The International Journal of Engineering and Science (IJES)
|| Volume || 8 || Issue || 3 Series I|| Pages || PP 76-79|| 2019 ||
ISSN (e): 2319 – 1813 ISSN (p): 23-19 – 1805

The influence of Yield criterion on springback prediction in V-bending process

Peter Mulidrán[1], Emil Spišák[1], Miroslav Tomáš[1], Marek Vrabeľ[2], Miroslav Greš[2]

[1]Institute of Technology and Material Engineering ,[2]Prototyping and Innovation Centre
Faculty of Mechanical Engineering, Technical University of Košice, Košice, Slovakia
Corresponding Author; Peter Mulidrán

--***ABSTRACT***--

To achieve precise springback prediction, it is important to describe correctly stress and strain state during the forming process and after the load removal. The accuracy of the springback prediction depends on the material model, which describes the deformation behavior of steel sheets. In each 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, 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´s hardening model. Achieved data from numerical simulation were compared with experimental test results.

Keywords –V-bending, springback prediction, sheet metal forming, numerical prediction

---

Date of Submission: 25-02-2019 Date of acceptance: 18-03-2019

I. INTRODUCTION

Bending is one of the most used sheet forming methods and it represents plastic deformation of the material when the bending moment is applied. Accurate plastic forming of the steel sheets requires, at the design stage of forming process, 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 is a 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]

Springback phenomenon is influenced by many parameters (Fig.1). Mainly process conditions (friction coefficient, forming speed, etc.), geometry (punch, die, blank geometry, etc.), used material (Yield Strength, anisotropy, strain, hardening, etc.) and numerical variables (type, size and number of elements, yield surface model, hardening model, etc.).

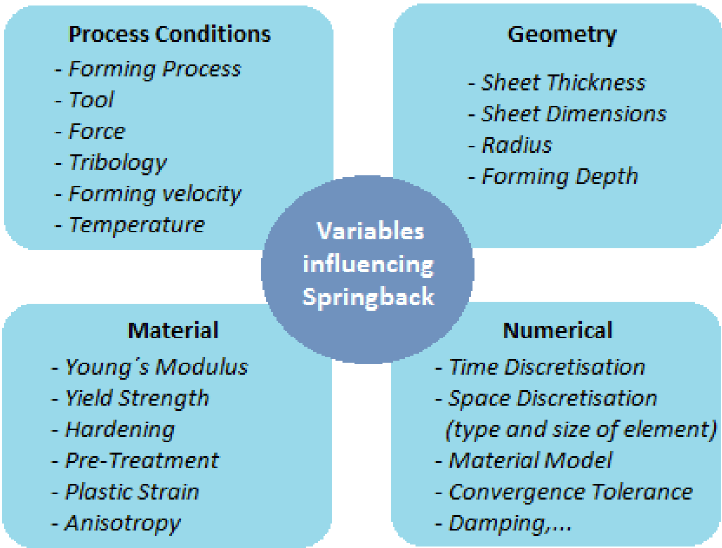

Fig. 1 Variables influencing springback prediction

In this contribution, 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 work, springback prediction results of V – Shaped part made of deep drawing quality steel achieved with use of the numerical simulation are 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´s hardening model were used for springback evaluation using CAE software. Also effect of bending, calibration force on springback was evaluated. Sheet thickness for both 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 tested steel

Material	**Yield strength σ_y [MPa]**	**Tensile strength σ_u [MPa]**	**Uniform elongation A_g [%]**	**Strain hardening exponent n [-]**	**Planar anisotropy coefficient R [-]**	**Poisson´s ratio V [-]**
DC06	148	293	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 2. Radius used for punch was 4 mm. Radius used in die was 2 mm. Bending angle was 60°. Accuracy of the numerical simulation was set to fine. With this setting, program automatically generates mesh parameters. Triangle elements were used in simulation. 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 0.27.

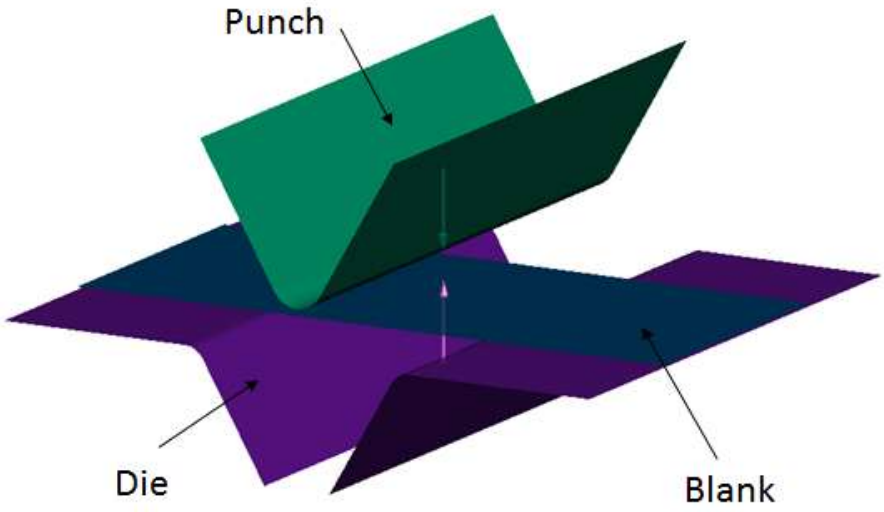

Fig. 2 CAD model of the tool used in the numerical simulation of V-bending process

III. SPRINGBACK SIMULATION, EVALUATION AND RESULTS

In this current study, finite element simulation of forming V – shaped part made of DC06 steel (Fig.3) 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 criterion tested. Also influence of forces on springback, which were achieved from numerical simulation, was compared with real test results. Figure 3 shows bending forces measured during V-bend testing.

