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CONTENT

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ISOTHERMAL DEFORMATION OF PREPARATIONS FROM OF ALUMINUM ALLOYS DURING ROLLING

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Abstract

The article analyzes the advantages of isothermal deformation of aluminum alloy blanks in the rolling process compared to deformation under normal conditions. Technological parameters, such as expansion and pressure, of the process of rolling of aluminum alloy billets, in conditions close to isothermal, are investigated.

The dependences of the expansion and pressure of the alloy on the rolls on the degree of deformation, heating temperatures of the workpieces and rolling dies during rolling in smooth rolls are determined.

Keywords: rolling, stress, deformation, non-uniformity of deformation, stress-strain state, gauges, plots.

Formulation of the problem. The introduction of low-waste technological processes of stamping of billets of aluminum alloys is due to the significant use in products of alloys with high metal consumption (0.15 - 0.3), high complexity, long cycle of manufacturing high-quality stamped blanks (usually 2-3 stamping with intermediate operations on -heating, trimming, etching, stripping) and tasks to improve metal-saving technologies [1-5]. Widespread use of aluminum alloys is determined by their physical, technical and mechanical properties. The application of the rolling process of workpieces, in conditions close to isothermal, makes it possible to maximize the effect of superplasticity, because the deformation of heated workpieces will be carried out with a tool heated to the deformation temperatures (or close to them). This scheme will reduce the deformation force by increasing the ductility of the processed metal, which occurs due to the full flow of processes that reduce its hardening. Uniform deformation of the workpiece, in the absence of areas of difficult deformation and local overheating, provides a good and comprehensive processing of the structure, and as a result, reduces the scatter of properties in the volume of the workpiece.

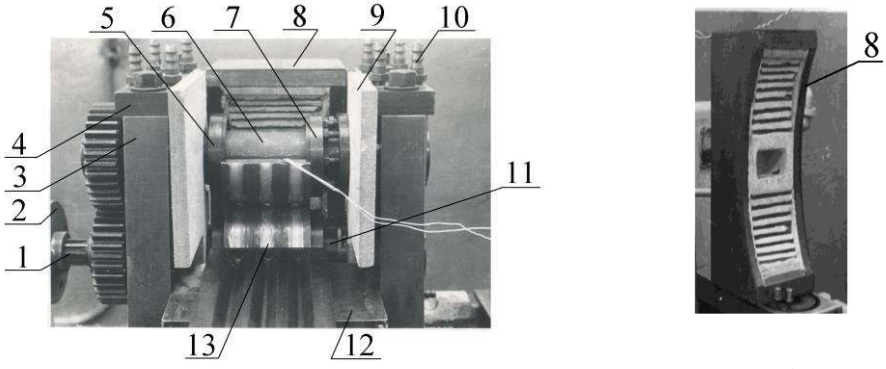
Currently, very little work has been published to study the possibilities of rolling workpieces in isothermal conditions and close to them. Therefore, research on the effect of temperature, rate of deformation, the degree of deformation on the technological parameters of rolling workpieces in conditions close to isothermal actual, which can lead to plasticity and reduce deformation efforts, improve the quality of semi-finished products.

Experimental studies on the influence of degrees of deformation, heating temperatures of workpieces and rolling dies, studies of the macrostructure of rolled workpieces, as well as use for experiments, alloy AK6, alloys AK4, AK4-1, AK8, AMg1, AMg2, AMg 6, AMC.

The purpose of the work consists in the study of technological parameters (expansion and pressure), the process of rolling billets of aluminum alloys in conditions close to isothermal, determining the dependence of the expansion and pressure of the alloy on the rolls on the degree of deformation, heating temperatures of blanks and rolling dies.

Presentig main material.

The experiments were performed according to the method described in [6] on the experimental setup [2] shown in Fig. 1.



a *b*

Fig. 1. Installation for rolling in isothermal conditions deformation (a); fragment of furnace (b) [2]

The installation is intended for definition of optimum parameters and thermomechanical characteristics at rolling of preparations in the conditions approached on the temperature factor to isothermal.

In order to ensure the rigidity of the shafts and maintain a constant center-to-center distance during deformation, the installation is made on the type of two-support forging rollers. To maintain the temperature of the workpiece and heat the working tool (rolling dies inserted directly on the rolls), the installation is equipped with a heating device inserted from the back.

To avoid jamming due to heating of the bearing units of the working shafts, the outer pair housings are made with holes-channels to ensure the circulation of running water. The drive of installation allows to regulate frequency of rotation of shafts that provides removal of characteristics at various speed modes.

