Design of Fuel Bundle Welding Equipment Using a Remote Mock-up Test

Soo-Sung Kim, Geun-Il Park and Jung-Won Lee
Recycled Fuel Development Dept., Korea Atomic Energy Research Institute, Daejeon
sskim7@kaeri.re.kr

1. Introduction

The design of remote welding equipment for a fuel bundle fabrication was undertaken to establish the optimum welding processes in a DUPIC mock-up facility. An initial investigation for a hands-on fabrication outside the hot cell was performed, and the constraints of the welding equipment for the hot cell conditions was considered.[1] Generally, a gas tungsten arc welding, laser beam welding, friction welding, and electrical resistance welding process were assessed as candidates for this application. Preliminary welding performances to improve the resistance welding process were also examined. The resistance welding process was determined to be the best in a hot cell for joining an end-plate to end caps.

This paper presents an outline of the developed welding equipment for a bundle fabrication and reviews the detailed design of a remote welder by using a manipulator. The design of the fuel bundle welding equipment by using a 3D drawing method was also investigated.

2. Design of Welding Equipment and Results

2.1 A Process of Fuel Bundle Assembling

A remote welding system of a hot cell environment consists of a resistance welder, a mater-slave manipulator, and controller. The main head of welding equipment will be used by the multi-pulse type method. Modular remote welding equipment for the fabrication of fuel bundle in a hot cell was made by upgrading the design of welding equipment for multi-pin, fuel-assembly manufacture. In this manufacturing process sequence of fuel bundles, the fuel elements which were welded by the end caps were firstly positioned in an assembly fixture, in which the top part of a fuel bundle was welded. Finally, the bottom part of the fuel bundle, after rotating 180°, was welded to the bottom end-plate. In this process, a master-slave manipulator was required to be designed and assembled to be handled easily because a remote operation was carried out by using a slave manipulator in a hot cell. Modular welding equipment made up of three subassembly parts, was designed with the modular concept, and was compact in comparison with a previous welder in a remote manner.

2.2 Design of Modular Welding Equipment

The remote welding equipment [2] consisted of a base frame, a main head using by a single electrode, a branch electrode indexer, an end-plate magazine loader, and a bottom assembler. Fig. 1 shows the basic division of the welding equipment, and Fig. 2 through Fig. 3 illustrated the design of the welding equipment. A main head part provides an accurate location and orientation of the upper and lower fuel bundle during an end-plate welding operation. A main head part, as shown in Fig. 4, dispenses and loads either the servo motors of the x-y stage unit or the tungsten electrodes of the weld head during the bundle-welding operation. A base frame part for the manufacturing equipment can be easily put into the loop door of the DFDF facility as shown in Fig. 5. Each of these subassembly parts of the remote welding equipment was designed in modules to facilitate maintenance by a remote manipulation.

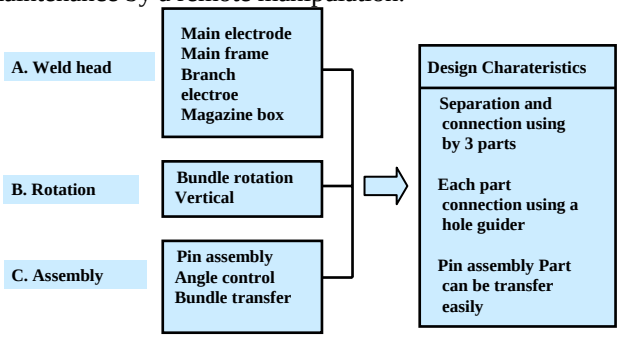


Fig. 1 Basic division of the welding equipment.

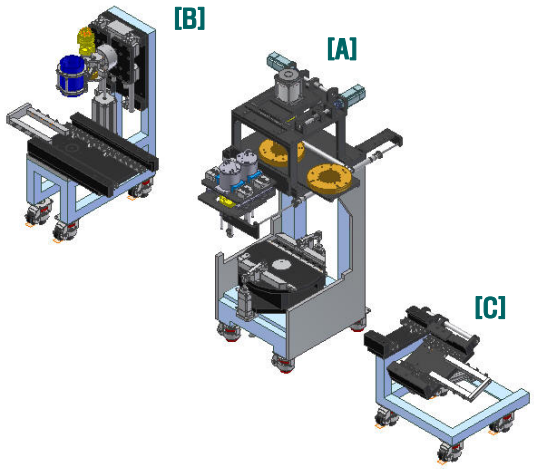


Fig. 2 Design configuration of the welding equipment.

