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IMPROVING THE QUALITY OF AXISYMMETRICALLY DRAWN PRODUCTS USING DIFFERENTIATED HEATING OF THE SHEET BLANK'S FLANGE

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Undoubtedly, one of the most widely used processes of sheet metal stamping is the process of drawing and, in particular, axisymmetric drawing of cylindrical blanks without thinning and with thinning of the wall. The drawing ratio is one of such process schemes' main technical and economic indicators. Reducing the ratio ensures a decrease in the total number of transitions and intermediate annealings, which contributes to the expansion of the range of finished products, a reduction in the labour intensity of production and a decrease in the costs of its manufacture. However, reducing the drawing ratio will lead to an increase in tensile stresses in the dangerous section. The consequence of such an increase in stresses will be an increase in the probability of destruction of deformed blanks and, therefore, a decrease in the output coefficient of suitable metal products [1].

To avoid this dilemma, it is necessary to prevent the increase of stress. This means that in order to reduce defects such as ruptures, it is necessary to reduce the magnitude of tensile stresses in the flange area without reducing the drawing ratio. For example, it is possible to reduce the deformation resistance of the metal in this area. Such a reduction can be ensured if differentiated heating of the flange of a sheet blank (Fig.1).

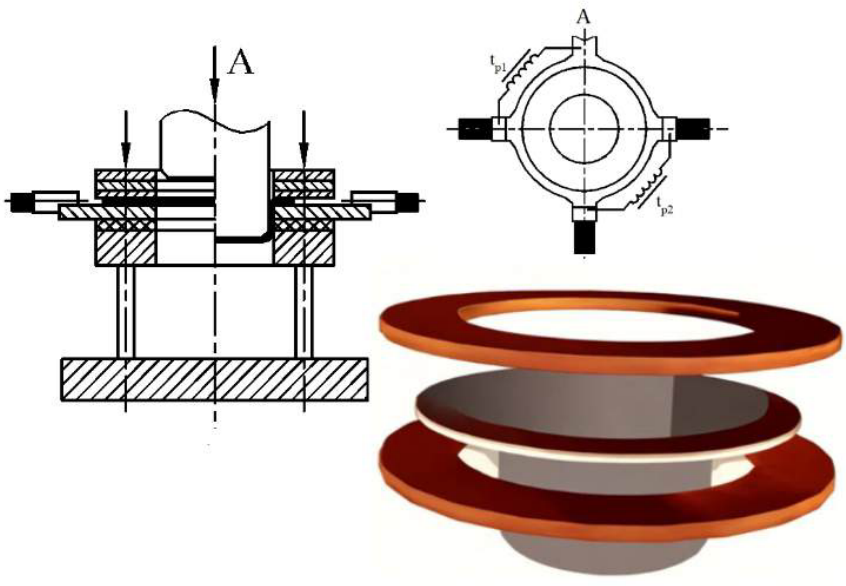

Figure 1. Schematic of flange heating.

The application of general heating of the sheet blank throughout its entire volume, in addition to softening of the metal in the flange, will cause similar softening in the hazardous section zone. It is necessary to reduce the temperature of the metal in the dangerous section and reduce the deformation resistance in the flange to ensure the product's quality and prevent defects. This simultaneously provides the increased differentiated heating of the flange and cooling of the wall of the drawing product (Fig. 1). When implementing this heating scheme, the metal deformation resistance is significantly reduced, which leads to a decrease in the maximum integral technological stresses of the drawing process. At the same time, in the dangerous section area, the metal is practically not softened due to the structural shielding of this section from the external heating source, as well as due to the forced cooling of the punch and the drawing radius.

As a result, when drawing with differentiated heating of axisymmetric cylindrical products of the "cup" type, it is possible to obtain parts whose height is 1.2...1.4 diameters in one technological operation. This contrasts cold drawing without heating, where such a ratio can be obtained only after two or more intermediate operations.

