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FACTORS AND CAUSES THAT INFLUENCE THE SPRINGBACK INTENSITY IN THE CASE OF DRAW PARTS MADE FROM METAL SHEETS

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Abstract: *¶ Drawing of the sheet metal parts is always accompanied by an undesired phenomenon known as springback. Springback occurs after the part is set free of the constraints – forming forces, tools – and leads to a shape of the final part different from the nominal ones. The knowledge of the factors that influence this phenomenon is useful for the accurate design of the forming processes and forming tools. The present paper performs an analysis of the factors that influence the springback phenomenon in the case of conical and hemispherical drawn parts made from metal sheets.*

Key words: *springback, drawing processes and tools.*

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1. INTRODUCTION

Drawing of the sheet metal parts is always accompanied by an undesired phenomenon known as springback. Springback occurs after the part is set free of constraints – forming forces, tools – and leads to a shape of the final part different from the nominal ones. The deviations generated by springback are given by the difference between the geometric parameters of part in its fully loaded condition (conforming to the tooling geometry) and when the part is in its unloaded free state. The factors that influence the springback intensity include the following: the variations of the process, part and material parameters, such as tools geometry, blankholder force, friction condition, material properties, sheet thickness, part dimensions and complexity etc. [1, 2, 3, 4] The knowledge of the factors that influence the springback phenomenon is very useful for the accurate design of the forming processes and forming tools.

The present paper performs an analysis of the factors that influence the springback in the case of the hemispherical and conical drawn parts made from steel sheets by using a conical punch.

2. CONDITIONS OF SIMULATION

The algorithm applied to analyze the geometric deviations of conical draw parts was as follows:

- firstly, a conical part was obtained by the simulation of the deep drawing process;
- secondly, the forming results obtained into ABAQUS/Standard program were imported in order to obtain the part springback;
- after the determination of the final shape of part, it was performed the comparison between the final and nominal shapes in order to establish the form error; the optimum solution of this problem is the utilization of the CAD software (in the present case the AutoCAD software).

The analysis concerning the springback effects was performed by simulation using the ABAQUS/CAE software. The simulation was performed for the conical parts made by using a conical punch from E220 steel sheets - along and normal to the loading direction. The materials elastic properties used for simulation were as follows: Young's modulus 2×10^5 MPa, Poisson's ratio - 0.3, density - 7800 kg/m^3. The main dimensions of the finished parts are presented in the Fig. 1.

A three dimensional model was used for the simulation. The geometry and dimensions of the models used in simulation are shown in Fig. 2.

The models were created in order to ensure the simulation of the quasi-static problem and to obtain the state of equilibrium after the forming operation. The blank was considered as deformable with a planar shell base.

The integration method was Gaussian with 5 integration points for every node, equal distributed through the thickness of the shell. The elements used for the blank mesh were of S4R type. The blank-holder, punch and die were modeled as rigid surfaces. Contact interactions between the blank and the tools were modeled using penalty method. In order to describe the plastic behavior of the used material, ten points were chosen from the

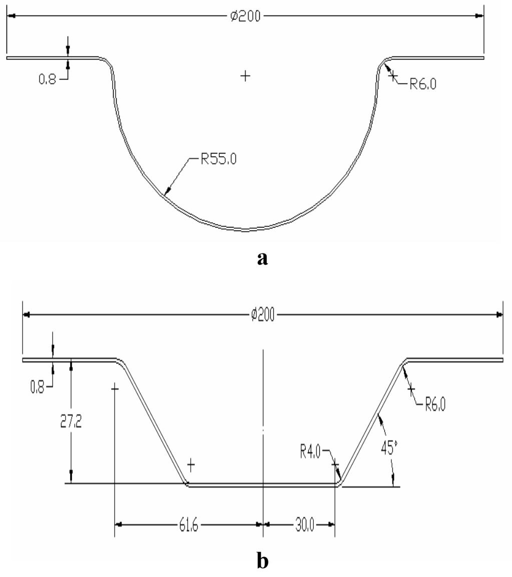

Fig. 1. Geometry of the analyzed parts: *a* - hemispherical part; *b* - conical part.

