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Finite Element Analysis of Hydrogen Diffusion Problems in Materials

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ABSTRACT

In spite of decades of research effort, hydrogen assisted cracking is still the most serious problem in steel welding. Hydrogen embrittlement is still not clear, and a coupled diffusion elastic-plastic stress analysis is needed to model the effects of hydrostatic stress and hydrogen trapping due to plasticity on the hydrogen distribution in a body. The finite element method is a very useful tool for this purpose. In 1988, P. SOFRONIS and R. M. McMEEKING [1] established a FEM model for the effect of the hydrostatic stress and trapping on the hydrogen distribution in plastically deforming steel. Like this, they could investigate the hydrogen concentration near a blunting crack tip under small-scale yielding conditions. Unfortunately, their hydrogen transport model didn't provide the correct balance of hydrogen concentration into the considered material.

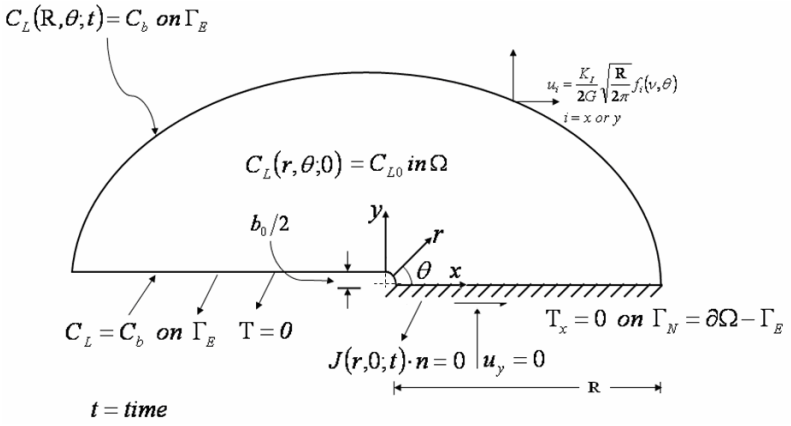

Fig. 1 Description of the boundary and initial conditions for the one side coupled diffusion and elastic-plastic problem under small scale yielding conditions.

Based on their work, another model, that provides the correct balance of hydrogen, and also shows a strong dependence of the hydrogen concentration in lattice sites on the strain rate, has been developed by A.H.M. KROM, R.W.J. KOERS, and A. BAKKER [2].

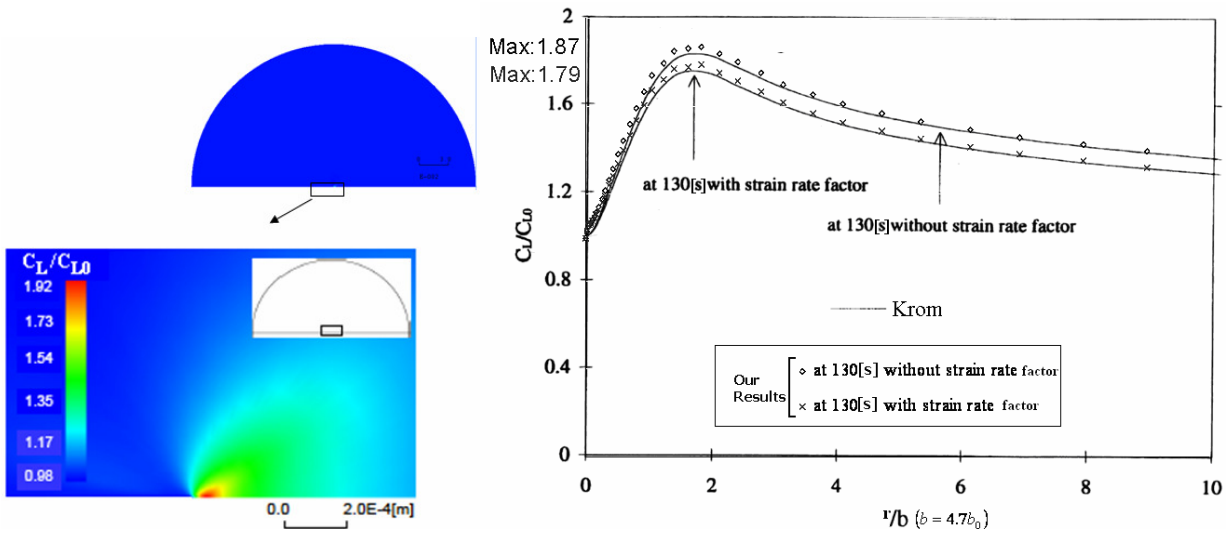

Fig. 2 Hydrogen concentration near the crack tip after 130[s]. The concentration is normalized by the initial concentration. As we can see, our results show good agreement with those previously obtained by Krom et al..

In a previous study[3], we managed to get Krom et al. results, using a non-symmetric coefficient matrix for each time step, but we have also noticed the appearance of some numerical complications for high Peclet numbers.

The goal is to apply a stabilization technique to our scheme, to overcome the above problem.

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