# Searching for the length scale of stress corrosion - Discussion of fracture paper #10

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2015

*Document Version:*
Publisher's PDF, also known as Version of record

Engineering Fracture Mechanics
An International Journal

ELSEVIER

iMechanica Blog

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30 January 2015

According to the Swedish Plant Inspectorate the major part of all reported fracture related failures in Sweden are due to stress corrosion. I guess it is more or less a reality everywhere. The association with accidents is probably because it comes without warning and usually at surprisingly low loads. Just a mm sized spot of decomposing grease is enough to create a locally extremely acid environment. In an otherwise friendly environment this often not even considered as a possibility by the designer.

The paper for this discussion is:

"Further study on crack growth model of buried pipelines exposed to concentrated carbonate-bicarbonate solution", B.T. Lu, Engineering Fracture Mechanics vol. 131 (2014) pp. 296-314.

A stress corrosion cracking model is developed. The main character of the fracture processes is a repeated breaking and healing of a passivating oxide film. When it is intact it prevents the metal from being dissolved by an aggressive environment, and when it is broken, metal ions escape from the surface and the crack thereby advances. The bare metal surface quickly becomes covered by a new thin oxide film when it is exposed to air and moist. To keep up with the oxidisation rate a sufficient strain rate has to be maintained in the crack tip region.

The authors study the combined effect of cyclic loading leading to stress corrosion cracking and mechanical fatigue with good results. The model is used successfully in describing the behaviour of several experimental results reported by different groups.

In ESIS review no. 3 the importance of knowing the length scales of fracture processes was emphasized. In the present paper this is fully understood. The crack tip is confined to a point that is under KI control. To deal with the problem of assigning a strain rate to the singular stress field, the strain rate a short distance (a few microns) ahead of the crack tip is selected. It seems to be an accepted practice by more than the present author and the precise distance is regarded to be a material parameter. However, I feel a bit uncertain about the physical reasons for the actual choice.

Is it possible that there is no length scale that is simultaneously relevant to both the mechanical and the chemical processes. Assume that the width of the blunted tip is a few microns as it is given by KI. We also

have an oxide film of a few nm that covers the blunted surface. A distance of a few nm is not likely to be exposed to any gradients of the strain field where the meaningful distances are of the order of microns. In this case the film thickness seems irrelevant. The dissolution of the metal takes place around the crack tip and keeps the growing crack blunt. With the only length scale relevant to the mechanical state being provided by the stress intensity factor the result would be a self-similar shape and a constant stress and strain field in the crack tip region.
A consequence would be that the crack growth rate would be independent of the remote load. Something like that can be seen in the paper "Q.J. Peng et al. Journal of Nuclear Materials 324 (2004) 52–61" that is cited in the present paper. Fig. 2 test 3 shows almost constant growth rate in spite of an almost doubled remote load.
A length scale of a few microns is introduced in the discussed paper. What could be the relevance of the choice? Is a length scale always necessary?

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