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FINE BLANKING AND PIERCING

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Abstract: *Fine blanking and piercing are advanced methods of cold stamping. Fine blanking and piercing can be done either by using some special dies, with zero or negative clearances between the punch and die, installed on classical presses, either with dies operated by special presses (with double or triple effect). Therefore, fine blanking and piercing replace the classical methods to obtain parts through classical blanking and piercing and their subsequent calibration on contour through stamping. Fine blanking and piercing are well-known in production under the name of fine stamping. By applying these operations one may obtain parts made of sheet metals having a thickness s = 1…20 mm. For fine stamping, the following conditions are imposed to the material: physical mechanical properties suitable for this kind of processing, isotropy of mechanical properties, minimum sheet metal thickness tolerances.*
Key words: *fine blanking, fine piercing, dimensional accuracy, surface quality.*

1. INTRODUCTION

The shearing process in fine stamping is analogue to cutting by precision shearing. Therefore, this is based on previous compression principle of the blank in the shearing zone at a pressure ˝p˝ which can reach the material's yield stress ($p \le R_{p0,2}$). As a result of a high hydrostatic pressure, which acts on the blank, its material is subjected to a spatial stress state of compression-type which favors the stability of deformation and improves the plastic properties of the material. This procedure allows manufacturing of some parts whose precision belongs to class 7 according to the ISO norms.

The fine blanking/piercing process occurs through plane flow. The process itself consists in two stages which both contribute to the manufacturing of highly accurate parts:

- Preliminary spatial compression stage of the blank in the shearing area until the material begins to flow in the plastic regime;
- Shearing stage through plane flow in which the separation of the finished part from the blank occurs.

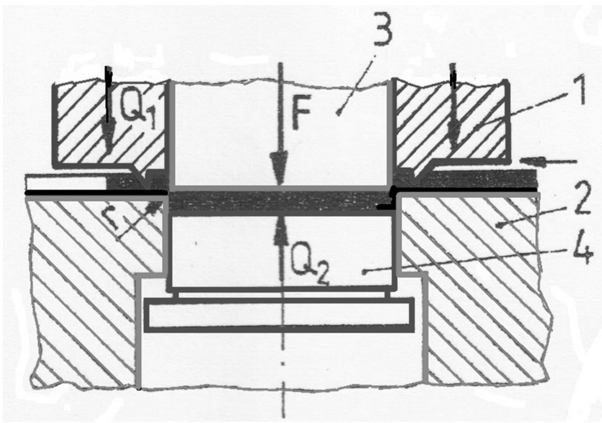

Fig. 1. Principle of part separation from the blank through fine stamping: 1. Clamping plate; 2. Stamping die; 3. Punch; 4. Part ejector

Figure 1 shows the main elements of a fine blanking die when the blank material has the thickness [1]:

$$s \le 4.5 \ldots 5 \text{ mm} \quad (1)$$

The radial compression of the material is made with the clamping plate 1, through its ribs, having a triangular shape in the cross section. As the rib enters the blank, it presses the material against the punch surface and the die cavity. The axial compression of the blank is made between the punch 3 and the ejector 4, which is operated by the force Q_2. The clamping plate is also operated by the Q_1 force, while the punch is acted by the blanking force F.

2. TECHNOLOGICAL PARAMETERS OF FINE STAMPING

In order to obtain high quality parts, one must know the technological conditions which apply to this advanced method of stamping. Hence, high quality parts are obtained when the tensile strength R_m of the material is larger than the value [1]

$$R_m \geq 700 \text{ N/mm}^2 \qquad (2)$$

but not higher than 800 N/mm^2.

The precision blanking die will be made with a radial compression rib will be located on the clamping plate 1 (see Figure 1). In this case, the geometry of the rib will be adapted according to Figure 2, and its geometric parameters are established according to the values listed in Table 1 [1].

Table 1

Geometric parameters of the rib [1].

