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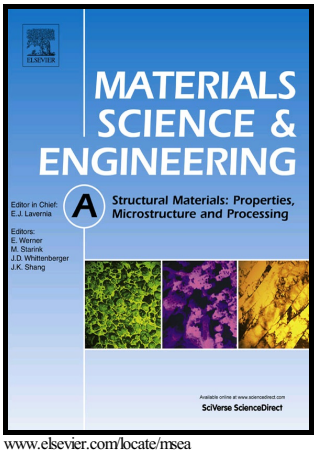

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Strain hardening and nanocrystallization behaviors in Hadfield steel subjected to surface severe plastic deformation

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Abstract:

A gradient nanocrystalline layer with a thickness in a range of millimeter magnitude was successfully produced on the surface of Hadfield steel by a novel severe plastic deformation technology, high speed pounding. The surface hardness was measured, and the microstructure evolution during nanocrystallization process was characterized by X-ray diffraction and transmission electron microscopy. Results showed that the hardness increment and nanocrystallization in Hadfield steel were obtained at different stages under high speed pounding. The first stage was strain hardening, where surface hardness of the Hadfield steel increased gradually during high speed pounding until a steady-state value was obtained. The hardening degree and rate of the Hadfield steel were determined by deformation stress and strain rate, respectively. The second stage was microstructure nanocrystallization, at which twin boundaries interacted with dislocations to form general high angle grain boundaries. In this stage, the surface hardness of Hadfield steel remained basically the same. Moreover, a physical model was established to explain the strain hardening and surface nanocrystallization behaviors in accordance with the microstructure evolution at different stages in Hadfield steel.

Keywords: Severe plastic deformation, Strain hardening, Nanocrystalline, Hadfield steel

1. Introduction

Surface severe plastic deformation (S^2PD) procedure can be used as a typical surface nanocrystallization technology to refine the surface of conventional coarse-grained materials to obtain gradient microstructure throughout the thickness [1-2]. This procedure has been used to produce nanocrystalline layer without any voids and defects at the surface of various metals and alloys, such as iron alloy [3], copper [4, 5], carbon steel [6], stainless steel [7, 8] and nickel/nickel-based alloys [9, 10]. Lu et al. [11, 12] prepared cylindrical gradient