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

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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)]

Our previous studies about the dissimilar joint between F82H and 15Cr-ODS suggests that ODS should be placed at the advancing side while F82H is set at the retreating side.[2)] Figure 1 shows the overviews of dissimilar joint, where the insert position of tool and the rotational speed were varied. The traveling speed and the compressive load for tool were 50 mm/min and 2 ton, respectively. From these results shown in Fig. 1, it was found that the good joint could be obtained when the tool was inserted in F82H and F82H was placed at the retreating side.

Since 12Cr-ODS was produced through this joint research project, the trial researches about the dissimilar joint between F82H and 12Cr-ODS were conducted according to the above results. From these trials, it was revealed that the sound joint could be obtained by reducing the total heat input due to the difference of mechanical properties between 15Cr-ODS and 12Cr-ODS. In concrete terms, the compressive load of tool, the rotational speed and the probe length should be changed. So, the probe length was set as 1.0 mm for 1.5 mm thickness 12Cr-ODS while

| Insert Position of Tool | ODS Advancing Side (AS) | | F82H Retreating Side (RS) | |
|---|---|---|---|---|
| 250 rpm |  10mm | Probe was broken |  | Good |
| 200 rpm |  | Probe was broken |  | Insufficient of heat input |

Fig. 1 Overview of dissimilar joint between 15Cr-ODS and F82H by FSW.

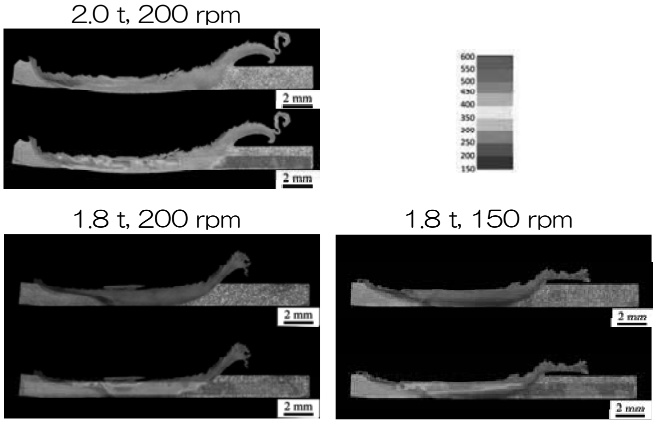


Fig. 2 Cross sectional Vickers hardness distributions in F82H/12Cr-ODS joints joined by FSW.

the 1.3 mm length probe was employed for 1.5 mm thickness 15Cr-ODS. Then dissimilar joints between F82H and 12Cr-ODS were manufactured by using FSW where the compressive load was varied from 1.8 to 2.0 ton, and the rotational speed was changed from 150 to 200 rpm. Figure 2 shows the cross sectional views and Vickers hardness distributions of joints. The flat joints could be obtained when the compressive load was 1.8 ton, whereas the joint was bended by the excessive load in the case of 2.0 ton compressive load. Also, it was found that the hardness in the stir zone was almost homogeneous when the rotational speed was 200 rpm, while the hardness in the stir zone distributed along the plate thickness in the case of 150 rpm. Since FSW is one of the solid state joining methods and the smaller heat input is preferred, the 150 rpm seems to be an appropriate condition for the dissimilar joint between F82H and 12Cr-ODS.

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[1,2)]. So, by changing the beam position precisely, F82H and SUS316L were butt joined by using 4kW fiber laser and the microstructural changes near the weld metal was examined before and after the post weld heat treatment (PWHT) (1 h at 720 $^{o}$C). Also, the tensile strength of joint after PWHT was evaluated. From the results, it was found that the micro hardness of weld metal partially decreases after PWHT by shifting beam position to SUS316L because its phase seems to move from only the martensitic phase to the mixture of austenitic and martensitic phases. In addition, the tensile test indicates that the tensile strength of weld metal is higher than that of SUS316L and the fracture occurs at the base metal of SUS316L regardless of laser beam position.

1) Serizawa, H. et al.: Ann. Rep. NIFS (2011-2012) 228.
2) Serizawa, H. et al.: Ann. Rep. NIFS (2011-2012) 256.