EFFECT OF FRICTION CONDITIONS ON THE SPRINGBACK PARAMETERS OF THE CYLINDRICAL DRAWPARTS

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Abstract: Springback is an inherent phenomenon in all sheet metal forming processes. It affects the shape and dimensional precision of the drawn parts and, in its turn, depends on the interaction of tools design, process parameters and part geometry. In the present work the effect of the friction conditions on the springback parameters of the cylindrical drawn parts is analyzed.

Keywords: blankholder force, springback parameters, cylindrical parts

1. INTRODUCTION

Sheet metal forming involves the transformation of a flat sheet into a useful shape. A common problem in this transformation is the distortion in the shape of the drawn part that occurs when the deforming load is removed or when the part is removed from the tooling. This dimensional change is called springback, being one of the most important phenomena that affect the quality of drawn parts. In its turn, the amount of springback depends on the interaction of all components of the forming system: tools design, process parameters and part geometry.

The purpose of the present work is to compute the effect of the friction conditions on the springback of the cylindrical drawn parts. The analyze will be made by simulation, using the finite element method, due to the main advantages of this technique: enables proper selection of almost all parameters implied into the forming process (size and shape of the blank, tools geometry, friction condition, holding force, etc.) and save the cost of time and money, respectively.

2. METHODOLOGY AND CONDITIONS OF SIMULATION

The algorithm boarded to quantify the geometric deviations of cylindrical draw parts, which make the object of this paper was as fallows (Fig. 1):

- firstly, the cylindrical cups were obtained by the simulation of the deep drawing process into ABAQUS/Explicit;
- secondly, import the forming results into ABAQUS/Standard program 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 and compared with the nominal shape, in order to quantify the springback amount. The favourable environment for this is a CAD software (in present case AutoCAD software).

A three dimensional model was used for the simulation. Only quart of the model is solved using symmetry conditions. The blank was considered deformable with a planar shell base while the tools were considered analytical rigid. Thus, numerical integration (Gaussian with 5 integration points through the thickness) is 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 such. A slave-master concept was used for the contact problem to impose penalty regularization.

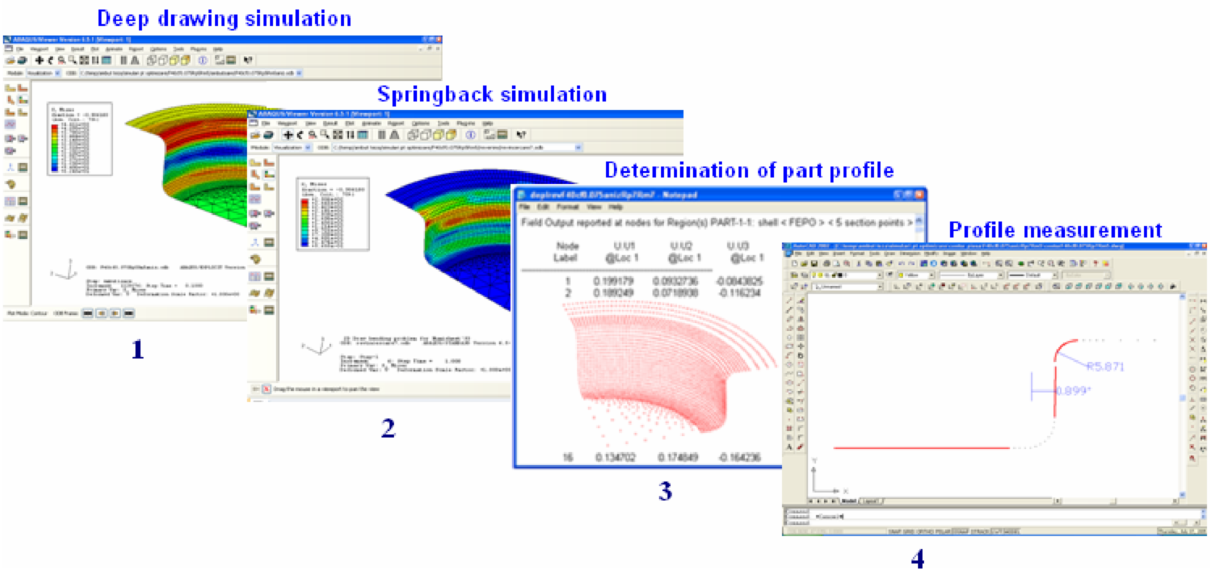
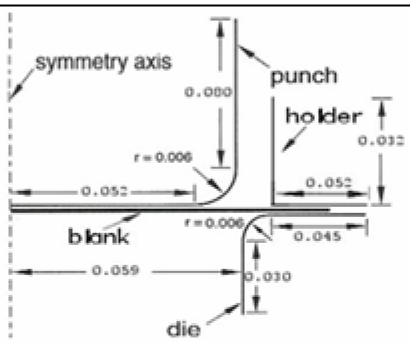


