A semi-analytical method to evaluate the J-R curve for the surface-cracked round bar under three-point bending

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Abstract

The current paper presents a semi-analytical method for obtaining J -R curves of round bars with elliptical cracks. This method derives the semi-analytical expressions between load and displacement, J -integral and displacement for surface-cracked round bars, based on the energy density equivalence principle, taking into account the effect of material and crack size. The validity of semi-analytical expressions examined by three-dimensional finite element analysis shows that load~displacement curves and J -integral~load curves predicted by the expressions match well with the simulation results. Through fracture toughness testing conducted on the carbon steel 45, the load~displacement data are used to calculate the average J -R curves for the surface-cracked round bar by the semi-analytical expressions. With the distributions of J -integral along the crack front obtained from three-dimensional finite element analyses, this study also determines the J -R curves at different crack-front points.

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