Submitted to CBECIMAT (2020)

Influence of processing temperature on the microstructural evolution of an Al-Mg alloy processed by high-pressure torsion

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Abstract

An Al-3Mg alloy was processed by high-pressure torsion (HPT) at either room temperature (RT ≈ 300 K) or 450 K and the influence of processing temperature on the microstructural evolution was examined using microhardness measurements and X-ray analyses. The Vickers hardness of the annealed alloy (~55 Hv) increased with increasing numbers of turns and saturated at ~200 and ~170 Hv after 20 turns of HPT at RT and 450 K, respectively. The results revealed a prominent reduction in the crystallite sizes of the Al-3Mg alloy after 0.5 HPT turn. These sizes slightly decreased with increasing deformation and attained lower bounds at ~100 and ~150 nm after 20 HPT turns at 300 and 450 K, respectively. For both temperatures, the dislocation density (ρ) of the annealed metal increased by two orders of magnitude after 0.5 turn of HPT ($\rho \approx 5 \times 10^{13}$ m^{-2}). Further straining led to a gradual increase in the dislocation density for the metal processed at RT and it appeared to saturate at 8×10^{13} m^{-2} after 20 HPT turns. Conversely, the ρ values decreased with increasing numbers of turns when processing was carried out at 450 K beyond 0.5 HPT turn and this trend continued even after 20 turns where $\rho \approx 2 \times 10^{13}$ m^{-2}. It is concluded that HPT processing at 450 K is extremely beneficial to the thermal stability of Al-Mg alloys as it promotes a sizable reduction in the dislocation density without significantly affecting the strength and refinement level attained by HPT at RT.

Keywords: Aluminium alloys; hardness; high-pressure torsion; severe plastic deformation; thermal stability.