Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, November 2-3, 2006

Torque Measurement of Welding of Endplug-Endplate using Multi-pin Remote Welding System

Koo Dae-Seo, Kim Soo-Sung, Park Geun Il, Lee Jung-Won, Song Kee-Chan
Korea Atomic Energy Research Institute, ndskoo@kaeri.re.kr, sskim7@kaeri.re.kr, ngipark@kaeri.re.kr, jwlee3@kaeri.re.kr, kcsong@kaeri.re.kr,

1. Introduction

As fuel bundles in PHWR irradiates, inner pressure in claddings of fuel rods increases owing to outer pressure and fission products of nuclear fissions. Because of leak possibility of welding between cladding and endplug, this welding part connects with safety of nuclear fuel rods[1]. Because of importance of this welding part, weldability of endplug-cladding of nuclear fuel rods is continually researched. Welding method for research and commercialization is classified as melting, solid type welding or resistance welding. Endplug-cladding welding of nuclear fuel rods in PHWR takes advantage of resistance upset butt welding using multi-cycle mode[2-3]. This method makes weld flash and shapes re-entrant corner owing to welding heat due to resistivity, contact resistance of cladding-endplug, and inelasticity deformation due to pressure. Welding part between cladding and endplug receives stresses and makes small cracks[4]. In this study, remote welding system for multi-pin assembly was designed, fabricated and welding specimens of endplug-endplate were made using electrical resistance method. The torques of welding between endplug and endplate were measured. These results on welding current, pressure of main electrode and pressure of branch electrode were analyzed. Weldability between endplug and endplate was confirmed through metallographic examinations. In the future, optimal welding examinations due to welding current, welding pressure and welding time will be performed to improve weldability of endplug-endplate .

2. Specimens Fabrication and Torque Measurements

Figure 1 shows fabricated multi-pin remote welding system. Remote welder consists of power supply unit, welding head unit, rotation unit of fuel bundles, control unit and supply unit of endplates, x-y stage, jip plate exchanger, electrodes. Welding specimens were fabricated by welding endplug of zircaloy-4 on 31, 37(locations of outer rods), 17, 19(locations of inner rods) of endplate due to welding current, welding pressure and welding time using multi-pin remote welding system. The torques of outer and inner rods in welding between endplug and endplate are measured. These results on welding current, pressure of main electrode and pressure of branch electrode are analyzed.

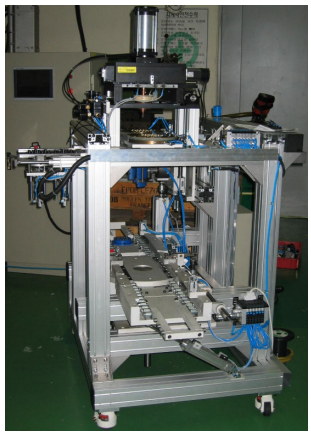

Figure 1. Multi-pin remote welding system.

3. Results Analysis and Discussion

Figure 2 shows the torques of outer and inner rods in welding between endplug and endplate duo to welding current. The torques of outer rods were bigger than those of inner rods. Fig. 3 shows the torques of outer and inner rods in welding between endplug and endplate duo to pressure of main electrode under welding current 5000 ampere, pressure 50 psi of branch electrode.

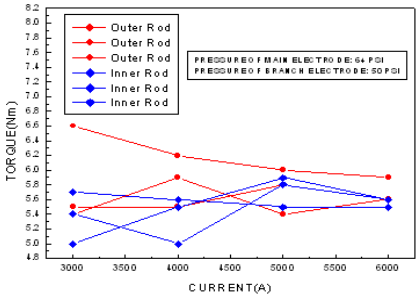

Figure 2.Torques of weldments between endplugs and endplates due to current.

The torques of outer rods in welding between endplug and endplate indicated increasing trend as pressure of main electrode increases, and those of inner rods indicated no increase as pressure of main electrode increases from 73 to 87 psi. Figure 4 shows the torques of outer and inner rods in welding between endplug and endplate duo to pressure of branch electrode under welding current 6000 ampere, pressure 87 psi of main electrode. The torques of outer rods on pressure 50- 65

psi of branch electrode were, on the whole, bigger than those of inner rods.

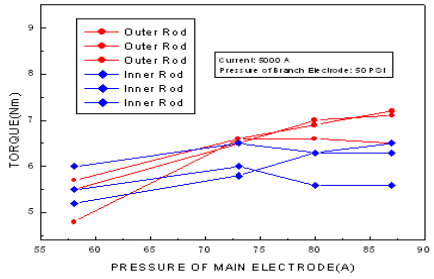

Figure 3.Torques of weldments between endplugs and endplates due to pressure of main electrode.

