International Journal of Modern Trends in Engineering and Research
www.ijmter.com
e-ISSN No.:2349-9745, Date: 2-4 July, 2015

Investigation of Springback design process parameters and effect of unloading Elastic Modulus in V bending of Aluminium HE9

Gayatri J Abhyankar[1], Milind S Yadav[2], Milind S Kirkire[3]

[1]*Department of Mechanical Engineering, FAMT, Ratnagiri* gayatri.abhyankar1@gmail.com
[2]*Department of Mechanical Engineering, FAMT, Ratnagiri* yadav_milind@yahoo.com
[3]*Department of Mechanical Engineering, FAMT, Ratnagiri* milind.kirkire@gmail.com

Abstract- This paper focuses on investigation of design process parameters which mainly affect the Springback. Elastic Modulus is considered as the factor related to material and bending angle, punch radius and material thickness are considered as the factors related to the V bending process. The results of experiments for varying elastic modulus at different plastic strains were regressed and the regression equation gave the relationship between elastic modulus and plastic strain which can be used for more accurate prediction of Springback. The further experiments were conducted for V bending to find the effect of critical process parameters on Springback for aluminium (HE 9). The percentage contribution of each parameter causing springback was calculated. The material thickness was found as the most significant parameter causing springback in aluminium (HE9). Hence in order to minimize the Springback in aluminium (HE9), material thickness needs to be effectively controlled. The confirmation experiments were conducted for validation. The results of the confirmation experiments were found to be within the confidence interval.

Key words- Springback, V bending, material parameter, Unloading Elastic modulus, process parameters.

I. INTRODUCTION

Manufacturing of high-precision sheet metal component is the major objective of industries such as: automotive, electronics, and housing-utensil industries. It is well established that the prediction of final geometries of deformed parts strongly depends on the elastic properties of the material [1]. Elastic modulus can be considered as one of the most influencing parameters on springback and its simulation using finite element analysis (FEA) and the effect of inelastic recovery on springback needs to be considered so as to get a more precise springback simulation [2]. Hence, accurate prediction of the plastic strain is of great importance to obtain a precise final geometry of a deformed part, particularly in springback prediction. At the same time the tool geometry is of utmost importance as far as accuracy of the bent parts is concerned [3]. Process parameters for design of spring-back and spring-go can be investigated in V-bending process using Taguchi technique.

Many times the modifications for minimizing springback need to be considered, one of them is the coined-bead technique. The conventional coined-bead technique could only prevent the spring-back. In contrast, the sided coined-bead could prevent both the spring-back and the spring-go by setting a suitable geometry and position [4].

The effect of process parameters and the shape of workpiece on the springback need to be considered. The results of research in wipe bending for perforated components are studied [5]. Geometry parameters and material hardening effect are important parameters affecting springback. The effects of geometry parameters and material hardening characteristic on springback are studied and artificial neural network is used to map the complex and non linear relationship [6].

One of the most important materials used is high strength steel in forming industries. It is found that thickness is the main dimension of the workpiece which affects springback, thicker the blank is, the less the springback variation [7]. The springback analysis of thin bent sheets on elastomeric die is also done [8].
The springback prediction precision can be considerably improved by considering the variation in the Young's modulus with plastic deformation by repeated loading and unloading experiment [9]. This work focuses on experimental investigation of Elastic Modulus as the factor related to material and process parameters i.e. bending angle, punch radius and material thickness as the factors related to the V bending process using Aluminium (HE 9). The degree of importance of process parameters is predicted by the Taguchi technique. Experimental confirmation is done using the optimized process parameters for spring-back.
The first step in this research was to conduct tension tests on universal testing machine for getting unloading elastic modulus. The unloading elastic modulus for more precise prediction of springback is very important [9], according to which the tensile tests were carried out to get precise values of unloading elastic modulus.
The next step was to develop relation between unloading elastic modulus and plastic strain. By using regression analysis the relation between unloading elastic modulus and plastic strain was developed which can be used for more precise prediction of springback.
The second phase of the research involved the experimentation for V bending. The critical design process parameters were identified. Levels of critical parameters were set and experimental set up accommodating all the variations in the levels of critical process parameters was prepared for experimentation. As the experimentation was carried for three critical parameters with two levels, orthogonal array L8 was selected. Experimentation for V bending was conducted on universal testing machine. Springback for all 8 experiments was measured using Optical profile projector.
The experimental results were analyzed using MINITAB 16 and percentage contribution of each critical process parameter was calculated. The results were validated by conducting validation experiments. Springback is dependent on material properties and parameters involved in bending process.

