EXPERIMENTAL AND SIMULATION ANALYSIS OF SPRINGBACK IN THE CASE OF A DRAWN HALF-RIM MADE USING TOOLS CORRECTED BY APPLYING THE TAGUCHI METHOD OF OPTIMIZATION

C. Schnakovszky, G. Brabie, B. Chirita, C.Chirila, C. Axinte

University of Bacau, Romania

Abstract: Springback of draw parts considerably affects their accuracy and deviations from the theoretical profile, this instability phenomenon determining the following changes of the part shape and geometric parameters: arching of the part sidewall, modification of the angle formed by the part bottom and the sidewall, modification of the angle between the flange and the sidewall. Hence, in order to obtain the desired accuracy of the draw parts it is necessary the development of a method for the reduction or the elimination of the springback. The present paper presents the results of an experimental analysis of springback parameters resulted in the case of a draw half-rim manufactured by using tools corrected in the designing stage by applying the optimization Taguchi's method.

Keywords: springback, draw half rim, corrected tools, Taguchi's method

1. INTRODUCTION

Springback of draw parts considerably affects their accuracy and deviations from the theoretical profile, this instability phenomenon determining the following changes of the part shape and geometric parameters: arching of the part sidewall, modification of the angle formed by the part bottom and the sidewall, modification of the angle between the flange and the sidewall. Hence, in order to obtain the desired accuracy of the draw parts it is necessary the development of a method for the reduction or the elimination of the springback.

An optimal solution can be obtained by using the process simulation in combination with a statistical modelling that allows the mathematical description of the influence of different process parameters on the draw part geometry and accuracy. For this purpose, the factorial design offers the possibility to use a statistical method – for example Taguchi method. This method uses some predefined tables and on their basis it is possible to establish the relative importance of process parameters and their interactions on the springback intensity. The Method is applied in the following six steps: 1. Definition of geometric parameters that characterize the geometric deviations of the part. 2. Selection of process parameters that influence the part geometry and its field of variation. 3. Selection of the model of linear or quadratic polynomial dependence and construction of fractioned factorial plane of experiment. 4. Process simulation according to experimental plane and the measurement of geometric deviations of the resulted parts. 5. Calculation of coefficients of the polynomial models and verification of the models. 6. Optimization of the process parameters in order to obtain the desired geometric parameters of the draw part. The paper presents the results of an experimental analysis of the springback parameters resulted in the case of a draw half-rim manufactured by using tools corrected in the designing stage by applying the optimization Taguchi's method.

2. LABORATORY SCALE AND SIMULATION FORMING TESTS USING THE CORRECTED TOOLS

2.1 Conditions of investigation

The geometry of the analyzed part is presented in Figure 1 and the geometry of tools corrected according to the geometry resulted by applying the Taguchi optimization method is presented in Figure 2. The experimentally and simulation investigations using the corrected tools were performed in the following working conditions: blank holder force BHF = 75 kN, friction coefficient μ = 0.15.

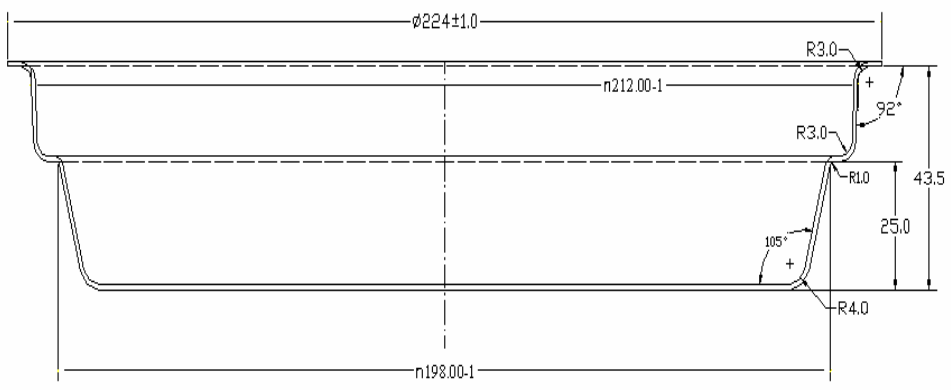
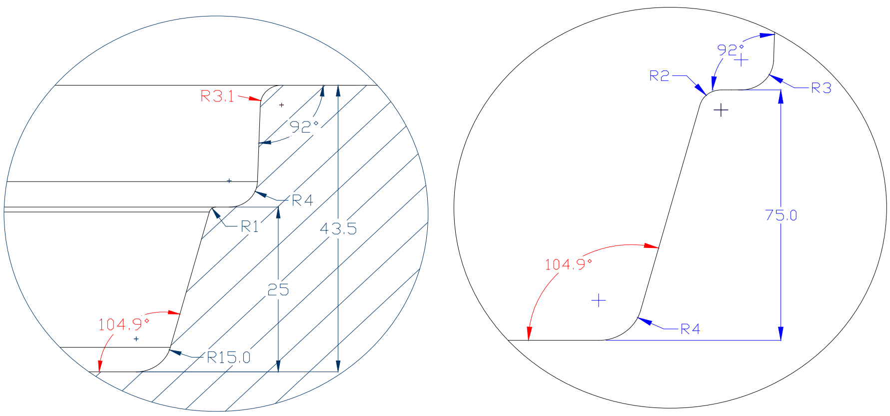


Fig. 1 Geometry of the desired part after drawing



a. Die detail b. Punch detail

Fig. 2 Geometry of the corrected tool

2.2 Verification by experiment of the optimized tools and process

Using the optimized tools the resulted parts presents the deviations given in Table 1. The experimental analysis was performed for the following blank holder force: 75 kN.

