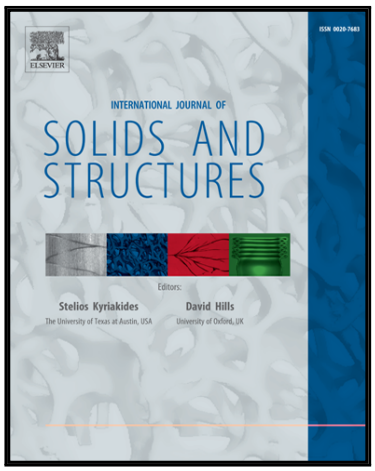

Transition from convex to concave of equal plastic work contours for wrought magnesium alloy under multi-axial loading

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Transition from convex to concave of equal plastic work contours for wrought magnesium alloy under multi-axial loading

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Abstract Due to non-proportional stress state in the forming process, an extruded AZ31 magnesium alloy is subjected to combined axial loading-torsion test. Pre-elastic axial tension and compression along extruded direction is performed firstly, then torsion loading with the axial stress unchanged, denoted as TT (Torsion after Tension) and TC (Torsion after Compression) loading is implemented respectively. The results show that the shape of the Equal Plastic Work Contour (EPWC) changes remarkably from convex to concave as plastic deformation increasing. Accordingly, the EPWC cannot act instantaneously as plastic potential which take place under proportional loading path. The microstructure of failure samples were observed to clarify the reason of transition from convex to concave. It is found that the twinning behavior is different during torsion after different axial stress which results from the variation of stress state during torsion and the restricted activity of twinning with c/a ratio decreasing. For pure torsion, the stress state facilitate the growth of twins. For pre-loading samples, the activity of twinning is restricted with the c/a ratio decreasing. However, the stress to activate twinning is satisfied under TC loading with the compressive stress component increasing with pre-elastic compression. The compressive stress component decrease with pre-elastic tension under TT loading. Therefore, twinning is activated under pure torsion and TC loading. Furthermore, the barrier effect of twin boundaries and dislocation-twin interaction strengthen basal slip and prismatic slip resulting in dislocation hardening. Texture hardening takes place by reorientation of grains induced by twinning. Both dislocation hardening and texture hardening lead to high strain hardening rate under pure torsion and TC loading. Therefore, the strain hardening rate and flow stress are much higher under pure torsion and TC loading than that of TT loading. Consequently, a transition from convex to concave of EPWC is obtained in large plastic strain.

Keywords: convex transition; equal plastic work contour; twinning; non-proportional loading; wrought Mg alloy

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1. Introduction

Due to high strength-to-weight ratio, the application of magnesium alloys can reduce CO_2 emission and promote fuel economy in automotive and aerospace industry (Hirsch and Al-Samman, 2013). However, wrought magnesium alloys with a low-symmetry hexagonal close-packed (HCP) lattice structure have strong initial texture. The available slip systems are limited and twinning is a main deformation mechanism at room temperature (Agnew and Duygulu, 2005). Depending on the