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INVESTIGATION OF SPRINGBACK IN U SHAPE BENDING WITH HOLES IN COMPONENT

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ABSTRACT

One of the sensitive features of the sheet metal forming is the elastic recovery at the time of unloading called springback. Sheet metals are prone to some amount of springback depending on elastic deformation. Obtaining the desired size and shape of the component and also design of die and punch depends on the knowledge of the amount of spring-back. So the accurate prediction of the springback is very important. The springback is affected by the factors such as sheet thickness, material properties, tooling geometry etc. In the present paper the effect of various parameters such as sheet thickness, ratio of die radius to sheet thickness i.e. R /t ratio, strength coefficient and strain hardening exponent on springback are studied for the U shape component without holes and with holes in it.

KEYWORDS: U bending, Springback, FEA, Sheet thickness, R /t ratio.

1. INTRODUCTION

Bending process is a very widely used process in forming of parts. These processes are used by automobile industry and aerospace industry for forming of the various parts needed in making the structure of the automobile and airplane. Precision of the formed parts is affected by the elastic recovery during unloading. Because of the elastic recovery, final shape of component is not as desired. This change in shape due to elastic stresses is called springback. Correct prediction of springback is therefore very important as it assist in the design of punch and die. It also helps to obtain the desired shapes with accuracy. Springback measurement by experimental process is costly and time consuming. In the recent year finite element software are very widely used for the prediction of the springback.

LIU Xiaojing et al. [1] investigated the influences of material parameters and process variables for springback for U-shaped parts and studied the effects of material hardening model, element size, the number of integration points and virtual punch velocity on springback prediction accuracy using FEA. Agus Dwi Anggono et al. [2] proposed a new method to compensate the die tool shape due to elastic deviation. M. Bakhshi-Jooybari et al. [3] studied the influence of experimental and numerical parameters such as sheet thickness, sheet anisotropy and punch tip radius for V and U die bending. Luc Papeleux and Jean-Phillippe Ponthot [4] described a classical benchmark of NUMISHEET 93 for U-die bending and studied the influence of parameters such as BHF, friction, spatial integration, time integration scheme on springback. Komgrit Lawanwong et al. [5] with aim to reduce spring-back value of sheet metal in U bending process used the corner setting technique to reduce springback. He observed that, the corner setting technique reduces springback in bending process but requires high bending force. B. Chongthairungruang et al. [6] used the different material models in Finite Element Analyses of a U-shape forming and compared for investigating the springback effect. Y. Song et al. [7] studied three point bending method used for the T-section beam bending and the prediction model of springback is developed using artificial neural network approach. Chen and Shen-fu ko [8] studied the L-bending process and proposed the reverse bend approach to reduce the springback. Aysun Egrisogut Tiryaki et al. [9] investigated the springback for wipe-bending process and developed an artificial neural network prediction model from the data obtained by FEA. He suggested the use of ANN for prediction of non-linear and complex springback problem. S. K. Panthi et al. [10] used the finite element code RRL-FEM which was able to handle large deformation. Particularly he focused on the effect of load on springback for varying thickness and the radius of the die. K. P. Li et al. [11] studied the sensitivity of numerical parameters such as number of through-thickness integration points, the angle of contact per shell element, and the tolerances for equilibrium and contact in analysis of springback using finite element analysis (FEA). Ying Gao et al. [12] studied the springback in large diameter longitudinal welded pipes JCO. Dmitry V. Zhmurkin et al. [13] studied influence of shot velocity, shot size, multiplicity of shot and effect of friction coefficient on springback for shotpeening process. Yanwei Zhang et al. [14] studied the sheet metal forming process using finite element analysis for large elastic-plastic deformation. He studied springback in the bending process for R/t, bending clearance between punch and cavity and curve of springback vs. material response.

A lot of research has been done in the last decade to find the springback characteristics for the components without hole in it. Springback for the components with hole is hardly characterized. In the industry many components are formed with holes in it. In the present paper the springback is investigated, for different sheet thicknesses, R/t ratio and yield strength, for the different materials such as IS513D, IS513EDD and DP600, with holes in component and compared results without holes in component

2. MAERIAL PROPERTIES

Three materials with different material properties as listed in the table 1 were selected for study purpose. The materials selected for the study purpose are widely used in sheet metal forming of parts in automobile industry.

