Development of a Friction Welded Tube for Preventing a Leakage of Coolant into a Capsule

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1. Introduction

An instrumented capsule has been developed at HANARO (High flux Advanced Neutron Application ReactOr) for the neutron irradiation tests of nuclear reactor materials [1]. The temperature of the specimens during a irradiation is controlled by adjusting the internal He gas pressure in the capsule. After an irradiation test, the main body of a capsule is cut off at the bottom of the protection tube with a cutting system and it is transported to the IMEF hot cell and dismantled for post irradiation tests. At this cutting stage, the reactor coolant leaks into the capsule through the gas control pipe and it causes some troubles for the post irradiation analysis. To prevent a coolant leakage during a cutting, aluminum tube is especially attractive because of its superior workability. However, present structures made of stainless steels can not be entirely replaced with aluminum structures, by taking into account the strength, although it is possible to replace part of a structure with aluminum tube. In this case, it is necessary to join stainless steel to aluminum. Sound joints have been hardly obtained, owing to the formation of a large amount of brittle intermetallic compounds in the weld and to their big difference of the thermal expansion coefficients when using a conventional fusion welding [2]. Friction welding is known to be more effective in joining dissimilar metals when compared with a fusion welding, because it is a solid state process [2]. The friction welded tube has been also known to be applied in the irradiation capsules in JMTR (Japan Materials Testing Reactor) [3]. In the present study, a friction welded tube developed for the prevention of a coolant leakage into a capsule is described. The friction welded tube will be applied to all of the material capsules in HANARO.

2. Methods and Results

2.1 Design and Welding of a Friction Welded Tube

Based on the HANARO irradiation capsule design, a friction welded tube was designed as shown in Fig. 1. The commercially available type 1050 aluminum and type 304 austenitic stainless steel rods were used. At first, the rods were friction welded at Taekwang Tech co. and then machined to a final tube by a long drill machine at S&T Daewoo co. The aluminum alloy was bonded to the stainless steel using a continuous drive friction welding method. The welding parameters of a rotational speed 1,600rpm, friction pressure P_1 0.7MPa, upset pressure P_2 0.9MPa, and upset time t_2 0.2 sec and friction time t_1 0.3 sec were kept constant.

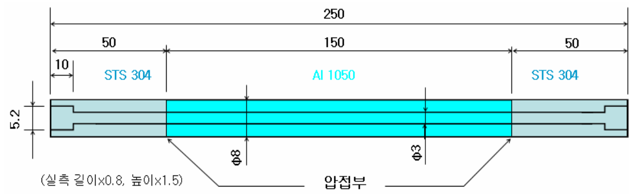

Figure 1. Drawing of a STS304-Al-STS304 friction welded tube for HANARO irradiation capsule.

2.2 Analysis of the Welded Interface

For the analysis of the welded interface, the microstructures and the joint strengths of the friction welded rod samples were examined. Fig. 2 shows the optical micrograph of the joint in the vicinity of the weld interface. It means a sound joint between two materials without any defects.

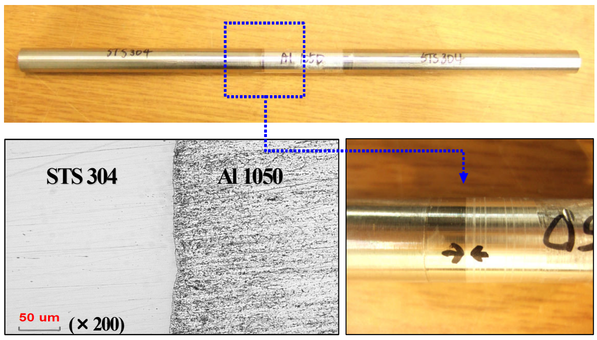

Figure 2. Optical micrograph of a STS304-Al-STS304 friction welded rod.

Figure 3 shows the Vickers hardness at the axial centerline of the joints. The hardness of the welded specimen decreased drastically across the interface and the thickness of the interface seems to be less than 2mm. Several joint rods were machined to half size tensile specimens. The joint strength was evaluated by tensile testing at room temperature using a Instron type machine and the joints after a tensile testing are shown in Fig. 4. The half size testpieces fractured in the 1050 alloy. It means that there was a sound welding between the STS304 and Al1050 alloys and it seems to be related to their similar FCC(face centered cubic) structure. And it also means that there were no harmful intermetallic compounds and they have higher strengths than the aluminum matrix.

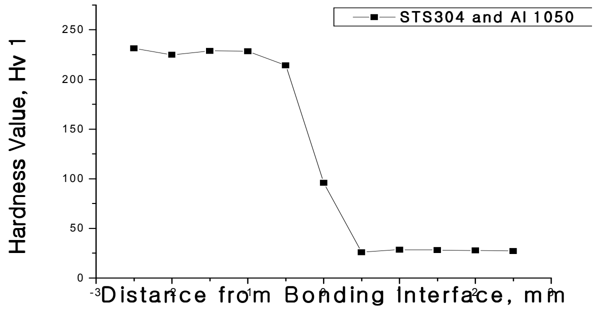

Figure 3. Vickers hardness in the vicinity of weld interface.

Figure 4. Appearance of the fractured tensile testpieces.

2.4 Friction Welded Tubes

For the final friction welded tube to apply it to a capsule system, a double friction welded rod was drilled at both end sides by using a long drill machine. Figure 5 shows the final tube samples drilled to have holes of 4 and 5 mm inner diameters, respectively. The friction welded tube is already known to have enough sealing effect during a cutting process in the HANARO system [6]. Therefore, the first friction welded tube will be applied to the 07M-13N irradiation capsule this year.

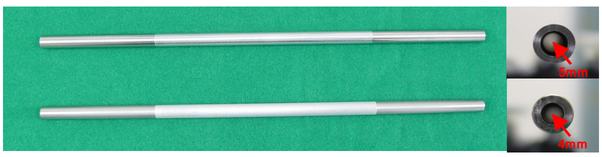

Figure 5. The final friction welded tubes for HANARO application.

3. Conclusion

A new friction welded tube between STS304 and Al1050 alloys was developed to prevent a coolant leakage into a capsule during a capsule cutting process in HANARO. The first friction welded tube will be applied to the 07M-13N irradiation capsule and irradiated in the HANARO reactor this year.

REFERENCES

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