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Effects of process variables on microstructure and tensile properties of friction stir welded ARAA

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Plasma facing component such as breeding blanket and divertor in fusion reactors are supposed to be assembled by welding and joining of parts made of reduced-activation ferritic-martensitic (RAFM) steel, and accordingly the structural integrity is significantly affected by the properties of the joint. Conventional fusion welding results in a wide heat-affected zone (HAZ) where a well-known type IV cracking occurs in RAFM steels under creep condition. In the present work, an attempt was made to butt weld the ARAA (advanced reduced-activation alloy; the Korean RAFM steel) sheets by the friction stir welding (FSW) technique, for which we investigated how the welding condition and post-weld heat treatment (PWHT) affect the microstructure and tensile properties of the joint. Microstructure of the as-welded ARAA was found to consist of a martensitically transformed zone (MTZ), a mixed zone (MZ) of fresh martensite and heat-affected tempered-martensite structures, HAZ, and base material in order outward from the welded interface. The hardness measurements showed a significant hardening in MTZ, an abrupt decrease of hardness towards HAZ in MZ, and the lowest hardness in HAZ. It is noteworthy that increasing the rotational speed and applied load, or decreasing the traveling speed increased the width of MTZ and reduced that of HAZ, which in turn led to increases of the tensile yield strength and ductility of the as-welded ARAA. PWHT conducted at 700 C resulted in transformation of martensite to tempered-martensite in MTZ and MZ while no significant change occurred in other zones. Such changes of microstructure reduced the gradient of hardness between MTZ and HAZ and the degree of strain-localization in HAZ. It is proposed that FSW technique can be utilized for butt welding of thin RAFM steel parts.

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