UDC 622.692.4

The influence of plastic deformation on properties of gazars.

Karpov V.Yur., Komissarchuk O.V.

National metallurgical academy of Ukraine,

4 Gagarina avenue, Dnepropetrovsk 49600, Ukraine

Abstract

Processes of change of mechanical properties and microtexture of castings from gazars, deformed through rolling and drawing are introduced. The undertaken studies showed that while rolling the deformation of billets is greater than while drawing. The hardness of deformed billets in the as-annealed condition in 1.5 – 2 times higher than the hardness of uniform-sized monolithic rod. The hardness of pieces in the non-annealed condition was still higher. Effect of monolithic areas formation inside the porous structure was identified, which is connected with motion of defects of crystalline lattice. The ways of rolled stock hardening from gazars are suggested.

Keywords: *rolling, drawing, strength-to-density ratio, strain, porosity, flow limit.*

Introduction

Aim of research is to study the changes of new type of cast porous anisotropy material mechanical properties, gazars, under their cold plastic deformation.

Conventional technology of gazar production [1, 2] allows to obtain porosity 20-25 micron dia at 25-30 % of total porosity. To get diametrically smaller pores is more complicated, but manufacturing industry requires a lot the reduction of pores basic size [3, 4]. Plastic deformation allows to get the samples of gazars with the necessary size of pores.

Material and equipment

For strain test of gazars the billets of brass casting form of 10 and 20 mm dia and 100 and 130 mm in length were produced.

Phenomenology of gazars cold strain was performed both for free longitudinal rolling and for drawing of round. Rolling was performed on double-pass mill in each groove and tipping of the billet through 90°. Squeezing of a billet diametrically was ~ 40%, the strain of a billet in each groove was ~ 10%.

Drawing of billets was executed on articulated drawing mill. The die blocks with hole conical camber (canting angle to the axis of drawing is 14°), die block material – WCo8 alloy with abraded surface. Drawing speed was 0.2 m/sec. As grease the soap powder was used. One-time squeezing to diameter in one pass was ~ 10%.

Mechanical properties of the material were determined on completion of elongation testing of test rods, run on the multiple-purpose pull test machine of TTDM-L type at strain rate $3x10^{-3}$ c^{-1}.

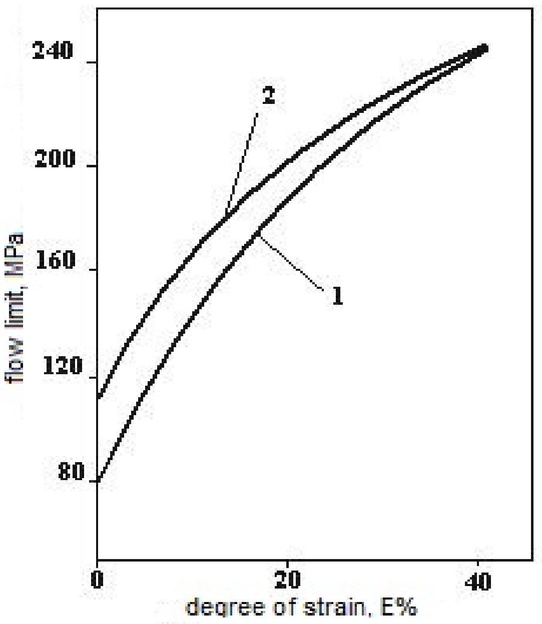
Research results

Deformed pieces of gazars showed better mechanical characteristics under all degrees of strain. Rolled rod of the gazar at 10 mm thickness after annealing for stress relief had hardness in 1.5- 2 times higher than a uniform-sized monolithic one. Non-annealed deformed gazar piece had hardness in 2-3 times higher than a monolithic rod 10 mm dia.

While instrumental examination of deformed gazar pieces there observed the dependence of their flow limit on degree of strain (fig. 1a). With increase of strain degree of copper gazars the flaw limit increased, but this dependence is not lineal. Ultimate resistance of gazars pieces with increase of porosity reduced (fig. 1b).

Fine-structural investigations showed that there take place opinion of changing the thin division walls between pores into areas with small amount of structural defects (similar to a structure of metallic whiskers) [5, 6]. While reducing intervals between pores, the hardness of gazars pieces was increasing (fig. 2).

The ultimate resistance increase of deformed gazars was fixed along the horizontal of real cross-section that is connected with decrease of division walls thickness between pores. In 115-40 micron interval of thicknesses the ultimate resistance has not changed and in 40-20 interval there was its increase, which grew along with decrease of division walls thickness (fig.3).



