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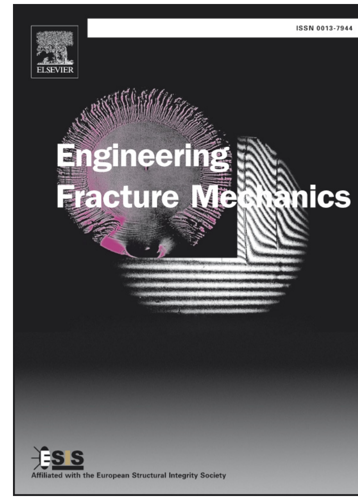

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An engineering methodology for constraint corrections of elastic-plastic fracture toughness - Part II: Effects of specimen geometry and plastic strain on cleavage fracture predictions

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Abstract

This work extends a micromechanics model for cleavage fracture incorporating effects of plastic strain to determine the reference temperature, T_0, for an A515 Gr 65 pressure vessel steel based on a modified Weibull stress ($\tilde{\sigma}_w$). Non-linear finite element analyses for 3-D models of plane-sided SE(B) and PCVN specimens define the relationship between $\tilde{\sigma}_w$ and J from which the variation of fracture toughness across different crack configurations is predicted. The modified Weibull stress methodology yields estimates of T_0 from small fracture specimens which are in good agreement with the corresponding estimates derived from testing of larger crack configurations.

Keywords: Cleavage Fracture, Local Approach, Weibull Stress, Plastic Strain, Probabilistic Fracture Mechanics

1 Introduction

The increasing demand to ensure acceptable levels of structural safety, including repair decisions and life-extension programs for aging structures, has spurred the development of advanced procedures for cleavage fracture assessments of critical engineering components such as, for example, nuclear reactor pressure vessels (RPVs), hydrocarbon-processing industry (HPI) pressurized equipment and storage tanks, among others. Current defect assessment procedures of large engineering structures [1, 2, 3] employ macroscopic measurements of cleavage fracture toughness (such as the J-integral at cleavage instability, J_c, or the critical Crack Tip Opening Displacement, CTOD or δ_c) derived from laboratory testing of conventional fracture specimens containing deep, through cracks ($a/W \geq 0.5$). These toughness measures must satisfy parametric limits on the crack-tip deformation relative to crack length, specimen thickness and remaining crack ligament such that high constraint conditions, similar to those of small-scale yielding (SSY), are maintained over microstructurally significant size scales at the crack-tip region. However, much previous research shows the potentially strong effects of specimen geometry and loading mode on cleavage fracture toughness values (J_c, δ_c) measured

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