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Mesoscale Simulation of the Early Evolution of Ductile Fracture in Dual-Phase Steels

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Abstract
In this study, finite element simulations synchronized with in-situ tensile tests have identified microstructural damage models in a 600 MPa grade dual-phase steel with 10% martensite volume fraction. Firstly, in-situ tensile tests have been carried out on a double-notched, flat-plate, tensile specimen. These experiments have shown that the damage in this steel is dominated, up to moderate tensile strains, by fracture of the martensite islands and decohesion at the martensite/ferrite interfaces. Secondly, FE simulations have been conducted, by using 2.5D meshes that were adjusted to the real shape of the martensite islands, as revealed by the micrographs. The ductile fracture of the martensite was described by a three-parameter fracture envelope defined by Bao and Wierzbicki, where the equivalent strain to fracture is expressed as function of the stress triaxiality. The stiffness of the ferrite/martensite interfaces has been described by a four-parameter cohesive model of Xu-Needleman type. The comparison of the experimentally determined sequence of damage events with the FE simulations has allowed adjusting the damage parameters of the model and validating them up to equivalent plastic strains exceeding locally 0.60. After determination of the damage parameters, the event sequence of martensite fracture and ferrite/martensite decohesion, as well as the pattern of the strain localization in the ferrite phase, were quite satisfactorily predicted by the FE simulations. Furthermore, the results obtained have shown that the martensite fracture and the interface decohesion have a significant influence on the stress and strain partitioning between the two phases, and hence also on the pattern and intensity of the strain localization and on the void growth and coalescence during the subsequent deformation stages.

Keywords
A. Ductile fracture; A. Microvoids; B. Elasto-plastic material; B. Dual phase steel; C. Finite elements

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