Evaluation of SPACE code for natural circulation test of Hanbit unit 2

Seyun Kim [a*], Minhee Kim [a]
[a]*KHNP Central Research Institute, 70, Yuseong-daero, 1312-gil, Yuseong-gu, Daejeon, 34101, KOREA*
[*]*Corresponding author: seyun.kim@khnp.co.kr*

1. Introduction

SPACE (Safety & Performance Analysis Code for Nuclear Power Plants) has been developed 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 passive cooling phenomenon in the actual nuclear power plant, a natural circulation test of Hanbit unit 2 was simulated with SPACE code.

2. Analysis method

2.1 Test outline

The natural circulation test was conducted at Hanbit unit 2 on October 20, 1986. This initial startup program test was structured to demonstrate the capability of the Nuclear Steam Supply System for removing fission product decay heat by natural circulation [2]. A natural cooldown test of reactor coolant system was performed at Hanbit unit 2 as a part of the initial power ascension program. Although the initial plant conditions and setpoints of the safety and control systems are well known, there are limitations in quantity and quality of available data. The data acquisition instrument uncertainty is estimated 1.5%. The natural circulation test was initiated by manual trip of all three RCPs, and then maintained the RCS in hot standby for 30 minutes.

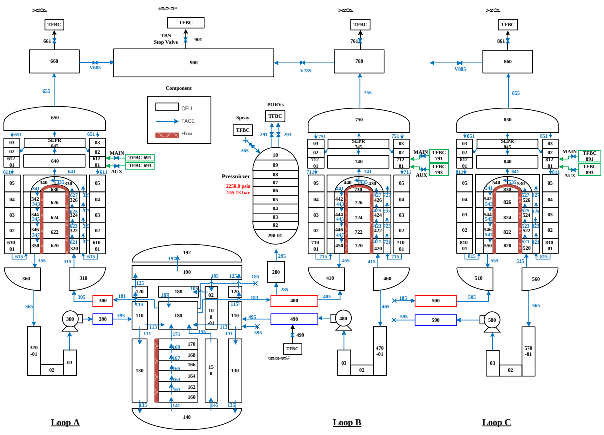

Figure 1 SPACE nodalization of Hanbit unit 2

2.2 SPACE input model

SPACE model for Hanbit unit 2 is prepared on the basis of the RETRAN input model [2] and RELAP input model [3]. The 2.16_20150805a version of SPACE code is used in the analysis [1]. The nodalization diagram of Hanbit unit 2 is depicted in Fig. 1. The plant is modeled with 125 fluid cells, 152 connections between cells and 36 heat structures. The 3% power (83.3MWt) of nominal power was applied in the calculations.

3. Analysis results

3.1 Steady-state results

The calculation for steady-state condition is performed for 2000 seconds. The control inputs for the pressurizer initial pressure and level and the steam generator initial pressure and level, the core inlet temperature are prepared for the steady-state calculation.

