THE INVESTIGATION OF THE INHOMOGENEITY OF THE DEFORMATION DISTRIBUTION IN THE RING WORKPIECE

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Abstract

The results of experimental research of heterogeneous distribution of deformations in thick ring billets under the influence of axial load are presented in the paper. It is revealed that in the case of ring products, there is a difference between the values of the main deformations on the opposite radial surfaces, relatively to the line of separation of the metal current, which is not observed in the sediment of solid cylindrical workpiece.

Introduction

Determination of the stress-strain state is one of the fundamental factors in the development of new technologies for the production of spare parts by methods of metal forming. In this case the casting discontinuity in the distribution of deformations in the metal shrinkage has an enormous influence on the stress-strain state.

The researches of the famous scientists demonstrate availability of different zones of deformations in the rebuffed cylinder and formation of a so-called "forging cross"[1]. However, in the scientific literature there is no data on the distribution of the inhomogeneity of deformation in the draft of cylindrical workpiece with a through central hole, which determines the relevance of further theoretical and experimental studies in this direction.

The aim of the present work is to study the process of sedimentation of annular parts to reveal regularities in the distribution of the inhomogeneity of plastic deformation in metal.

Preparation of an experimental study

In order to carry out a laboratory experiment on the distribution of the inhomogeneity of plastic deformation, two samples of lead were molded and machined in circular billets with the following dimensions: outer diameter – 100 mm, internal diameter – 50 mm, height – 25 mm (Fig. 1)

Segments were cut out of the obtained circular billet and then a dividing grid was sketched after polishing the inner surface. The application of a coordinate grid with dimensions of 1x1 mm was carried out with the aid of a reference marking plate by the method of imprinting vertices on the surface of a segment. Figure 2 shows a segment with a plotted grid.

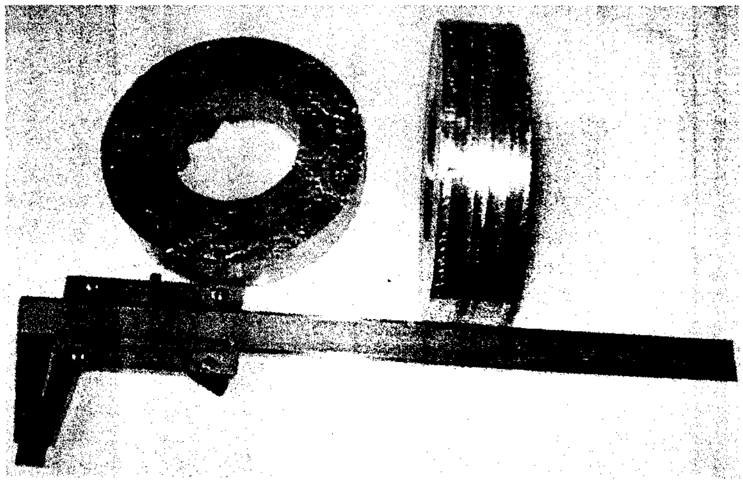

Fig. 1. Ring samples after machining

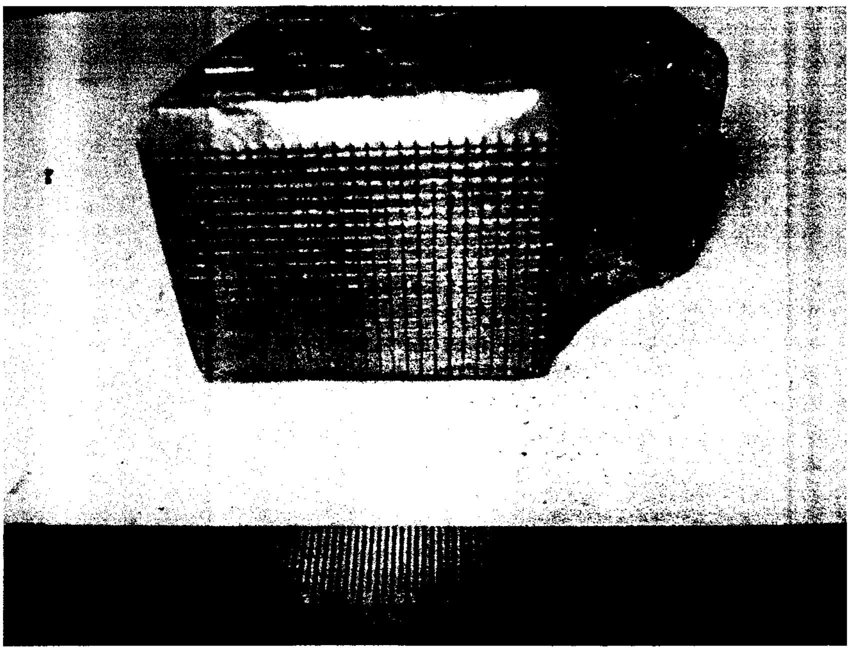

Fig. 2. Segment with a plotted grid

The Procedure for conducting an experimental study

The segment with the already applied grid was soldered using Wood's alloy with the rest of the workpiece. The preforms were deposited on a laboratory hydraulic press (Figure 3) with a force of 100 tf with a deformation rate of $\varepsilon = 0.5$.

