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Analysis of LOCV(Loss Of Condenser Vacuum) for OPR1000 using the SPACE

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1. Introduction

For validation of SPACE code developed by KHNP, the LOCV(loss of condenser vacuum) accident for OPR1000 is analyzed with SPACE code and results are compared with those from RETRAN code. The LOCV can occur from break in the circulation system, break in the condenser vacuum system, etc. The analysis assumes turbine trip at the beginning of the accident. In the actual plant, the steam bypass control system and the reactor power cutback system reduce the pressure increase of the pressurizer and steam generator from turbine trip. However, in this analysis, steam bypass system and reactor cutback system are not used. The LOCV result in stopping of steam flow to turbine and feed water flow to steam generator. This reduces heat removal to the secondary side and causes pressure increase in primary and secondary side.

2. Methods and Results

2.1 Safety criteria

The safety criteria for LOCV are as follows.

* RCS maximum pressure < 2,750 psia
* Main steam system maximum pressure < 1,397 psia

2.2 Code Modeling

The LOCV analysis used the SPACE code version 2.16. The results from SPACE are compared with those from RETRAN. For LOCV, the most important model is heat transfer model from primary system to secondary system. Basically, heat transfer coefficient included in the code is used. Fig 1 and 2 are SPACE&RETRAN nodalization.

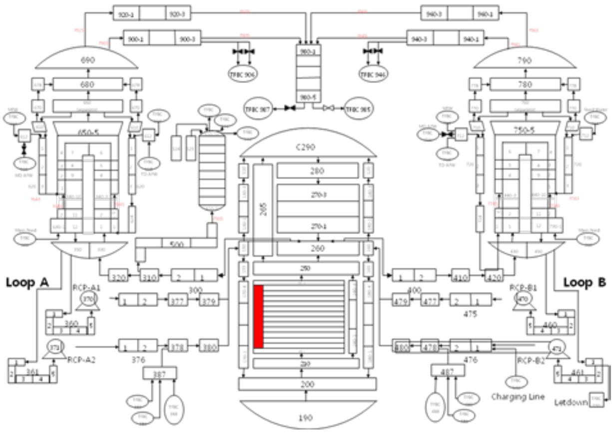

Fig. 1. SPACE nodalization.

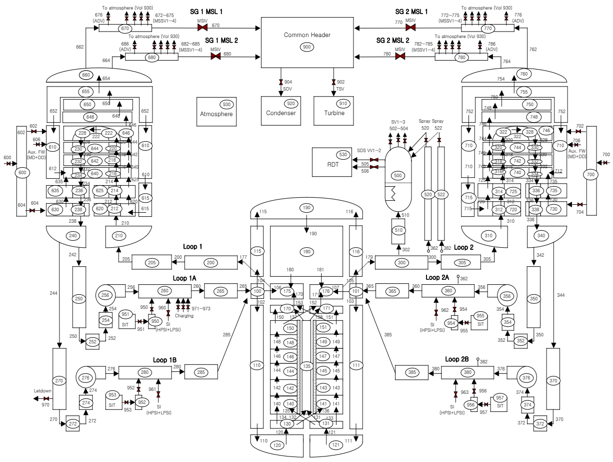

Fig. 2. RETRAN nodalization

2.3 Initial conditions and boundary conditions

For LOCV, important input parameters are initial core inlet temperature, initial reactor coolant flow, initial pressurizer pressure, initial pressurizer water level and initial steam generator inventory. For these conditions, the most limiting initial conditions are steady state initial core inlet temperature, maximum initial reactor coolant flow, minimum initial steam generator water level, steady state initial pressurizer pressure and water level. At these conditions maximum pressure of reactor coolant system occurred. The initial conditions are shown Table Ⅰ.

Table I: Initial conditions

Parameter	Initial conditions	
	SPACE	RETRAN
Core power	2871.3MW$_t$	2871.3MW$_t$
RCS flow	141.32x10^6 lbm/hr	140.96x10^6 lbm/hr
PZR water level	899.1ft^3	900ft^3
SG water level	40%WR	40%WR
PZR pressure	2,260psia	2,260psia
Core inlet temp.	565.1^{o}F	564.5^{o}F

2.4 Sequence of events

The sequence of events for LOCV from two codes are shown Table Ⅱ.

Table II: Sequence of Events

Event	Set value	Time (sec)	
		SPACE	RETRAN
LOCV start	-	0.0	0.0
PZR hi pressure RX trip	2,421psia	4.96	6.14
PSV open	2,540psia	6.84	7.52
Max. RCS pressure	2,541psia	6.87	7.91
MSSV open	1,314.7 Psia	8.59	8.22
PSV close	2,072.64 psia	13.07	14.56
Max. SG pressure	1,368.62 psia	13.74	17.3
Aux. injection	500 gpm	55.80	55.80
Manual cooling	-	1,800.0	1,800.0

2.5 Analysis results

In case of LOCV, the analysis was focused on maximum pressure. The analysis results for main parameters are shown Fig. 3~10.

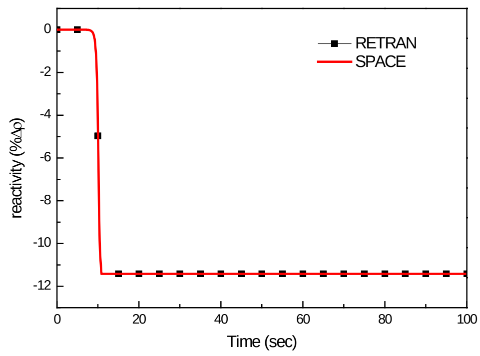

Fig. 3. Total reactivity.

