The International Journal of Engineering and Science (IJES)
|| Volume || 8 || Issue || 5 Series I || Pages || PP 20-24|| 2019 ||
ISSN (e): 2319 – 1813 ISSN (p): 23-19 – 1805

The influence of process conditions on springback in bending process

Peter Mulidrán[1], Emil Spišák[1], Miroslav Tomáš[1], Janka Majerníková[1], Ivan Gajdoš[1]

[1]Institute of Technology and Material Engineering,Faculty of Mechanical Engineering, Technical University of Košice, Košice, Slovakia

Corresponding Author : Peter Mulidrán

---***ABSTRACT***---

In the sheet metal forming process, the steel, in this case deep drawing quality steel DC06 exhibits springback effect, which is governed by strain recovery of material after the load removal. In this work, numerical simulation of a V-shape part bending was performed and compared with experimental data. Springback is related to many parameters like forming conditions, tool geometry and material properties such as sheet thickness, yield stress, work hardening, strain rate sensitivity and elasticity modulus.

In this contribution, the influence of process conditions on springback effect of V - shaped part made of deep drawing quality steel DC06 was investigated. In the numerical simulation, two types of Yield criterion: Hill48 and Barlat were used in combination with Swift hardening model. Achieved data from numerical simulation were compared with experimental test results.

Keywords –bending, springback prediction, sheet metal forming, process conditions

---

DATE OF SUBMISSION: **10**-05-2019 DATE OF ACCEPTANCE: 2**7**-05-2019

I. INTRODUCTION

Bending process is one of the most used sheet forming technologies and it represents plastic deformation of the material when the bending moment is applied. Accurate forming or bending of the steel sheets, at the design stage of process, requires taking into account specific properties of the sheet material, i.e., Young's modulus, yield stress, ratio of yield stress to ultimate tensile stress, and microstructure of the material [1].

The non-uniform strain state at the section of bent material leads to existence of residual stress after load releasing. This stress produces springback which is manifested by unintended changes in the shape of the part after the forming. The measure of the springback value can be springback coefficient or angle of springback [1].

Springback involves small strains, similar in magnitude to other elastic deformation of metals. As such, it was formerly considered a simple phenomenon relative to the large-strain deformation required for forming. Nonetheless, appreciation for the subtleties of springback in two areas has grown dramatically. In particular, high precision is needed for the large strain plastic response that directly affects the stresses in the body before removal of external forces. The unloading, while nominally linear elastic for most cases, it can show remarkable departures from an ideal linear law. [2-5]

A common countermeasure against springback is to design forming dies that anticipate springback compensation, but the compensation amount is a difficult question even for experienced die designers, and field practice is largely based on trial and error. Nowadays it is possible to use finite element analysis for more accurate prediction of springback. [5-8]

Allowances have to be made in die design so that the final product will meet the designer's objective for both appearance and ease of assembly. Also in the sheet metal industries as automotive industries, accurate predictions of sheet metal parts including stress-strain distribution and thickness are necessary [9].

In this contribution, the influence of process conditions (tool radius R and bending force F) on springback effect and its prediction of V-shaped part were investigated. Two types of Yield criterion: Hill48 criterion and Barlat criterion were used in the numerical simulation of bending steel sheet. Springback data achieved from these simulations were then compared and analyzed with the experimental test results.

II. PROCESS CONDITIONS, MATERIAL PROPERTIES, GEOMETRY USED IN TESTING

In this study, springback prediction results of V – Shaped part made of deep drawing quality steel achieved with use of the numerical simulation were evaluated and compared with experimental test results. In the FE analysis it is important to input correct process, geometrical, numerical and material variables. Two types of yield surface models: Hill48 model and Barlat model in combination with Swift hardening model were used for springback evaluation using CAE software. Also effect of bending radius R and calibration force F on springback was evaluated. Sheet thickness of the used materials was 0,85 mm. Material properties of the used steel are shown in Table 1. Forming velocity was set to 1 mm/s for the punch. The rectangular shaped blank, which was used in this work had dimensions of 90 mm by 40 mm was used.

