Available online at www.elixirpublishers.com (Elixir International Journal)

Mechanical Engineering

Elixir Mech. Engg. 69 (2014) 23073-23075

ISSN: 2229-712X

Prediction of Springback in Sheet Metal Forming Using FEA and Neural Network

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ARTICLE INFO

Article history:
Received: 21 February 2014;
Received in revised form:
29 March 2014;
Accepted: 7 April 2014;

Keywords
U bending,
Springback, FEA,
Sheet thickness, R/t,
Neural Network.

ABSTRACT
One of the most sensitive features of the sheet metal forming is the elastic recovery during unloading called springback. Sheet metals are prone to some amount of springback depending on elastic deformation. Obtaining the desired size and design of die depends on the knowledge of the amount of this springback. 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 this paper the effect of various parameters such as sheet thickness, ratio of die radius to sheet thickness, strength coefficients on springback are studied. Also a Neural Network prediction model is prepared and the results of FEA and NN model are compared for springback.

Introduction

Bending is a very widely used process in forming of the parts. Precision of the formed parts is affected by the elastic recovery during unloading. Due to the elastic recovery, final shape of the 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. Also it helps to obtain the desired shapes with accuracy.

Measuring the springback by experimental process is costly and time consuming. In the recent years finite element softwares are very widely used for the prediction of the springback.

Volkan Esat et al. [2] studied the springback of different aluminum material with different thickness, by using commercially available FEA software. Aysun Egrisogut Tiryaki et al. [3] investigated springback of wipe bending process based on results obtained from FEA and prediction model of springback was developed by neural network. M. Bakshi-Joybari [4] studied the effect of significant parameters including sheet thickness, sheet anisotropy and punch tip radius on springback/spring-go in V die and U die bending process. Jean-Philippe Ponthot [5] studied the influence of various parameters such as Blank Holder Force, friction, spatial integration, time integration scheme for U draw bending by using commercial code OPTRIS.

In the present paper the springback is investigated by using finite element analysis, for various, sheet thicknesses, R/t ratios and strength coefficients, for different three materials listed in the table 1. Neural Network model is developed for prediction of springback and the results are compared with FEA results.

Nomenclature:

R-die radius
t-sheet thickness
R/t-Ratio of bending radius to sheet thickness
Ys-Yield strength
K-strength coefficient
n-strain hardening exponent

Material Properties:

Three materials with different material properties as shown in the table 1 were selected for the study purpose. The materials for the study purpose are selected in such a way that they cover wide range of properties. Also these materials are widely used in sheet metal forming.

Table 1. Material properties

Sr. No.	Material	YS [MPa]	UTS [MPa]	K [MPa]	n
1	IS513D	322.0	208.0	559.84	0.21
2	DP600-HDG	416.8	618.2	929.03	0.13
3	5182 Aluminum	133.07	281.1	538.00	0.29

Component Details: Header

The Dimensions of the U shape component taken for study purpose are as below.
Height=26mm,
Width=30mm,
Length=270mm.
Thickness=varied

U bending and Finite Element Simulation

U bending processes are widely used in forming the sheets in U shape. U bending processes were simulated by using software hyperform. The tools are assumed rigid and the blank as deformable. The die punch set up is as shown in figure 1.

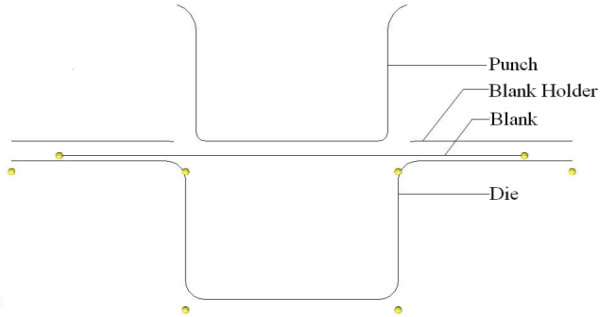

Figure 1. Die-Punch set up

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Table 2. Springback for different materials with various t, R/t and K