Fig. 1 The algorithm of springback computation

The material properties and process parameters have been defined as it is shown in table 1.

Tab. 1. Process parameters and material properties

 **Drawing depth:** 30 [mm] **Drawing speed:** 18 [mm/min] **Blankholder force:** 5, 10, 30, 50, 85, 100, 125 [kN] **Friction coefficient:** 0.075	**Material: FEPO 5MBH** Sheet (deformable): - mass density: $\rho = 7800$ [kg/m^3] - Young's modules: $E = 2 \cdot 10^5$ [MPa] - Poisson's ratio: 0.3. - isotropic on elastic field and anisotropic on the plastic field Tooling (analytical rigid surface) **Blank description** - Element type S4R and S3R - Integration points 5 - Blank dimension: - diameter: 200 mm - thickness: 0.8 mm

3. RESULTS OF SIMULATION

The theoretical dimensions of the finished part and the geometrical parameters whose variation was supervised during the investigation are shown in Figure 2, where:

- R_d is the adjustment radius between side wall and flange of the piece;
- R_p is the adjustment radius between bottom and side wall of the piece;
- h is the height of the lateral wall;
- α is the flange angle;
- β is the inclined angle of the side wall.

a. theoretical profile b. analyzed parameters

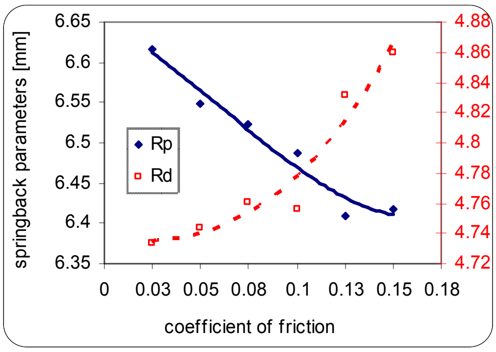
Fig. 2 Geometry of the cylindrical parts

Besides the above mentioned parameters it was also investigated the circularity deviations of the lateral wall of the parts. For this purpose, measurements were performed in two different section of the wall – at 11 mm and 21 mm distance from bottom of the part.

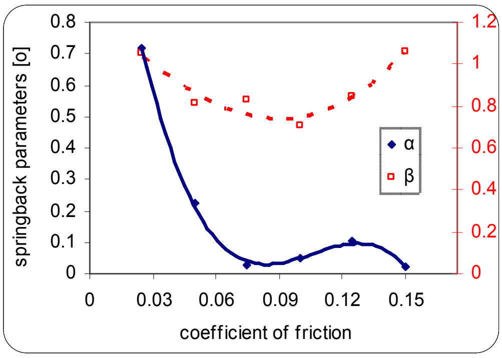
The numerical values of the analysed parameters and their variation curves are shown in table 2 and figure 3, respectively. The circularity deviations are presented in figure 4 respective table 3.

