MARS3.1 Assessment using Ulchin 5 Pre-operational Test, "Turbine Trip and Natural Circulation"

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Abstract

MARS (Multi-dimensional Analysis for Reactor Safety) code assessment were done using Ulchin 5 pre-operational test, named "Turbine Trip and Natural Circulation Test", which was performed at 2004. MARS3.1K is new released version for regulatory purpose and extensive assessment for KINS. The UCN6 nodalization and input preparation were performed according to quality assurance format. The results shows that MARS3.1K predicted very well the behavior of UCN 6 parameters including hot and cold leg temperature, pressurizer pressure and level.

I. INTRODUCTION

KINS launched the first 3-years stage project of the national mid- and long-term R&D plan, which aims at structuring a best-estimate (BE) reactor thermal-hydraulic analysis system (hereinafter, RETAS), composed of the computer codes as self-maintainable and technology-independent as practicable.

In this paper, an assessment is provided for one of verification and validation works of MARS3.1K of RETAS (REactor Thermal-hydraulic Analysis System).[1]

II. DESCRIPTION OF TEST[2]

Generally, natural circulation is necessary to maintain core integrity during LOOP (Loss of Offsite Power). Turbine Trip and natural circulation test is the one of the most important pre-operational test to ensure the design purpose to demonstrate that the plant responds and is controlled as designed following a turbine trip from ≥ 95% power without the Reactor Power Cutback System (RPCS) in service.

Test procedures are as follows;

a. Manual Turbine Trip
b. Automatically open Turbine Bypass Valves (TBVs) and is maintaining steam generator pressure in accordance with Main Steam Header Setpoint
c. Automatic Reactor Trip (Diverse Protection System)
d. FWCS #1 and #2 operate automatically to maintain steam generator levels
e. Followings should ne conformed
   - No SIAS or ESFAS actuations have occurred.
   - No Pressurizer Safety Valves have lifted.
   - No Main Steam Safety Valves have lifted
f. After the plant has achieved stable conditions, trip all four(4) RCPs as simultaneously as possible and then perform the Natural Circulation Cooldown

III. COMPUTER CODE MODEL

III.A Description of MARS3.1K[3]

The backbones of MARS are RELAP5/MOD3.2 and COBRA-TF. MARS development was initially intended to make the most of the merits of the two codes: the former is a versatile and robust system analysis code based on 1-D two-fluid model for two-phase flow, whereas the latter is based on a 3-D two-fluid, three-field model. In this assessment, one dimensional model was used because there were no significant multi-dimensional phenomena.

III.B Nodalization of nuclear power plant

In order to simulate the Ulchin 5 pre-operational test, the nodalization was used as shown in figure 1. Nodalization was performed according to MARS user's guidelines and all calculation sheet follows quality assurance format.

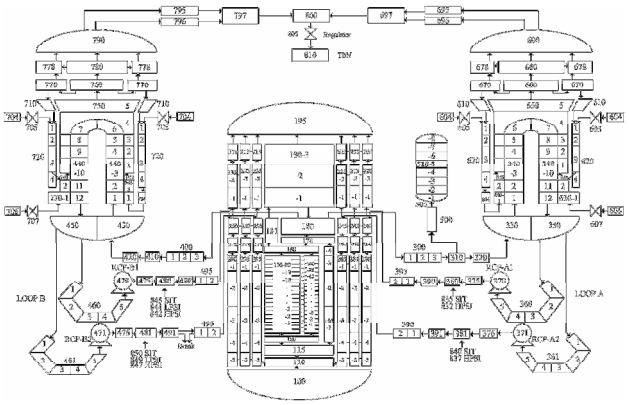

Figure 1. Ulchin 5&6 MARS3.1K Nodalization

III.C Plant Control Modeling[4]

To simulate the Ulchin 5 pre-operational test correctly, pressurizer level control system (PLCS) and pressurizer pressure control system (PPCS) should be modeled. PLCS was modeled as charging and letdown and PPCS was simulated by pressurizer heaters (backup heater and proportional heater) and spray. Of course, the MARS input models of PLCS and PPCS were consisted of time dependent junctions/volumes, control variables and general tables.

IV. RESULTS AND DISCUSSIONS

Originally, "Turbine Trip and Natural Circulation Test" were performed at 2004 and there were two sets of test results. First set was named natural circulation test and second set was reactor trip test. In this paper, Natural circulation test was described

At 0 second, simulation starts as steady state by 100 seconds. At 100 seconds, turbine stop valve was tripped manually, and 0.5 seconds later, reactor trip followed. At 2100 seconds, reactor coolant pump was tripped manually to test natural circulation. Calculation was terminated at 5000 seconds.

