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On the plastic anisotropy of an aluminium alloy and its influence on constrained multiaxial flow

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ABSTRACT

The influence of plastic anisotropy on the mechanical behaviour of a rolled aluminium plate under quasi-static loading conditions is studied experimentally and numerically. Material tests in different directions with respect to the rolling direction of the plate were carried out on various specimen shapes providing a wide range of stress states. The Yld2004-18p anisotropic yield function was identified through uniaxial tensile tests, shear tests and upsetting tests. This yield function was found to provide an adequate description of the significant anisotropic behaviour of a high-strength AA7075-T651 plate. Numerical simulations of all the material tests were then performed with an elasto-plastic material model using both the anisotropic and an isotropic version of the yield function. The numerical predictions of the mechanical response for notched tensile tests obtained with the isotropic version of the material model clearly over-estimated the experimental results. Similar results have been reported in the literature on other materials using isotropic constitutive relations. This over-estimation was significantly reduced when using the anisotropic version of the material model, and the reason why plastic anisotropy is so important for an accurate prediction of the notch-strengthening effect is explained. It was also established that the exponent of the yield function Yld2004-18p has a strong influence on the results for the notched tensile tests. When the exponent of the yield surface was assigned a sufficiently high value, an almost perfect fit between the numerical predictions and the experimental results was obtained.

1. Introduction

Structural components in various aluminium alloys are widely used by the automotive and aircraft industries. A variety of different extrusion techniques, rolling processes and forming operations is used to manufacture these components. Because of the extreme deformations taking place during processing, such components may have highly anisotropic properties. This anisotropy is an important material factor determining the magnitude of local deformations and may have significant effects on the final shape of the component and local strain instabilities during operation. Thus, the anisotropic behaviour during deformation must be taken into account if one wants to correctly predict the mechanical behaviour of an aluminium component.

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