Prediction of the ductility limit of sheet metals during forming processes using the loss of ellipticity approach

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The prediction of the ductility limit of sheet metals during forming processes represents nowadays and ambitious challenge. To reach this goal, a new numerical approach, based on the loss of ellipticity criterion [1], is proposed in this work. A polycrystalline model is implemented as a user-material (UMAT) into ABAQUS FE code. The polycrystalline aggregate is associated with each integration point of the FE mesh. To derive the mechanical behavior of this polycrystalline aggregate from the behavior of its microscopic constituents, the self-consistent model is used [2]. The mechanical behavior of the single crystals is described by a finite strain rate-independent constitutive framework, where the Schmid law is used to model the plastic flow. The condition of loss of ellipticity at the macroscale, where the macroscopic behavior is derived by using the self-consistent scheme, is used as ductility criterion in the FE modeling. This numerical approach, which couples the FE method with the self-consistent scheme, is used to simulate some forming processes (deep drawing process, Nakazima test…), and the above criterion is used to predict the ductility limit of the studied sheets during these operations.

[1] B. Budiansky and N. A. Fleck, J. Mech. Phys. Solids, 4, 183–211 (1993).

[2] P. Lipinski and M. Berveiller, Int. J. Plasticity, 5, 149–172 (1989).