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PHYSICAL MODELING OF TWO-STAGE AXIS- SYMETRICAL WORKPIECE FROM 0749 Al ALLOY

Mileta Janjić
Faculty of Mechanical Engineering
Cetinjska 2, Podgorica
Montenegro

Sreten Savićević
Faculty of Mechanical Engineering
Cetinjska 2, Podgorica
Montenegro

Milan Vukčević
Faculty of Mechanical Engineering
Cetinjska 2, Podgorica
Montenegro

ABSTRACT

The results of the axis-symetric deformation in open dies, obtained by the experimental-theoretical discretization method has been presented in this paper. Also, there have been given basic theoretical hypotheses of the method, along with an experimental investigation. By using that method deformation modelling at die forging of the step-down axisymetric elements is carried out. Part of obtained results are presented in the paper throught effective strain.

Keywords: deformation, strain, discretization, current lines

1. INTRODUCTION

The field of investigating both geometrical and mechanical parameters at open die forging is actual and not still researched. The very complexity of the problem imposes the necessity of using interrelated approaches: theoretical, experimental and numerical ones. A special attention is to be pained to a class of axisymetric elements, being used very often.

The use of Finite Element Method (FEM) of the deformation parameters calculation is constantly being enhanced by the increment of simplicity of usage, development of advanced software, reducing a time for the preparation of input data and obtaining of a wide spectrum of output information. Beside this, the questions asking whether entry data were correctly taken and are the obtained results valid always are being raised [1,2,3].

2. DISCRETE METHOD ASSUMPTION

The of axisymetric strain elements, in its nature, is two dimensional one, thus a strain analysis may be observed within the plain of a cross-section along a workpiece axis. To make a strain analysis, a current picture is observed. The given current line has originated from the current lines of the previous technological procedure of getting rods by upsetting in hot state, these being straight lines parallel to a workpiece axis [4].

The analysis that follows is based on the hypothesis that, the distance between the current lines in radial direction due to a plastic deformation, may be changed in the course of deformation in single current lines, but the lines can't be overlapped.

To make a stress-strain analysis, it is necessary to determine the strain across the workpiece cross section. For determining the numerical deformation values in the points of the longitudinal workpiece cross-section based on the current picture, a division in both radial and axial direction (Figure 1.) is made.

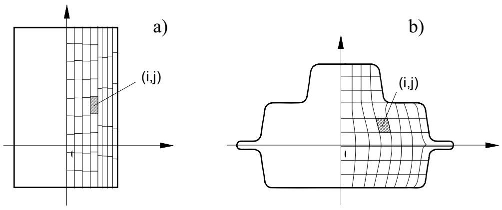
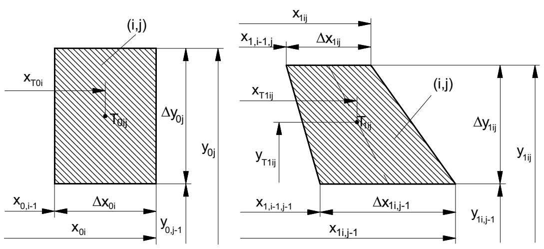


Figure 1. Workpiece current line picture in: a) non-deformed and b) deformed state

The division in radial direction is marked by the index i. The division according to the vertical of the deformed current picture is made with a constant step $\Delta y_{1j}=\Delta y_1=$const., marked with the index j. Thus, M pieces in the radial direction is obtained, and i=1,2,...,M, and N pieces in axial direction so j=1,2,...,N, in which case N≠const., due to a gradual characteristic of the workpiece geometry.

