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The Effect of Bulk Alloy Composition on Driver Mechanisms for Irradiation-assisted Stress Corrosion Cracking

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Abstract

A significant amount of research is currently being performed worldwide to develop a deterministic understanding of the causes of irradiation assisted stress corrosion cracking (IASCC). Both radiation-induced segregation (RIS) and radiation-induced hardening of the matrix have been theorized to contribute to IASCC. The amount of RIS and matrix hardening and the IASCC response of a reactor structural component are all dependent on the bulk composition. In this work, five alloys have been studied: Fe-18Cr-8Ni alloy (bulk composition corresponding to 304 stainless steel), Fe-18Cr-40Ni (bulk composition corresponding to 330 stainless steel), and Fe-16Cr-13Ni, Fe-16Cr-13Ni-2.5Mo, and Fe-16Cr-13Ni-2.5Mo+P (bulk compositions corresponding to 316 stainless steel). Following irradiation with high-energy protons, the change in hardness and microstructure due to irradiation are investigated. Increasing the bulk nickel concentration, which is known to mitigate IASCC, increases matrix hardening and increases the magnitude of radiation-induced segregation. Therefore, alloys with greater RIS and greater hardening are not necessarily susceptible to IASCC. The analysis shows that decreases in lattice parameter and shear modulus due to radiation-induced segregation correlate with a decreased susceptibility to irradiation assisted stress corrosion cracking (IASCC). Whereas traditional thinking on IASCC assumed RIS was a contributing factor to cracking, it may be that properly controlled RIS can be used to mitigating cracking.

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