Researches Regarding Hot Plastic Deformation of Ultrasonic Concetrator Energy used for stomatology attendance

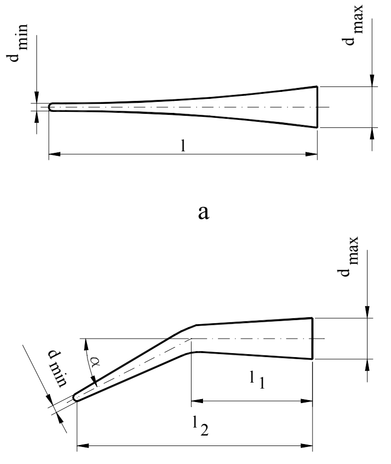
GHEORGHE AMZA , ALEXANDRU DUMITRACHE-RUJINSKI
OANA ELENA RADOCEA , ZOIA APOSTOLESCU,
Materials Tehnology and Welding
Polytehnica University of Bucharest
Splaiul Independentei, 313, 060042, Bucharest,
ROMANIA
amza@camis.pub.ro http://tms.camis.pub.ro

Abstract: - Ultrasonic energy concentrators are items subjected to intense fatigue phenomenon. This paper presents a hot plastic deformation method to obtain ultrasonic energy concentrator. The presented method is adapted to the specific form of ultrasonic energy concentrators used in dentistry.

Key-Words: - Ultrasonic energy concentrator, hot plastic deformation

1 Introduction

One of the forms commonly used in ultrasonic energy concentrator design used in dentistry is the exponential type [1], [2], [3]. The final part of such a concentrator is defined by: D_{min}, D_{max}, L_1, L_2, α, and the curve describing the profile of the concentrator (Fig.1, b). To obtain such a concentrator, we have to obtain a blank as shown in fig.1, a. The blank will undergo further processing by plastic deformation in order to obtain the bending angle.



a

b

Fig. 1. Representation of the final part of an exponential concentrator used in dentistry.
a - blank ultrasonic concentrator b - drawing ultrasonic energy concentrator.

The exponential profile of the concentrator can be obtained by deformation of a cylindrical body whose temperature varies along its axis. The temperature variation leads to a change of modulus of elasticity (Fig. 2) and thereby resistance to flow [4]. Under axial deformation, the reducing of the cross section is directly proportional to the temperature variation along the axis.

2 Manufacturing ultrasonic concentrator by hot plastic deformation

To obtain a ultrasonic energy concentrator by the method described above is necessary to solve three problems: establishing the law of variation of temperature along the axis of the cylindrical body subjected to deformation according to the law of variation of the concentrator profile, establishing the necessary force for the deformation process, the timing deployment process.

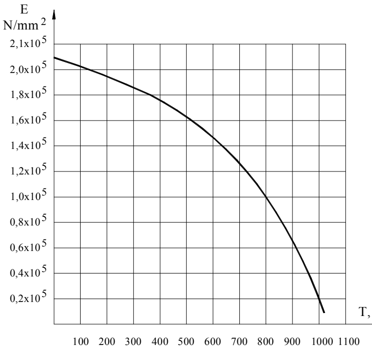


Fig. 2. Variation of elasticity modulus of steel versus temperature.

2.1 Establishing law of variation of temperature along the axis of the body subjected to deformation according to the law of variation of the concentrator profile

By varying the temperature of the material we can change the elasticity and hence its yield (Fig. 2). Local change in body temperature under deformation can be obtained through several methods, one of which being oxyacetylene flame heating [7].

2.2 Establishing the necessary force for deformation process

Deformation force is directly influenced by characteristics of the material under deformation and its dimensions. Deformation process can be assimilated by impact tensile test of metallic materials. Blank will be kept in balance under axial tensile forces and radial forces of compression.

The calculation of the needed force in deformation process must takes into account the value of multiplier impact, because the deformation force is applied by impact. Adjusting the deformation energy is possible by varying drop body weight and height of fall. The variation of these two elements can provide the needed energy for deformation process

2.3 Setting up the running of the process

The concentrator profile depends on the law of temperature distribution in blank under deformation. Distribution patterns of temperature must remain constant during the deformation process. Maintaining constant temperature distribution law is possible only if the heating system are running during the deformation process. Realization of such a mobile system of heating is difficult.

The problem of the temperature variation can be solved by substantial reduction of time spent in the deformation process. This is possible if the deformation is achieved by impact. Extremely short time in which the deformation process takes place does not allow a significant change of temperature patern. For determining the conduct of the process we must take into account the fact that for hot plastic deformation, increasing speed of deformation leads to increased resistance to flow of material. The principle scheme of the plant used for the impact deformation of the blank is shown in figure 3.

