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J-integral analysis of surface cracks in round bars under combined loadings tension

Abstract

This paper presents a non-linear numerical investigation of surface cracks in round bars under combined bending and torsion loadings by using ANSYS finite element analysis (FEA). Due to the non-symmetrical analysis, a full finite element (FE) model was constructed and special attention was given at the crack tip of the cracks. The surface cracks were characterized by the dimensionless crack aspect ratio, a/b = 0.6, 0.8, 1.0 and 1.2, while the dimensionless relative crack depth, a/D = 0.1, 0.2 and 0.3. The square-root singularity of stresses and strains was modeled by shifting the mid-point nodes to the quarter-point locations in the region around the crack front. The proposed model was validated with the existing model before any further analysis. The elastic-plastic analysis under the loading was assumed to follow the Ramberg-Osgood relation with strain hardening exponent, n = 5 and 10. J values were determined for all positions along the crack front and then, the limit load was predicted using the J values obtained from FEA through the reference stress method.

Keywords — Finite element analysis, j-integral, limit load, stress intensity factor, surface crack