ACTA STEREOL 1995; 14/1: 57-60
STERMAT'94
ORIGINAL SCIENTIFIC PAPER

ON THE INFLUENCE OF REDUCTION ON THE GRAIN GEOMETRY IN HOT HYDROSTATIC EXTRUDED BRASS SAMPLES

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ABSTRACT

Grain size and shape in commercial brass type 65/35 samples after hot hydrostatic extrusion have been studied. Samples have been extruded with different reduction ratios (defined as billet cross section area over produced wire cross section area) varying from 54 to 225. Cylindrical billet of 50 mm diameter heated to 800°C has been used for all reduction ratios. Studies of microstructure have been carried out by means of automatic image analyzer connected to light microscope on sections parallel to the axis of extruded wires. It has been found that with increasing reduction ratio the grain size decreases, especially in the range of smaller reductions. It has been also noticed, that shape of grain depends on the distance of the tested area from the surface of the sample. Distance from the surface has been found to have a bigger influence on the shape factor of grains than the reduction ratio. A brief proposition of interpretation of changes in shape factor with the distance from sample surface is given.

Key words: brass, grain shape, grain size, hot extrusion, hydrostatic extrusion, microstructure.

INTRODUCTION

The extrusion of copper and brass materials is a forming process that optimally meets the exacting demands on product quality and economy. Constant and consistent development of this technology and equipment has led to a considerable increase of extrusion plant efficiency (see for example Steinmetz A, Staschull WT, 1991 or Ovchinnikov AG, Volchaninov KK, Khabarov AV, 1991). On the other hand the technology is still mainly experience-driven and the microstructure changes occurring during process are not yet completely known.

The grain size and shape in a polycrystal are well-known to influence the mechanical properties of polycrystalline materials (see for example Brittain CP, Armstrong RW, Smith CG, 1985, Armstrong RW, 1986, Bucki JJ, Kurzydlowski KJ, 1992, Kurzydlowski KJ, Bucki JJ, 1993). On the other hand grain size and shape are strongly effected by materials processing technology. After hot hydrostatic extrusion grain geometry is mainly influenced by plastic deformation mechanisms and dynamic and static recrystallization occurring during deformation and the subsequent cooling process.

MATERIAL AND METHODS

The specimens were prepared from commercial brass type 65/35. The detailed chemical composition of the material used is given in Tbl. 1.

Table 1. Chemical composition of the material studied.

Element	Cu	Pb	Fe	Sn	Zn
weight %	64.4	0.02	0.01	0.006	balance

Samples were extruded by means of technology described in detail elsewhere (Kozlowski MS, Mazur A, 1994). The billets before extrusion were heated to 800°C. All samples were extruded from the same type of cylindrical billet (of 50 mm diameter), so different reductions were obtained by means of different diameter of die and resulting wire.
The reduction ratio, R, is defined as billet cross section area, A_0, over produced wire cross section area, A. Detailed information on reduction ratios used in the present study is given in Tbl. 2.

Table 2. Diameter d of resulting wire in mm and reduction ratio R for samples studied

d mm	6.80	5.81	4.81	3.82	3.33
R	54	74	108	171	225

An example of microstructures of samples obtained after extrusion is shown in Fig.1. The size and shape of grains were measured using an automatic image analysis system connected to a light microscope. Specimens were prepared using standard metallographic procedures. Measurements were made on sections parallel to the extrusion direction located as close as possible to the axis of the produced wire. The measured parameters included the equivalent diameter d_{eq} and maximum diameter d_{max} of each grain. For the characterization of grain shape the ratio of the above mentioned parameters was used. It has been found (Kurzydlowski KJ, McTaggart KJ, Tangri K, 1990, Kurzydlowski KJ, Bucki JJ, 1991) that d_{max}/d_{eq} ratio is a valuable measure of grain elongation and can be used as an effective shape factor.

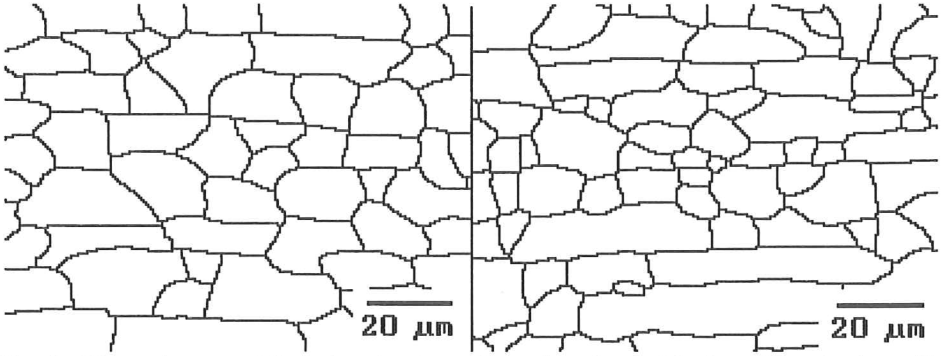

Fig. 1. Binary images of the microstructure of samples after hot hydrostatic extrusion with reduction ratio of 54 (left) and 225 (right).