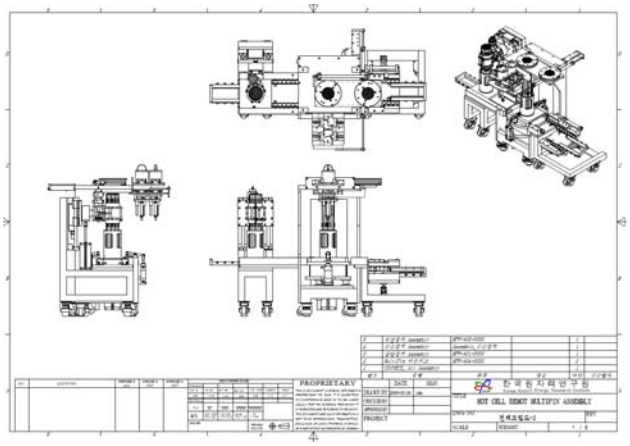
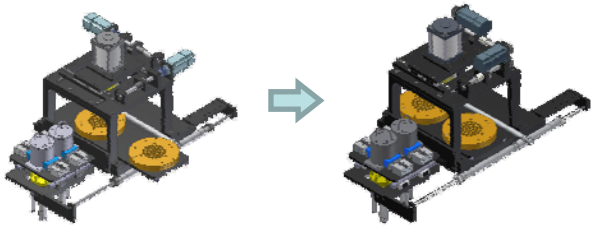
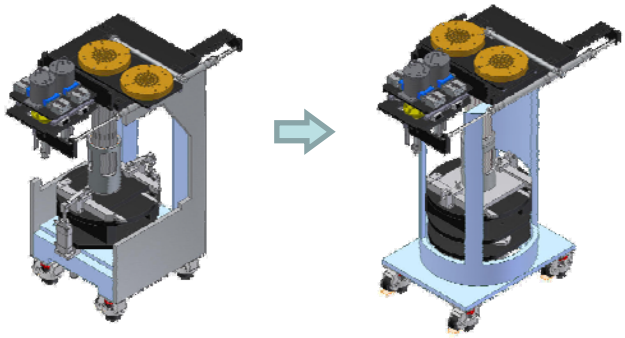


Fig. 3 Design drawing of the welding equipment.



(Previous subassembly part) (Improved subassembly part)

Fig. 4 Design change of the main head part.



(Previous subassembly part) (Improved subassembly part)

Fig. 5 Design change of the base frame part.

The modeling design of the modular remote-bundle-welding equipment was conducted by making a 3D configuration. Analysis and development of the remote welding equipment with the Pro-E Wildfire 3.0 program, produced by the PTC after completing the basic drawing for the remote welding equipment. Based on the modeling design, a welding operation in a hot cell by using the manipulator was analyzed with the aid of auxiliary exploded and re-assembled functions, and an animation using by the Pro-E design method, as shown in Fig. 6. The installation and exchang of main parts such as a damaged weld head using the electrode and the branch electrodes for the remote operation in a hot cell were also checked and analyzed. All the modular components of the assembling parts can also be remotely exchanged or maintained. A mock-up simulation test was also carried out to check on technological matters for a remote operation and each element for processing sequence. It was confirmed that the mock-up simulation test showed the process sequence and the remote welding operation in a hot cell environment using an animation with the Pro-E design method.

Fig. 6 Exploded and re-assembled functions of the overall assembler.

3. Conclusion

This study was implemented to develop the remote welding equipment for a bundle fabrication and to review the basic drawings by means of a 3D design consideration. To establish the reliability of the resistance welding process and the modularized welding system, it was also necessary to carry out a simulation of a remote operation by using a 3D animation method. So, the optimum welding equipment would be applied to the end-plate welding operation for a bundle fabrication in a hot cell.

Acknowledgements

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REFERENCES

[1] J. D. Sullivan, AECL's Progress in Developing the DUPIC Fuel Fabrication Process, The 10th KAIF/KNS Annual Conference, 1995.
[2] Bundle Assembly Welding Equipment, GE Canada Nuclear Products, Contract Item No. A7. 2, 1995.