The verification of the geometrical deviations of the draw pieces after drawing and after additional operations obtained from experimental investigations was performed by using a 3D scanning machine.

Table 1

Geometric parameters of the part	Theoretical	Experiment	Deviation
R [mm]	3	3.28	+0.28
H1 [mm]	25	25.3	+0.3
H2 [mm]	43.5	43.39	+0.11
α [grd]	105	105.52	+0.52

2.3. Verification by simulation of the optimized tools and process

Using the optimized tools and process parameter the resulted parts presents the geometry shown in Fig. 3 and the deviations given in Table 2.

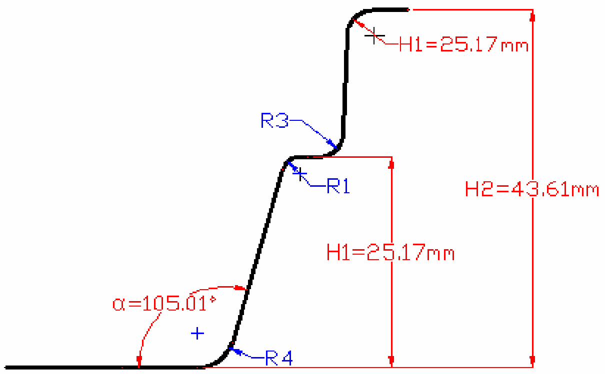


Fig. 3 Geometric parameters of the part obtained from simulation after tools correction

Table 2

	Parameter values for which the function L has a minimum value				Values resulted for the followed dimensions			
	F [kN]	μ	Rd [mm]	β [grd]	R [mm]	H1 [mm]	H2 [mm]	α [grd]
Theoretical	72.46	0.12	3.09	104.92	3.14	24.82	43.16	104.59
Simulation					3.38	25.17	43.61	105.01
Deviation					+0.24	+0.35	+0.45	+0.42

From the results given in the above-presented table we can observe a small variation in comparison with the initial geometry of tool.

3. CONCLUSIONS

1. The design of devices for the half rim drawing was performed using the Taguchi optimization method for stamping processes of homogeneous steel sheets. The following two models were applied in optimization of tools geometry: linear model and quadratic model.

2. The corrected tools were manufactured according to the geometry resulted by applying the optimization method. The experimentally and simulation investigations using the corrected tools were performed in the following working conditions: blank holder force BHF = 75kN, friction coefficient $\mu = 0.15$.
3.The corrected tools allowed obtaining the improvement of the shape and dimensions accuracy of the draw parts by a considerable decreasing of all four considered springback parameters and deviations. The resulted relative deviations from the nominal dimensions are as follows: R_1 10%, H_1 0,4%, H_2 0,45% and α 0,47%
4.The values obtained from simulation are very close to those obtained from experiment.

Acknowledgments

This research was performed with the financial support from the European Commission in the frame of the "5 Frame Programme".

References

[1] Apostolos P., a.o. – *TOOLING AND BINDER DESIGN FOR SHEET METAL FORMING PROCESSES COMPENSATING SPRINGBACK ERRORS*, Int. J. Mech. Tools Manufact., 4, 503-526, 1996
[2] Chirita B. – *CONTRIBUTII TEORETICE SI EXPERIMENTALE PRIVIND FENOMENUL DE REVENIRE ELASTICA LA INDOIREA IN U A TABLELOR METALICE*, Teza de doctorat Univ. Politehnica Bucuresti, Decembrie 2004
[3] Choi K.K., Kim N.H. – *DESIGN OPTIMIZATION OF SPRINGBACK IN A DEEPDRAWING PROCESS*, AIAA Journal vol. 40, no. 1, p.147-153, 2002
[4] Ghouati O., Joannic D., Gelin J.C. – *OPTIMIZATION OF PROCESS PARAMETERS FOR THE CONTROL OF SPRINGBACK IN DEEP DRAWING*, Proc. of the 6th Int. Conf. on Numerical Methods in Industrial Forming Processes, Numiform'98, 1998
[5] Hsu T.C., Shien I.R. – *FINITE ELEMENT MODELING OF SHEET FORMING PROCESS WITH BENDING EFFECTS*, , J. of Mat. Proc. Tech. 733-737, 1997
[6] Papeleux L., Gohy S., Collard X., Ponthot J.P. – *SPRINGBACK SIMULATION IN SHEET METAL FORMING USING IMPLICIT ALGORITHMS*, Int. Conf. Numisheet'99, p. 23-28, Besancon, 1999
[7] Ponthot P.J., a.o. – *NUMERICAL SIMULATION OF SPRINGBACK IN SHEET METAL FORMING*, ECCOMAS 2000, 1-19, 2000
[8] Sabourin F., Brunet M., Vives M.- *3D SPRINGBACK ANALYSIS WITH A SIMPLIFIED THREE NODE TRIANGULAR ELEMENT*, Numisheet'99, p. 17-22, Besancon, 1999
[9] Shu J.S., Hung C. – *FINITE ELEMENT ANALYSIS AND OPTIMIZATION OF SPRINGBACK REDUCTION: THE "DOUBLE-BEND" TECHNIQUE*, Int. J. Mach. Tools Manufact. 36, 423-434, 1996
[10] Zimniak Z. – *TOOLING DESIGN COMPENSATING SPRINGBACK ERROR AFTER DEEP DRAWING AND TRIMMING OPERATION, ESAFORM* - The 5th International Conference on Material Forming, Krakow, p. 531-534, 2002