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THE GEOMETRY OF THE CONTACT SURFACE DURING PLASTIC DEFORMATION

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ABSTRACT
In modern mechanical engineering, the development of a technological process for processing stamping forms on shaped surfaces remains the most important task of today. Before processing the shaped surfaces, it will be necessary to study the working surfaces of the stamping molds. This article describes methods for determining the geometric parameters of the surface when processing stamping forms on shaped surfaces, in particular, the drawing structures of the cutting zone of shaped surfaces, the penetration of the cutter into the cutting zone and data on the conditions of editing in the cutting zone.

Keywords: cutting area, consistency, durability, punching, punching design, cutting parameters.

In the process of separate hardening treatment, the geometric parameters of the contact zone are set at the first stage. When studying the geometry of the contact zone, one basic contact parameter is usually determined, given that it is the main dominant indicator that determines the results of a separate hardening treatment of surface plastic deformation.

In the future, we can consider any body of rotation as a deforming element.

During the contact of the deforming element with the part, a change in the half-width of the contact along its length is characterized. The maximum half-width and length of the contact, the change in the depth of insertion of the deforming element along the line of its maximum loading.

These geometric parameters determine the nature of the distribution of deformations and stresses over the contact area. In turn, the resulting deformation forces and directly depend on the geometric parameters of the deforming elements, the size and type of the surface of the part.

The geometric parameters of the contact area during separate hardening treatment in many design dependencies refers to deforming elements having the simplest shape of the working surface: a ball, a cylinder, a straight circular cone or a combination of these surfaces. During processing, the resulting contact shape is an ellipse or rectangle. Currently, there is no unified methodology for solving this problem, which makes it difficult to conduct a comprehensive analysis of the obtained dependencies and the problem of finding the optimal shape and size of deforming tools and equipment that provide the best processing conditions in terms of simultaneously ensuring the accepted criteria for performance and quality of the surface layer.

Thus, in order to analyze the influence of geometric parameters and technological factors of processing, it is necessary to determine the mathematical relationship between the design parameters of deforming elements and materials, the dimensions of the workpiece and the technological factors of processing.

All the parameters of the contact zone listed above are determined through the law of change of the contact along its length and the depth of insertion of the deforming element along the line of maximum loading. In turn, they depend on the radius of the workpiece, the shape and size of the deforming element.

The conducted studies have shown that the forming elements in surface plastic deformation with an accuracy of up to several percent can be considered quite rigid. They, in turn, simplify the development of a mathematical model, and do not require consideration for the geometry of the contact. During the deformation processing, the material of the part is solid and has no breaks.

The conducted studies have shown that the axes of the deforming rollers during processing rotate relative to the axis of the part by the angle of insertion and self-tightening. In order to create a teardrop-shaped contact shape, the self-tightening angle helps to reduce axial forces by moving the deforming element along the v and n o th line on the surface of the part.

Consider the deformation of a deforming element when it is compressed by two opposite forces. The diameter of a cylindrical deforming element located between two compressing faces, taking into account contact and general deformations, is determined by the formula.

$$\Delta D = 4P\frac{1-\mu^2}{\pi E}\left(0{,}41 + ln\frac{2D_p}{\sqrt{\frac{P\cdot D_p}{E}}}\right)$$

where P is the forces acting on the roller from opposite sides; μ is the Poisson's ratio; E is the modulus of elasticity; Bp is the diameter of the compressed cylinder

