8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

Modelling of hydrogen transport, trapping and embrittlement in plastically deforming materials

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Key Words: *Hydrogen, Embrittlement, Fracture, Stress-assisted diffusion, Plasticity*

ABSTRACT

Hydrogen embrittlement poses a serious challenge for metallic materials, in particular when dealing with stringent conditions, in terms of required strength and/or corrosive environment. The understanding of microscopic details of hydrogen transport, interaction with the microstructure and trapping is an important tool for design of high strength steel to be use in environments where hydrogen pick up takes place.

We developed a model of hydrogen embrittlement that incorporates the following features: i) stress-assisted transport of hydrogen through the metal lattice; ii) trapping of hydrogen by microstructural defects; iii) fracture based on cohesive modelling or damage criteria. The present model is similar to the SCO model [1], with some additional features, e.g., trapping. The generality of the model allows for the incorporation of different kinds of traps, corresponding to various approximations of the general McNabb-Foster transport equation. These traps may be already present in the original material or appear because of deformation. The model also allows for the comparison of alternative fracture criteria, which may incorporate known details about the microstructure.

The effect of several system variables was analysed, namely, loading conditions, geometry, prior plastic strain and trapping parameters. We considered in particular the effect on threshold stress intensity and crack propagation rates. The calculations capture the main experimental trends, encouraging further developments.

REFERENCES

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