§29. 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 vanadium alloys have been developed as the structural materials for blanket module of fusion reactors. In spite of spectacular progresses 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.

Based on various previous researches from the viewpoints of fusion reactor material science, fusion design engineering and welding science, the dissimilar joints shown in Table 1 were selected as the most candidate joints for studying their reliability and potential.

Since the recent advanced high-brightness lasers such as fiber laser and disk laser are new heat source with high beam quality which can produce MW/mm^2 class power density similar to the electron beam, the fiber laser welding is expected to minimize input energy in the weld joints. So, the applicability of fiber laser welding to the butt joint between F82H and SUS316L was examined by using 4kW fiber laser. The position of laser beam was varied from the contact face to SUS316L side. Also, the welding speed was varied to examine the heat input influence of the weldability.

Since the diameter of laser beam was only 0.2 mm, the lack of penetration was observed in the cases that the laser beam was shifted at 0.3 mm to SUS316L. On the other hand, the welding defect was not observed in the cases that the shift was less than 0.2 mm as shown in Fig. 1, where laser position and welding speed were listed in the bottom. From the results of indentation test, it was found that the hardness of heat affected zone (HAZ) in F82H increased in all cases while that of weld metal (WH) increased in only the case that the laser beam was not shifted. Although there were not any microstructural changes in HAZ and WM after the post weld heat treatment (PWHT) at 720 ^{o}C for 1 hour,

Table I Dissimilar joint selected as most candidates for contributing fusion reactor with high efficiency.

Materials	Joining Method
F82H & SUS316L	High-brightness Laser Welding
F82H & ODS	Friction Stir Welding
Vanadium Alloy & Ni-base Alloy	Diffusion Bonding Brazing

ODS : Oxide-Dispersion-Strengthened Alloy

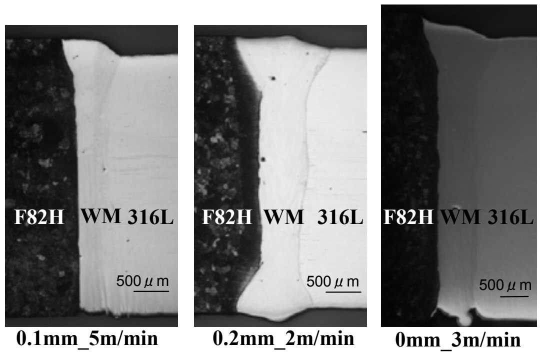

Fig. 1 SEM images of dissimilar joints between F82H and SUS316L produced by 4kW fiber laser.

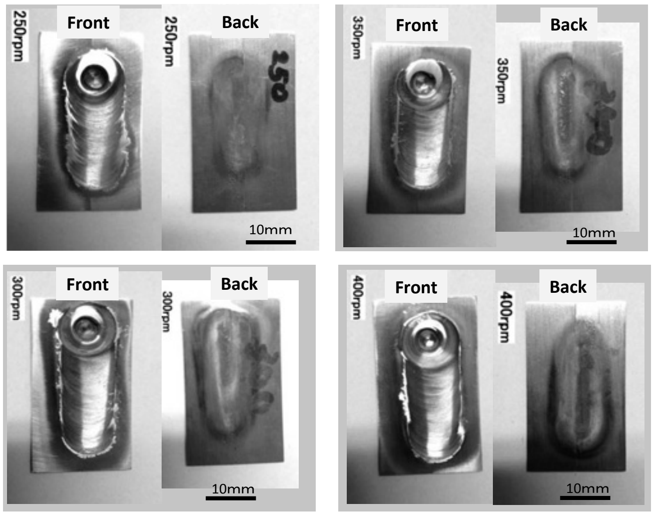

Fig. 2 Top and bottom surfaces of ODS joint by FSW.

the hardness of HAZ decreased to almost the same as the base metal in the cases that the laser beam was shifted at more than 0.1 mm to SUS316L. On the other hand, in the case that the laser beam was not shifted, the hardness of HAZ and WM did not change to the base metal after PWHT. Then, it was revealed that the appropriate control of laser beam position would be a key issue to develop the candidate dissimilar joint between F82H and SUS316L.

Before developing the dissimilar joint between F82H and ODS, the applicability of friction stir welding (FSW) to ODS was examined. The two plates were butt joined by using FSW, where the rotational speed was varied from 250 to 400 rpm. The FSW tool had a cylindrical shoulder of 12 mm in diameter and a probe of 4 mm in diameter and 1.3 mm in length. The traveling speed and the compressive load for tool were 50 mm/min and 2 ton, respectively.

Figure 2 shows the top and bottom surfaces of ODS joints joined by FSW. Since the higher rotational speed has the larger heat input during FSW, there was a relatively larger heat affected zone in the case with the rotational speed of 400rpm. However, any defects were not observed in both top and bottom surface regardless of the rotational speed. So, the appropriate condition for FSW of ODS could be obtained according to the microstructural analyses and mechanical evaluation.