Evaluation of SPACE code for simulation of inadvertent opening of spray valve in Shin Kori unit 1

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1. Introduction

SPACE (Safety & Performance Analysis Code for Nuclear Power Plants) has been developing by KHNP with the cooperation with KEPCO E&C and KAERI. SPACE code is expected to be applied to the safety analysis for LOCA (Loss of Coolant Accident) and Non-LOCA scenarios. SPACE code solves two-fluid, three-field governing equations and programmed with C++ computer language using object-oriented concepts [1]. To evaluate the analysis capability for the transient phenomena in the actual nuclear power plant, an inadvertent opening of spray valve in startup test phase of Shin Kori unit 1 was simulated with SPACE code.

2. Analysis model

2.1 Outline of the transient

In 17th Sep. 2010, Shin Kori unit 1 was in the startup test phase. The transient was initiated with the inadvertent opening of isolation valve in the shutdown cooling heat exchanger and the inadvertent opening of the isolation valve of the containment spray in hot shutdown condition (mode of operation 4). 423 tons of coolant was sprayed in the containment for 37 minutes. Sequential lo-lo flow alarm and pressurizer low level alarm was followed. The RCP trip, the shut off of letdown and the maximum charging flow were taken by operator [2].

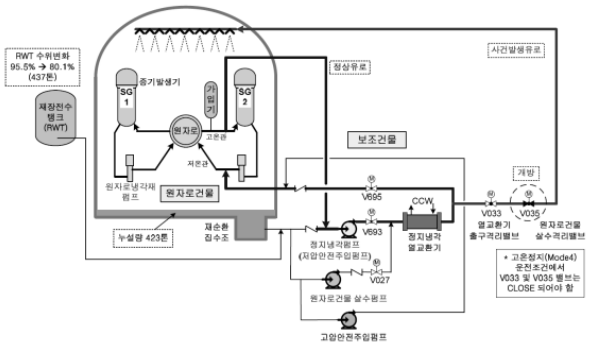

Fig. 1 Schematic of inadvertent opening of spray valve in Shin Kori unit 1

2.2 SPACE Model

SPACE model for Shin Kori unit 1 is prepared on the basis of the MARS input model [3].

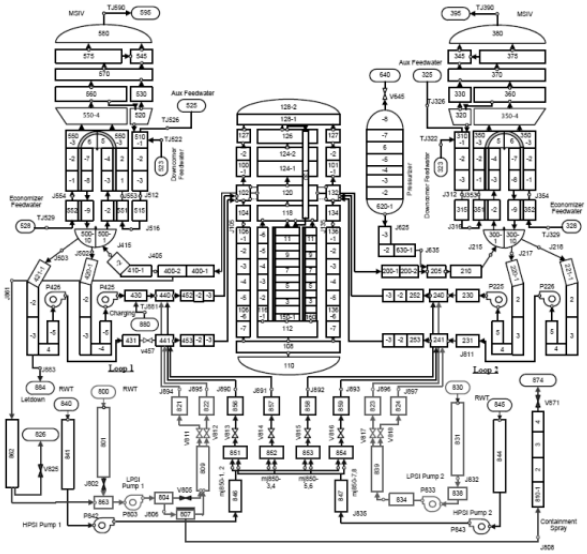

Fig. 2 Nodalization diagram of Shin Kori unit 1

The 2.00 version of SPACE code is used in the analysis [1]. The nodalization diagram of Shin Kori unit 1 is depicted in Fig. 2. The plant is modeled with 233 fluid cells, 303 connections between cells and 231 heat structures. The decay heat of 3.59MW was applied conservatively in the calculations.

3. Analysis results

3.1 Transient analysis results

The calculation for steady-state condition is performed for 1037 seconds. The transient calculation is performed from 1037 to 3700 seconds when the low pressure safety injection is stopped. The calculated results with SPACE are compared with the measured data in plant and calculated values of MARS-KS code.

The abrupt decrease of the volume flow rate in shutdown cooling system at 2100 seconds is shown in Fig. 3 and is mainly due to the vapor entrainment resulted from the core uncovery. The recovery of the volume flow rate in shutdown cooling system occurs at 2200 seconds by safety injection. The pressurizer pressure and level behaviors are well predicted in calculations as presented in Fig. 4 and 5. The difference between calculations and measurement in 2200~3200 seconds seems to be resulted from the two-phase mixing phenomena of safety injection coolant.

