Effect of sheet thickness and R/t ratio on Springback in sheet metal forming

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Abstract

The forming process is the process in which the sheet is formed into desired shape. Sheet metal forming processes are very widely used by automotive industry, home utensil manufacturing industry etc. One of the problems associated with the sheet metal forming process is the springback. Springback is a complex phenomenon as it depends on many process parameters such as die radius, tooling geometry etc. and material properties such as sheet thickness, strength coefficient, strain hardening exponent etc. In this paper the effect of sheet thickness and R/t ration on springback is studied for the material IS513D both by the experimental and FEA method and their results are compared.

Keywords- *Sheet thickness; R/t ratio, Springback; forming.*

I. INTRODUCTION

Sheet metal bending processes are very widely used by automobile industries for forming of the components used in making of vehicle body and door panels. Also these processes are used in aircraft industry, home appliance industry, food industry and in construction of furniture panels, drums of various diameters, panels for electronic components, large spherical vessels and cylindrical vessels etc. Bending process is one in which a planer sheet is plastically deformed into curve one. When component is bent, it tries to regain its shape and therefore the desired shape of the component is not obtained. It affects precision of the component and hence the precision of the formed part is a major problem in bending of sheet metals. All bending processes are subjected to more or less amount of springback because of elastic recovery during unloading.

In the past many researchers have worked so as to investigate springback and also to study the various parameters affecting springback and to reduce it. In this paper the literature review of the process parameters and material parameters such as sheet thickness, R/t ratio, on the springback is studied.

S. K. Panthi et al. [1] modeled sheet metal bending process for large deformation based on total elastic incremental plastic strain. Use of software capable to handle large deformation an elasto-plastic analysis for sheet metal bending process is done to predict the springback. This study was carried out so as to observe the effect of some geometric parameters like die radius, thickness of sheet, sector angle etc. and mechanical material properties such as yield stress, Young's modulus, strain-hardening exponent and lubrication condition on the springback. It is found that with increase in yield stress there is increase in springback. Also as the Young's modulus increases springback is found decreasing and friction has negligible effect on springbagk. Recep Kazan et al. [2] studied the springback for the wipe-bending process.

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Initially the data was obtained from FEA and prediction model of springback was developed by of neural network based on data obtained by FEA. The effect of ratio of die radius to sheet thickness on springback was studied which shows that initially up to R/t ratio equal to 3 the springback is constant and for further increase in R/t ratio springback increases with increase in R/t ratio. M. Bakhshi Jooybari et al. [3] studied the springback experimentally as well as numerically for V and also for U-die bending operation. The effect of various parameters such as sheet thickness, sheet anisotropy and punch tip radius on spring-back/spring-go is studied for CK67 (DIN 17222) steel sheet. The experimental and the FEA results were compared. Also the results obtained by two bending processes i.e. the results of V die and U die bending were also compared. Ozgur Tekaslan et al. [4] studied four different bending with intention of reducing the springback viz. two methods with punch holding on the die and two methods without punch holding on the die. In the first method a die gap equal to sheet thickness was kept between the die and punch to avoid effect due to squeezing of the material at the bending section (profile). Punch was held for 20 seconds on the sheet metal and then the punch was raised to relieve the load on the material. In second method a gap between die and the punch is kept equal to material thickness but the punch was not held on the sheet this time. The punch was retracted as soon as it reached at the end of forming depth. In the third method punch was completely lowered up to the bottom of the die. Thickness of sheet metal material between the die and punch was neglected in this method totally. Here also the punch load was kept on the material for 20 s at the end of forming stroke. In fourth method the thickness of sheet metal was neglected completely again to make punch and die contact possible and the punch load was not held on the sheet material. It was found that holding the punch longer time on the material reduces the springback. Also they studied the effect on springback by different methods for various bend angles. They also found that springback increases with increase in sheet thickness and ending angle. Zemin Fu et al. [5] investigated the springback and FEM simulation of multiple-step incremental air-bending forming. A punch was designed according to the model, geometric planning of multi-step incremental-forming process was performed and incremental-forming processes were simulated. Finally a semielliptical-shaped work piece was manufactured with the simulation results. This study could provide theoretical and practical guide for sheet metal multiple-step incremental air-bending forming and tools design. Y. E. Ling et al. [6] in order to reduce the time spent on manual corrections of die, they investigated the effect of various parameters like die clearance, die radius, step height and step distance on the springback, for L-bending using FEA. It was observed that the die clearance and die radius has more influence on springback as compared to step height and the step distance. Yanwei Zhang et al. [7] studied the sheet metal forming process for large elastic plastic deformation using finite element analysis making theoretical and methodological contributions to the subject. Sheet metal bending process was simulated using finite element analysis software ANSYS. The springback phenomenon was examined in greater details by taking a specimen of A3 sheet. The analysis of springback presents values in the bending process as well as curve of springback vs. relative bending radius R/t, curve of springback vs. bending clearance between punch and cavity, curve of springback vs. material response (stress-strain curve) during plastic deformation.

