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A COMPARASION OF DEFORMING STATES OBTAINED USING PHISICAL DISCRETIZATION METHOD AND DEFORM SIMULATION OF BULK FORMING IN OPEN DIE

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ABSTRACT
A numerical Finite Element Method (FEM) simulation of bulk forming in open dies of step-like axis-symmetrical elements from aluminium alloy in hot state is made in this paper. The simulation is performed in DEFORM 2D programme of American SFTC company. Besides a wide spectre of parameters obtained by simulation, attention has been paid to parameters of deformation state given in the example of the central point of the experimental plan. The obtained results are shown in the form of 3D diagram. These diagrams are compared with experimentally obtained results and the regression analyses results.
Keywords: Bulk Forming, Deforming State, Strain, FEM, DEFORM, Simulation, PDM

1. INTRODUCTION
Within deformation treatment, bulk forming in open dies, is specially recognized by its complexity. Apart from the efforts made by a great number of researchers, it may be said that are no definitely accepted solutions, this being conditioned by the fact that at this kind of material treatment, it is difficult to reconcile two criteria: correctness and simplicity of solutions. This means that the field of researching deformation parameters is actual and not investigated enough. The complexity of problem conditioned the necessity of using a common theoretical, experimental and numerical approach [1,2].
Ana approach of numerical simulations by the finite elements method has been widely accepted today for deformation process analysis. Although there are wide possibilities of numerical simulations, both from the aspect of possibilities of application to different deformation processes, and from the aspect of obtaining a wide spectre of results, there are some limitations. Due to these limitations, results have to be vrified experimentally [3].
FEM numerical simulation in this paper was done by using one of the best software packages DEFORM 2D intended for alalyzing plane and axis-symetrical deformation [3,4].

2. NUMERICAL FEM SIMULATION
In order to compare the results of the phisical discretization method [5] and numerical simulation by the finite elements method, simulation is performed in all the points of experimental plan from the previous paper. Necessary data for DEFORM simulation in one of the central points of the plan, are given in Table 1. Other parameter values are taken from default values of DEFORM software package.
Inputting data and generating a network of 1000 finite element, a data base for initial step is formed, marked as -1. All is input into *Pre-processor* module [6].
The process of numerical simulation is performed in *Simulation engine* module, and the obtained results are stored and kept in data base. To show the results, *Post-processor* module is used. A finite form with the network of finite elements in sieze in dies is given in Figure 1. Deformation parameters may be obtained in the form of cut diagrams (Figure 2.).

Table 1. Input data for DEFORM simulation in the central plan point

Simulation Controls	Simulation Parameters	Units UNIT	☑SI			
		Geometry GEOTYP	☑Axisymmetric			
	Step Controls	Number of simulation steps	NSTEP=1000			
		Step increment to save	STPINC=10			
		Primary die	PDIE(1)=1			
		Steps by	☑Stroke			
		Stroke per step	DSMAX=0.1 [mm]			
	Stopping Controls	Primary die displacement	SMAX=0,13.1215 [mm]			
Material Properties	Flow Stress data	Constant	(C)=30.3443 [MPa]			
		Strain exponent	(n)=0.097808			
Objects	Name: Upper die ☑Rigid	Geometry		X [mm]	Y [mm]	R [mm]
			1	0	44.12	0
			2	9.6503659	44.12	1
			3	10	33.94	1
			4	19.3007320	33.94	1
			5	20	24.12	1
			6	35	24.12	0
			7	35	44.12	0
		Movement controls			Speed 2 [mm/s]	
					Angle -90°	
	Name: Lower die ☑Rigid	Geometry		X [mm]	Y [mm]	R [mm]
			1	35	0	0
			2	35	10	0
			3	20	10	1
			4	19.3007320	0	1
			5	0	0	0
	Name: Preparation piece ☑Plastic	Geometry		X [mm]	Y [mm]	R [mm]
			1	0	0	0
			2	16.7800000	0	0
			3	16.7800000	33.94	0
			4	0	33.94	0
		Mesh	Number of mesh elements	MGNELM=1000		
Inter Object Interface	Upper die - - Preparation piece	Contact relation CNTACT	☑Master-Slave			
		Friction model FRCFAC	Shear			
		Friction	FRCFAC=0.114			
	Lower die - - Preparation piece	Contact relation CNTACT	☑Master-Slave			
		Friction model FRCFAC	Shear			
		Friction	FRCFAC=0.114			