Separately is observed an elementary piece in position (i,j) (Figure 1.), which in a non-deformed state has a shape of a rectangle, whereas in a deformed state its shape approximates to trapezoid. An elementary piece in both non-deformed and deformed state, with characteristic dimension marks, is given in Figigure 2. The first index in the marks is 0 or 1 and refers, respectively, to both non-deformed and deformed state, whereas the indexes (i,j) refer to the piece position in longitudinal cross-section of a workpiece.



a) b)

Figure 2. Elementary piece in position (i,j): a) non-deformed and b) deformed state

Logarithmic strains of an elementary piece (Fig.2.) in radial, tangent and axial directions represent logarithmic relation functions of the corresponding piece dimensions in both deformed and non-deformed state are given in expressions:

$$\varphi_{\rho ij} = \ln\frac{\Delta x_{1ij}}{\Delta x_{0i}}\text{, i=1,2,...,M; j=1,2,...,N;} \tag{4}$$

$$\varphi_{\theta ij} = \ln\frac{x_{T1ij}}{x_{T0i}}\text{, i=1,2,...,M; j=1,2,...,N;} \tag{5}$$

$$\varphi_{hij} = \ln\frac{\Delta y_{1ij}}{\Delta y_{0ij}}\text{, i=1,2,...,M; j=1,2,...,N;} \tag{6}$$

where:

Δx_{1ij}, Δx_{0i} - are radius growths of a piece in deformed and non-deformed state,

x_{T1ij}, x_{T0i} - the piece centre of gravity radii in deformed and non-deformed state, and

Δy_{1ij}, Δy_{0ij} - the piece growths in deformed and non-deformed state.

To determine logarithmic strains, it is also necessary for the expressions (4) to (6), to determine sub-logarithmic dimension relations, this being done by known piece geometry in deformed state based on the recorded current picture and the volume constancy conditions at deformation.

The cited logarithmic strains are simultaneously main deformation logarithmic degrees, i. e.:

$$\varphi_{1ij}=\max(\varphi_{\rho ij},\varphi_{\theta ij},\varphi_{hij})\text{, i=1,2,...,M; j=1,2,...,N;} \tag{7}$$

$$\varphi_{3ij}=\min(\varphi_{\rho ij},\varphi_{\theta ij},\varphi_{hij})\text{, i=1,2,...,M; j=1,2,...,N.} \tag{8}$$

Due to the volume constancy condition which my be written in the for of:

$$\varphi_{\rho ij}+\varphi_{\theta ij}+\varphi_{hij}=0\text{, i=1,2,...,M; j=1,2,...,N;} \tag{9}$$

The mean logarithmic strain is:

$$\varphi_{2ij}=-(\varphi_{1ij}+\varphi_{3ij}),\ i=1,2,...,M;\ j=1,2,...,N; \tag{10}$$

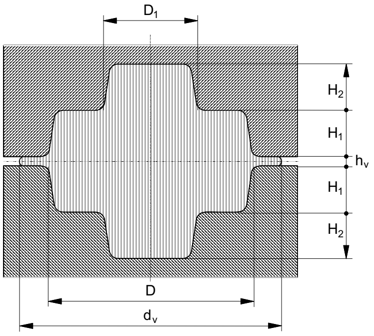
Effective logarithmic strain of an elementary piece is expressed by the main deformation units by formula:

$$(\varphi_i)_{ij}=\frac{\sqrt{2}}{3}\sqrt{(\varphi_{1ij}-\varphi_{2ij})^2+(\varphi_{2ij}-\varphi_{3ij})^2+(\varphi_{3ij}-\varphi_{1ij})^2}\ ,\ i=1,2,...,M;\ j=1,2,...,N; \tag{11}$$

3. EXPERIMENTAL INVESTIGATIONS

As the process of open die forging is a wide concept, both from the point of view of the billet geometry an technological conditions, is accepted:

1. The family of gradual axisymetric elements with two height steps on both side of the grade die plane (Figure 3.). The dies are made of tool steel for work in hot state designated with X38CrMoV-5-1 [5].



