Kinetics of the Ferrite/Austenite Phase Transformation in the HAZ of a 2205 Duplex Stainless Steel Weldment Based on Spatially Resolved X-Ray Diffraction Observations

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Abstract

Spatially resolved X-ray diffraction (SRXRD) with high intensity synchrotron radiation provides for the direct real time observation of the ferrite (δ)/austenite (γ) transformation in the heat affected zone (HAZ) of a 2205 duplex stainless steel during the GTA welding. A semi-quantitative map of the progression of the δ/γ phase balance under the heating and cooling conditions prevalent throughout the HAZ has been developed from a series of these SRXRD scans. This map provides the basis for modeling the kinetics of the δ/γ phase transformation under typical welding conditions. It also shows a decrease in the ferrite fraction on heating, followed by a recovery to the original ferrite fraction on cooling at locations within the HAZ. Such behavior is supported by thermodynamic calculations. However, the kinetics of these reactions has yet to be evaluated using the diffusional redistribution of either substitutional (Cr, Ni) or interstitial (C and N) elements. A model, coupling the calculation of the thermal history of the weld with the diffusion of various alloying elements, including nickel, chromium, molybdenum, and nitrogen, across the δ/γ interface, is developed here. Results from this model in conjunction with SRXRD and microstructure characterization are used to determine the rate controlling steps for phase transformations in DSS welds. Based on these calculations, a more complete model of the HAZ microstructure is developed.

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