EXPERIMENTAL ANALYSIS OF THE SPRINGBACK PARAMETERS OF THE CYLINDRICAL DRAWN PARTS

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Abstract: Springback is an instability phenomenon that affects the dimensional accurace of the drawn part. In order to find a method wich allow to eliminate or at least to control the springback, it is necessary first to analyze the variables which influence its magnitude.
The pressent work deals with the effect of the blankholder force coupled with the friction conditions on the springback parameters of the cylindrical drawn parts.

Keywords: blankholder force, friction conditions, springback parameters

1. INTRODUCTION

Sheet metal forming involves the transformation of a flat sheet of metal into a useful shape. A common problem in this transformation is the undesired shape change of the formed part after the removal of the forming load. This phenomenon is called springback and results from changes in strain produced by elastic recovery. It often causes difficulties in part assembly, an extra work being usually necessary to compensate for the shape deviations. Therefore, accurate prediction of springback in sheet metal forming operations is essential to improve the quality of the stamping parts. In order to accomplish this task, it is necessary to know what the factors are and how they influence the amount of springback.

The purpose of this work is to experimentally analyze the effect of the blankholder force coupled with the friction conditions on the springback behavior of the cylindrical drawn parts.

2. METHODOLOGY AND TESTING CONDITIONS

In order to quantify the effect of the process parameters on the springback of the cylindrical draw parts, the following steps were done:

- deep drawing of the cylindrical draw parts;
- three-dimensional scanning of the obtained parts and measurement of the resulted profiles;
- estimation the dimensional deviations of the parts.

2.1 Deep drawing of the cylindrical parts

The tests were carried out under the following experimental conditions:

- blankholder force between 2.5 kN and 140 kN;
- drawing speed: 18 mm/min;
- with/without lubrification.

The cups were made in steel FEPO 5MBH whose properties are presented in tab. 1. The blank dimensions were 200 mm diameter per 0.08 mm thickness. During the experiments, blankholder force variation was obtained using a hydraulic device manually driven, and a manometer for indicate the pressure. A blankholder force of

2.5kN, resulted in flange wrinkling (fig. 1,a) while at 140kN, the material fracture occurred (fig.1,b). Any such phenomena were obtained for the blankholder force values within the interval 5 ÷ 125kN.

Tab. 1. Material properties

FEPO 5MBH Steel					
Chemical composition (% max.)	C = 0.1; P = 0.034; S = 0.035; Mn = 0.45				
Rolling direction [deg.]	Young's modulus [MPa]	Tensile strength [MPa]	Total elongation [%]	Anisotropy coefficient, r	Work hardening coefficient, n
0	182	280	42	1.655	0.234
45	185	271	38	1.564	0.232
90	188	274	28	2.143	0.233

a. flange wrinkling b. material fracture

Fig. 1 Defects of drawn parts

2.2 Three-dimensional scanning of the cylindrical draw parts

The geometrical parameters of the parts profile resulted at the end of the deep drawing process were determined by three-dimensional scanning, using the 3D scanning machine (fig. 2). The draw parts are scanned by touching with a piezoelectric sensor. The scanning results can be saved in a file of pix type or can be exported in another format desired by the user. In this research, the results were exported into AutoCAD in order to carry out the parts measurements.

Fig. 2 Scanning the drawn part

2.3 Estimation the dimensional deviations of the parts

In order to estimate the parts deviations caused by the springback phenomenon, the above resulted geometry was compared to the prescribed one. The theoretical dimensions of the finished part and the geometrical parameters whose variation was supervised during the experimental investigation are shown in fig 3, 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

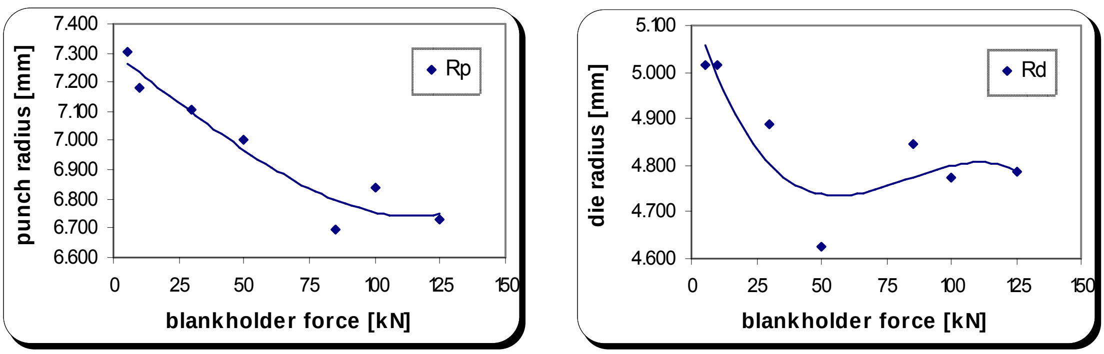
3. TESTING RESULTS

3.1 Experimental results concerning the influence of the blankholder force on the springback parameters in the case of deep drawing without lubrication of the cylindrical parts

The values of the springback parameters and their variation curves as a function of blankholder force are presented in tab. 2 and fig. 3 respectively.