In figure 2, hot leg temperature was predicted well and loop average temperature also well predicted as shown in figure 3. But in pressurizer pressure and level showed that some differences appeared after reactor trip.

As shown in figure 4, the calculated lowest pressure was lower than plant data and pressurizer pressure follows the shape of plant data with almost same difference. These differences might result from the overall reactor coolant system (RCS) volume error in input or resulted from the differences between design and real performances of charging pump and pressurizer heaters. Another possible reason may be steam table error in MARS. In general, these differences can be acceptable but these differences will be studied.

In figure 5 and 6, steam common header pressure and steam generator level behaviors showed good agreement with data.

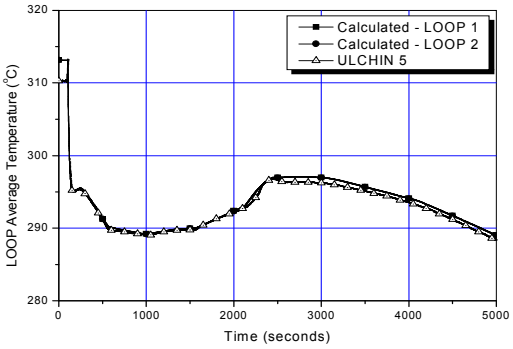

Figure 2. Ulchin 5 Loop Average Fluid Temperature

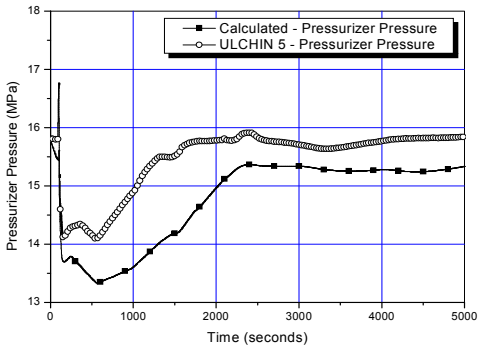

Figure 3. Ulchin 5 Pressurizer Pressure

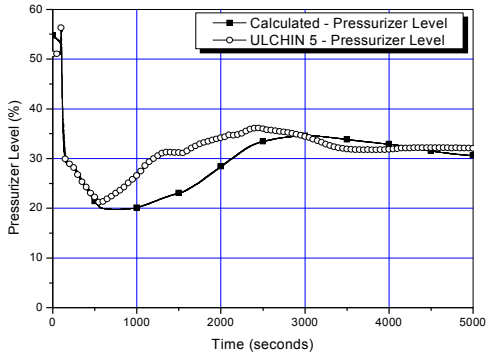

Figure 4. Ulchin 5 Pressurizer Level

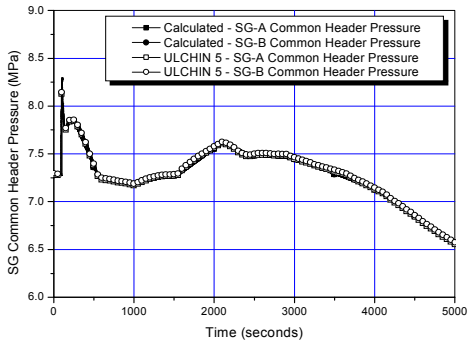

Figure 5. Ulchin 5 Steam Header Pressure

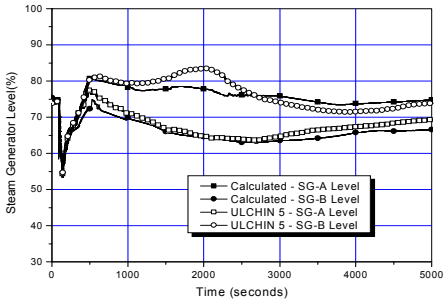

Figure 6. Ulchin 5 Steam Generator Level

V. CONCLUSIONS AND FUTURE WORKS

MARS3.1K version assessment was performed and the code calculation results showed that RCS temperature and secondary thermal-hydraulic parameters were well predicted but pressurizer T-H parameters such as liquid level.

As future works, the followings will ne performed.

- Investigation of overall reactor coolant system (RCS) volume error in Ulchin input
- Investigation of the differences between design and real performances of charging pump and pressurizer heaters
- Steam table error in MARS using more extensive assessments

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