Biaxial Deformation of Cast AZ80 Magnesium Alloy

P.S. Tomlinson[1], H. Azizi-Alizamini[1], W.J. Poole[1], C.W. Sinclair[1], M.A. Gharghouri[2]

[1] Department of Materials Engineering, University of British Columbia, Vancouver, BC, Canada
[2] NRC Canadian Neutron Beam Centre, Chalk River Laboratories, Chalk River, ON, Canada

Materials Science

Main Following prior work on 6061 aluminum alloy, biaxial testing of as-cast AZ80 magnesium alloy was conducted using a combination of axial stress and internal pressure using the same experimental setup as Marin et al. [1], illustrated in Figure 1, but with the addition of strain tracking using a LaVision 3D Digital Image Correlation system. The purpose of this work was to investigate the correlation between biaxial loadings and texture evolution which is expected to be quite strong in magnesium alloys resultant of the material's propensity for deformation induced extension twinning which brings with it an 86° lattice rotation.

Samples were tested in axial tension (parallel to CD), axial compression, hoop tension (parallel to TD) and biaxiality ratios ($\sigma_{\theta\theta}/\sigma_{zz}$) of 0.4 and 0.9. The results, both mechanical and textural were then compared with those calculated by a Visco-Plastic Self Consistent simulation code [2] for which input parameters have already been developed for this material [3].

Magnesium alloys are known to be highly anisotropic and prone to significant textural evolution during mechanical testing resulting from deformation twinning. Texture measurements were conducted on an as machined and heat treated sample. The ODF for this data is presented in Figure 2 along with the VPSC input texture which was created using the neutron diffraction data.

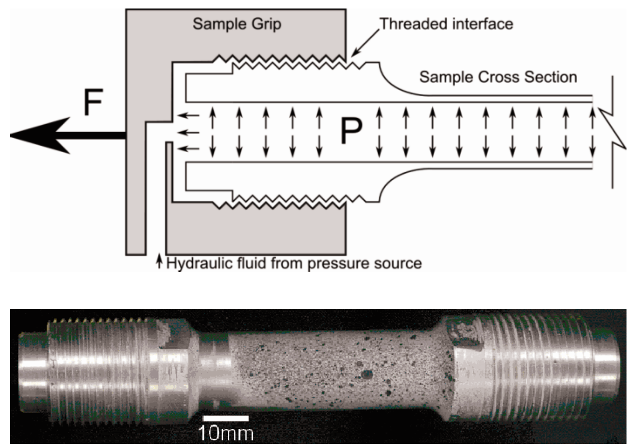

Figure 1 (top) Sample setup employed for testing. A combination of internal pressure and axial load permits various biaxiality levels at yield [1]. (bottom) Optical macrograph of sample with speckle pattern applied for DIC.

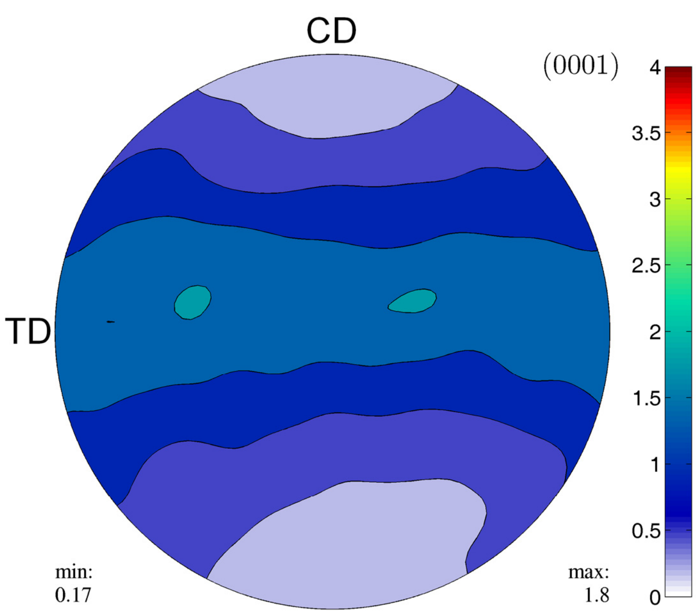

Figure 2 (0001) equal area pole figures illustrating the initial texture, (left) experimentally determined (reconstructed from the ODF), (right) the input texture used for VPSC.

VPSC simulations where run for the various loading conditions and the predicted textures where then compared with those which were observed experimentally through neutron diffraction. Figure 3 presents these pole figures and in all cases, the VPSC pole figure is shown which correlates with the failure strain of that sample. While the intensity of the simulated pole figures tends to be stronger than that observed experimentally, it can be seen that the general trends in textural evolution agree. In the case of axial tension, there is a strengthening of the banded texture, indicating that many of the limited number of grains which were favourably oriented for twinning, have done so, rotating from the top and bottom of the pole figure towards the central band. As the degree of hoop stress increases through the 0.4, 0.9 and hoop stress conditions, the level of twinning from the sides of the pole figures towards the centre increases as extension twins rotate the material. Finally, in the -1 biaxiality condition and axial compression condition, the compressive load induces extension twinning which empties to strong central band in the pole figure, redistributing the intensity at the top and bottom.