D=40 [mm]
H_1=10 [mm]
H_2=10 [mm]
D_1=20 [mm]
d_v=50 [mm]
h_v=1 [mm]

Figure 3. Workpiece in die seizure

2. The material investigated is aluminium alloy 7049 (to ASTM) of a chemical composition given in Table 1.

Table 1. Chemical composition of aluminium alloy / Wt. %

Mat.	Fe	Si	Ti	Cu	Zn	Cr	Mn	Mg	V	Ni	Ad.
7049	0.35	0.25	0.1	1.2-1.9	7.2-8.2	0.1-0.22	0.2	2-2.9	-	-	0.2

3. A workpiece of cylindrically shaped dimensions: ϕ33.4×39.7 [mm].
4. The investigation is carried out at hot treatment temperatures of the given alloy: T=440[°C].
5. Deformation is realised by low deformation velocity: v=10 [mm/min].
6. The proces has been carried out with a graphite grease lubrication, at which the friction coefficient is: μ=0.1.

After the workpiece is deformed and cooled being treated by the universal milling machine its one half was removed up to the axisymetry. A flat surface was polished by a polishing machine by the water grinding paper, first roughly with granular abrasive of P222 followed by fine granulation of P360. The fine polished flat surface was abraded by a 30% water solution of NaOH for 15 [min].

After abrasion, there appeared currents on the cross section surface. These currents are, infect the deformed current lines of the previous upsetting process that were the lines parallel to the ϕ profile axis, out of which the billets were made.

The current picture is recorded by the tool microscope, by measuring coordinating points of a certain number of currents (11÷15). The coordinative system is adopted in a way that the ordinate overlaps with the billet axis, where as abscissa passes through the middle of the flash. The recorded current plan picture is given in Figure 4.

Measuring at the above mentioned the experimental procedures were done by a precise analog-digital measuring system, consisting of sensor unit, measuring bridge, transitional unit, A/D card and computer [6].

Two inductance sensors placed on an universal grinding machine utilising the possibility of a precise moving of the working table were used to make record of the workingpiece current lines.

An inductance sensor gives the values to coordinate points of current lines in radial direction and another in axial direction.

A deformation state for the sample cross-section given by 3D diagram in Figure 5. is obtained by an experimental-theoretical discretization method.

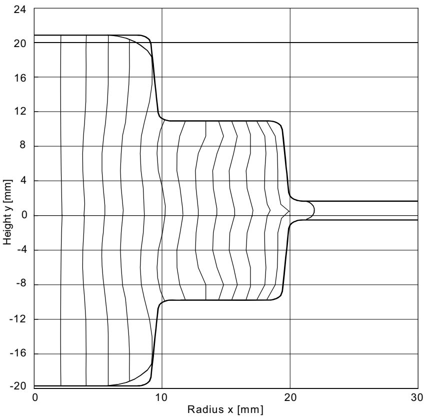


Figure 4. Billet current picture or ε=84.98%

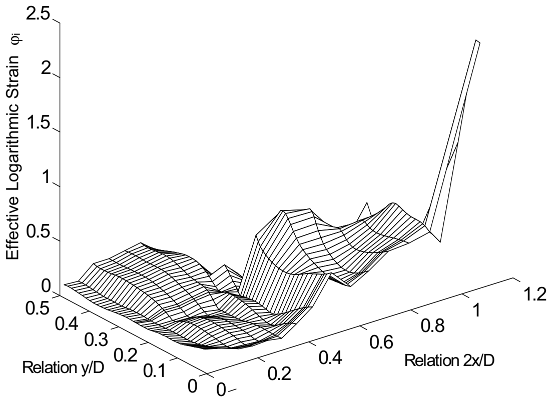


Figure 5. Deformation state obtained by the discretization method for ε=84.98%

4. CONCLUSIONS

The processes of die forging are followed by a high geometrical and physical non-linearity, this conditioning special difficulties at their analysis. The methods of finite elements and experimental-theoretical discretization based on the division of the workpiece into a finite number of small pieces according to the deformation phases favour their analysis. The analysis possible by a strong computer support. A relatively good result accordance is achieved. The deviations are conditioned by some method disadvantages and their direct applications as: difficulties when taking into account high non-linearity at the method of finite elements and not doing that at shear deformation components by experimental-theoretical discretization method.

5. ACKNOWLEDGEMENTS

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