Experimental Study on spring back Phenomenon in Sheet Metal V- Die Bending

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Abstract- *Metal forming processes are compression-tension processes involving wide spectrum of operations and flow conditions. The result of the process depends on the large number of parameters and their interdependence. The selection and optimization of various parameters is still based on trial and error methods. Prediction of spring back is essential for the design of tools used in sheet metal bending operation. This investigation aims to clarify the process conditions of three different bending operations including angle, sheet thickness, and varying width cross section of raw material of CRC-D Steel sheets, by performing Design of Experiments on the basis of Response surface methodology. This paper investigates the elastic behavior of the sheet metal after loading and unloading of die at certain load and only charactersing how much spring back occurs at particular combination of RSM.*

Keyword: Sheet metal Forming, Springback, RSM, ANOVA.

1. INTRODUCTION

Sheet metal bending plays a very important role in the manufacturing industry. As the industry develops, the size of the components being produced gets smaller and tolerances on them gets tighter. The geometrical accuracy of a bent part is crucial in determining the quality of the component. Analysis of the process of sheet metal bending reveals a phenomenon called spring-back. Spring-back is the term used to describe the elastic recovery of sheet metal after a bending operation. Problems relating to spring-back do not only affect formed components, but also affect the design of the bending tools such as the forming dies. When a sheet undergoes a bending operation, usually on presses, it is deformed to a certain degree and takes the shape of the die. However, as soon as the die is removed, the sheet recovers slightly towards it original shape. In other words, the sheet does not maintain the final radius of curvature of the load condition, but it recovers elastically to a much larger final radius of curvature.

2. LITERATURE REVIEW

In the research conducted by ozgur Tekoylon [1] they determine the spring back of stainless steel sheet metal in v-bending dies they shown four different bending method use in the field most two cannot employed for spring back and that holding the punch longer on the material bent reduce spring back where on increase in thickness of the material and bending angle increases the spring back values spring back value vary between 0.5^0 to 5^0 In the study of M.A osnon M. shazly [2] A theoretical model developed for the air bending process and v-die bending experiments are conducted. Based on the compression between spring back ratios predicted using the developed theoretical air bending model and the v-die bending process is suggested their finding is that for a given limit of the striking coining force spring back ratios are affected by sheet thickness bend radius and material parameters. Sutasn thipprokmas [3] studied the behaviors of the punch height in the portion v-die bending and its affect on bending angle this study is based on the FEM to investigate the effect of punch height. The FEM simulation result revealed that the effects the punch height on the bending angle were clearly theoretically clarified based on the material flow analysis and stress distribution. The punch height affected the gap between the work piece and the die as well as the reversed bending zone which result in a non required bending angle.

Therefore applying a suitable punch height created a balanced of compensating the gap between the work piece and the die and the stress distribution on the bending allowance and reversed bending zone. Amul Borodor, M.D. Deshpande [4] studied the finite element analysis of spring back of sheet metal in wipe bending process. The main purpose of the work is spring back prediction of sheet metal copper alloy and investigation into the causes of the spring back. Such as process parameter geometry of the tools etc. in concluding work prediction model of spring back in wipe bending process was developed using finite element method cod e (ANSYS APDL 14.0) and or over bend approach is applied to compensate the spring back and obtained spring back for different process parameter and validated by analytical model. From the investigation of finite element analysis it shows that the die radius has a significant amount of effects on the spring back.

The result from analysis for die shoulder shown that the increase in die shoulder radius increases the spring back hence to avoid the spring back use of smaller die radius is recommended in their study. M.V. Inamdar, P.P. Date S. V.

Sabnis [5] find out the effects of geometric parameters on the spring back in sheet a five material subjected to air V-bending This work aims study at this interaction using 2^4 factorial design of experiment for each of five different material and analysis the spring back using statistical model. On performing statistical analysis they conclude that spring back in all the material studied depends strongly on the die gap / sheet thickness (w/t) ratio and angle of bend. The design of the tools in air V-bending should be material dependent. The fixed effects model leads to the some significant factors and interactions of the random effect model.

3. EXPERIMENTAL SET UP

3.1 Materials

Dimensions of the samples were 60x30, 60x15, 60x5 mm, and thickness levels are 1, 1.5 and 2 mm. The idea behind the selection of small sizes is the reason that determining spring-back is thought to be more accurate on narrower surfaces. Experiments included 20 bending for material and combination set up according to level of DOE.

These sheet metals were bent on a Power press bench with one stroke at a time, and each sheet bent was measured finely on CMM to, minimize measurement error. Spectrometric chemical analyses of the materials were made.(c-0.032, Mn-0.19,Cr-0.01,Ni-0.01,Mo-0.002,S-0.007,P-0.015,Si-0.02 and hardness-46,47HRB) While setting measures of the die, acceptance and experimental formulas applied in the research so far have been considered. In manufacturing the die, lathe, milling machine, forming mill, wire erosion mill, drilling bench, tempering oven, guillotine, hydraulic saw bench, and decoupage saw bench, hardness measurement device, hydraulic press benches, and their equipments were used.

3.2 Experimental Methods

Combination of various materials and process parameters make the exact estimation of spring-back difficult. Some experiments were carried out for the investigation of the effects of some of the materials and parameters. During these experiments, combination provided by DOE was considered for spring back prediction values. As the whole experiments conducted on power press a direct contact methodology was applied to experiment that is at a single stroke complete deformation take place in the specimen. In given set of the experiments, approximately 20 sheet metals were bent. Then, the results of the 20 sheet experiments were compared.