Table 1.Material properties

Sr. No.	Material	YS [MPa]	UTS [MPa]	K [MPa]	n	r0	r45	r90
1	IS513EDD	151	279.2	501	0.241	1.8	1.11	1.81
2	IS513D	204	326	559.84	0.203	1.29	1.33	1.3
3	DP600	350	712.98	1080	0.14	0.9	0.9	0.9

2.1. Nomenclature

R - Die radius in mm.
t - Sheet thickness in mm.
R/t - Ratio of bending radius to sheet thickness.
K - Strength coefficient MPa.
n - Strain hardening exponent
YS - Yield strength in MPa.
UTS - Ultimate tensile strength MPa.
r - Lankford coefficient.

2.2. Component details

The Dimensions of the U shape component (header head) taken for study purpose are as listed below.

Height = 24 mm,
Width = 30 mm,
Length = 270 mm.
Thickness = varied as 0.8 mm, 1 mm and 2.0 mm.

3. METHODOLOGY

3.1 Finite Element Simulation

In this investigation, the commercial code Hyperform with radioss solver is used for forming the blank and predicting the springback. The blank shape is obtained in radioss one step. The blank and the die are modelled in the Hyperform itself. The punch is extracted from the die. The die punch set up for U shape forming is as shown in the figure 1 and it is for rectangular channel. The formed up component with hole is shown in figure 2.

The die, punch and binder are assumed to be rigid while the blank is assumed deformable. The Hill Orth tabulated material model is used to define the blank properties. The punch presses the blank inside the die, due to which the blank is formed into the desired shape. The sheet thickness of the component is varied in steps as 0.8 mm, 1 mm and 2.0 mm for each material. The punch corner radius is 2 mm. The results are obtained for different sheet thicknesses for all the three materials. These results are listed in table 2. The various parameters used during finite element analysis are as given below.

- Die radius – 2 mm fixed.
- Punch radius - 2 mm fixed.
- Blank thickness - Varied as 0.8 mm, 1 mm and 2 mm.
- Blank Holder Force - 10000 N.
- Coefficient of friction - 0.125.
- Clearance between die and punch - 10% of sheet thickness.

