Development of Remote Welding Equipment for a DUPIC Bundle Fabrication

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1. Introduction

The design of remote welding equipment for a DUPIC bundle fabrication was undertaken to establish the optimum welding processes in a hot cell environment. 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 were considered[1]. Generally a gas tungsten arc welding (GTAW), laser beam welding (LBW), friction welding (FW), and resistance welding (RW) process were assessed as candidates for this application. Preliminary welding performances to improve the RW process were also examined. The RW process was determined to be the best in a hot cell environment for joining an end plate to end caps. The greatest advantage of the RW would be a qualified process for an overlapping plate welding for which there is extensive production experience.

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

2. Design Considerations and Results

2.1 A Process Sequence of Bundle Assembling

A remote welding system of hot cell environment consists of RW equipment, 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 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 endplate. In this process, a master-slave manipulator was required to be designed and assembled to be handled easily because a remote operation by using a slave manipulator in a hot cell was carried out. Modular remote bundle welding equipment made up of four subassembly parts was designed with the modular concept and compact in comparison with a previous welder for the multi-pin fuel assembly fabrication in a remote manner.

2.2 Design of Modular Remote Welding Equipment

The remote welding equipment [2] consists of a main frame, a weld head using by a single electrode, a branch electrode indexer, an endplate magazine loader, and a bottom assembler. Fig. 1 shows the basic design concept of the welding equipment and Fig. 2 through Fig. 5 illustrates the design changes of the main parts. The base frame itself consists of a singled W-Cu electrode, a step-down transformer, an air cylinder or other means of applying a change of the W-Cu electrode using by a head pin as shown in Fig. 2 and Fig. 3. A branch electrode indexer provides an accurate rotation of the upper and lower fuel bundle during an end plate welding operation. A rotary indexer driven by the servo motor is adjustable to allow the length of the overall shafting to vary as the indexing units are raised and lowered. The shafting for a remote operation is fitted together by means of linear guide and linear bearing slides. A jigging plate using the Be-Cu branch electrodes as shown in Fig. 4 provide an accurate seat for the bundle end plates and 37 elements. This part aligns the W-Cu electrode with the ends of 37 elements during a welding operation. An endplate loading mechanisms are used for the upper and the lower units. An endplate magazine loader as shown in Fig. 5 dispense and load either the upper or the lower end plates to the bundle welding operation. A re-loadable magazine provides the supply of endplates to the units, which are dispensed one at a time by an air cylinder. A tuner unit of a bottom assembler is incorporated into the endplate transfer gripper tooling to execute rotation of the end plate required during transfer. This unit is very robust and thereby adheres to the permissible load restrictions thus it will require no maintenance. Each of these subassembly parts of the remote welding equipment was designed in modules to facilitate a maintenance by a remote manipulation.

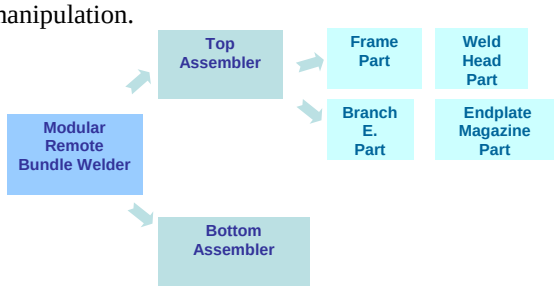
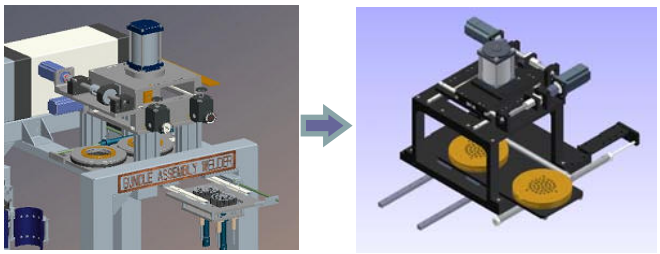
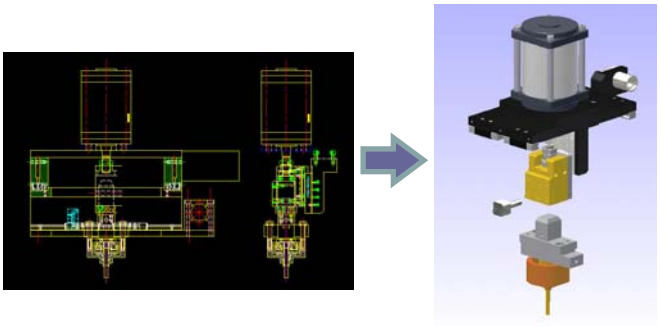


