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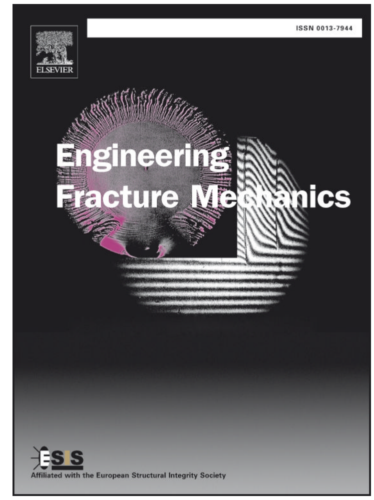

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FRACTO-SURFACE MOBILITY MECHANISM IN HIGH-STRENGTH STEEL WIRES

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Abstract
Stress corrosion cracking, a mechanism governing steel deterioration, has yet to be fully understood. This article introduces a supplement to the surface mobility mechanism proposed by Galvele to include fracture mechanics principles. In the model proposed, anodic dissolution is regarded as the source of vacancies that would be driven by a stress gradient to the crack tip under non-stationary conditions. Denominated the fracto-surface mobility mechanism (FSMM), it explains material mechanical failure based on vacancy diffusion across the metal surface.

Keywords: Stress corrosion; steel; hydrogen embrittlement; surface mobility; fracture mechanics.

1. INTRODUCTION

Stress corrosion cracking (SCC), a mechanism involved in steel deterioration, has not been satisfactorily explained to date. Of the many mechanisms proposed to explain brittle failure in metals under stress, the five deemed here to be most relevant are: i) Parkins's anodic dissolution [1, 2]; ii) film-induced cleavage, the theory for which was developed by Newman [3]; iii) Galvele's surface mobility mechanism [4-6]; iv) Magnin et al.'s environmentally assisted cracking mechanism [7-9]; and v) hydrogen embrittlement [10-13].

Each mechanism can explain different SCC cases and each mechanism has different apreciations and contribution of different authors [14]. Following it is described succinctly previous mechanisms. In the anodic dissolution (AD) model, the key kinetic parameter is electrochemical anodic dissolution at the crack tip. Whilst anodic dissolution at the crack tip is acknowledged in film-induced cleavage (FC), this model focuses on mechanical properties and micro-notches as the cause of microscopic cracks. The surface mobility mechanism (SMM) adopts a different approach, in which cracks advance due not to anodic dissolution but to the diffusion of atomic vacancies generated at the lips of the crack near the tip. This is the sole model that proposes equations to predict the crack propagation rate, which also take into consideration the onset of hydrogen during the process, thereby expanding SCC theory to include hydrogen embrittlement. The environmentally enhanced plasticity model combines the effects of the environment and mechanical stress [10]. This mechanism, in which cracks are assumed to grow discontinuously in approximately 1 μm steps, also envisages the effect of hydrogen at the crack tip in the yield zone. Other mechanisms have been put forward to predict crack propagation based on hydrogen embrittlement (HE) only [11, 15-21] and new HE models are presently under development that combine first principles simulations and finite element analysis [13, 22, 23].