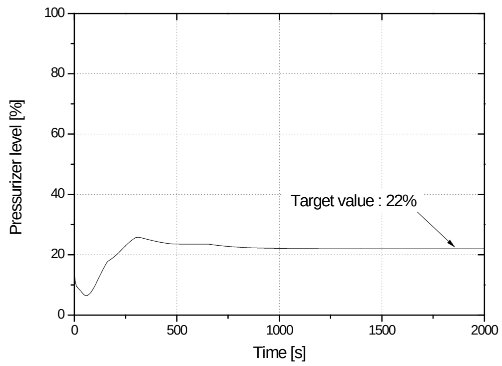

Figure 2 Steady-state result of pressurizer level

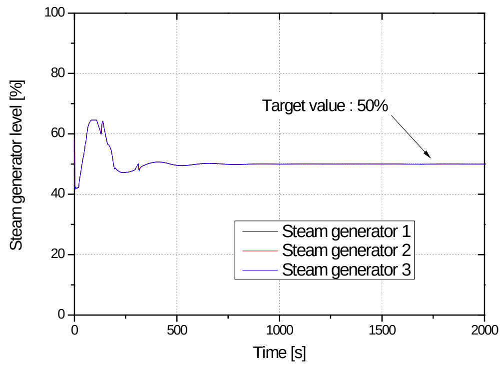

Figure 3 Steady-state result of steam generator level

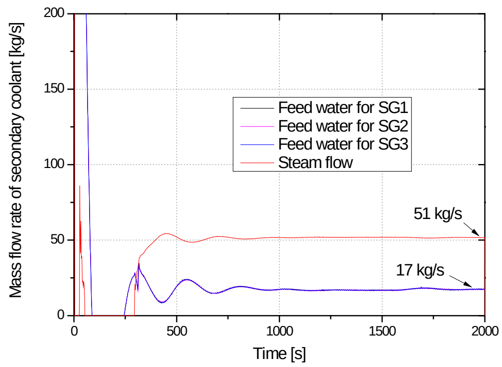

Figure 4 Steady-state result of secondary coolant flow

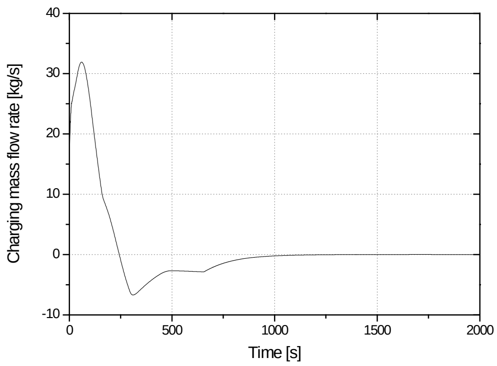

Figure 5 Steady-state result of charging flow

3.2 Transient analysis results

The transient calculation is performed for 1800 seconds when quasi-equilibrium state is obtained. The calculated results with SPACE are compared with the measured data in plant. After the RCP trip, the RCS flow coasted down exponentially. After 300 seconds, it reaches to the equilibrium flow. The hot leg temperatures increases as the RCS flow decreases and results in pressurizer water level increase. The RCS temperature is determined by the steam dump flow rate in the constant steam pressure mode. The hot leg temperature increases sharply due to the sudden reduction of RCS flow.

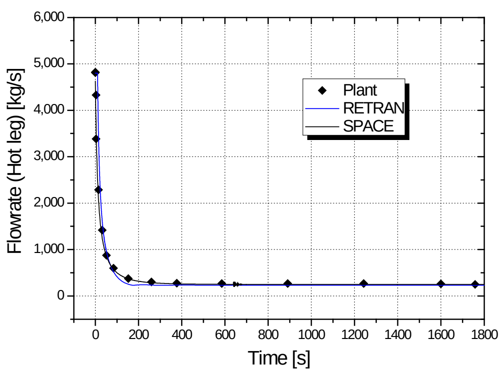

Figure 6 Mass flow rate in hot leg

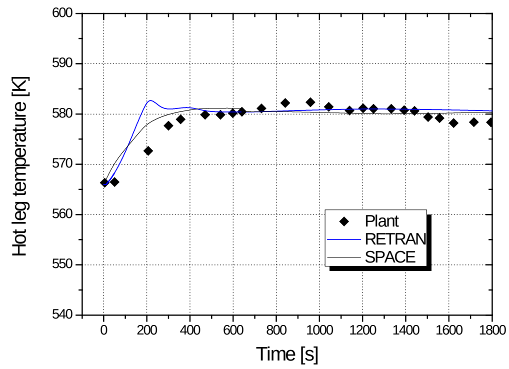

Figure 7 Temperature of hot leg

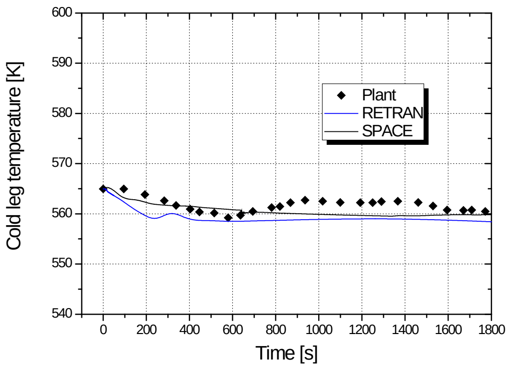

Figure 8 Temperature of cold leg

4. Conclusions

To evaluate the analysis capability for the passive cooling phenomenon in the actual nuclear power plant, a natural circulation test of Hanbit unit 2 was simulated with SPACE code. The major parameters of natural circulation in transient are well predicted in SPACE calculations when compared to the plant data. The SPACE code has sufficient capability to simulate passive cooling phenomena.

Acknowledgement

This work was supported by the Nuclear Research & Development of the Korea Institute of Energy Technology and Planning (KETEP) grant funded by the Korea government Ministry of Trade, Industry and Energy (MOTIE).

REFERENCES

[1] SPACE 2.16 Users Manual, KHNP, 2015.
[2] N. Arne, S. Cho and H. J. Kim, Assessment of RELAP5/MOD2 Computer Code Against the Natural Circulation Test Data from Yong-Gwang Unit 2, NUREG/IA-0125, 1993.
[3] S. Cho, N. Arne and H. Kim, Studies of the best estimate mrthodology for safety assurance of Korea nuclear unit (I), KRC-87N-J01, 1990.