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

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ABSTRACT

Dual-phase steels have long been used for their excellent mechanical properties in terms of strength and ductility balance combined to low costs. The good compromise results from the different properties of the constituent phases, ductile ferrite and hard martensite. Dual-phase steels can be produced with 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.

As a step towards the objective of investigating the fundamental damage mechanisms governing the fracture toughness of dual-phase steels, a model for plastic behavior and for damage mechanisms related to microstructure has been developed. This work investigates the effects at single and multi-grain levels, using a two-scale strategy based on FE calculations performed on unit cells, following earlier works ([2], [3]). An important outcome is that, although structural heterogeneities - among others morphology - have a limited impact on effective plastic behavior, they considerably influence the mechanical fields at the micro-scale and thus largely impact 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. Being able to incorporate a large number of different particles distributed differently in the microstructure in addition to a distribution of critical stress for nucleation, this model introduces a statistical description of the material while using relatively simple damage evolution laws.

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