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II. NOMENCLATURE

R-die radius
t- sheet thickness
K-strength coefficient
n-strain hardening exponent
C-clearance between die and punch

III. MATERIAL PROPERTIES

The material used for the forming of U shaped component is IS513D. The material properties for this material are listed as below.

Material-IS 513D
Yield Strength-208 MPa.
Ultimate Tensile Strength-322 MPa.
Strength coefficient (K) = 551 MPa.
Strain hardening exponent (n)-0.21.

IV. RESULT AND DISCUSSION

A. Effect of sheet thickness on springback

To investigate effect of sheet thickness experimentally on springback, sheets of thickness 0.8 mm, 1.0 mm and 2.0 mm for the materials IS513, are cut along the rolling direction. Then these sheets are formed in U shape by using the mechanical press. The obtained experimental results for springback are listed in the table 1. To investigate the effect of sheet thickness numerically FEA simulations are run for different sheet thicknesses such as 0.8 mm, 1.0 mm and 2.0 mm, for the same material and the results obtained by FEA are listed in table 1. The comparative results for components obtained by FEA and experimental method are plotted on graph as shown in the figure 1.

Table 1: Springback obtained by FEA and experimental method for different sheet thicknesses and die radii

Material	R (mm)	t (mm)	R/t	Springback (degree)		K (MPa)	n	%tage error
				(FEA)	Experimental			
IS513D	2	0.8	2.50	1.238	1.198	559.84	0.21	3.23
IS513D	2	1.0	2.00	0.946	1.044	559.84	0.21	9.38
IS513D	2	2.0	1.00	0.599	0.677	559.84	0.21	10.57
IS513D	3	0.8	3.75	1.264	-	559.84	0.21	-
IS513D	3	1.0	3.00	0.953	-	559.84	0.21	-
IS513D	3	2.0	1.50	0.619	-	559.84	0.21	-

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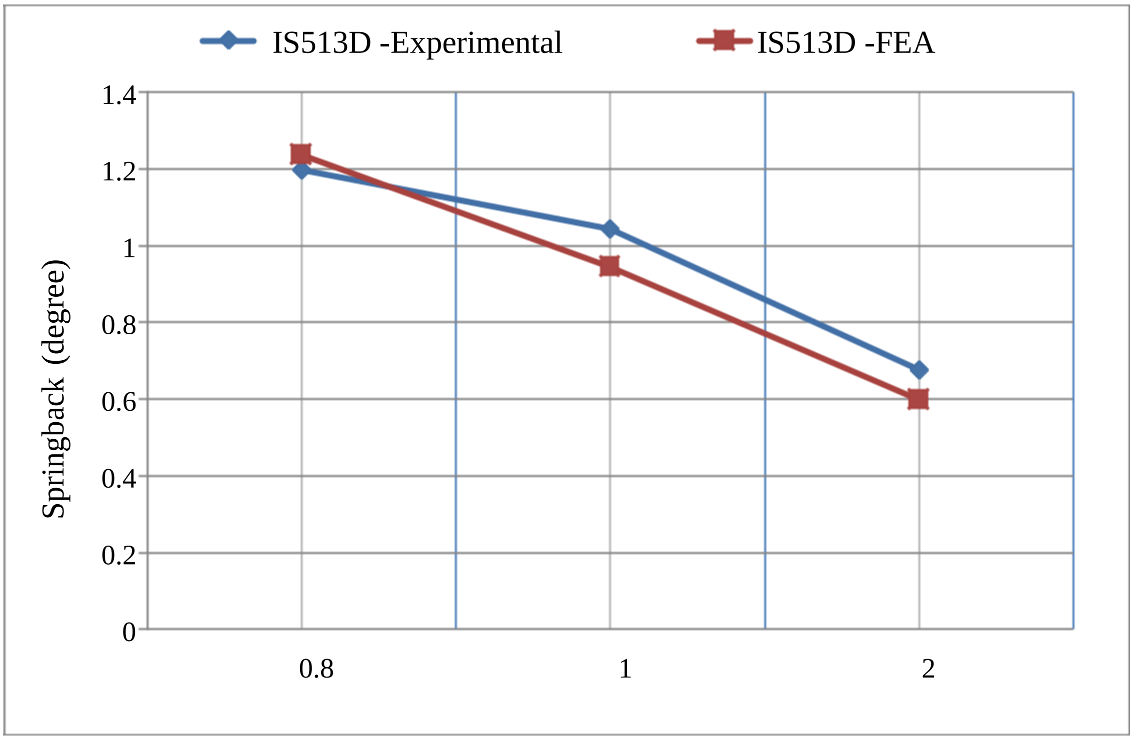

Sheet thickness - t mm

Figure 1 Comparison of experimental and FEA results for effect of sheet thickness on springback for IS513D material.

