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A novel yield locus description by combining the Taylor and the relaxed Taylor theory for sheet steels

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ABSTRACT

Recently, several flexible constitutive equations have been proposed for sheet forming simulations. However, various mechanical tests are required to determine the material parameters needed for such models. In the present work, effort has been made to investigate the correlation between the polycrystal plasticity based yield loci and those determined from mechanical tests, in order to define yield functions easily and accurately with minimum experimental work. The results for different materials indicate that, in many cases, the Hill'48 quadratic yield function conventionally fitted with the plastic anisotropy *R*-values deviates significantly from measured yield loci. The Hill'48 yield function fitted with the uniaxial and biaxial yield stresses is quite close to the measured one, but with large deviation in the strain ratios for strong anisotropic materials. A careful comparison of the measured yield loci and those calculated from the Taylor full constraint model and the relaxed model indicates that the yield loci derived from the Taylor full constraint model capture the shape of the measured ones in general, but they are less elongated in the stretching direction, and the stretching factor is usually smaller than that derived from the relaxed Taylor model. The measured biaxial points are between those calculated from the two Taylor models. Based on the two yield loci derived from the Taylor models, a new combined model referred to as CTFP is proposed. The new model retains roughly the shape of the yield loci derived from the Taylor full constraint model, but the size is scaled using the averaged biaxial points of each model in the stretching regime. The proposed new description has been validated using several forming steel grades. This model can be used as virtual experiment for complicated mechanical tests, such as the plane strain tension, balanced biaxial stretching and shear test. The stress and strain data from the virtual experiments, together with the stress and plastic anisotropy measured in the uniaxial tensile test, are easily deployed as input data for other constitutive equations used in sheet metal forming simulations. Forming limit diagrams were predicted using different material constitutive models. The difference between the measured FLD and the calculated ones is remarkable. A profound analysis of the phenomena and a systematic study of intrinsic material parameters on the FLDs is needed.

1. Introduction

Finite element (FE) simulation has become a powerful modelling technique in the automotive industry. As a result, the number of trials for stamping, which are often quite expensive and time-consuming, can be significantly reduced and the development time for new models shortened. The reliability of FE modelling depends not only on the numerical description of the problem, but also on the description of process parameters and the constitutive material models used. An important

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