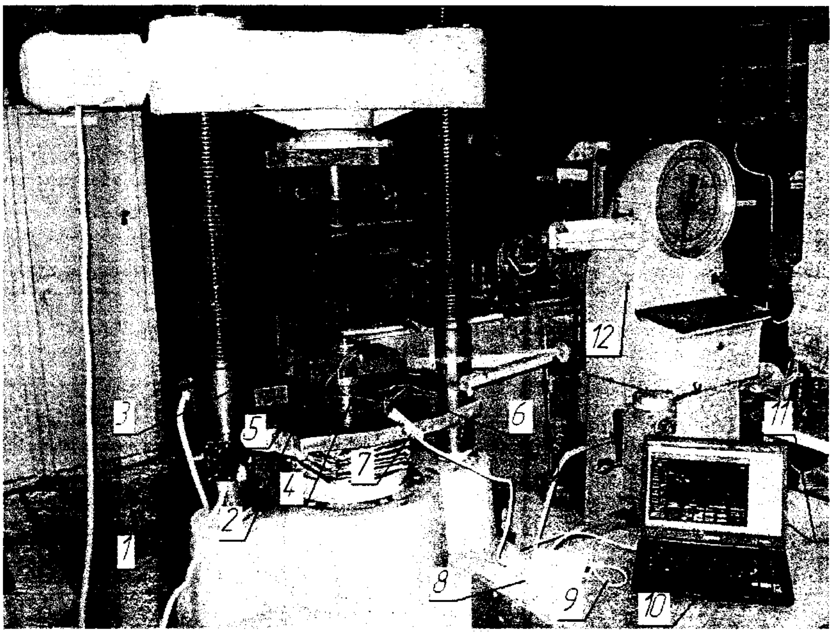

Fig. 3. Equipment for the experiment: 1 – hydraulic press, 2 – lower backing plate, 3 – upper plate, 4 – circular workpiece, 5 – mesodose, 6 – contacts of mesodose, 7 – ADC cable, 8 – ADC, 9 – ADC and laptop connection cable, 10 – laptop, 11 – laptop connection cable, 12 – manometer

The segment was separated from the workpiece with a previously applied dividing grid after deformation. Using the graphic editor, measurements of the changed cell sizes after deformation were made (Fig. 4).

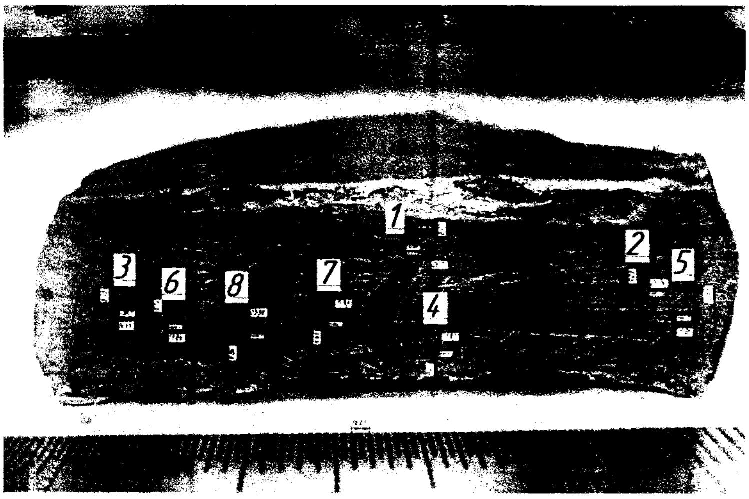

Fig. 4. Part Segment after shrinkage

Schematic representation of the location of the cells of the segment, which the main deformations were calculated after the precipitation, is shown in Fig. 5.

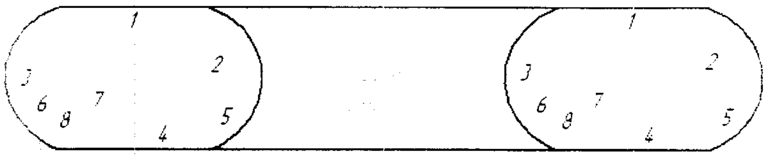

Fig. 5. Schematic location of the cells for which the deformations were calculated after the precipitation

The main deformations in the sample after the precipitation were calculated according to the following formulas:

$$\bar{\varepsilon}_1 = ln\frac{r_1}{r_0}, \bar{\varepsilon}_2 = ln\frac{r_2}{r_0}, \qquad (1)$$

where r_0, r_0 and r_2 – is the radius of the circle and the principal semiaxes of the ellipse, respectively, $r_0 = 0{,}5 = const$

Based on the results of calculations, a summary table (1) of the values of the main strains of the sample at different points of the segment connector plane was completed.

