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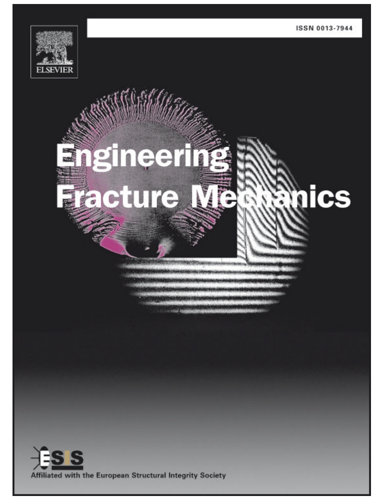

A Local Approach to Cleavage Fracture Modeling: An Overview of Progress and Challenges for Engineering Applications

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A Local Approach to Cleavage Fracture Modeling: An Overview of Progress and Challenges for Engineering Applications

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Abstract

This paper provides an overview of recent progress in probabilistic modeling of cleavage fracture phrased in terms of a local approach to fracture (LAF) and the Weibull stress concept. Emphasis is placed on the incorporation of plastic strain effects into the probabilistic framework by approaching the strong influence of constraint variations on (macroscopic) cleavage fracture toughness in terms of the number of eligible Griffith-like microcracks which effectively control unstable crack propagation by cleavage. Some recent results based on a modified Weibull stress model to predict specimen geometry effects on J_c-values for pressure vessel grade steels are summarized in connection with an engineering procedure to calibrate the Weibull stress parameters. These results are compared against corresponding fracture toughness predictions derived from application of the standard Beremin model. Finally, the robustness of LAF methodologies, including specifically the Weibull stress approach, is critically examined along with a discussion of key issues and challenges related to engineering applications in fracture assessments of structural components.

Keywords: Cleavage Fracture, Local Approach, Weibull Stress, Plastic Strain, Constraint Effects

1 Introduction

The increased demand for more accurate structural integrity and fitness-for-service (FFS) analysis of a wide class of engineering structures, including nuclear reactor pressure vessels, piping systems and storage tanks, has stimulated renewed interest in advancing current safety assessment procedures of critical structural components, including life-extension programs and repair decisions of aging structures. Simplified fracture mechanics based approaches for quantitative analysis of material degradation, as of interest in assessments of crack-like flaws formed during in-service operation, focus primarily on the potential for catastrophic failure due to low toughness behavior. Specifically for ferritic materials at temperatures in the ductile-to-brittle transition (DBT) region, such as carbon and low-alloy steels typically used in many structural applications, unstable fracture by transgranular cleavage still represents one the most serious failure modes as local crack-tip instability may

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