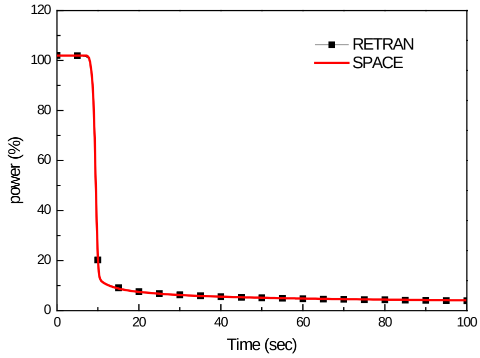

Fig. 4. Reactor power.

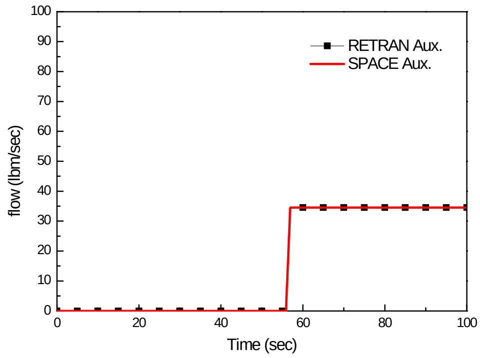

Fig. 5. Auxiliary feed water flow rate.

Fig. 3, Fig. 4 and 5 are the total reactivity, the reactor power and the auxiliary feed water flow rate. The reactivity and auxiliary feed water flow rate are same as RETRAN as these are supplied as boundary conditions.

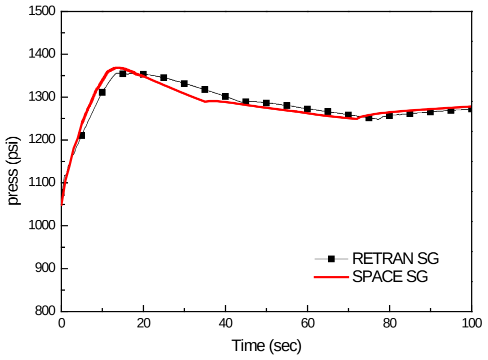

Fig. 6. Steam generator pressure.

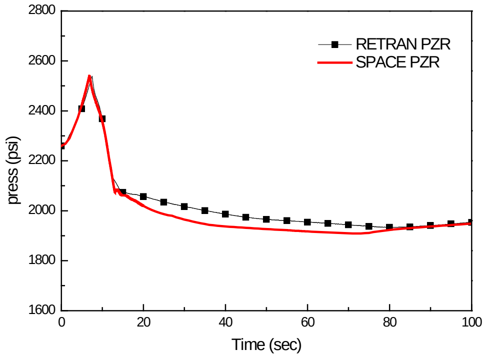

Fig. 7. Pressurizer pressure.

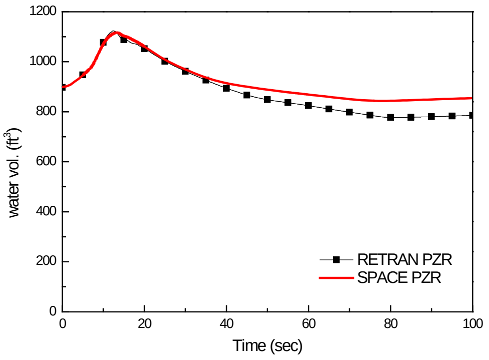

Fig. 8. Pressurizer water volume.

Fig. 6 is pressure of the steam generator. The maximum pressure of the steam generator from SPACE is higher than RETRAN, but is below the pressure limit. Fig 7 and 8 are the pressure and water volume of the pressurizer. Two parameters from SPACE are similar to the RETRAN results.

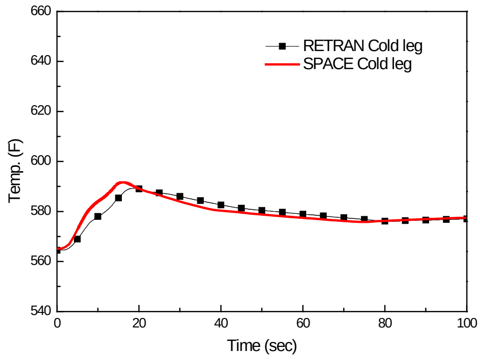

Fig. 9. Cold leg temperature.

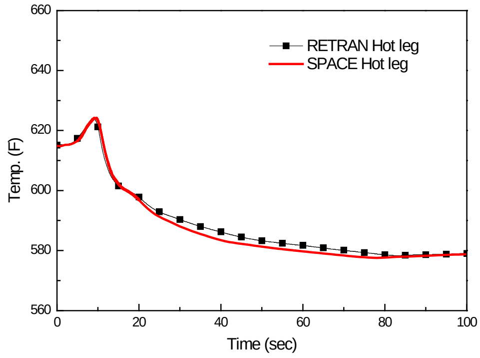

Fig. 10. Hot leg temperature.

Fig. 9 and 10 are temperature of the cold leg and hot leg. The temperatures from SPACE are similar to the RETRAN results.

3. Conclusions

Using the SPACE, the thermal hydraulic behavior of the LOCV accident for OPR1000 was analyzed. The results are compared with RETRAN code. The results of two codes were very similar. From these results, SPACE has the ability to simulation LOCV for OPR1000.

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