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FACTORS AND CAUSES THAT INFLUENCE THE SPRINGBACK INTENSITY IN THE CASE OF CONICAL DRAW PARTS MADE FROM STEEL SHEETS BY USING CYLINDRICAL AND CONICAL PUNCHES

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Abstract: *The cold plastic forming of metal sheets generates an undesired phenomenon known as springback. Springback occurs after the tools removing and the forming forces become equal to zero – and leads to a shape and dimensions of the final part different from the theoretical ones. The study and analysis 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 by simulation using ABAQUS software of the factors that influence the springback phenomenon in the case of conical drawn parts made from steel sheets by using cylindrical and conical punches.*

Key words: *springback, deep drawing, conical part*

1. INTRODUCTION

Springback is a phenomenon of elastic nature determined by the distribution of residual stresses on the section of the formed part. Springback is not only manifested by the modification of the state of stress/strains in the formed material but also by the modification of the geometric shape of the formed parts. In the case of deep drawing the springback problem is very complex because of the complex loading and complex geometry of the formed part. The springback parameters in the case of a drawn part can be as follows: modification of the curvature radius and angle of inclination of the part walls and the difference in height. Generally, the springback is positive, but negative value can be registered in the case of increased blankholder forces and part radii smaller than punch radii. [1, 2] The main factors that influence springback phenomenon after drawing are as follows: punch and die radii, initial clearances, lubricating conditions, blankholder force and shape, material chemical composition and mechanical properties, sheet thickness.

The general conclusions presented by different researchers concerning the influence of different factors on springback intensity indicate different senses of its variation. [3, 4, 5].

The present paper is a research concerning the influence of different factors on springback parameters in the case of conical draw parts made from steel sheets.

2. CONDITIONS OF SIMULATION

The analysis concerning the behaviour of the homogeneous metal sheets was performed by simulation using the ABAQUS-Explicit software. The simulation was performed for the parts made from FEPO 5MBH steel sheets. The materials were considered elastic-plastic with an isotropic hardening.

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. A two dimensional model was used for the simulation. The geometry and dimensions of the part and model used in simulation are shown in Figs. 1 and 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 analysis of the sheet-drawing process was based on the axisym-

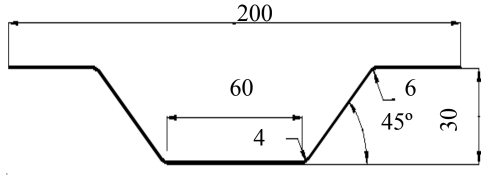


Fig. 1. Geometry of the parts.

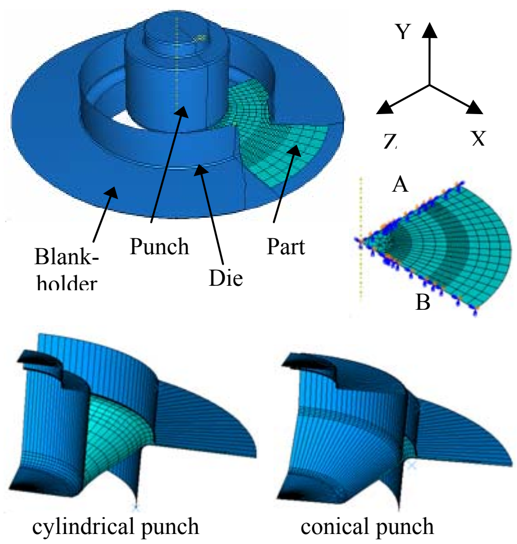


Fig. 2. Geometry of the model used in simulation.

metric condition. Because of the axisymmetry of the plate, only the right-half portion of the tools and workpiece were modelled, in order to reduce the calculation time. Also, to save the calculation time, the punch, the die and the blankholder were simulated as rigid bodies. The blanks were considered deformable with a planar shell base.

The integration method was Gaussian with 7 integration points for every node, equal distributed through the thickness of the shell. The elements used for the blank meshes were of CAX4I type. The blank-holders, punches and dies were modelled as rigid surfaces. Contact interactions between the blanks 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 working parameters were as follows: drawing depth: 62 mm, drawing speed: 18 mm/s, blank holding force: 20 kN…..50 kN; friction coefficient: μ = 0.005 … 0.1.

3. INVESTIGATION RESULTS

The investigations concerning springback were performed in the above presented conditions and in the following two drawing cases: using cylindrical punch and using conical punch. The springback parameters resulted for different values of blankholder force are presented in Fig. 3 and Table 1.

By analyzing the springback intensity in the case of the investigated conical draw parts - in the both cases of cylindrical and conical punches, the following general aspects can be remarked:

- the radius of connection between part bottom and wall increases to the increase of blankholder force;
- the radius of connection between part flange and wall decreases to the increase of blankholder force;
- the springback angle of the part flange decreases to the increase of blankholder force;
- in the case of cylindrical punch the springback parameters have higher values than in the case of conical ones.

