Abstract

At the microscopic scale, a plastically deformed material constitutes a nonlinear system with a large number of parameters related to the presence of defects (dislocations, impurities, precipitates, etc.). These microscopic heterogeneities lead, in general, to homogeneous macroscopic plastic flow in a large interval of deformation. Thus the flow stress increases with the applied strain rate. However, in certain conditions of temperature, strain rate and deformation, interaction between dislocations and their transport can lead to an instable plastic flow, in particular in face-centered cubic (fcc) materials where dislocations present a high mobility. Thus, a uniform plastic flow regime gives way to a localized deformation mode. In such conditions, the complexity and the non-linearity of the microscopic parameters generate instabilities of plastic flow; localizations appear on a macroscopic scale by the spontaneous formation of heterogeneities and defects, sometimes regular and propagatifs, which can be observed on the surface of the deformed material. A commonly observed heterogeneous plastic flow is the Portevin-Le Chatelier (PLC) phenomenon. It is due to dynamic strain aging (DSA), i.e., a dynamic interaction between solute atoms and mobile dislocations. The solute atoms diffuse to and pin mobile dislocations during their temporary arrest at local obstacles (forest dislocations, precipitates, etc.). Instabilities arise when the waiting time of dislocations at obstacles is of the order of the diffusion time of the solute atoms. The repeated breakaway of dislocations from the solute clouds reduces the strain rate sensitivity (SRS) of the flow stress which becomes negative. Therefore, the strain localizes into narrow deformation bands and gives rise to serrated stress-strain curve at constant applied strain rate. The purpose of the present work is focused on the analysis of the temporal aspects of the PLC effect in the Al-2.5%Mg alloy. We have investigated the Portevin “Le Chatelier characteristics at room temperature in annealed and cold rolled Al-2.5%Mg alloys. We have shown that the heat treatment affects significantly the jerky flow, namely, the range of instability, the critical strain for the onset of serrations and the ductility of the alloy. We interpret our results in accordance with dynamic strain aging mechanisms.

Keywords: Plastic Flow, Annealing Process