Material-IS513D						Material-DP600-HDG					Material-5182 Aluminum				
Sr. No.	R	t	R/t	K	Springback	R	t	R/t	K	Springback	R	t	R/t	K	Springback
1	2	0.8	2.5	559	0.714	2	0.8	2.5	929	3.430	2	0.8	2.5	538	1.888
2	2	1.0	2.0	559	1.177	2	1.0	2.0	929	2.998	2	1.0	2.0	538	0.678
3	2	1.5	1.33	559	1.687	2	1.5	1.33	929	2.335	2	1.5	1.33	538	0.224

Table 3. Comparison of Springback by FEA and Neural Network

Sr. No.	t	R/t	K	n	Springback predicted by FEA	Springback Predicted by NN	Percentage Error
1	1.5	2.0	538.0	0.29	0.328	0.3191	2.713
2	1.2	2.5	559.0	0.21	0.714	0.7483	4.583
3	1.0	2.0	929.0	0.29	3.289	3.1271	4.922

Finite Element Simulation:

In this investigation, the software 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 modeled in the Hyperform itself by using geometry create features. The punch is extracted from the die. The die punch set up is as shown in the figure 1.

The various parameters used during finite element analysis are as below.

-Punch velocity-5000mm/sec.

- Die radius- 2mm fixed.

-Punch radius-2mm fixed.

-Blank thickness-Varied as 0.8mm, 1mm and 1.5mm for each material.

-Blank Holder Force-10000N

-Coefficient of friction-0.125

-Clearance between die and punch-10% of thickness

Effect of Sheet Thickness:

To investigate the influence of sheet thickness, FE simulations are run for the various sheet thicknesses as 0.8mm, 1mm and 1.5mm for each material. The obtained results are listed in table 2.

Effect of R/t:

To study the effect of ratio of die radius to sheet thickness, the ratios of R/t are obtained from the results of various sheet thicknesses and die radius. The results obtained are given in table 2. The graph of springback Vs. R/t ratio is plotted in figure 3.

Effect of Strength Coefficient:

To investigate the influence of strength coefficient, FE simulations are run for the various sheet thicknesses as 0.8mm, 1mm and 1.5mm for materials with different strength coefficients. The obtained results are listed in table 2.

Neural Network:

Neural network is a network of neurons with input layer, hidden layers and the output layers. The figure 5 shows the simple feed forward network. This Neural Network model with two hidden layers is prepared by trial.

The activity of the input units represents the raw information that is fed into the network. The activity of each hidden unit is determined by the activities of the input units and the weights on the connections between the input and the hidden units. The behaviour of the output units depends on the activity of the hidden units and the weights between the hidden and output units.

Calculating the springback from the table checking is very difficult. Neural network is used to map the non linear relationship between the various parameters, so the neural network can be used to map the springback from the charts.

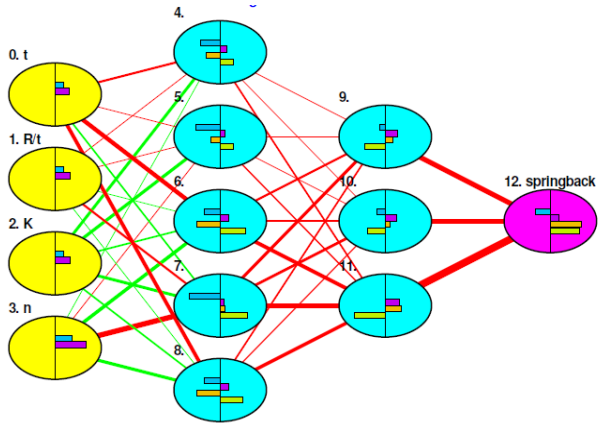

Figure 5. Neural Network Model

Result and Discussion:

Figure 2 shows the effect of sheet thickness on the springback. It is seen from the figures, 2 the springback increases with increase in sheet thickness for the material IS513D. But for the DP600-HDG and 5182 Aluminum, the springback decreases with increase in thickness.

