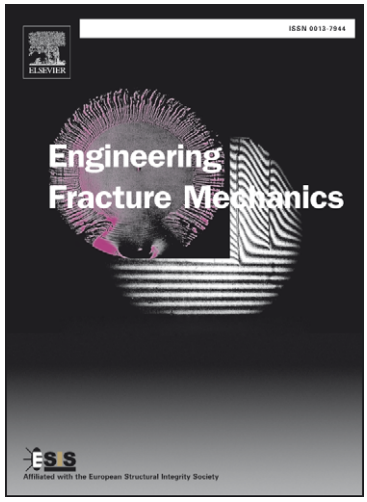

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Abstract

This paper considered the test specimen thickness (TST) effect on the fracture toughness of a material J_c in the transition temperature region for 3 point bending (3PB) specimens. Fracture toughness tests and elastic-plastic finite element analyses (FEA) with non-standard test specimens, which are non-standard because the specimen thickness-to-width ratio B/W was varied in the range of 0.25 to 1.5, were conducted. Based on these tests and the FEA results, it was demonstrated that the "planar" ($4\ _t,\ _{22c}$) failure criterion—which states that cleavage fracture after significant plastic deformation occurs when the crack opening stress $_{22}$ at a distance from the crack-tip that is equal to 4 times the crack-tip opening displacement $_t$ exceeds a critical value $_{22c}$—was verified to effectively explain the TST effect. This ($4\ _t,\ _{22c}$) criterion also successfully predicted the tendency of J_c to saturate to some bounding value for B/W=1.0. This tendency was similar to that of the T_{33}-stress, which is the out-of-plane elastic crack-tip constraint parameter. Because the ($4\ _t,\ _{22c}$) criterion could predict the TST effect on J_c and because the criterion could predict the bounded behavior of J_c for large B/W, the TST effect was concluded to be mainly mechanical in nature, which the weakest link model fails to predict. The mechanical cause of the TST effect on J_c was considered to be an out-of-plane crack-tip constraint, and one of its measures of magnitude is the T_{33}-stress.

Key words: Fracture mechanics; Constraint effect, Fracture toughness, Cleavage fracture, Transition temperature, Thickness effect, 3PB specimen.