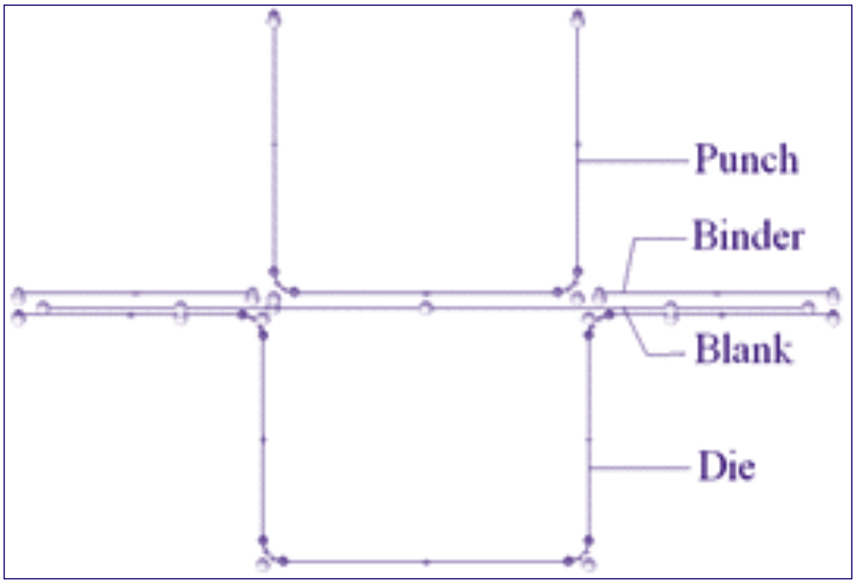

Figure 1 Die-Punch set up

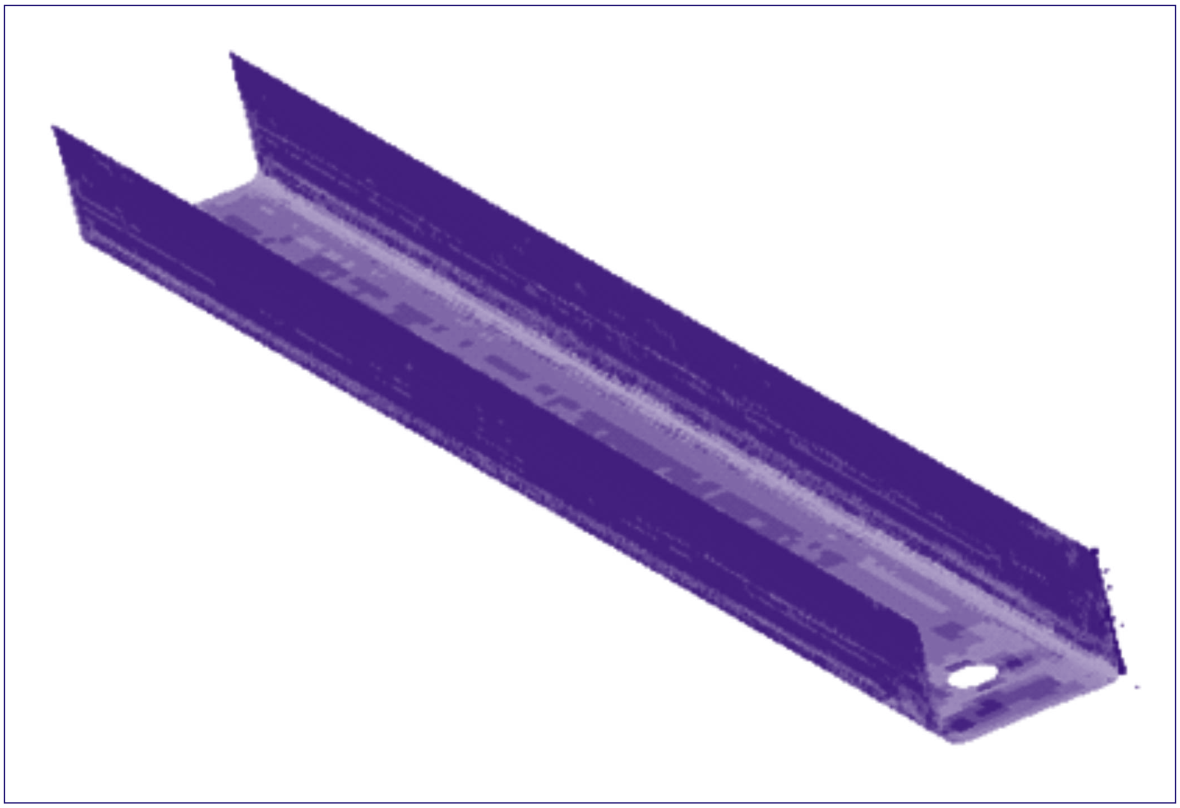

Figure 2 Formed up component with 8 mm hole

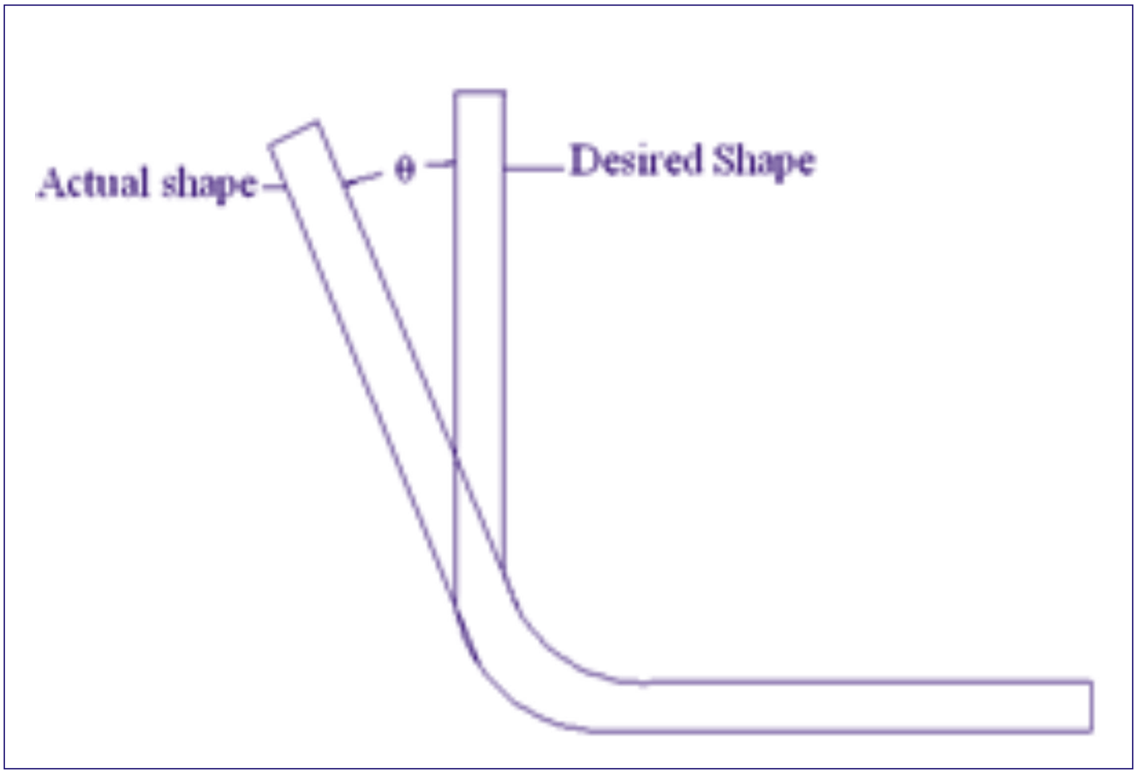

Figure 3 Schematic for springback measurement

3.2 Experimental Procedure

For obtaining the experimental results samples with holes were prepared by cutting the sheets in rolling direction and punching the hole in the sheet. Samples without hole were prepared just by cutting the sheets along the rolling direction. These samples with hole and without hole were formed in the mechanical press. The springback for the component with hole was measured adjacent to the hole. The schematic diagram for springback measurement of U shape is shown in figure 3. The experimental results obtained are listed in table 2.

Table 2 FEA and experimental Springback obtained by for various sheet thicknesses, strength coefficient and strain hardening exponent

Material	R (mm)	t (mm)	R/t	Springback (degree) without hole		Springback (degree) with 8 mm hole		K (MPa)	n	Percentage error-FEA and Experimental
				(FEA)	Experimental	(FEA)	Experimental			
IS513D	2	0.8	2.50	1.238	1.198	1.072	1.128	559.84	0.21	3.23
IS513D	2	1.0	2.00	0.946	1.044	0.683	0.846	559.84	0.21	9.38
IS513D	2	2.0	1.00	0.599	0.677	0.573	0.593	559.84	0.21	10.57
DP-600	2	0.8	2.5	2.857	-	2.617	-	1080.00	0.14	-
