MODELING THE FREQUENCY-DEPENDENT HYDROGEN-ASSISTED FATIGUE CRACK GROWTH IN ENGINEERING ALLOYS

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The aim of this paper is to present a mechanistic model to describe frequency-dependent hydrogen-assisted fatigue crack growth (*HA-FCG*) in a variety of engineering alloys exposed to hydrogenated environments. Intrinsic da/dN vs. frequency data generated at constant ΔK for various microstructures of 7000 aluminium alloys, austenitic stainless steels, and steel alloys immersed in chloride aqueous solutions exhibit a high-frequency regime that can be described by $da/dN \propto 1/(f)^a$. As the frequency is reduced, the HA-FCG generated at constant ΔK show a frequency independent regime below a critical frequency (f_{crit}) where da/dN become essentially constant over a wide range of frequencies. A model is proposed where the HA-FCG rate at a given ΔK is primarily governed by H diffusion and accumulation ahead of the crack-tip at a distance where the tensile and hydrostatic stresses are at their maximum values. The critical frequency at a given ΔK corresponds to a saturated H concentration level attained at the crack-tip peak local stress resulting in a f-independent plateau HA-FCG rate for all $f < f_{crit}$. The model predictions of the frequency-independent rate show good agreement with FCG data for several alloys exposed to hydrogenated environments. The f-dependent HA-FCG is postulated to be the result of the competing effects of H diffusion and the dominate crack-tip trapping processes.