Development of a Desktop Simulator for APR1400 Nuclear Power Plant

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1. Introduction

It is essential for utilities to possess a full-scope simulator for operator training and operation test for operators[1,2]. But it is very expensive and sometimes lack of fidelity if processes of developing the simulator and designing the plant are in parallel. It is due to the situation that simulator development stage sometimes precedes the plant design stage and modifications may occur to the design of the plant in construction stage. Moreover, after the build of full-scope simulator, operators need to wait their turns to use it since there are lots of needs for the full-scope simulator in operator trainings and operation tests. In an attempt to build a low cost and efficient simulator, a desktop simulator has been developed. This model is described herein.

2. Methods and Results

In this section some of the techniques used to develop the desktop simulator are described. The desktop simulator includes thermal-hydraulics model, BOP model, and HMI model.

2.1 Simulator Platform

For now, all simulators for APR1400 have been developed using 3KEYMASTER™ as their environment software. In order to have coherency, it was chosen as the desktop simulator platform. 3KEYMASTER™ is fully object-oriented and one of the state-of-the-art simulator environments.

2.2 Simulator Model

Simulator models of the desktop simulator are almost same as existing APR1400 simulators[3]. NSSS and BOP model of APR1400 simulator has been integrated on 3KEYMASTER™.

A RELAP5 R/T, which is a real-time version of RELAP5 Mod 3.2, is used for simulating the thermal-hydraulics and the core model. The primary and the secondary system of NSSS are expressed tangibly using 3KEYRELAP5 graphic tool. The visualization of the primary system is shown in Fig. 1.
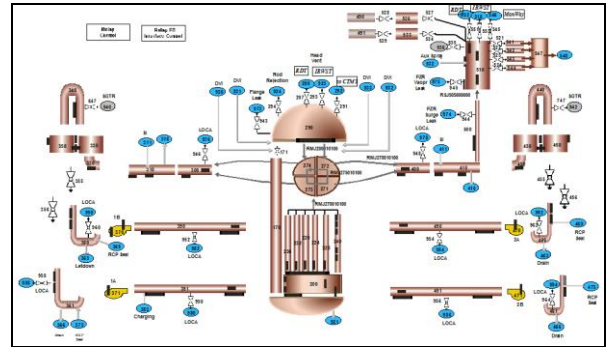

Fig. 1. Visualization of the primary system

2.3 HMI Model

The main purpose of the desktop simulator is to provide an environment for operators to be familiarized with the plant's operations. In order to achieve the goal, HMI model was developed to be as same as their plant or full-scope simulator.

To embody the main control room into a desktop simulator with six display monitors, we assigned each monitor a special role.

First, instructor station is assigned to one monitor. Operators can insert malfunctions and monitor trends of plant parameters through this instructor station.

Second, fixed mimic section of the large display panel(LDP) is assigned to two monitors. The fixed mimic section displays continuously a high level plant mimic with information. Fig. 2 shows the fixed mimic section for RO.
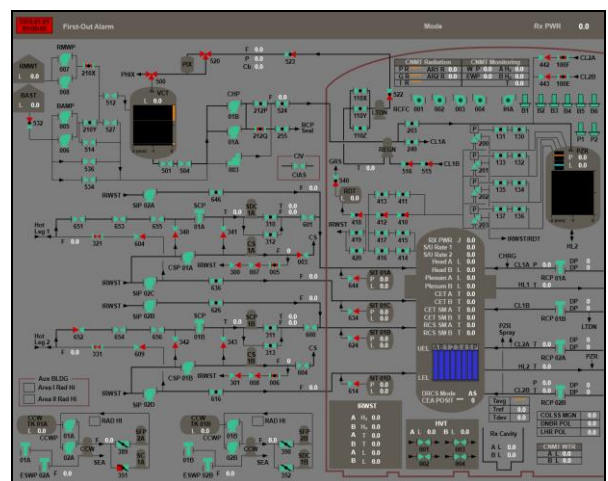

