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Frequency-Dependent Fatigue Crack Growth in Stainless Steels in Simulated LWR Environments

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The author has recently developed a model to predict an upper-bound fatigue crack growth (FCG) rate for a metastable stainless steel immersed in various hydrogenated environments at ambient temperature and proposed that the high-frequency regime behavior is governed by hydrogen diffusion and can be adequately described by da/dN ∝ 1/(f)□ where □ varied depending on the alloy microstructure, applied stress intensity factor (□K), loading ratio, and the environment. The model predicts a frequency-independent upper-bound FCG rate for solution-annealed 304 type stainless steel as a function of the maximum stress intensity factor (Kmax). The model prediction shows good agreement with FCG data for 304 stainless steel in different hydrogenated environments.

The main objectives of this paper are two-fold. First, to compile fatigue crack growth (FCG) data generated at variable frequency from the open literature for different austenitic stainless steels exposed to simulated light water reactors (LWR) environments and to characterize the time-dependency of the possible governing crack-tip processes. Second, an attempt will be carried out to check the applicability of the prediction model to FCG data of stainless steels in LWR conditions taking into consideration the high-temperature effects on the mechanical properties and hydrogen diffusivity. The modified model prediction will be compared with available data in the literature. An upper-bound FCG prediction model for stainless steel exposed to hydrogenated water environments can be used for service-life assessment methods.

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