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SOME RESEARCHES ON THE CUTTING PROCESS USING A STAMPING DEVICE

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ABSTRACT

The cutting process of the parts from the plates and strips consists in the action of two active elements of the stamping machine: device punch and active plate. The main actors on which the cutting process depends are the thickness and the mechanical characteristics of the material to be cut, the state of the edges of the active elements and the clearance between the active elements. This paper presents the results of the research on the variation of the stamping force depending on the thickness and the stamp clearance for the maximum cutting force.

KEYWORDS: cutting process, stamping force

1. Introduction

Stamp cutting stamping is a deformation process of the sheets and strips used to obtain various parts by a cutting operation: cutting out, perforation, cutting off, notching etc. (fig.1).

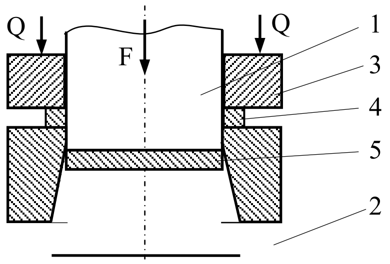

Fig. 1. *Scheme of the stamp cutting process: 1-punch, 2-active plate, 3-restraint plate, 4-initial material (band), 5-cut out part*

Under the action of the force F applied on the punch 1, between the edges of the punch and the active plate 2 a shearing stress and strain states are developed. As an effect, a cutting process is developed and the cut out part 5 is separated from the initial band 4.

In the case of the precise cutting out process, a restraint plate 3 may be used on which fastening force is applied. This way, the precision of the worked part is better.

The character of the stress state during the cutting process is described in Figure 2. The stages of the cutting are: the first stage is the elasto-plastic behavior of the material (Fig.2.a). The sharpened edges are cutting effectively the material fibres. In this stage the force increases reaching a maximum value and then rapidly decreases to zero.

At the moment of maximum value of the force in the edge of the punch and of the active plate, the cracks are developed (fig.2b).

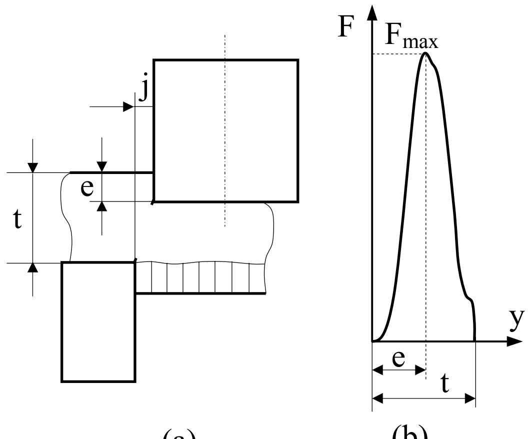

Fig. 2. *Cutting stage of the stamping process: (a) the scheme of the cracks appearance, (b) force variation at the cutting process*

Under optimum conditions, the directions of the cracks coincide. In this case the maximum force value will be minimum. This happens when the value of the stamp clearance is optimum.

Also, for optimum value of the clearance between the punch and the active plate, the precision of the dimension and quality of the cut border is better.

2. Experimental conditions

The experiments made with a stamping device are rendered in the Figure 3.

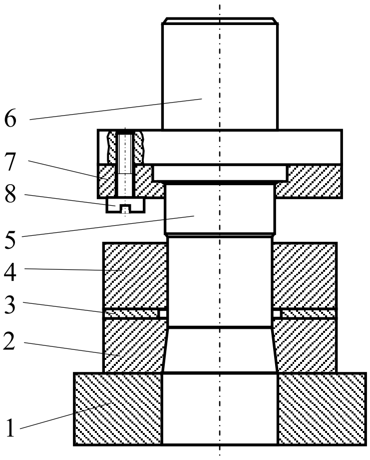

Fig. 3. Stamping device:
1-support plate, 2-active plate, 3- guiding rules, 4-guiding plate, 5-punch, 6-centering spigot 7-port-punch plate, 8-screw.

The dimensions of the active elements of the stamping device are rendered in Table 1.

***Table 1.** Dimensions of the active elements*

Diameter of active plate hole, [mm]	25	25	25	25
Diameter of punchess, [mm]	24.95	24.8	24.6	24.4
Clearance, [mm]	0.05	0.2	0.4	0.6

The samples were prepared in low carbon steel strips (1.26x30x600 mm); the chemical composition of the steel is rendered in Table 2 and its mechanical characteristics in Table 3.

***Table 2.** Chemical composition of the steel*

Chemical composition, %					
C	Mn	Si	P	S	Al
0.142	0.531	0.246	0.021	0.019	0.023

***Table 3.** Mechanical characteristics of the steel*

Rp0.2 [MPa]	Rm [MPa]	A_{10} [%]	Z [%]
224.7	354.5	32.4	53.7

The experimental stand was a hydraulic press of 300 kN maximum pressing force, equipped with a data acquisition system type Spider 8 usable in the dynamic pressing processes.