Technical characteristics of the installation are given in table 1.

Table 1

Technical characteristics of the installation

Nominal force	кН	20
Wheelbase of shafts	mm	160
Shaft speed	мін $^{-1}$	12 – 60
The diameter of the initial workpiece	mm	30
Seat dimensions:		
diameter	mm	80
length	mm	135
Drive power	кВт	10
Heating temperature of the deforming tool	°C	до 500
Type of heating device	Електроопір	
High-voltage	В	220
Heater power	кВт	4
Wire diameter (nichrome)	mm	0,6

Installation for rolling workpieces in conditions close to isothermal (Fig. 1 (a)) consists of a welded housing 3, which includes bases and two vertical racks. The uprights have grooves for the installation of four sliding bearing housings, which are fastened with tightened slats 4. In bearings, as in the supports, rotate the upper 6 and lower drive 11 rolls. The latter is connected to the drive via the splined connection 1 of the clutch 2, and to the upper shaft via a gear ratio (1: 1 ratio), which ensures their synchronous rotation. The wheelbase of the shafts is adjustable in the range of 0.5 - 2.0 mm with the help of calibrated gaskets. On the rolls between the fixed 5 and the movable 7 washers are fixed rolling dies 13. To introduce the workpiece into the working area of the rolling dies strictly along the axis of the stream and its edge at 900 at the transitions from stream to stream in the front part of the installation is provided with wiring 12, and on the rear side of the housing is fixed heating device 8. The fittings 10 are used to supply and drain cooling running water. Control, regulation and registration of temperature of heating of preparation and rolling dies is provided by the KSP-4 recording device.

This paper describes experimental studies of technological parameters of rolling (expansion, Δb - movement of metal in the transverse direction, which causes significant tensile stresses in the edges of the rolled workpiece and reduces the total resistance to deformation) of aluminum alloy blanks AK4, AK4-1, AK8, AMg1, AMg2, AMg6, AMC in smooth conditions temperature to isothermal.

To determine the influence of the degree of deformation, the heating temperature of the rolling dies on the expansion and deformation resistance, blanks of the above alloys with dimensions Ø14x150 mm heated to a temperature of 450 ° C [7] were rolled in smooth rolls with degrees of deformation 30, 40 and 50%. Rolling dies were heated sequentially to a temperature of 20, 50, 100, 150, 200, 250, 300, 350, 400, 4500 C. The temperature was measured with a chromel-alumel thermocouple and regulated using a recorder KSP. The frequency of rotation of the shafts was $0{,}2^{-1}$. Methods of strain gauge, optical and electron microscopy, X-ray microanalysis, and mathematical statistics were used in experimental studies.

Analysis of experimental data presented in table. 2 and in fig. 2 shows that the expansion relative to the cross section of the workpiece during rolling in rolling dies having a temperature of 20 ° C and a degree of deformation of 30, 40 and 50% increases by 20, 30 and 42%, respectively. This is due to the fact that with increasing degree of deformation, the volume of the metal in width, and expansion, all other things being equal, increase.

Table 2

The value of expansion Δb relative to the cross section workpieces depending on the degree of deformation ε and heating temperature rolling dies $t_в$

Expansion	Температура, $t_в$		
	20^0 C	250^0 C	450^0 C
	ε = 30%		
	2,856	2,086	1,708
	ε = 40%		
	4,2	3,64	3,3
	ε = 50%		
	5,88	5,2	4,65

The nature of the behavior of the dependences of the expansion on the heating temperature of the rolling dies in the range of 20 - 250 ° C (Fig. 2) can be explainedслідуючим. At a temperature of stamps of 20 ° C and degrees of deformation of 30, 40, 50%, the contact area of collision of metal with rolling dies is small, considering flattening of round preparation of Ø14 mm. In this case, the axial compressive stresses in the direction along the deformation are insignificant in comparison with the compressive stresses acting in the transverse direction, so there is an expansion. Decrease of expansion with increase in temperature of heating of rolling dies due to increase in plasticity of the processed metal and proceeding of the processes reducing its strengthening.

