Development of the Tele-operation Interface Module of DMU for the ACP

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1. Introduction

The use of computer-based tools and methods in the development process is essential respectively quality, time and costs. The mainly computer-based development of products using 3D CAD systems offers many advantages regarding optimization of time, costs and quality. But on the other hand it leads quickly to a restricted, reduced perception of the product during the development process. Therefore the digital mock-up(DMU) requires the virtual engineering to improve the perception of the computer-based models, respectively the product. In this research, we established the DMU of the Advanced Spent Fuel Conditioning Process(ACP). Also, for effective utilizing the digital mockup, we developed the user interface module such as the data acquisition and display module and the external input device interface module.

2. Overview of ACP

The reliable and effective management of the spent fuel has become a worldwide mission. One of the alternatives is pyroprocessing. Pyroprocessing recycles the uranium resources that reside in the spent fuel. Korea Atomic Energy Research Institute (KAERI) is also developing this process namely the ACP. The ACP transforms the ceramic type uranium into a metallic form by reducing the uranium oxide by lithium in a high temperature molten salt bath while removing the high heat and radioactive sources. In such a way, the volume, radioactivity and the heat generation of the spent fuel can be greatly reduced.

3. Establishment of Digital Mockup for ACP

3.1 Development tool for DMU

For developing the DMU, we used the IGRIP (Interactive Graphics Robot Instruction Program) software. IGRIP is a product of Dassault Co. and is a computer based robotic workcell simulation package for design, evaluation, and analysis. The IGRIP has two simulation language and a low-level interface library as GSL(Graphic Simulation Language) and CLI (Command Line Interpreter) and LLTI(Low Level Telerobotic Interface).

The GSL is a procedural language used to control the behavior of simulation models. GSL incorporates conventions commonly used in high-level computer languages with specific enhancements for model's motion and simulation environment inquires. The CLI is a powerful communication, command, and control system for accessing and operating IGRIP system. It is accessible from both inside and outside the IGRIP menu system. LLTI uses remote tele-operation with on-line parallel monitoring of external devices. This process uses on-line, bidirectional communication to provide a realistic, real-time simulation that reflects changes in the working environment as the work progresses.

3.2 Building the virtual device of equipment for ACP

Figure 1 shows the process flow for building the DMU using IGRIP packages. The first stage for building the virtual device is the 3D modeling. Figure 2 shows the 3D model of process equipment and remote handling device for the ACP. After modeling the process and maintenance equipment, the virtual device is created by assigning the kinematics to part model.

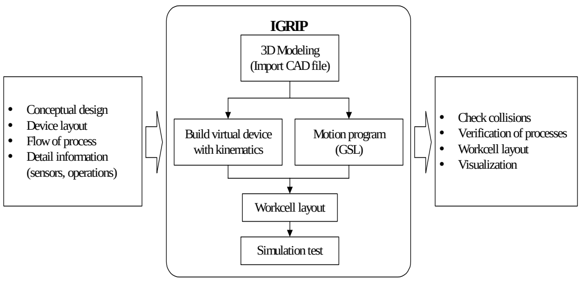

Figure 1. The process flow of building the digital mockup.

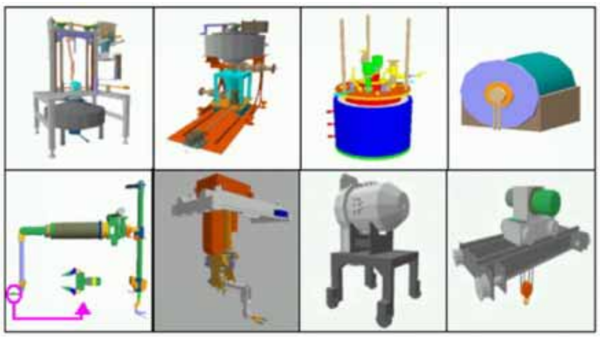

Figure 2. 3D model of the process equipment and the remote handling device for the ACP.

