Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 25-26, 2012

Development of the HANARO Research Reactor Simulator for Operator Training

Kee-Choon Kwon *, Jang-Yeol Kim, Jae-Chang Park, Seung-Wook Lee, In-Ah Hwang, Dong-Young Lee
Korea Atomic Energy Research Institute, Daedeok-dearo 989-111, Yuseong-gu, Daejeon, Korea
**Corresponding author: kckwon@kaeri.re.kr*

1. Introduction

HANARO (High-flux Advanced Neutron Application ReactOr) is multi-purpose research reactor in Korea Atomic Energy research Institute, and is operating since 1995. It is needed that training and retraining programs for the operating staff, including: reactor manager, shift supervisors, reactor operators, and others working at the research reactor facility. Recently, we developed HANARO research reactor real-time simulator for operating staff training to satisfy these programs [1]. The development of computer-based training simulator have provided an easy understanding of reactor physics, operation, and control. Real-time simulator is recognized as the ultimate training tool because they allow experiencing, in a dynamic mode, every type of operational condition which can be encountered including: start up, variation of power, shut down, operation during accidents, etc [2]. Also, the simulator will be used as a dynamic test-bed for the reactor regulating system control algorithm.

2. Real-time Simulator

In this section, the simulator architecture, mathematical modeling, Human-Machine Interface (HMI), instructor station, and test results are described.

2.1 Simulator Configuration

The simulator hardware consists of host computer (DELL Precision T5500, Window 2008 Server), 6 operator stations, network switch, and large display panel as shown in Fig. 1. HANARO hard-wired panel is not simulated , and is replaced by soft panel.

The simulator software is divided into three major parts : a mathematical modeling program, which executes the plant dynamic modeling program in real-time; an instructor software that manages user instructions; and a human machine interface module as a graphical user interface. Fig. 2 shows the simulator software configuration.

2.2 Mathematical Modeling

HANARO research reactor is open-tank-in-pool type and 30MWth power capacity. HANARO consists of reactor core, primary cooling system including reactor pool, primary cooling water purification system, reflector cooling system, emergency water supply system, spent fuel pool cooling and purification system, secondary cooling system, and hot water layer system.

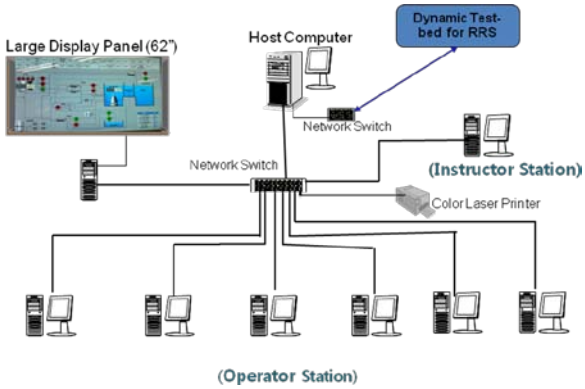

Fig. 1. HANARO simulator hardware configuration.

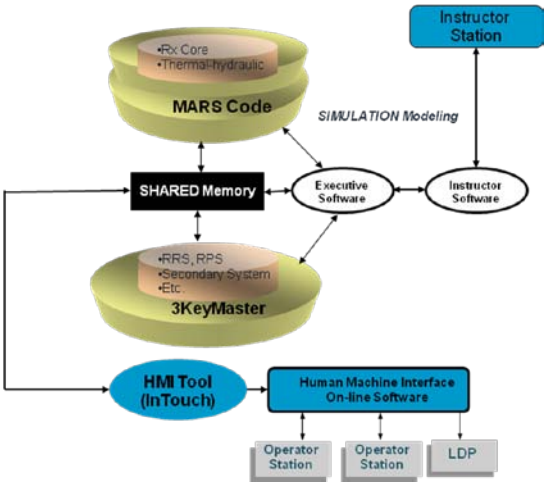

Fig. 2. HANARO simulator software configuration.

