International Journal of Plasticity 27 (2011) 1103–1125

Contents lists available at ScienceDirect

International Journal of Plasticity

journal homepage: www.elsevier.com/locate/ijplas

A micro mechanical study on failure initiation of dual phase steels under tension using single crystal plasticity model

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A R T I C L E I N F O

Article history:
Received 21 May 2010
Received in final revised form 9 December 2010
Available online 16 December 2010

Keywords:
Dual phase (DP) steel
Failure mechanism
Crystal plasticity finite element method (CPFEM)
Microstructural modeling

A B S T R A C T

Both experimental and numerical methods were employed to investigate the mechanism of failure in dual phase steels. The tensile test was interrupted in different steps to capture the mechanism of void initiation and void growth during material failure. The results can be considered as a first report for the commercial DP800 steel. Numerical simulations, which were carried out using the real micro-structure, are able to predict the void initiation in the material. In addition, through the numerical simulation a new understanding of the deformation localization was gained. Deformation localization, which causes severely deformed regions in the material, is most probably the main source of rupture in the final stages of the failure. In the SEM micrographs of the material after failure some voids are observable which can validate the results obtained by the simulation.

1. Introduction

Dual phase steels are among the most important advanced high strength steel (AHSS) products recently developed for the automotive industry. This group of steels is very interesting for light weight constructions because it combines a high ultimate strength with a high fracture strain. On the market, DP800 steels with an ultimate strength of 800 MPa and a nominal fracture strain of approximately 20% are available. Another advantage of this material is its low yield strength, high hardening ratio and absence of discontinuous yielding. For this reason dual phase steel sheets are well suited for forming and deep drawing processes.

The microstructure of dual phase steels typically consists of a soft ferrite phase with dispersed islands of a hard martensite phase. The harder martensite grains explain the high strength of theses material in terms of a composite effect on yield stress and work hardening (Bouaziz and Embury, 2007; Kumar et al., 2008). Despite many simplifications; the composite model is able to describe the material hardening with quite good accuracy. To investigate the problem of failure the microstructure of the material has to be described and considered more accurately. There exist three kinds of other phases in the ferrite matrix: (1) large (>4 μm) martensite grain, (2) medium (between 1 and 2 μm) ceramic inclusions of aluminum-oxide or manganese-sulfide and (3) small (nano scale) carbide particles. While carbide particles contribute to the strength of material by impeding the motion of dislocations, the ceramic inclusions exist in the material as undesirable relics from production process or from raw materials. The martensite phase is an essential component of DP steels to increase the strength of material. The effects of these three phases have to be considered in describing the failure mechanism of dual phase steels.

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0749-6419/$ - see front matter
doi:10.1016/j.ijplas.2010.12.001