

The role of the anisotropy in the process of advanced deformation and damage in metal sheets

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Abstract: The objective of the paper is the material anisotropy in the nonlinear solid mechanics. The anisotropy has non trivial influence on the process of body deformation, even if we deal with linear kinematic and constitutive theories. The situation is more complicated for the advance inelastic deformation and for the evolution of intrinsic microdamage.

1. Introduction

The schematic classification of the anisotropy in thermo-mechanics is presented in Fig. 1. First, we can distinguish the *initial anisotropy*, which is connected with the initial properties of the body, such as the initial internal structure (e.g. transverse isotropy for wood, orthotropy for cold rolled metal sheets or composites) or the initial distribution of microdamages. Secondly, we can distinguish the *induced anisotropy* caused by plastic/viscoplastic effects (kinematical hardening) or the nucleation, coalescence and evolution internal microdefects. Initially isotropic material, can become fully anisotropic due to the evolution of internal structure [1].

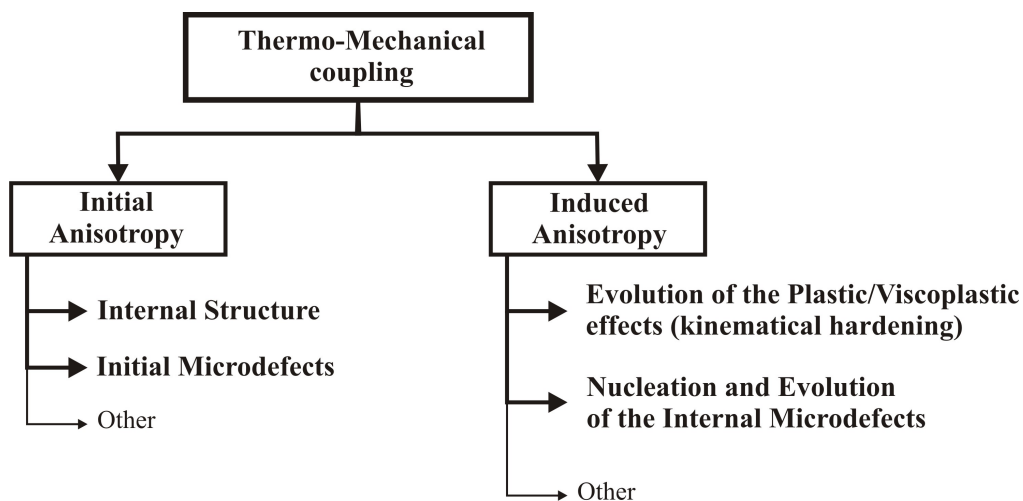


Fig. 1. The classification of the influence of the anisotropy the thermo-mechanical process.

2. Important features of the anisotropic body

As mentioned, anisotropy generates non trivial properties of the body. To better understand their role, let us summarise the important and interesting features of anisotropic body [2]:

1. strain and stress are not coaxial,
2. from the 21 unknowns in the stiffness (or compliance) elasticity tensor only 6 are dimensional parameters (6 Kelvin moduli [Pa] + 12 stiffness distributors [-] + 3 orientation angles [-]),

3. components of the stiffness (or compliance) elasticity tensor change when the reference system in the physical space is changed, so in general, do not represent material constants,
4. there exist anisotropic materials that transmit longitudinal elastic waves in exactly the same manner as isotropic material (in this case the anisotropy is completely undetectable in experiments with longitudinal waves).

3. Numerical example

As an example, the evolution of the induced anisotropy in metal sheets (modelled as an intrinsic anisotropic microdamage), during fast tension test, will be presented.

The material model is stated in terms of the continuum mechanics, in the framework of thermodynamics. The intrinsic anisotropic microdamage, described by the second ordered tensorial field, is introduced as a state variable in constitutive structure [1].

It will be shown, that initially isotropic material, becomes anisotropic during the process of deformation, and simultaneously, the information about the progressive anisotropic damage direction and velocity till the loss of continuity can be analysed. The results of analysis make the description of the problem wider and help to predict process development.

The constitutive relation, is implemented as a user subroutine in the finite element Abaqus environment, and explicit integration rule is used.

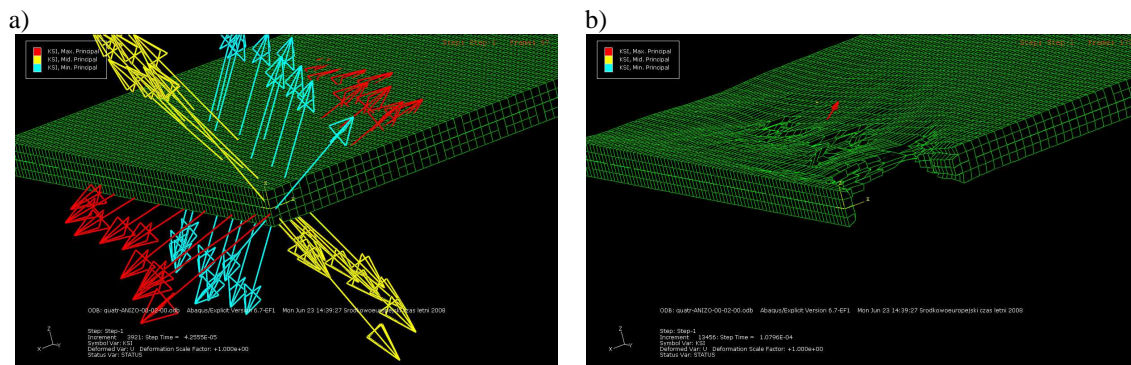


Fig. 2. a) Plot of the principal directions of damage tensor - predicted damage path is in the plane perpendicular to the maximum eigenvalue (red arrow) ; b) mode of damage (loss of continuity).

References

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- [2] J. Rychlewski, A qualitative approach to Hooke's tensors. Part II, *Archives of Mechanics*, 53, 1, pp. 45-63, 2001.

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