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

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ABSTRACT
A common problem in sheet metal forming is represented by the distortion in the parts shape that occurs when the deforming load is removed. This shape distortion accompanied by dimensional changes is called springback and it is generated by the changes in strain produced by elastic recovery. Residual stresses are one of the factors that have a significant influence on the springback generating. This paper analyses the influence of different factors and causes on the springback intensity in the case of conical draw parts made by drawing of metal sheets.
Keywords: springback, drawing process, conical parts

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 conical drawn parts made from steel sheets by using a conical punch.

2. CONDITIONS OF SIMULATION
The algorithm applied to analyse 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 $2x10^5$ MPa, Poisson’s ratio 0.3, density 7800 kg /m3. The main dimensions of the finished part are presented in the Figure 1.

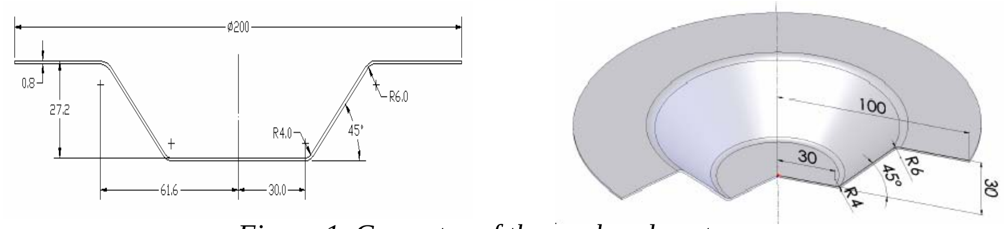


Figure 1. Geometry of the analyzed part

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

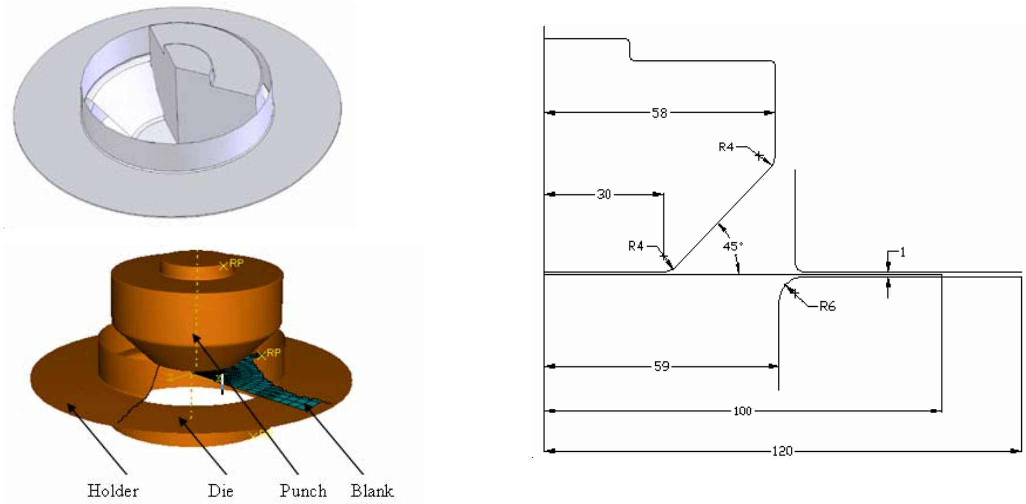


Figure 2. Geometry of the model used in simulation

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 modelled as rigid surfaces. Contact interactions between the blank and the tools were modelled using penalty method. In order to describe the plastic behaviour of the used material, 10 points were chosen from the 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: $\mu = 0,005$ and $\mu = 0,15$. The working parameters were as follows: drawing depth = 30mm, 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. The above mentioned values were chosen from the optimum fields of their variation determined by applying the fractional factorial plans of experiment (Taguchi method).

3. SPRINGBACK PARAMETERS DETERMINED FROM SIMULATION

The resulted geometrical parameters of the draw parts are presented in figure 3.

