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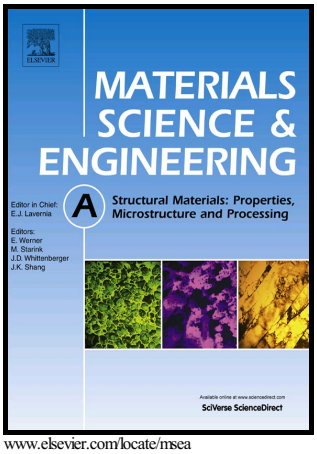

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A Study on Aging Carbide Precipitation Behavior of Hadfield Steel by Dynamic Elastic Modulus

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Abstract: In the present study, the carbon atom distribution and carbide precipitation behavior of Hadfield steel under three distinct states, namely, the quenched Hadfield steel, the deformed Hadfield steel (coarse grain), and the nanocrystallized Hadfield steel, were studied using dynamic thermomechanical analysis, transmission electron microscopy, three-dimensional atom probe, X-ray diffraction, and optical microscopy. Results showed apparent differences in elastic modulus change in the Hadfield steel under three distinct states in the dynamic thermomechanical analysis. Those results proved that the dynamic elastic modulus could be used to determine carbide precipitation behavior in steels during heat treatment. The carbide precipitation temperatures of the nanocrystallized Hadfield steel and the deformed Hadfield steel were higher than that of the quenched Hadfield steel. This phenomenon was attributed to the promoted diffusion of carbon atoms to the stress field of defects during plastic deformation and nanocrystallization process. This process induced a more homogeneous distribution of carbon atoms in the Hadfield steel. As a result, the precipitated carbides were much finer and more dispersive, especially in the nanocrystallized Hadfield steel.

Key words: Hadfield steel; Carbides; Elastic modulus; Nanocrystalline microstructures

1 Introduction

Severe plastic deformation (SPD), such as equal channel angular pressing, accumulative roll bonding, surface mechanical polishing, and shot peening, is considered the main method to prepare dense, nonpolluting, and ultrafine-grained microstructure materials [1–4]. However, these materials are in a thermodynamically metastable state because of wide grain boundary and lattice distortion induced by SPD [5–8]. Except for the evolution in grain size, twin density, and dislocation density, SPD could also result in the redistribution of alloying elements, and influence phase transformation [9–12]. Therefore, the microstructure evolution, including the kinetics and thermodynamics of phase transition, the microstructures, and the phase structures of the ultrafine-grained and nanocrystallized metal material prepared by SPD would change during heat treatment.

Hadfield steel is a type of stable single-phase austenitic steel. Compared with other steels,

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