Parameters of the extraction of a thin-walled glass made of corrosion-resistant steel 12X18N10T

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Abstract. Methods of metal processing by pressure are one of the most advanced technological methods of manufacturing thin-walled spatial parts. The volumetric stamping methods used ensure high productivity while maintaining product quality. Cold volumetric stamping is one of the main types of metal forming in many branches of mechanical engineering, as it most fully meets the requirements of approximating the shapes and sizes of workpieces to finished parts. Determining the rational technology of the stamping process is a fundamental factor in the development of the production of a new product. Hollow parts with a bottom of the "glass" type are usually obtained by direct or reverse extrusion. The maximum deformation and minimum wall thickness of the part in this case is determined depending on the technological deformability of the workpiece. The design of technological processes of cold volumetric stamping of thin-walled parts of the "glass" type involves solving a number of complex tasks: determination of the stress-strain state; determination of punching forces, loads, etc. The use of traditional methods of designing technological processes of cold volumetric stamping does not always allow us to solve these tasks and ensure the optimal combination of the required quality of the finished part and the minimum time and cost of production. One of the effective approaches to solving these problems is the use of computer-aided design systems based on computer technologies: CAD and SAE systems - software complexes for automated engineering analysis of volumetric stamping processes.

1 Introduction

Various technologies can be used to manufacture parts made of high-strength steels. Choosing a rational method of processing corrosion-resistant stainless steel is an urgent task and allows you to manufacture parts in accordance with the requirements of customers. Cold stamping is a method of plastic deformation of metals. It is widely used for cold pressure treatment. Cold stamping can be volumetric or sheet. The choice of the workpiece depends on the material and type of the product [1-3]. Cold sheet stamping is used for the manufacture of products in aircraft and rocket engineering, transport engineering, production of household appliances, chemical devices, etc. Cold stamping makes it possible to minimize metal
consumption, reduce the complexity of manufacturing products, since products after stamping practically do not need subsequent cutting processing [4]. Deformation of the workpiece without preheating allows you to obtain a large dimensional accuracy and better surface quality compared to pressure treatment at high temperatures [5]. Cold stamping significantly increases productivity and facilitates the use of mechanization and automation of production.

**The aim of the study** is to identify the limiting parameters when drawing a thin-walled glass made of 12X18H10T steel for the design of a stamp.

**Research methods.** Mathematical modeling of the process of drawing a part of the "glass" type was carried out in the DEFORM calculation complex.

## 2 Calculation part

The technical characteristic of 12X18N10T steel ensures good workability of the metal during hot or cold plastic deformation. The technological process of cold volumetric stamping in general always includes two main stages: the preparation of the source material for stamping and the actual stamping. Preparation for stamping consists in preliminary heat treatment to obtain a structure suitable for cold extrusion - annealing of the deformable material. The purpose of annealing is to reduce the resistance to deformation and increase the plasticity of the material.

The shape of the workpiece is chosen based on two principles [6-8]: to achieve the highest material utilization coefficient; to obtain the highest extraction coefficient (Fig. 1). For the manufacture of the "Glass" part, we use a sheet of 0.8 mm, sheet size 200x1200mm. The workpiece for obtaining the part is a circle. To calculate the area of the workpiece, we use the Compass software package - the surface area of the workpiece: S = 10435.86 mm².

![Fig. 1. "Glass" part: a - 3D model of the part; b – 3D model of the workpiece; c - drawing of the workpiece](image)

The formula for determining the diameter of the workpiece has the form [11]:

\[
D_{zag} = \sqrt{d^2 + 4d_{cp}(h + \Delta h)},
\]

where \( h = 59.7 \) mm is the height of the part; \( d = 44.4 \) mm is the inner diameter of the cylinder; \( S = 0.8 \) mm is the thickness of the sheet metal; \( d_{cp} = d + S = 45.2 \) mm is the average diameter of the cylinder, mm; \( \Delta h = 2.5 \) mm — allowance for trimming the upper edge of the cylinder, mm.

The workpiece for drawing the "Glass" part is a circle Ø115.3 mm thick 0.8 mm. Material utilization factor KIM=(F·n)/(B·L)·100%, where \( F = 10435.86 \) mm² is the area of the workpiece, mm²; B is the width of the sheet, mm; L is the length of the sheet, mm; n is the number of parts obtained from the sheet. KIM =26740•8/200/1200 =89%.
For the thickness of the material \( S = 0.8 \) mm; the size of the jumpers when cutting the contour of the part \( a = 1.2 \) mm, \( b = 1.2 \) mm. Determination of the radius of rounding the edge of the matrix from the inequality:

\[
\frac{S_0}{D_0} < \frac{1 - 1.09k_B}{1.07 - (5,5 + \frac{R_M S_0}{S_0})},
\]

where \( R_M \) is the radius of the rounded edge of the matrix.

When performing an inequality, the formation of folds is possible. To avoid this, it is necessary to apply a clamp (Fig. 2). According to the calculation \( 0.007 \leq 0.04 \). It is necessary to apply a clamp.

![Fig. 2. Design scheme with a clamp](image)

The diameter of the hole in the matrix is assumed to be equal to the diameter of the part: \( Dm = Dd = 48 \) mm. The diameter of the punch is reduced by the size of the gap: \( Dn = Dm - 2m \),

where \( m \) is the one—sided gap between the matrix and the punch, mm.