Tab. 2. Numerical values of the geometrical parameters

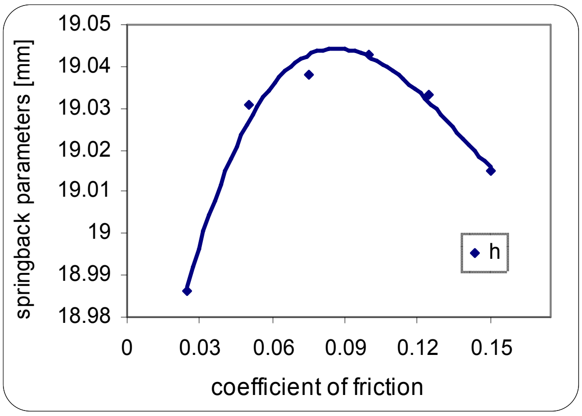
Material = FEPO 5MBH, Part height = 30 mm, F= 50 kN					
Coefficient of friction	**R_p [mm]**	**R_d [mm]**	**h [mm]**	**α [º]**	**β [º]**
μ = 0.025	6.617	4.733	18.986	0.717	1.050
μ = 0.05	6.549	4.744	19.031	0.224	0.812
μ = 0.075	6.523	4.761	19.038	0.028	0.829
μ = 0.1	6.488	4.756	19.043	0.049	0.704
μ = 0.125	6.410	4.832	19.033	0.102	0.850
μ = 0.15	6.418	4.860	19.015	0.022	1.057



a.

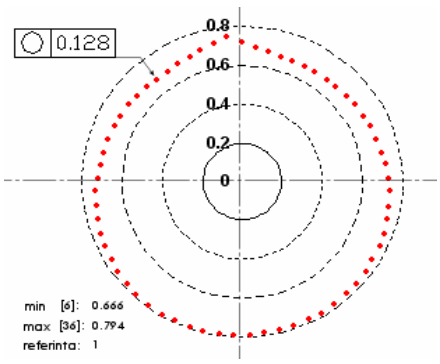


b.

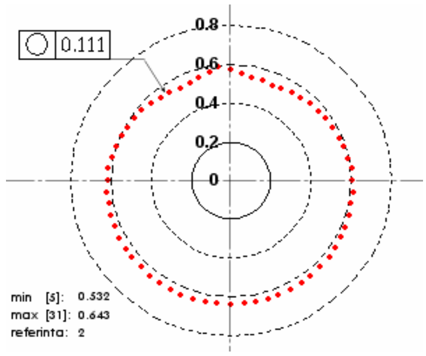


c.

Fig. 3 Variation of the springback parameters



a. **μ = 0.025**



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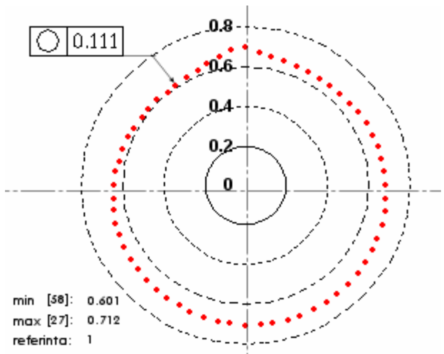
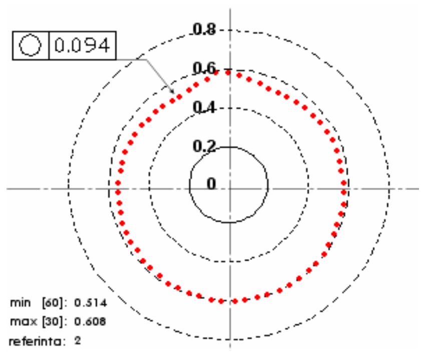


