Development of STS 316L End Cap Welding Technology for a Fuel Irradiation Test

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1. Introduction

The irradiation test of dual cooled fuel rod specimens was planned for the evaluation of a nuclear fuel performance.[1,2] To establish the fabrication process, and for satisfying the requirements of the irradiation test, an GTA(Gas Tungsten Arc) welding machine for the dual cooled fuel rod specimens was developed, and the preliminary welding experiments were performed to optimize the welding process conditions. Cladding tubes of 15.9 and 9 mm for the outer and inner diameters, respectively with a 0.57 mm thickness and end caps were used for the specimens.

This paper describes the experimental results of the GTA welds and the micrograph examinations of the GTA welded specimens corresponding to various welding conditions for the dual cooled fuel irradiation test. The investigations revealed that the present GTA process satisfied the requirements for the fuel irradiation test in the HANARO research reactor.

2. Materials and Experimental Results

2.1 Specimen Materials

All the specimens of the end caps and cladding tubes were made of STS 316L. Fig. 1 shows the components of a fuel rod specimen for the welding tests.

2.2 Welding Chamber

Welding chamber was developed as shown in Fig. 2 by using a GTA head torch in order to achieve a circumferential welding. The GTAW machine consists of a weld head torch, a vacuum chamber and a specimen holder. The torch head of the GTA welder used the linear guider method. The inert gas in the vacuum chamber was He of a UPC grade(99.9995%), and the vacuum rate was 5×10^{-2} torr.

2.3 Examination Procedure

The macro-sections of the dual cooled fuel rod specimens were investigated by a micrograph to determine the penetration depth of the STS 316L cladding tube. The welded specimens using the caps and cladding tubes were polished and etched electrically with the following etchant : H_2O 90%, oxalic acid 10% (Vol.%).

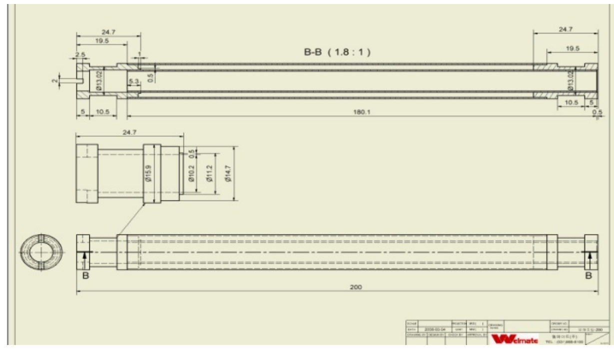
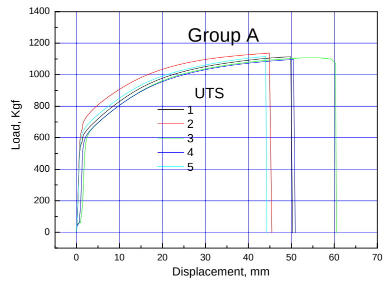


Fig. 1. Drawing of the fuel rod welding specimen components.

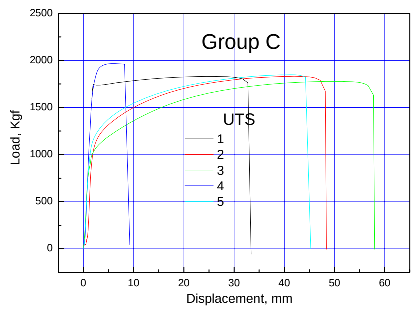
Fig. 2. Photography of the GTA welding chamber.

2.4 Investigation of the GTA Welded Specimens

In order to obtain the tensile strength of the corner (Group A) and butt (Group C) joints of the dual cooled fuel rod samples, the tensile strength values were measured on five of each welded specimens. It was found that the tensile strength of the TIG welded specimens were higher than that of the base metals. No significant difference could be found between the tensile properties of welded specimens and the joint geometry of the Group A and Group C. The failure of the transverse welded specimens occurred in the base metal near from the welded zone. Fig. 3 shows the stress-strain curves for the STS 316L welded specimens with Group A and Group C.



(Group A : corner joint)

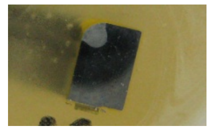
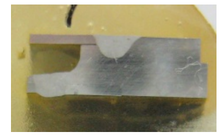
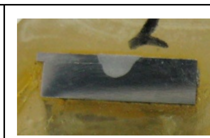


(Group C : butt joint)

Fig. 3. Stress–strain curves for STS 316L welded specimens with Group A and Group C.

In these welding sample tests using the welding procedure specification, end cap welded specimens were performed by a visual examination, He leak inspection and metallography examinations to check the penetration depth and the weld defects. Fig. 3 shows comparatively the macro-sections of the corner and butt welded specimens. All the specimens show that the penetration depth is very deeper than that of the thickness of the STS 316L cladding tube, and weld defects of the fuel specimens were not found. Especially it also shows that the bead width of the corner joint was slightly wider than that of the specimens with 25A of welding current. This was probably due to the higher fusion rates when compared with that of the previous geometry conditions during the solidification of the weld metal. In this experimental result, the soundness of the end cap welds quality for the dual cooled fuel rod specimens was confirmed by the macro-section of the welds and the microstructure examinations.

Fig. 4. Macro-sections of STS 316L end cap welds with dual cooled fuel rod specimens.

		
28A CORNER JOINT	40A BUTT 1 JOINT	40A BUTT 2 JOINT

3. Conclusion

The GTA welds for a dual cooled fuel rod for a fuel irradiation test were good in an inert He gas chamber. All the GTA welded specimens were free of defects and had good penetration depths, and the tensile strength was higher than that of the base metal. Based on these welding experiences, a fuel rod specimen will be provided for a fuel irradiation test at the HANARO research reactor.

Acknowledgements

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