Science Arts & Métiers (SAM)

is an open access repository that collects the work of Arts et Métiers ParisTech researchers and makes it freely available over the web where possible.

This is an author-deposited version published in: https://sam.ensam.eu
Handle ID: http://hdl.handle.net/10985/10435

To cite this version:

Gérald FRANZ, Farid ABED-MERAIM, Tarak BEN ZINEB, Xavier LEMOINE, Marcel BERVEILLER - Strain localization analysis using a large strain self-consistent approach - 2007
STRAIN LOCALIZATION ANALYSIS
USING A LARGE STRAIN SELF-CONSISTENT APPROACH

G.Franz1, F.Abed-Meraim1, T.Ben Zineb2, X.Lemoine3, M.Berveiller1
1 : LPM CNRS UMR 7554 ENSAM CER de Metz, 4 rue Augustin Fresnel 57078 Metz Cedex 3
2 : LEMTA CNRS UMR 7563 ESSTIN - UHP, 2 Rue Jean Lamour 54519 Vandoeuvre-Lès-Nancy
3 : Centre Automobile Produit ARCELOR Research, S.A. Voie Romaine BP 30320 57283 Maizières-
les-Metz

Mechanisms of ductility loss

Plastic mechanisms of ductility loss

Structural origin: wrinkling, buckling
Material origin: localization, necking

Damage mechanisms of ductility loss

Cavitation
Failure

Context of the study

Forming Limit Diagram (FLD)

• Forming limit of sheet metal = state at which a localized strain initiates during forming
• Ductility loss characterization using Forming Limit Diagram (FLD) developed first by Keeler (1963) and Goodwin (1968).
• Path-dependent representation

Metallurgy impact (texture, grain size, …) Strain path dependence

Aims of the study

• Ductility loss prediction for Dual Phase Steels and sequential strain paths
• Optimization of microstructural properties of the sheet forming steels

Single crystal modeling

• The statistically stored density mechanisms dislocations, are represented by isotropic hardening

Plastic anisotropy evolution

TEXTUAL ANISOTROPY (crystallographic network + morphologies)
STRUCTURAL ANISOTROPY (intragranular microstructure)

Assumptions

• Elastic-plastic behavior
• Large strain formulation
• Body-Centered Cubic (BCC)
• Plastic strains only due to slip processes (<110) slip direction family and (110), (112) slip plane families

Elasticity \( \sigma = C : \varepsilon \)
Plasticity \( \varepsilon = \varepsilon^L + \varepsilon^p \)

Elastic-plastic tangent modulus

\( ^{\varepsilon^L} \varepsilon \) = \( ^{\varepsilon^L} \varepsilon + \varepsilon^p \)

Plastic anisotropy evolution

Dual Phase prestrain

\( t^p = t^p (1 - \psi^p) + \sum_{i=1}^{3} \psi^p_i \)

Isotropia hardening

\( t^h = t^h (1 - \psi^h) + \sum_{i=1}^{3} \psi^h_i \)

Latent hardening

\( t^l = t^l (1 - \psi^l) + \sum_{i=1}^{3} \psi^l_i \)

Scale transition

What is the link between local and global strain?

Voluntary average

Fourth order localization tensors

Relation between A and B

Ductility loss criterion

Assumption: the onset of localization is along a band (Rice, 1976)

Field equations

Boundary conditions

Ellipticity loss

Microscopic validation

TEM micrograph

Intensity of dislocations walls

Polarity of dislocations walls

Macroscopic validation

Field equations

Boundary conditions

Ellipticity loss

Multiscale model with intragranular modeling

 reproduces correctly the intragranular microstructure during monotonic and sequential loading paths
 gives better results concerning macroscopic behavior during changing loading paths than model without intragranular modeling

Conclusions

Multiscale model without intragranular modeling

 reproduces correctly the shape and the level of direct FLD for mild steel and dual phase
 reproduces the strain-path dependence of complex FLD

\( \sigma \), \( \varepsilon \)

\( ^{\varepsilon^L} \varepsilon \)