EXPERIMENTAL ANALYSIS CONCERNING THE INFLUENCE FACTORS ON SPRINGBACK PHENOMENON IN THE CASE OF CYLINDRICAL DRAWN PARTS

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Abstract: Springback is one of the phenomenons that greatly affect the accuracy of the sheet metal parts obtained by forming processes. In its turn, springback is affected by different factors as material properties, tools geometry, process parameters, whose influence is needed to be analysed in order to know how to control them such that the material springback be minimum.
In this paper, the experimental analysis concerning the influence of blankholder force and friction conditions on the springback phenomenon in the case of cylindrical deep drawn parts is presented.

Keywords: experimental analysis, springback, cylindrical deep-drawing process

1. INTRODUCTION

Due to the complex loading the material is obeyed during the deep drawing process, the quality of the resulted parts will be always more or less influenced by the material springback. But the quality of deep-drawn parts is assigned to their dimensional and shape accuracy and hence, the objective of each deep-drawing process is to obtain parts whose geometry be closed as much as possible to the prescribed theoretical profile, respective the effect of springback be minimum. In order to accomplish this goal, a very good knowledge of three categories of factors implied into process and their interaction is necessary, respective:

- the working conditions (blankholder force, friction between material and tools, drawing force, drawing speed, etc.);
- the tools geometry (punch radius, die radius, punch-die clearance, etc.);
- the material characteristics (chemical composition, Young's modulus, coefficient of Poisson, anisotropy, etc).

The study of all these variables is quite laborious and expensive and this is the reason for that in this paper the experimental analysis concerning the influence of only two process parameters (blankholder force and friction conditions) on the springback phenomenon will be presented.

2. METHODOLOGY AND TESTING CONDITIONS

2.1 Determination of the material characteristics

The experimental analysis was performed in the case of cups made from FEPO 5MBH steel sheets. The material mechanical properties were determined by uniaxial tensile tests on a universal testing machine equipped with Hottinger cell force of 25tf and an electronic data acquisition system, type Spider 8. The measurement of specific strains for determination of stress-strain curves was performed by using a uniaxial extensometer and Hottinger electric resistive wire strain gauges. The data acquisition, processing and visualisation were performed by using a Catman - Professional software. The used rate of data acquisition was of 5 points/sec for a crosshead-rate of 10 mm/min. The specimens were cut as a function of the rolling direction being achieved sets of specimens corresponding to the directions of 0º, 45º and 90° and were worked by milling and grinding in order to obtain the prescribed dimensions. The reference length of the specimen was equal to 50 mm (**fig. 1**). To obtain a good accuracy of the results, three specimens were tested for each determination.

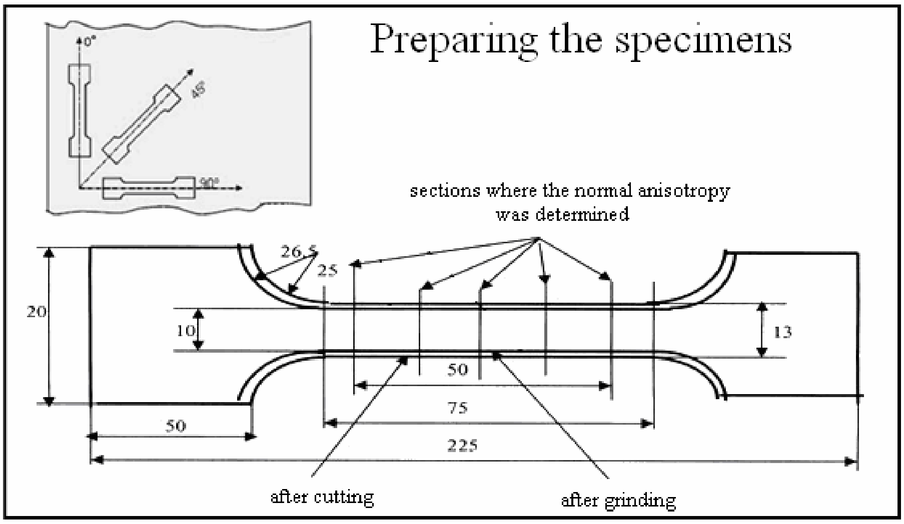

Fig. 1 Preparing the sheet specimens

2.2 Testing equipment

The tensile tests were performed by using the equipment presented in **fig. 2**. The variation of the blankholder force was achieved by using a hydraulic device manually driven, the fluid pressure being indicated by a pressure manometer of 250bar. Measurement of the punch stroke was performed by using an inductive displacement transducer and the punch load was measured by using a force cell of 25tf. The die components are presented in **fig. 3.**

