12th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2008, Istanbul, Turkey, 26-30 August, 2008

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

Gheorghe Brabie
University of Bacau,
157 Marasesti street, Bacau
Romania

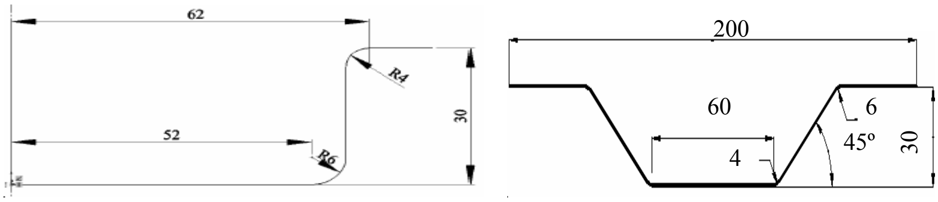
Mioara Radu – Costache
University of Bacau,
157 Marasesti street, Bacau
Romania

ABSTRACT
The cold plastic forming of metal sheets generates a undesired phenomenon known as springback. Springback occurs after the tools were removed and the forming forces become equal to zero – and leads to a shape 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 of the factors that influence the springback phenomenon in the case of the cylindrical and conical drawn parts made from steel sheets.
Keywords: deep drawing, conical and cylindrical parts, springback

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

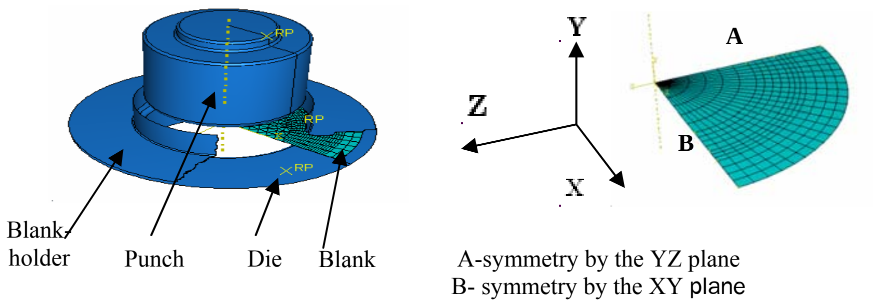
2.CONDITIONS OF SIMULATIO
The analysis concerning the behaviour of the homogeneous metal sheets was performed by simulation using the ABAQUS-Explicit software. The simulation was performed for the parts made from FEPO 5MBH steel sheets. The materials elastic properties used for simulation were as follows: Young's modulus $2x10^5$ MPa, Poisson's ratio 0.3, density: 7800 kg /m3. A two dimensional model was used for the simulation. The geometry and dimensions of the parts and models used in simulation are shown in figures 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 axisymmetric condition. Because of the axisymmetry of the plate, only the right-half portion of the tools and work-piece 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.

