A Development of a Power Control System for APR1400 simulator

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1. Introduction

Recently digital I&C systems are widely adopted for the nuclear power plants(NPPs). For application of new digital I&C systems in nuclear power plants(NPPs), it is required to satisfy the proven technology requirement. Therefore the simulators are needed for verifying the design of the digital I&C systems. The full-scope simulator is being developed to evaluate specific design feature and choice and to support the iterative design and validation in the MMIS design of APR1400 nuclear power plant. The simulator consists of the process model, control logic model and MMI for the APR1400. The PCS of APR1400 MMIS is implemented into the simulator.

2. PCS Description

PCS is one of the major control systems and consists of Reactor Regulating System (RRS), Control Element Drive Mechanism Control System (CEDMCS), and Reactor Power Cutback System (RPCS).

RRS determines the control rod speed and the direction of control rod movement based on the power difference. The function of the CEDMCS is to control the motive power and holding power applied to Control Element Drive Mechanism (CEDM) and thus to control the direction, rate and duration of Control Element Assemble (CEA) motion.

RPCS generates control bank drop, turbine setback to 60% load and turbine runback signals to maintain RCS under reduced power level without reactor/turbine trip when main feedwater pump trip, RPCS demand, and manual rod drop.

3. Develop Method For PCS

2.1 Use case method

A use case driven approach is proposed to develop a simulation model for PCS. In this approach, a system is considered from the point of view of its users. User's view of the system is based on interactions with the system and the resultant responses. In use case driven approach, we initially consider the system as a black box and look at its interactions with the users. From these interactions, use cases of the system are identified. Then the system is modeled using these use cases as functions. PCS use case diagram is shown in Fig. 1 [1,2].

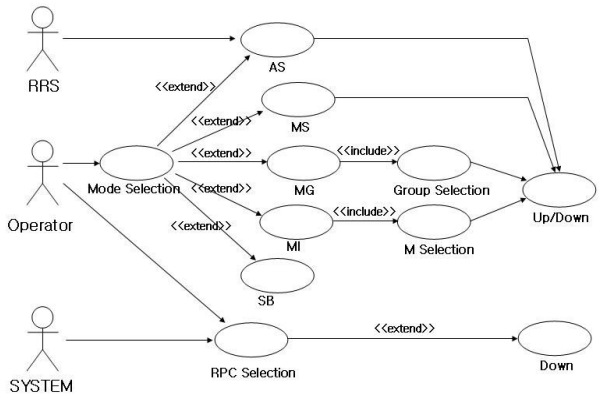

Fig. 1 PCS Use case diagram

2.2 The SIMPORT Simulation System

SIMPORT is a PC-based, real-time, object-oriented simulation software package operating under Windows NT. Software architecture consists of a control and communication manager in a multiple client/server environment [4]..

2.3 PCS MODELING APPROACH

The PCS for the APR1400 includes three Distributed Control Systems (DCS). The SIMPORT provides only standard library control models. Modeling, however, the first and second systems, RRS and RPCS, we utilized the standard MASTER Logic and control tool of SIMPORT and the CEDMCS was developed in custom object model using Visual C++[5] which should be imported into the MASTER environment. Fig. 2 shows the modeling of RRS and RPCS, and Fig. 3 shows the modeling of CEDMCS.