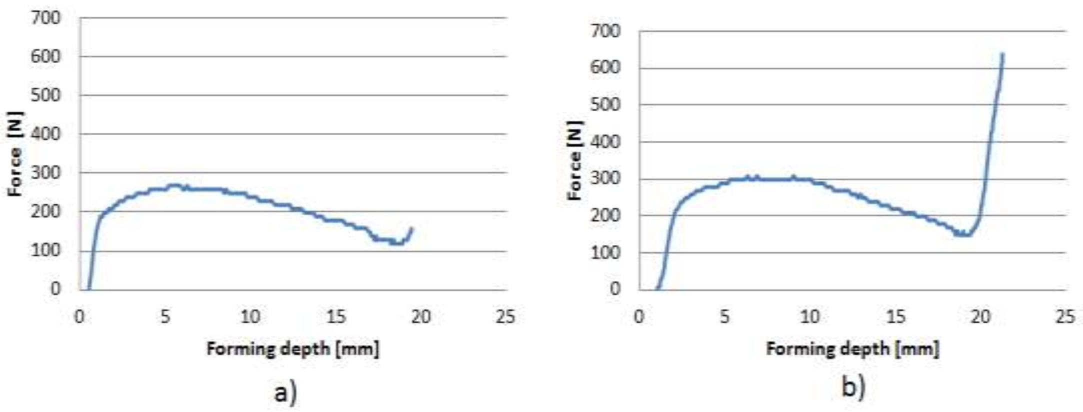

Fig. 3 Forces measured during V-bend testing – bending without calibration force (a), bending with calibration force F=610 N(b)

Figure 4 shows graphs with obtained values of springback – arm opening angle ß of the formed DC06 steel. The springback in V-bending is dependent on bending force 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. Springback results obtained from numerical simulations show higher values on the opening angle ß than experimental test results.

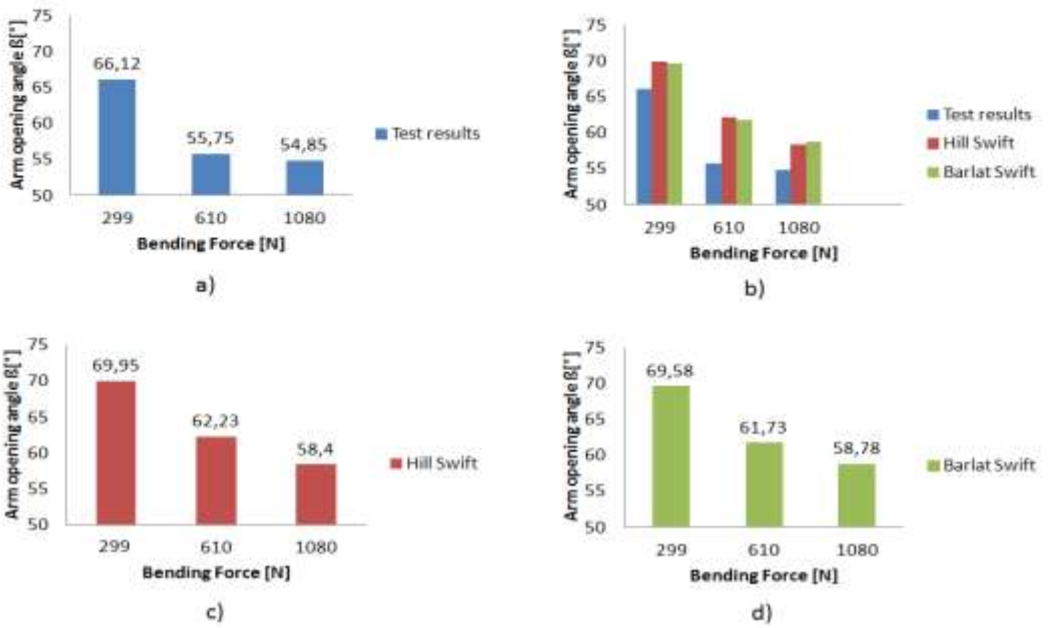

Fig. 4 Graphs showing opening angle ß [°] and bending (calibration) force F [N] from the test results (a), overall comparison of test and numerical results (b), numerical results obtained using Hill48 yield criterion (c), numerical results obtained using Barlat yield criterion (d)

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. 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. Further research is needed to study the influence of advanced yield surface models and strain hardening models on the springback of formed parts. These advanced models could bring results which could be in better correlation with real experimental test results.

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]. S. Toros, A. Polat, F. Ozturk, Formability and springback characterization of TRIP800 advanced high strength steel. Materials and Design 41 (2012), 298–305.

Peter Mulidrán" The influence of Yield criterion on springback prediction in V-bending process
" The International Journal of Engineering and Science (IJES), 8.3 (2019): 76-79