Tab. 2. Geometrical parameters of the drawn parts

Material: FEPO 5MBH, Part height: 30 mm, without lubrication					
Blankholder force [kN]	**R_p [mm]**	**R_d [mm]**	**h [mm]**	**α [deg]**	**β [deg]**
F = 5	7.303	5.015	17.653	0.796	0.826
F = 10	7.180	5.017	17.820	1.553	0.920
F = 30	7.103	4.889	17.896	0.370	0.644
F = 50	7.006	4.625	18.244	0.626	0.398
F = 85	6.697	4.845	18.690	0.126	0.226
F = 100	6.842	4.772	17.645	0.404	1.293
F = 125	6.863	4.785	18.234	0.288	1.177



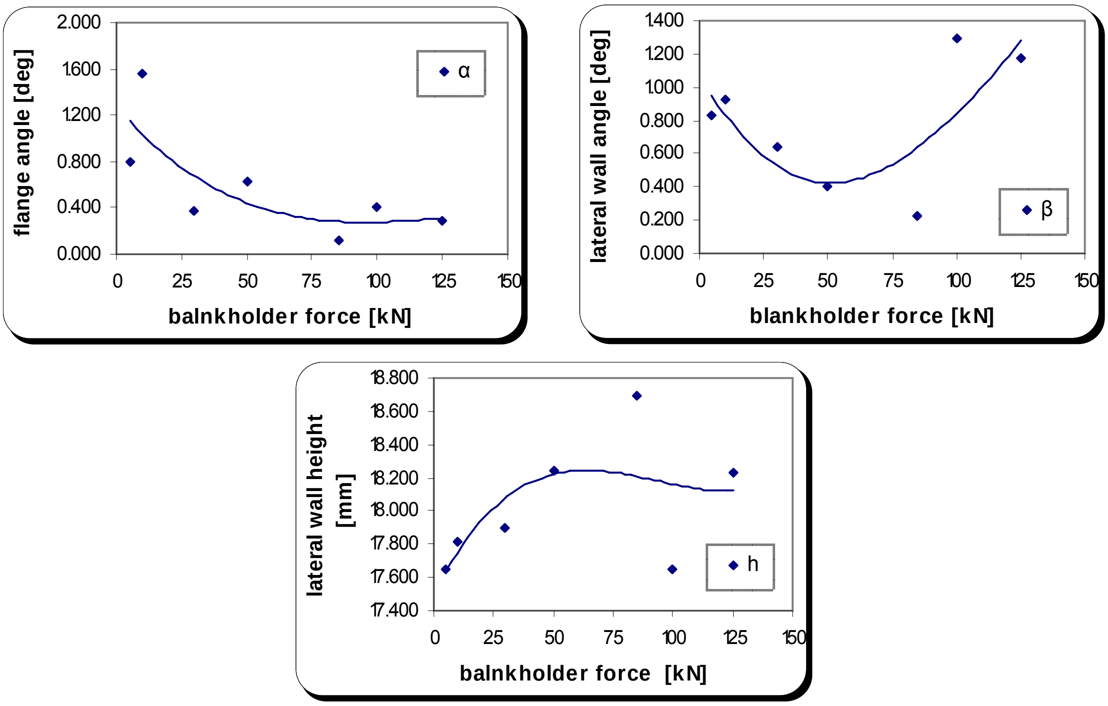


Fig. 3 Variation of the springback parameters

3.1.1 Conclusions

From the analysis of the above presented results, following observations can be made:

- 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 blankholder force determines the springback decreasing;
- in the zone of the die radius, the springback variation is changing as function of a "key" value of the blankholder force (50kN); so:
  - for F < 50 kN, the force increasing determines the springback decreasing;
  - for F > 50 kN, a rise tendency of the springback can be observed at the force increasing, influencing thus the comportment of the material from the adjacent zones (diminishes the height of the lateral wall and increases its inclination with ≈70%);
- the flange angle decreases as the blankholder force increases.

3.2 Experimental results concerning the influence of the blankholder force on the springback parameters in the case of deep drawing with lubrication of the cylindrical parts

The values of the springback parameters and their variation curves as a function of blankholder force are presented in tab. 3 and fig. 4 respectively.