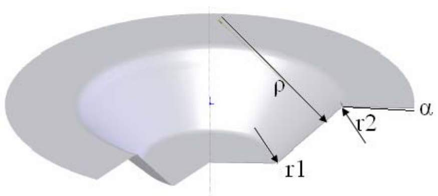
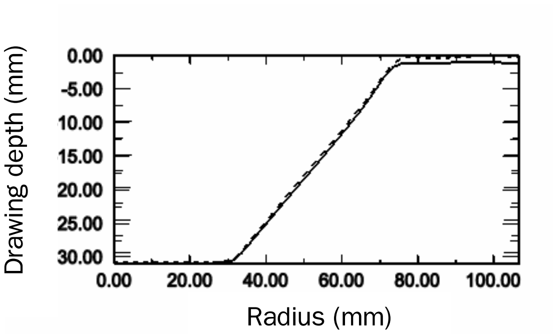


Figure 3. Elastic springback parameters

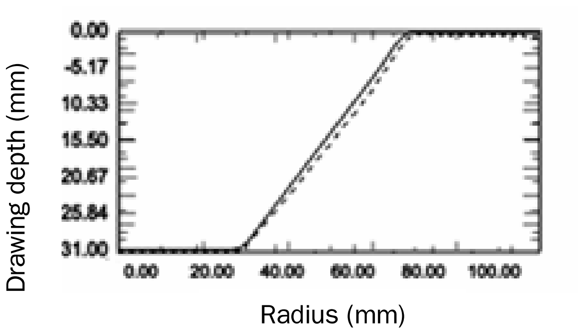
The numerical values of deviations from the nominal profile of these parameters, obtained for different blankholder forces and different tool geometries and after the measurements in AutoCAD of the profile resulted from simulation, are presented in tables 1 and 2 and graphical represented in figures 4 and 5, respectively.

Table 1 Deviations caused by springback in the case of parts obtained for BHF=20kN, different friction coefficients and different punch and die radii

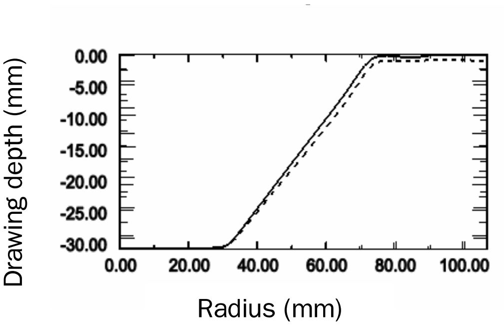
Case	BHF [kN]	Rp [mm]	Rm [mm]	μ	Deviations from r_1[mm]	Deviations from r_2[mm]	ρ [mm]	Deviations from α[grd]
				0.005	**0.556**	**0.28**	**97.835**	**0.77**
a	**20**	**4**	**6**	**0.15**	**2.648**	**0.852**	**85.767**	**-0.30**
				0.005	1.244	-1.587	13.491	-0.53
b	20	4	4	0.15	0.79	0.904	20.147	-0.15
				0.005	2.53	-1.068	35.513	0.09
c	20	6	4	0.15	2.33	0.785	33.037	0.32
				0.005	2.45	1.062	98.851	0.95
d	20	6	6	0.15	2.56	0.432	87.007	0.38



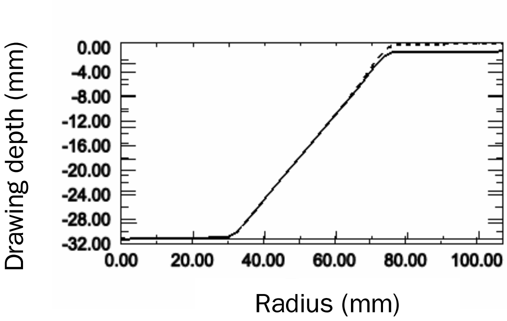
a.



b.



c.



d.