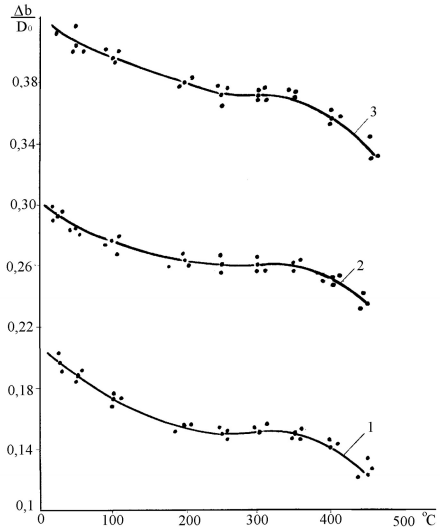


Fig. 2. Dependence of expansion on the degree of deformation and heating temperature of rolling dies (degree of deformation: 1 - 30%; 2 - 40%; 3 - 50%)

In the range of heating temperatures of rolling dies 250 - 350 ° C at a constant degree of deformation, the expansion does not change, and the change in the degree of deformation increases the absolute values of expansion by 15, 26, 37% relative to the cross section of deformed workpieces, respectively, with degrees of deformation 30, 40 and 50%. This is due to the equality of the axial compressive stress along and across the deformation, as well as the equality of the displaced in these.

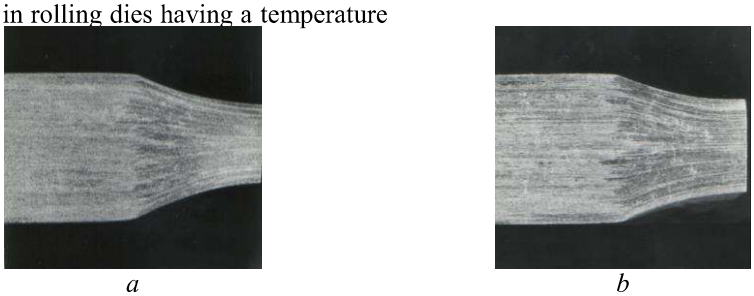
With increasing heating temperature of rolling dies to 4500 C and rolling of workpieces with degrees of deformation of 30, 40 and 50%, the values of expansion relative to the cross section of the workpiece decrease and are 12.2, 23.6, 33%, respectively. The reduction of expansion is due to the increase of the axial compressive stress directed along the deformation, the processes that reduce the hardening of metals, the absence of zones of difficult deformation.

The analysis of the change in expansion showed that with increasing heating temperature of the rolling dies, the values of expansion decrease. Thus, the values of expansion are obtained at the heating temperature of the rolling dies to $t_в$ = 250 and 450° C at deformation ε = 30 % decrease in relation to the expansion during rolling of workpieces in rolling dies having a temperature of 20 ° C, respectively, by 37 and 67, 2%. Decrease expansion when $t_в$ = 450 °C relatively $t_в$ = 250 °C is 22%.

Similarly, the analysis of changes in the values of expansion during rolling of the workpieces at a degree of deformation of 40, 50% and other equal conditions showed that the expansion decreases by 15, 4 i 27, 3 % (ε = 40 %), 13 i 26, 45, 50 %. Decrease expansion when $t_в$ = 450° C relatively $t_в$ = 250° C is 10,3 % (ε = 40%), 11,8 % (ε = 50 %).

Analyzing fig. 2 shows that changing the degree of deformation from 30 to 50% increases the value of expansion without changing the nature of their dependences on the heating temperature of the rolling dies. It was noted above that with increasing degree of deformation of the metal in width and expansion, other things being equal, increase.

In fig. In Fig. 3 presents the macrostructure of the longitudinal section of rolled blanks of alloy AK6 in smooth rolling dies in one pass at a temperature of blanks and rolling dies 470 ° C, degrees of deformation of 40 and 50%. The conducted researches (- macro, - micro, mechanical properties) of quality of rolled preparations, in the conditions close to isothermal, corresponded to requirements of the technical documentation.



a *b*

Fig. 3. Macrostructure of longitudinal sections of rolled blanks in smooth rolls. Alloy AK6, Ø 14×150 mm., temperature of preparations and rolling dies 470 ° C: a - the degree of deformation of 40%; b - degree of deformation 50%

Table 3

The value of relative pressure P_{om} depending on the heating temperature rolling dies $t_в$ and the degree of deformation ε

№ п/п	ε = 30%		ε = 40%		ε = 50%	
	$t_в$, ^{0}C	P_{om}	$t_в$, ^{0}C	P_{om}	$t_в$, ^{0}C	P_{om}
1	20	0,4	20	0,5083	20	0,6664
2	250	0,2498	250	0,2747	250	0,3
3	300	0,2365	300	0,2498	300	0,2664
4	350	0,2232	350	0,2415	350	0,2581
5	400	0,2166	400	0,2365	400	0,2548
6	450	0,2133	450	0,2365	450	0,2548

From the analysis of table. 3 and fig. 4 shows that the relative pressure of the metal on the rolls $P_{om} = 1 - \frac{P_0 - P_1}{P_0}$ decreases with increasing heating temperature of rolling dies and most intensely with increasing degree of deformation.

