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Modelling of damage and fracture in the microstructure of multiphase steels

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ABSTRACT

Multiphase steels are new Advanced High Strength Steel (AHSS), which have been developed for the automotive industry according to economic and environmental challenge through the reduction of car body weight. These steels show an attractive mechanical properties, namely, high strength and good formability because of the coexistence of harder and softer phases in their microstructure. The outstanding properties of multiphase steels can be utilised by adjusting the type, amount, formation and spatial distribution of the different phases. In the experimental investigations two failure modes were simultaneously observed, cleavage and dimple fractures.

To describe the influence of the heterogeneous microstructure on the mechanical properties and the complex fracture mechanisms of multiphase steel, a micromechanics-based approach is presented using representative volume elements (RVE). Real microstructures are considered in a two dimensional model and cohesive zone [1] is applied to represent the debonding of martensite-ferrite interfaces. Figure 1 illustrates a two dimensional RVE of a dual phase steel. The different microstructure morphologies cause inhomogeneous deformation on the micro-scale. The phenomenological damage development, the crack initiation and propagation in the microstructure can be described in the modelling.

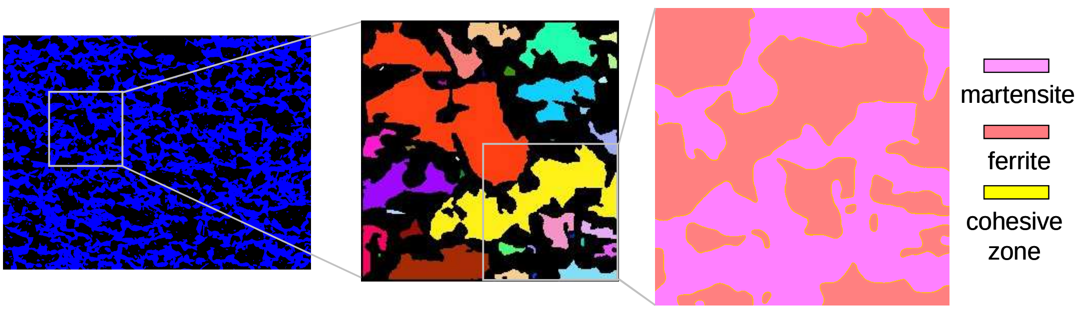

Figure 1: 2D representative volume element (RVE) of a dual phase steel

Furthermore, three dimensional RVE under consideration of the determined phase fraction is used to investigate the local ductile fracture initiation. Figure 2 shows a 3D RVE of a TRIP steel. The Gurson-Tvergaard-Needleman (GTN) damage model [2] is employed to describe the dimple fracture arising in the ferritic phase. Here, the influence of void evolution on the yield potential of a ductile matrix material is taken into account. To specify effective mechanical properties for constituent phases, isotropic elastic plastic material laws based on dislocation theory and local chemical composition from literature are used [3]. A microstructure-based failure criterion for the material characterisation in sheet metal forming of multiphase steel is the main purpose of this study. At the failure moment, local strain partitioning between different phases are studied. The influences of the local states of stress on the failure development are also examined.

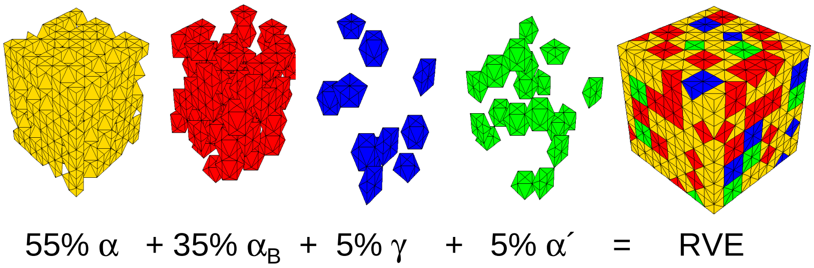

Figure 2: 3D representative volume element (RVE) of a TRIP steel

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