PREDICTIVE MODELLING OF HYDROGEN ASSISTED FRACTURE

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ABSTRACT

Hydrogen embrittlement is arguably one of the biggest challenges in structural integrity. Hydrogen is ubiquitous and causes catastrophic failures in metallic components. The ductility and fracture resistance are drastically reduced in the presence of hydrogen and these effects increase with material strength. High strength steels exhibit hydrogen assisted cracking in very benign environments (e.g., due to humidity) and a significant fracture toughness reduction with hydrogen concentration (by up to 90%!). Decades of metallurgical progress are effectively compromised by the effect of hydrogen and a problem that was mostly bounded to aggressive environments, e.g. oil and gas extraction, is now pervasive in numerous applications, from bridges to cars.

The speaker and his collaborators have been engaged in the development of models capable of predicting hydrogen assisted cracking as a function of the environment, the material and the loading conditions. To solve this longstanding challenge, research efforts were focused on four fronts: (1) the mechanisms of hydrogen embrittlement, (2) the plastic response at the small scales involved in crack tip deformation, (3) the characterization of hydrogen transport and the electrochemistry-diffusion interface, and (4) the development of robust numerical methods for crack propagation. The combination of these efforts into a mechanism-based framework for hydrogen embrittlement led to an unprecedented level agreement with experimental measurements. The promising results achieved over a wide range of scenarios have attracted the interest of industrial partners and technical standards organizations, paving the way to extending the success of Virtual Testing

Emilio Martínez-Pañeda, Ph.D.

Research Fellow
Cambridge Centre for Micromechanics
University of Cambridge

Emilio Martínez Pañeda is an 1851 Research Fellow at the Cambridge Centre for Micromechanics (University of Cambridge), led by Profs. Norman Fleck and Vikram Deshpande. Before joining the University of Cambridge in 2017, he was an H.C. Ørsted Fellow at the Technical University of Denmark (DTU), a post that he took immediately after finishing his 3-year PhD degree in June 2016. During this 6-year academic career, Emilio has published more than 20 scientific papers (h-index: 11), supervised 6 PhD students, conducted research at 5 leading institutions, and attracted and managed over 1M$ in research funding. Emilio is the recipient of a number of competitive fellowships such as the 1851 Research Fellowships, the Marie Curie Individual Fellowship, or the Wolfson Cambridge Junior Research Fellowship. His current research interests lie in the field of applied mechanics; more specifically in plasticity, fracture mechanics, coupled diffusion-deformation theories, and mechanism-based models for damage. His work has been recognized through several awards, including the Acta Student Award, the Springer PhD Thesis Prize, the Brunel Award and the Extraordinary Doctoral Prize for the Best PhD Thesis in Engineering.