UDK 621.77.043 DOI: 10.20535/2409-7160.2023.XXIII.279251

Increasing the mechanical properties of cast aluminum alloy

N.K. Zlochevska, V.A. Titov, V.V. Ivanytsia
Igor Sikorsky Kyiv Polytechnic Institute, Kyiv, Ukraine

Abstract: *The paper considers the issues of increasing the mechanical properties of the secondary aluminum alloy AK7. To improve the properties used the scheme of screw expanding pressing (SUE). The results of experimental studies have shown that the strength characteristics increase, and their values increase in relation to the source metal by 15%, after the second treatment by 20%, after the third by 25%. The relative elongation of the samples in the experiments on uniaxial stretching, practically unchanged. The value of microhardness increases with increasing degree of accumulated deformation. It is shown that after the third transition in the central zone the value of the accumulated deformation is approximately equal to the amount of deformation after the first pass in the edge zone.*
Key words: *screw widening pressing, shear deformations, plastic deformation, secondary aluminum alloy, mechanical properties.*

In modern mechanical engineering, the use of parts made of cast aluminum alloys is very promising. The advantages of using cast alloys are as follows: the possibility of obtaining castings of a complex configuration, which are as close as possible to the dimensions of the finished parts, as well as the cost-effectiveness of molding. Insufficient stability of operational and physical and mechanical properties obtained by traditional casting methods narrows the field of application in responsible structures.

Today, it is more economically profitable to use secondary aluminum alloy smelting [1]. Due to the presence of harmful impurities (the most harmful impurity is iron, an increase to 1% leads to a 1.2–1.5 times decrease in the tensile strength limit, the use of secondary material leads to a decrease in mechanical properties. Due to intensive plastic deformations (IPD) (deformation of alloys under conditions of large deformations of pure shear) it is possible to increase and shape mechanical properties. The most common schemes for realizing pure shear deformations are equal-channel angular pressing [2–4] and screw extrusion [5–6]. In our work, we used the scheme of screw widening pressing (SWP).

The goal **of the work** is to improve and form the properties of the secondary aluminum alloy AK7.

Methodology of research: The melt was produced from secondary charge materials. The liquid metal was poured into a thin-walled casting mold made of aluminum foil. The pouring temperature was equal 640°C. Thermal conditions of metal solidification corresponded to casting in sand molds. Therefore, the content of the mass fraction of iron impurity within 0.8%

The scheme of experimental samples somewhat exceeds the requirements of DSTU 2839-94. The limit iron content in the alloy according to the requirements of the standard should not exceed 0.6% when casting in sand molds and 1.0% when casting in a mold.

The chemical composition of aluminum alloy AK 7 [9] is given in table. 1. Mechanical properties in table. 2.

Table 1

Chemical structure, %

Float	Al	Mg	Mn	Fe			Si
				З,В	К	Д	
АК7	basis	0,2–0,5	0,2–0,6	1,1	1,2	1,3	0,6–0,8
АК7ч	basis	0,2–0,4	–	0,6	1,0	1,5	0,6–0,8

Table 2

Mechanical properties

Float	$\sigma_в$, MPa	$\sigma_{0,2}$, MPa	δ, %
АК7	240	160	2

Before pressing, heat treatment was carried out according to the hardening regime and short-term artificial aging: heating according to the hardening regime took place to a temperature of 535±5°C, followed by cooling in water with a temperature of 20–100°C to ensure stable mechanical properties. After hardening, the aging process was carried out, the workpiece was heated to a temperature of 150±5°C and kept in the oven for one hour.

The analysis of mechanical properties showed that the strength characteristics increase depending on the processing cycles. Indicators increase by 15% after the first treatment, by 20% after the second treatment, by 25% after the third treatment, in relation to the original metal. In experiments on uniaxial stretching, the relative elongation of the samples does not change.

When the degree of accumulated deformation increases, the value of microhardness increases. Along the radial coordinate from the center to the edge of the workpiece, the amount of accumulated deformation increases. Shear deformation causes an increase in microhardness values.

In fig. 1 shows a comparison depending on the accumulated deformation after several passes of the microstructure of the sample material in the central and edge zones.