RESULTS

The influence of the reduction ratio on the size of grains is shown in Fig.2. The results of equivalent diameter measurements are shown for two locations of the testing area - one just under, and the other 1 mm from the surface of the sample.

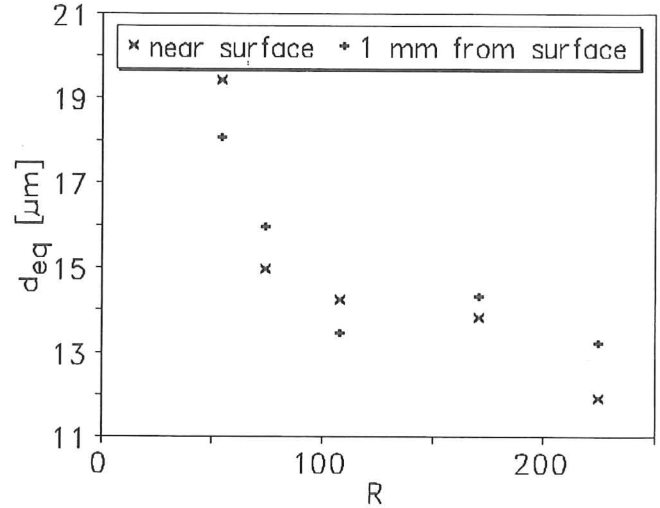

Fig. 2. The influence of the reduction ratio on the grain equivalent diameter.

During measurements it has been noticed that results within each sample depend on the distance of the tested area from the surface of the sample.
Fig.3. shows the influence of the distance of measurement field from the surface on the d_{max}/d_{eq} shape factor for different values of the reduction ratio. The general tendency can be observed, that for a thin, ca. 1 mm., layer near the surface the shape factor value increases with increasing distance from the surface. In the core of the sample the shape factor is found to vary irregularly and no clear tendency can be observed. Fig. 3. also shows that, especially for the outer layer of extruded wires, grain shape factor is more influenced by the distance from the surface than by reduction ratio.

DISCUSSION

Observed grain size change with increasing reduction ratio follows expectations for the influence of extrusion process on grain size (see for example Arkhipov RG et al., 1987, Bashenko AP et al., 1987). For both distances from the surface, used to obtain data for Fig. 2, grain size decreases with increasing reduction ratio. While the difference of grain sizes between for lower reduction ratios 54 and 74 is rather rapid, the following changes with

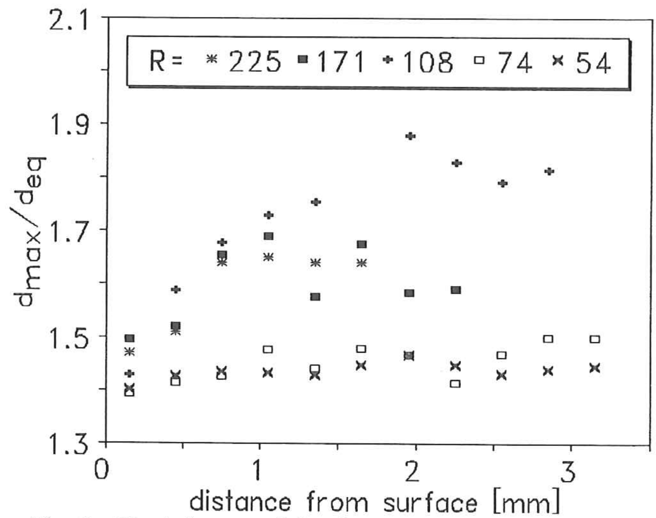

Fig. 3. The influence of the distance from sample surface on shape factor d_{max}/d_{eq} for samples after extrusion with different reduction ratio.

increasing reduction are rather small, but keep general tendency. The decrease in shape factors for outer layer of samples can be probably interpreted as the influence of different extrusion conditions (stress and yield distribution) and different cooling conditions than that in the inner part (core) of the samples. Also free surface can have strong influence on equilibrium of grain boundaries, forcing them perpendicular to the surface orientation of grain boundaries. In this outer area one can observe a rather weak influence of reduction ratio on the shape factor of grains, while the influence of reduction ratio on grain shape is much bigger in the core area.

ACKNOWLEDGMENTS

Valuable discussions with Professor K.J. Kurzydlowski are appreciated. One of authors (JJB) is grateful to the Polish Science Foundation for the financial support.

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