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STUDY OF SEVERE PLASTIC DEFORMATION BY TORSION TEST

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ABSTARCT

High Torsion Pressure (HPT) is an advanced tool for inducing very significant grain refinement in a wide range of metals. In this research were studied parameters of severe plastic deformation using the torsion test. The material used in this research was a polycrystalline Cu-Al-Ni *alloy. For inducing in this material an ultrafine grain structure the thermo mechanical parameters were determined.*

KEYWORDS: Severe Plastic Deformation, HPT, torsion test.

1. Introduction

Nowadays ultrafine grained materials, especially nanocristaline materials (grain size smaller than 100 nm) [1, 2, 3, 4], attract scientific interest. For obtaining ultrafine structures two severe plastic deformation methods are very well known: High Pressure Torsion and Equal Channel Angular Extrusion [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15]. In the present study torsion test was applied to define the specific severe plastic deformation parameters.

The researches provide specific information for HPT method in a special case of hard deformable bronzes which required hot plastic deformation.

2. Material and procedures

The program material is a copper alloy. The chemical analysis (optical spectroscopy) is presented in table 1.

The Cu-10wt. %Al-4 wt. %Ni bronze was elaborated in laboratories of *Dunarea de Jos* University of Galati. The cast ingots are conic shape. Cylindrical billets Φ30 x 30 mm have been cut away and plastic deformed by hot extrusion. Torsion test samples were machined from extruded Φ10 x 120 mm shapes.

The dimensions of calibrated zone of the torsion test sample are Φ6 x 36 mm.

Table 1

Al	Ni	Sn	Pb	Mn	Si	Cu
9.95	3.99	0.06	0.02	0.06	<0.01	Rest

The torsion test machine has direct hydraulic motor driven F112 10 PFC 20. For study of material behavior below 1000^0C a tubular furnace is attached. For cooling the samples after high temperature test also a cooling system with cold water is attached (fig.1).

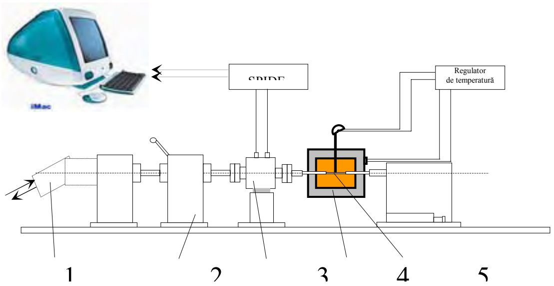

Fig. 1 *Torsion test machine*
1. Hydraulic engine, 2. Gear box,
3. Hottinger torsion measurement device,
4. Furnace, 5. Sample

Mechanical parameters were measured using a equipment type Hottinger Spider 8.

Before the torsion test the samples were heated at 200^0C, 400^0C, 600^0C, 800^0C and 900^0C for 15 minutes.

After breakage, the samples were rapidly cooled in cold water. One part of each sample was metallographic prepared. The metallographically study was performed using a Philips microscope.

For each sample the torsion moment – strain diagram was achieved. Upper 400^0C torsion test temperature, the end of samples were axially looked.

In this case additional axial stress is induced in the sample body.

4. Results and discussions

Torsion test shows an important decrease of the maximum torsion moment from 25 Nm for 20^{0}C to 0.4 Nm for 900^{0}C (figure 2). In the same time strain increases from 0.1 to 6.8

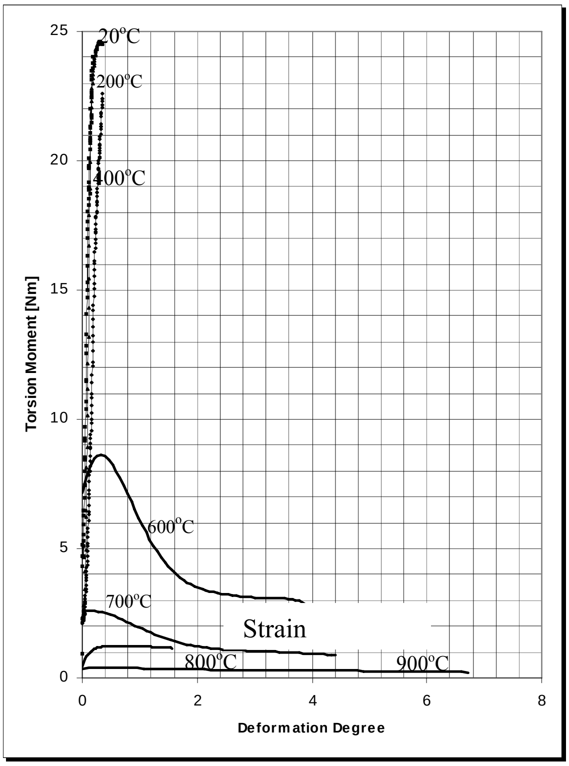

Fig. 2. *Variation of torsion moment with strain for different temperatures*

This behavior of CuAl10Ni4 is normal. The material is hard deformable at 20^{0}C but the plasticity runs up when the temperature increases.

