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STRAIN MODELLING AT AXI-SYMMETRICAL DEFORMATION PROCESS IN OPEN DIES

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ABSTRACT
The paper deals with determination of axi-symmetrical element strain state. A numerical simulation for the given conditions was carried out by using DEFORM-2D software package: for process continuity according to deformation phases and applying DEFORM results. By using the mentioned methods, in a relatively simple way, results graphically interpreted in the paper were achieved. An analysis and comparison of the obtained results for convex and concave dies were done.
Keywords: Numerical Simulation, FEM, DEFORM-2D, Discretization, Open Die

1. INTRODUCTION

Bulk deformation, by its complexity, is specially treated within deformation process. To successfully projecting of any technological deformation treatment procedure, strain state parameters are of great importance. Computer system development made bulk deformation process construction and simulation possible and offered to a customer a great variety of analyzing results obtained, as well as on insight into all activities to provide instantaneous and reliable data on all parameters taking part in deformation process.

Due to a rapid computer technique development, a numerical approach to solving problems has been adopted lately. The *Finite Element Method* - FEM has been used as the mightes numerical method, more commercial software packages for numerical bulk deformation process simulation have been made. One of the most known software packages is DEFORM, being produced by *Scientific Forming Technologies Corporation* (SFTC), where simulation and the results obtained that are presented in this paper have been carried out.

2. INPUT PARAMETERS OF NUMERICAL INVESTIGATIONS

The elements given in Fig. 1. and Fig. 2. are being considered in this paper.

- Deformation is realized at low constant deformation speed, $v=2$ *[mm/s]*.
- Hardening curve parametres are $c=30.34434$ an $n=0.097808$ for *AlMgSi0,5* aluminium alloy and temperature $T=440$ *[°C]*.
- Friction factor is $m=0.114$.

Working-pieces are cyllindrical, of diameter $d_0=33.56$ *[mm]*. Height h_0 is determined out of the constant working piece bulk conditions before and after pressing process for adopted die dimensions that are given in Fig. 1. and Fig. 2. and it amounts to $h_0=33.94$ *[mm]* for convex tool shape, and $h_0=29.58$ *[mm]* for concave tool shape.

Coordinates, whose dislocations will be followed in numerical experiment and whose stress-strain deformation states parameters will be determined, have been adopted [9]. Total number of node points for convex die is 154, whereas for concave one-it is 140.

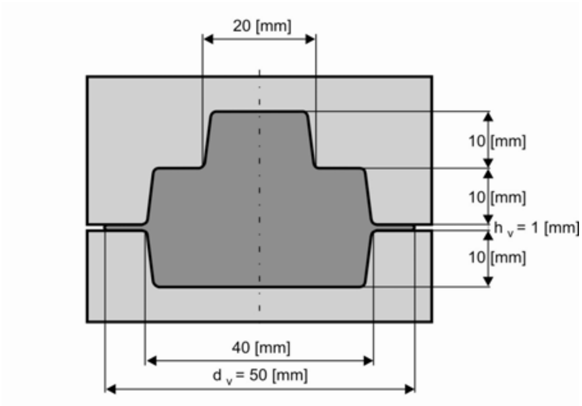

Fig. 1. Working-piece in a die for stepped convex die shape

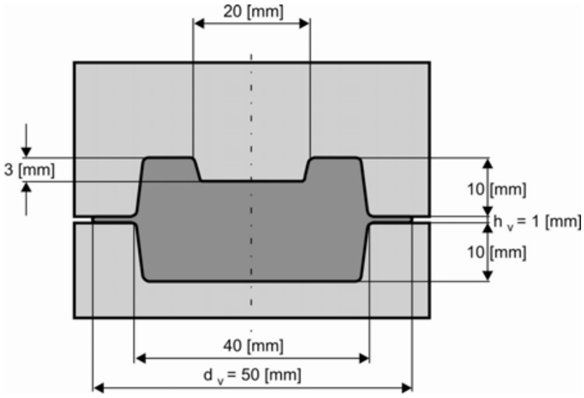

Fig. 2. Working-piece in a die for stepped concave die shape

3. NUMERICAL SIMULATION

Based on the numerical simulation [9], node coordinates per deformation phases are obtained, representing input parameters for determining stress-strain state. Point arrangement at the end of deformation process for convex die shape is given in Fig. 3., whereas for concave one, it is given in Fig. 4. By *Data Extract* order node coordinates in each phase of bulk deformation are obtained.