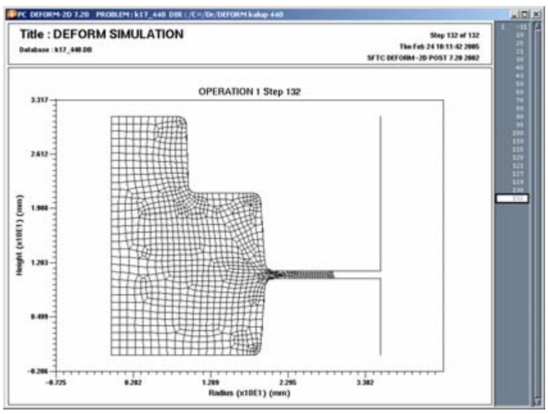


Figure 1. A working piece in seize with dies at the end of deformation process

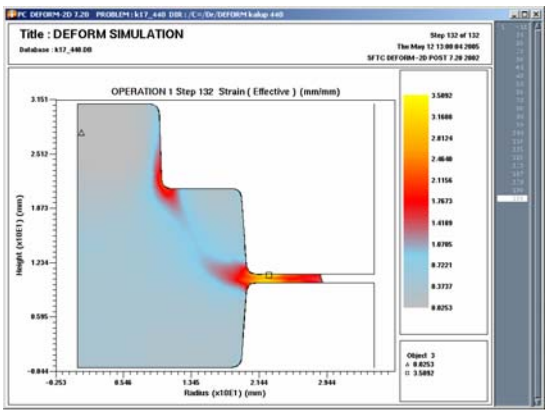


Figure 2. Effective deformation obtained by DEFORM simulation

3. ANALYSIS AND STRAIN COMPARATION

Shaded diagrams are suitable for visual insight into distribution of parameter values along the cross-section of a working piece, but they are not convenient for determining numerical values. Aiming at overcoming this problem, it is possible to take out numerical values of these parameters for all the saved steps, by an order "*Data Extract*" out of data base, and based on these values 3D diagrams may be obtained (Figure 3.).

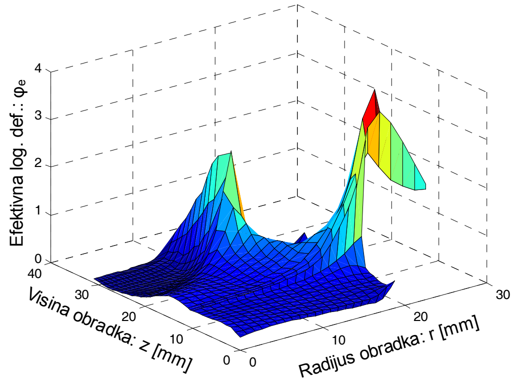
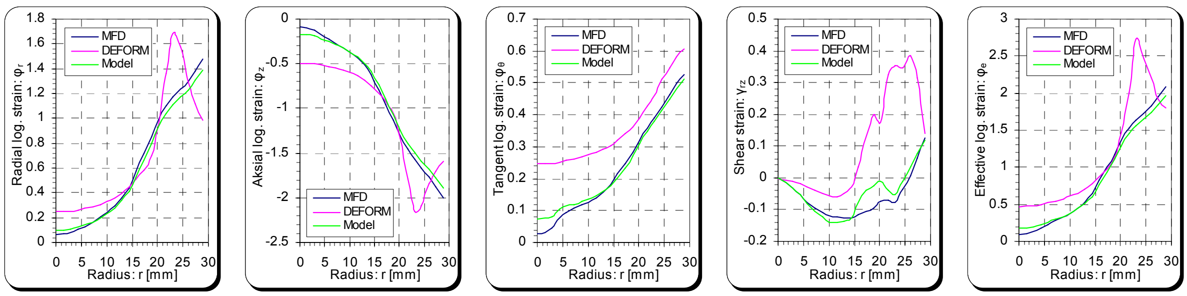


Figure 3. 3D diagram effective logarithm strain φ_e in central plan point obtained by DEFORM simulation

Based on 3D diagrams, it is possible to compare the values of deformation parameters obtained by PDM, DEFORM simultion and based on the models obtained by regression analisis, the values may be compared for all cross-sections in meridial plane of the working piece.As an example are given the comparisons in the cross-section of the wreath plane of a working piece (Figure 4.).



a) b) c) d) e)

Figure 4. Comparisons of deformation parameters obtained by PDM, DEFORM simulation and regression anayisis in the cross-section of the wreath plane of working piece:
a) Radial logarithm strain; b) Aksial logarithm strain; c) Tangent logarithm strain;
d) Shear strain; e) Effective logarithm strain

4. CONCLUSION

From the diagram on Figure 4. it is possible to notice the differences in values obtained by PDM method and DEFORM simulation. The differences are, above all, the consequence of the way of determining parameters. At PDM, strains were determined according to a model of small strains for the whole deformation process, so there are errors at deformation components obtained as partial deviation of displacement along the cross-section in meridial plane. On the other hand, the phisical discretization made, is relatively rough at the places of high geometrical non-linearity, so that by interpolation of displacement between networ nodes, their adequate change is not obtained.

By numerical DEFORM simulation by the finite element method, apart from the working piece discretization, the discretization of the process on increments is carried out, so that each increment determines components and by a cumulative sum a final logarithm strain is obtained. However, due to different simplicities in mathematical FEM apparatus, there appear some errors, that do not correspond to a real state, and is manifested, above all, in a poorer filling of die in certain points of

experiment plan and instability of single deformation parameters for hidher-degree strain and deviations of deformation force for experimentally obtained values.
Thus, there is a need for further improvement of PDM. It relates to decreasing plate groove dimensions for producing segmental preparation pieces. This is possible to obtain by a further development of plate cutting technology and producing a finer comb-like knives for cutting.
By discretization of the deformation process in open dies and determination of stress and deformation parameters in the obtained results is also increased. In the case, the components of logarithm strain tensor is determined on the base of displacement according to phases. A total logarithm strain due to the caracteristic of additivity, represents a sum of logarithm strains obtained for single deformation phases.

5. REFERENCES

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