A Study on the Design of CPS for i-SMR

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1. Introduction

Recently, the design and development of about 80 SMR (Small Modular Reactor) power plants worldwide are underway, some of which are being commercialized. In Korea, the development of Korean SMR is being carried out under the name of i-SMR. i-SMR has 4 reactor modules, 1 integrated control room, and 3 operators in terms of plant operation. That is, 3 operators in one control room will perform 4 reactor module operations.

Computer-based procedures have been applied to nuclear power plants from the 2000s worldwide. KHNP developed the CPS (Computerized Procedure System) in the early 2000s and has been applying it to APR1400 type nuclear power plants such as SKN3&4, SHN1&2, and SKN5&6 since 2016. The CPS will be also applied to i-SMR. However, it is not appropriate for the same type CPS as APR1400 to apply to i-SMR. Because i-SMR has different operation characteristics from APR1400 as mentioned above. Therefore, the existing CPS needs design chance for being applied to i-SMR. This paper describes the study on applying CPS to i-SMR.
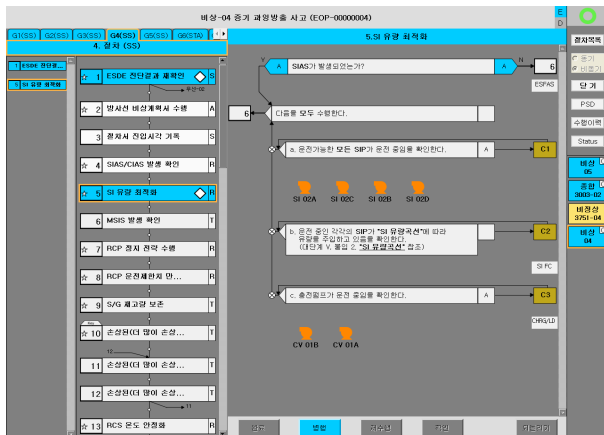

Fig. 1. User interface of the CPS for APR1400 [1]

2. Applying CPS to i-SMR

2.1 i-SMR operating circumstance

i-SMR has one MCR (Main Control Room) where 3 operators perform 4 reactor module operations [2]. Each of the 3 operators has his own operation console.

Each console consists of some FPDs (Flat Panel Displays) which show plant information for operation.

I-CPS (CPS for i-SMR) will use one of the FPDs of each operator's console for 4 reactor module operations. I-CPS will be able to perform procedures at 3 kinds of operation modes such as normal operation, abnormal operation, and emergency operation. The one of i-SMR characteristics is to enable load-following operation through simultaneous control of 4 reactor modules.

2.2 Design Considerations of I-CPS

In order to meet control of 4 reactor modules with 3 operators, various designs need to be applied. For example, there can be expanded application of automation for operation convenience, passive system application for safety, compact design for maintenance and so on.

In case of operations with I-CPS, the automation of performing procedures is essential, and the automation must be guaranteed high confidence.

I-CPS is considered to apply partial automation of performing procedure though it is not fully automated. It is possible to apply partial automation if passive systems are applied.

Also, I-CPS needs to consider procedures for operating each reactor module as well as procedures for operating integrated procedures for more than 2 reactor modules simultaneously, because of supporting load-following operation using multi reactor modules. In addition, if a facility is fully automated, the procedures related to the performance of the facility need to be removed in i-SMR. The more fully automated, the fewer procedures will be required.

The design of I-CPS is being carried out concurrently with other system designs such as information system and control system. The mutual influence between each system always needs to be considered.

2.3 Proposal of I-CPS Design

I-CPS design and development starts with i-SMR top-tier requirements. Figure 2 shows the design process of I-CPS. In accordance with design specification, I-CPS will be developed. After that, I-CPS is installed in a simulator for i-SMR and used for 3-person operating validation. Figure 3 shows conceptual user interface of I-CPS. There are 4 areas for each reactor module procedures and 1 area for

integrated procedures in the form of a tab movement method. User interface of I-CPS has 5 panes such as Title, Step overview, Step detail, Step supplement, and Step monitoring.
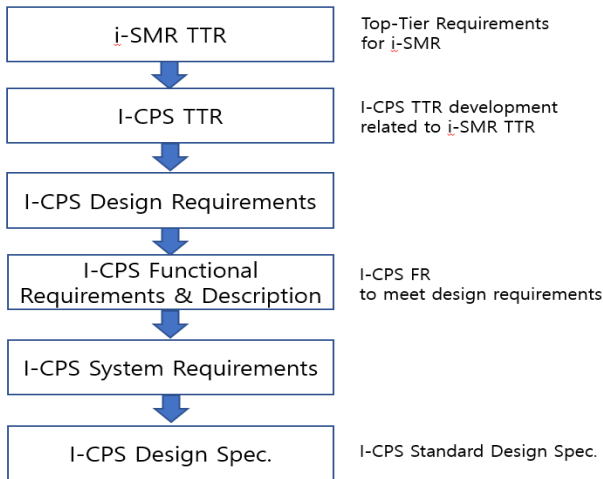

Fig. 2. Design Process of I-CPS

Title pane includes the procedure title and the step title currently being performed. Step overview pane shows the overview of the steps in the procedure. Step detail pane includes instructions, components for control or status monitoring of the step. Step supplement pane includes additional information such as contingency information, supplement information, and so on of the step. Step monitoring pane shows the steps which were performed by operators but not completed.

Fig. 3. Conceptual User Interface of I-CPS

Detailed design for each pane is currently underway. This detailed design requires the development of procedures for i-SMR and design linkage with other systems, such as information system and control system. Unlike the existing procedures developed for APR1400, the development of new procedures that reflect i-SMR

operation characteristics is required.

3. Conclusions

I-CPS design for applying to i-SMR is in progress. The design includes various considerations such as each reactor module operation, multi reactor modules operation, automation level, new procedure development and so on. I-CPS will be used for 3-person operating validation of i-SMR and improved continuously.

REFERENCES

[1] KHNP, SKN5&6 CPS System Design Specification, Rev6, 2022
[2] KHNP, Plant Design Description for i-SMR, 2023