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Numerical Simulations of the Growth and Deflection of a Stress-Corrosion Notch on the Interface between Two Brittle Materials on Ship Body

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ABSTRACT

A front-tracking finite element method is used to compute the evolution of a crack-like defect that propagates along a bi-material interface by stress driven corrosion, which often happens on the ship body. Depending on material properties, loading, and temperature, simulations predict five possible behaviors for the flaw. The range of material parameters and loading conditions that leads to each type of behavior is calculated. For conditions where steady-state interfacial notch growth occurs, the tip velocity is computed as function of material and loading.

KEY WORDS: Corrosion; FEM; Interface; Static Fatigue.

INTRODUCTION

On the interface of two materials on ship body in corrosive environment, some pre-existed cracks will propagate. When the length of the crack reaches some critical value, a sudden fracture may occur, which is so called delayed stress-assisted corrosion fatigue problem. It is of great interest to simulate the process of crack evolution and then predict the life of the components.

In this work, a front-tracking finite element method is used, with Charles-Hillig model, to compute the evolution of a crack-like defect that propagates along a bi-material interface by stress driven corrosion. Depending on material properties, loading, and temperature, simulations predict five possible behaviors for the flaw: (1) The notch may blunt, so that a fatigue threshold exists for the composite; (2) The flaw may branch out of the interface, and thereafter propagate as a stable notch; (3) The notch may branch out of the interface, and then progressively sharpen at its tip, with both the notch tip curvature and stress approaching unbounded values; (4) The flaw may propagate as a stable notch parallel to the interface; (5) The notch may propagate parallel to the interface, but with the tip curvature and stress progressively increasing without limit. Through calculation for many cases, the range of material parameters and loading conditions that leads to each type of behavior is determined. And eventually, for conditions where steady-state interfacial notch growth occurs, the tip velocity is computed as function of material and loading.

MODEL DESCRIPTION

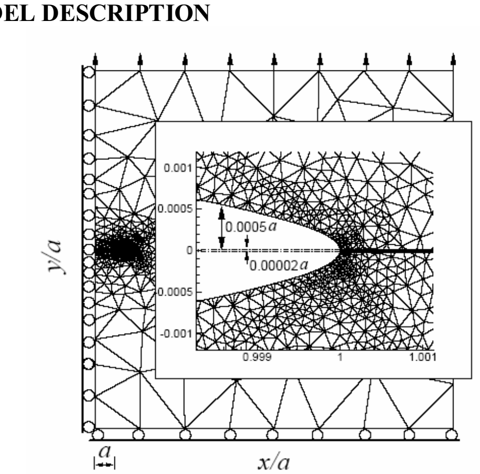

Fig. 1 Idealized geometry used to study the growth of a blunt crack-like flaw on a bi-material interface, showing a typical finite element mesh. The chain lines indicate the interface, whose thickness is $2\times10^{-5}a$. Each element shown is a six node triangle.

Our idealized model is illustrated in Figure 1. Two dissimilar materials are bonded across a planar interface, on which it is assumed to contain a single crack like flaw, with