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SOME RESEARCHES CONCERNING THE DEEP DRAWING PROCESS OF THE RECTANGULAR BOX

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ABSTRACT

The deep drawing process of the rectangular boxes is difficult difficulties because of the complexity of the stress and strain states. This paper presents the results of the researches on the variation of the stamping force in function of some deformation factors and the variation of the micro-structure in the maximum deformation zone.

KEYWORDS: sheet, strip, deformation, rectangular box, stress and strain states

1. Introduction

The deep drawing is a deformation process of the sheets and strips for obtaining box type parts (Fig. 1).

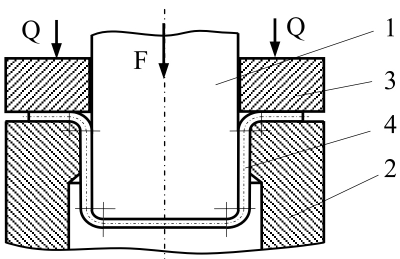

Fig. 1. *Scheme of the stamp process: 1-punch, 2-die, 3-blank hold, 4-stamped part.*

Under the action of the force F on the punch 1, the semi-product 4 flows in the space, between the punch and the die 2. On the blank hold (restraint plate) the force Q is applied and avoids the folds appearance. If the folds appear, the flow of the material is blocked and the semi-product breaks.

The form and dimensions of the plate semi-product are established according to from and dimensions of the final part.

Thus, in case of the revolution parts the plate semi-product has a disc form. The thickness of the disc is equal to the thickness of the sheet or strip and the diameter is established in function of the dimensions of the final part apply the equality of the surface areas.

The surface area of the disc is equal of the surface area of the final part.

In case of the rectangular cup the plate semi-product is composed by two side pairs and four corners in the disc form (Fig. 2).

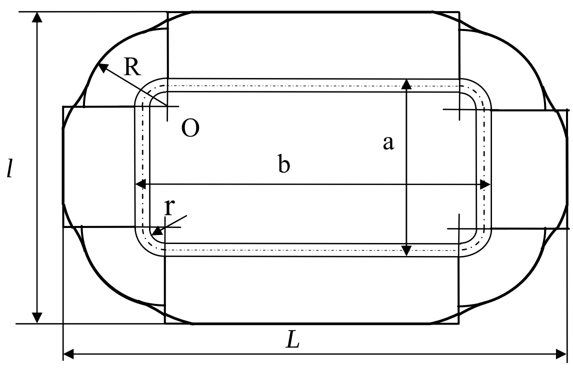

Fig. 2. *The form of the plate semi-product.*

The stresses and strains states, in the zones of the corners are very complex.

During the stamping process the material flows and forms the corner of the part. In the same time, the material of the side, been next by the corner, is drawn in the space of the corner.

Thus, in the corner and in the proximity of the part corner, the important variation of the thickness and of the micro-structure and properties of the material takes place.

In function of the concrete values of the geometrical factor of the stamped part, the deep drawing process is made of one, two or more stamping operations.

For establishing the number of deep drawing operations *n,* are recommended various methods.

One of these is the following:

1. We calculate the value of deep drawing coefficient *m*, defined by the equation below:

$$m = 1.27\frac{a+b}{L+l}$$

2. Using the Table 1 we will establish the number of stamping operations.

***Table 1.** Establishing the stamping operations*

n	**Relative thickness**, $(t/(L+l)\times 50)$			
	2÷1.5	1.5÷1.0	1.0÷0.5	0.5÷0.2
2	0.40-0.45	0.43-0.48	0.45-0.50	0.47-0.53
3	0.32-0.39	0.34-0.42	0.36-0.44	0.38-0.46
4	0.25-0.30	0.27-0.32	0.28-0.34	0.30-0.36
5	0.20-0.24	0.22-0.26	0.24-0.27	0.25-0.29

If the calculated coefficient is greater than the maximum value recommended in the Table 1, corresponding to *n=2*, the stamping may be performed by one deep drawing operation. Contrary, the number of stamping operations results from Table 1. The researches systematized in this paper refer to the variation of the stamping force in function of the part height and thickness.

2. Experimental conditions

The experiments were made with a stamping device centered and mounted at the hydraulic press with the maximum force of 120 kN.

The drawing of the stamping device is rendered in Figure 3.

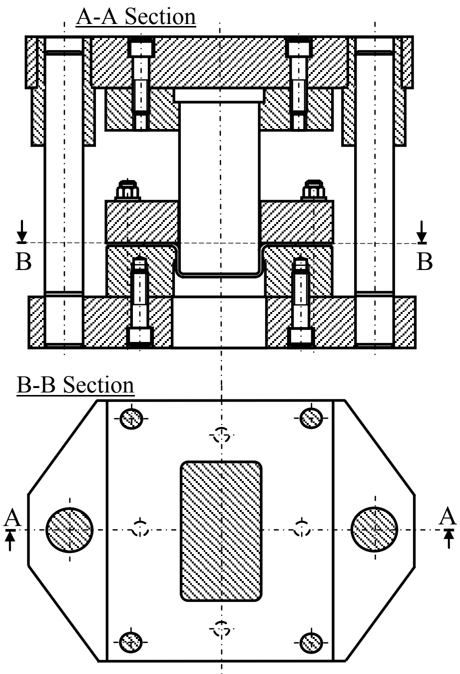

***Fig. 3.** Deep drawing device.*

For the experiments we used steel strip for the deep drawing with thickness of 0.3; 0.5 and 0.8 mm.

