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DAMAGE COMPUTATION FOR NON-MONOTONIC MULTIAXIAL SOLICITATIONS APPLIED TO ANISOTROPIC DUCTILE STEEL GRADES

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ABSTRACT

Cold forming processes are still widely used in the metal industry to produce parts at high production rates with high mechanical strengths and close repetitive tolerances. On the other hand, cold deformation requires very ductile materials in order to produce parts without significant damage. Besides, during multi-stages cold forming processes, the materials is submitted to non-monotonic multiaxial solicitations and sometimes, even reverse loadings. For such complex strain path, the prediction of damage evolution becomes really intricate.

The aim of this paper is to highlight the specific points to be addressed in order to get predictive damage computation for cold forging processes modelling. On the basis of a classical isotropic Lemaitre damage model [1], we first compare numerical predictions with experimental results. This model gives a good prediction for damage localization. However the critical damage value identified on a simple tensile test is clearly not adapted to predict crack initiation for a more complex industrial process. As the first predictions are not satisfactory, some enhancements are added to account for some particular aspects of damage computation for cold forging processes: influence of compressive states on damage evolution, anisotropy, complex multiaxial strain paths and influence of stress triaxiality [1, 2, 3, 4].

To complete this study, an experimental campaign is achieved for two ductile steel grades. First, macro-mechanical tests are performed for different orientations in order to measure the ductility and the anisotropy of the materials. As materials are generally submitted successively to tensile and compressive mechanical solicitations during forming processes, some specific mechanical tests have been realized on diabolo-shape specimens [5]. Particular attention is paid to the influence of pre-compression on materials ductility and on materials anisotropy.

To understand the role of particles on damage mechanisms, in-situ tensile mechanical tests are performed. Scanning electron microscopy (SEM) and X-Ray tomography are used for the in-situ characterizations of microstructure evolution. The stages of nucleation, growth and coalescence are observed and discussed depending on the solicitation direction with respect to the grain flow orientation.

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