Evaluation of Design Models of Process Equipments for Use in PRIDE: Remote Operability and Maintainability

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1. Introduction

Process equipments for pyroprocessing are being developed at KAERI (Korea Atomic Energy Research Institute). Those equipments should be operated and maintained in a fully remote manner in the argon gas-filled cell of PRIDE (PyRoprocess Integrated inactive DEmonstration facility) at KAERI because direct human access to the in-cell is not possible during an operation due to the high toxicity of the argon gas. To make such process equipments remotely operable and maintainable, their design developments have been tested and evaluated in a simulator before they are constructed. A simulator as a means of evaluating the remote operability and maintainability of the design models of process equipments for pyroprocessing is described, and results of the design models tested and evaluated in a simulator are presented.

2. Simulator and Evaluation Results

In this section overall configurations of a simulator is described. Evaluation results of the design models of the process equipments from remote operation and maintenance viewpoint are also demonstrated. The design models of the process equipments in this work include ones of electro-refining process, electro-winning process and waste salt regeneration & solidification process.

2.1 Simulator

The simulator in this work is a tool of creating a virtual facility of PRIDE. Virtual in this paper denotes the representation and simulation in software of an object or environment. The simulator will provide an efficient means for simulating and verifying the conceptual design, design developments, arrangements, and rehearsal of the pyroprocessing equipment (hereafter, refer to process equipment) from the remote operation and maintenance viewpoint in a virtual process environment by using various virtual functions in advance. As shown in Fig. 1, the simulator [1] from the model viewpoint mainly consists of the geometry that allows the process equipments to be installed, the apparatuses by which the process equipments are operated and maintained in a remote manner, and the process equipments that perform specified tasks of each process. The geometry that is the work environment of PRIDE is modeled by software. The apparatuses that are attached in the geometry are thirty four pairs of mechanical MSM (Master-Slave Manipulators), one BDSM (Bridge transported Dual arm Servo-Manipulators), one overhead crane, and auxiliary devices or tools. They are modeled in software. The process equipments which are ones of an electrolytic reduction system, electro-refining system, electro-refining system and waste salt regeneration & solidification system necessary for the pyroprocessing technology development are also modeled by software.

In the simulator, the 3D models of the geometry, apparatuses and process equipments are imported in the VRML format and connected together to produce a virtual PRIDE, called a PRIDE DM (Digital Mock-up). As shown in Fig. 2, the PRIDE DM has a configuration of 40.3x4.8x6.4 (LxWxH) m and is a full-scale mock-up of the PRIDE modeled in software that is under construction at KAERI. Thus, the simulator includes all the virtual geometry, virtual apparatuses, and virtual process equipments required to produce a functional virtual simulation system of the PRIDE.

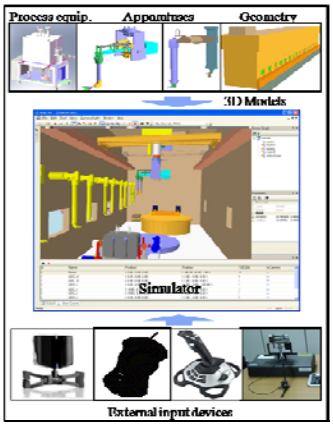

Fig. 1. The functional connections of the simulator.

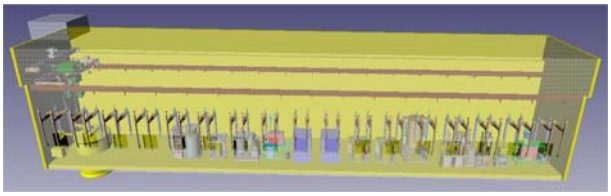

Fig. 2. The virtual PRIDE created in the simulator.

The simulator has a function of enabling an operator to move the virtual process equipment to a desired position inside the PRIDE DM when needed. Real external input devices allow an operator to control the virtual slaves of virtual MSM and BDSM as well as a virtual crane installed inside the PRIDE DM. Thus, an operator can simulate the virtual apparatuses and process equipments that he or she wants to test in the virtual work environment of the PRIDE DM by using external input devices.