3. Experimental results and comments

3.1 Variation of the stamping force

The dimensions of the rectangular stamped part are rendered in the Figure 4.

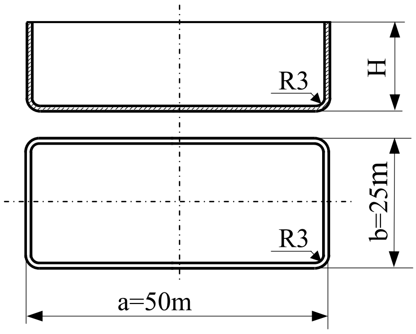

***Fig. 4.** Dimensions of the stamped part.*

The height of the stamped parts was of 8.0; 10.0; 12.0; 14; and 16 mm.

The variation of the force in the time of the deep drawing process, for the thickness of the strip of 0.3 mm is rendered in Figure 5.

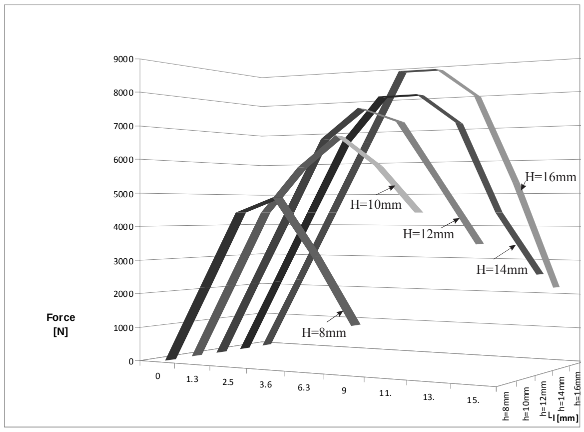

***Fig. 5.** Stamping force for thickness of 0.3mm.*

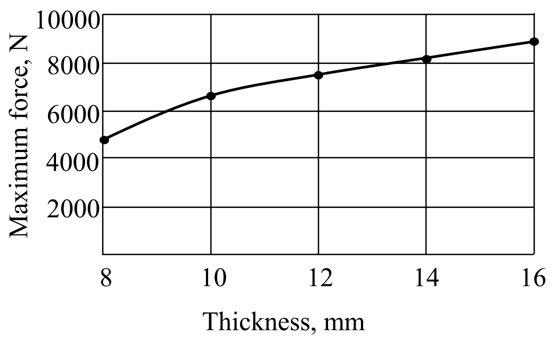

***Fig. 6.** Variation of maximum stamping force with the height of the stamped part for thickness of 0.3 mm.*

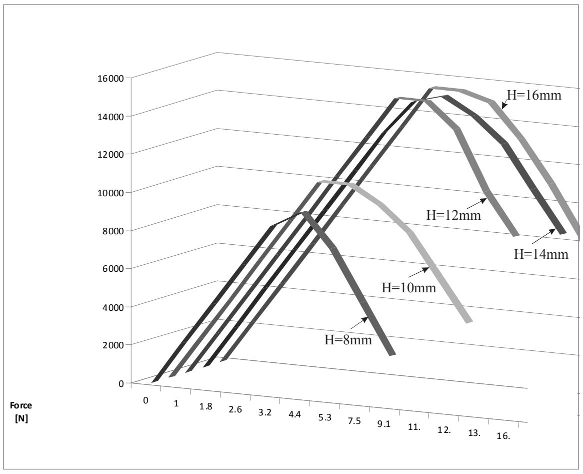

Fig. 7. *Stamping force for thickness of 0.5mm.*

The variation of the maximum stamping force in case of the thickness of 0.5 mm is rendered in Figure 8.

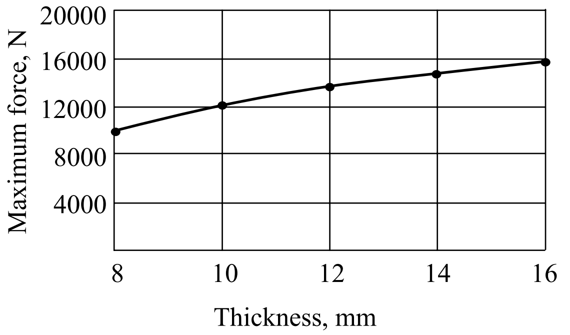

Fig. 8. *Variation of maximum stamping force with the height of the stamped part for thickness of 0.5 mm.*

The variation of the force during the deep drawing process for the thickness of the strip of 0.8 mm is rendered in Figure 9.