From the figure 1 it is seen that with increase in sheet thickness springback decreases. It is because as the sheet thickness increases, distribution of bending stress is taking place over more thickness from the neutral axis. Therefore the residual stresses are smaller in comparison with the material having smaller thickness.

B. Effect of R/t ratio on springback

To study an effect of ratio of die radius to sheet thickness i.e. R/t ratio on springback, experimental results are obtained for various sheet thicknesses as discussed in the above section A. From the results of springback for various sheet thicknesses, results are obtained for various R/t ratios and these results for R/t ratio are listed in table 1. The results of R/t ratio vs. springback are plotted in figure 2. Figure 2 shows the comparison of experimental results and results obtained by FEA for different R/t ratio.

From the figure 2, it is seen that with increase in R/t ratio springback increases. These results are in agreement with earlier published results [5, 6, and 7]. This is because with increase in sheet thickness springback decreases and with increase in die radii springback increases.

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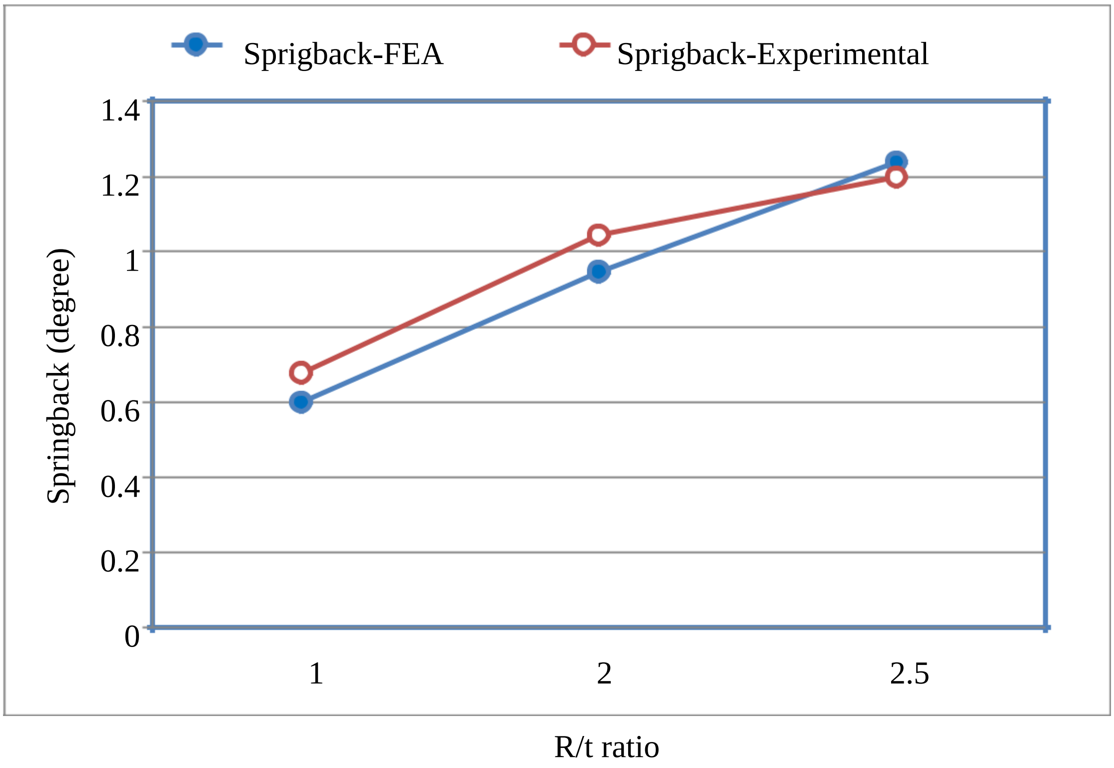

Figure 2 Comparison of experimental and FEA results for effect of die radius on springback for IS513D material.

V. CONCLUSION

The following conclusions can be made based upon the obtained results.

1. Springback depends on sheet thickness and decreases with increase in sheet thickness.
2. Springback due to forming also depends on die radius and with increase in R/t ratio springback increases
3. The results obtained by FEA are in good agreement with the experimental results with maximum 10 % error.

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