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MICROSCOPIC ANALYSIS OF HYDROGEN DEGRADATION IN 316L STEEL FOR FUSION ENGINEERING

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This paper analyzes the final results of the work which the authors have been performing for the European Fusion Technology Programme (*the NET TEAM*), as a part of a task entitled: "Hydrogen effects and water corrosion in reference 316L steel and welds". The contribution deals with the experimental evaluation —by scanning electron microscopy (SEM) techniques— of the micromechanical degradation produced by hydrogen in AISI TYPE 316L solution-annealed austenitic stainless steel, a material frequently used in nuclear engineering and design.

The experimental programme included fracture tests of round notched specimens in air and hydrogen environments. Two notch geometries —sharp and blunt— of very different radii were used, to analyse the influence of the notch geometry (and therefore of the stress state in the vicinity of the notch tip) on fracture in both environments. The hydrogen-embrittlement fracture tests were slow strain rate (SSR) type in aqueous solution of H_2SO_4 1N plus As_2O_3, and hydrogen was introduced into the sample by cathodic polarization during the tests. A wide range of strain rates was covered, to obtain very different degrees of hydrogen degradation.

A detailed SEM fractographic analysis was performed on the broken samples which had suffered different degrees of hydrogen-assisted micro-damage as a consequence of the very different values of the embrittlement time (test duration). The analysis allows the elaboration of micro-fracture maps (MFMs) of the whole fracture surface (cross-section of the notched samples) to evaluate —from a quantitative point of view— the micro-mechanical damage produced by the hydrogen charging during the tests. Quantitative evaluation of the MFMs was performed by means of an image analysis equipment.

The micromechanical damage created by hydrogen is concentrated in a external circumferential ring with the same center as the cross sectional area of the notched samples. The microscopical appearance of this *embrittled zone or damaged area* is very rough and irregular at the micro-scale, with evidence of *secondary cracking*, in contrast with the smooth surface (at the micro-scale) created by micro-void coalescence (*dimpled fracture*) in the inner core which is not embrittled by hydrogen and thus fails by mechanical reasons.