Role of crystallographic texture and patterns of stored dislocations on deep drawability

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Formability of sheet metals can be tested by stretching, for example be applied in the rolling direction x_1. Suppose that failure occurs at a plastic strain ε_1 and that the ratio between the plastic strains normal to the sheet (ε_3) and in the transverse direction (ε_2) is kept constant. Several tests are carried out for several such ratios. A graph called 'forming limit curve' (FLC) or Goodwin (1968)-Keeler(1965) diagram showing these combinations of $\varepsilon_2/\varepsilon_1$ is then made, see for example Nakazima, Kikuma and Hasuka (1968). The lowest formability is usually found when the minor strain is zero, the major being not very large either. A purely mechanical model predicting such curve has been proposed by Marciniak and Kuczynski (1967). They used a von Mises yield locus and a $\sigma_{vM}(\varepsilon_{vM})$ hardening law. The model calculates the evolution of a hypothetical small surface defect. Failure happens when the depth of the defect reaches an assumed critical size. Results depend on this choice, the shape of the forming limit curve nevertheless being usually well predicted. The von Mises yield criterion can be replaced by polycrystal models (such as the Taylor model) which take the crystallographic texture into account (Van Houtte and Tȯth, 1993). Another issue is the effect of a change in deformation path during the forming process. A given material that suffers such "path change" (example: first biaxial stretching ($\varepsilon_2/\varepsilon_1 =1$) followed by plane strain) can either feature a much lower formability (early failure) or a much larger (postponed failure). Not only the plastic anisotropy caused by texture plays a role here. Teodosiu and Hu (1995) identified effects due to the interaction between the dislocation patterns stored in the material during the deformation mode of the initial test and the new dislocations generated during the second deformation mode. This idea has been taken up by Hiwatashi et al. (1998), who describe a version of the Marciniak-Kuczynski model in which both the texture and the initial dislocation structure (induced by pre-straining) are taken into account. Comparisons between experimental and predicted FLCs are given for cases with and without strain path changes (Van Houtte et al. (2003) and (2007)). Some of these results are rather frightening: sudden failure occurring immediately after a strain path change.

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