ANALYSIS BY SIMULATION OF THE INFLUENCE OF PROCESS PARAMETERS ON THE SPRINGBACK OF DEEP-DRAWN PARTS

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Abstract: The impact of process parameters on the springback intensity in the case of cylindrical deep-drawn parts is investigated. The study is focused on the influence of two parameters, respectively blankholder force and friction conditions, in order to assess the accuracy of the virtual obtained parts.

Keywords: simulation analysis, process parameters, springback, cylindrical drawn parts

1. INTRODUCTION

The forming of sheet metal into a desired and functional shape is a process which requires a detailed prediction of springback to avoid contingent assembly problems. Springback, the change in shape between the fully loaded and unloaded configurations, is reported in the literature to be influenced by process parameters, material properties and tools geometry. Knowing how these factors affect the springback intensity, we will be able to control them in order to obtain desired accuracy of the formed parts.

In this paper, the influence of two process parameters on the springback intensity and, hence, on the parts accuracy are studied. The analysis is performed by using the simulation with finite element method, in the case of cylindrical deep-drawing process.

2. METHODOLOGY AND SIMULATION CONDITIONS

Determination by simulation of the springback intensity in the case of cylindrical deep-drawn parts consisted in the following steps (figure 1):

- first, the cylindrical cups were obtained by simulation of the deep drawing process into ABAQUS/Explicit;
- second, the import the forming results into ABAQUS/Standard programme was performed in order to simulate the unloading phase (obtaining the parts springback);
- the parts profile was then determined on the base of the displacements resulted after deep drawing and springback;
- the above resulted profiles were measured with a CAD software and compared with the nominal shape, in order to quantify the springback.

A three dimensional model was used for the simulations. Only a quart of the model was solved using symmetry conditions. The blank was considered deformable with a planar shell base while the tools were considered analytical rigid (table 1). Thus, numerical integration (Gaussian with 5 integration points through the thickness) was involved only for the work-piece material. The stress-strain curve of the FEPO steel was implemented point-by-point rather than using a curve fit equation. A slave-master concept was used for the contact problem to impose penalty regularization. The blankholder force value was varied between 2.5kN and 140kN respective the friction coefficient value was varied between 0.025 and 0.175.

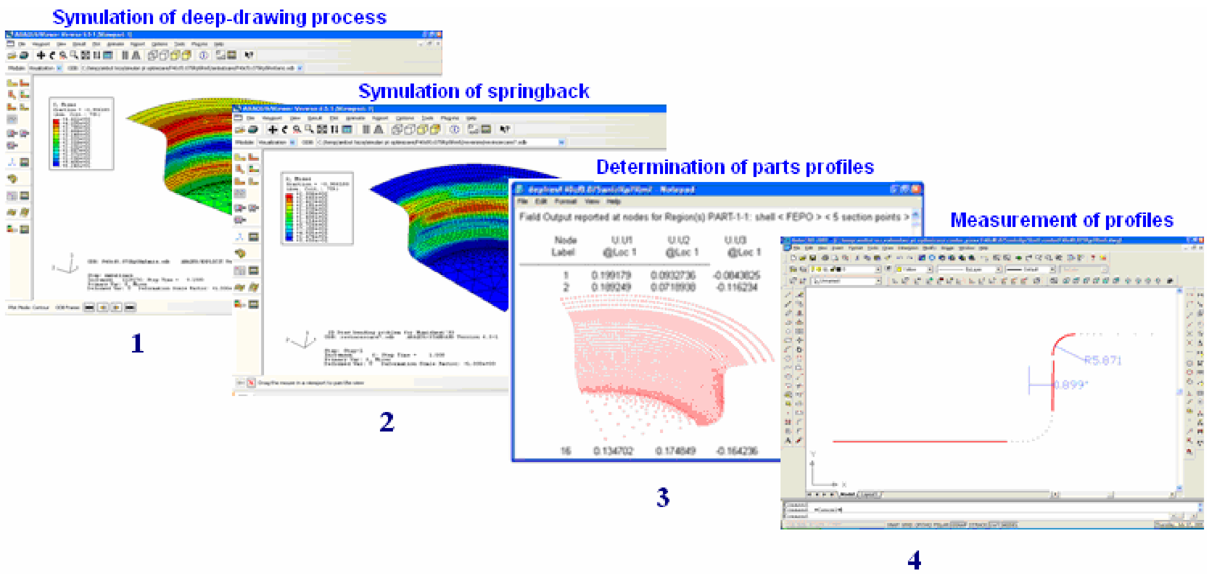

Fig. 1 Steps of springback quantification

Table 1

Code: **Abaqus/Explicite**	**Blank properties**	
	Blank dimensions	200 mm diameter x 8 mm thickness
	Blank discretization	
	Element type	shell (S4R and S3R)
	Number of elements	2462
	Integration points	5
	Tool discretization	
	Tool type	analytical rigid surface
	Process parameters	
	Punch stroke	30 mm
	Blankholder force	2.5kN ÷ 140kN
	Friction coefficient	0.025 ÷ 0.175
Code: **Abaqus/Standard**	**Springback**	
	Unloading strategy	tool removal