The results indicate that for this alloy and input parameters used, VPSC simulation of the uniaxial and biaxial loading conditions presented here, appear to show good agreement with respect to texture evolution. Future work will expand into AZ80 alloy in an extruded condition with stronger texture in order to investigate the robustness of the simulations' ability to handle differing input textures.

References

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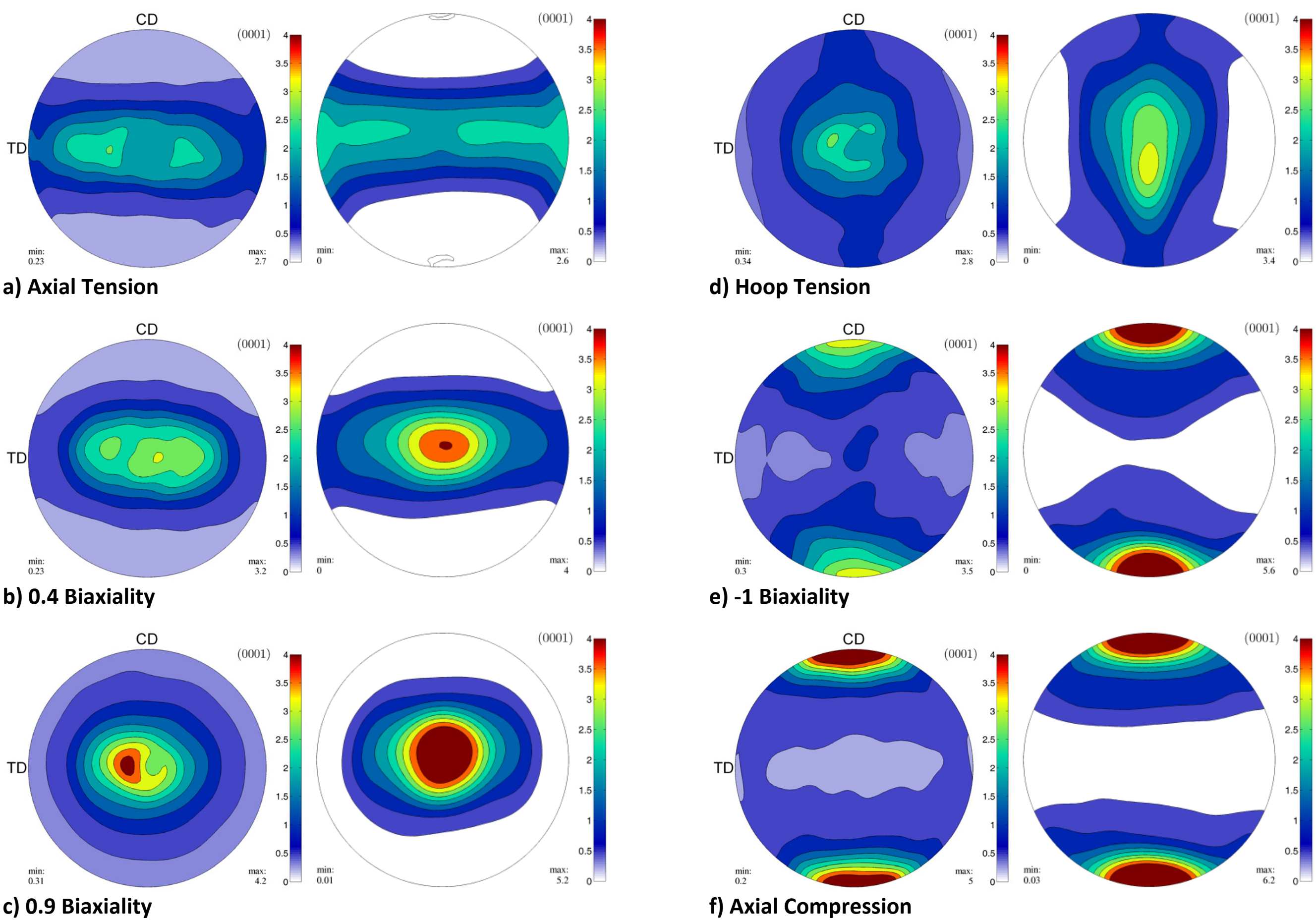

Figure 3 (0001) pole figures for (a) Axial Tension, (b) 0.4 Biaxiality, (c) 0.9 Biaxiality, (d) Hoop Tension, (e) -1 Biaxiality, (f) Axial Compression. In all cases the left pole figure presents experimental data and the right pole figure presents the texture predicted by VPSC.