Fig. 1 Basic design concept of a remote welding equipment.



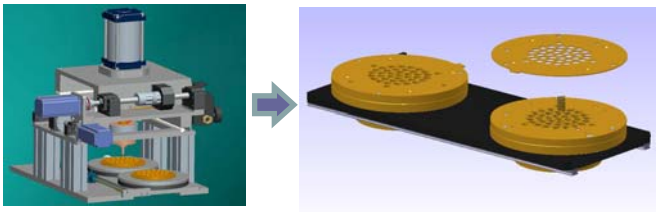
(Previous subassembly part) (Developed subassembly part)

Fig. 2 Design change of a main frame part.



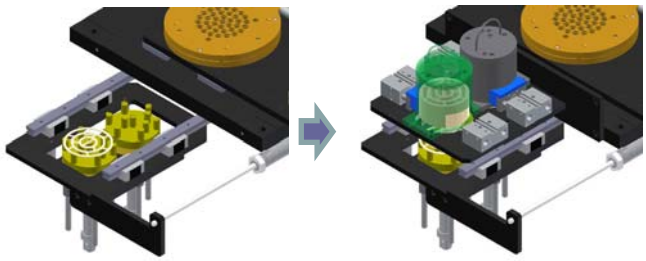
(Previous subassembly part) (Developed subassembly part)

Fig. 3 Design change of a weld head part.



(Previous subassembly part) (Developed subassembly part)

Fig. 4 Design change of a branch electrode part.



(Previous subassembly part) (Developed subassembly part)

Fig. 5 Design change of an endplate magazine part.

Modeling design of the modular remote bundle welding equipment was conducted by making 3D configuration, analyzing and developing of the remote welding equipment with Pro-E Wildfire 3.0 program produced by the PTC after completing the basic drawing for a 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. Installing and exchanging of main parts such as a damaged weld head using the W-Cu electrode and the Be-Cu 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. The 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 by an animation with the Pro-E design method.

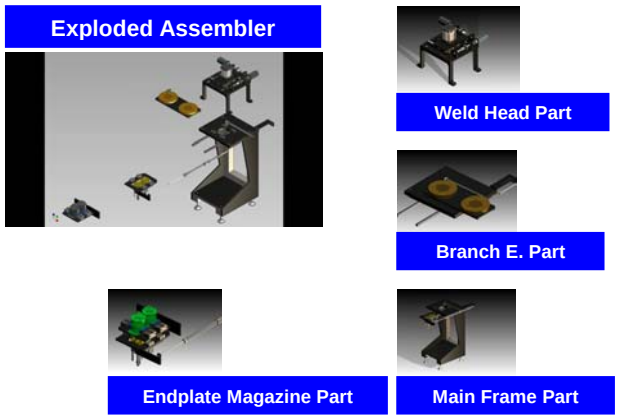


Fig. 6 Auxiliary exploded and re-assembled functions of a top assembler.

3. Conclusion

This study was implemented to develop the remote welding equipment for a DUPIC bundle fabrication and to review the basic drawings by means of a 3D design consideration. To establish the reliability of the RW process and the remote welding system, it is necessary to carry out a simulation of a remote operation by using a 3D animation method. So, the optimum welding equipment will be applied to the remote end plate welding process for a DUPIC bundle fabrication.

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.