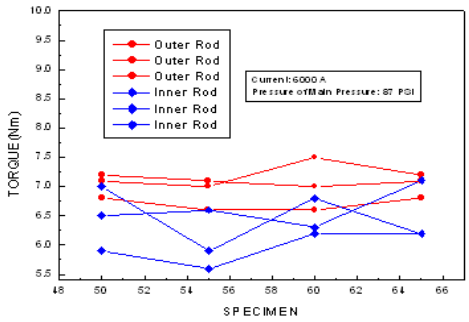

Figure 4.Torques of weldments between endplugs and endplates due to pressure of branch electrode.

Figure 5 shows the torques of outer and inner rods in welding between endplug and endplate on welding current 7000 ampere, pressure 73 psi of main electrode, and pressure 55 psi of branch electrode. The torques of inner rods were, on the whole, bigger than those of outer rods. Figure 6 and Figure 7 shows photographs of longitudinal cross sections with 30, 50 multiplications on welding between endplug and endplate, respectively. It was confirmed that the melting and mixing of weldment of endplug-endplate from middle parts of these photographs were not pertinent. The additional welding examinatons will be carried out for confirmnation of weldability between endplug and endplate of fuel bundles.

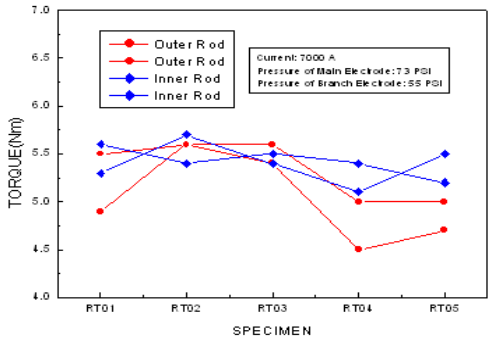

Figure 5.Torques of specimen weldments between endplugs and endplates due to welding condition.

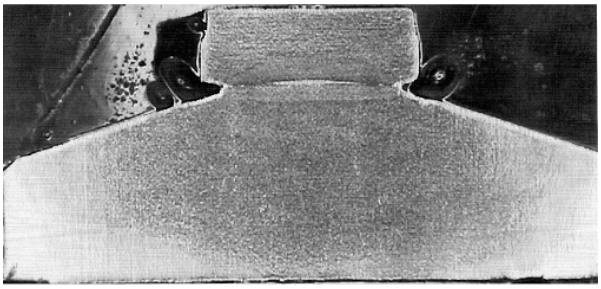

Figure 6. Photograph of cross section of weldments between endplugs and endplates(magnification 30).

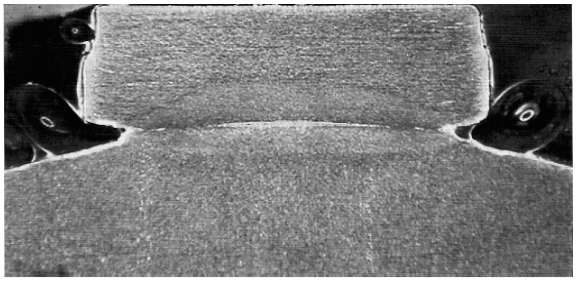

Figure 7. Photograph of cross section of weldments between endplugs and endplates(magnification 50).

4. Conclusion

Welding specimens on welding between endplug and endplate were fabricated using multi-pin remote welding system. The torques of welding specimens were measured and analyzed. The torques of outer rods of welding specimens due to welding current were, on the whole, bigger trend than those of inner rods. In the future, weldability of weldment between endpug and endplate of fuel bundles will be confirmed by performing optimal welding condition examinations.

References

[1] Truant. P.T., CANDU Fuel performance: Power Reactor Experience, AECL-MISE-250-3 rev.1, 1983.
[2] Vagi, J. J., Koppenhofer, R. L. and Martine, P. C.: Methods for End Capping Zirconium Clad Reactor Fuel Pins, Weld. J., Feb., pp. 78-84, 1959.
[3] Kanne, W. R. Jr., Solid-State Resistance Welding of Cylinders and Spheres, Weld. J., May, pp. 33-38, 1986.
[4] C. J. Park, et al., “A Study on the Characteristics of Zr-4 End Cap Welded Joints Using Resistance Upset Welding,” J. of the Korean Welding Society, Vol. 10, No. 4, p. 241, 1992.