Modelling Mechanical Behaviour of Mg Alloys in Channel Die Compression test

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Introduction

The yield and work hardening behaviors of wrought magnesium alloys are strongly sensitive to not only the microscopic textures but also to the stress states applied. The present work aims to develop a comparatively simple engineering equation capable of capturing the effect of texture on the stress-strain response of magnesium alloys. The channel die compression test is used to verify the proposed model.

Model development

An arbitrarily textured aggregate comprises two populations: one fraction twins during the deformation and the other fraction only undergoes slip. The macroscopic flow stress can therefore be given by:

$$\sigma = \left(1 - X_T\right)^{S}\sigma_s + X_T\sigma_T \qquad (1)$$

where X_T is the volume fraction of grains in which twinning is expected, ${}^{S}\sigma_S$ is the stress in the non-twinned grains, and σ_T is the stress in the twinned region and is the combination of the twinning stress σ_{0t} and the stress ${}^{T}\sigma_s$ due to slip:

$$\sigma_T = \left(1-\chi\right)\sigma_{0t} + \chi\,{}^{T}\sigma_s \qquad (2)$$

where χ approaches unity with increasing strain.

Methodology

The specimens used in the channel die compression test were cut from a rolled plate in such a way that the compression direction (CD) was inclined to the plate normal (ND) by an tilt angle, α (Fig. 1). Five values of α were employed: 0, 22, 45, 68 and 90 degrees.

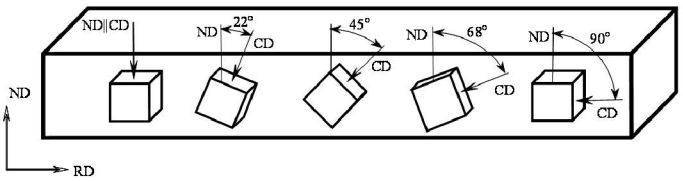

Fig. 1. Samples cut from a plate with five tilt angles.

During testing the samples were constrained in the transverse direction (TD) of the plate but extended along the rig channel (ED) under loading (Fig. 2) .

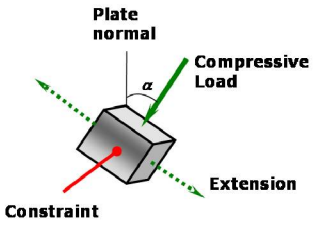

Fig. 2. Channel die compression.

Correlation of theory with test

The model is capable of predicting that with increasing α the flow stress at low strains drops initially and then remains relatively constant for α = 45, 68 and 90 degrees. The lowest maximum flow stresses was achieved in the sample with α = 45 degree (Fig. 3).

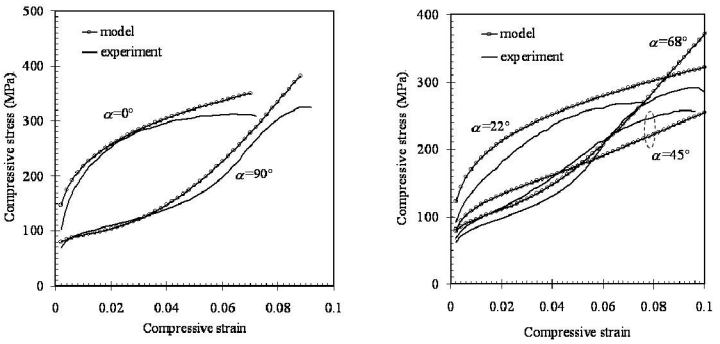

Fig. 3. True flow curves from channel die tests and modelling.

The model values predicted for the twin volume fraction fall between the low optical results and the high EBSD readings (Fig. 4).

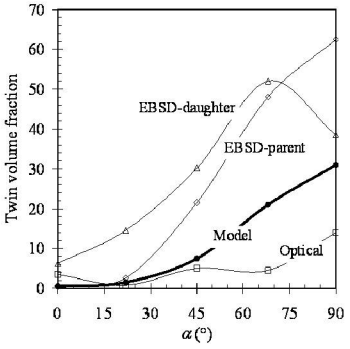

Fig. 4. Variation in the twin volume fraction among the different channel die samples.

The twin fractions predicted by the present model were also used to generate a set of reoriented grains. The calculated textures agreed well with the test results (Fig. 5).

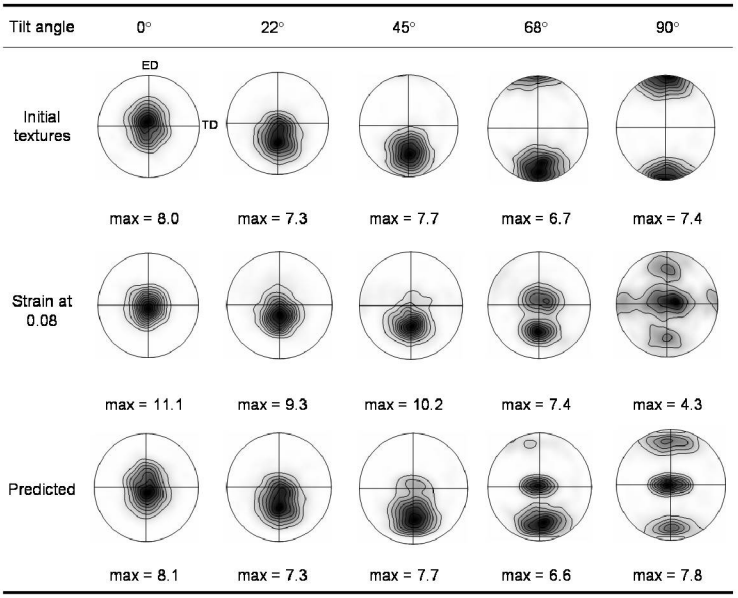

Fig. 5. Basal pole figures showing initial and deformed textures, and the textures predicted from only a consideration of twinning.

Acknowledgements

This work was funded by the ARC Discovery project scheme.