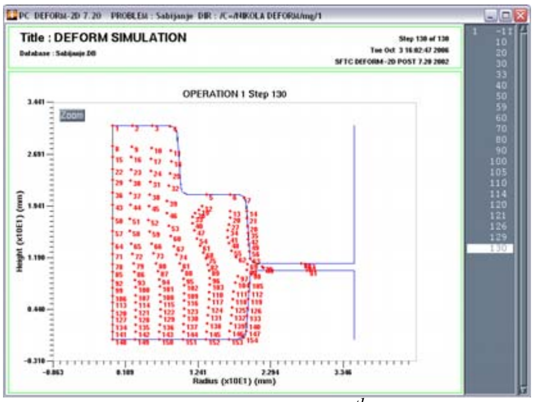

Fig. 3. Point arrangement in 13^{th} phase obtained by DEFORM simulation for convex die

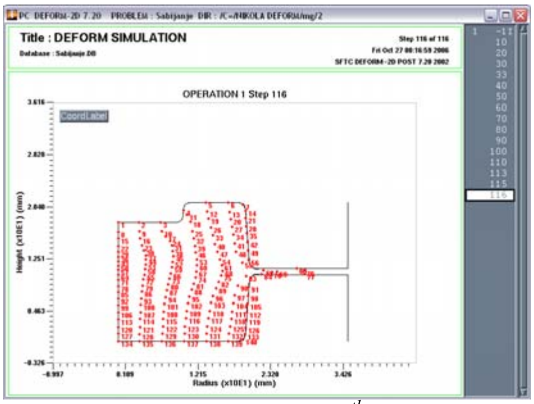

Fig. 4. Point arrangement in 12^{th} phase obtained by DEFORM simulation for concave die

3.1. Numerical experiment for process continuity

Deformation and kinematic parameters are determined on the base of the obtained node coordinates at the end of deformation process, i.e. point dislocation. Out of the numerical simulation data, deformation components and deform speed are obtained [9]. Stress is determined by using visioplasticity method. Data are processed in MATLAB. Input data are: node coordinates at the beginning r_{p0} and z_{p0} and at the end of deform process r_{pk} and z_{pk}, $k=13$ for convex die (Fig. 3.) and $k=12$ for concave die shape (Fig. 4.), hardening curve parameters c and n, as well as the results derived from deformation and kinematic analyses [9]. The method is based on obtained axial σ_z, strain component, by solving a basic equation of visioplasticity [6], where main problem is to determine integration constant *C*. The only points where it is possible to determine axial stress component values are points for maximum radius value at the wrieth level (Fig. 1. and Fig. 2.). These values are determined out of radial stress components in these points being equal to zero: $\sigma_r=0$. Other deformation and kinematic parameters are know, where effective stress is determined along with corresponding hardening curves for effective deformation value.

It is possible to determine normal stress values in all the points of meridial cross-section of a working-piece in a previous by described way. Other stress components are determined by using Levy-Mises equations [6].

Effective stress values at the and of deformation process in the observed points of meridial cross-section of a working piece are given in the form of three-dimension diagram in Fig 5. and Fig. 6.

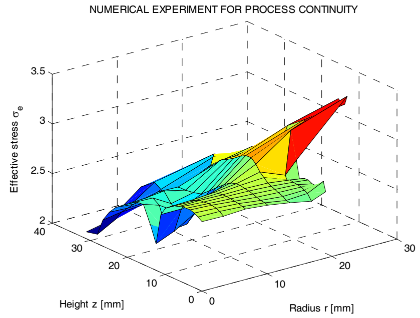

Fig. 5. Effective stress σ_e for convex die shape

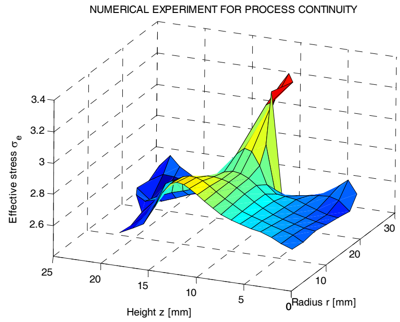

Fig. 6. Effective stress σ_e for concave die shape

3.2. Numerical experiment per steps

At numerical stepped experiment, deformations at each phase are determined, where final deformation and speed values are obtained by known procedures and methods [9]. Stress is determined in an analogons way using visioplasticity method. Effective stress values at the end of deformation are given in the shape of three-dimension diagram in Fig. 7. and Fig. 8.

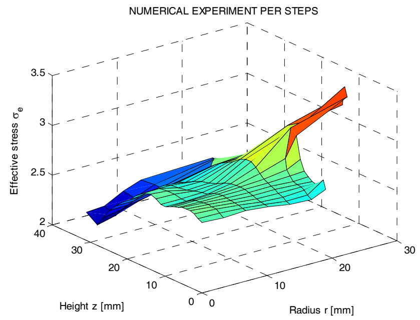

Fig. 7. Effective stress σ_e for convex die shape

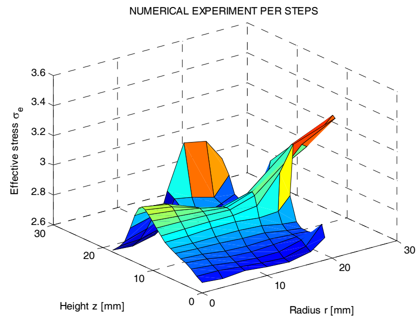

Fig. 8. Effective stress σ_e for concave die shape

3.3. DEFORM Results

Stress change values in each phase of the observed process, for adopted node points for convex and concave die shaps, direcly from DEFORM-2D software package are obtained.
The values of such effective stresses at the end of deform process are given in Fig. 9. and Fig. 10.