It should be for the efficient use of this scheme, and it is necessary to know the effect of temperature on the reduction of deformation resistance and all energy-force parameters of the process. The displacement method is used in the calculations of the traditional cold scheme of axisymmetric drawing [2]. According to this method, the generatrix of the sheet blank into elements is divided, among which the radial displacement of the peripheral elements is known. According to these displacements, the stress-strain state of the remaining elements is calculated using the continuity condition flow theory (equilibrium equations and the relationship between stress and strain). At each stage of the calculation, the change in the thickness of the deformed sheet blank is taken into account. The finite element method is used to analyze the displacements of elements on the edge of the matrix, and the traditional work balance method is used to determine the increments of meridional stresses. The displacement of the neutral layer caused by tensile stresses and external friction forces is not taken into account. This reduces the accuracy of calculations, especially the assessment in a dangerous section, and does not allow adequate prediction of the occurrence of defects.

It is proposed that these mathematical models be improved to introduce the consideration of non-uniform temperature distribution on the flange. Distributions of normal contact stresses $q_{\rho ki}$ on the flange radius from the pressing force Q, external friction coefficients $f_{\rho 1ki}$, $f_{\rho 2ki}$ and differential heating temperature $t_{\rho ki}$ of the flange can be presented as power dependences:

$$q_{\rho ki} = q_{1k} + (q_{0k} - q_{1k}) \cdot \left[\frac{\rho_{ki} - R_B}{R_{Hk} - R_B}\right]^{a_q};$$

$$f_{\rho 1(2)ki} = f_{1(2)ki} + \left(f_{01(2)k} - f_{11(2)k}\right)\left[\frac{\rho_{ki} - R_B}{R_{Hk} - R_B}\right]^{a_{f1(2)}};$$

$$t_{\rho ki} = t_{1k} + (t_{0k} - t_{1k})\left[\frac{\rho_{ki} - R_B}{R_{Hk} - R_B}\right]^{a_t},$$

where R_B - is the inner radius of the flange section of the sheet blank; q_{ok}, q_{1k}, $f_{01(2)k}$, $f_{11(2)k}$, t_{0k}, t_{1k} - are the reference values of normal contact stresses, coefficients of external friction and heating temperature of the flange in sections along the outer R_{Hk} and inner R_B radii of the flange, respectively; a_q, $a_{f1(2)}$, a_t - are the power indices characterizing the shape of the distribution diagrams (Fig. 2)

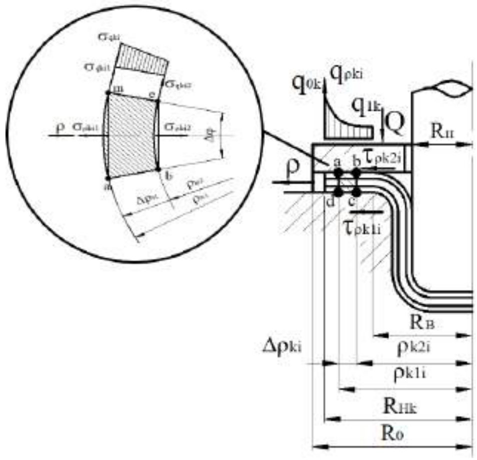

Figure 2. Calculation scheme of the integral deformation zone and its elementary part.

Conclusion. It is necessary to increase the drawing ratio and not allow the tensile stresses to improve the quality and increase the productivity of the axisymmetric drawing process. For this purpose, differentiated heating of the flange. In order to effectively optimize the process modes, we propose to use power dependences of the temperature distribution in the mathematical model, which will allow for the unevenness of the temperature along the flange to be taken into account. The complex and multifactorial nature of the calculated distributions obtained in these cases confirmed the feasibility of the implemented numerical approach.

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МОДИФІКАЦІЯ МЕТОДОЛОГІЇ РОЗРАХУНКУ ПРИСТРОЯ ДЛЯВИДАЛЕННЯ ВОДИ З ПОВЕРХНІ КАНАТУ ЗА ДОПОМОГОЮ РІВНЯННЯ RANS

Темченко В.В.
аспірант

Шахтні підйоми відіграють ключову роль у процесі підземного видобутку корисних копалин, оскільки забезпечують транспортуваннімя матеріалів, обладнання та персоналу між поверхнею та робочими горизонтами шахти. Даний тип підйому, як правило, є єдиним на шахті та відрізняється високою енергоємністю, що робить його одним із найважливіших елементів усього шахтного виробничого комплексу. Вихід з ладу шахтного підйому може