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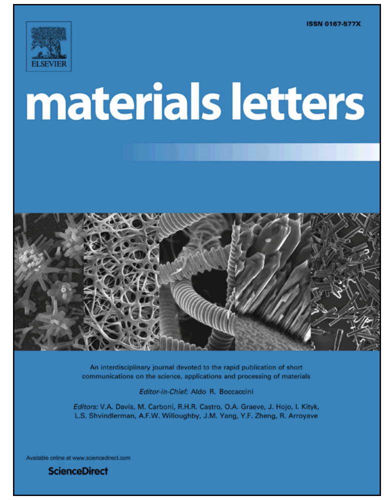

Rotary extrusion as a novel severe plastic deformation method for cylindrical tubes

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Rotary extrusion as a novel severe plastic deformation method for cylindrical tubes

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Abstract

The cylindrical tubular parts of a high-strength magnesium alloy were processed by a novel severe plastic deformation method (rotary extrusion: RE) at the same strain rate and deformed temperature under various revolutions. The effects of this process on the grain refinement and microhardness of the Mg-12Gd-4.5Y-2Zn-0.4Zr alloys were investigated. The results demonstrated that the tube microhardness decreased as the rotary revolutions increased, whereas the matrix and the second phases became significantly homogeneous. The dynamic recrystallization occurred in the RE process. When the temperature and the strain rate were constant, the grains increased in size as the revolutions increased, whereas the dynamic recrystallization refinement and the grain growth were in dynamic competitive relationships.

Keywords: Metal forming and shaping; Microstructure;Severe plastic deformation; Rotary extrusion; Mg-12Gd-4.5Y-2Zn-0.4Zr;

1. Introduction

The magnesium alloys containing Gd have received significant attention in recent years, since excellent mechanical properties are demonstrated [1-3]. The alloys subjected to plastic deformation could obtain the fine-grained strengthening effect and exhibit superior mechanical properties [4]. Various severe plastic deformation (SPD) techniques have received significant attention in recent years, due to the corresponding efficiency in the tensile strength improvement of metallic materials without the toughness reduction [5,6].

The major methods already established for the fabrication of UFG materials are the high pressure torsion (HPT) [7], the twist extrusion (TE) [8], the multi-directional forging (MDF)[9], the cyclic extrusion and compression (CEC). Recently, an increasing interest in the equal-channel angular pressing (ECAP) [10], and the simple shear extrusion (SSE) [11] has appeared. These processes could provide a near uniformity and accumulate quite high strains in massive billets with a high number of passes. In contrast, these methods are usually utilized in the preparation of massive billets and samples of flakes with both low diameter and thickness, where a limitation exists that restrict the materials from being utilized for high-sized shell components.

In this present work, a combined backward extrusion and torsion method was introduced as a suitable process for the production of homogeneously deformed magnesium cylindrical tubes.

2. Principles of Rotary extrusion

The mold required for this new process consisted of two parts: the punch and the die. The rotary extrusion process is presented schematically in Fig.1(a). The initial cylindrical billet was placed into the die. Consequently, the billet was backward extruded along the gap between the punch and the die. During extrusion, the die was continuously rotated by the motor drive.

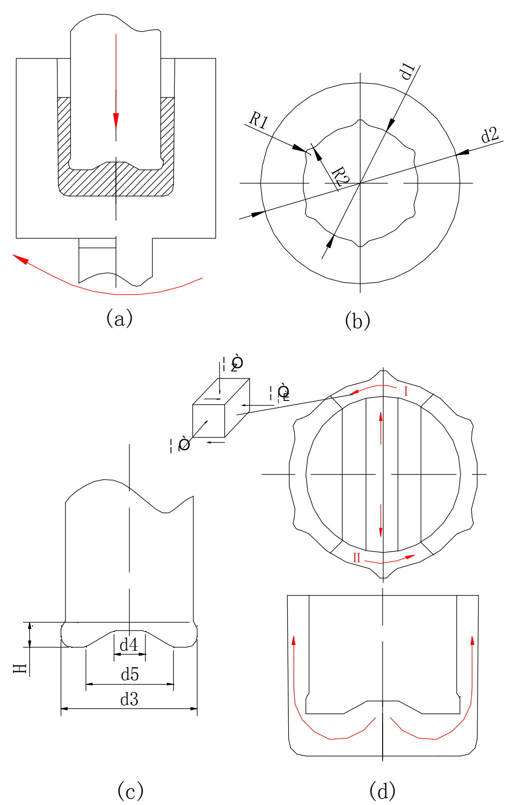

Fig. 1 Schematic of RE process; (a) Working principle diagram of RE, (b) and (c) Structure parameters for RE mold, (d) Stress state and flow pattern of deformation zone

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