§28. R&D of Joining Technology between Dissimilar Materials for Metallic Components in Blanket

Serizawa, H., Ogiwara, H., Mori, H., Fujii, H., Saida, K. (Osaka Univ.),
Nogami, S., Hasegawa, A. (Tohoku Univ.),
Kimura, A., Kasada, R. (Kyoto Univ.),
Tanigawa, H., Hirose, T. (Japan Atomic Energy Agency),
Nagasaka, T., Nishimura, A., Muroga, T., Sagara, A.

Reduced activation metallic materials such as F82H and ODS (oxide-dispersion strengthened alloy) have been developed as the structural materials for blanket module of fusion reactors. In spite of spectacular progress for these metallic materials, it is unrealistic to contribute the whole blanket system by using only these materials due to the economical efficiency. So, the joining method between the reduced activation materials and other metallic materials has to be developed in order to realize the fusion reactors with high efficiency in the future. In this research, friction stir welding (FSW) of F82H & ODS and high-brightness laser welding of F82H & SUS316L are selected as the most candidate joining methods for studying their reliability and potential according to our previous surveys[1)].

Before developing the dissimilar joint between F82H and ODS, the applicability of FSW to ODS has been examined by changing the rotational speed from 250 to 400 rpm with keeping the same values of traveling speed and compressive load[1)]. There were not any defects on the top and bottom surfaces after FSW in any cases. Figure 1 shows cross sectional views and Vickers hardness distributions of joints with 250 and 400 rpm. From the microstructural observations, it was found that the stir zone became larger with increasing the rotational speed. Vickers hardness distributions indicated that the surface was largely heated in comparison with the bottom and Vickers hardness at the surface became smaller than that at the bottom. Also, in the case of 250 rpm, the hardness of stir zone at the middle and the bottom kept that of the base material and it was considered that the change of hardness of stir zone might be prevented by setting the rotational speed to be less than 250 rpm. Moreover, from the measurements of grain size of stir zone, it was revealed that the Hall-Petch relation was established between the hardness and grain size regardless of the rotational speed.

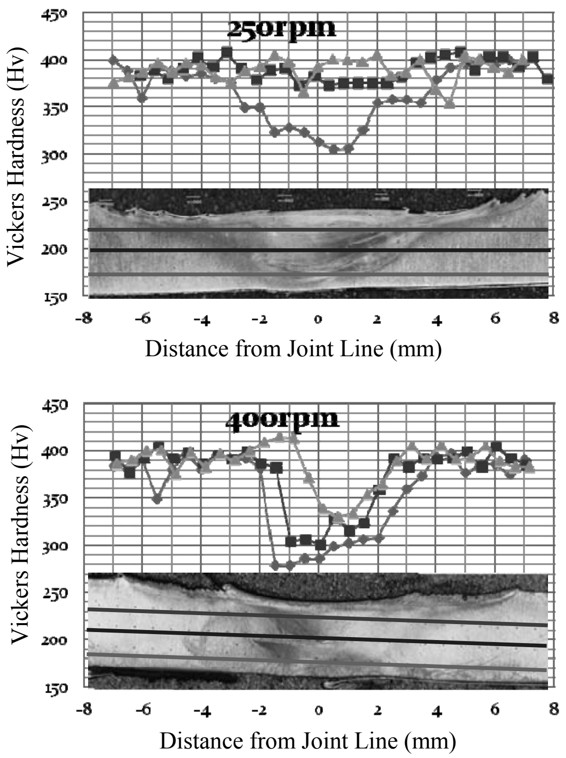


Fig. 1 Cross-sectional Vickers hardness distributions in F82H/ODS joints joined by FSW.

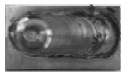
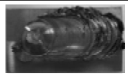
Insert Position of Tool	Advancing Side (AS)		Retreating Side (RS)	
ODS	 10mm	Probe was broken		Insufficient of Heat Input
F82H		Good		Probe was broken

Fig. 2 Overview of dissimilar joint between ODS and F82H by FSW.

According to the above results, it is confirmed that FSW is the most candidate joining method for ODS, then FSW was applied for joining two plates of ODS and F82H. Figure 2 shows the overviews of dissimilar joints between ODS and F82H, where the insert position of tool and the position of plate to weld direction were varied. The traveling speed, the compressive load for tool and the rotational speed were 50 mm/min, 2 ton and 200 rpm, respectively according to the results of ODS joint. In these four cases shown in Fig. 2, the good joint was obtained when the tool was inserted in F82H and F82H was set to the advancing side. So, the microstructural analyses and mechanical evaluations will be conducted in order to reveal the appropriate condition for FSW of ODS-F82H joint.

Regarding the high-brightness laser welding of F82H & SUS316L, it has been found that the laser beam position should be shifted to SUS316L and the beam position is the most important factor to develop the candidate F82H-SUS316L joint[1)]. So, by changing the beam position and the welding speed, F82H and SUS316L were butt joined by using 4kW fiber laser and their Charpy impact energy were measured before and after the post weld heat treatment (1 h at 720 ^{o}C). From the results, it was found that the Charpy energy increased by applying the heat treatment. In addition, the Charpy energy before the heat treatment increased by shifting the beam position. However, when the welding speed was 4 m/min, the Charpy energy after the heat treatment was decreased by shifting the beam position. So, in order to reveal the mechanism of this decrease, the further evaluations will be conducted.

1) Serizawa, H. et al: Annual Report of National Institute for Fusion Science, April 2011 – March 2012 (2012) 228.