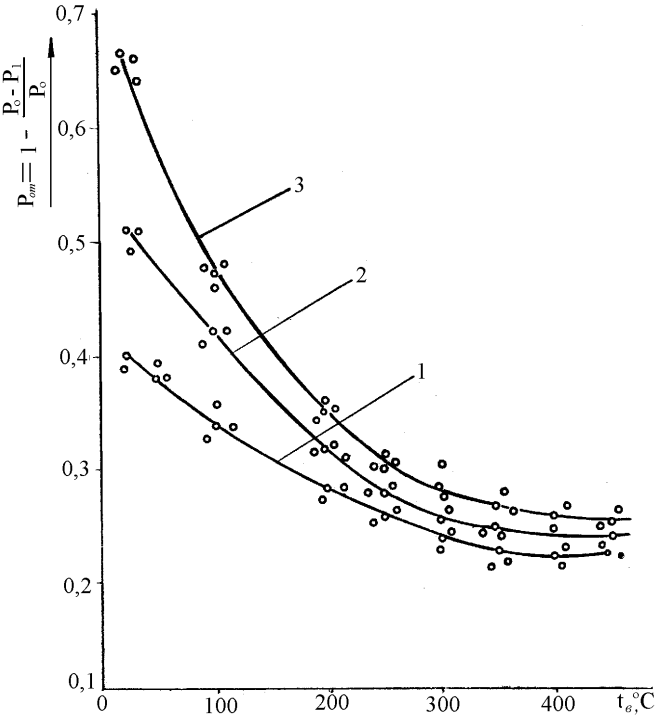


Fig. 4. Dependence of relative pressure of metal on rolls on temperature heating of rolling dies and the degree of deformation: 1 – 30%; 2 – 40%; 3 – 50%

Thus, by increasing the heating temperature of the rolling dies to 250, 350 and 450 ° C, the pressure on the rolls decreases compared to the pressure values at the deformation of the workpieces in the rolling dies having a temperature of 20 ° C and degrees of deformation 30, 40, 50% respectively: 250 ° C - 62.45%, 54 %, 45 %; 350° C – 55,8 %, 47,5 %, 38,73 %; 450° C - 53,3%, 46,5 %, 38,2 %.

In the range of heating temperatures of rolling dies 300 - 450 ° C, the metal pressure on the rolls at different degrees of deformation changes slightly, and when the rolling dies reach the workpiece temperature of 450 ° C and increase the degree of deformation is almost stabilized (Fig. 4)..

Analysis of experimental data presented in Fig. Fig. 4 shows that when rolling workpieces on forging rollers, in conditions close to isothermal, the metal pressure on the rolls decreases from the heating temperature of the rolling dies most intensely in the temperature range 20 - 350 ° C. Subsequent heating of the rolling dies does not lead to a significant reduction in pressure and impractical, leads to additional energy consumption. In addition, there is the appearance of scale on the surface of the rolling dies.

In another series of experiments, blanks of alloys AK4, AK4-1, AK8, AMg1, AMg2, AMg6, AMC having the size Ø 14×150 mm., heated in a chamber furnace of electrical resistance to temperatures 300, 350, 400, 450, 470 $^{+10}$ °C rolled in smooth rolling dies, which were heated sequentially to temperatures 20, 50, 100, 150, 200, 250, 300, 350, 400, 470 °C. Rolling was performed with degrees of deformation of 30 and 40%. The results of experimental data are presented in Fig. 5, 6.

