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Non-linear reversible behaviour of metal alloys at low stresses

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The reversible behaviour of metals is more complex than the generally assumed linear behaviour. This is primarily due to the reversible behaviour of dislocations. This work aims to investigate the fundamentals of non-linear stress-strain reversible behaviour at low stresses of industrial-grade metal alloys. Mechanical testing was performed in two different modes: incremental plastic deformation and cyclic loading-unloading below the yield stress with a focus on the measurement of small strains and corresponding stresses occurring in the pre-yield regime. The non-linearity was quantitatively analysed, as opposed to the common approximation of an empirical determination of apparent Young's modulus. The dislocation structure parameters – dislocation density and average segment length were obtained from extended Kocks-Mecking plots by application of a recently proposed pre-yield model. The detailed analysis of the experimental evidence on the non-linear elastic behaviour, hysteresis and microplasticity will be used to further investigate and extend model descriptions that are based on the dislocation behaviour of the material. The physical basis of the model will allow for quantification of these deviations in the pre-yield region, which are large enough to be significant in industrial processes.

Keywords: Anelastic behaviour, Dislocation structure, Pre-yield model, Cyclic stress-strain curve, Microplasticity

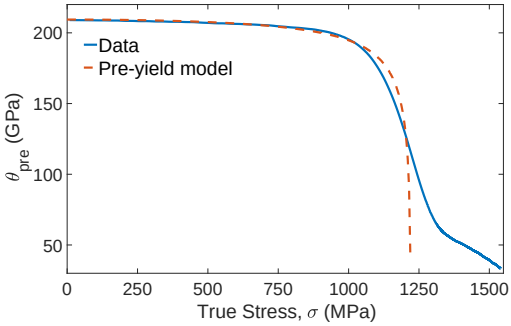

Figure 1. Extended Kocks-Mecking plot (in blue) and pre-yield model (in orange) applied to tensile test data for the first cycle of incremental plastic deformation.