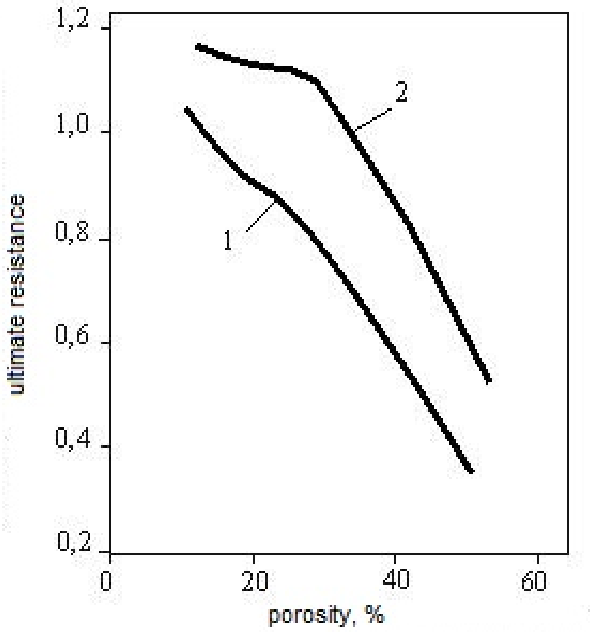


Figure 1 a – the influence of degree of strain on flow limit of gazars; b – the influence of porosity on the ultimate resistance of gazars; 1 – along the plane section, 2 – along the real section.

The results obtained confirm the suggestion about the fact, that increasing of gazar hardness may be achieved through thinning of division walls between pores, that is possible only if the strain of pieces is strong. At high-grade plastic strain the rim zone of gazars densifies up to welding of pores parts with formation on the surface almost monolithic highly-defective layer, which also improves hardness of deformed pieces of gazars.

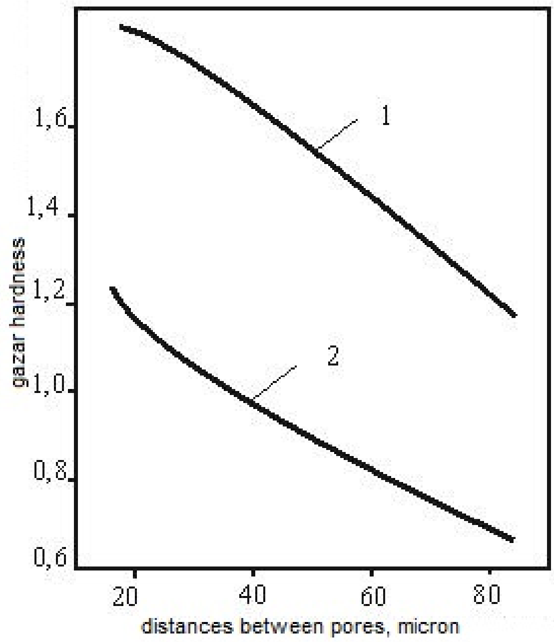


Figure 3 The influence of intervals between pores on: 1 – hardness of copper gazars along the

surface of real cross section of the sample ;2 - ultimate resistance along the surface of real cross section of the sample.

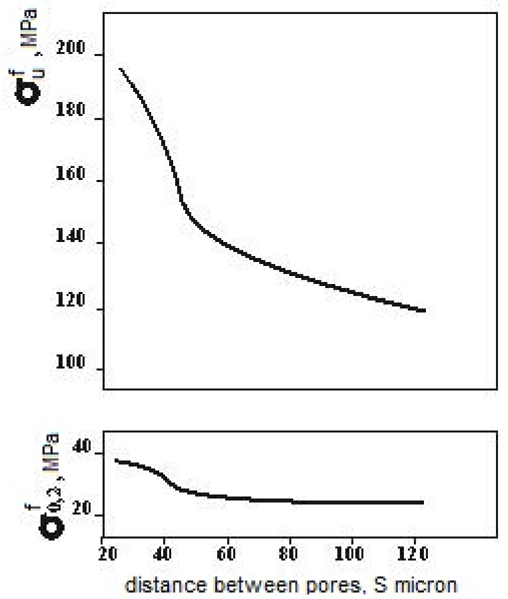
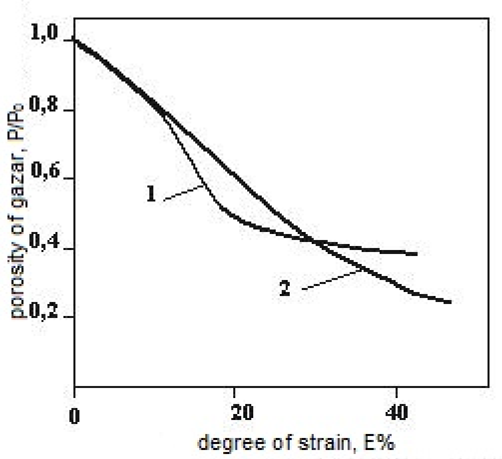
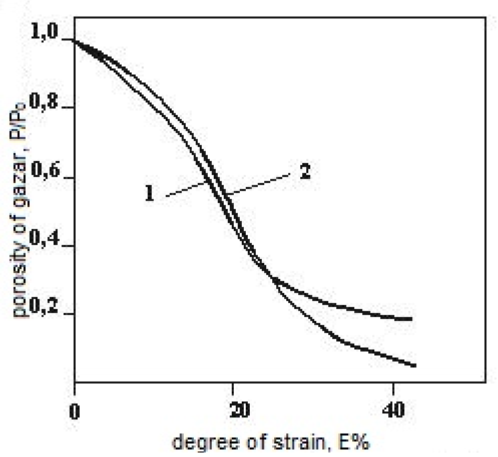


Figure 3 The influence of intervals between pores on hardness of copper gazars samples deformed in 30% and annealed.