a. **μ = 0.05**



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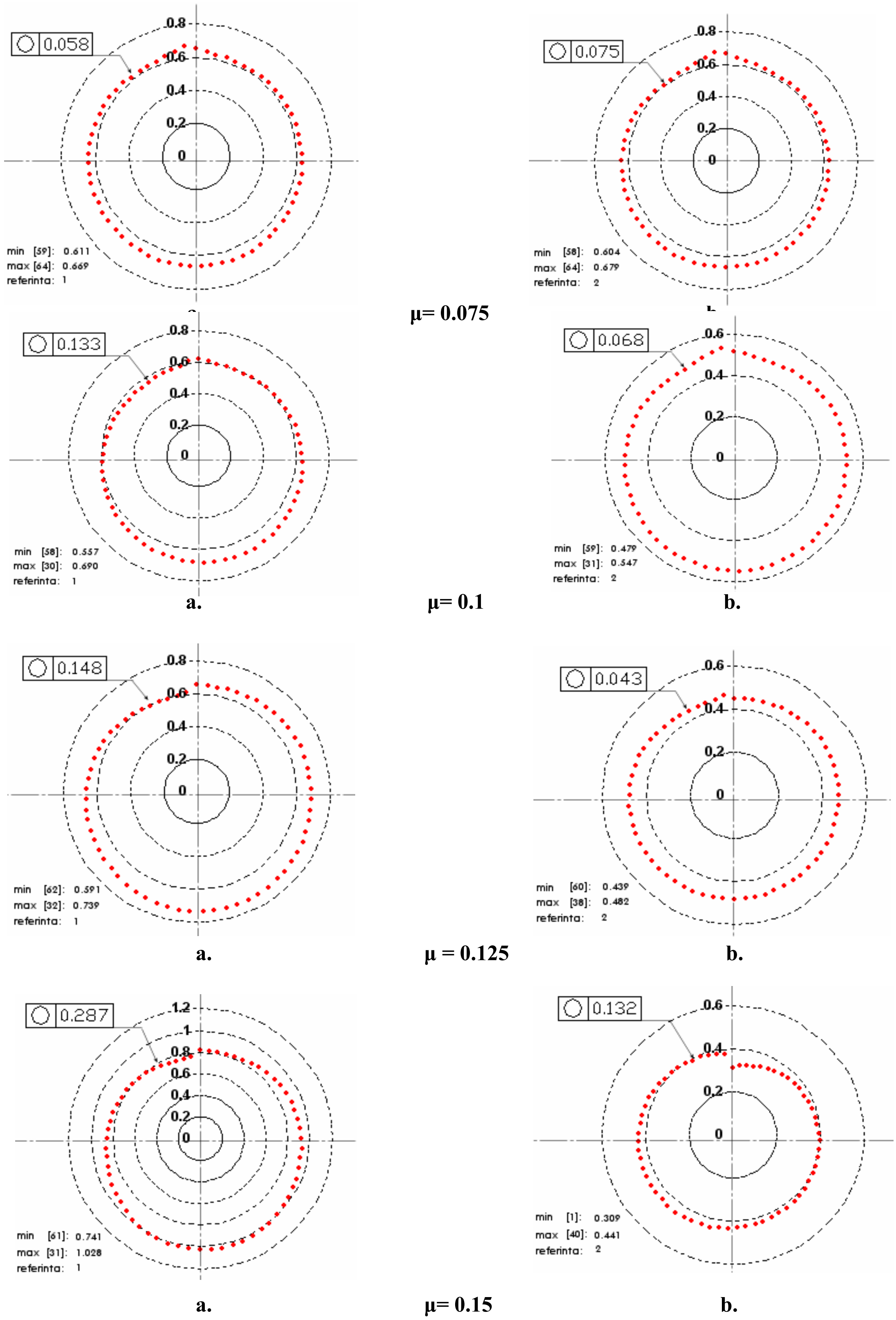

Fig. 4 Circularity deviations of the wall (reference 1- 21 mm; reference 2- 11 mm from the bottom of the part)

Tab. 3 Circularity deviation of the lateral wall of the part [mm]

