Validation of *i*SAM Using the Plant Startup Test

Chansu, Jang*, Kilsup, Um
KEPCO Nuclear Fuel, 493, Deokjin-dong, Yuseong-gu, Daejeon, 305-353, Korea
**Corresponding Author: csjang@knfc.co.kr*

1. Introduction

For the export of the nuclear fuel, KEPCO Nuclear Fuel (KNF) has developed the KNF-owned safety analysis method, *i*SAM [1], which is the acronym of "**i**ntegrated Non-LOCA **S**afety **A**nalysis **M**ethodology."

In the *i*SAM, KNF standard RETRAN model developed to analyze all the Non-LOCA transients by KNF and best-estimate RETRAN code [2] are used. RETRAN code is a flexible, transient thermal-hydraulic code developed for the United States electric power industry under the sponsorship of the Electric Power Research Institute (EPRI). The applicability of the *i*SAM to FSAR Chapter 15 design basis events for OPR1000 and APR1400 has been confirmed already and the licensing process is going on now.

In this paper, to supplement validation of *i*SAM, Yonggwang Unit 3 natural circulation and turbine trip test [3] is assessed with KNF standard RETRAN model and compared with measured plant data.

2. Analysis Methods

The important analysis methods and assumptions used in the validation calculation are described herein.

2.1 Initialization of KNF standard RETRAN model

Table 1 shows the initial plant conditions used for the validation calculation. The KNF standard RETRAN model is initialized as close as possible to the initial plant conditions. The pertinent initial conditions and transient forcing functions are briefly discussed below.

The RETRAN model is initialized to match the plant initial conditions of feedwater flow and steam line pressure. The core inlet temperature, pressurizer pressure, pressurizer level, steam generator level, and reactor coolant flow rate are set to the initial plant values. The steam generator pressure is initialized with a value to yield the initial steam line pressure approximately.

Core physics parameters are assumed to be at beginning-of-cycle (BOC) conditions since test was carried out at the initial plant startup. Therefore, a small negative moderator temperature coefficient, minimum Doppler feedback characteristics and a maximum delayed neutron fraction are used.

The feedwater inlet enthalpy is defined as function of turbine load and is adjusted in the RETRAN model to match plant test data.

Table 1. Initial conditions

Parameters	Values
Core power, % of nominal	98.61
Core inlet temperature, ˚F	565.3
Pressurizer pressure, psia	2252.03
Pressurizer level, %	51.8
SG level, %	43.8
RCS flow rate, gpm	347,707
FW flow rate, lbm/sec	1736.0
FW enthalpy, Btu/lbm	432.2

2.2 Forcing Functions

For the simulation, the main feedwater flow rate and steam bypass dump valve flow rate profile obtained from the plant test are directly used in RETRAN model because of the irregularity of measured data. Figure 1 presents the feedwater flow rate. This is first forcing function driving the transient.

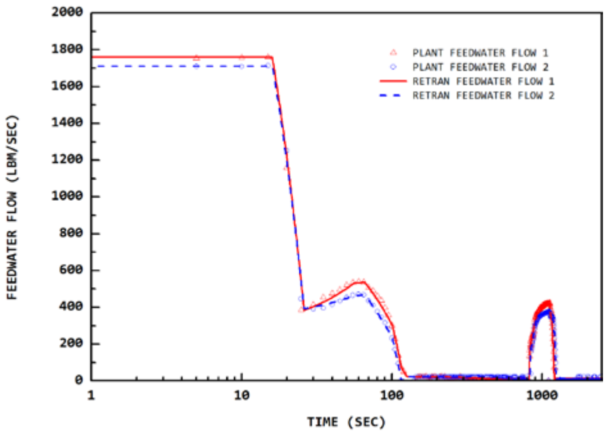

Fig. 1. Feedwater flow rate vs. time.

2.3 Sequence of Events

During the natural circulation and turbine trip test, the operator tripped manually the turbine at 15.0 seconds and the reactor coolant pumps 1, 2, 3 and at 650, 660, 665, and 670 seconds respectively. As a result of turbine trip, reactor was tripped at 16.0 seconds automatically.

To simulate the same situation in RETRAN model, the manual trips of turbine and reactor coolant pumps at the operator action time are considered. This is the second parameter driving the transient. Table 2 shows the sequence of events of the plant test and Figure 2 indicates the behavior of the reactor coolant pump speed. Calculation is performed up to the time point (2,700 seconds) when the stable natural circulation is well established.

Table 2. Sequence of events

Event	Plant(s)
Turbine trip	15
Reactor trip	16
Steam bypass valve open	20, 400, 625
RCPs trip	650,660,665,670

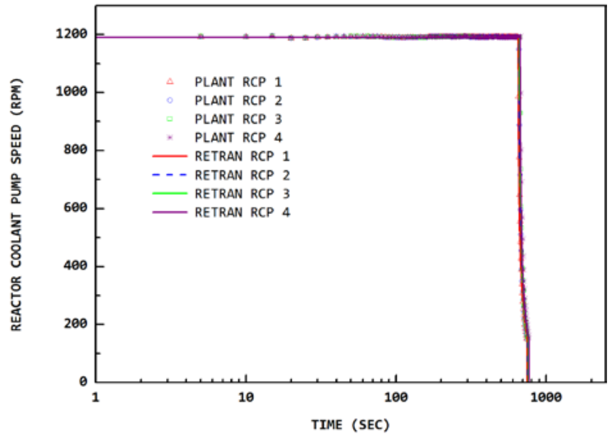

Fig. 2. Reactor coolant pump speed vs. time.