Fig. 3. Springback parameters.

Table 1

Values of springback parameters

BHF [kN]		20	35	50
cylindrical punch	R_2 [mm]	6.44	6.48	6.81
	R_1 [mm]	4.87	4.31	4.26
	α [°]	–0.95	–0.53	–0.25
conical punch	R_2 [mm]	6.33	6.37	6.412
	R_1 [mm]	4,425	4.419	4.416
	α [°]	–0.67	–0.38	–0.13

The deviations of the parts from the theoretical profile – measured in the most important points along the part profile (Fig. 4) - are graphical presented in Fig. 5 and 6. The variation of deviations from the theoretical profile measured in different points along the part profile presents the following aspects:

- the deviations have approximately the same variation along the part profile for all values of blankholder force;
- on the part bottom the deviations are approximately equal to zero;
- in the zone of connection bottom - wall the deviations have small positive values but after this zone the deviations become negative for all blankholder forces and will touch the highest values on the part flange;
- the deviations resulted in the case of conical punch have approximately the same values like in the case of cylindrical ones; an exception from such variation was registered in the flange zone and in the zones of connection wall - bottom and wall - flange where the deviations have higher values in the case of conical punch.

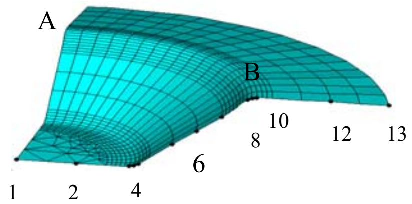
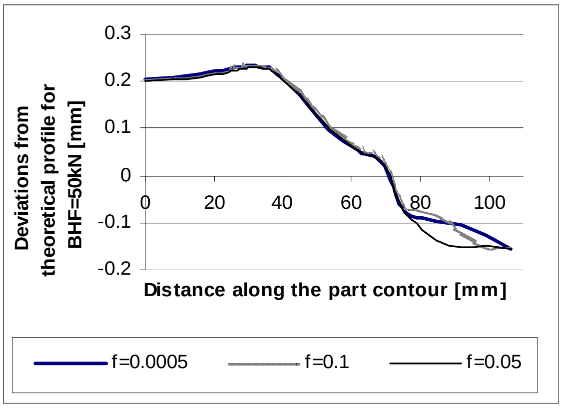
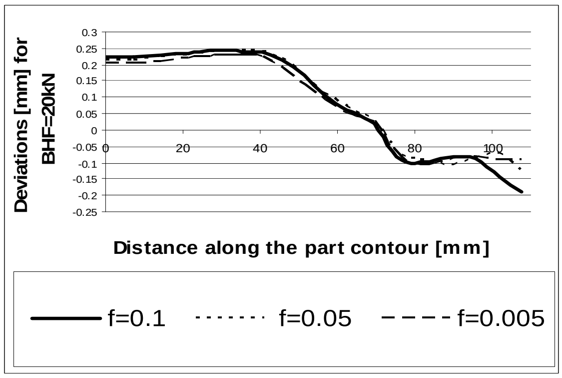


Fig. 4. Points of measurement of the stresses and part deviations.

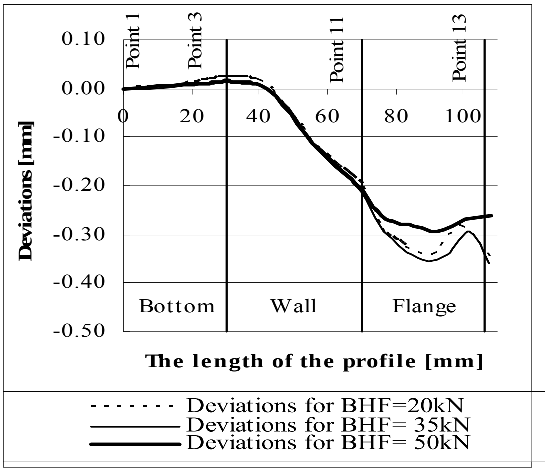


a. case of conical punch

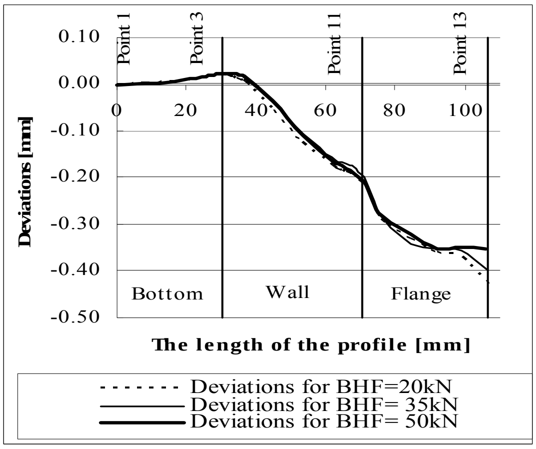


b. case of cylindrical punch

Fig. 5. Variation of deviations from the theoretical conical profile, measured along the part profile - as a function of different friction coefficients.