DP-600	2	1.0	2.0	2.272	-	1.916	-	1080.00	0.14	-
DP-600	2	2.0	1.00	1.750	1.620	1.573	1.462	1080.00	0.14	7.42
IS513EDD	2	0.8	2.50	1.160	1.051	1.025	0.946	501.00	0.2415	9.48
IS513EDD	2	1.0	2.00	0.746	0.762	0.609	0.719	501.00	0.2415	2.09
IS513EDD	2	2.0	1.00	0.549	0.597	0.516	0.504	501.00	0.2415	1.30

4. RESULT AND DISCUSSION

4.1. Influence of sheet thickness without hole and with hole in component

To investigate the effect of sheet thickness, FE simulations are run with different sheet thickness such as 0.8 mm, 1 mm and 2 mm, for each material with holes and without holes in the component. To obtain the experimental results the sheets of all the materials were cut along the rolling directions. The hole of 8 was punched in it and then the sheets were formed, in the mechanical press. The obtained results are listed in table 2. Figure 4 shows the comparison of experimental results effect of sheet thickness with hole and without hole on the springback and figure 5 shows the comparison of FEA results for sheet thickness with hole and without hole on springback. It is seen from the figures 4 and 5 that the springback decreases with increase in sheet thickness. The similar pattern is obtained for the component with hole and the component without holes, with decreased springback for components with hole.