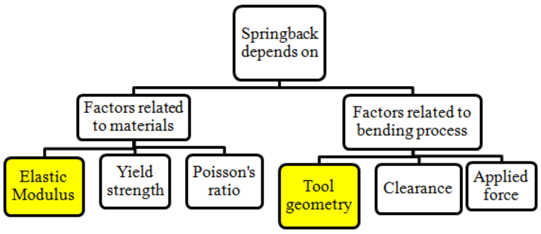

Fig.1 Factors affecting Springback

The materials properties on which springback depend are elastic modulus, yield strength and Poisson's ratio. The main process parameters deciding springback are tool geometry, clearance and applied force. Figure 1 highlights the scope of this work.
The aim was to find the relation between unloading elastic modulus and plastic strain which can be used to get more precise springback prediction and to investigate the critical parameters affecting springback in V bending process.

II. EXPERIMENTSTION AND ANALYSIS

2.1 Experiments for Tensile Tests

The standard tensile tests specimens were prepared by precision turning. The 60 ton Universal testing machine (UTM) is used for these uniaxial tension tests with a precise extensometer. The specimens were loaded to some plastic strain with constant speed and then unloaded to zero. And then the same specimen was loaded to another plastic strain and then unloaded to zero as shown in figure 2. In order to get sufficient data, 5 specimens of Aluminium HE9 were tested to get more precise results.

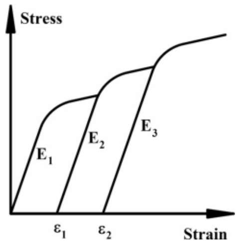

Fig. 2 Scheme of the method for measuring unloading Elastic modulus [2]

In the same way one specimen was unloaded 4-5 times for different plastic strains. Each experiment gave one value of plastic strain and one value of unloading elastic modulus.

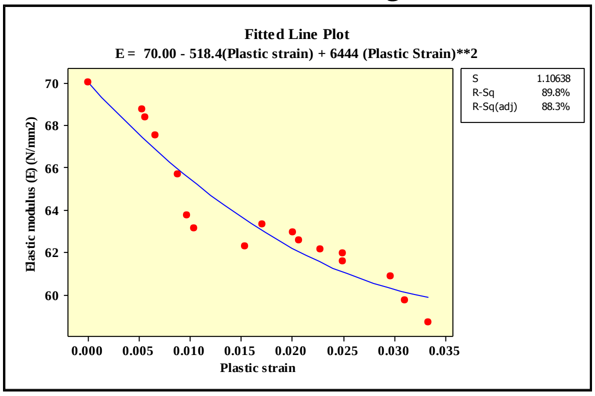

Fig.3 Graph showing relation between unloading elastic modulus and plastic strain for Aluminium HE9

As the use of unloading elastic modulus is required for springback prediction, the precise values of unloading stress and strain are calculated. Very precise values of change in length while unloading are taken and used for calculation of unloading plastic strain. From the elastic stage of the stress–strain, the relation between unloading elastic modulus and plastic strain is calculated by line regression. Statistical software package MINITAB16 was used for the analysis. The fitted line plot for Aluminium HE9 is shown in figure 3.