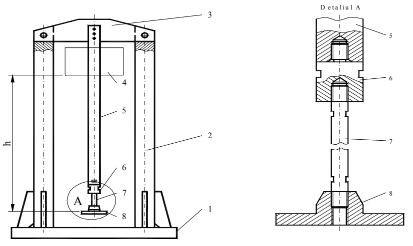


Fig. 3. The principle scheme of the plant used for experiments:
1 - motherboard, 2 - column, 3 - beam, 4 - drop body, 5 - guide, 6 - reduction; 7 - sample, 8 - buffer

3 Determining the model for calculating the strain in the blank

To calculate shock deformation δ can be used the following relation:

$$\delta = \psi \delta_s \tag{1}$$

where: ψ - is the multiplier impact δ_s - static deformation produced, in mm. Multiplier impact is defined by:

$$\psi = \sqrt{\frac{2h}{\delta_s}} \tag{2}$$

where h- is the height of fall in mm. Plastic deformation produced by static load P is given by

$$\delta_s = \frac{Pl}{EA} \tag{3}$$

where: P- is the static load in N, L - blank length in mm, E - modulus of elasticity in N/mm^2; A - cross section area in mm^2.

To take account of elasticity modulus changes caused by temperature variations along the axis of the blank subjected to deformation we will make the following simplifying assumptions: blank will be split into a finite number n of segments with equal length; the temperature is constant along a segment and modules of elasticity for each segment are in geometric progression of ration K. Simplifying assumptions listed above for spliting blank in a two or three segments is shown in figure 4. Keep in mind that a body of length l, we obtain two symmetrical blanks L / 2.

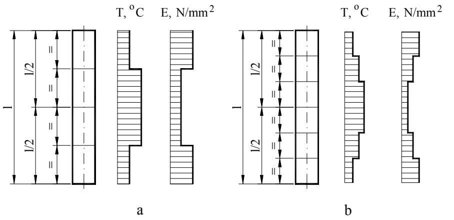


Fig. 4. Synthesizing simplifying assumptions: a, b – spliting blank into two or three segments

Total deformation resulting from the application of static load P for the case shown in figure 4 is given by:

$$\delta_{s_{tot}} = 2\left(\frac{P\frac{l}{4}}{E_o A} + \frac{P\frac{l}{4}}{EA}\right) \tag{4}$$

The modulus of elasticity variation is characterized by:

$E = KE_o$; $0 < K \le 1$; $K = 1$ for $T = T_o$ (5)

Relationship (4) assumes the form:

$$\delta_{s_{tot}} = \frac{Pl}{2E_o A}\left(1 + \frac{1}{K}\right) \tag{6}$$

Applying the same reasoning to the case presented in figure 4, b, total deformation is given by:

$$(\qquad \delta_{s_{tot}} = \frac{Pl}{3E_o A}\left(1+\frac{1}{K}+\frac{1}{K^2}\right) \qquad 7)$$

It is noted that the total deformation generated by applying static load P in the general case of blank spliting into a finite number n of equal lenght segments can be expressed by:

$$\delta_{s_{tot}} = \frac{Pl}{nE_o A}\sum_{i=1}^{n}\frac{1}{K^{i-1}} \qquad (8)$$

Reducing cross section due to the blank deformation can be determined by applying constant volume law. There fore, it can be determined the concentator profile obtained after the deformation process.

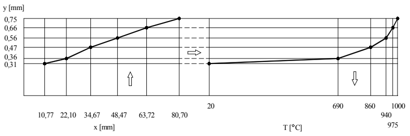


Fig. 5. Strain-temperature diagram for divided blank into 6 segments

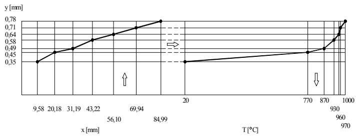


Fig. 6. Strain-temperature diagram for divided blank into 7 segments

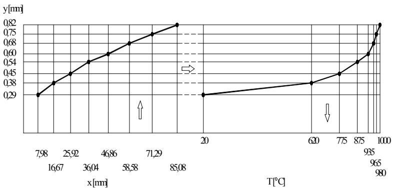


Fig. 7. Strain-temperature diagram for divided blank into 8 segments

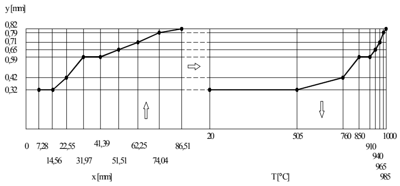


Fig. 8. Strain-temperature diagram for divided blank into 9 segments

Obtained data by the method above is summarized in figures 5 ... 8.

Conditions for the experiments were: temperature reached in the central blank zone 1000oC, blank extremities temperature 20 ° C, blank diameter 2.5 mm, blank length 50 mm, the energy supplied by the deformation process 450 J, K ration 1.6 respectively 1.4.

