Near-threshold behavior of mode II and III fatigue cracks in ferritic and austenitic steel

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In the pre-cracked or notched specimens, the long cracks can keep growing under shear loading modes II or III until the final fracture provided that the remote ΔK_{II} (ΔJ_{II}) or ΔK_{III} (ΔJ_{III}) are sufficiently high (Paris-Erdogan and/or near-fracture region). In the near-threshold region, however, the plastic zone size is comparable to (or less than) the characteristic microstructure distance and crack-wake asperities do not mutually destroy by an abrasive wear. Consequently, both the interactions of the crack front with microstructure barriers and the asperity interactions in the crack wake lead to local kinking and/or twisting followed by crack propagation under local modes I, I+II, I+III or I+II+III. Thus, the resulting crack path geometry usually appears to be very complicated; the factory-roof fracture morphology is one of apposite examples. Also in smooth specimens under torsion, the stage-II fatigue cracks mostly propagate in mode I along the principal planes inclined at 45◦ to the specimen axis. In general, however, there is still a poor knowledge of growth micromechanisms of shear-mode cracks and conditions of their transfer to mode I propagation. Diversity of microstructures and the related crack-wake friction levels of fatigue pre-cracks in metallic materials was, most probably, the reason for a high scatter in previously obtained shear-mode threshold values $\Delta K_{II,th}$ and $\Delta K_{III,th}$. Moreover, these rather sporadic data could be seriously challenged with respect to well-known problems with performing relevant experiments.

This study is focused on the behavior of near-threshold long fatigue cracks under remote modes II and III in the ARMCO iron and the austenitic steel. Main emphasize is given to differences in mode II and III fracture morphologies and the related crack paths. In order to obtain sufficiently reliable results, an extended statistical analysis was carried out using both the SEM-based stereophotogrammetry and the optical chromatography. Careful measurements of nearly effective thresholds $\Delta K_{IIeff,th}$ and $\Delta K_{IIIeff,th}$ were also performed by means of two different experimental arrangements for either of the two loading modes. The results are discussed in a context with previously obtained data for various metallic materials.