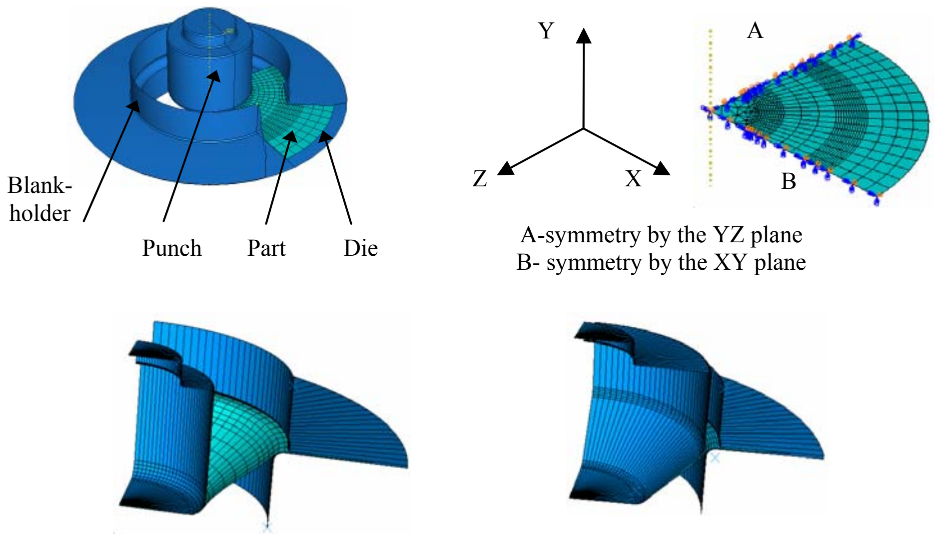


a.cylindrical part *b.conical part*

Figure 1. Geometry of the parts



a.cylindrical part



cylindrical punch *conical punch*

b.conical part

Figure 2. Geometry of the model used in simulation

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 materials were considered elastic-plastic with an isotropic hardening. The working parameters were as follows: drawing depth: 62 mm, drawing speed: 18 mm/s, blank holding force: 20 kN…..60 kN; friction coefficient: $\mu = 0{,}005 \ldots 0{,}15$.

The variation of deviations from the theoretical cylindrical profile, measured along the part profile for different blankholder forces and friction coefficients, are shown in Fig. 3 and the values of springback parameters are given in table 1. The variation of deviations from the theoretical conical profile, measured along the part profile for different blankholder forces and friction coefficients, are shown in Fig. 4 a – case of cylindrical and b -conical punches, and the values of springback parameters are given in tables 2 and 3.

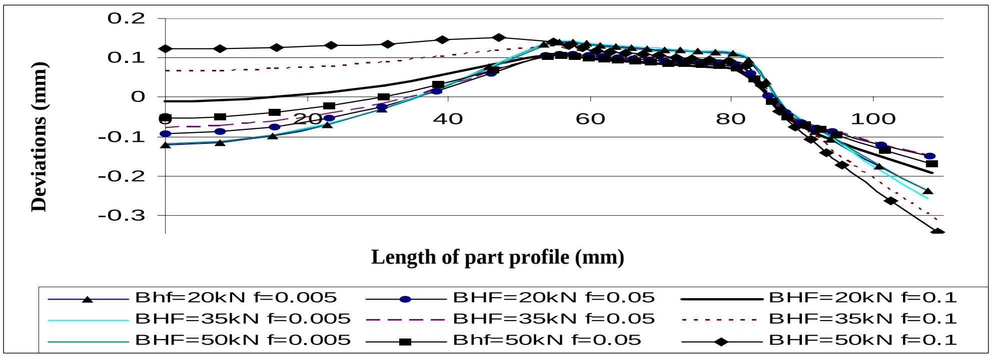
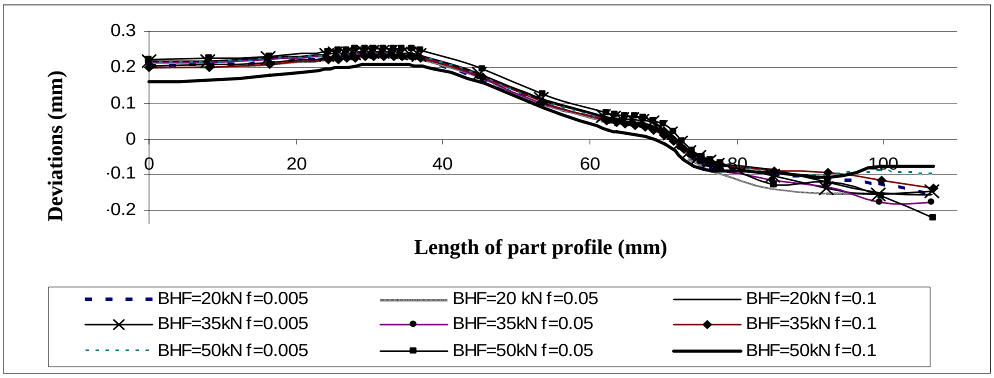