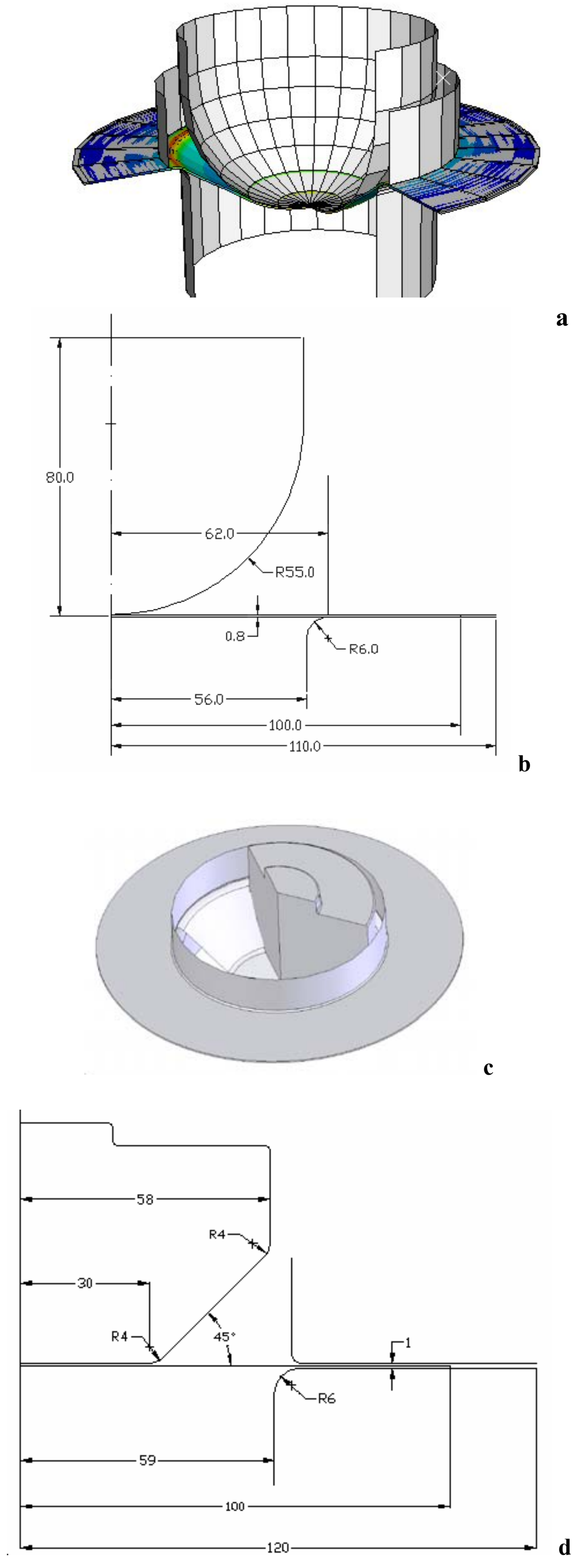

Fig. 2. Geometry of the model used in simulation: *a* - hemispherical part 3D; *a* - hemispherical part 2D; *c* - conical part 3D; *d* - conical part 2D.

stress – strain diagram. The materials were considered elastic-plastic with an isotropic hardening. The following friction coefficients were used for the contact between blank, punch, die and blankholder: μ = 0.005 and μ = 0.15. The working parameters were as follows: drawing depth = 30 mm, drawing speed = 54 mm/s, punch radii (R_p) were equal to 4 mm the smallest and to 6 mm the greatest, die radii (R_m) were equal to 4 mm the smallest and to 6 mm the greatest, blankholder force (*BHF*) = 20kN and 40 kN.

2. RESULTS OF INVESTIGATION

2.1 Case of hemispherical part

The results of the experimental and by simulation investigations are presented in Fig. 3 and 4. A comparison between experimental and simulation results is presented in Fig. 5.

2.2 Case of conical part

The numerical values of deviations from the nominal profile of these parameters, obtained for different blankholder forces and different tool geometries and after the measurements in AutoCAD of the profile resulted from simulation, are presented in Tables 1 and 2 .

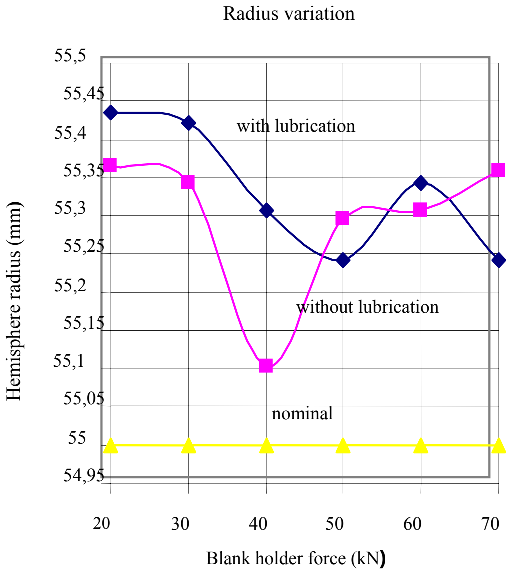

Fig.3. Hemisphere radius variation as a function of blankholder force and friction coefficient.

