UNUSUAL BEHAVIOR OF LONG CRACKS AT LOW DK: MARCI EFFECT

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In this article, an unusual dip and then acceleration or a plateau in the fatigue crack growth (FCG) rate, da/dN, at low values of stress intensity factor range, ΔK (around or below ΔKth), is discussed. Conventional application of linear elastic fracture mechanics to FCG analysis assumes that da/dN decreases monotonically with decreasing ΔK and approaches the threshold value of ΔK_{th} with da/dN ≤ 10-7 mm/cycle. However, such monotonic behavior is only reported consistently in vacuum, whereas in an active environment such as humid lab air, some materials exhibit a dip and acceleration in da/dN-ΔK at around ΔKth for long cracks tested in both constant K_{max} and R ratio conditions. Other materials exhibit a plateau between10^{-7}-10^{-6} mm/cycle where FCG rates are hardly affected by decresing applied DK. On the other hand, in vacuum, these alloys show continously decreasing FCG rate till $3x10^{-10}$ mm/cycle. This unexpected da/dN-ΔK behavior is not understood and cannot be explained based on the plasticity, roughness, or oxide induced crack closure (PICC, RICC, or OICC) assumptions. An understanding of this unusual behavior and the physics behind it represents a challenge to the scientists and engineers. Overlooking or ignoring it would only delay future progress in better modelling and safe fatigue life prediction of structures under service loads.