Effect of Hydrogen on the Fracture Mechanisms of Tempered Martensitic Steels

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Abstract

Hydrogen strongly affects the fracture mechanisms of tempered lath martensitic steels. Quasi-cleavage hydrogen-induced fracture surfaces are often observed in the presence of hydrogen instead of ductile morphology of air-tested specimens. In lath martensitic steels, hydrogen embrittlement depends on the hydrogen fugacity, the susceptibility of the steel and the service mechanical request. Using an assembly of a permeation test on a tensile machine, this work aims to study the effect of hydrogen on the fracture of two martensitic steels. The susceptibility to hydrogen embrittlement is investigated for different mechanical states (several notches geometries), strain rates and hydrogen concentrations. Afterwards, a finite element calculation was performed for each specimen design based on the classical local approach of fracture. This model provides the mechanical parameters' distributions (stress and strain) within the bulk of the specimen during loading up to fracture. The designed mechanical tests followed by FEM modelling is an efficient method to investigate the impact of hydrostatic stress and plasticity to the fracture process. A correlation was found between the quasi-cleavage zones and the highest levels of plastic strain and hydrostatic stress. Additionally, mobile hydrogen enhanced the plasticity contribution to the fracture process significantly.

Key words: fracture mechanism; hydrogen embrittlement; lath martensite; FEM modelling