Table 1 Mechanical properties of DC06 steel

Material	**Yield strength σ_y [MPa]**	**Tensile strength σ_u [MPa]**	**Young´s modulus E [GPa]**	**Uniform elongation A_g [%]**	**Strain hardening exponent n [-]**	**Planar anisotropy coefficient R [-]**	**Poisson´s ratio V [-]**
DC06	148	293	210	27.9	0,261	1,724	0,3

Tool geometry is also important factor in sheet metal forming. Imported CAD model of tool, used in simulation is shown in Figure 1. Two different values of bending radius were used in experimental work: 1 mm and 3 mm radius. Bending angle was 90°. Accuracy of the numerical simulation was set to fine. With this setting, program automatically generates mesh parameters. Triangle elements were used in numerical simulations. Initial element size was set to 3 mm with max. refinement level of 2. Radius penetration was set to 0.16; number of integration points was set by software to 11. Maximum time step was set to 0.5 s and coefficient of friction value was set to 0.27.

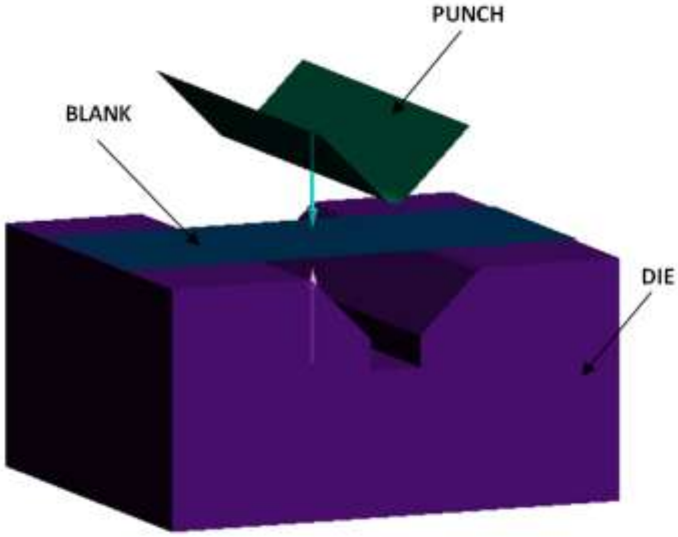

Fig. 1 CAD model of the bending tool used in the numerical simulation

III. SPRINGBACK SIMULATION, EVALUATION AND RESULTS

In this current study, finite element simulation of forming V – shaped part made of DC06 steel was conducted and numerical data were compared with experimental test results. For evaluation of the springback of the formed part, opening angle of arm ß [°] was measured in cross section after springback calculation with use of both yield criterions and both hardening models. Also influence of forces on springback, which were achieved from numerical simulation, was compared with real test results. Figure 2 shows bending forces measured during V-bend testing using punch with radius of 3 mm.

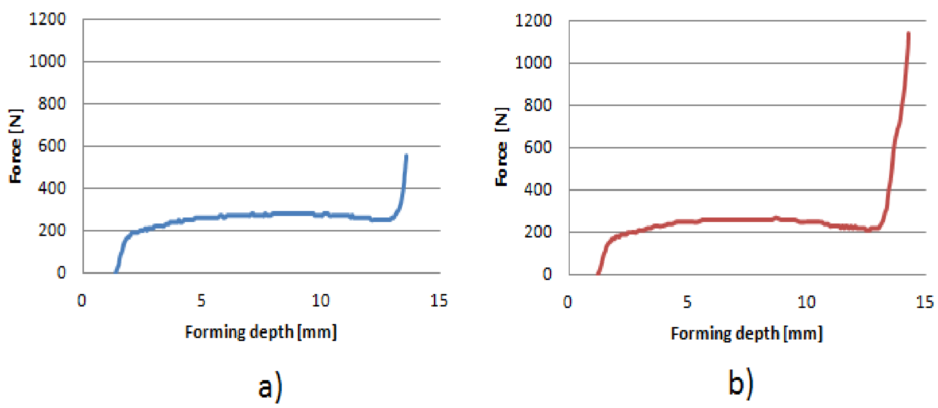

Fig. 2 Forces measured during V-bend testing – bending with calibration force F=550 N (a), bending with calibration force F=1140 N(b)