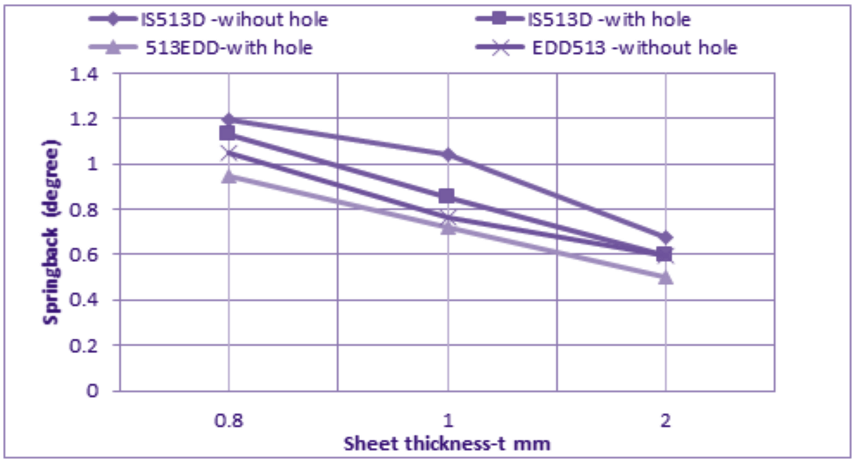

Figure 4. Comparison of experimental results for effect of sheet thickness with hole and without hole on springback for IS513D and EDD513

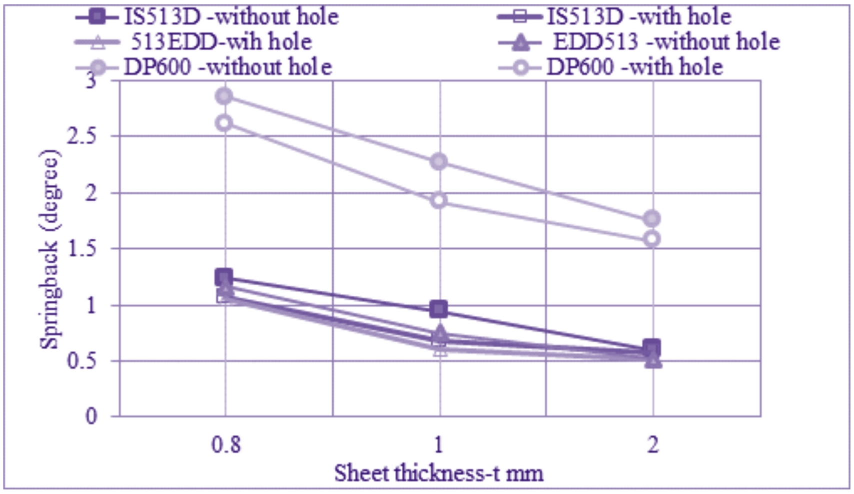

Figure 5 Comparison of FEA results for effect of sheet thickness with hole and without hole on springback for IS513D, EDD513 and DP-600

4.2. Effect of R/t without hole and with hole in component

To find the effect of ratio of die radius to sheet thickness, the various R/t ratios are obtained for the different sheet thicknesses. The results are tabulated in table 2 and are plotted on graph in figure 6 and 7. Figure 6 shows the comparison of springback obtained for experimental results with holes and without holes in component for various R/t ratios and figure 7 shows the comparison of FEA results. It is clear from the figures 6 and 7 that the springback increases with increase in R/t ratio both for the components with hole and without hole. It is because with increase in sheet thickness the springback decreases and for increase in die radii springback increases therefore for increase in R/t ratio, increase in springback is observed [9].

