Crack Orientation and Residual Stress on Stress Intensity Factors of Welded Steel Joints

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Abstract

Assessing the structural integrity of a cracked weldment is significant in engineering. When cracks are detected during welding inspection, they must fit the mechanical resistance of the structure. Generally, fracture mechanics supplies the essential tools to examine cracked structures in order to determine a fracture criterion for loading conditions. This study explores the effect of residual stress (RS) and crack orientation on determining the stress intensity factor (K_I) in mode I for a welded joint using the extended finite element method (XFEM). This research consists of two parts. The first part is a 3D thermo-mechanical finite element (FE) analysis that is established to study the temperature history and the residual stress distribution of a welded joint. The second part is a 3D FE crack model that establishes two cases of cracks, longitudinal and transverse cracks, in order to calculate K_I and J-integral values at the middle surface of a thin butt joint. K_I is calculated for cracks under applied external stress and residual stress. The results demonstrate that the effect of the welding residual stress on K_I is either beneficial or detrimental, depending on the stress distribution and sign. Moreover, the results indicate the significance of RS and crack orientation on K_I. From the simulation performed during the analysis, we show that the longitudinal crack in case (I) has higher K_I values than those in case (II) for the transverse crack. Finally, the finite element results are in good agreement with the analytical results.

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