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Issue Article

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QUALITY ANALYSIS OF A BOX-SHAPED PART AFTER DEEP DRAWING

Abstract: *Sheet metal drawing provides medium-precision thin-walled hollow parts. The production of box-shaped parts by volumetric deformation is associated with deviations from the geometry of final product in accordance with the drawing requirements, significant material stresses, and other problems. Thus, the prediction of the condition of a plastically deformed box part and the analysis of the causes of deep drawing instability will reduce production defects by optimizing the technological process.*

Key words: *deep drawing, deformation, box-shaped part, finite element, material.*
Language: *English*

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1. Introduction

Sheet metal drawing is used to produce thin-walled hollow parts such as cups, boxes, pipes, etc. [1-2]. Depending on the geometric shape of the punch and the die hole, it is possible to produce cylindrical, cubic, and parallelepiped-shaped parts. Features of drawing of cylindrical and box-shaped parts are presented in works [3-11]. The drawing of cylindrical hollow parts is accompanied by uniform plastic deformation of the material volume due to the most optimal geometric shape of the die hole. The drawing of box-shaped hollow parts is accompanied by the formation of an excess volume of material on the blank flange and the occurrence of significant plastic deformations at the conjugation of side walls with other elements of the part. The results of computer modeling of the box-shaped part drawing process allowed for a qualitative prediction of the plastic deformation of sheet metal, the quantitative determination of excess material, and the analysis of deviations from the geometric shape of the resulting part.

2. Materials and methods

The deep drawing process of sheet metal was implemented in dynamics using the LS-DYNA program. A square-shaped blank (100×100 mm) with a thickness of 2 mm and the properties of 2024 aluminum alloy was subjected to plastic deformation. In parallel with the sheet metal model, models of a cube-shaped punch and a die with a cube-shaped hole were constructed. The clearance between the outer surface of the blank and the forming surface of the die hole was taken to be 1 mm. The working part of the punch was rounded to a radius of 5 mm. A blank holder model was used to reduce the formation of wrinkles on the flange of a deformed sheet metal. A technological force of 15 kN was applied to the blank using a punch. The models of the forming and auxiliary parts of the drawing die were accepted as absolutely solid bodies (they were not deformed).

3. Results and discussion

The Figure 1 shows the results of computer modeling of the deep drawing process for a box-shaped part. The blank was pulled into the forming hole of the die to a depth of 30 mm. To increase the view of the deformed blank, the models of the punch and the blank holder were not displayed. The wire model represents the die. To assess the degree of plastic deformation, the volume of the blank model was divided into finite elements (a mesh was generated).

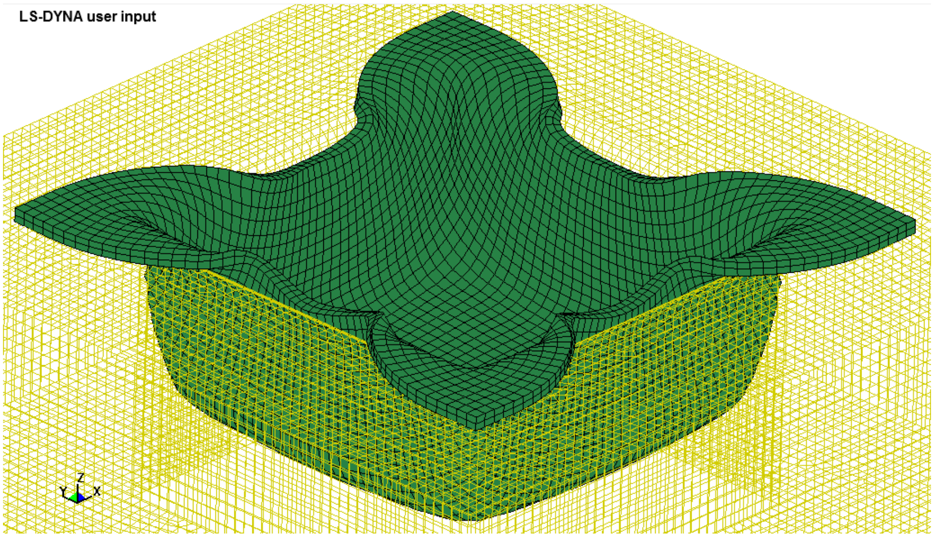

Figure 1. Three-dimensional model of the box-shaped part after drawing.

Due to the clearance, the walls of the box-shaped part are formed at an angle. Excess material located on the flat surface of the die causes the side walls of the part to become curved (concave). The volume of excess material in the blank of various overall dimensions can be determined by summing the number of finite elements on the flange. The volume of one finite element (with standard model partitioning) is 1.7 mm^3.

At the conjugation of side walls of the part, there are maximum deformed sections 6.8 mm long from the upper flat surface of the die. The geometry and size of finite elements demonstrate the type of material deformation in the part. Thus, it can be noted that the volume of material located in the area of the side walls and the bottom of the part is subjected to stretching, while the volume of material located between the excess flange and the rib is subjected to compression.

4. Conclusion

To reduce the errors in manufacturing a box-shaped part by plastic deformation, it is necessary to remove the excess material from the blank of the calculated volume and increase the radius of rounded corners at the conjugations of contact surfaces of the die hole. It is also possible for the material to break at the joints between the side walls and the bottom and flange due to excessive deformation, which can be eliminated by using an effective lubricant, reducing the drawing modes, increasing the number of consecutive deformation stages, and using a reasonable pressing force of the blank holder.

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