No.	Blank thickness s [mm]	Geometric parameters of the rib [mm]		
		l	h	r
1.	1,0…1,8	1,0	0,3	0,2
2.	1,8…2,2	1,4	0,4	0,2
3.	2,2…2,8	1,7	0,5	0,2
4.	2,8…3,2	2,1	0,6	0,2
5.	3,2…3,8	2,5	0,7	0,2
6.	3,8…4,5	2,8	0,8	0,2

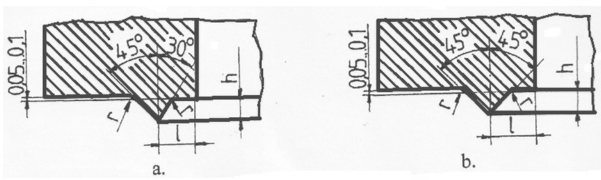

Fig. 2. Geometry of the compression rib: a – asymmetric shape; b – symmetric shape when the blank thickness is greater than 5 mm (in this case, both the clamping plate and the shearing die will be provided with radial compression ribs of the blank in the shearing area)

According to Figure 1, the total force F_t at precision stamping is determined by using the following relationship:

$$F_t = F + Q_1 + Q_2 \qquad (3)$$

where F represents the shearing force, Q_1 is the force needed to press the rib in the blank material, and Q_2 is the ejection force exerted by the counter-punch.

The shearing force F is calculated as in the case of a classical blanking process using the formula

$$F = p.s.\ \tau\ , \qquad (4)$$

in which p is the perimeter of the shearing contour, s is the thickness of the metallic sheet, and τ is the material strength in pure shearing regime.

The force needed to press the rib in the blank material (Q_1) is determined by using the relationship

$$Q_1 = p_1.Q' \qquad (5)$$

where p_1 represents the rib perimeter and Q' is the specific clamping force per unit length [1].

The ejection force exerted by the counter-punch (Q_2) is determined as follows:

$$Q_2 = p_2.A \qquad (6)$$

where p_2 represents the pressure exerted by the counter-punch on the metallic sheet [1] and A is the cross-sectional area of the counter-punch.

In order to create optimum conditions for the fine blanking process, the blanking with negative clearance between punch and die needs a pressing force 2.0…2.5 times higher than in the case of a classical blanking [2].

3. STAGES OF THE FINE BLANKING PROCESS

The principle of this kind of blanking process resides in developing a high-stress state in the region located near the cutting edges of punch and die, in combination with an accurate control of the separation speed of the detached part from the metallic sheet (v = 5…15 mm/s).

The stages of a fine blanking process using mobile punching dies and blank pre-clamping are shown in Figure 3 [2].

In the first stage, the metallic sheet is brought in the working area (Fig. 3.a) and put on the blanking die 1. The clamping plate then presses the sheet against the die (Fig. 3.b) and embosses the compressing rib (Fig. 3.c). In the following stage, the punch 2can be moved downwards to separate the part (Fig. 3.d and e).

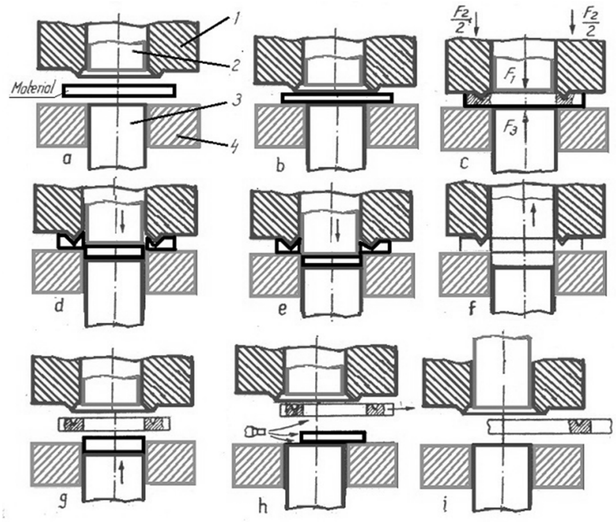

Fig. 3. Fine blanking stages (case when a mobile punch is used in combination with blank pre-clamping)

The motion of the punch continues until the part is completely detached from the metallic sheet (Fig. 3.f).

The counter-punch 3 moves in the same direction as the punch 2, but develops a force F_3 having an opposite direction. After its complete separation from the metallic sheet, the part it is taken from the cutting die 1 (Fig. 3.g). The removal of the finished part from the work are of the die is made by using a compressed air jet (Fig. 3.h). In the last stage, the feed with metallic sheet can be done mechanically or manually (Fig. 3.i).

The sequence of stages shows that the fine blanking process takes place under special conditions which ensure a high dimensional accuracy, together with a very good smoothness and perpendicularity of the cutting profile.