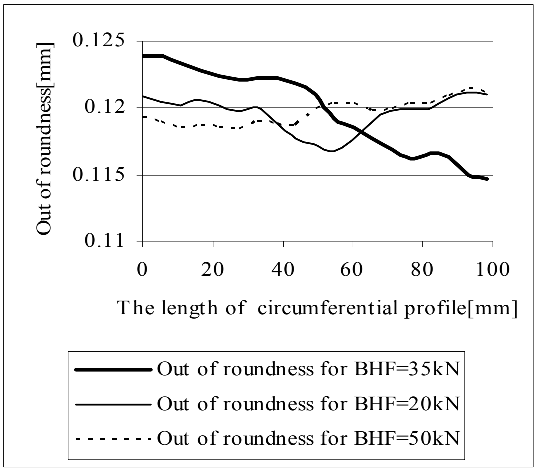


a. case of cylindrical punch

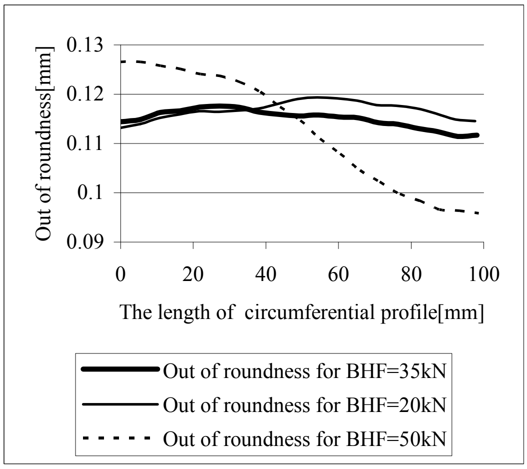


b. case of conical punch

Fig. 5. Deviations of the parts from the theoretical profile – measured in different points along the part profile - as a function of different blankholder forces.



a. cylindrical punch



b. conical punch

Fig. 6. Deviations from circularity in the zone of connection between wall and flange.

The deviations resulted as a function of variation of the friction conditions have approximately the same variation for all investigated values of friction coefficients; an exception from such variation is presented on a small zone near the border of the part flange.

The variation of deviations from the circularity of part measured in the zone of connection between wall and flange is presented in Fig. 6.

By analyzing the deviations from the theoretical circularity measured in the zone of connection wall - flange and along the circular segment AB (Fig. 5), the following aspects were observed:

- the deviations have had very small values in the both cases – conical and cylindrical punches;
- in the case of cylindrical punch, for a blankholder force equal to 20 or 50 kN, the deviations have had a small variation, the highest values being touched at the middle of the AB circular segment;
- for a blankholder force equal to 35kN the deviations values decreased in the sense from A to B;
- in the case of conical punch, for a blankholder force equal to 20 and 35 kN, the deviations have had a small variation and for a blankholder force equal to 50 kN the deviations decreased in the sense from A to B.

4. CONCLUSIONS

The variation of springback parameters in the case of a conical drawn part as a function of blankholder force presents the following aspects:

- the increase of blankholder force will lead to the increase of the radius of connection between part bottom and wall increases, to the decrease of the radius of connection between part flange and wall and of the springback angle of part flange;
- in the case of cylindrical punch the springback parameters have higher values than in the case of conical ones.

The variation of springback parameters can be explained by the modification of the stresses state of the material depending on blankholder force values. Thus, the utilization of high blankholder forces in drawing will block the flow of the material into the flange and the die cavity; the material flow blocking will lead to the elimination of the differences in the states of stress between the outer and inner faces of the part, especially on the wall and will have positive consequences on the reduction of springback parameters.

The variation of deviations from the theoretical profile due to springback in the case of a conical drawn part and measured in different points along the part profile presents the following aspects:

- the deviations have approximately the same variation along the part profile for all values of the blankholder force;
- the deviations have approximately the same variation along the part profile for all values of the friction coefficient;
- on the part bottom the deviations are approximately equal to zero;
- in the zone of connection bottom - wall the deviations have small positive values but after this zone the deviations become negative for all blankholder forces and will touch the highest values on the part flange;
- the deviations resulted in the case of conical punch have approximately the same values like in the case of cylindrical ones; an exception from such variation was registered in the flange zone and in the zones of connection wall - bottom and wall - flange where the deviations have higher values in the case of conical punch.

The springback phenomenon and its effects on the part geometry are caused by the differences resulted between the states of residual stresses on the outer and inner faces of part, especially in the zones of connection wall - bottom and wall – flange.

The springback intensity can be influenced to a great extent by the variation and values of the major components of residual stresses that act along the part profile. The deviations from the circularity of part can be caused by the variation and values of the minor components of residual stresses that act along the part circumference [6].

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