Figure 4. Deviations caused by springback in the case of parts obtained for BHF=20kN

Table 2 Deviations caused by springback in the case of parts obtained for BHF=40kN, different friction coefficients and different punch and die radii

Case	BHF [kN]	Rp [mm]	Rm [mm]	μ	Deviations from r_1[mm]	Deviations from r_2[mm]	ρ [mm]	Deviations from α[grd]
				0.005	**0.667**	**0.378**	**20.808**	**0.54**
a	**40**	**4**	**6**	**0.15**	**0.872**	**0.481**	**72.482**	**0.37**
				0.005	0.390	-1.55	36.316	0.43
b	40	4	4	0.15	0.681	-0.28	28.522	0.06
				0.005	2.559	-1.37	30.461	0.76
c	40	6	4	0.15	2.526	-0.44	31.975	0.11
				0.005	2.489	0.222	90.088	0.765
d	40	6	6	0.15	2.336	0.465	113.85	0.11

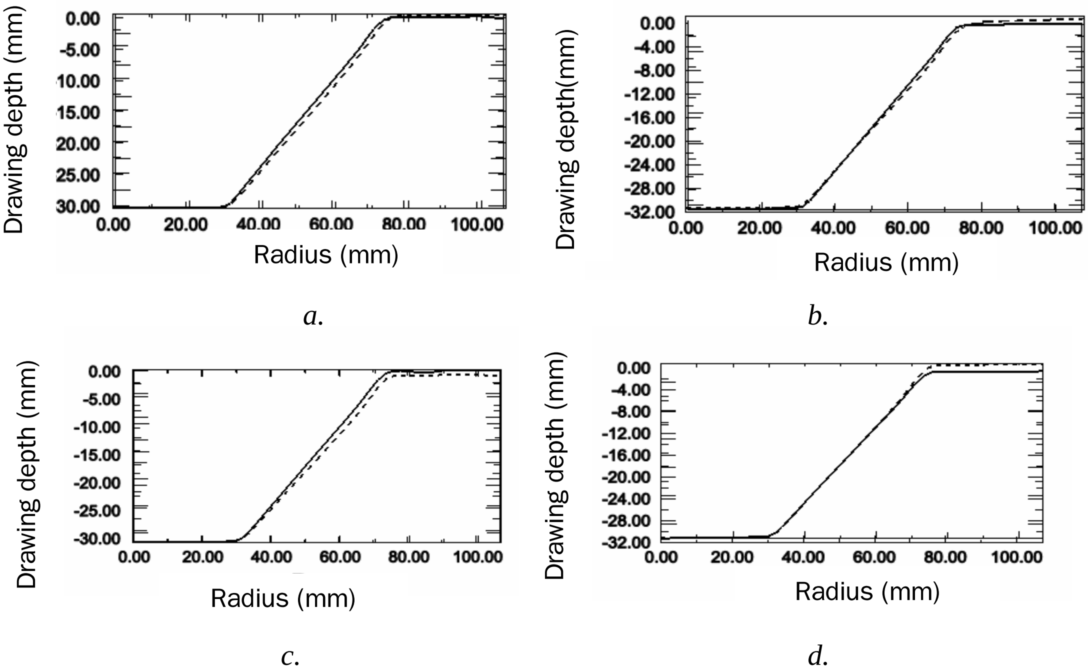


Figure 5. Deviations caused by springback in the case of parts obtained for BHF=40kN

4. CONCLUSIONS

The analysis of the above presented results emphasises the following aspects concerning the deflections of the conical draw parts: the 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; as concerned the influence of the friction coefficient, its increase determined an increase of the springback parameters; the punch-radius increasing determines the increase of the r_1 and r_2 springback parameters but a decrease of the α springback parameter; the minimum amount of the springback parameters was obtained for maximum blankholder force and minimum friction coefficient but sometimes the sense of variation of springback parameters are changed from plus to minus; the die-radius decreasing determines the decrease of the all springback parameters; the minimum amount of the springback parameters was obtained for maximum blankholder force and minimum friction coefficient but sometimes the sense of variation of springback parameters are changed from plus to minus. Based on the result of this work, it can generally be concluded that in the case of conical draw parts made by using a conical punch, 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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5. REFERENCES:

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