3. SIMULATION RESULTS

3.1 Results of simulations with friction coefficient μ = 0.075 and different blankholder forces

The simulation of deep-drawing process was performed by using values of the blankholder force between 2.5kN and 140kN. In the case of blankholder force value equal to 2.5kN, the wrinkling of part flange resulted (fig. 2.a) while for the blankholder force value equal to 140kN the material fracture occurred, near the zone corresponding to the punch radius (fig. 2.b).

The geometrical deviations from the theoretical profile of virtual parts due to the springback phenomenon, in the case of deep-drawing with constant friction coefficient (μ = 0.075) and different blankholder forces are presented in table 2, where:

r_p - is the radius of connection between the part bottom and part sidewall
r_d - is the radius of connection between the part flange and part sidewall

α - is the angle of the flange
β - is the inclination angle of part sidewall
h - is the height of the part sidewall.

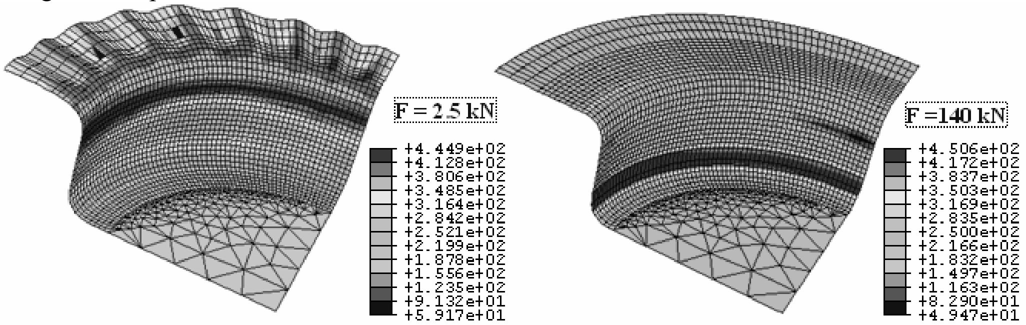

Fig. 2 Flange wrinkling respective material fracture

Table 2

Material = FEPO 5MBH, Part depth = 30 mm, μ = 0.075					
Blankholder force [kN]	**r_p [mm]**	**r_d [mm]**	**h [mm]**	**α [deg]**	**β [deg]**
F = 5	0.986	0.888	-1.074	0.817	1.066
F = 10	0.725	0.799	-1.341	0.717	1.041
F = 30	0.739	0.906	-1.111	0.188	0.992
F = 50	0.723	0.763	-0.978	0.028	0.829
F = 85	0.527	0.850	-1.024	0.170	0.856
F = 100	0.420	0.900	-0.960	0.064	0.875
F = 125	0.348	0.977	-1.004	0.035	0.969

3.2 Results of simulations with blankholder force BHF = 50kN and different coefficients of friction

The simulation of deep-drawing process was performed by using the following values of the friction coefficient: 0.025, 0.05, 0.075, 0.1, 0.125, 0.15 and 0.175.
The geometrical deviations from the theoretical profile of virtual parts due to the springback phenomenon, in the case of deep-drawing with constant blankholder force (BHF = 50kN) and different coefficients of friction are presented in table 3. In the case of using a friction coefficient equal to 0.175 the material fracture occurred, also near the zone corresponding to the punch radius (fig. 3).