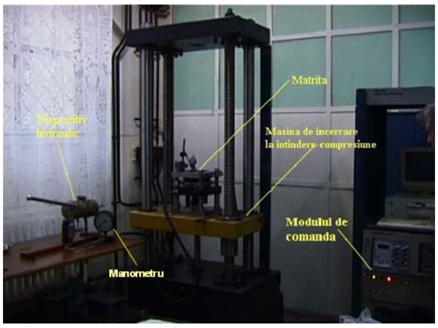

Fig. 2 Testing equipment

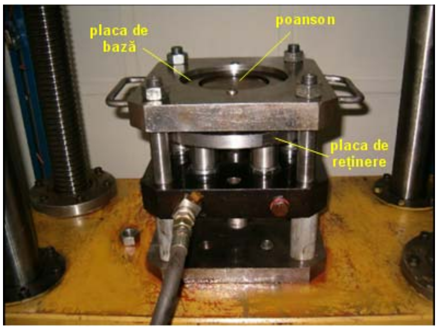

Fig. 3 Die components

2.3 Experimental conditions

The tests were carried out by using the following experimental conditions: values of the blankholder force between 2.5kN and 140kN, drawing speed 18 mm/min, with/without lubrication. The blank dimensions were 200mm diameter per 0.8 mm in thickness.

The geometrical parameters of the part profile resulted at the end of the deep-drawing process were determined by three-dimensional scaning , using a 3D scaning machine - Roland Modela MDX-15. The scaning results were then exported into a CAD software in order to carry out the part measurements.

The nominal dimensions of the finite part and the geometric parameters whose variation was investigated in order to quantify the amount of springback are presented in **fig. 4**, where: r_d is the radius of connection between the part flange and part sidewall, r_p is the radius of connection between the part bottom and part sidewall, α is the angle of the flange, β is the inclination angle of part sidewall and h is the height of the part sidewall.

theoretical profile analyzed geometric parameters

Fig. 4 Geometry of the part

3. EXPERIMENTAL RESULTS

The experimental tests were performed by using values of blankholder force between 2.5kN and 140kN. When a blankholder force equal to 2.5kN was used, the wrinkling of the part flange occurred while the usage of a blankholder force of 140kN lied to the part tearing near the zone of the punch radius.

The values of the geometrical deviations from the theoretical profile of parts due to the springback phenomenon, in the case of deep-drawing without lubrication of the cylindrical parts, by using different blankholder forces, are presented in **tab. 1**.

Tab. 1

Values of the geometrical deviations from the theoretical profile of parts

Material = FEPO 5MBH, Part depth = 30 mm, without lubrication					
Blankholder force [kN]	r_p	r_d	h	α	β
F = 5	1.303	1.015	-2.347	0.796	0.826
F = 10	1.180	1.017	-2.180	1.553	0.920
F = 30	1.103	0.889	-2.104	0.370	0.644
F = 50	1.006	0.625	-1.756	0.626	0.398
F = 85	0.697	0.845	-1.310	0.126	0.226
F = 100	0.842	0.772	-2.355	0.404	1.293
F = 125	0.863	0.785	-1.066	0.288	1.177

The values of the geometrical deviations from the theoretical profile of parts due to the springback phenomenon, in the case of deep-drawing with lubrication of the cylindrical parts, by using different blankholder forces, are presented in **tab. 2**.

Tab. 2

Values of the geometrical deviations from the theoretical profile of parts

Material = FEPO 5MBH, Part depth = 30 mm, with lubrication					
Blankholder force [kN]	r_p	r_d	h	α	β
F = 5	1.313	1.032	-2.061	0.630	0.613
F = 10	1.044	0.898	-2.056	0.104	0.568
F = 30	0.911	0.703	-1.434	0.357	1.473
F = 50	1.077	0.795	-2.075	0.063	0.661
F = 85	1.018	0.941	-1.548	0.377	1.630
F = 100	0.382	0.919	-1.414	0.409	0.882
F = 125	0.58	0.898	-1.64	0.362	1.653

4. CONCLUSIONS

The analysis of the obtained results emphasised the following aspects concerning the springback of the cylindrical drawn parts:

- due to the springback phenomenon the geometrical parameters of the resulted parts differ from the theoretical ones;
- in the zone corresponding to the punch radius the blankholder force increasing determines the springback decreasing, both when lubrication is/ is not used;
- in the zone corresponding to the die radius, the springback variation is changing as a function of a “key” value of the blankholder force, 50kN, respectively. So, related to the experimental results:
  - for BHF < 50kN, the force increasing determines the springback decreasing;
  - for BHF > 50kN, a rise tendency of the springback can be observed to the force increasing, influencing thus the behaviour of the material from the adjacent zones.
- after springback the sidewall height results smaller than the theoretical one (with ≈ 1.5 mm), the variation curve having a rising tendency to the increasing of blankholder force;
- in the case of deep drawing without lubrication, the inclination angle of the part sidewall decreases as the blankholder force increases till 50kN; when bigger than 50kN blankholder forces are used, the inclination sidewall angle greatly increases (with ≈ 70%). In the case when lubrication is used, the blankholder force increasing determines the sidewall angle increasing.
- the flange angle decreases as the blankholder force increases in the case of deep drawing process without lubrication; when the lubrication is used, α decreases for BHF < 50kN and increases for BHF > 50kN.
- the dimensional deviations are bigger in the case of deep drawing with lubrication (especially for BHF > 50kN) compared to the deviations resulted in the case of deep drawing without lubrication (**fig. 5**). Lubrication reduces the friction between tools and metal sheets, this fact leading to an easier flow of material into the die cavity, reducing thus the control exercised by the blankholder force.

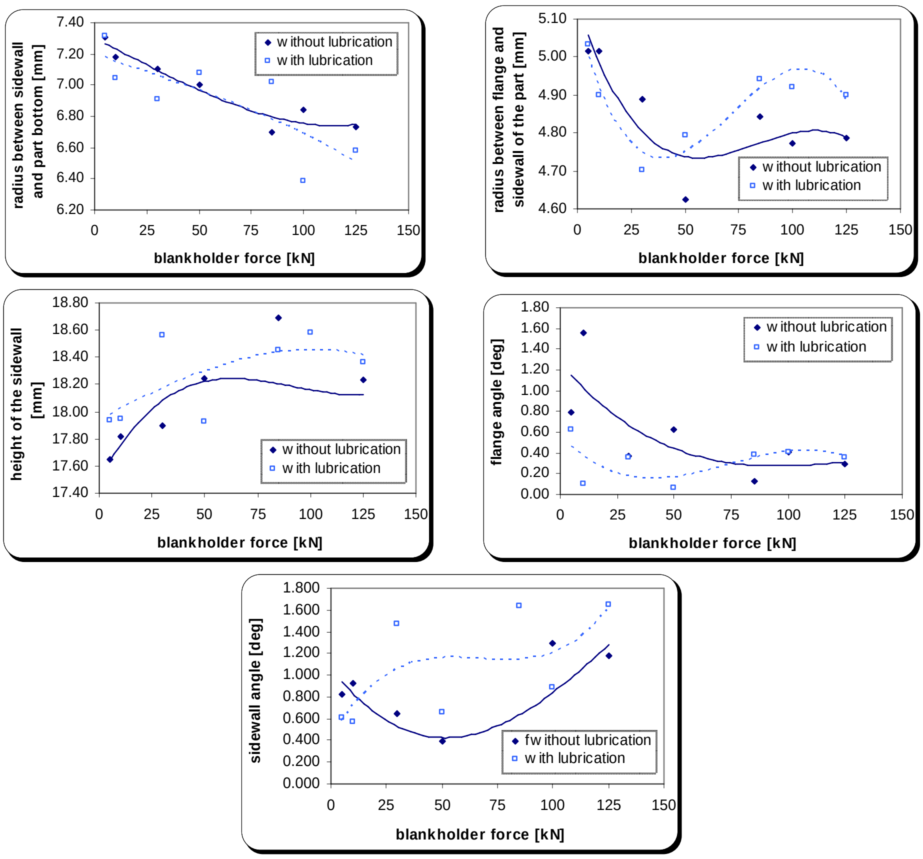

Fig. 5 Comparative analysis of the experimental results

5. REFERENCES

Axinte C., (2006), *Theoretical and experimental researches concerning the springback phenomenon in the case of cylindrical deep-drawn parts*, Ph. D. Thesis.