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EXPERIMENTAL RESEARCHES ON THE LOBE DEFORMATION PROCESS

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ABSTRACT

In this work are presented the physical model, experimental conditions and researches concerning the lobe process. For this purpose it was created a physical experimental system composed of the deformation die, the hydraulic press and the data acquisition system – resistive force transducer, the electronic tensometer Spider 8, and the computer. The experiments are focused on the establishing of the force variation during the deformation process.

KEYWORDS: physical model, lobe, deformation, force

1. Introduction

The force at the lobe deformation process is, generally, calculated with the empirical mathematical expressions. One of these is shown above [1]:

$$F = k \cdot p \cdot S \quad (1)$$

In this relation k is coefficient whose values are rendered in Table 1, p – the pressure applied on the material and S is the plan surface of the lobe (Table 2).

Table 1. *Values of the coefficient k*

Advised values of coefficient *k*	
t ≤ 1 mm	t = 1 – 1.5 mm
0.7 – 0.8	1.0 – 1.6

Table 2. *Values of the pressure, p*

Pressure *p* [daN/mm$_2$], for:		
Light steel	Brass	Aluminum
30 – 40	20 – 25	10 – 20

For evaluation of the deformation force we can consider the maximum values of the deformation degree.

Thus at the final moment of the deformation process we have the maximum strain in the superior section of the lobe (Fig.1).

The effective dimensions of the stamped lobe are: D of 24 mm, d of 18 mm, h of 5 mm, R of 2 mm, r of 1 mm.

In this section, the strain has the maximum value ε_{max} that may be calculated in function of the local decreasing of the thickness [2].

Between the strain and real stress there is a correlation defined by the hardening equation.

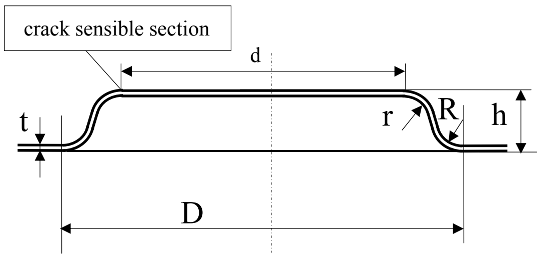

Fig. 1. *Scheme of the stamped lobe*

For example:

$$\sigma = \sigma_0 + \sigma_1 \cdot \varepsilon^n \quad (2)$$

Where σ_0 is the yield stress in the actual deformation conditions, σ_1 -constant, and n is the hardening coefficient.

Thus for maximum value of the strain it results the maximum value of the stress, respectively:

$$\sigma_{max} = \sigma_0 + \sigma_1 \cdot \varepsilon_{max}{}^n \quad (3)$$

Using the equation (3) we can write:

$$F_{max} = S \cdot \left(\sigma_0 + \sigma_1 \cdot \varepsilon_{max}{}^n\right) \quad (4)$$

In this equation, S is the effective value of the cross area in the superior section of the part, respectively:

$$S = l \cdot t_{ef} \quad (5)$$

where l ($l = \pi \cdot d_b$) is the length of lobe bottom and t_{ef} is the effective value of the thickness in this section.

In the practical calculus, we can use a relation:

$$F_{max} = k_1 \cdot S_0 \cdot \sigma_r \quad (6)$$

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In this relation, S_0 is the initial area of the superior section (for thickness t_0), σ_r is the ultimate tensile stress and k_1 is a coefficient with values approach unit.

2. Experimental conditions

The aim of this work is to establish in the experimental way the variation of the force at the lobe stamping process.

The laboratory conditions of the lobe stamping are the following:

- The samples are cut from steel strip for sever drawing deep, with 0.6 mm thickness,
- the lobe die showed in the figure 2,
- force resistive transducer,
- the data acquisition system,

Fig. 2. *The experimental lobe die: 1-hydraulic press, 2-lobe die, 3-resistive force transducer.*

Fig. 3. *General view of the experimental system.*

3. Experimental results

The experimental program had the following objectives:

- establishing the force variation;
- visualizing the microstructure aspect;
- estimation of crack sensible section.

The dimensions of samples were: the length of 80 mm and the width of 30 mm. In each sample were stamped two lobes.

For example, in the Figure 4 is shows one stamped sample.

Fig.4. *Example of stamped sample.*

For establishing the sensible crack section, we prepared a micrographic prove and we analyzed the variation of the thickness.

In the section A, the thickness of the sample presents a visible decreasing (Fig. 5).

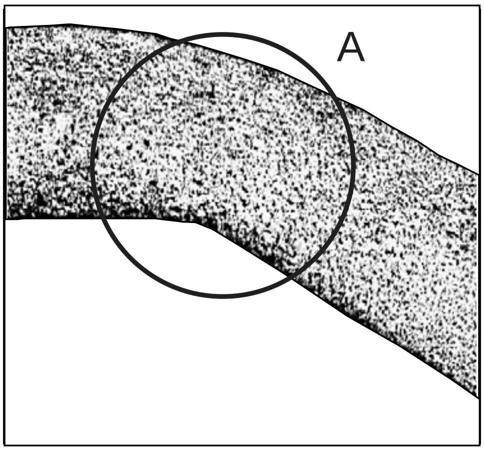

Fig. 5. *Aspect of stamped sample section (×50, Nital attack 5).*

The decreasing of the thickness in the critical section is of approximately 80%. Moreover, in this zone the structural hardening of the material has a great intensity.