Figure 3 shows effect of R/t on the springback, while the figure 4 shows the effect of strength coefficient on springback. It is clearly seen that with increase in strength coefficient there is increase in springback.

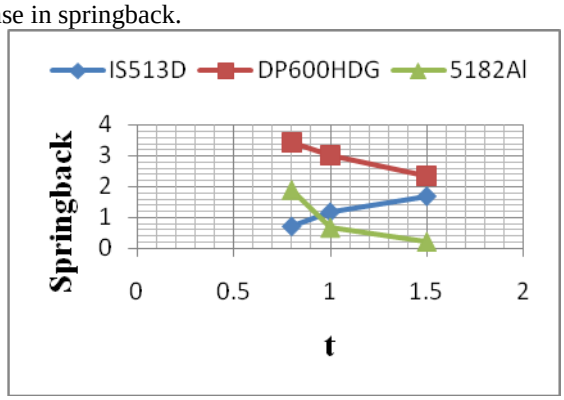

Figure 2. Graph of springback Vs Sheet thickness.

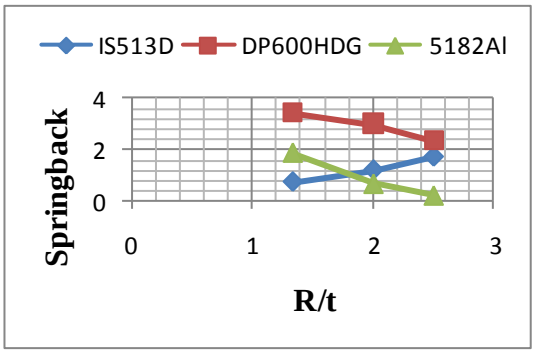

Figure 3. Graph of springback Vs R/t.

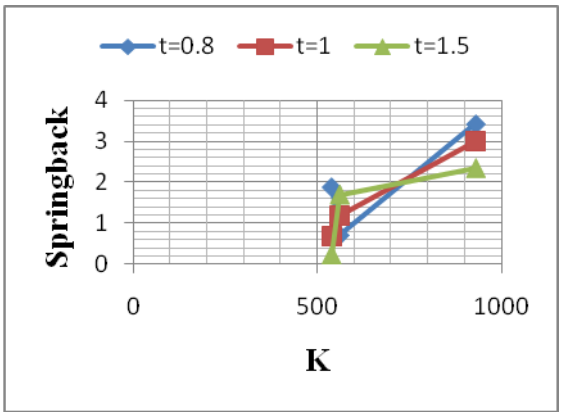

Figure 3 Graph of springback Vs K.

Relative Sensitivity and Relative importance:

The relative sensitivity and relative importance are shown in the tables 4 & 5. It is seen that strength coefficient is most sensitive for the springback, while strain hardening coefficient is most important.

Table 4: Relative sensitivity

Column	Input Name	Change from	to	Sensitivity	Relative Sensitivity
2	K	538.0000	929.0000	0.778617368	
0	t	0.8000	1.5000	0.380434765	
3	n	0.2100	0.2900	0.333308992	
1	R/t	1.3300	2.5000	0.294892525	

Table 5: Relative Importance

Column	Input Name	Importance	Relative Importance
3	n	8.7128	
2	K	8.2974	
0	t	8.2924	
1	R/t	3.4789	

Conclusion:

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

- For IS513D the springback increases with increase in sheet thickness while for 5182 Aluminum and DP-600 HDG, springback decreases with increase in thickness.
- For IS513D the springback increases with increase in R/t, while for 5182 Aluminum and DP600-HDG, springback decreases with increase in R/t.
- It is also seen that the springback increases with increase in the strength coefficient.
- Results obtained by Neural Network and FEA are in good agreement.

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