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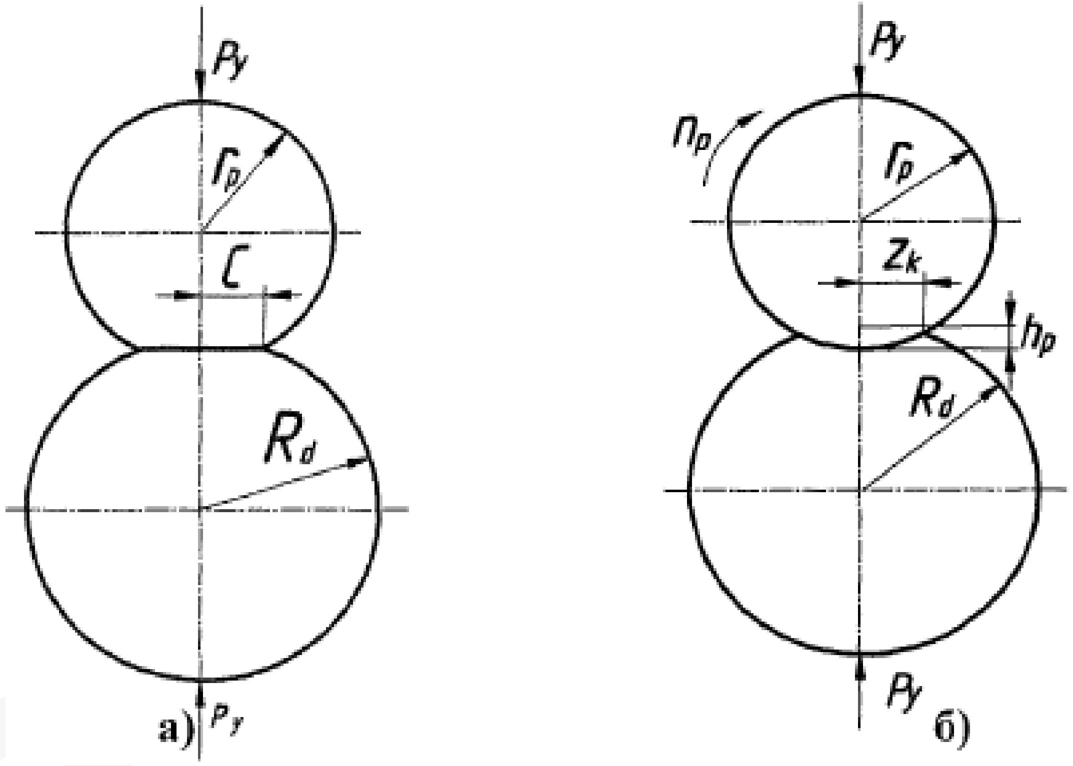

Fig. 1 Features of deformation of two cylindrical bodies: a)-with elastic identical properties of the bodies, b)-with elastic-plastic deformation of the part by a solid deforming element

The calculation results are shown in the graphs (Fig. 1). The relative deformation of the rollers does not depend much on the diameter, but only on the loading force and does not exceed 3% when maximum values assigned in production conditions (up to 30 kN). Thus, the deforming element with surface plastic deformation can be assumed to be sufficiently rigid and not take into account the change in its radius during deformation.

To check the adequacy of the analytical solution, a computer simulation of the compression of a cylindrical roller between two absolutely rigid plates was performed. Ap818 was used for the software. The obtained simulation results are presented in Fig. 2.

