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AN EXPERIMENTAL COMBINATION OF LOADING PATH AND STRAIN RATE CHANGE - MICROSTRUCTURE EVOLUTION AND FLOW BEHAVIOR FOR A BCC AND FCC MATERIAL

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Strain paths are usually non-proportional during deep drawing operations. In many cases, this may result in the development of oriented dislocation structure [1, 2], which result in anisotropic flow, hardening and complex stress-deformation behavior. A further step is the implementation of different strain rates during strain path changes, which will be presented in this work. An interstitial free (IF) steel and an EN AW-6016 T4 aluminum alloy were pre-strained via plane-strain deformation at room temperature under three different strain rates up to 100 s^{-1}. The pre-strained materials were subsequently tested in different directions under uniaxial tension at room temperature and a quasistatic strain rate (10^{-3} s^{-1}). While the aluminum alloys pre-deformed at quasi-static and high strain rate exhibit nearly equivalent features during the second uniaxial tension deformation, a drop in yield stress (Figure 1) is detected for the steel material with increasing strain rate in the first deformation process. The strain hardening rate is increased and the cross hardening effect is less pronounced with higher strain rate in the first deformation process. This effect of strain rate during pre-straining on the subsequent mechanical response for the steel material can be rationalized by differences in dislocation structure evolution during plane-strain deformation: While quasi-static strain rates result in cell structure formation by recovery, a far more homogeneous dislocation distribution is obtained during deformation at dynamic strain rates. These dislocations increase the yield stress during the subsequent uniaxial deformation while transient strain hardening is suppressed due to a lack of adequate dislocation cell structure for the dynamically pre-strained material. Furthermore, a systematic study of the microstructure evolution during the first and second deformation process in combination with the strain rate and the tested material will be presented.

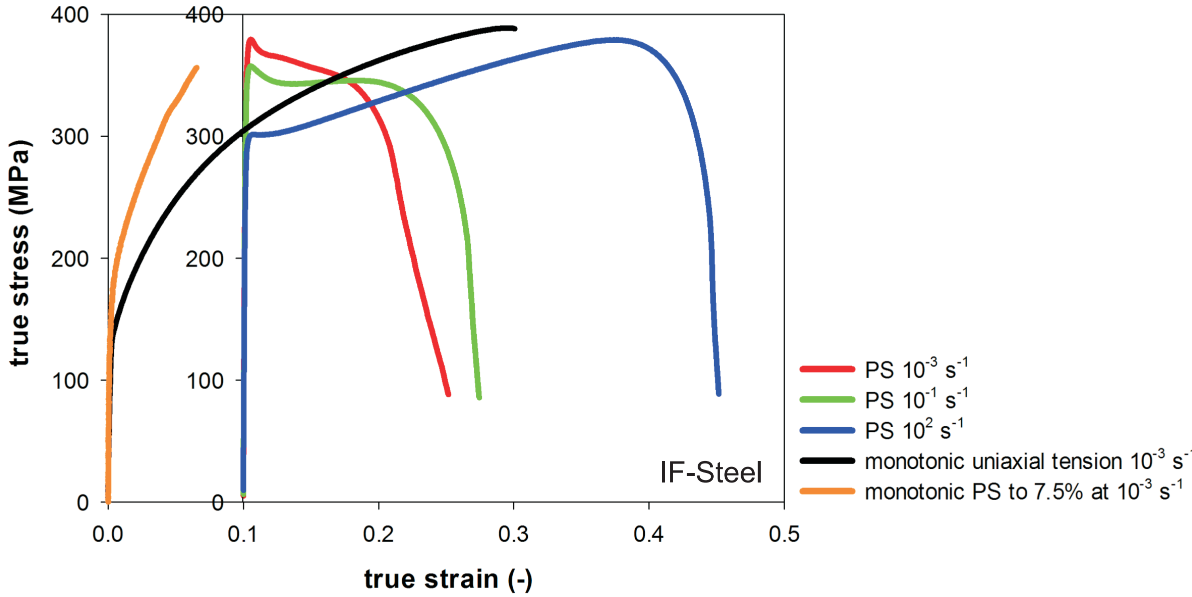

Figure 1: Flow curves in uniaxial tension (quasistatic) after 10% Plane-Strain tension (PS) deformation at different strain rates from 10^{-3} s^{-1} (red), 10^{-1} s^{-1} (green) and 100 s^{-1} (blue). In comparison the monotonic curves in uniaxial (black) and plane-strain (orange) tension are shown.

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