JOURNAL OF MATERIALS PROCESSING TECHNOLOGY 209 (2009) 856–863

journal homepage: www.elsevier.com/locate/jmatprotec

A study of flow characteristics of nanostructured Al-6082 alloy produced by ECAP under upsetting test

Ahmed S.M. Agena *

Budapest University of Technology and Economics, Department of Materials Science and Engineering, Bertalan L u. 7, P.O. Box 1521, Budapest 1111, Hungary

ARTICLE INFO

Article history:
Received 20 November 2006
Received in revised form
12 February 2008
Accepted 23 February 2008

Keywords:
ECAP technology
Cold forging
True stress–true strain curves

ABSTRACT

The flow behavior of nanostructured Al-6082 alloy material has been investigated in this paper using an upsetting test. Specimens were produced by the equal channel angular pressing (ECAP) technique and test samples were taken from the three perpendicular axes of the produced parts. The true stress–true strain curves were plotted for all specimens in three directions. Computer software and the Ludwik equation were used to analyze the true stress–true strain curves data in order to determine the stress and strain parameters by plotting the fitted curves onto the true stress–true strain curves. The deformed specimens clearly showed anisotropic behavior.

1. Introduction

NC materials are conventionally processed by a number of methods such as gas condensation, ball milling with subsequent consolidation, and severe plastic deformation (SPD). The first two methods are often characterized by the presence of some residual porosity or impurities (Valiev et al., 2000). The SPD methods are free from these disadvantages and are more convenient for investigation of the role of grain boundaries on the physical properties of different materials. Two common variants of the SPD methods are equal channel angular pressing (ECAP), which has also been called equal channel angular extrusion (ECAE), and severe plastic tensional straining (SPTS) (Alexandrov and Valiev, 1999). In the ECAP process, a rod-shaped sample is pushed through a die containing two channels. These channels are equal in cross-section and intersect at an angle (2Φ) (Meyers et al., 2005), which is usually equal to 90°, as shown in Fig. 1a. Nagarajan et al. (2007) have recently shown that during the ECAP process, the material is subjected to a large plastic shear deformation, which leads to ultra-fine grain size.

According to the previous work, (Yoshinori et al., 1998), there are three kinds of passes (routes):

- In route A, the sample is pressed through the ECAP die repetitively without rotation.
- In routes B and C, the sample is rotated between each pressing around its longitudinal axis by an angle of 90° or 180°, respectively, as shown in Fig. 1b. In this paper, the fourth and eighth passes of route C, in addition to pass one, are used to investigate the mechanical behavior of this material.

2. Experimental procedure

In the upsetting experiments, specimens of cylindrical shape with a diameter of 10 mm and height of 10 mm were used in order to overcome the deviation of the longitudinal axes and

* Tel.: +36 1 463 1114; fax: +36 463 1366.
E-mail address: ahmedajina21@yahoo.com.
0924-0136/$ – see front matter
doi:10.1016/j.jmatprotec.2008.02.081