4. QUALITY AND PRECISION OF PARTS OBTAINED THROUGH FINE BLANKING

Obtaining the needed quality and accuracy in fine blanking is conditioned by assuring some technological and constructive parameters which are needed in order to separate the part. The main technological parameters of the fine blanking process are the following ones: pre-clamping pressure in the cutting area, counter-punch pressure, rib stamping pressure, and separation speed. Among the geometric parameters of the blanking tools, the most important are the following ones: fillet radius of the die cutting edge, height and geometry of compression rib, clearance between punch and die, distance between the cutting edge and the compression rib, and lubrication applied to the tool and blank surfaces.

The parts manufactured by fine blanking procedures have no burrs and the quality of their shearing surface is comparable to the quality of the parts subjected to grinding. When the parts are made from high-strength steel, the roughness of the shearing surface is [1]:

$$R_a = 0.4 \ldots 0.8\ \mu m \qquad (7)$$

In the case of parts made from milder steel, the roughness of the shearing surface is [1]:

$$R_a = 0.8 \ldots 1.6\ \mu m \qquad (8)$$

The dimensional accuracy of the parts belongs to classes 6…8 according to STAS 8105.

In order to evaluate the quality of the parts manufactured by fine blanking procedures, a finite element simulation of such a process has been performed [5]. The results referring to the quality of the shearing surface are shown in contrast with the ones obtained in the case of a classical blanking process (see Fig. 4).

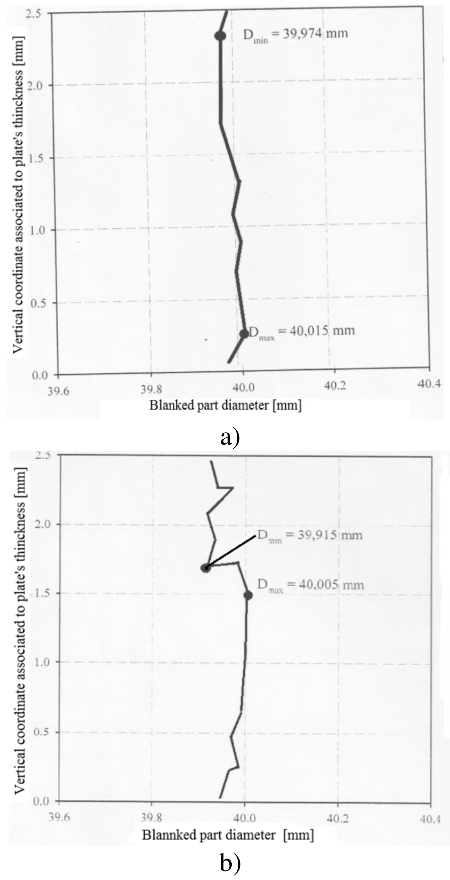

Fig. 4. Diameter variation of a circular part manufactured by fine blanking (a) and classical blanking (b) procedures

5. CONCLUSIONS

The fine blanking process takes place in conditions different from those met in classical blanking. The differences consist in:

- Assuring a lower separation speed
- Creating a high-stress state in the shearing region
- Using tools having zero or negative clearance between punch and die
- Lubricating the surfaces of the blank and tools.

The success of the fine blanking operations depends on the control of some parameters such as the clearance between the punch and die, as well as the pressure exerted by the clamping ring and counter-punch on the blank.

6. REFERENCES

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DECUPAREA ŞI PERFORAREA DE PRECIZIE

Rezumat: Decuparea şi perforarea de precizie sunt metode avansate de ştanţare la rece. Aceste procedee se pot realiza fie cu ajutorul unor ştanţe speciale având joc nul sau negativ între elementele active, acţionate de prese clasice, fie cu ştanţe acţionate de prese speciale (cu dublu sau triplu efect). Decuparea şi perforarea de precizie înlocuiesc metodele clasice urmate de calibrarea conturului ştanţat. Decuparea şi perforarea de precizie sunt cunoscute în practica industrială şi sub denumirea de procedee de ştanţare fină. Prin aceste operaţii se pot obţine piese din tablă având grosimea s = 1 … 20 mm. Pentru ştanţarea de precizie se impun materialului următoarele condiţii: proprietăţi fizico-mecanice adecvate acestei prelucrări, izotropia proprietăţilor mecanice, abateri minime la grosimea tablei etc.

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