Using relations (9) and (10) are defined the axial

$$x = \sum_{i=1}^{n}\left(l+\delta\right)_i \qquad (9)$$

deformation x and the reduced cross section y by:

$$y = d - d' \qquad (10)$$

It is noted that relations (9) and (10) define the body profile obtained by the deformation process. Charts strain - temperature shown in figure 5 ... 8 are useful for rapid determination of the temperature variation law for a given concentrator profile. It is noted that a chart is only valid for a particular material and a specific deformation energy [8], [9], [10]. Use of diagrams shown in figure 9 and consists of two stages: a - setting; b – determination of required temperature.

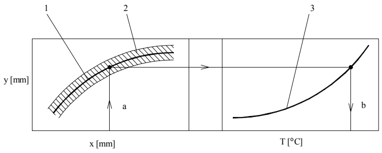


Fig. 9. How to use the deformation-temperature diagrams:

a - setting cross section reducing b - determining the appropriate temperature;

1 - curve describing the concentrator profile ,2 - Band of proportionality, 3 - curve describing the temperature variation. [11],[12].

Any point on a curve contained in a corresponding band of proportionality is the curve describing the temperature variation.

4 Conclusions on obtaining exponential concentrator profile used in dentistry

To increase fatigue resistance of the concentrator is recommended to obtain preforms by hot plastic deformation. The presented method is based on change of mechanical properties of a material depending on temperature. Thus, under the action of the same deformation force, zones with different properties will deformate differently;

The concentrator profile is directly influenced by the law of temperature distribution. This law should not change during the deformation process. A simple solution for solving this problem is substantially reduction of the time spent in the deformation process. Deformation will be achieved by stretching the blank. Maximum speed of deformation process is determined experimentally at 5.4 m / s;

To apply this method diagrams can be drawn to determine the temperature variation law versus concentrator profile. Charts will be drawn for similar properties materials groups. For accurate results it is recommended to draw charts for each material. Charts will include information on deformation energy;

The main advantage obtained by applying this method for manufacturing ultrasonic energy concentrator is given by the flow structure resulted by hot plastic deformation. This will lead to a better resistance to fatigue of the concentrator during operation. It should be noted that fatigue is the main phenomenon during operation. Another advantage is the simplicity of the equipment used in deformation process. To increase the dimensional range of parts that can be processed with the same equipment, it was designed with variable mass and height of fall;

The disadvantage of the method consists of complex heating system necessary to achieve each temperature distribution law along the blank axis. To eliminate this disadvantage is recommended to use this method to obtain ultrasonic energy concentrator only in mass production.

References:

[1] Gheorghe Amza, D. Barb, F. Constantinescu, Systems ultraacoustice *Technical Publishing House*, Bucharest, 1988

[2] Gheorghe Amza, Systems ultraacoustice, *Editura Academiei*, 2005

[3] Gheorghe Amza, V. O. Rîndaşu, G. M. Dumitru, C. Gh. Amza, Treaty of materials technology *Romanian Academy Publishing House*, Bucharest, 2002

[4] Gheorghe Buzdugan, Strength of Materials, *Editura Academiei RS Romania*, Bucharest, 1986

[5] Gheorghe Amza, C. Borda, M. Marinescu, D. Arsene, Design of ring-type ultrasonic motor, *Publisher University "Petru Maior"* Targu-Mures, 6, 7-14, Targu-Mures, 2000

[6] Gh Amza, C. Borda, Reaserch as concerns the influence of the friction between the active and activated element in the ultrasonic motors working, *Materials Science and Technology, International Conference, 15-21, Sibiu, 1999*

[7] Gh Amza, A. Dumitrache-Rujinski, Recherches theoriques et experimentales concernant la mise en forme des concentrateurs d'energie ultrasonore par deformation plastique, *TQSD06*, *Bucharest, Romania, 2006*

[8] Gheorghe Amza, C. Luchian, DF Nitoi, F. Dumitrache, C. Borda, M. Voda, Experimental and Theoretical Reaserches Regarding Ultrasonic Welding Process Optimization of the polymeric *Matrix Composite Materials*, *Plastics*, Vol.46, No.3, 2009, pp.327-335

[9] Gheorghe Amza, A. Hadar, Z. Apostolescu, C. Gh. Amza, L. Anton, Numerical determination of functional parameters ultraacustice systems used in ultrasonic welding of smart composites, *Plastics*, Vol.49, No.2, 2007, pp.121-128.

[10] Gheorghe Amza, A. Hadar, Z. Apostolescu, G. Gârleanu, L. Anton, Theoretical and experimental contributions concerning the influence of acoustic parameters in the ultrasonic welding of smart composites, *Plastics*, Vol.44 No.1, 2007, pp. 60-65.

[11] Davidson R., Roberts S.S.J., *Internal monitoring of structural composite materials*, Second European Conference on Smart Structures and Materials, Glasgow, October 1998.

[12] Gutawescki G.G., *Advanced Composite Manufacturing,* Advanced Composite Conference – 8th, Chicago, 1992.