These experiments were performed under ideal conditions. Adverse conditions, (like dust, heat etc.), which could affect the experimental results were eliminated. Each experimental piece was meticulously put in the die and bending process carried out. Later on, they were prepared even carefully for measurement process. Experimental pieces were put through cold bending after cleaning the burrs on the specimens. Each specimen bent was measured by a CMM.

3.3 Controllable Variables:

Springback depends upon number of variables like punch radius die radius, punch height, varying width, thickness, angle, clearance and other machining parameters. From all these variables it is found from above literature the varying width (mm), angle (degrees) and thickness (mm) are taken as controllable variables whereas other parameters are constants.

3.4 Measurement

The varying width and thickness measured by Vernier caliper and micrometer. The spring-back measured by Coordinate Measuring Machine (CMM)

3.5 Experimental Parameters

The experiments were carried out on power press machine. There are three input controlling factors selected at three levels. Details of parameters and their levels are used shown in the table 1 below.

Table 1: Controlling factors and levels selected.

Factors	Level 1	Level 2	Level 3
Width (mm)	5	15	30
Thickness (mm)	1	1.5	2
Angle (degrees)	30	60	90

The response surface study of central composite design (CCD) refers to evaluation of the anticipated model is obtained from Minitab14. The experimental design matrix is obtained by response surface methodology by using Minitab 14 software is shown in table 2 below.

Table 2: Experimental design matrix using RSM

Run Order	Angle	Thickness	Width	Spring-back
1	90	1.5	15	1.231
2	30	2	30	1.15
3	30	1.5	15	-1.18
4	60	1	15	3.118
5	60	1.5	15	-2.828
6	30	1	5	1.447
7	60	2	15	1.658
8	90	1	30	2.532
9	60	1.5	15	1.89
10	60	1.5	30	-1.348
11	90	2	5	-5.325
12	60	1.5	15	-0.4562
13	30	2	5	1.514
14	60	1.5	15	0.486
15	90	1	5	-3.263
16	60	1.5	5	1.603
17	30	1	30	4.992
18	90	2	30	1.1175
19	60	1.5	15	0.3772
20	60	1.5	15	-0.155

4. RESULT AND DISCUSSIONS

For CRC-D by applying ANOVA it is observed that spring-back (response) linearly decreases as angle proceeds from 30^0 to 90^0. As the thickness increases from 1mm to 1.5mm, spring-back nearly zero,. Further increase in thickness from 1.5mm to 2mm spring-back slightly increases. The variation of spring-back is linearly proportional with the varying width cross-section from 5mm to 30mm. The graph 1 shows the interaction of variables with the response.

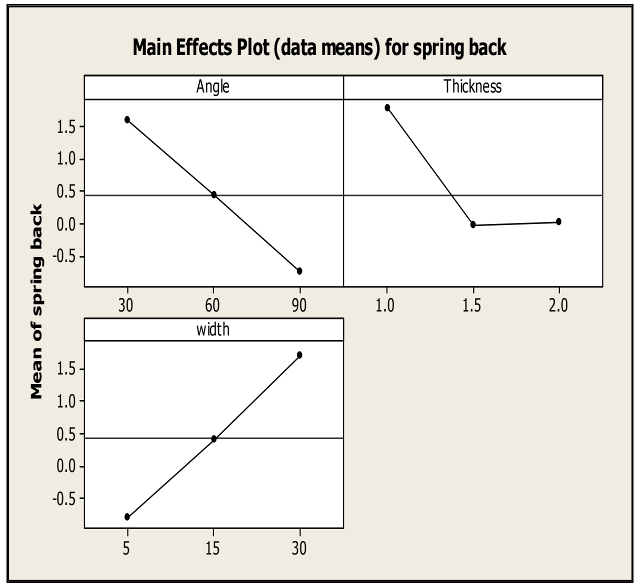

Chart-1: Mean effect plot

The graph 2 shows the comparison of actual and calculated spring-back by regression analysis. It shows the trend of experimental and calculated is nearly same with some unavoidable errors within 90% confidence level.

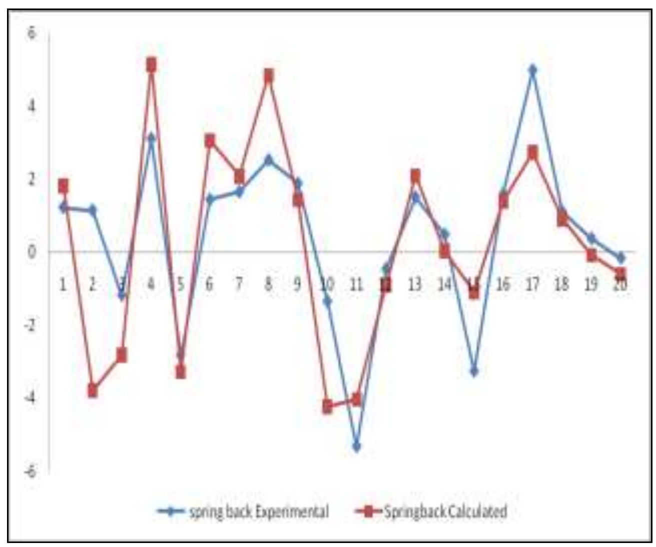

Chart-2:Comparision of Experimental and Calculated Spring-back

Estimated Regression Coefficients for spring back using data in un coded units are in equation 1 which is given below.

Spring back = (15.7341+0.00231669 x Angle - 20.9861 x Thickness+.0230181 x Width-7.53353E-04 x Angle x Angle + 6.73791 x Thickness x Thickness-0.00550248 x Width x Width+0.00248750 x Angle x Thickness+ 0.00268157 x Angle x Width-0.0658328 x Thickness x Width) …………………………………………..Equation 1

5. REFERENCES

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