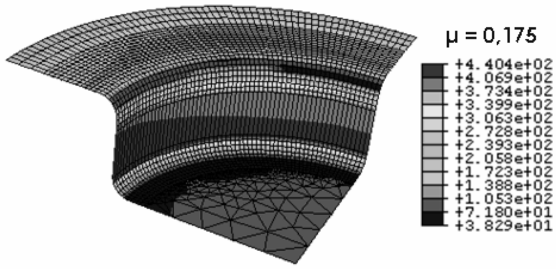

Fig. 3 Material fracture in the case of using μ = 0.175

Table 3

Material = FEPO 5MBH, Part depth = 30 mm, BHF = 50 kN					
Coefficient of friction	**r_p [mm]**	**r_d [mm]**	**h [mm]**	**α [deg]**	**β [deg]**
μ = 0.025	0.617	0.733	-1.014	0.717	1.050
μ = 0.05	0.549	0.744	-0.969	0.224	0.812
μ = 0.075	0.523	0.761	-0.962	0.028	0.829
μ = 0.1	0.488	0.756	-0.958	0.049	0.704
μ = 0.125	0.410	0.832	-0.968	0.102	0.850
μ = 0.15	0.418	0.860	-0.986	0.022	1.057

4. CONCLUSIONS

- Material springback generated deviations of geometrical parameters of the part from the theoretical profile.
- Both, in the case of using different blankholder forces and different coefficients of friction respectively, the same tendency of variation of the springback parameters was encountered; however, the effect of the blankholder force is more pronounced (figure 4).
- Based on the simulation results, the optimum domains of process parameters were established, such that all the analyzed springback parameters have the values close to the nominal ones. So the resulted optimum domain of the blankholder force values was 40kN÷90kN and for the coefficient of friction the optimum domain was 0.075÷0.1.

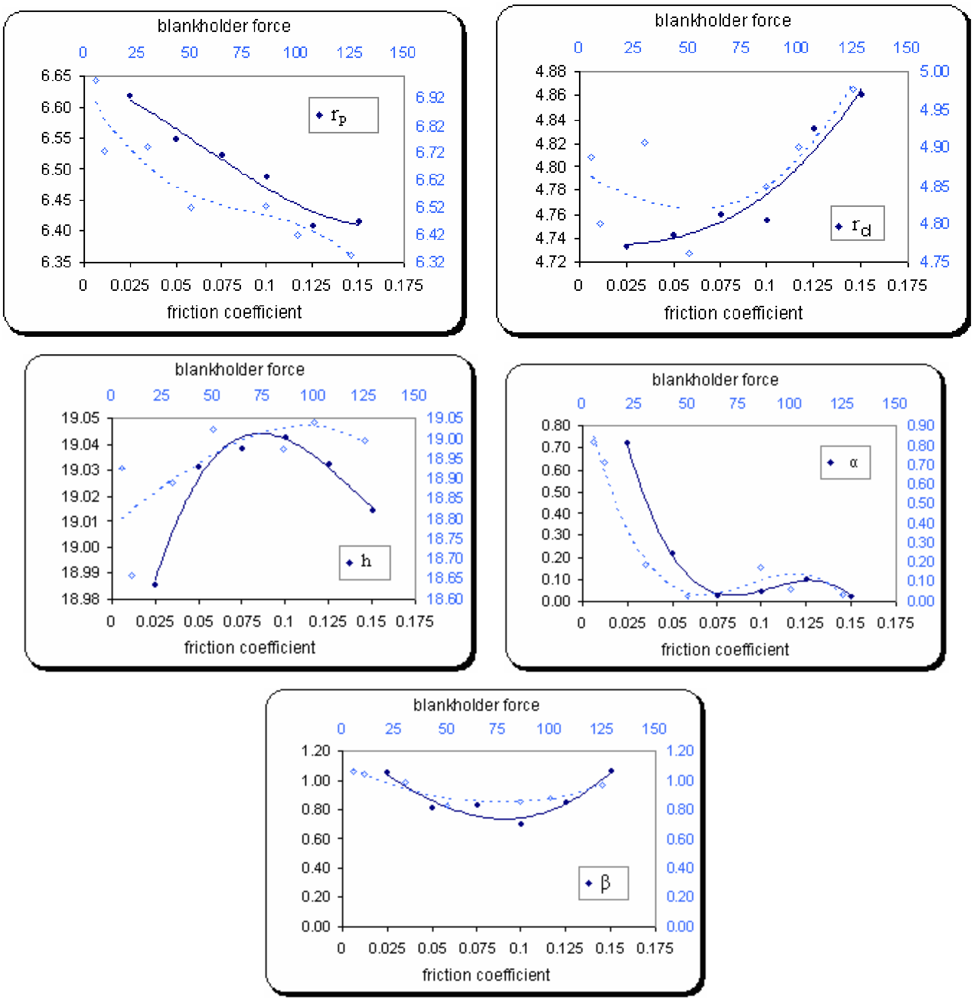

Fig. 4 Comparative analysis of the simulation results

5. REFERENCES

[1] Axinte C., *Theoretical and experimental researches concerning the springback phenomenon in the case of cylindrical deep-drawn parts*, PhD Thesis, Bucharest 2006