The analysis of microstructure showed, that porosity and cross section of gazar pores reduction while rolling run more intensive than while drawing. While rolling the metal piece in deformation zone flows both along the longitudinal and radial directions. When drawing the deformation of pieces run by means of additional longitudinal tensile stress formation, while radial metal flow reduces. The metal part moving radially is much smaller. Thereafter piece deformation along the longitudinal direction is stronger, than while free rolling. Total deformation of pieces while drawing is always smaller (fig. 4). This difference may be about 20-40 %.



a



b

Figure 4 The influence of deformation on gazar porosity:deformation through drawing; (b) – deformation through rolling: 1 - P – porosity = 15%, 2 – P= 30%.

While study of piece structure after recrystallization process it was fixed that in porous metal structure there exist coarse monolithic buildups (fig.5). Before annealing there were no such buildups. It may be connected with secondary recrystallization process and migration of crystal defects to the pores, acting as active substitutional sites. This theory is confirmed by the great amount of small crystals and the structure of pores around monolith.

The results obtained show the necessity of further researches concerning the structure and properties of gazars in the course of their cold plastic strain and after it. This research work may contribute to receipt of new easier, but harder constructional materials for modern manufacturing industry needs.

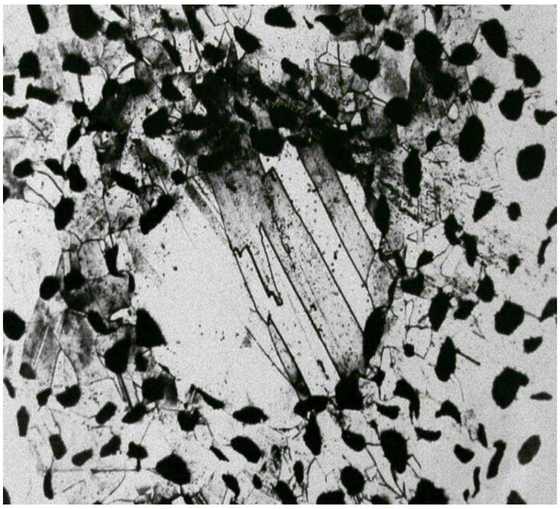


Figure 5 Monolithic formations inside porous structure of gazar after annealing, x 50.

Conclusions

High degree of gazar deformation changes the structure of pores and the distance between them. While thinning of division walls between pores up to 10-20 micron one may observe hardening process of the pieces, which is similar to the hardening effect of metallic whiskers. This is true both for rolled and drawn pieces.

Flow limit and ultimate resistance of gazar pieces depending on the type of deformation reduces in 2-3 times compared with monolithic pieces.

Fine-structural investigation showed, that while rolling the reduction of porosity and cross section of gazar pores run more intensive, than while drawing. For achievement of similar properties and structure of gazar pieces while drawing their deformation should be 25-40% higher than while rolling.

The shape of gazar pores, subjected to strong deformation, changes from cylindrical into slit-like.

Rim zone of deformed pieces with great amount of flaws increases gazar hardness, but after annealing their hardness reduces due to the degradation of defect structure of rim zone.

Active increasing of substitutional sites and dislocations during recrystallization process inside the porous structure leads to formation of monolithic areas, that is explained by defects transversion into pores, which are the active flows for them.

References

1. Karpov, V. Jur., Shapovalov, V.I., Karpov, V.V. (2007). Hydrogen is alloying element of eutectic alloys- gazars. Theses of international conference VOM- 2007, Donetsk, May 21-25, p.p. 577-580.

2. Karpov, V. Jur. (2007). Mechanical-and-physical properties of gazars, *PCMM.2007*, No5. p.p. 34-37.

3. Guliaev, G.I., Ivshin, P.M., Erochin, I.N. (1975) Continuous plugless rolling technology. *Moscow: Metallurgy*, p. 263.

4. Andrievskii, A.S.(1982). Priperties of sintered pieces. *Powder metallurgy*, No 1,p.p. 37-42.

5. Berezhkova, G.I. (1969). Whisker crystals. *Moscow: Science*, p. 155.

6. Bokstein, S.Z.(1971). Structure and properties of metallic alloys. *Moscow: Metallurgy*, p. 495.