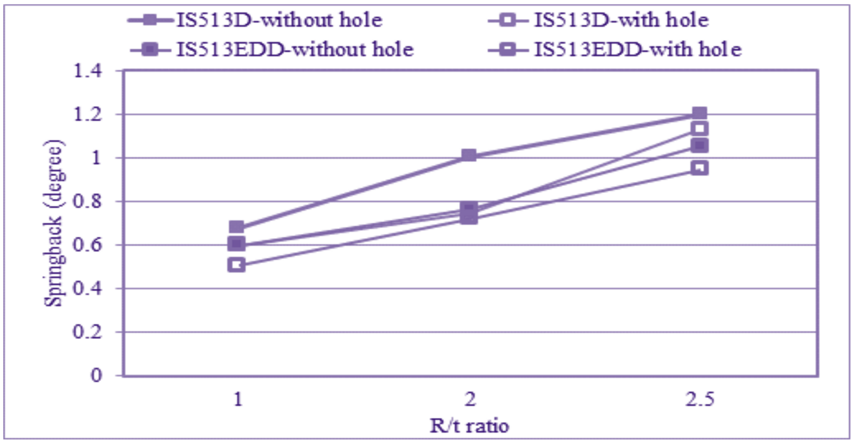

Figure 6. Comparison experimental results with hole and without hole in component for effect of R/t ratio on springback

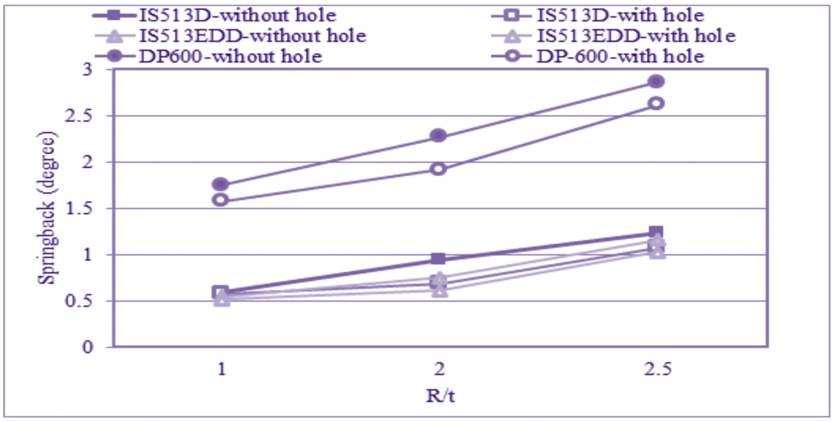

Figure 7. Comparison FEA results with hole and without hole in component for effect of R/t ratio on springback

4.3. Effect of yield strength without hole and with hole in component

To observe the effect of yield strength on springback the FE simulations are run for different sheets with holes and without holes for materials such as IS513D, IS513EDD and DP600, having different yield strengths. Also the experimental results were obtained for IS513D and IS513EDD material with hole and without hole in the component. The obtained results are listed in table 2 and plotted in the figures 8. Figure 8 show that with increase in yield strength springback increases both for the components with hole and without hole. It is because as yield stress of material decreases the residual elastic stresses remaining in the bent area for that material decrease causing the less springback for lower yield strength materials.

