Stress corrosion cracking mechanism on the basis of the interaction model of dislocation and hydrogen around a crack tip

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1. Introduction

Mechanisms of dissolvent anodic chemical reaction and hydrogen embrittlement were proposed as stress corrosion cracking mechanics (SCC). The former is feasible for the case of plastic deformation dominant metals and the latter is for high strength metals such as high strength steels.

However, in spite of low yield stress, a discontinuous cleavage-like fracture is sometimes observed during SCC for ductile fcc alloys.

In this paper, we proposed stress corrosion cracking model on the basis of interaction of dislocation and hydrogen around a crack tip to predict discontinuous cleavage-like fracture during SCC for ductile fcc alloys. Furthermore, we conducted numerical analyses using this proposed model.

2. Results and Conclusion

The physical model is shown in Fig. 1. Brittle fracture is considered to be induced by inverse pile-up with high dislocation density emitted from a stressed source. For ductile materials such as pure iron, the maximum dislocation density at the end of the dislocation free zone (DFZ) is not so high as shown by the dotted line in Fig. 2.

However, when hydrogen cluster exists near the slip line, the inverse pile-up with high dislocation density occurs at the site of hydrogen cluster, as shown by the solid line in Fig. 2. This will cause cleavage fracture. That is, when hydrogen cluster originated by dissolvent chemical reaction exists near the dislocation slip line, the subcritical cleavage fracture can be observed even for such ductile materials. This result is in good agreement with experimental result obtained by other literature.

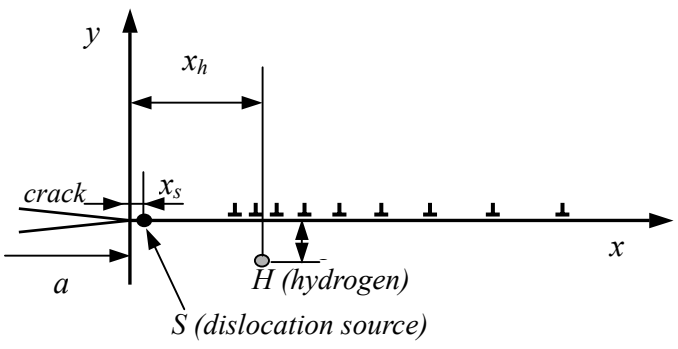

Fig.1 Proposed model in which the source emitting the dislocation group is located at the tip of the crack under hydrogen atmosphere condition.

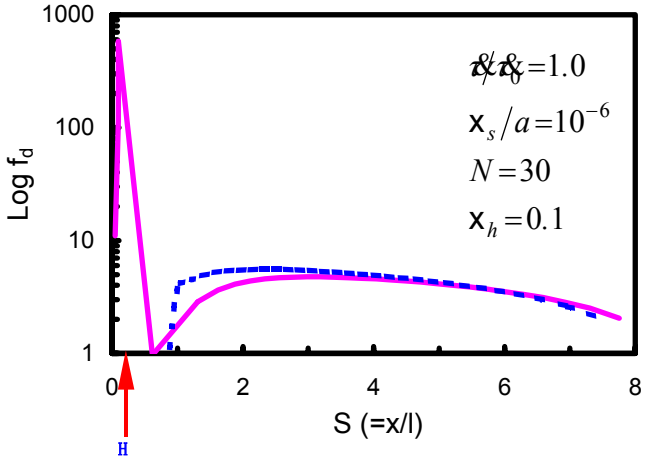

Fig.2 Numerical results on dislocation distribution under the interaction between crack, dislocation groups and hydrogen.