11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

MULTI-SCALE CRACK PROPAGATION ANALYSIS FOR STRENGH ASSESSMENT OF POLYCRSTALINE MATERIALS

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Key Words: *Multi-scale Simulation, Crack Propagation Simulation, Crystal Plasticity*

The objective of this study is to develop a method of multi-scale crack propagation analysis to assess the residual strength of welded structures subjected to chemical attack. The macro-scale crack growth rate is determined by both the micro-scale cracking with plastic deformations and the change of iron and vacancy concentrations over time. The crystal plasticity model [1] and the damage model are employed to simulate the micro-scale crack propagation induced by the diffusion processes of ion and vacancy at the crack opening. The generation of vacancy is caused by the efflux of ion, and the damage evolves with the change of mass density during the diffusion process [2]. A polycrystalline aggregate is regarded as a representative volume element (RVE) for micro-scale analyses and its spatial size is set to be much larger than the plastic deformation region around the crack tip. The displacement to be imposed at the external boundary of this RVE is determined by the stress intensity factor that is a field parameter around the macroscopic crack tip. The macroscopic crack growth law is suggested from the results of a series of micro-scale simulations with imposed macroscopic displacements associated with assumed stress intensity factors; see e.g., Brinckman et al [3]. The parameters of crack growth law also depend on the environment conditions caused by the chemical reactions with diffusion processes. Linearly elastic material behaviour is assumed for the overall steel structure with a macroscopic crack, with which the stress intensity factors are evaluated. The proposed method enables us to simulate the crack propagation to assess the residual strength of the overall structure subjected to different environments by means of the crack growth law that is pre-determined numerically by the microscopic analysis that reflects the stress intensity factors evaluated at macro-scale.

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