The motion destination position of a virtual device model is represented by a tag point that is a Cartesian coordinate frame with x, y, and z axes. To determine the position of a tag point in the layout, a part model of a virtual device model must be used to attach the tag point. With the attachment, the position of a tag point can be determined with respect to the base coordinate system of the part model of device model to which the tag point is attached.

A virtual device's motion represents a movement of the base frame or TCP frame of a device model to a tag point in the layout world. To generate this type of motion, the device model must have inverse kinematics. In this category, a manipulator model represents the general case, where the TCP frame of the manipulator model is required to move to a tag point defined in the workcell.

3.3 Establishment the DMU for the ACP

For the establishment of the DMU, the process equipment and maintenance devices are modeled in 3-D graphics and the appropriate kinematics are assigned. As described above section, several virtual devices are created. As shown in figure 3, the DMU of the ACP is established using IGRIP to analyze and define the maintenance processes of the process equipment instead of using a real mockup. Also, the virtual workcell of the ACP is implemented in the graphical environment, which is almost identical to that of the real environment.

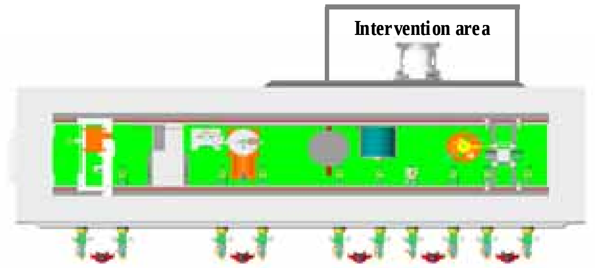

Figure 3. Digital mockup for the ACP

The virtual device simulates the real device and should be tested before laying out the virtual work cell. In the DMU, the virtual device of master-slave manipulator is mounted on to the hot cell wall and the telescopic servo manipulator (TSM) is attached to transporter such as crane. Also, the several virtual devices such as a crane, TSM, vol-oxidizer, reduction reactor, uranium melting furnace, non-destructive assay system, etc., are arranged in the hot cell.

The virtual devices assigned with various mobile attributes such as a relative position, kinematic constraints, and a range of mobility. A jogging motion of each joint of them is tested on the DMU.

4. Development of Tele-operation Interface Module for DMU

The virtual devices in the DMU are activated only by the GSL and CLI or jogging motion. Therefore, one simple motion of the virtual device such as a TSM requires numerous sets of input data of each joint. Thus, the continuous motion of the TSM can be hardly represented. Also, users are required the various information for effective using the DMU. To deal with this problem, in this research, we developed the tele-operation interface module.

As shown in Fig 4, the tele-operation interface module consists of the external input device interface and user information display interface. The interface program of external input device with 6 DOF is designed using the LLTI and the user information display interface module is developed using the IGRIP AXXESS library on the MS Visual C++ platform.

To activate the external input device interface system, a set of user I/O is designed including LLTI for connecting the Phantom device. The interface routine is designed to receive the 6 DOF input data and to create the data structure according to LLTI data specification. Also, the information display module is well responded by the event of the DMU as a real-time

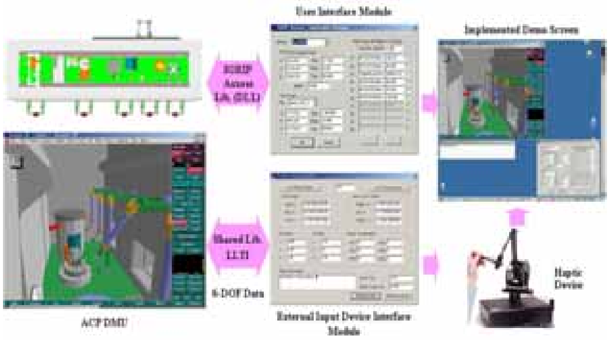

Figure 4. Implementation of the tele-operation interface module for DMU

5. Conclusion

In this research, we established the DMU for the ACP. Also, for improving the user interface and effectiveness, we developed the tele-operation interface module for DMU. The result of this implementation shows that the continuous motion of the manipulator using the external device interface can be easily represented and the information display screens are well responded to the simulation situation.

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