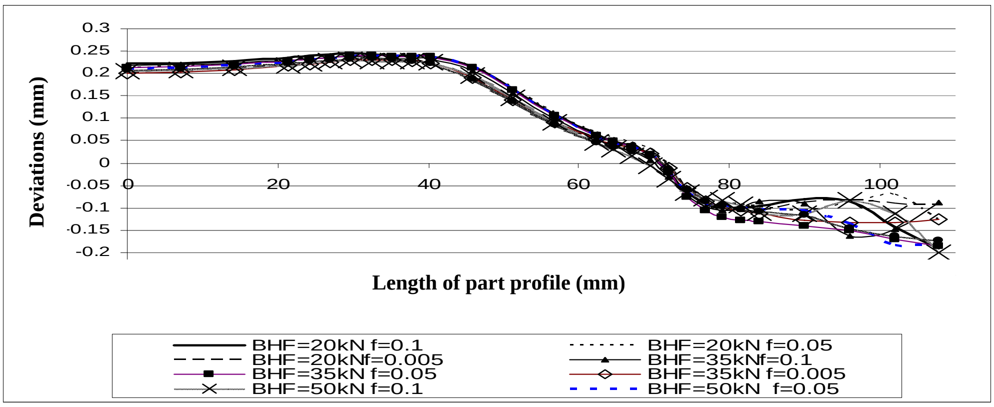
Figure 3. Variation of deviations from the theoretical cylindrical profile, measured along the part profile

Table 1. Values of springback parameters for different blankholder forces and friction coefficients

Process parameter	BHF [kN]	20			35			50		
	f	0.005	0.05	0.1	0.005	0.05	0.1	0.005	0.05	0.1
Springback parameter	wall - flange radius of connection [mm]	4.45	4.51	4.61	4.43	4.63	4.84	4.43	4.77	4.40
	bottom – wall radius of connection [mm]	6.47	6.425	6.41	6.46	6.51	6.41	6.45	6.41	6.39
	springback angle [°]	-0.57	-0.49	-1.32	-0.63	0.63	0.39	-0.58	-0.46	-0.71



a.case of conical punch



b.case of cylindrical punch

Figure 4. Variation of deviations from the theoretical conical profile, measured along the part profile

Table 2. Values of springback parameters - case of conical punch

process parameters	BHF [kN]	20	35	50
	f	0,1		
springback parameters	Flange radius [mm]	6.44	6.48	6.81
	Bottom radius [mm]	4,87	4.31	4.26
	Springback angle of the flange [°]	-0.95	-0.25	-0.53

Table 3. Values of springback parameters - case of cylindrical punch

process parameters	BHF [kN	20	35	50
	f	0,1		
springback parameters	Flange radius [mm]	6.33	6.17	6.412
	Bottom radius [mm]	4,425	4.419	4.416
	Springback angle of the flange [°]	-0.67	-0.38	-0.13

4. CONCLUSIONS

The deviations from the from theoretical profile of parts due to springback, measured along the part profile in the case of a cylindrical drawn part as a function of different blankholder forces and friction coefficients, are generally small; thus, for the applied balnkholder forces the deviations vary between +0,12 till -0,17mm and for the used friction coefficients between +0,12 till -0,25mm.

The variation of the springback parameters as a function of different blankholder forces and friction coefficients in the case of a cylindrical drawn part takes place in small limits and it can be explained by the modification of stresses and strains state of the material depending on blankholder force and friction coefficient values. Thus, the utilization of high blankholder forces in drawing blocks the flow of the material into the die cavity, leading to the elimination of the differences among the stresses and strains state on the two faces of the part, especially in the sidewall region, with 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 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.

5.REFERENCES

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Acknowledgments. This research was performed with the financial support of the Romanian Ministry of Education and Research in the frame of the CEEX Research Programme.