3. Results of Comparison

In this section, key important parameters simulated with KNF standard RETRAN model are presented compared with plant test data. The values referred as "PLANT" in the figures represent measured data from plant test. Pressurizer pressure, steam generator pressure, and reactor coolant temperatures are depicted in Figures 3, 4 and 5 respectively. As per the figures, quite close resemblance between them is found.

Meanwhile, the power-to-flow ratio is considered to check the cooling effect via the natural circulation. That is, the plant undergoing the RCPs' coastdown can be cooled down appropriately by natural circulation if power-to-flow ratio is below one. Normally the power-to-flow ratio may be estimated as the ratio of the enthalpy difference between cold leg and hot leg to that for the nominal condition. The predicted power-to-flow ratio during the stable natural circulation phase is 0.37, which is very close to the plant data of 0.45.

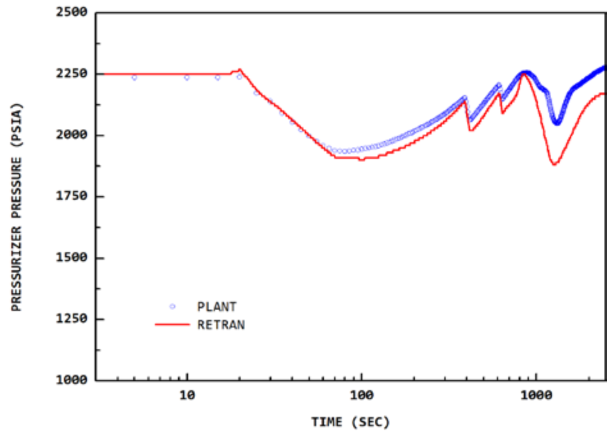

Fig. 3. Pressurizer pressure vs. time

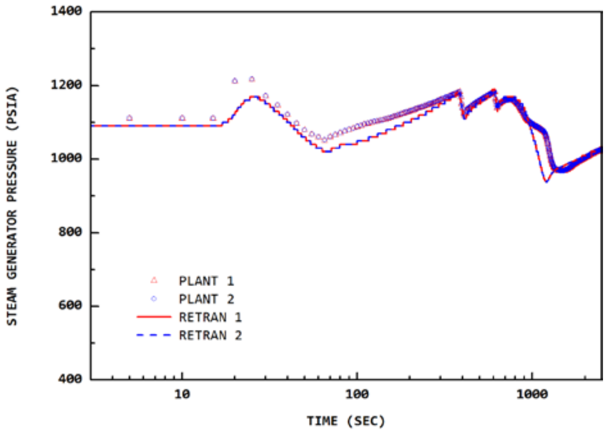

Fig. 4. Steam generator pressure vs. time

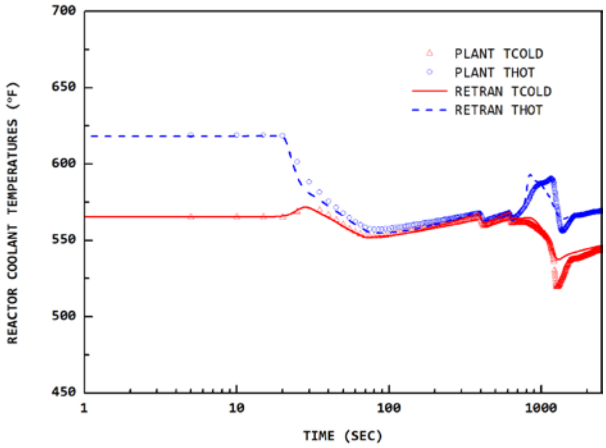

Fig. 5. Reactor coolant temperatures vs. time

4. Conclusions

In order to validate the applicability of the iSAM to all the Non-LOCA transient analysis, Yonggwang 3 natural circulation and turbine trip test is simulated with the KNF standard RETRAN model and compared with measured plant test data. Comparison results show that principal behaviors predicted by RETRAN model are quite similar to the measured plant data and analogous power-to-flow ratio is estimated. Thus, it is confirmed that *i*SAM can be utilized in the plant simulation as well as all the Non-LOCA transient analyses.

REFERENCES

[1] "Applications of Integrated Safety Analysis Methodology to Reload Safety Evaluation," Nuclear Engineering and Technology Vol. 43 No. 2, April 2011.
[2] "RETRAN-3D - A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid-Flow Systems," Electric Power Research Institute, December 1997.
[3] "YGN 3 PAT Evaluation Report for Turbine Trip and Natural Circulation," Korea Atomic Research Institute, April 1995.