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Technology of manufacturing of multiple core stamp tools by plastic deformation

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Abstract: This article describes a new method for manufacturing of multiple core stamp tools by plastic deformation. The technique of geometric parameters of connected elements of multiple core tools designing necessary for the production of the proposed technology is developed.

Key words: punch, stamping tools, blank, assembling by plastic deformation

1. Introduction

One of the main factors that significantly affects the durability of the tool for punching holes in the stamping manufacture is a complex of the mechanical properties of the material from which the working elements of the tool are made [1; 2; 3]. For example, the resistance of punches made from U10A steel is 40-80 thousand strikes and for the punches made from X12M steel - 150-200 thousand ones [4].

Thus the manufacturing costs of steel punches X12M are 2.5-2.7 times higher than that one of similar design and purpose made of steel U10A. Reducing tooling costs by saving expensive alloy steels is an important task of tool production. In some cases this problem can be solved by applying a compound tool, wherein the most loaded part of the working tool is made of tool steel and other construction elements from a cheap carbon one.

2. Basic part

For manufacturing of such class tool is offered a new way, based on the open punching of a blank.

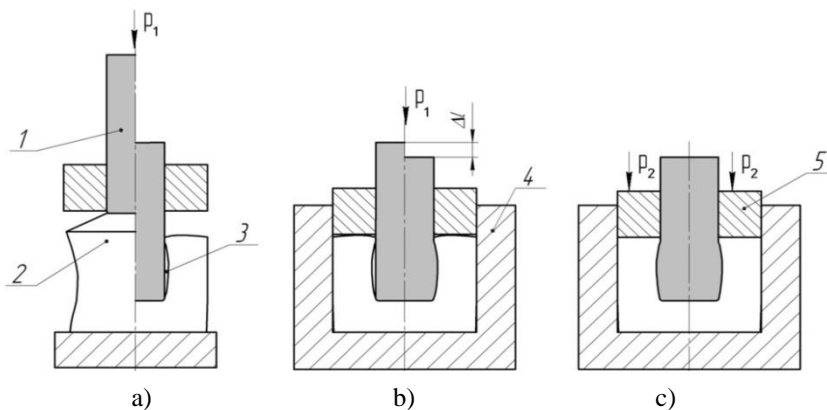


Figure 1. A method of manufacturing of a bimetallic core tool by punching.

The proposed technology of the compound punching tool by punching consists of four stages. In the first stage by the penetration of core 1 is carried out an open broach of body blank 2 (Figure 1a) heated up to forging temperature, while in the process of penetration owing to metal displacement features in the open punching between the cylindrical surface of the core and the side surface of the body blank cavity is formed an annular gap 3. The contoured shape of the body blank is selected taking into account the non-uniformity of deformation, hot upset in a height at the open punching. This shape provides a cylindrical shape of the body blank after open punching, i.e with minimum barrel shape of the side surface without sink mark, but forming an annular gap θ_3 .

At the second stage after the localized heating of the assembled blank a hot upset of the rod part by an amount Δl (Fig. 1b) is made. Thus there is a prefabricated compound in the matrix 4, due to the filling of the annular gap by a rod material.

At the final stage the final assembly of permanent connection by hot upset of body blank by an annular tool 5 in order to create the contact pressure sufficient to forge welding on the bonding surfaces (Fig. 1v). Theoretical fundamentals of the constituent permanent joints obtaining composite permanent joints by a plastic deformation are described in details in the works [5; 6; 7].

To implement this technology of precast rod stamp tools by a plastic deformation is necessary to develop a technique of contour blank designing. For this purpose, the process of form changing of cylindrical blanks in the open punching is studied.

Figure 2 shows the calculation scheme for determining the form changing parameters in the open punching with the diameter $d = 0,3 \div 0,7D_0$. The choice of this range is due to the fact that when $d < 0,3D_0$ the deformation of the blank is local, since the process of punching begins to move into the process of pressing the punch in the half-space that goes beyond the general case of deformation at the open punching, and if the size of the punch $d = 0,7 \div 1,0D_0$ due to the small immersion of the punch it does not provide a blind hole in the blank [8], which excludes the possibility of obtaining a permanent connection.

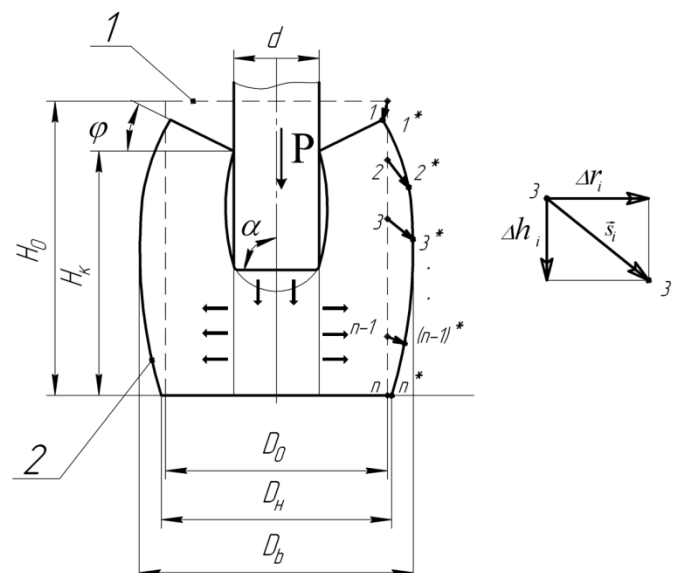


Figure 2. Analysis of forming a cylindrical blank at the open punching

Basic regularities of the form changing of a cylindrical blank at the open punching are considered in the works [9; 10]. Blank dimensions before punching are characterized by height H_0 and the diameter D_0 of the blank (contour 1). As a result of punching the blank shrinks, and its height becomes H_K . The preform acquires the shape of a barrel with a barrel diameter D_b (contour 2). By figures 1, 2, ... n are shown the initial situations of the equidistant points on the lateral surface, wherein