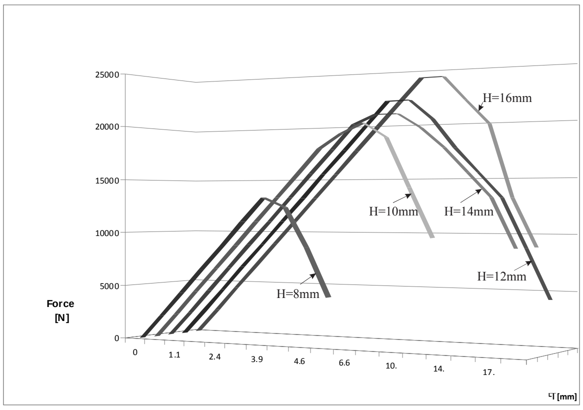

Fig. 9. *Stamping force for thickness of 0.8mm.*

The variation of the maximum deep drawing force in case of the thickness of 0.8 mm is rendered in Figure 10.

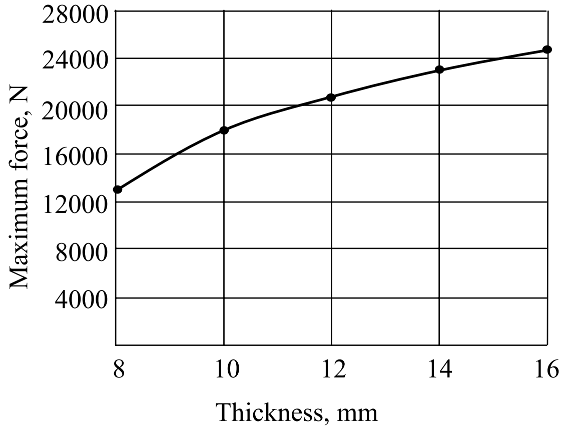

Fig. 10. *Variation of maximum stamping force with the height of the stamped part for thickness of 0.5 mm.*

In a 3D form, the variation of the maximum force in function of the thickness of the strip and the height of the stamped parts is rendered in Figure 11.

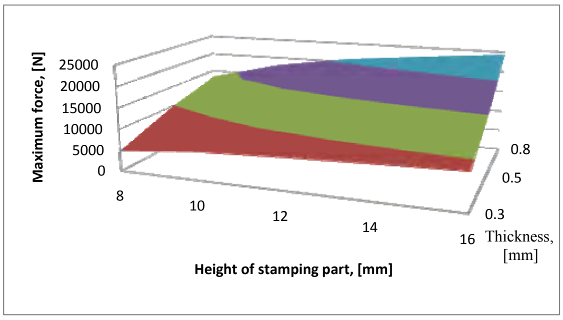

Fig. 11. *The variation of the maximum force with the thickness and the height of the parts.*

We can observe that the force during the deep drawing process increases attains a maximum value and decreases until the end of the deformation process.

The maximum value of the force corresponds to greater values of the removing of the superior stamping device when the stamped part height increases.

The thickness does not have a notable influence on the position of the maximum value of the stamping force.

The maximum value of the stamping force increases when the height of stamped parts and thickness of material increase.

3.2. Aspect of the microstructure at the stamping process

The great non-uniformity of the deep drawing process determines the variation of the microstructure of the deformed material, specially, in the corner zone. In Figure 12 we show the microstructure aspect in the frontal wall of the part. The microstructure corresponds to the base state of the material and consists of ferrite and carbide. The crystalline grains are, practically non-deformed.

Fig.12. *Micro-structure of material in the frontal wall of the stamped part (Nital 5).*

In Figure 13 we show the microstructure aspect in zone of the corner of stamped part. The deformation of the grains is evident.

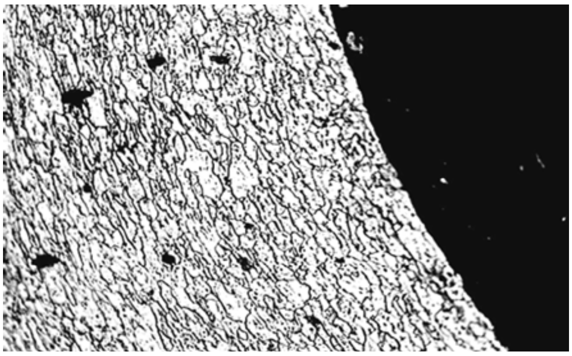

Fig.13. *Micro-structure of material in the corner zone of the stamped part (×200, Nital5).*

The strain intensity is great, relatively, and non-uniform. Because the strain intensity is greater in the points to the exterior of the part wall, the intensity of the crystalline grains deformation is greater in these points.

4. Conclusions

The deep drawing process of the rectangular part is very difficult because of the complex stress and strain states.

The quality of the process and product is defined by the quality of the material and the values of the technological factors.

For this reason the researches in the aim of the assurance of the quality are justified.

In the paper the variation of the force in the time of the stamping process and the variation of the maximum force with the thickness and the height of the part were established. The force variation in the time of the deep drawing process is a function with the maxim.

The maximum value of the force increases with the thickness and the height of the part.

The microstructure in the corner of the part is very affected.

The crystalline grains extend in the direction of the principal strain.

The extension of the grains is greater at the exterior of the part wall.

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