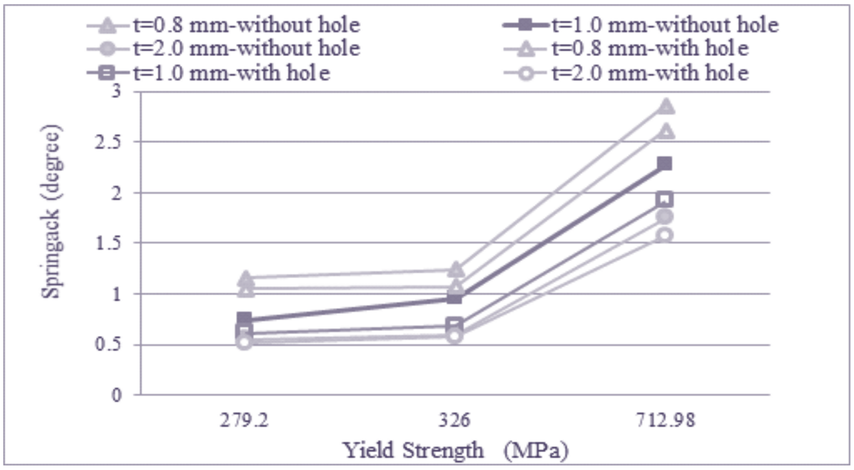

Figure 8. Effect of strength coefficient on springback-comparison of results with hole without hole in component.

5. CONCLUSION

From the obtained results for different materials the following conclusions can be drawn.

- Springback decreases with increase in sheet thickness both for the component with hole and without hole, this is because with increase in sheet thickness there is resistance for the movement of sheet. The similar patterns are obtained for components with hole and without hole, with decreased springback for components with hole.
- The springback increases with increase in R/t ratio both for the components with hole and without hole.
- It is also seen that the springback increases with increase in yield strength for the components with hole and without hole.
- Experimental results are found in good agreement with FEA results and similar patterns of the results are obtained for the components with hole and without hole with decrease in springback for the component with hole. It is because with presence of holes the residual stresses remaining in the bent area are reduced causing the springback to decrease.

REFERENCES

1. *LIU Xiaojing, ZHANG Yanshen, QIN Haibin, Research on Springback Characteristic and prediction Accuracy Control of Advanced High Strength Steel, IFOST 2010 Proceedings.*
2. *Agus Dwi Anggono, Waluyo Adi Siswanto, Badrul Omar, Combined Method of Spring-forward and Spring-back for Die Compensation Acceleration, IEEE, 2011.*
3. *M. Bakshi-jooybari, B. Rahmani, V. Daeezadeh, A. Gorji, The study of springback of CK-67 steel sheet in V-die and U-die bending process, Material and Design, 30, pp.2410-2419, 2009.*
4. *Luc Papeleux, jean-Phillippe Ponthot, Finite element simulation of springback in sheet metal forming, Journal of Material Processing Technology, pp.126-126, 785-791, 2002*
5. *Komgrit Lawanwong, Varunee Premanond, (2010) The Study of Reduction of Spring-back in U Bending Die Process, 2010 2nd International Conference on Mechanical and Electronics Engineering , ICMEE 2010.*
6. *B. Chongthairungruang, V. Uthaisangsuk, S. Suranuntchai, S. Jirathearanat, Springback prediction in sheet metal forming of high strength steels, Materials and Design 50, pp.253–266, 2013.*
7. *Y. Song, Z. Yu, Springback prediction in T-section beam bending process using neural networks and finite element method, archives of civil and mechanical engineering 13, pp.229–241, 2013.*
8. *Fuh-kuo Chen, Shen-fu ko, Deformation analysis of springback in L-bending of sheet metal, Journal of Achievements in materials and manufacturing Engineering, Vol. 18, pp.1-2, 2006.*
9. *Recep Kazan, Mehmet Firat, Aysun Egrisogut Tiryaki, Prediction of springback in wipe bending process of sheet metal using neural network, Material and Design 30, pp.418-423, 2009.*
10. *S. K. Panthi, N. Ramkrishnan, K.K. Pathak, J. S. Chouhan, An analysis of springback in sheet metal bending using*

Finite Element Method (FEM), Journal of Material Processing and Technology 86, pp.120-124, 2007.

11. *K.P. Li, L.M.Geng and R.H.Wagoner, Simulation of Springback with the Draw/Bend Test, IEEE, 1999.*
12. *Dmitry V. Zhmurkin, Ned E. Corman, Chales D. Copper and Robert D. Hilty, 3-Dimensional Numerical Simulation of Open-barrel Crimping Process, IEEE.*
13. *Yanwei Zhang, Guohua Cui, Finite Element Simulation of Springback in Sheet Metal Bending, 2009, IEEE.*

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