QUALIFICATION OF THE IN-SITU BENDING TECHNIQUE TOWARDS THE EVALUATION OF THE HYDROGEN INDUCED FRACTURE MECHANISM OF MARTENSITIC FE-C STEELS

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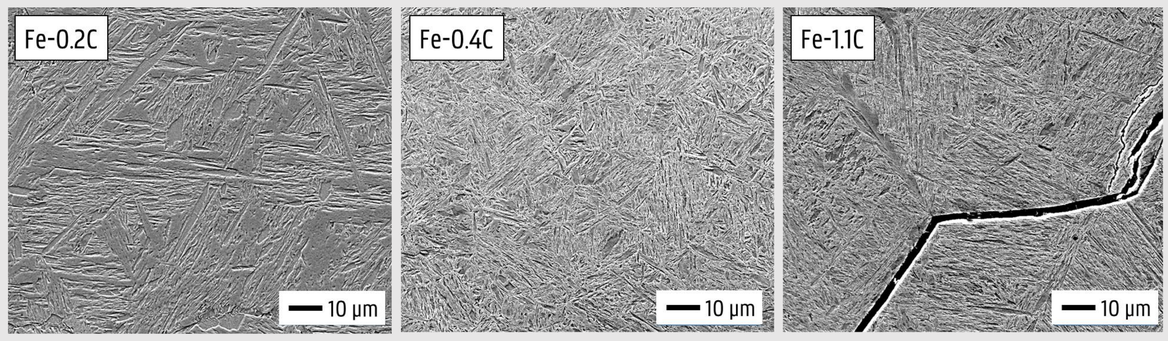
Introduction

A new method to investigate the mechanical degradation of intrisically brittle steels in the presence of hydrogen is proposed. Simplified martensitic Fe-C steels with a varying carbon content are used in order to limit the number of influencing factors, i.e. precipitates, inclusions, second phases… The two objectives are to (i) qualify the in-situ bending method for brittle materials and (ii) investigate the hydrogen embrittlement (HE) mechanism for martensitic Fe-C steels.