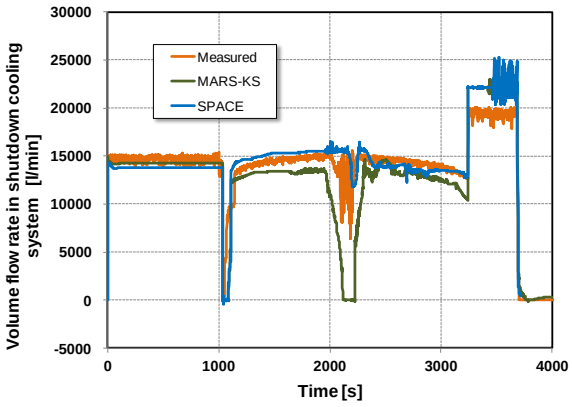

Fig. 3 Volume flow rate of shutdown cooling system

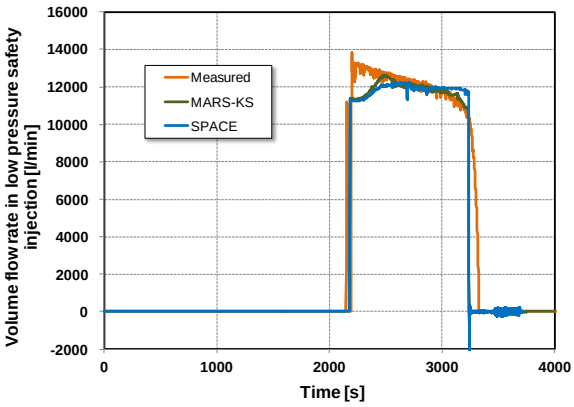

Fig. 6 Volume flow rate of LPSI

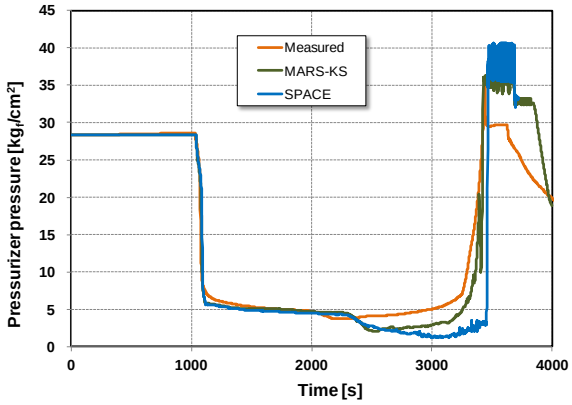

Fig. 4 Transient pressure behavior of pressurizer

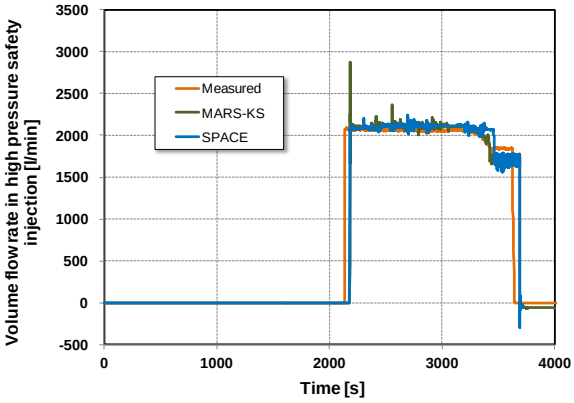

Fig. 7 Volume flow rate of HPSI

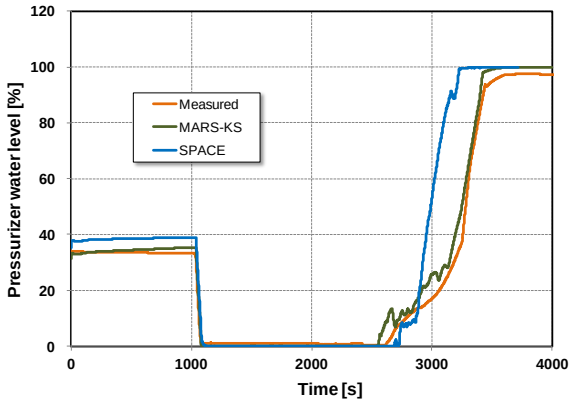

Fig. 5 Water collapsed level of pressurizer

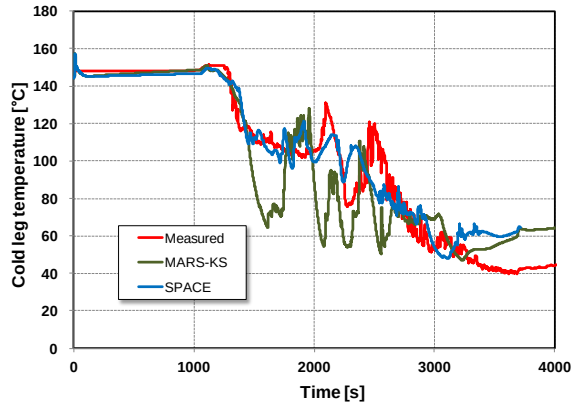

Fig. 8 Transient temperature behavior of cold leg

In Fig. 6 and 7, the volume flow rate of low pressure safety injection and high pressure safety injection are depicted. The calculated cold leg temperature shows good agreement with the measured one as presented in Fig. 8.

4. Conclusions

To evaluate the analysis capability for the transient phenomena in the actual nuclear power plant, an inadvertent opening of spray valve in startup test phase of Shin Kori unit 1 was simulated with SPACE code.

The major parameters in transient are well predicted in SPACE calculations.

REFERENCES

[1] SPACE 2.00 Users Manual, KHNP, 2012
[2] KHNP, Nuclear Power Plant Event Report, S01-10-007-Safety, 2010
[3] Young Seok Bang, et al., Assessment of Thermal-hydraulic Behavior following the Spray Event at Shinkori Unit 1 Using MARS Code, Transactions of Korean Nuclear Society Spring Meeting, Taebaek, Korea, May 26-27, pp.625-626, 2011