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Interrelation between the Portevin Le-Chatelier effect and necking in AlMg alloys

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ABSTRACT

Plastic flow instability caused by the Portevin Le-Chatelier (PLC) effect and its influence on the necking instability were studied in a binary and a precipitation-strengthened AlMg alloy using the digital image correlation (DIC) technique. Coarse-grained structure and two different fine-grained states distinctly distinguished by dislocation density were produced in both alloys using similar routes of thermomechanical processing. The patterns of stress serrations and strain localization observed at different strain rates include virtually all common types of behavior of the PLC effect. Besides, particular spatiotemporal patterns testifying to a concurrency between the propagation and localization of deformation bands are detected at low strain rates. Despite this diversity, the analysis of deformation curves with smoothened-out serrations bears evidence that the onset of necking always corresponds to the geometric Considère condition. Nevertheless, visualization of the evolution of the local strain-rate field using DIC indicates that the two mechanisms of plastic instability are closely interrelated and modify each other's behavior. The neck formation is associated with a progressive immobilization of the PLC bands, ending by the ultimate strain localization. The coexistence of two kinds of instability during necking gives rise to specific spatiotemporal patterns including oscillatory strain localization.

Keywords: Portevin-Le Chatelier effect; microstructures; metallic material; fracture mechanisms; strengthening mechanisms.