The results of the regression gave the relation between unloading elastic modulus and plastic strain for Aluminium HE9 as: **E = 70.00 - 518.4(Plastic strain) + 6444 (Plastic Strain) **2.** This relation can be used for prediction of Springback in V bending process.

2.2 Analysis for V bending of Aluminium HE9

The 60 ton universal tensile testing machine was used for V-bending experiments. Aluminium (HE9) sheets of 30 mm width, 60 mm length and 3 mm, 5 mm thickness were used as a work piece material. Punch radius, material thickness and bending angle are selected as critical parameters. The experiments were conducted by deciding appropriate levels of the critical parameters. As the experimentation involves three critical parameters and two levels hence orthogonal array L8 is selected. The variation in the angle, springback is taken as response. The springback was examined in terms of angle using the Optical Profile projector having a least count of 5´.

2.3 Experiments for V bending

The experiments for V-bending were conducted by making suitable attachments to mount the punches and dies on universal testing machine. The punches and dies are made up of Mild Steel and hardened using induction hardening. The punches and dies are manufactured using shaping machine. The actual experimental set up of V bending is shown in figure 4

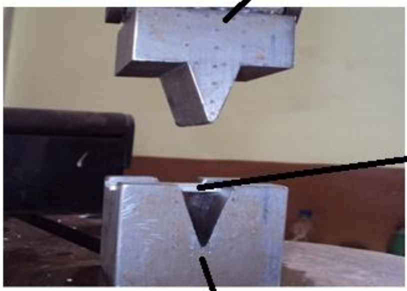

Fig. 4 Experimental set up for V bending

The data is analyzed using signal to noise ratio (S/N ratio). Smaller the better criterion is used as the Springback (response) is desired to be minimum.

Table 1: Orthogonal Array L8

Runs	**Punch radius (mm)** (factor1)	**Material thickness (mm)** (factor2)	**Bending angle (°)** (factor3)	**Springback (min)** (response)	**Springback (°)** (response)
1	2	3	30	55	0.917
2	2	3	60	20	0.333
3	2	5	30	10	0.167
4	2	5	60	5	0.083
5	3	3	30	25	0.417
6	3	3	60	55	0.917
7	3	5	30	20	0.333
8	3	5	60	15	0.25

It can be easily seen from figure 5 that the variation of the material thickness is greater as compared to the variation of the other two factors. Hence, material thickness is the most affecting parameter for Springback in Aluminium HE9.

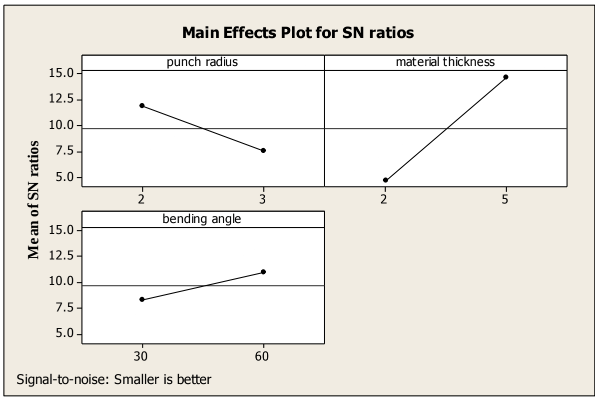

Fig. 5 Main effects plot for S/N ratios for Aluminium HE9

Hence, the material thickness is found to be the most affecting parameter for springback in V bending process for Aluminium HE9.

Table 2: Percentage contribution results

Process parameters	Bending angle (θ) (°)		Material thickness(t) (mm)		Punch radius (R_p) (mm)	
	30	60	3	5	2	3
$(\frac{S}{N})_{ij}$	8.36	10.99	4.66	14.69	11.87	7.49
Sum of squares SS_i	3.4585		50.3		9.59	
% contributions	5.45		79.4		15.15	