2.2 Evaluation of Design Models of Process Equipments

The 3D models of the process equipments for pyroprocessing were tested and evaluated in the PRIDE DM from the viewpoint of remote operation and maintenance by using the simulator described in the preceding session. These 3D models are ones of electro-refining process, electro-winning process, and waste salt regeneration & solidification process. Each process consists of two or three auxiliary equipments depending on its characteristics. During tests, the 3D models of equipments for each process were positioned at their locations pre-assigned inside of the PRIDE DM. They were rearranged at optimal locations after evaluating the accessibility of virtual slaves of both MSM and BDSM to their operable or maintainable positions. Table 1 shows the major evaluation results obtained from the tests of remote operability and maintainability conducted on the 3D models of equipments for each process. The only results that modifications are seriously required are described.

3. Conclusions

A simulator is a useful means for evaluating the remote operability and maintainability of process equipments for pyroprocessing at their design development stage before they are constructed. Remote operability and maintainability of the design models of process equipments were tested and evaluated by using a developed simulator. Evaluation results were feedback to developers of process equipments, thereby making modifications and improving the design completeness of process equipments from the viewpoint of remote operation and maintenance.

ACKNOWLEDGMENT

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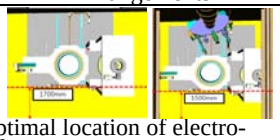
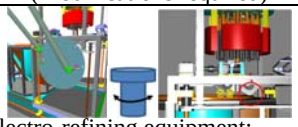
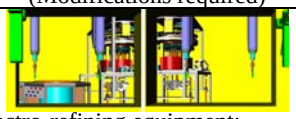
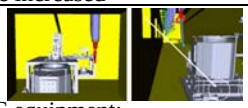
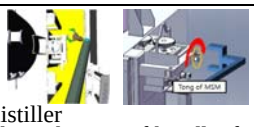
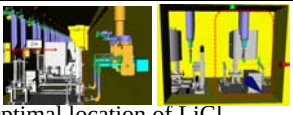
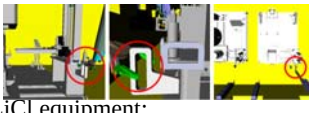
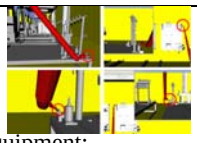
REFERENCES

[1] K. Kim, *et al*., Robotic Virtual Manipulations of a Nuclear Digital Mock-up System, Assembly Automation, Vol.31, p.17, 2011.

Table I: Major Evaluation Results

3D models of equipments	Accessibility or Arrangements	Remote operability (Modifications required)	Remote maintainability (Modifications required)
Electro-refining process	 Optimal location of electro-refining equipment - Front face to be located at distance between 1.2 and 1.5 m apart from an operating window	 Electro-refining equipment: - Redesigning handles for lifting and moving a upper cover from a viewpoint of MSM's tongs or crane - Vertical stroke of flange holder to be increased	 Electro-refining equipment: - Redesigning and relocating a motor module for exchanging anode basket so that, when flange is at its top position, it is visualized and handled by MSM and BDSM
Electro-winning process	 Optimal location of LCC equipment: - Center position to be located at 0.8 m apart from an operating window	 LCC equipment: - Making the size of guides taller - Vision to be secured	 Cd distiller - Making the size of handle for securing driving motors bigger - Vision to be secured
Waste salt regeneration & solidification process	 Optimal location of LiCl equipment: - Center position to be located at 2 m apart from an operating window	 LiCl equipment: - Vision to be secured - Redesigning a shape of handle from a viewpoint of MSM's tongs - Use of motor with brake for holding a rotary device when rotated	 LiCl equipment: - Changing positions of lifting rings located at rear part of a base frame - Considering a center of gravity of lifting rings located at upper part of heating module