The experiments focused on the influence of the stamp clearance on the value of the force and on the precision and quality of the samples.

3. Results and analysis

The variation of the force during the cutting process is rendered in Table 4 and is represented in graphic form in Figure 4.

***Table 4.** Experimental values of the cutting force*

Clearance j, mm	Relative clearance j/t	Move-ment y, mm	Relative movement y/t	Force, F, $\times 10^3$,[N]
0.05	0,040	0.315	0.250	15.05
		0.472	0.375	20.01
		0.630	0.050	23.52
		1.165	0.625	27.15
		0.964	0.755	28.71
0.20	0.159	0.315	0.250	12.82
		0.472	0.375	18.05
		0.630	0.050	22.02
		1.165	0.625	25.44
		0.964	0.755	27.29
0.40	0.318	0.315	0.250	12.04
		0.472	0.375	16.83
		0.630	0.050	20.51
		1.165	0.625	23.31
		0.964	0.755	24.29
0.60	0.476	0.315	0.250	14.25
		0.472	0.375	18.24
		0.630	0.050	22.43
		1.165	0.625	25.05
		0.964	0.755	26.51

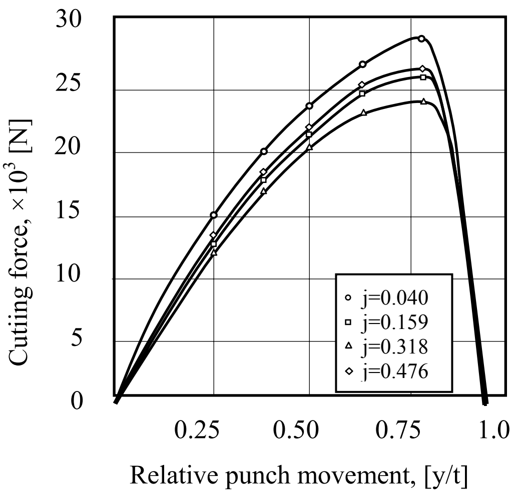

***Fig. 4.** Force variation during the cutting process*

The maximum force is developed for a 0.755 relative value of the punch movement.

The dependence of the maximum force on function of the stamp clearance is represented in Figure 5.

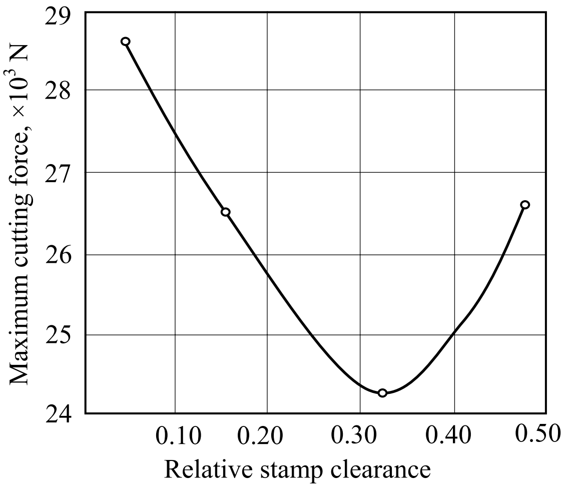

Fig. 5. *Variation of the maximum cutting force with therelative clearance*

For small values of the relative stamp clearance the cutting force has great values. When the relative stamp clearance is increased, the maximum value of the force decreases until the minimum value which corresponds to the 0.318 value of the relative stamp clearance. When the relative stamp clearance increases the value of the cutting force increases.

It is clear that the optimum value of the stamp clearance during the cutting process is 0.318.

The stamp clearance has influence on the precision of the cut part. The dimensions of the cut part were measured with a micrometer the precision of which is 0.001 mm.

The results are rendered in the table 5.

Table 5. *Effective deviation during the cutting process*

j	j/t	D_p	D_0	$\Delta = D_p - D_0$
0.05	0,040	25.014	25.0	+0.014
0.20	0.159	25.005	25.0	+0.008
0.40	0.318	24.993	25.0	-0.007
0.60	0.476	24.976	25.0	-0.024

The precision of the cut parts is showed in figure 6.

4. Microstructure in the cutting zone

Specific cut stress and strain states develop in the cutting zone causing the crystalline grains to be deformed by rotation, elongation and fragmentation.

At the beginning of the cutting process the grains are deformed in the proximity of the punch edge and the deformation is transmitted into the thickness of the part (Fig.7).