Coefficient of friction					
0.025	**0.05**	**0.075**	**0.1**	**0.125**	**0.15**
Circularity deviation at 11 mm from the bottom of the part					
0.111	0.094	0.075	0.068	0.043	0.132
Circularity deviation at 21 mm from the bottom of the part					
0.128	0.111	0.058	0.133	0.148	0.287

4. CONCLUSIONS

In the case of simulation of the cylindrical deep-drawing process with different coefficients of frriction (0.025, 0.05, 0.075, 0.1, 0.125, 0.15) and a blankholder force F =50 kN, after the measurement of the resulted profiles, the following aspects were observed:

- due to the springback phenomenon, the geometric parameters of the parts differ to the theoretical one;
- at the level of the punch radius, the increasing of the friction coefficient determines the springback increasing while in the zone of the die radius an inverse phenomenon it happens (fig. 3,a);
- the intensification of the friction conditions determines the decrease of the flange angle (fig. 3, b);
- the inclination of the lateral wall decreases for the values of the friction coefficient smaller than 0.1; for the friction coefficient bigger than 0.1, the springback increases till the values approximate equals with those corresponding to the less friction conditions. In order to understand a such comportment of the material, will be necessary to perform a study concerning the distribution of strains and stresses within the deformed part. In addition, it is possible that the friction coefficient became higher than the specified one at the level of the tools radii, while in other regions of the part to be lower than the prescribed one, although the same friction coefficient was assumed for the whole contact surfaces.
- the conditions of friction between sheet and tools influence the circularity deviations of the lateral wall of the part (fig. 5). Besides, the deviations became higher as the distance between the bottom of the part and the section where the measurements were performed increases (for the friction coefficient bigger than 0.075, the increasing is ≈60% - see tab.3).

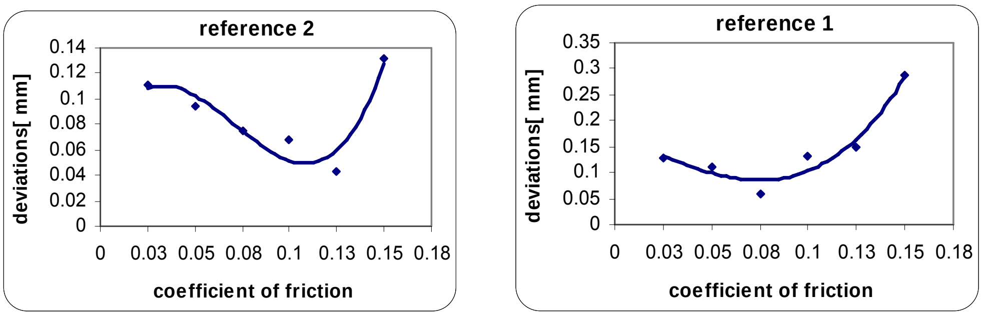

Fig. 5 Variation of the circularity deviations of the lateral wall as a function of friction conditions

Based on the above results, an optimum domain of the friction coefficient (**[0.075-0.1]**) was established, such that all the analyzed springback parameters have, as far as possible, values close to the nominal one (fig. 6).

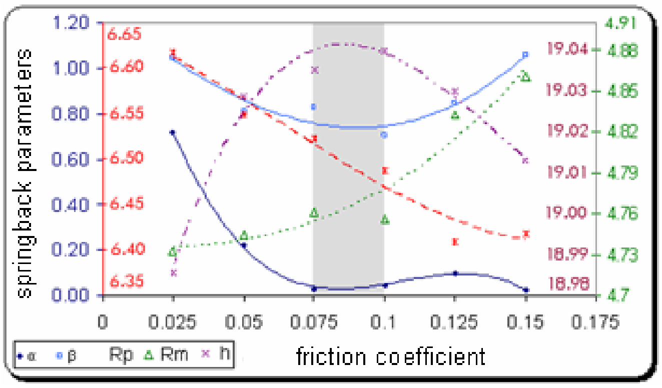

Fig. 6 Optimum domain of the friction coefficient

5. BIBLIOGRAPHY

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