Tab. 3. Geometrical parameters of the drawn parts

Material: FEPO 5MBH, Part height: 30 mm, with lubrication					
Blankholder force [kN]	**R_p [mm]**	**R_d [mm]**	**h [mm]**	**α [deg]**	**β [deg]**
F = 5	7.313	5.032	17.939	0.630	0.613
F = 10	7.044	4.898	17.944	0.104	0.568
F = 30	6.911	4.703	18.566	0.357	1.473
F = 50	7.077	4.795	17.925	0.063	0.661
F = 85	7.018	4.941	18.452	0.377	1.630
F = 100	6.382	4.919	18.586	0.409	0.882
F = 125	6.580	4.898	18.360	0.362	1.653

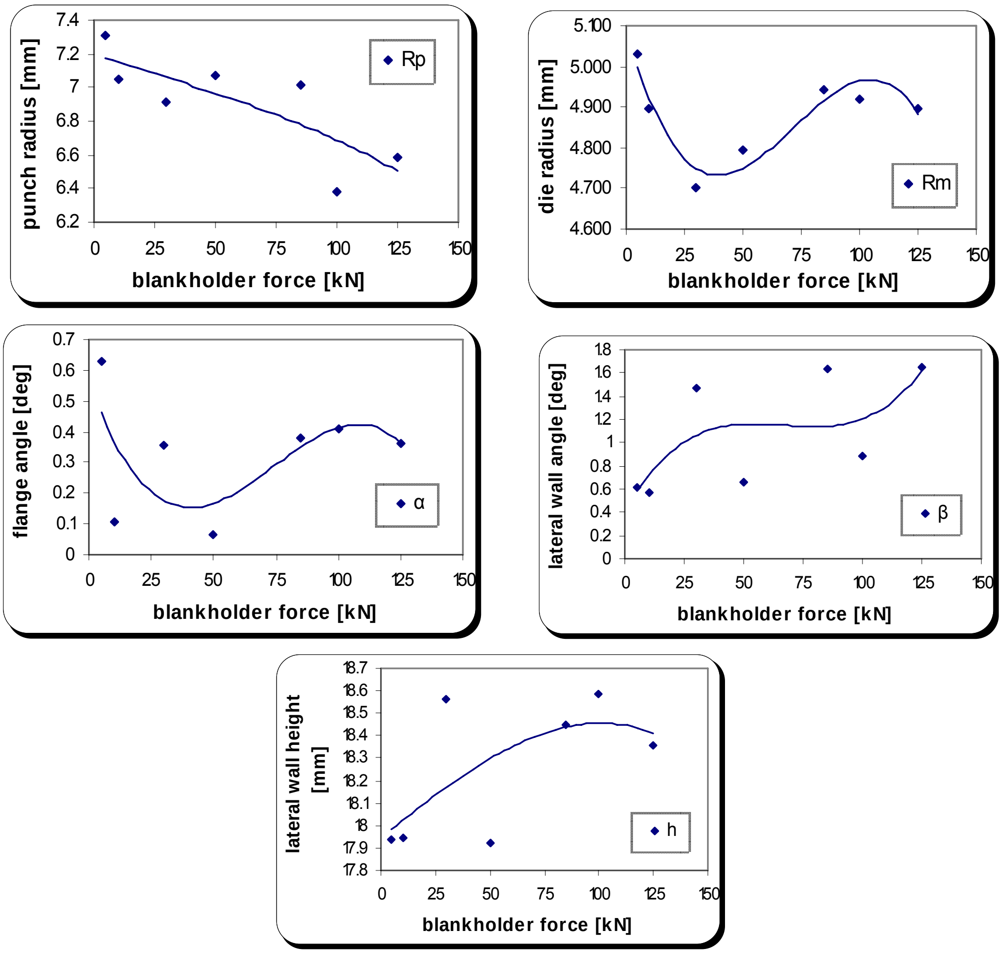


Fig. 4 Variation of the springback parameters

3.2.1 Conclusions

Based on the above results the fallowing observations can be drawn:

- 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 blankholder force determines the springback decreasing ;
- at the level of the die radius, the springback decreases as the blankholder force increases till around 50kN; for the forces bigger than 50kN, the springback increases, affecting the material comportment from the adjacent regions.
- the difference between prescribed height of the lateral wall and the real height become lower as the blankholder force increases.

4. CONCLUSIONS

- The experimental analysis was performed in order to determine the influence of the process parameters (blankholder force coupled with friction conditions) on the springback parameters of the cylindrical drawn parts;
- The geometrical entities chosen to quantify the springback of the part were: the zones corresponding to the tools radii (**R_d**) and (**R_p**) respectively, the height of the lateral wall (**h**), the flange angle (**α**) and the inclination of the lateral wall (**β**).