Table 1. Results of calculation of the main deformations

№ cells	$\bar{\varepsilon}_1$	$\bar{\varepsilon}_2$
1	0,92	0,10
2	1,16	0,02
3	0,60	0,10
4	0,79	0,15
5	0,96	0,46
6	0,91	0,20
7	1,16	–0,17
8	1,08	0,13

It can be seen from Table 1, that different values of the main deformations are applied to different points of the segment, which indicates the inhomogeneity of plastic deformation.

Many outstanding scientists have studied the heterogeneity of plastic deformation. The most well-known experimental results of the inhomogeneity of plastic deformation are the Gubkin's S.I. data, which he obtained when the cylindrical billet was drafted [2].

According to the results of the experiments the scientist showed that the zones I (Figure 6), which are adjacent to the ends of the workpiece, are deformed quite insignificantly. It can be explained by the influence of frictional forces on the contact surfaces, which create quite sharply expressed compression in these zones.

These zones are the zones of "delayed" or "hindered" deformation [1]. The metal in them seems to be less pliable, and they seem to wedge the zone II between them, the deformation of the elements of which is most intense both in the axial and radial directions. According to E.P. Unksov [3] in the fields of separation of the first and second zones, the metal of the latter one seems to flow around the first zone, moving in the direction of the ends. This, in scientist's opinion, explains the presence of a transition of the lateral surface elements to a contact surface, which is especially noticeable for d/h <1.

The intensity of deformation of Zone III occupies an intermediate position between the first two ones. As the degree of precipitation increases or when samples with large d / h ratios are precipitated, zone III decreases sharply, and zones I and II practically merge and the deformation covers the volume of these two zones with a pronounced bulk stress state due to the approach of the contact surfaces. Uniformity of deformation increases, and barrel-shape form decreases.

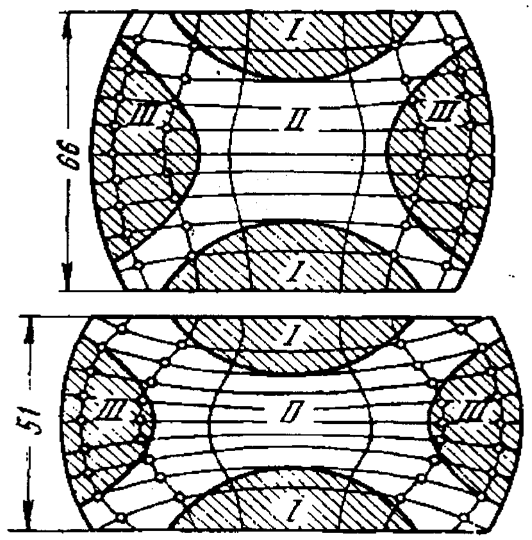

Fig. 6. Zone creation at draft [3]

However, studies on the distribution of inhomogeneity of plastic deformation of axially symmetric products with a central hole (ring-type details) have not been considered in the literature.

In the case of a solid cylindrical body, the sediment of the ring products has its differences. In particular, the internal radial surface decreases during the precipitation process, tending to zero, which causes additional deformation resistance from the inner part of the ring, thereby measuring such a technological parameter as the radius of the neutral surface. This parameter is often used in determining the technological parameters of forging and stamping.

If you analyze the data from Table. 1, it can be concluded that the values of the main deformations in the zone of the outer and inner radial surfaces are different (cells 3 and 5). In the case of a solid cylindrical body (Figure 6), the values of the main deformations in the zone of the outer surface are the same.

Conclusions

The analyzed experimental data on the distribution of the main deformations in the sample to be deposited indicate that the deformation distribution is irregular in both ,in the general case, on inner and outer surfaces, in particular.

Comparing the obtained experimental data with the data of other authors, one can be convinced of the general regularity of the distribution of the inhomogeneity of plastic deformation in the volume of the metal. However, there is a difference. In the case of annular articles, the difference in the values of the principal deformations on opposite radial surfaces is observed with respect to the metal flow separation line. The data of the experimental study were obtained for the first time and require further study.

Literature

1. Storozhev M.V.: Teoriya obrabotki metallov davleniem.: Mashinostroenie, 1977, s. 422.
2. Gubkin S.I.: Teoriya obrabotki metallov davleniem. M.: Metallurgizdat, 1947, s. 532.
3. Teoriya kovki i shtampovki: ucheb. Posobie, pod obsch. red E. P. Unksov, A. G. Ovchinnikova. M.: Mashinostroenie, 1992, s. 719.