n – number of points. By the figures 1^* , 2^* , ... n^* are shown the final positions of the same points after punching. Moving from the initial position is characterized by a vector $\vec{s}_i(\Delta r_i, \Delta h_i)$, wherein Δr_i and Δh_i – amount of displacement i – points in the radial and axial directions, respectively.

Area of the constrained deformation 3 moves downward, pushing the metal from the deformation source 4 in the radial direction, moving apart the annular region 5. The bending of the sample side surface leads to the formation of a gap between the punch and punching element whose volume is V_3 . The volume of the annular gap in the punching can be characterized by the following relative value

$$\theta_3 = \frac{V_3}{V_{B.H.}} 100\% , \quad (1)$$

wherein V_3 – the volume of the annular gap, mm³; $V_{B.H.}$ – the volume of the embedded portion of the cylindrical punch, mm³.

The contour of the upper end surface rotates by an angle φ , that forms a sink marks.

On the basis of experimental studies are obtained the mathematical models of size dependence of the final form changing of the blank Δr_i , Δh_i , D_b , D_H , H_K , φ , θ_3 on a diameter d/D_0 , blank height H_0/D_0 , angle at the base of the punch α . Accepted values of the varied factors: the diameter of the punch $d/D_0 = 0.3 \div 0.7$; blank height $H_0/D_0 = 0.5 \div 1.5$. (for large values H_0/D_0 it is difficult to ensure the stability of disposable punch); angle at the base of the punch $\alpha = 45^\circ \div 90^\circ$. The depth of the punch penetration - $0.8H_0$ (greater depth of punching leads to a removable jumper and is mainly used for punching of a through hole in the blank).

Based on these studies a method of designing the geometric parameters of the contoured blank according to the drawing of the final compound product is developed. The first step is the calculation of the dimensions of D_0 and H_0 cylindrical blank 3, the annular gap value θ_3 , taper rod angle α and length of the immersed part of the rod $l_{B.H.}$.

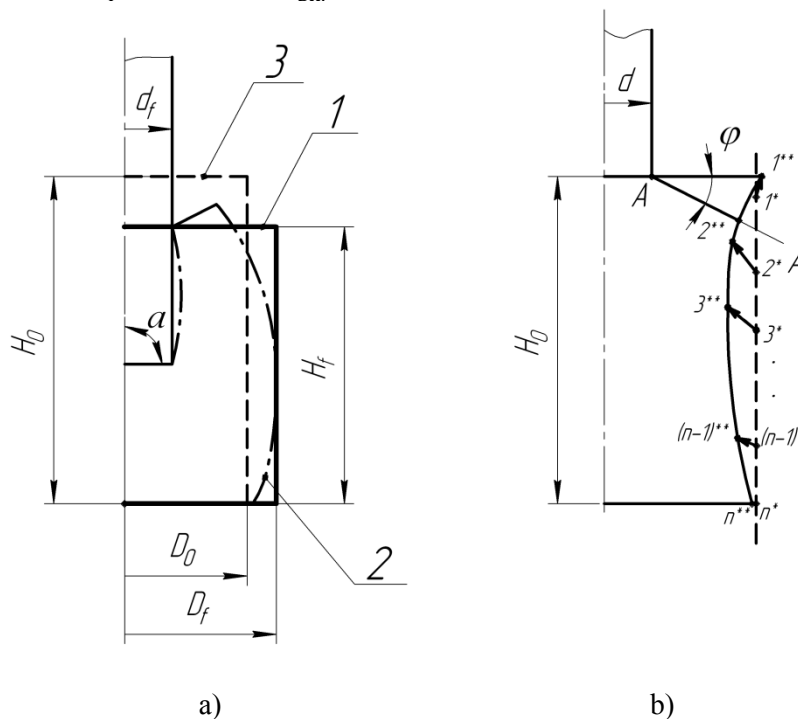


Figure 3. Designing of the contoured blank

The contour of the given cylindrical blank 2 after punching has to fit into the contour of the final compound tool 1 with the dimensions d_f , D_f и H_f (fig. 3, a).

After determining the dimensions of the cylindrical blank point displacement values of its side surface are calculated in the radial Δr_i and axial Δh_i directions and the sink marks angle of the upper end surface φ . The obtained values are used in the construction of countered blank contour (see. Fig. 3b).

The possibility of implementing of the proposed technology to manufacture precast rod stamp tools by plastic deformation is confirmed as by the results of simulation in the finite element modeling program complex as by manufacturing of experimental samples.

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