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水中爆接タングステン被覆材の耐熱衝撃特性及び、機械的特性に関する研究
Research on mechanical property and resistance to thermal shock of tungsten cladded steels by underwater explosive welding

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1. Introduction

The plasma facing components using tungsten-coated reduced-activation ferritic (RAF) steels are key technologies to realize the fusion reactor because these components will be used in severe environments with energetic particle irradiation at high temperatures. It is known that explosive welding is a solid-state welding using a controlled energy of a detonating explosive on the material surface. Generally, explosive welding is performed in the atmosphere by placing an explosive on the one surface of the flyer plate located away from the base plate to achieve a desired velocity during collision of the plates. The underwater explosive welding developed by one of the authors has been successfully applied in the joining of many kinds of similar or dissimilar materials including a tungsten foil on a copper base plate. In the last report, the underwater explosive welding was successfully used to clad tungsten on F82H. The present study reports mechanical properties and resistance to thermal shock of tungsten cladded steels made by underwater explosive welding.

2. Experimental Method

Underwater explosive welding was carried out at Shock Wave and Condensed Matter Research Center, Kumamoto University. The base plate used for the underwater explosive welding is F82H-IEA (Fe-8Cr-2W-V-Ta-0.1C) with 50 mm × 50 mm × 3 mm thickness. The flyer plate used is tungsten foil, purchased from the Nilaco Co., with 30 mm × 30 mm × 0.2 mm thickness. Details are described by bibliography [1] about an explosive and a setup of under explosive welding. After joining, the specimens were cut as ϕ3mm×0.4mmt for small punch (SP) tests. Moreover, the laser-thermal shock test were performed.

3. Result and Discussion

The load-deflection curves obtained from SP tests are shown in Fig. 1. The load-deflection curve of the “fracture” specimen shows two sudden drops of load which may correspond to the occurrence of crack in the specimen. Therefore the other tests were terminated after the first drop and the second drop. The result of cross-sectional observation on first drop specimen revealed that the first crack during the SP test occurred in the middle of tungsten part as a perpendicular one to the loading direction at a load of approximately 350-400 N under the bending with a constraint of the joint interface.. In the second drop specimen, the cracks propagated into both the surface of tungsten and the interface. Finally, the both tungsten and F82H was completely ruptured as shown in the Fig. 2 “fracture” specimen. These results imply that the interface have an good bonding strength compared with the strength of tungsten under the small punch loading. Results of laser-thermal shock test will be shown in the conference.

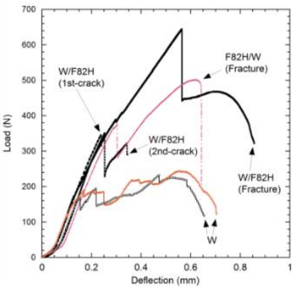

Fig.1 The fractographic study result in SP

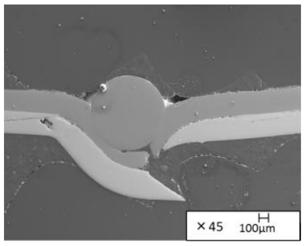

Fig. 2 Fracture specien

4. Conclusion

Underwater explosive welding was successfully utilized to clad tungsten on F82H RAF steel. SP tests on the welded specimens resulted in the cracking in the tungsten part firstly followed by the propagation into the surface of tungsten and the interface.

Reference

[1] K.Hokamoto, K.Nakata, A.Mori, S.Tsuda, T.Tsumura, A.Inoue, “Dissimilar material welding of rapidly solidified foil and stainless steel plate using underwater explosive welding technique”, Journal of Alloys and Compounds 472 (2009) 507-511