The calculated drawing force depends on the mechanical properties of the deformable metal and its thickness, the dimensions of the product, the drawing coefficient and the coefficient of friction between the workpiece and the die material [9].

For practical calculations, when determining the drawing force, the empirical formula is used [6]:

\[
P_V = \pi \cdot d_n \cdot S \cdot \sigma_B \cdot k = 3.14 \cdot 44.4 \cdot 0.8 \cdot 550 \cdot 1.25 = 76.7 \text{ kN},
\]

here \( k \) is a coefficient that takes into account the additional force required to push the deformable workpiece through the matrix \( (k = 1.25) \);

\( \sigma_B \) is the tensile strength of the deformable metal, for steel 12X18N10T \( \sigma_B = 550 \text{ MPa} \).

To prevent the formation of folds on the cylindrical walls of the product, a pressure ring or a folding holder is used in the exhaust die, pressing a part of the workpiece against the die matrix with a force \( Q \), the value of which should be sufficient so that the flange of the workpiece does not have the opportunity to form folds.
The total calculated drawing force $P_{pv}$ will be equal to the sum of $P_{pv} = P_v + Q$.

The clamping force $Q$ is calculated by the formula: $Q = F \cdot q = 7526.3 \cdot 2.5 = 18.8$ kH, where $F$ is the area of the workpiece that is under pressure at the initial moment of extraction; $q$ is the specific force of the clamping force on the deformable workpiece.

Specific clamping force $q=2.5$ for stainless steel.

The total calculated drawing force: $P_{pv} = 76.7 + 18.8 = 95.5$ kN.

The force of the Rpr process when selecting the pressing equipment is selected with a margin factor equal to 1.2:

$$P_{pr} = 1.2 \cdot P_{pv} = 1.2 \cdot 95.5 = 114.6$$ kN.

The operation of the hood is determined by the formula: $A = \frac{P_{pr} \cdot C \cdot h}{S_0}$,

where $h$ is the extraction depth, mm;

$C$ is the coefficient. $A=253$ N·m.

3 Research

Mathematical modeling of the process of single-circuit reverse extrusion of a part of the "glass" type was carried out in the DEFORM calculation complex [8-14]. The DEFORM software package is a specialized software tool that allows you to solve problems related to cold, semi-hot and hot stamping of materials, taking into account the nonlinear behavior of materials and large plastic deformations. According to the created 3D stamping model, the program automatically builds a finite element grid on the surface and in the volume of stamps and blanks, and also rebuilds it during the solution process as needed [15, 16]. With the help of the DEFORM package, a simulation of the process of cold extrusion of a part of the "glass" type was carried out [17-19]. The force acting on the punch during cold extrusion of the part at all stages of the technological process is determined (Fig. 3-5).

![Fig. 3](image)

Fig. 3. The dependence of the force on the punch on the wall thickness of the extruded part: $d / d_0$ is the characteristic of the wall thickness equal to the ratio of the diameter of the punch $d$ to the diameter of the die $d_0$.

The end of the formation of the curvature sections corresponds to the achievement of the maximum force $P = 103$ kN. At the third stage of deformation, there is an intensive decrease in the focus of plastic deformation [20].
The formation time of a suitable part with a given ratio of \( d / d_0 = 0.9 \) was 4 seconds.

As the study showed, with any \( d / d \) ratio, it is possible to apply a process scheme using a clamp at a punch speed \( V = 100 \ldots 120 \text{ mm/s} \). There are no breaks and folds in the model (Fig. 5, a). When the punch speed increases to \( V = 150 \text{ mm/s} \), the workpiece breaks (Fig. 5, b). The application of the process scheme without the use of a clamp at the punch speed \( V = 100 \ldots 150 \text{ mm/s} \) leads either to the rupture of the workpiece, or to the formation of folds and defects on the surface of the part (Fig. 5, c).

According to the obtained values of the process parameters, a stamp is designed (Fig. 6) for sheet stamping of parts and a press is selected to perform sheet stamping. The calculation of the main parts of the stamp for strength was made. The crumpling stress of the support surface of the punch head for the exhaust stamp: \( \sigma_{CM} = 48.26 < \left[ \sigma_{CM} \right] \left( \frac{H}{mm^2} \right) \). Compression stress of the punch: \( \tau_{CM} = 11.4 < \left[ \tau_{CM} \right] \left( \frac{H}{mm^2} \right) \). The estimated free part of the punch based on the longitudinal bend \( l = 55.03\ldots 61.4 \text{ mm} \).
Conclusions. The use of a specialized DEFORM software package for modeling technological processes of cold volumetric stamping allows you to quickly and with a high degree of accuracy determine the main parameters of the processes, the presence of possible defects and optimize the technology with a small expenditure of resources and time.

The results of the study confirm the fact that the process largely depends on the force on the punch, the wall thickness of the part and the stamping speed. The obtained results of modeling the cold stamping process in the DEFORM program of the steel 12X18N10T material allow us to determine the process parameters: - the process can be performed without a clamp and with a clamp; - the process is reliably ensured by stamping with a clamp; - force on the punch $P = 100 \ldots 110$ kN with a wall thickness of 0.8 mm of the part; - punch speed $- 100...120$ mm /s.

To clarify the results obtained, the following stages of the study are outlined – determination of the stress-strain state of the stamp elements and the resulting part.

References

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