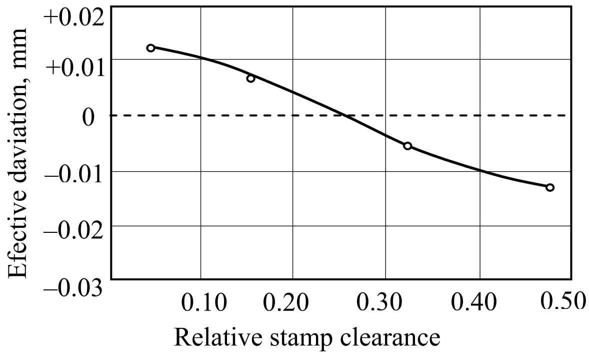

Fig. 6. *Precision of the cut part*

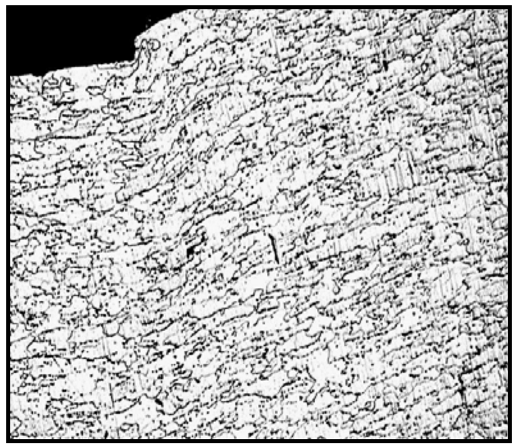

Fig. 7. *Microstructure in the cutting zone at the beginning of the cutting process (Nital 2%, ×200)*

At a later stage of the cutting process (Fig.8) the intensity of the grains deformation degree is very great, especially in the proximity of the punch edge.

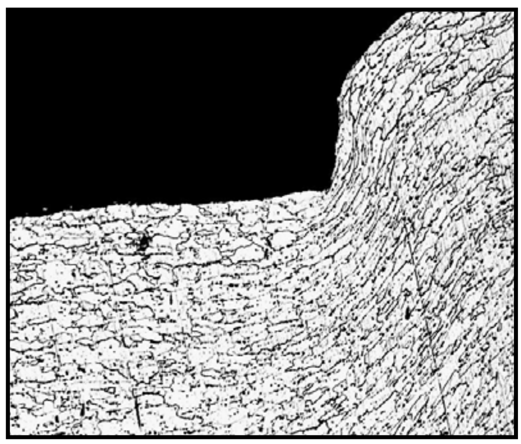

Fig. 8. *Microstructure in the cutting zone at an advanced stage of the cutting process (Nital 2%, ×200)*

For the final cutting process, in the proximity of the maximum level of the cutting force, the grains are very intensely deformed (Fig.9).

The deformation hardness is very intense and conditions for crack appearance are created.

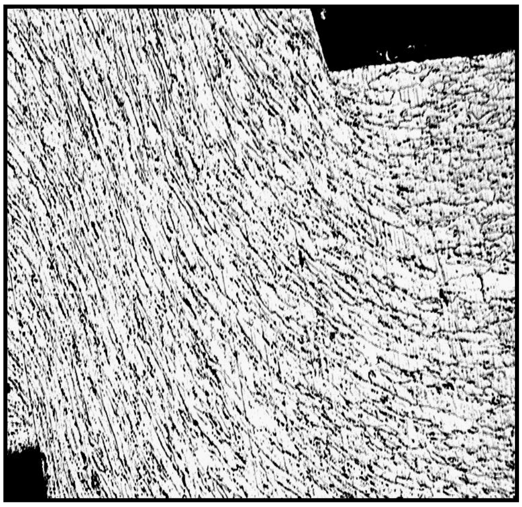

Fig. 9. *Microstructure in the cutting zone at the final stage of the cutting process (Nital 2%, ×200)*

Obviously, at the border of the cut part, the hardness, greater than the initial one, corresponds to the hardness of the material in the volume of the part, at a greater distance from the cut border.

This is the reason why we must be careful when the deforming process continues and the cut border of the part is intensely deformed during the following deforming operations.

4. Conclusions

The cutting process is characterized by complex and intense stress and strain states.

The force increases during the cutting process, reaches a maximum value and then decreases rapidly to zero. At the moment of the maximum value of the cutting force, in the proximity of the punch and of the plate edge, cracks are generated. Afterwards, the cutting process is developed by propagation of the cracks. The relative movement of the punch at the maximum value of the cutting force was 0.76, which corresponds to the great plasticity of the part material.

The minimum value of the maximum force corresponds to the 0.318 value of the stamp clearance.

The maximum precision of the part correspond at the 0.27 value of the relative stamp clearance.

The microstructure in the cutting zone is very strongly deformed and consequently the deformation hardening of the deformed material increases. As a result, the deformation behavior of the border of the cut part is reduced and the following deformation operation becomes more difficult.

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