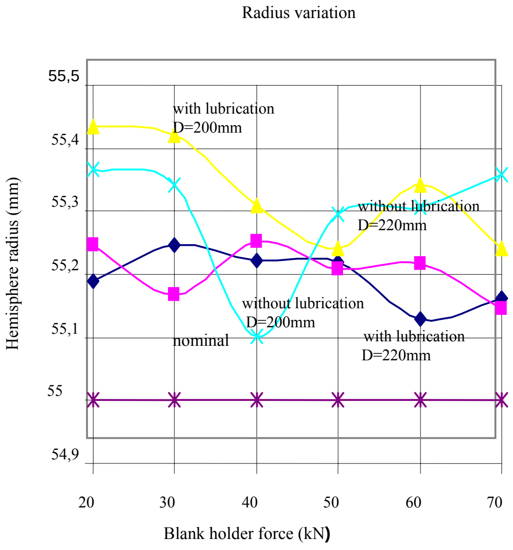

Fig.4. Hemisphere radius variation as a function of blankholder force, friction and part diameter.

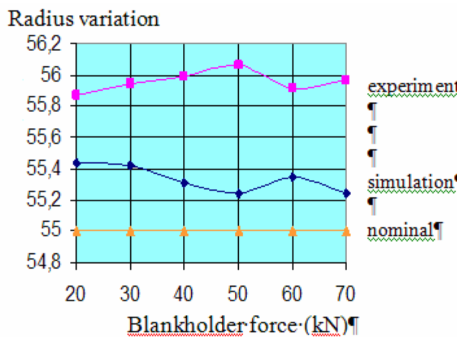

Fig. 5. Comparison between experimental and simulation results.

Table 1

Deviations caused by springback for BHF=20kN

Case	BHF	Rp	Rm	µ
a	**20 kN**	**4mm**	**6mm**	**0.005**
				0.15
b	20kN	4mm	4mm	0.005
				0.15
c	20kN	6mm	4mm	0.005
				0.15
d	20kN	6mm	6mm	0.005
				0.15

Deviations from r_1[mm]	Deviations from r_2[mm]	ρ [mm]	Deviations from α[grd]
0.556	**0.28**	**97.835**	**0.77**
2.648	**0.852**	**85.767**	**-0.30**
1.244	-1.587	13.491	-0.53
0.79	0.904	20.147	-0.15
2.53	-1.068	35.513	0.09
2.33	0.785	33.037	0.32
2.45	1.062	98.851	0.95
2.56	0.432	87.007	0.38

Table 2

Deviations caused by springback for BHF=40kN

Case	BHF	Rp	Rm	µ
a	**40 kN**	**4 mm**	**6 mm**	**0.005**
				0.15
b	40 kN	4 mm	4 mm	0.005
				0.15
c	40 kN	6 mm	4 mm	0.005
				0.15
d	40 kN	6 mm	6 mm	0.005
				0.15

Deviations from r_1[mm]	Deviations from r_2[mm]	ρ [mm]	Deviations from α[grd]
0.667	**0.378**	**20.808**	**0.54**
0.872	**0.481**	**72.482**	**0.37**
0.390	-1.55	36.316	0.43
0.681	-0.28	28.522	0.06
2.559	-1.37	30.461	0.76
2.526	-0.44	31.975	0.11
2.489	0.222	90.088	0.765
2.336	0.465	113.85	0.11

3. CONCLUSIONS

The general conclusions resulted from the above-presented analysis are as follows:

1. In the case of hemispherical part:

- increase of the blankholder force leads to the reduction of the springback parameters; an intensive variation of the springback angle was observed for small blankholder forces and of the walls curvature radius for greater blankholder forces.
- lubrication of the part and tools determines an easier increase of the springback parameters.
- increase of part diameter has a positive influence in maintaining the constant shape of the formed part.
- factors experimental and by simulation analyzed present the same effects on the springback intensity; hence, we can conclude that the simulation can well replace the experiment.

2. In the case of conical part:

- increase of blankholder force from 20 to 40 kN determined an increase of the r_1 and r_2 parameters and a decrease of the α springback parameters, by comparing with theoretical values;
- increase of the friction coefficient determined an increase of the springback parameters;
- punch-radius increasing determines the increase of the r_1 and r_2 springback parameters but a decrease of the α springback parameter; the die-radius decreasing determines the decrease of all springback parameters;
- minimum amount of springback parameters was obtained for maximum blankholder force and minimum friction coefficient, sometimes the sense of springback variation of parameters changes from plus to minus.

Based on the result of this work, it can be generally concluded that in the case of draw parts made from metal sheets, the increase of blankholder force can lead to favourable effects but the punch and die radii have to be maintained as nominal values

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