Figure 3 shows experimental values of measured springback – arm opening angle ß [°] of the formed DC06 steel for both punch radiuses: 3 mm a 1 mm. When the punch with smaller radius was used, then measured values of springback were lower in comparison with punch of 3 mm radius as seen in fig. 3. Also the higher the calibration force was used, the lower arm opening angle ß was measured. Interesting phenomenon happened when force of 1140 N was applied. The punch with radius of R= 1 mm showed much lower angle ß in comparison with punch of R= 3 mm. It is probably because of higher plastic deformation occurrence when 1 mm punch radius was used.

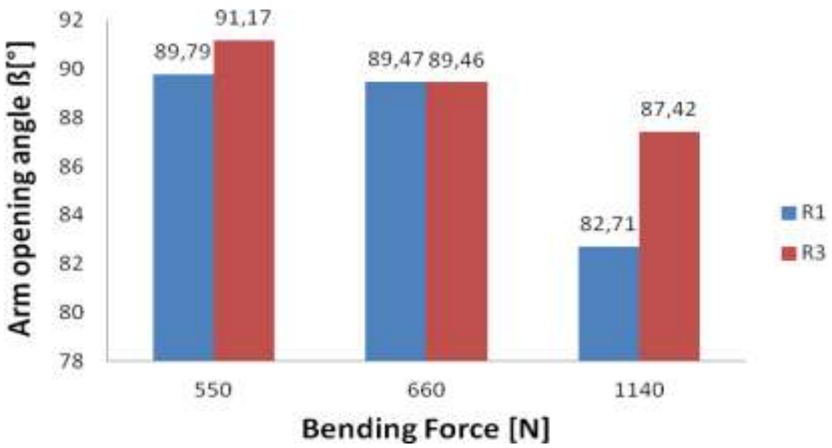

Fig. 3 Comparison of measured arm opening angle ß [°] for both punch radiuses R1 a R3 tested

Figure 4 and 5 show graphs with obtained values of springback – arm opening angle ß of the formed DC06 steel. The springback value, in V-bending is dependent on bending force F and bending radius R as it can be seen in these graphs. Different values of springback achieved in experimental testing process and in numerical simulations are also shown in this picture. In figure 4 springback values obtained from numerical simulations show higher values on the opening angle ß than experimental test results.

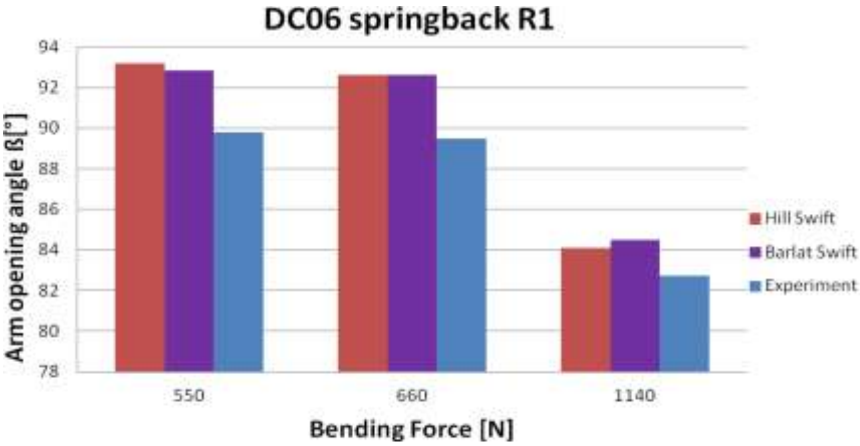

Fig. 4 Graph showing values of opening angle ß [°] and bending (calibration) force F [N] when punch with radius value of 1 mm was used