- The cylindrical deep-drawing process was performed in different experimental conditions: different blankholder forces (5, 10, 30, 50, 85, 100, 125kN) and different friction conditions (with/without lubrication); after the measurement of the resulted profiles, the following aspects were observed:
  - the springback phenomenon leaded to the increasing of the geometric parameters of the part compared to the nominal parameters (except the height of the lateral wall which resulted smaller than the theoretical one with about 1.5 mm);
  - the variation trend of the process parameters as a function of the blankholder force are approximate the same for both deep drawing with/without lubrication (fig.5);
  - in both cases remarked a "key" values of the blankholder force (**50kN**) to which reported the variation of the springback parameters.
  - when the lubrication is used, the material springback is generally more pronounced because the liquid pellicle eases the material flow into the die cavity, diminishing thus the effect exercised by the blankholder force.

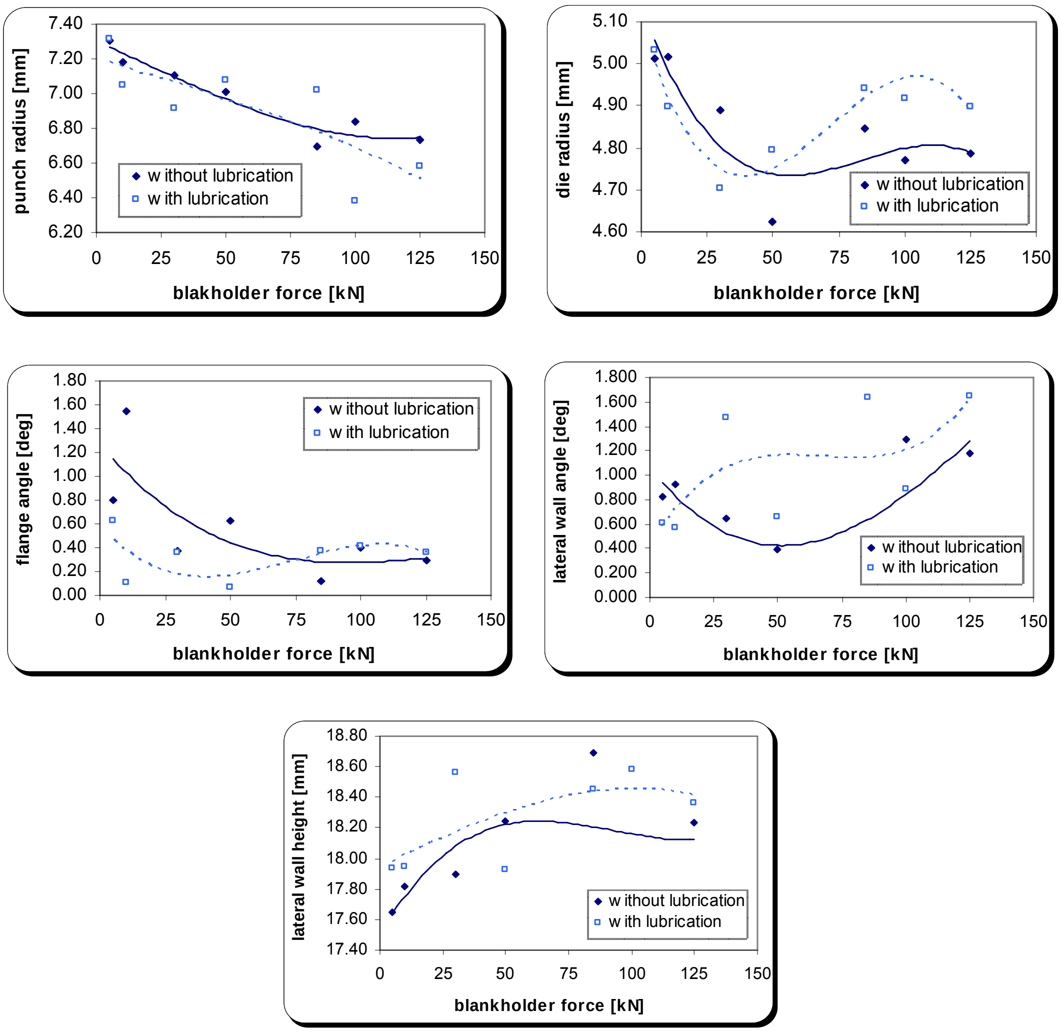


Fig. 5 Springback parameters obtained with different work conditions

5. BIBLIOGRAPHY

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