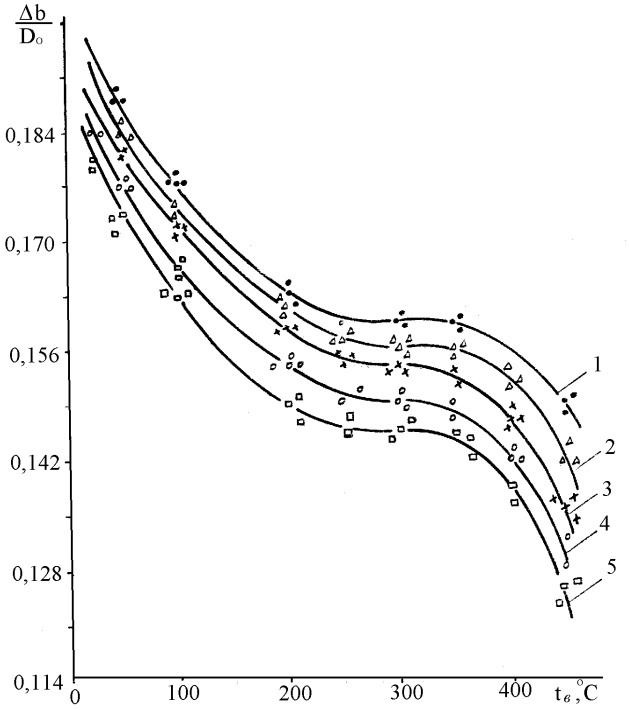


Fig. 5. The dependence of the expansion on the heating temperature of the workpieces and of rolling dies at a degree of deformation of 30%
(heating temperature of workpieces: 1 - 300°C; 2 - 350°C; 3 - 400°C; 4 - 450°C; 5 - 470°C.)

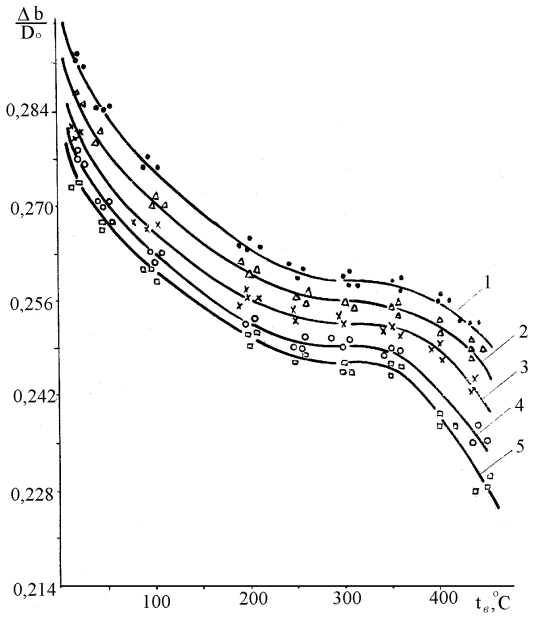


Fig. 6. The dependence of the expansion on the heating temperature of the workpieces and of rolling dies at a degree of deformation of 40%
(heating temperature of workpieces:1 - 300°C; 2 - 350°C; 3 - 400°C; 4 - 450°C; 5 - 470°C.)

Analysis of experimental data presented in Fig. 5, 6 shows that with increasing heating temperature of the workpieces and rolling dies, the expansion decreases due to the processes that reduce the strength of metals. It should be noted that in the range of heating temperatures of rolled dies 250 - 350 ° C, the expansion at a constant degree of deformation (similar to that shown in Fig. 2) is practically unchanged, and the change in the degree of deformation leads to an increase in its absolute values (Fig. 5, 6).

Conclusions

1. Analyzing the advantages of isothermal deformation, compared with the deformation of the metal under normal conditions, experimental studies of technological parameters (expansion, pressure) of the rolling process of aluminum alloy billets, in conditions close to isothermal.

2. Dependences of expansion and pressure of metal on rolls on degree of deformation, temperatures of heating of rolling dies and preparation at rolling in

smooth rolls are defined.

3. Analysis of experimental data shows that the rolling of the workpieces in conditions close to isothermal reduces the pressure of the metal on the rolls in two or more times. This is a confirmation of the plasticity of the metal during its deformation under isothermal conditions.

4. It is established that in the range of heating temperatures of rolling dies 250 - 350 ° C expansion and pressure of metal on rolls at rolling of preparations of aluminum alloys practically does not change. This is due to the lack of hardening of the metal under these conditions of deformation.

5. Rolling of aluminum alloy blanks, in conditions close to isothermal, is recommended to be carried out in dies heated to temperatures of 250 - 350 ° C, at which the values of the expansion values are constant, and the metal pressure on the rolls is minimal.

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METHOD FOR DETERMINING THE INTEGRATED VALUE OF A CONSTRUCTION PROJECT

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Abstract

This work is devoted to the peculiarities of using an integrated approach in the management of construction projects. It was shown that the integrated approach is used as a combination of the value approach with the management of the content of construction projects into a single integrated process. The processes of operation of these two control methods are considered and a simplified diagram of possible interaction is built. A simpler way of constructing a diagram for integration of value content management of construction projects was presented as a