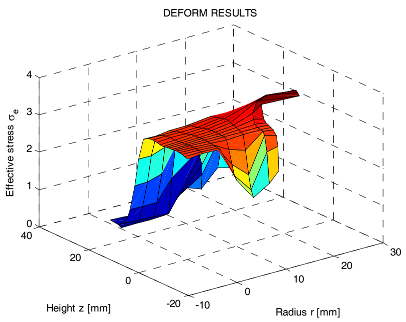

Fig. 9. Effective stress σ_e for convex die shape

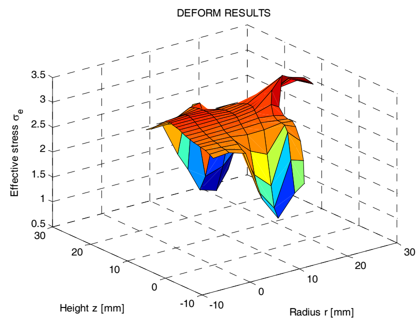

Fig. 10. Effective stress σ_e for concave die shape

4. ANALYSIS AND COMPARISON OF OBTAINED RESULTS

Based on the previously shown special diagrams and stress state parameter values derived from numerical experiment, analysis is made and such results are compared. A programme in MATLAB giving cross diagrams in meridial plane of a working-piece for the given P-P, cross-section passing through the wreath zone is made for complete stress analysis and comparisons. This P-P cross-section, corresponds to grade plane of a working-piece and height $z = 10.5$ *[mm]*.
Two-dimensional effective stress diagrams for all the three investigation procedures in meridial plane of a working-piece for characteristic P-P cross-section are given in Fig. 11. and Fig. 12.

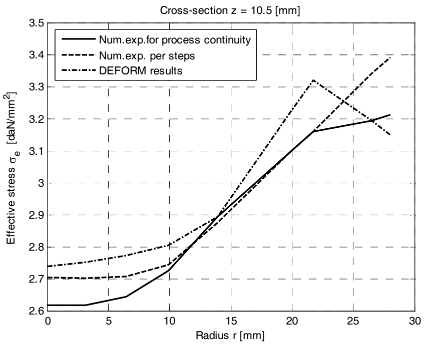

Fig. 11. Effective stress σ_e for convex die shape

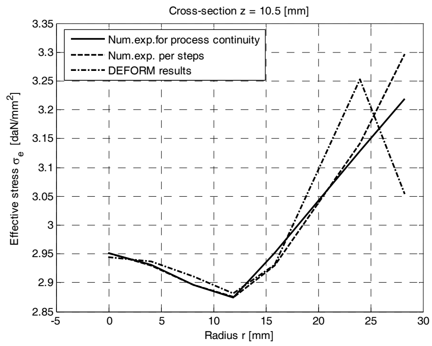

Fig. 12. Effective stress σ_e for concave die shape

At all three procedures, for all stress parameters, two value zones are clearly discreeted: wreath zone and zone corresponding to an inner die part (die zone), whereas the zone of second step of upper die is clear with concave die shape.

Comparing effective stress at all the three procedures of convex die, it is clearly seen that diagrams follow similar change character (pattern). Maximum effective stress values are in the wreath zone, for maximum radius value at numerical experiment for process continuity and per steps, whereas at DEFORM results, maximum value is at the end of the wreath, even at the first fourth of it. Minimum values are obtained in die zone at all the three procedures.

At concave die, a zone of the second degree is discreeted, where effective stress values of stepped procedure have maximum values close to those ones in the wreath zone, whereas less values are obtained for process continuity. At DEFORM results, maximum value is also obtained in wreath zone, and minimal one in the zone of the second die step.

5. CONCLUDING CONSIDERATION

Stress state differences obtained by using some procedures are primarily related to the way of deformation state parameter determination. At numerical experiment for process continuity, deformations are determined by the model of small deformations for the whole deform process. At stepped numerical experiment, however, deformations are determined according to phase dislocations, where total deformation is obtained as a sum of deformations for determined phases. At DEFORM results, deformations are determined by mathematical device using DEFORM-2D.

On the base of the results of the steps presented in this paper and analysis made, it may be concluded that it is more suitable to use stepped defprmation numerical experiment in numerical deformation process simulations for the said conditions, thus stepped discretization seems to be necessary in investigation process. A strong expansion of engineering and software nowdays makes it possible for body and process discretization in engineering research to had to a greater accuracy.

6. REFERENCES

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