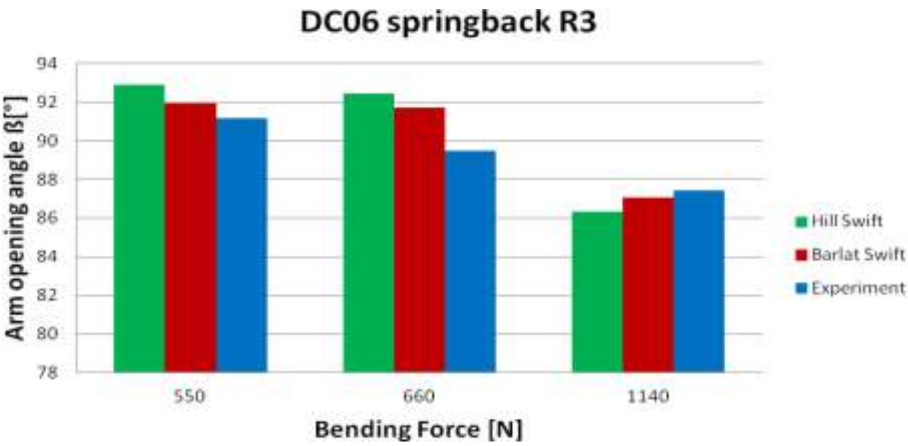

Fig. 5 Graph showing values of opening angle ß [°] and bending (calibration) force F [N] when punch with radius value of 3 mm was used

IV. CONCLUSION

Springback prediction of the V-shaped part, made of deep drawing quality steel DC06 with use of numerical simulation shows that for both Yield criterions used in simulation: Hill48 and Barlat show higher values of opening angle ß than the experimental test results in most cases. The main reason for it might be different stress, strain values and paths which depend on material model inputs, which can then significantly influence springback prediction. Punch radius also affects springback values, it can be said that, the smaller the punch radius is used, the lower values of opening angle ß will be obtained.

ACKNOWLEDGEMENTS

The authors are grateful to VEGA 1/0441/17 and APVV-17-0381.

REFERENCES

[1]. Dai, H.L.; Jiang, H.J.; Dai, T.; Xu, W.L.; Luo, A.H. Investigation on the influence of damage to springback of U-shape HSLA steel plates. J. Alloys Compd. 2017, 708, 575–586.

[2]. E. Spišák, J. Majerníková, Plastic deformation of tin coated steel sheet under different stress-strain states, Progressive technologies and materials. 3- B: Materials, 2009, 25-35.

[3]. Chongthairungruang, V. Uthaisangsuk, Experimental and numerical investigation of springback effect for advanced high strength dual phase steel, Materials and Design 39 (2012), 318-328.

[4]. J. Slota, E. Spišák, Determination of flow stress by the hydraulic bulge test, Metalurgija, 47(1), 2008, 13-17.

[5]. A. Sato, Journal of the Japan Society for Technology of Plasticity (JSTP). 46 (534), (2005), pp. 548-551

[6]. R. Wagoner, H. Lim, M.G. Lee, Advanced Issues in springback, International Journal of Plasticity 45 (2013), 3–20

[7]. E. Spišák, J. Slota, J. Majerníková, The Analysis of Plastic Strain of Single and Double Reduced Tinplates, Chemické listy, 105(S), 2011, 485-487.

[8]. T. Yoshida, K. Sato, K. Hashimoto, Springback problems in forming of High-Strength steel sheets and countermeasures. Nippon steel technical report no. 103 may 2013

[9]. M. Samuel, Experimental and numerical prediction of springback and side wall curl in U-bendings of anisotropic sheet metals, Journal of material processing technology, volume 105, 2013, 382 – 393.

Peter Mulidrán" The influence of process conditions on springback in bending process" The International Journal of Engineering and Science (IJES), 8.5 (2019): 20-24