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NUMERICAL SIMULATION OF THE CRACK TIP ELASTIC-PLASTIC STATE

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ABSTRACT

Hydrogen-enhanced localized plasticity (HELP) is recognized as an acceptable mechanism of hydrogen embrittlement and hydrogen-induced failure in materials [1]. A possible way by which the HELP mechanism can bring about macroscopic material failure is through hydrogen-induced cracking. The objective of this work is to simulate the distribution of hydrostatic stress and plastic strain around the blunting crack tip. The hydrogen transport model of Sofronis and McMeeking[2] is used in order to investigate the hydrogen-induced crack structurally. The boundary layer approach is applied to determine the elastic-plastic state around a blunting crack tip without having to model a complete geometry. The approach is valid as long as small scale yielding conditions hold [2,3]. Incompressibility of the plastic deformation is enforced by the technique of reduced integration point and concluded results are compared to the case without using this technique. Three different FEM softwares; ZeBuLoN, MSC.Marc and ADVENTURE-Solid are used for structural analysis and results are verified by previous works [2,4].

In Fig. 1, the equivalent plastic strain $\bar{\varepsilon}^{p}$ produced at 130 s plotted against the distance from notch root normalized by b i.e. crack opening displacement after 130 s in the undeformed configuration for θ=0 is compared with the result of Sofronis and McMeeking [2] by MSC. Marc. The comparison between the current analysis and the

previous one represents satisfying results (see Fig. 1). Incompressibility of material behavior was enforced by the method of selective or reduced integration.

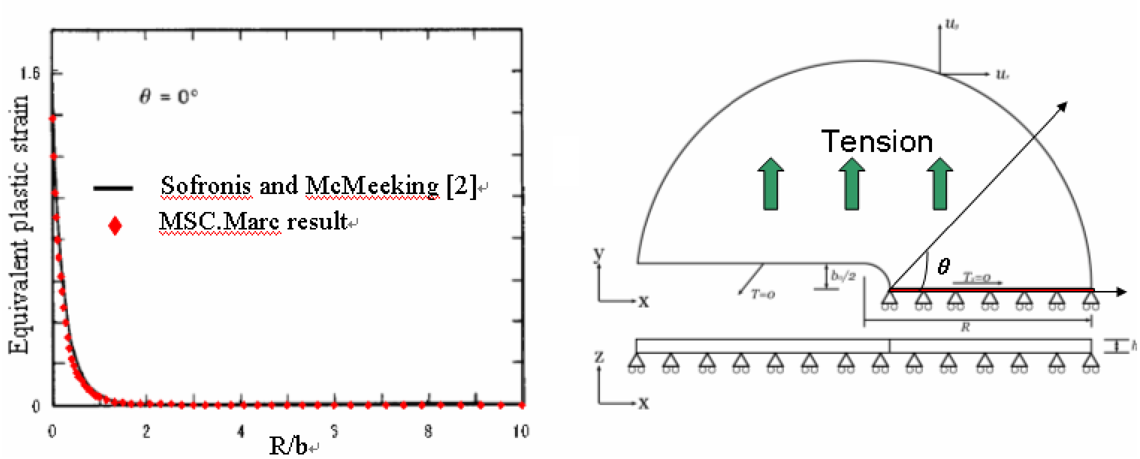

Fig. 1 Plot of equivalent plastic strain $\bar{\varepsilon}^p$ vs distance R/b for impure iron after 130 s when the crack opening displacement b is equal to $4.7b_0$

Fig. 2 illustrates the hydrostatic stress in the vicinity of the crack tip on symmetry line i.e. θ=0 after 130 s. In this figure, the results of ZeBuLoN analysis has been compared with Sofronis and Mc.Meeking [2] and Krom et al. [4].

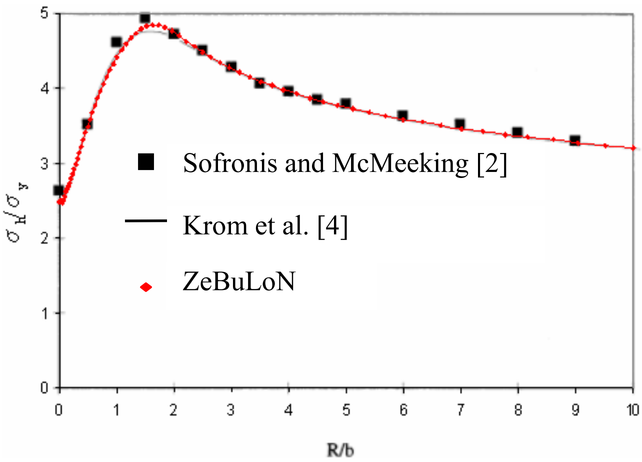

Fig. 2 Plot of normalized hydrostatic stress vs distance R/b for impure iron after 130 s when the crack opening displacement b is equal to $4.7b_0$

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