Fig. 2. Fixed mimic section of LDP – RO Section

Third, information processing systems (IPS) are assigned to two monitors. One is for RO and the other is for TO, respectively. IPSs display the primary interface for access to plant information. Operators can access CPS in these IPS displays. Sample IPS displays for RO and TO sections are shown in Fig. 3&4, respectively.
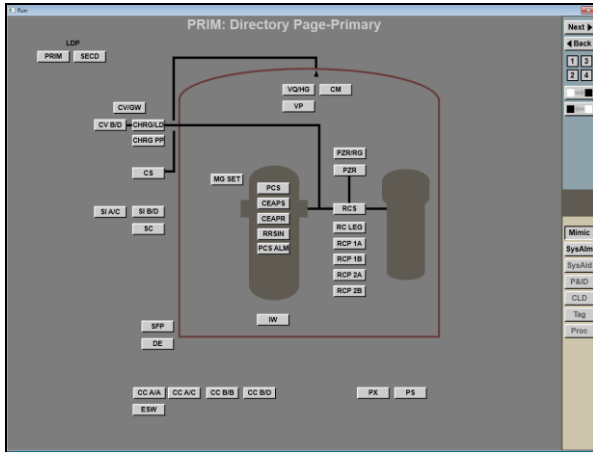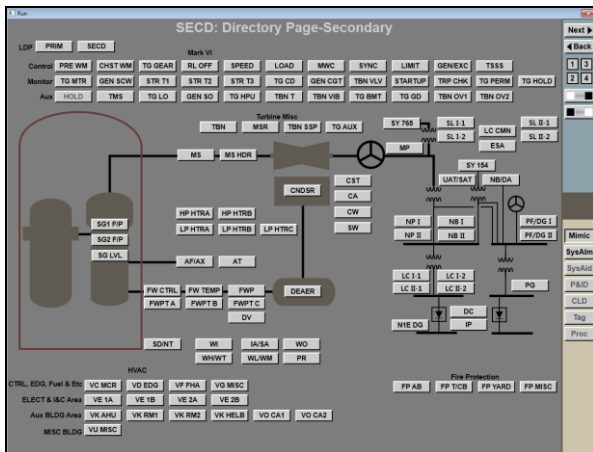

Fig. 3. Sample IPS Section for RO

Fig. 4. Sample IPS Section for TO

Last, two ESF-CCS soft control modules (ESCM) displays are assigned to one monitor. ESCMs provide monitoring and control of components features in a safety division using soft panel buttons. A sample ESCM section with its soft panel button is displayed in Fig. 5.
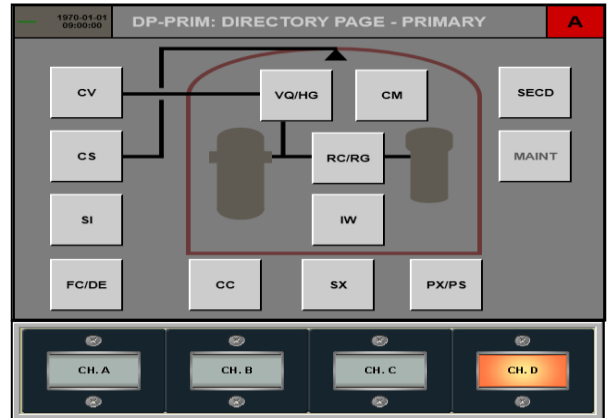

Fig. 5. Sample ESCM Section with Soft Panel Button

In addition to the HMI modules mentioned above, operators can access other HMI modules such as QIAS-P section and QIAS-N section.

3. Conclusions

Using desktop simulators for training operators is an efficient method for familiarizing operators with their plant's operation. A low cost and efficient desktop simulator for APR1400 has been developed, and brief features are introduced here. It is configured to mimic a full-scale simulator, and can be used for operators to be familiarized to their plant's operation. Since the size of the simulator is small enough to be fit in a desk, it can be used in a classroom or in an office at any time. It can also be used to evaluate design changes or modifications of the plant before implementing them to the plant.

REFERENCES

[1] ANSI/ANS3.5-2009, "Nuclear Power Plant Simulators for Use in Operator Training and License Examination", American National Standards Institute, 2009

[2] Code of Federal Regulations, Title 10, "Energy,"Part 55, "Operators' Licenses," available from Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

[3] M.S. Kim, J.H. Hong, and M.S. Lee, Development of Simulation Model and Acceptance Test for Barakah Unit 1 (Apr1400 Simulator), Proceedings of ICAPP 2015, May 03-06, 2015, Nice, France