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Jeong-Yeon Lee, Dirk Steglich, Myoung-Gyu Lee

PII: S0749-6419(17)30377-7

DOI: 10.1016/j.ijplas.2017.10.002

Reference: INTPLA 2253

To appear in: *International Journal of Plasticity*

Received Date: 29 June 2017

Revised Date: 7 September 2017

Accepted Date: 3 October 2017

Please cite this article as: Lee, J.-Y., Steglich, D., Lee, M.-G., Fracture prediction based on a two-surface plasticity law for the anisotropic magnesium alloys AZ31 and ZE10, *International Journal of Plasticity* (2017), doi: 10.1016/j.ijplas.2017.10.002.

Fracture prediction based on a two-surface plasticity law for the anisotropic magnesium alloys AZ31 and ZE10

Jeong-Yeon Lee[1], **Dirk Steglich**[2,*], **Myoung-Gyu Lee**[1]

[1] Department of Materials Science and Engineering, Korea University, Seoul 02841, Republic of Korea

[2] Institute of Materials Research, Materials Mechanics, Helmholtz-Zentrum Geesthacht, 21502 Geesthacht, Germany

[*]Corresponding author: dirk.steglich@hzg.de

Abstract: The objective of the present study was to characterize the fracture limits of two magnesium sheet alloys, AZ31 and ZE10, using classical and Mohr-Coulomb-type ductile fracture criteria and to evaluate these criteria for different loading conditions in the framework of finite element (FE) simulations. A recently proposed two-yield surface plasticity model, which separates the strain contributions of dislocation glide and mechanical twinning on the (10-12) plane, was adopted to describe the strength differential effect and anisotropic hardening behaviors of the magnesium alloys. The deformation and fracture behaviors of the materials were measured in uniaxial tension, U-notched tension, and shear, thus encompassing a wide range of stress states. The fracture criteria parameters were optimized using an experiment–simulation hybrid approach. The suggested deformation and fracture models were applied to the analysis of thin square tubes under two loading conditions, namely, axial tube compression and three-point bending. The simulation results were compared with those of the respective structure tests. The two-yield-surface model was found to be able to successfully reproduce the punch load–displacement responses in both cases, revealing its superior performance relative to the von Mises model. In the case of failure prediction, both the classical and Mohr-Coulomb-type fracture criteria resulted in similar predictions for tube compression. However, the failure prediction for three-point bending was found to be highly dependent on the fracture criteria, among which the MMC criterion provided the most realistic prediction. The prediction results were further analyzed by investigating the stress history and damage evolution in the critical regions of the specimens during tube compression and three-point bending.

Keywords: magnesium sheet alloy; strength differential effect; anisotropic hardening; ductile fracture criteria; finite element simulations