Influence of microstructural characteristics on the localization of plastic deformation

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Abstract :

The localization of plastic deformation in expanding shells of ductile metals in the form of necking is usually addressed, at the macroscopic scale, as a consequence of the development of instable perturbation modes of the homogeneous response of these structures (see [1] among the numerous recent papers on this topic). Still, the incidence of phenomena taking place at the mesoscale, i.e. the one of the crystalline structure, can be investigated by representing the grain aggregate constituting the material. We performed simulations of dynamic stretching plates in this aim with a crystal plasticity FE code [2]. Depending on the grain size and deformation rate, a competition emerged between localization starting from weak points of the aggregate and localization driven by structural modes (fig. 1).

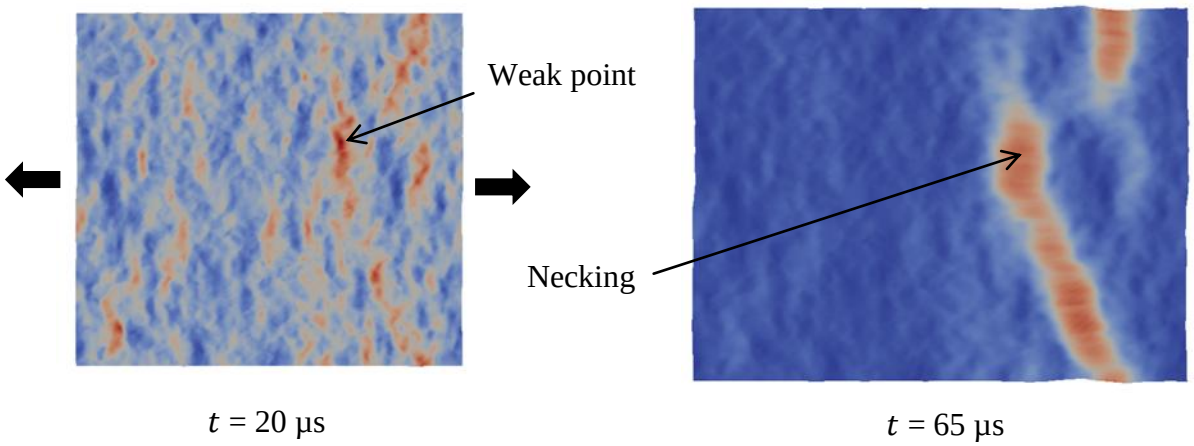

Fig. 1. Strain maps in plane strain stretching for a 4000 grain aggregate and stretching rate $\dot{F}_{XX}$ = 5000 s^{-1}.

Moreover, microstructural characteristics such as texture, dislocation densities or grain shapes induced by the forming process influence the organization of plastic deformation at the mesoscale since the early loading stage and, as a consequence, the final localization timescale and pattern. Specifically, in some cases, a texture with strong “fibers” tends to enhance the initial

strain heterogeneity due to coexistence of favorably and unfavorably oriented grains and to accelerate macroscopic localization. The effect of initial dislocation densities, depending on heat treatments applied during forming operations, is less clear since subsequent stretching tends to homogenize these densities between grains and yields localization pattern almost insensitive to them.

[1] M. Xavier, C. Czarnota, D. Jouve, S. Mercier, J.L. Dequiedt, and A. Molinari, "Extension of linear stability analysis for the dynamic stretching of plates : spatio-temporal evolution of the perturbation". *Eur. J. Mech. A Solids*, **79**, 1-19 (2020).

[2] J.L. Dequiedt and C. Denoual, "Localization of plastic deformation in stretching sheets with a crystal plasticity approach: competition between weakest link and instable mode controlled process", *Int. J. Solids Struct.*, **210-211**, 183-202 (2021).