In Figure 6 is shows the variation of the microstructure in the sensible crack section. Because the level of the deformation degree is great, the microstructure is strongly influenced.

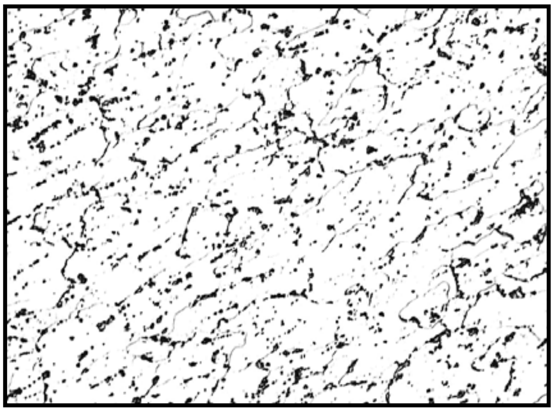

Fig. 6. *Aspect of crystalline grains in critical section, (×250, Nital attack 5).*

The crystalline grains are much deformed. Consequently, local hardening intensity is great and the probability that cracks appear in this zone is very great.

The variation of the force during of the lobe stamping process is shown in Figure 7.

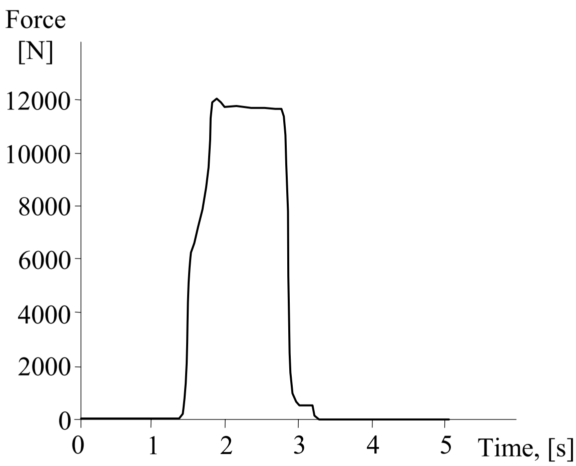

Fig. 5. *Variation of force during stamping process.*

The force rapidly increases up to the maximum value of 11190N, then it maintains at this value when the change of the movement sense.

The stress, in the sensible crack section, may be calculated in the function of the maximum value of the force using the above relation:

$$\sigma = \frac{F_{\max}}{\pi \cdot d \cdot t} \quad (7)$$

In the present conditions we have the level of the tensile strain in the critical section

$$\sigma = 329.97 \text{ N/mm}^2$$

that is 97.05 % of the conventional tensile stress σ_r of the material.

Considering the hardening coefficient by the plastic deformation, the real maximum stress, corresponding of the maximum deformation degree, is equal to 566.6 N/mm^2.

Thus the effective maximum stress at the lobe stamping process is 58.23% from the real maximum tensile stress of the material. Consequently, in the practical data conditions cracks not will appear.

The technological coefficient of the lobe stamping process, in the given case, is calculated as the ratio between the length of the unfolded form of the deformation zone and L and the diameter *D* of the same zone.

$$C = \frac{L}{D} \quad (8)$$

We have

$$L = 2\left[\frac{\pi}{2}(R + r) + 2\right] + d \quad (9)$$

respectively,

$$C = \frac{2}{D}\left[\frac{\pi}{2}(R + r) + 2\right] + \frac{d}{D} \quad (10)$$

In the data conditions we have C=1.309.

The cumulated deformation degree may be calculated as the logarithmic form, respectively:

$$\varepsilon = \ln\frac{L}{D} = 0.269$$

It results a great value of the cumulated deformation degree. The local deformation degree can be with 20-25% greater than the cumulated deformation degree.

This result confirms that the material has a good reserve for plastic deformation and the risk that cracks appear decrease.

4. Conclusions

The lobe stamping is a deformation process based on the local elongation of the material without its traction from the neighbor zone. Consequently, the elongation, at lobe stamping, takes place in the base of the thickness. Along of the lobe profile the dimension increases and the thickness decrease. In the point where the increasing of dimension, in the length direction, is greater, the decreasing intensity of the thickness is smaller.

This fact must be known in order to forestall the crack appearance.

In this context, it may be established the critical value of the deformation degree. The level of the deformation intensity, in the practical conditions, is defined by the deformation coefficient *C*, or the logarithmic strain.

The experiments systematized in this paper show the variation of the force during of the lobe deformation process, the variation of the thickness, specially, in the critical zone and the variation of the microstructure of the material.

In the critical section of the deformed zone the crystalline grains are deformed very much.

The experimental results and the calculated values of the maximum real stress and the maximum deformation degree show that it is unlikely that cracks should occur.

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