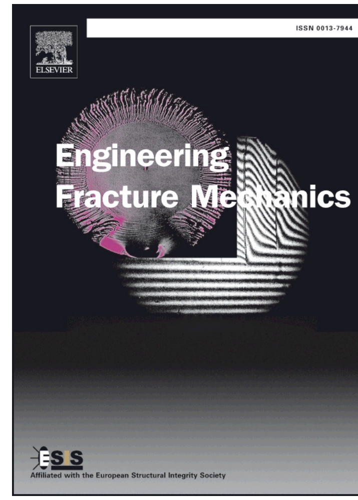

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Weight Function of Stress Intensity Factor for Single Radial Crack Emanating from Hollow Cylinder

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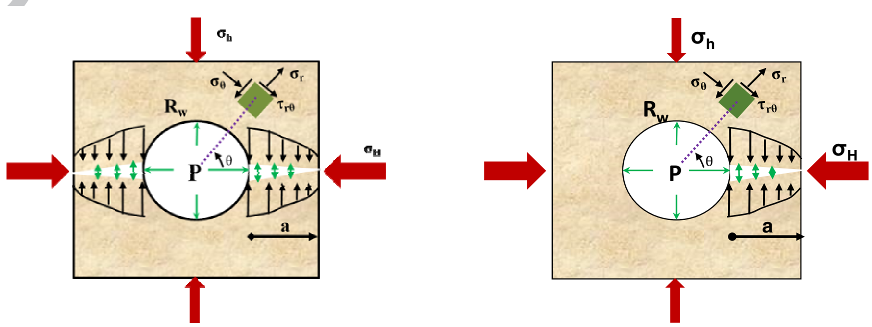
Abstract

Mode-I stress intensity factor (*SIF*) for single radial crack emanating from hollow cylinder in an infinite plane under complex nonlinear loadings is firstly solved with the weight function method. A weight function providing wide-spectrum expressions for such cracks is developed. The weight function based *SIFs* are validated against different boundary collocation based *SIF*s. Three correlations of weight function parameters are derived for simplifying engineering applications and numerical simulations. Finally, the parameters are applied to calculate *SIF* of inclined crack subjected to complex nonlinear loadings in hydraulic fracturing, and show great potential in addressing cracks initiation from hollow cylinder.

Keywords: *Stress intensity factor; Fracture Initiation; Weight function; Arbitrary loading; Single radial crack.*

Introduction

Symmetrical and single radial cracks emanating from hollow cylinder (call "borehole" in petroleum engineering) are not rare in civil engineering, drilling, cementing, perforation, and hydraulic fracturing (Fig.1). The determination of maximum in-situ stress, prediction of breakdown pressure, and simulation of fracture propagation path near the wellbore are contingent on the accurate calculation of *SIF* [1]. Inaccurate estimation of in-situ stress contrast may induce unexpected wellbore instability, lost circulation, premature screenout, and sand production [2]. Overestimation of breakdown pressure may lead to drilling induced fracture [3]. Therefore, having a reliable method for the calculation of *SIF* of radial cracks emanating from borehole is significant in petroleum geomechanics. Although J-integral method has been applied extensively in fracture mechanics [4, 5], it is not a convenient approach for field applications due to complex numerical integral. SIF derived from tabulated data is applied to calculate maximum in-situ stress from the data of mini-frac test [6], but with limitations. They are: (1) only applicable for specific geometry in the reference [7]; and (2) not appropriate for the case of nonlinear stress acting on fracture surface. Boundary collocation method is also applied to calculate *SIFs* for the fractures [8], but the solutions are: (1) only applicable for cracks aligning with the principal stress orientations; (2) not suitable for the cases with nonlinear stresses acting on fracture faces; and (3) not accountable for pressure inside fracture as shown in Fig.1-B.



A B

Figure 1 Stress distributions on symmetrical and single radial cracks emanating from borehole (a map view).