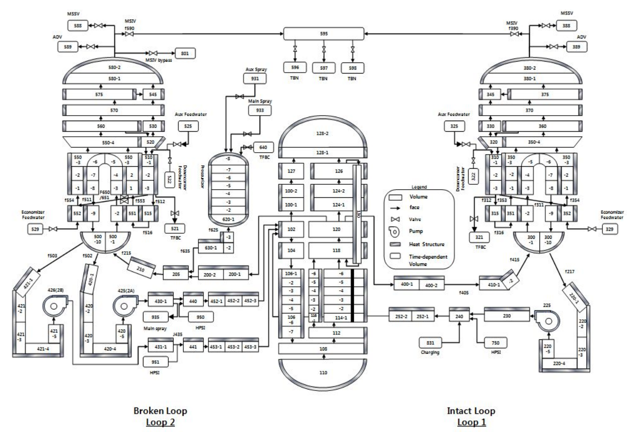

Fig. 1. SPACE Nodal Diagram of Hanul Unit 4 SGTR

Reactor is divided into cold leg nozzle, downstream downcommer, lower plenum, core inlet region, nuclear core, upper plenum, hot leg nozzle. Because single phase flow is dominant, multi-dimensional effect may be disregarded during the overall SGTR transient, downcommer is modeled to single channel which has 12 sub-components. It is assumed that reactor is zero power condition during the overall transient.

Primary loops are modeled to loop which is connected to failed SG and loop which is connected to intact SG respectively.

Charging pump is connected to loop and modeled by TFBC. Pressurizer is connected to hot leg of loop.

SG primary side is modeled to U-Tube, secondary downcommer, separator, steam dome. U-Tube is consists of 8 thermal components. Tube break area is assumed to 2.247 cm^2.

4. Results

Major parameters are presented in the following figures from Fig. 2 to 5. Figure 2 shows a comparison of HPSI flow rate for Plant, RELAP5 code and SPACE code predictions.

Figure 3 shows a comparison of total U-tube break flow rate for RELAP5 and SPACE code. SPACE code result shows similar with RELAP5 code result. From the figure 3, it is seems that SPACE code has a capability to predict the u-tube break flow for SGTR.

Figure 4 shows comparison of pressures for pressurizer and SG. SG pressure behavior of plant, RELAP5 and SPACE code result shows similar trend. But pressurizer pressure of plant result shows higher than those of RELAP5 and SPACE codes, because of uncertainty of plant operation data.

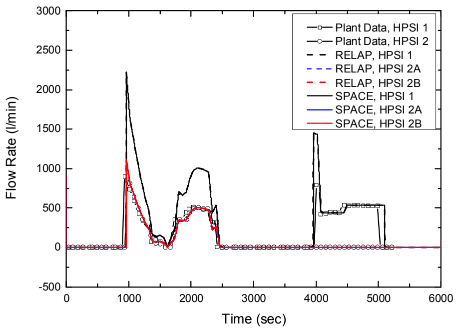

Fig. 2. Comparison of HPSI flow rate

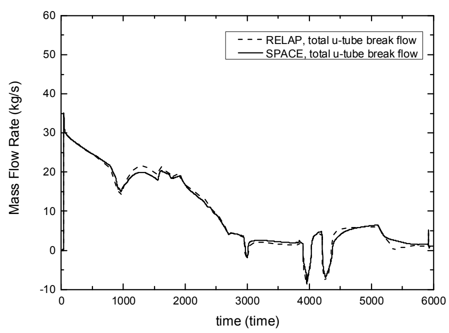

Fig. 3. Comparison of total U-tube break flow

Figure 5 shows a comparison of primary side and coolant temperature for plant, RELAP5 and SPACE code result. Overall trend for plant, RELAP5 and SPACE code result indicates similar behavior. Plant result shows different trend from RELPA5 and SPACE result. Amount of feed water rate and steam release rate is controlled under plant operation. But feed-steam rate is assumed constantly in assessment using the RELAP5 and SPACE code. Because of above methodology difference, there are some differences between plant and code (RELAP5 and SPACE) results.

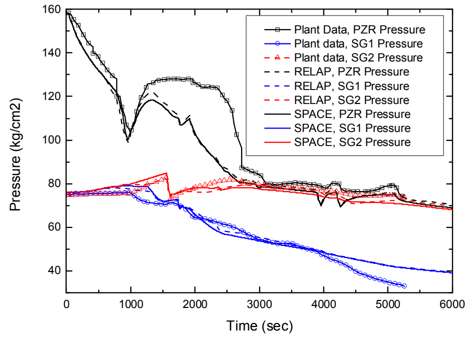

Fig. 4. Comparison of pressure for Pzr and SG

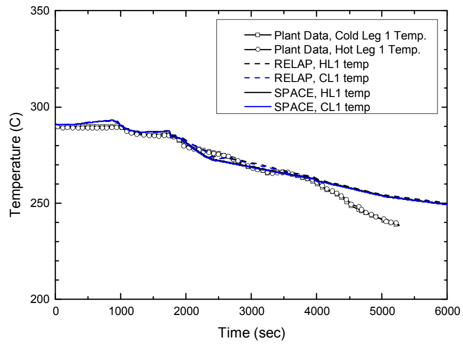

Fig. 5. Comparison of primary side coolant Temp.

3. Conclusions

The SGTR of Hanul Unit 4 has been simulated for the SPACE code V&V. The results have been compared with those of the plant and RELAP5.

Throughout the evaluation of SGTR of Hanul Unit 4 using the SPACE code, it is concluded that the SPACE code has a capability to predict the behavior of plant and thermal-hydraulic response caused by SGTR event.

REFERENCES

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