Fracture mechanisms of dual-phase steels exhibiting a platelet-like microstructure

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ABSTRACT

Dual-phase steels have long been used in the automotive industry for their excellent mechanical properties in terms of strength and ductility balance combined to a low processing cost. The good compromise between strength and ductility results from the very different properties of the constituent phases, namely ductile ferrite and hard martensite. Dual-phase steels can be produced with either equiaxed or platelet-like second phases. This latter microstructure moprhology can potentially lead to a very high fracture toughness [1].

Even though the behavior of dual-phase steels is well understood as for the effects of martensite volume fraction, composition and grain size in the case of equiaxed microstructures, the impact of morphology of martensite particle and of its orientation with respect to the loading direction has not been much investigated. Effects of structural heterogeneities on plasticity and damage behavior are also incompletely established. A better understanding of the latter variables is needed to guide the generation of steels with improved mechanical properties.

As a first step towards the general objective of investigating the fundamental damage mechanisms governing the fracture toughness of dual-phase steels, a model for the plastic behavior and for the damage mechanisms related to the microstructure has been developed. This work investigates the effects at single grain level and at the multigrain level, using a two-scale strategy based on FE calculations performed on unit cells, bypassing the large computational cost of full-field models on RVEs, following earlier works in [2] and [3]. An important outcome is that, although structural heterogeneities - among others morphology - have a limited impact on the effective plastic behavior until necking, they considerably influence the mechanical fields at the micro-scale and thus largely impact the damage behavior. The data extracted from the elastoplastic analysis are fed into a cellular automaton approach of the damage evolution [4] with the aim of taking into account the effect of microstructural heterogeneities on fracture strain.

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