In figure 2 is presented the optical micrograph for bronze CuAl10Ni4 in cast state. The microstructure presents solid solution α, eutectoid ($\alpha+\gamma_2$) and NiAl phase. The structure is dendritically specific for cast CuAlNi bronzes.

The microstructure is typical for this alloy. But after deformation we observe a refinement of structure (figures 3, 4, 5 and 6). The material is twisted and compressed in the same time because the axial stress. The axial stress becomes more important when the temperature increases. That because the plasticity increases maintaing the distance between the ends of the sample.

Fine structure is retained from deformation temperature to 20^{0}C because cooling. The cooling occurs when the test is finished and the sample breaks par way.

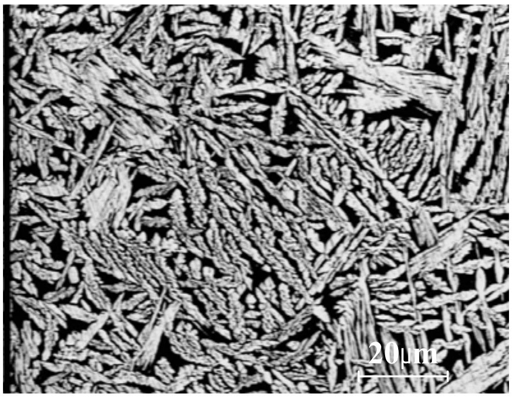

Fig. 3. *Optical micrograph cast CuAl10Ni4 alloy. Chemical composition: 9,95%Al, 3,99% Ni, Cu rest Attack: Fe Cl_3 10g, distilled water 120 cm^3, concentrate HCl 30 cm^3*

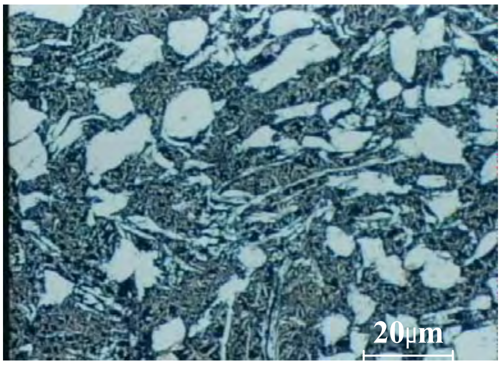

Fig. 4. *Optical Micrograph temperature 20^{0}C, strain rate 0.150 s^{-1}*

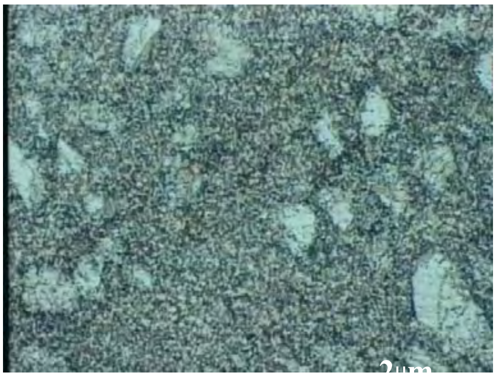

Fig. 5. *Optical Micrograph temperature 200^{0}C, strain rate 0.150 s^{-1}*

***Fig. 6**. Optical Micrograpf temperature 400^{0}C, strain rate 0.150 s^{-1}*

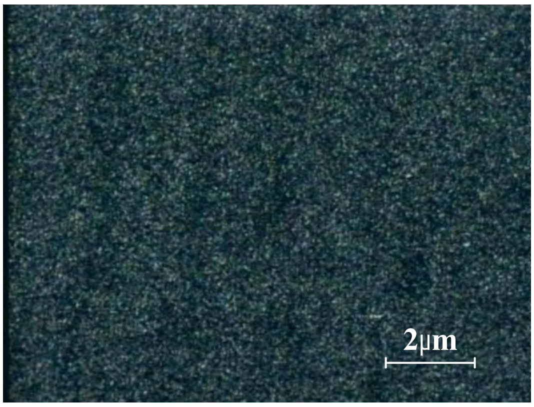

***Fig. 7.** Optical Micrograpf temperature 600^{0}C, strain rate 0.150 s^{-1}*

This observation is confirmed by the microstructures presented in figures 6 and 7.

The finest structures are obtained at 600^{0}C when the sample registers an important deformation degree.

4. Conclusions

The torsion test is a good method to determine the mechanical properties of materials due to certain advantages: constant strain rate, high deformation degree before breaking. Also in appropriate conditions this method allows to obtain fine and ultrafine structure.

This paper points out that, the torsion test made at different temperatures is a good method to determine SPD parameters for the hard deformable alloys which involve hot plastic deformation.

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