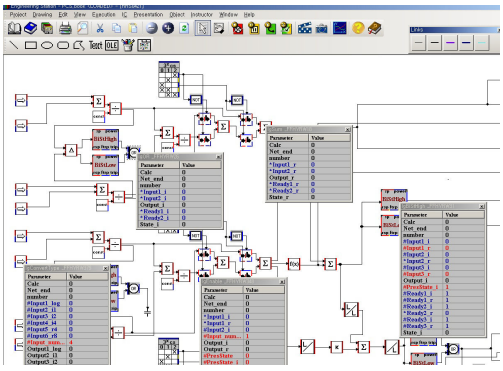

Fig. 2 Modeling of RRS, RPCS

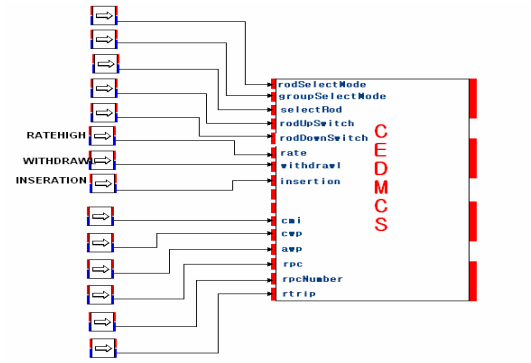

Fig. 3 Modeling of CEDMCS

4. Verification and Validation Of Simulation Model

4.1 Non-Integration Test

We verify the PCS simulation model for regulating groups operation in Auto Sequential mode. Fig. 4 shows the groups withdrawal operation in regulating group.

As shown in Fig. 4, the rod groups withdraw in a sequence from Group 1 to Group 5. Group(N) begins to withdraw when the distance between the group(N) and the group(N-1) reaches 60%. Fig. 5 shows the rod insertion operation in regulating group. As shown in Fig. 5, the rod groups inserts in a sequence from Group 5 to Group 1. Group(N-1) begins to insert when the distance between the Group(N-1) and the Group(N) reaches 60%.

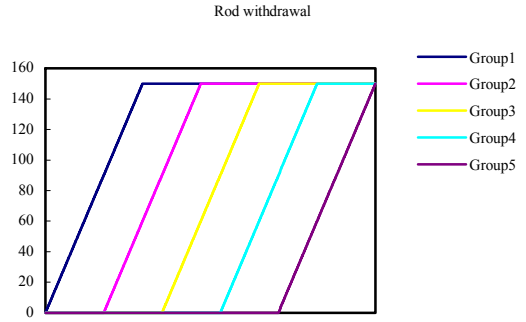

Fig. 4 Control rod withdrawal operation in regulating group

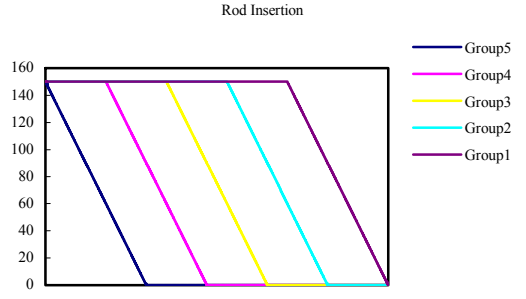

Fig. 5 Control rod insertion operation in regulating group

4.2 Integration Test

In the simulation of PCS, we verify PCS control the control rod speed and the direction of control rod movement based on the power difference and average RCS temperature error. As shown Fig. 6, the average RCS temperature follows to reference temperature. This verifies control function of PCS simulation model are correct.

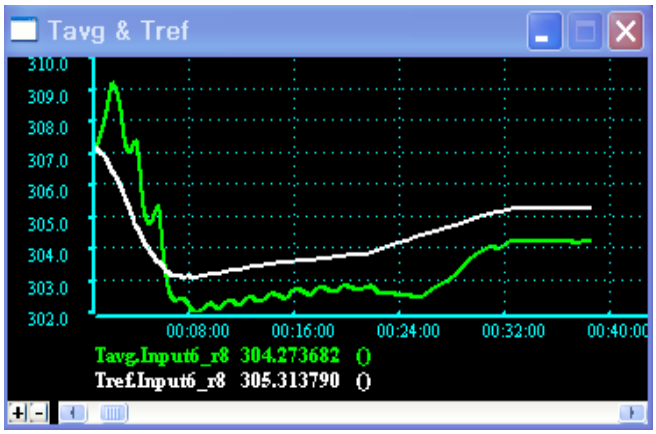

Fig. 6 Operational test result

5. Conclusions

The PCS simulation model has been developed with new methodology. The functions of PCS simulation model have been verified through the integration test of APR1400 simulator

Thus developing simulation model using Use case can be useful for developing simulation model. It is easily comprehensible by ordinary customers and is actually practicable in real simulation modeling for nuclear power plants.

REFERENCES

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