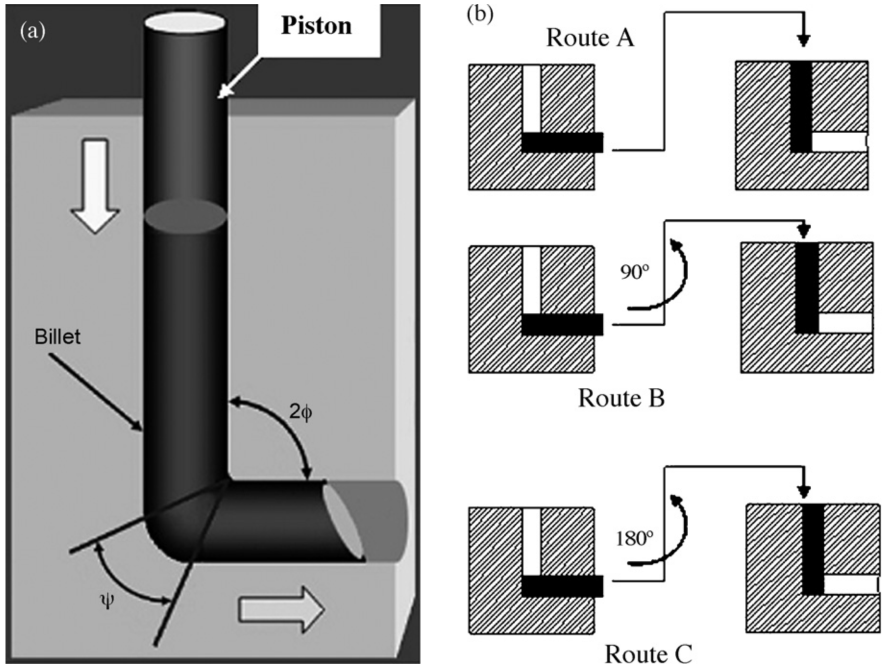

Fig. 1 – (a) ECAP die; (b) illustration of the three routes used for ECA pressing.

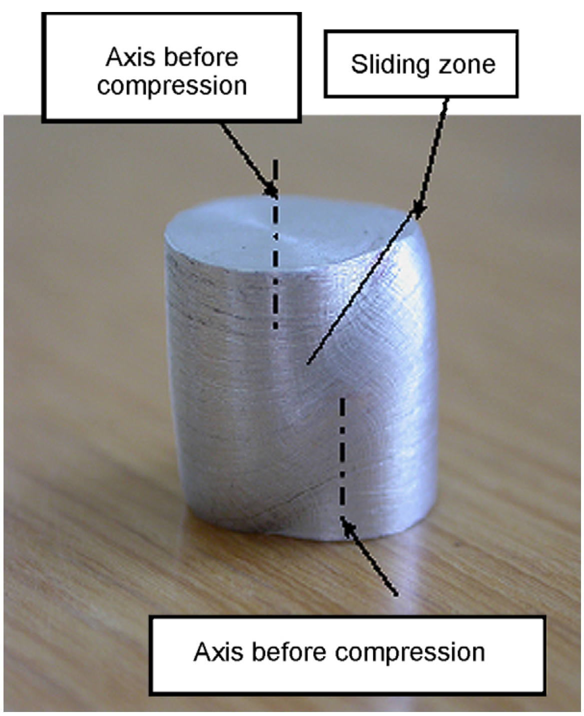

Fig. 2 – Typical shape (caused by the anisotropy) of compression specimen with 1.5 initial height to diameter ratio.

the typical sliding layers that appear in the other h/d ratios of the specimen, as shown in Fig. 2 (Muamar, 2005).

These specimens are produced by ECAP technology from the Al-6082 alloy and were cut out from the three directions of the axes. These directions are defined by the characteristics of *longitudinal* direction, *zero* direction, and 90° direction, as shown in Fig. 3.

To overcome specimen distortion, compression loading up to 500 N (0.5 kN) was applied to the specimen, which was then unloaded. After cleaning the end surfaces of the specimen, the height and the maximum and minimum diameters were accurately measured using digital Vernier calipers, which had 0.01 mm resolution. Then, the specimen was reloaded by a load increment of 0.5 kN over the initial load and the procedure was repeated until fracture occurred in the specimen.

The chemical composition of this alloy is given in Table 1. The upsetting test experiments were carried out at room

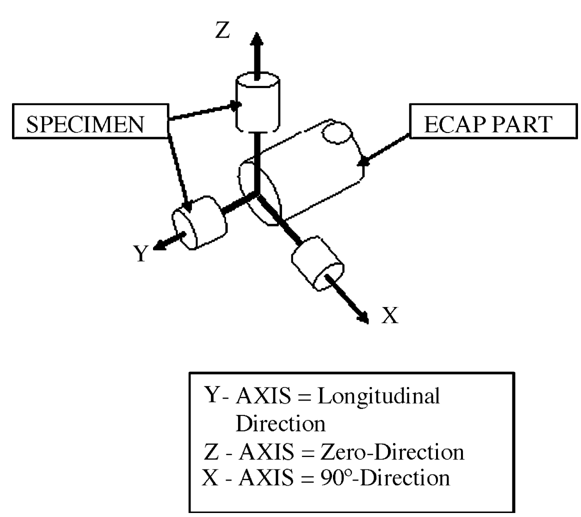

Fig. 3 – ECAP part and the direction of specimen axes.