Mathematical modeling module consists of two parts of modeling software. The reactor core and thermal-hydraulics of primary cooling system including reactor pool are modeled by Multi-dimensional Analysis of Reactor Safety (MARS) code. The balance of plant and control/protection logics are modeled by 3KeyMaster. MARS is a best-estimate system thermal hydraulics code with multi-dimensional capability [3]. 3KeyMaster is a commercial fully integrated simulation environment which provide real-time executive, instructor station software, and simulation modeling tools. Fig. 3 shows MARS modeling nordalization of reactor core, primary cooling system and reactor pool. Fig. 4 shows simulation example of compressed air service system modeled by 3KeyMaster.

23 system malfunctions are selected based on emergency operating procedure and abnormal operating procedure. Also, simulator provides each component malfunction modeled by 3KeyMaster.

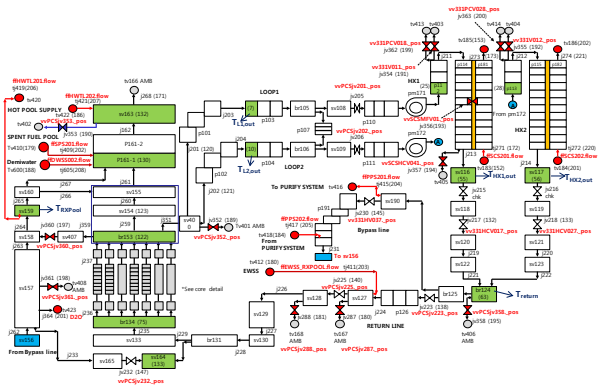

Fig. 3. MARS code nordalizaion of reactor core and primary cooling system

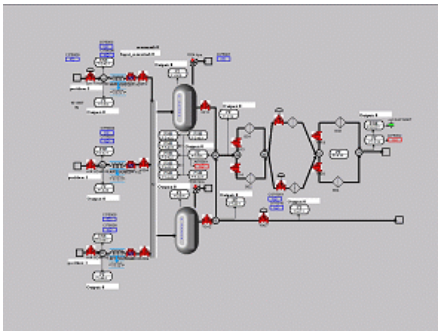

Fig. 4. Simulation example of compressed air service system

2.3 Human-Machine Interface

The HANARO simulator provides two kinds of HMI for the trainee. One is Operator WorkStation (OWS) which is functionally same as reference research reactor HANARO, the other is large display panel that provides overall status of HANARO and alarms. Typical OWS graphic display page which is replaced hard-wired panel is shown in Fig 5. The large display panel is shown in Fig. 6.

Fig. 5. Example of graphic display page

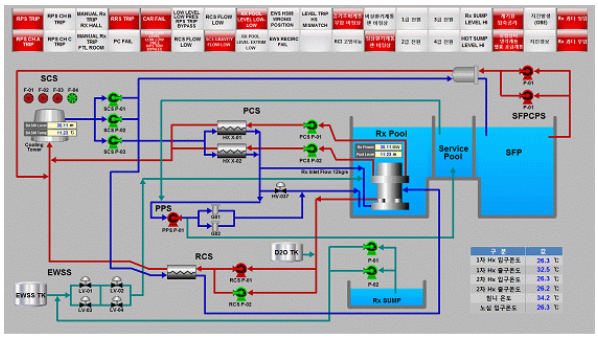

Fig. 6. large display panel

2.4 Instructor Station

The instructor station comprises all the instructions that should be necessary for running the simulator. This instructor station provides several types of instructions such as run/freeze, reset, snapshot, backtrack, insert system or component malfunction, execute remote function, etc.

2.5 Test

The developed simulator is tested by HANARO operator according to normal, abnormal, and emergency operating procedure. They issued lots of discrepancy report and all of them are resolved.

3. Conclusions

We developed HANARO research reactor simulator based on MARS code and 3KeyMaster simulation platform. We will develop Jordan research and training reactor simulator using the same simulation platform near future. The developed simulator will be used operator training in nuclear training center, and also used as dynamic test-bed for the replaced HANARO reactor regulating system control algorithm.

REFERENCES

[1] ANSI/ANS-3.5-2009, Nuclear Power Plant Simulators for Use in Operator Training and Examination, 2009.
[2] Richardo Pinto de Carvalho and Jose Rubens Maiorino, “A Research Reactor Simulation for Operators Training and Teaching,” PHYSOR-2006, Vancouver, Canada, September 10-14, 2006.
[3] KAERI/TR-2811/2004, MARS 3.0 Code Manual, Korea Atomic Energy Research Institute, 2004.