Mean-stress sensitivity of an ultrahigh-strength steel under uniaxial and torsional high and very high cycle fatigue loading

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Abstract

The influence of load ratio on the high and very high cycle fatigue (VHCF) strength of Ck45M steel processed by thermo-mechanical rolling integrated direct quenching was investigated. Ultrasonic fatigue tests were performed under uniaxial and torsional loading at load ratios of R = -1, 0.05, 0.3 and 0.5 with smooth specimens and specimens containing artificially introduced defects. Up to 2×10 ^{5} cycles, failure originated from surface aluminate inclusions and pits under both loading conditions. The prevailing fracture mechanisms in the VHCF regime were interior crack initiation under uniaxial loading and surface shear crack initiation under torsional loading. The mean-stress sensitivity and the fatigue strength were evaluated using fracture mechanics approaches. Equal fatigue limits for uniaxial and torsional loading were determined considering the size of crack initiating defects and the appropriate threshold condition for Mode-I crack growth. Furthermore, the mean-stress sensitivity is independent of loading condition and can be expressed by σ w R = σ w R = - 1 [?] 1 - R 2 0.63 and τ w R = τ w R = - 1 [?] 1 - R 2 0.63 .

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