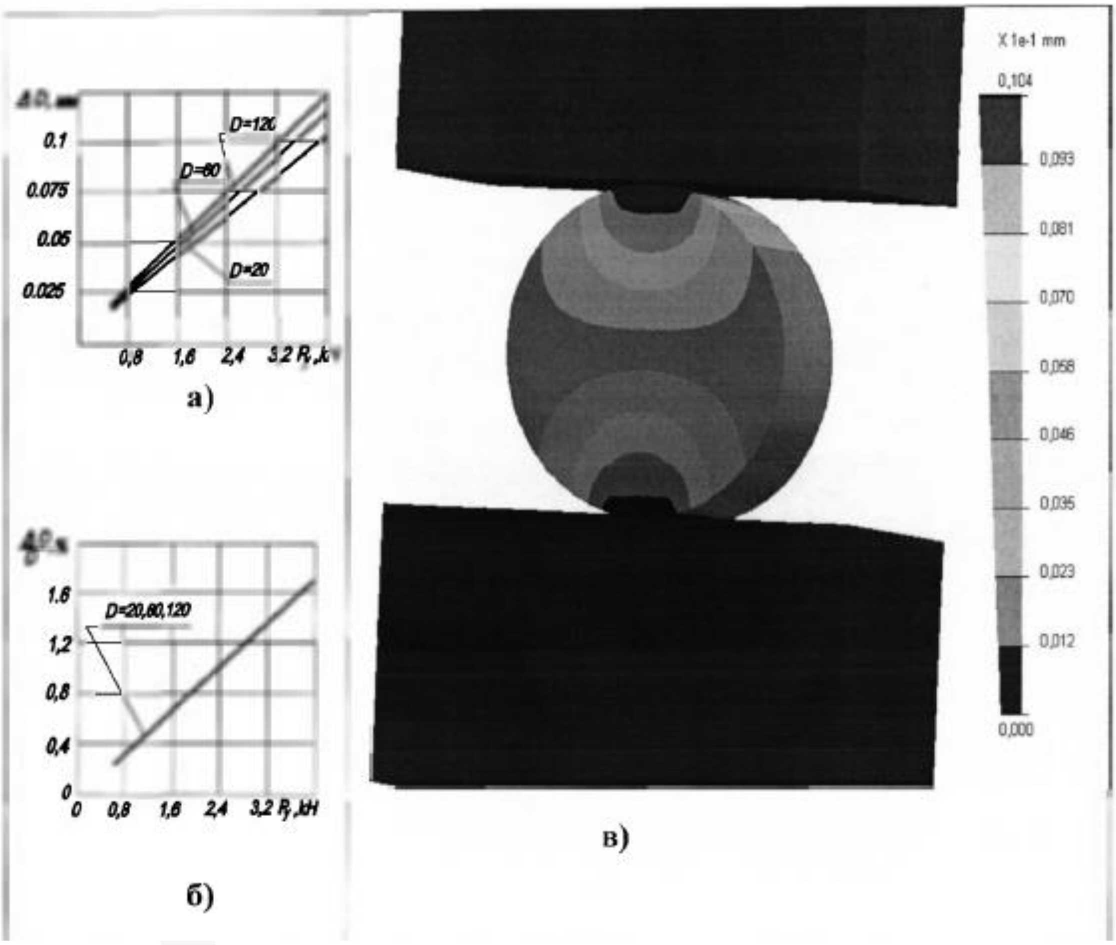

Fig. 2. Changes in the diameters of the rollers (D) (a) and their percentage (b) of the deformation force and the result of computer modeling of a cylindrical roller using ANSIS software, (c). The length of the roller Lp = 10mm; The deformation force 10 kN. The pressure plates are absolutely rigid.

As can be seen from the results obtained, the deformation of the roller is insignificant, therefore, the deforming roller in analytical calculations can be taken almost rigid, that is, when determining geometric parameters, its deformation can be ignored.

All parameters of the contact zone: maximum length, width, contact area, volume and surface area are determined through the law of variation of the contact half-width along its length.

To determine the parameters of the deforming elements and the relationship with the geometric parameters of the contact zone can be solved on the basis of a direct and inverse problem.

When solving a direct problem, the geometric parameters of the deforming element are set as initial data.

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When solving the inverse problem, the shape and dimensions of the contact zone are set. The necessity of the inverse problem lies in the fact that at first rational shape and dimensions of the contact zone can be set, at which the required stress distribution over the contact area and quality indicators of the surface layer are achieved, and then according to these data, the transition to the choice of design parameters of the deforming element and technological processing modes is carried out. Some questions can be solved more simply and rationally only on the basis of the inverse problem, for example, by setting the contact zone of the same size and shape, it is possible to investigate the influence of the shape and size of the deforming elements, the size and type of the surface to be treated on the deformation force.
When determining the parameters of the contact zone, and identifying the correspondence between the static imprint of the deforming element and the imprint that occurs when the deforming element is rolling along the elastic-deformable surface. The conditions for the formation of the contact zone in both cases are somewhat different and the relationship cannot be established through the development of an appropriate mathematical model. It should be borne in mind that the rolling process is referred to as static processes. It should be noted that for almost the entire processing period, with the exception of the initial short-term and final time intervals, the processing is stationary. Hence, it is possible to assume the constancy of the contact parameters over the entire processing time, and when developing dependencies for determining the parameters of the contact zone, consider the contact instantaneous and embedded in the part. The difference between the contacts during static indentation and rolling of the roller on the machined surface of the part can be determined on the basis of experimental studies.

CONCLUSION

Analysis of the obtained expression shows that the larger the diameter of the first insert and cutting tool, the higher the cutting depth parameter on the previously untreated surface, and the larger the radius of the machined surface, the lower the machining depth. The main task is to remove the deposit on the surface to be treated. In this case, the cutting parameters of the cutting tool and the thickness of the layer to be cut are important. When moving a cutting tool along a complex shaped surface, it is necessary to establish the optimal movement of the machining trajectory in CAD / CAM / CAE systems. Because the parameters of the cutting part of the cutting tool can be eaten, broken, the parameters of the cutting part can be changed during processing along the trajectory. This in turn affects the surface quality of the surface being cut. In this paper, the capabilities of CAD / CAM / CAE systems were used in machining the working part of stamp molds.

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