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Development of dissimilar-metals joint of oxide-dispersion-strengthened (ODS) and non-ODS reduced-activation ferritic steels

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Reduced-activation ferritic steels and their oxide-dispersion-strengthened (ODS) alloys are promising structural material for fusion blanket. The ODS steels are superior to the non-ODS steels in heat resistance and neutron irradiation resistance, however inferior in mass production. Since high temperature and high neutron dose area is limited at only the first wall section of the blanket, minimized application of ODS steels there is the most effective to utilize the advantage of ODS steels. In order to prove the feasibility of this advanced concept, dissimilar-metals joint of 9Cr-ODS steel and JLF-1 non-ODS steel were fabricated with electron-beam welding (EBW) and hot iso-static pressing (HIP) processes. Welding conditions were optimized based on systematic experiments with change in fabrication process parameters.

Hardening occurred in weld metal and heat-affected zones of EBW joint, and in base metals of HIP joint. The hardening is due to formation of quenched martensite phase. Since the hardening induces ductility loss, post-weld heat treatment (PWHT) was carried out for hardness recovery. In the case of EBW joints, the complete recovery of hardness was obtained by tempering at 780℃ for 1 h. In the case of HIP joint, carbide coarsening in the base metals and decarburization around the bonding interface were observed, in addition to the formation of quenched martensite. In order to recover all these microstructural changes, normalizing at 1050℃ for 1 h was required before the tempering. Tensile strength of the EBW joint was 580 MPa after the PWHT, and is equivalent to that of JLF-1 before EBW. Tensile strength of the HIP joint after the PWHT depends on HIP temperature. It was 370 MPa, 660 MPa and 580 MPa for 1000℃, 1050℃ and 1100℃ HIP specimens, respectively. The 1050℃ and 1100℃ HIP specimens fractured in JLF-1 base metal, while the 1000℃ HIP specimen fractured at the bonding interface. 1050℃ and 1100℃ are suitable for HIP temperature to maintain the strength of joint. Requirements for the dissimilar-metals joint in the structure design are the strength no less than that of JLF-1 base metal and no fracture at the bonding interface. These requirements are satisfied with proper welding conditions including PWHT. In conclusion, the advanced blanket utilizing ODS steels is feasible by using the bonding techniques developed in the present study.

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