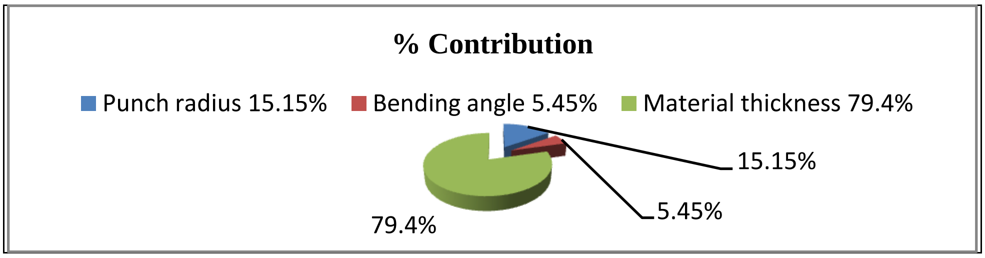

Fig. 6 Percentage contribution of each process parameter in Springback

The percentage contribution of each factor under study is represented by the pie chart shown in figure 6. The percentage contributions for springback of material thickness, punch radius and bending angle were 79.4, 15.15 and 5.45 respectively.

III. CONFIRMATION EXPERIMENT

The confirmation experiments are conducted by using the combination of factor levels which are obtained after the analysis and are identical to those used in the initial experiment

CONCLUSION

The unloading Elastic modulus varies with plastic strain for Aluminium (HE9) which can be used for more accurate prediction of Springback. The influence of each process parameter on the spring-back together with their calculated percentage contributions was effectively illustrated. The material thickness was found as the most significant parameter with a contribution of 79.4% causing springback in Aluminium HE9. Hence in order to minimize the Springback, material thickness needs to be effectively controlled. Hence, there is strong significance of the design of process parameters in V-bending process. Taguchi method was an effective tool to predict the amount of significance of the process parameters in the V-bending process through the designed experiments.

LIMITATIONS AND FUTURE SCOPE

This work is completely based on the experimental results. The validation is done by conducting the confirmation experiments. It could be interesting to do mathematical modelling of the entire V bending process. Also the Finite Element Analysis (FEA) could also be very effective for the same. The application of neural network or Fuzzy logic could be used for prediction of Springback.

REFERENCES

[1] S Chatti R. Fathallah(2012), A study of the variations in elastic modulus and its effect on springback prediction, International Journal of Material Forming, 12289-012-1106-7

[2] Hai Yan Yu (2009), Variation of elastic modulus during plastic deformation and its influence on springback, Materials and Design 30 , 846-850. Science Direct, Elsevier.

[3] S Thipprakmas (2012), Finite element analysis of sided coined-bead technique in precision V-bending process, International Journal of Advanced Manufacturing Technology, 00170-012-4207

[4] Sutasn Thipprakmas Wiriyakorn Phanitwong (2012), Process parameter design of spring back and spring go in V-bending process using Taguchi technique, Materials and Design 32 (2011) 4430-4436. Science Direct, Elsevier.

[5] V. Nasrollahi & B. Arezoo (2011), Prediction of springback in sheet metal components with holes on the bending area, using experiments, finite element and neural networks ,Materials and Design, 36 , pp.331–336. Science Direct, Elsevier.
[6] Recep Kazan, Mehmet Firat & Ayusun Egrisogut (2008), Prediction of springback in wipe-bending process of sheet metal using neural network, Materials and Design, 30, pp. 418–423. Science Direct, Elsevier.
[7] P. chen, Muammer Koc & Michael L. Wenner (2008), Experimental Investigation of Springback Variation in Forming of High Strength Steels, Journal of Manufacturing Science and Engineering Vol. 130 / 041006-1. Science Direct, Elsevier.
[8] M. T. Braga, L. A. Moreira Filho & M. A. Menezes (2010), Springback analysis of thin bent sheets on elastomeric die, International journal of material forming vol. 3 suppl 1:1075-1078
[9] Y.L. Liu, Y. X. Zhu, W. Q. Dong & H. Yang (2012), Springback prediction model considering the variable Young's modulus for the bending rectangular 3A21