Material characterisation

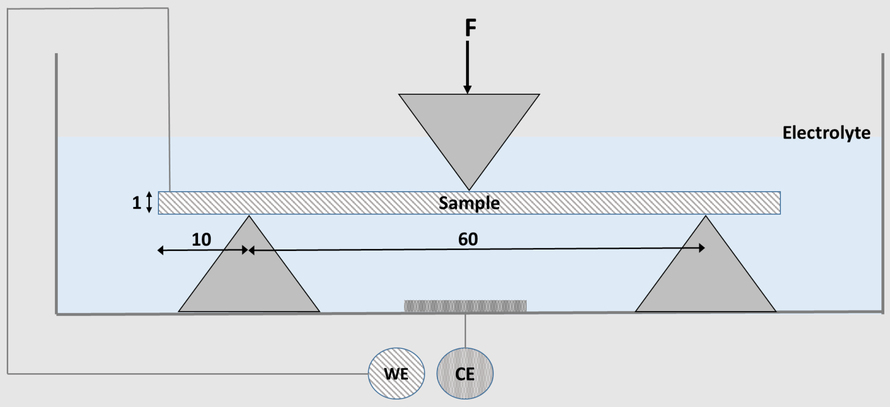


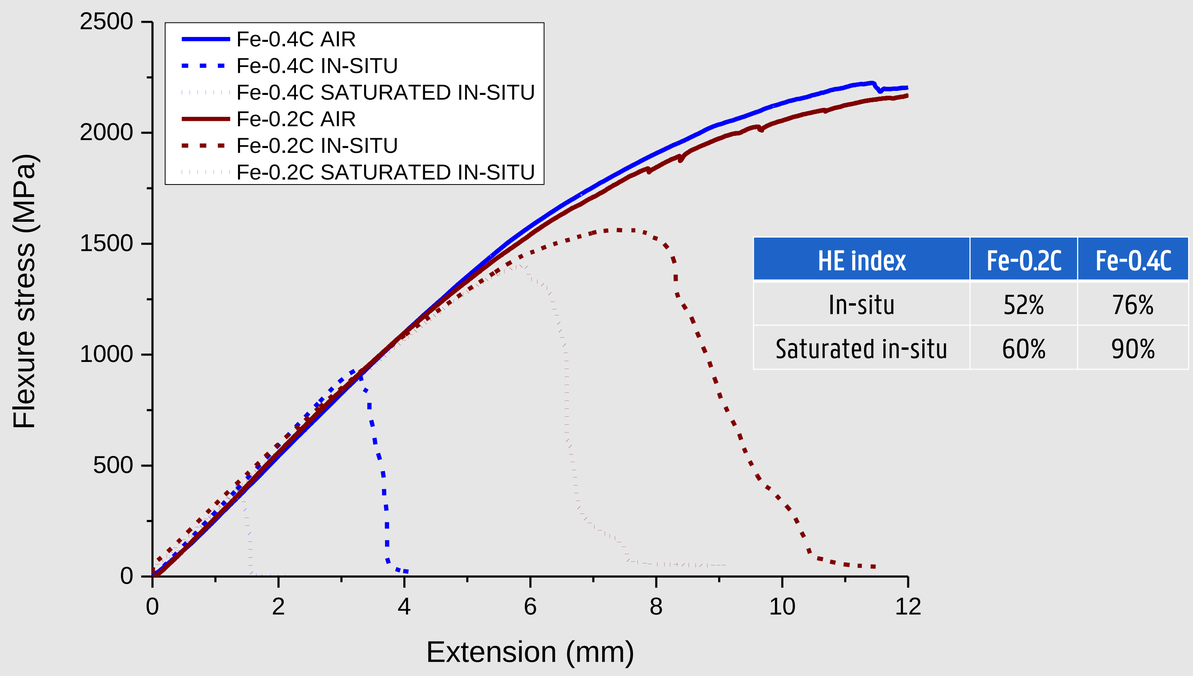
31.4 ± 2.8 µm
421 ± 29 HV3

32.2 ± 7.8 µm
672 ± 10 HV3

71.0 ± 8.2 µm
871 ± 17 HV3

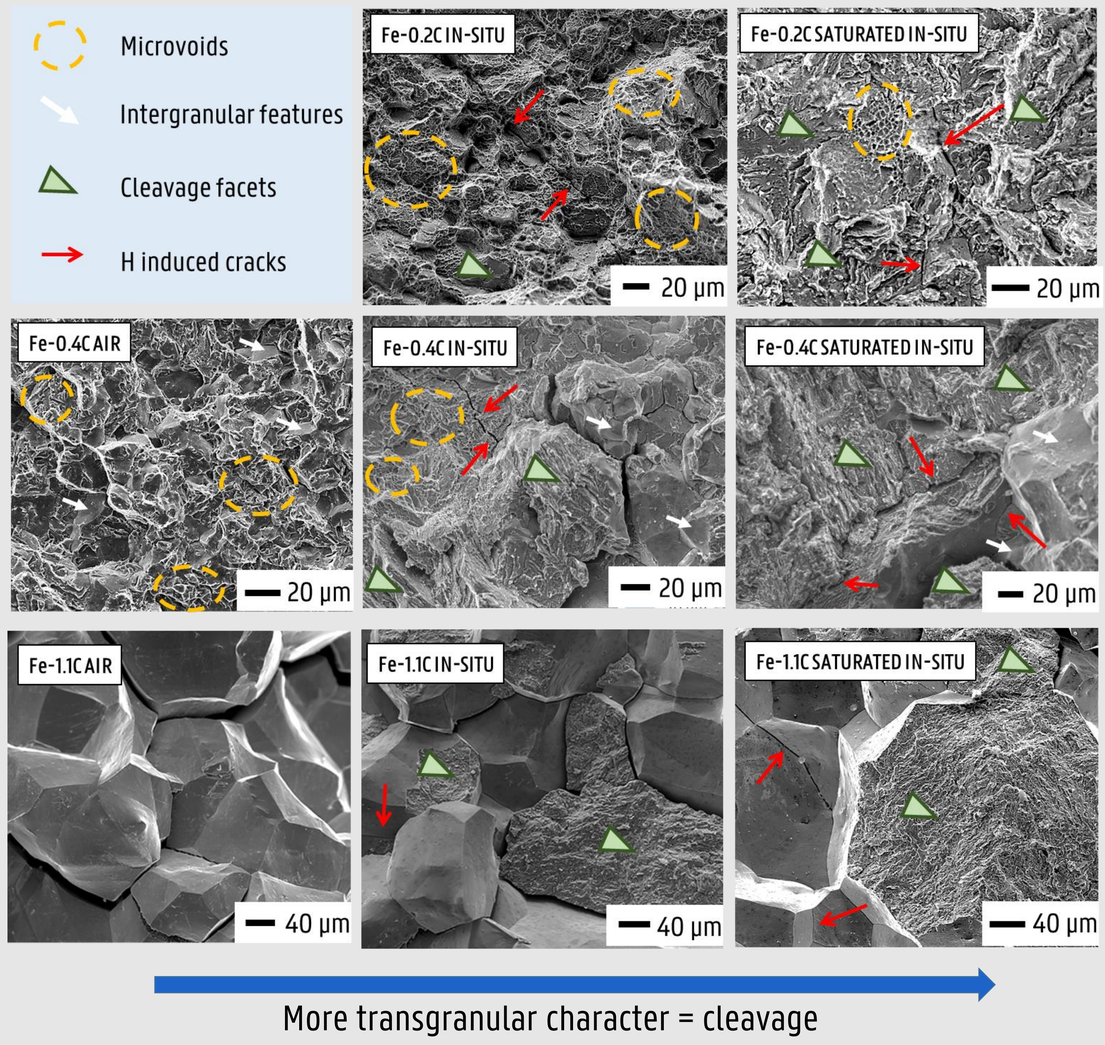
In-situ hydrogen bending



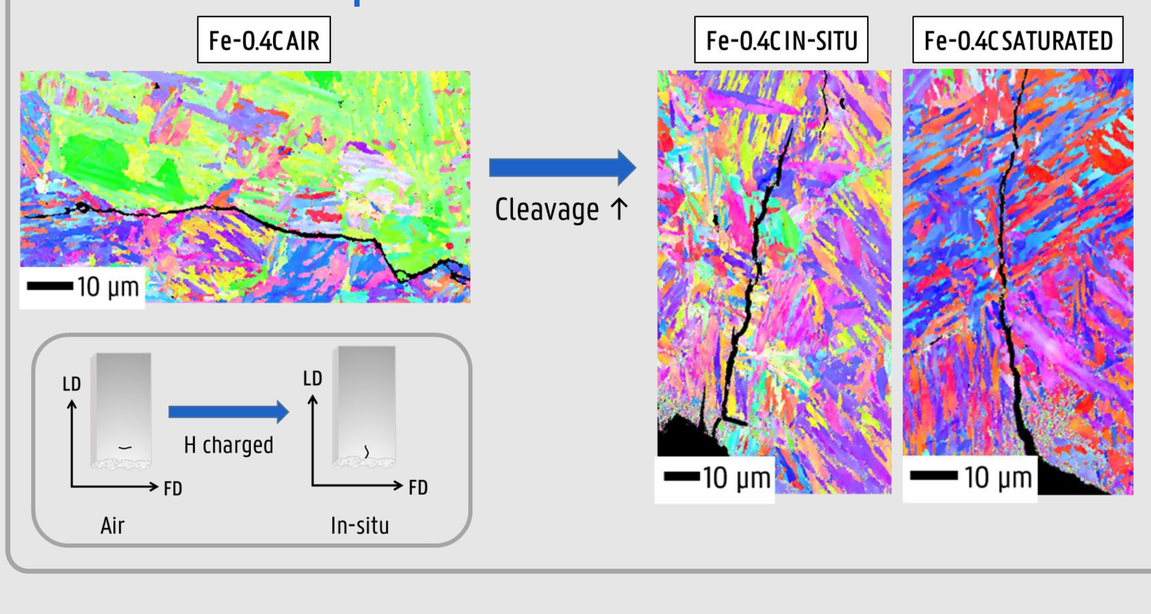


HE index	Fe-0.2C	Fe-0.4C
In-situ	52%	76%
Saturated in-situ	60%	90%

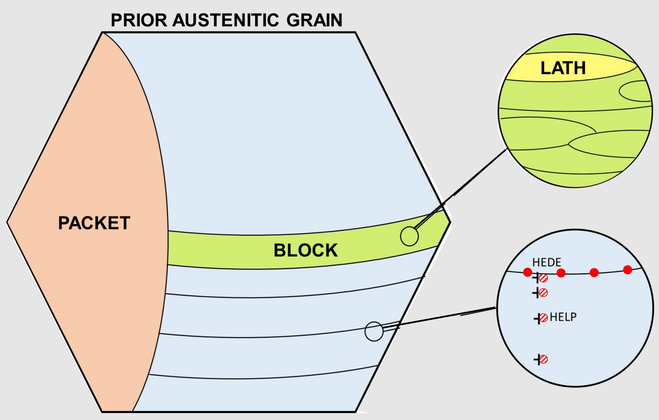
Fractography



EBSD on ND plane of fracture surface



Conclusions



- Reliable and reproducable results indicate that the in-situ bending technique is a suitable method to evaluate the susceptibility to HE of brittle materials.
- H causes a significant ductility loss in martensitic Fe-C steels which is characterized by a transition from a microvoid (Fe-0.2C), intergranular (Fe-1.1C) or mixed (Fe-0.4C) fracture surface to a cleavage fracture surface with additional cracking.
- HE mechanism = Hydrogen Enhanced Plasticity Mediated Decohesion (cf. A. Nagao et al., *J. Mech. Phys. Solid.* 112 (2018)):
  → H enhances dislocation movement (HELP) + H is trapped at the martensitic block boundaries
  → Dislocations pile-up + H accumulation weakens block boundaries (HEDE)

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