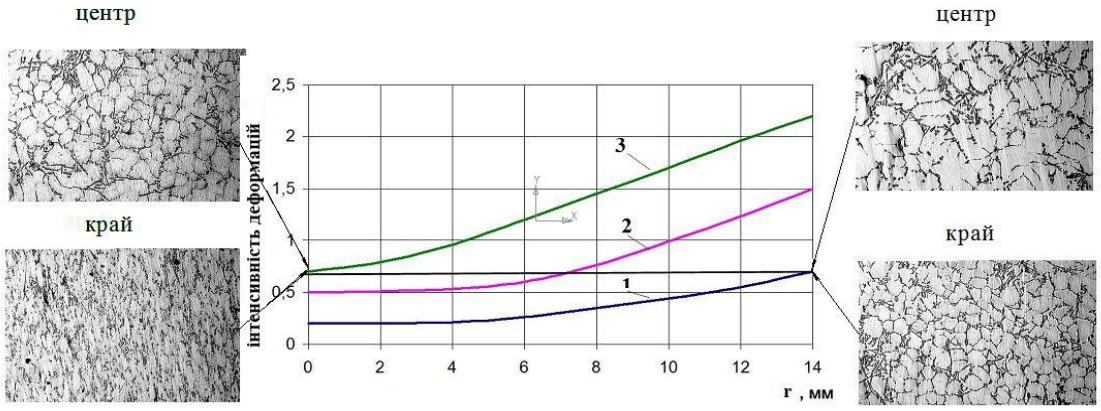

Fig. 1. Comparison of the value of the accumulated intensity of deformations for one (1), two (2), three (3) passes and the effect of this deformation on the structure of the workpiece material

It is shown that in the central zone after the third pass, the amount of accumulated deformation is close to the amount of deformation after the first pass in the edge zone. This is confirmed by the results of metallographic analysis.

Conclusions

The analysis of mechanical properties showed that the strength characteristics increase depending on the processing cycles. Indicators increase by 15% after the first treatment, by 20% after the second treatment, by 25% after the third treatment, in relation to the original metal. The amount of microhardness increases with an increase in the degree of accumulated deformation. It is shown that in the central zone after the third pass, the amount of accumulated deformation is close to the amount of deformation after the first pass in the edge zone. This is confirmed by the results of metallographic analysis.

Reference

1. Hynts E.Ch. Foundry production in the 20th century Analysis of the origins. Foundry production 2002, No. 7, pp. 6–8.
2. Voznyak Yuri The effect of radiation treatment on mechanical and thermal properties of semicrystalline polymers processed by severe plastic deformation / Yu. Voznyak // Macromolecular Research. 2017. Vol. 25, № 1. pp. 38–44.
3. D. Reinitz Alexander Equal channel angular extrusion of ultra-high molecular weight polyethylene / D. Reinitz Alexander, J. Engler Evan, M. Carlson Douglas, W. Van Citters Materials // Science and Engineering: C. – 2016. Vol. 67. pp. 623–628.
4. Yan Beygelzimer, Roman Kulagin, Yuri Estrin. Severe Plastic Deformation as a Way to Produce Architectured Materials. In book: Architectured Materials in Nature and Engineering, Eds. Y. Estrin, Y. Brechet, J. Dunlop, P. Fratzl. R. Dendievel, Springer, 2018. (in press)
5. ValievR.Z. Principles of equal-channel angular pressing as a processing tool for grain refinement / R.Z. Valiev, T.G.Langdon // Prog. Mat. Sci. – 2006. V. 51. pp. 881–981.
6. Chengpeng W, Fuguo L., Qinqhua L., Lie W. Numerical and experimetal studies of pure copper processed by a new severe plastic deformation method Materials Science and Engineering A 548 (June 2012) PP19-26
7. Patent 64346 of Ukraine, IPC B21C25/00 Matrix for strengthening material during repeated pressing /V.A. Titov, M.S. Tryvaylo, N.K. Zlochevska, E.V. Kondratyuk, G.I. Peychev. No. u201102822; statement 10.03.2011; published 10.11.2011, Bull. 21.
8. Zlochevska N.K. Some regularities in the formation of structural properties of the AK7ch casting alloy under conditions of intense plastic deformations / N.K. Zlochevska, V.M. Duka, V.V. Pimanov, P.S. Vyshnevskyi // Bulletin of NTUU "Kyiv Polytechnic Institute", "Mechanical Engineering" series. – 2011. - No. 62. pp. 251–254

Підвищення механічних властивостей ливарного алюмінієвого сплаву

Н.К. Злочевська, В.А. Тітов, В.В. Іваниця

Анотація: *Розглянуто питання підвищення механічних властивостей вторинного алюмінієвого сплаву АК7. Для підвищення властивостей використали схему гвинтового уширяючого пресування. Результати експериментальних досліджень показали, що підвищуються характеристики міцності. Показники підвищуються на 15% після першої обробки, на 20% після другої обробки, на 25% після третьої обробки, по відношенню до вихідного металу. При дослідах на одновісне розтягування відносне видовження зразків, не змінюється. Величина мікротвердості збільшується при збільшенні ступеню накопиченої деформації. Показано, що в центральній зоні після третього переходу величина накопиченої деформації наближено до величини деформації після першого проходу в крайовій зоні.*

Ключові слова: *гвинтове уширяюче пресування, деформації зсуву, пластична деформація, вторинний алюмінієвий сплав, механічні властивості.*