# Effect of Orientation on Springback for Component with Hole and without Hole

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***Abstract***

Many components are needed to be formed into different shapes depending upon their applications. Whenever the component is formed, it is associated with little or more amount of springback. It is because of the elastic stresses that remain in the bent up part. When the bending force is removed, the elastic stresses remaining in the bent up part try to relieve and due to relieving of these elastic stresses the formed up component try to regain its original shape. This movement of metal due to relieving of stresses is called springback.

In this paper the effect of orientation on the springback is studied for component with hole and without hole. The components are formed in U shape along rolling direction, $45^0$ to rolling direction and $90^0$ to rolling direction, with hole and without hole in the component. Springback is measured and compared for all the formed up components. It is seen that the springback is minimum both for components with hole and without hole formed along rolling direction. It is also seen that for the components with holes the springback is reduced as compared with the component without hole.

***Keywords-*** *Sprinback**;** orientationt; U shape; forming.*

## 1. INTRODUCTION

Forming is a process, which is used for making the components in different shapes. Springback is the major problem associated with forming process. Springback affects precision of formed up parts. So we are not able to get the desired shape due to springback. Springback is due to elastic recovery during unloading. The change in shape of the component due to elastic stresses is called springback. Therefore it becomes important to predict the springback for the design of punch and die so that the desired shapes can be obtained with accuracy.

In the past two decades a lot of study has been carried out. Recep Kazan et al. [1] studied springback for the process of wipe-bending. By using neural network, a prediction model to predict the springback was developed from data obtained by FEA. The effect of R/t ratio 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. Y. E. Ling et al. [2] so as 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 process using FEA. It was observed that the die clearance and die radius has more influence on springback in compared of step height and the step distance. R. Ankenas and R. Barauskar et al. [3] developed Finite Element model for sheet metal forming of U shaped benchmark, in S-DYNA and the results are validated by comparing with the experimental results published elsewhere. They studied the effect of blank holder force on springback and sensitivity of coefficient of friction to springback. Praveen kumar et al. [4] studied the effect of punch radius and clearance between the die and punch, for L bending using Finite element

approach. He also applied kriging interpolation to optimize sheet metal forming process. Jean-Philippe Ponthot et al. [5] investigated the influence of different parameters on springback by commercial code OPTRIS. S. K. Panthi et al. [6] studied the effect of load on springback, varying the thickness as well the radius of the die. M. Bakshi-jooybari et al. [7] studied the effect of various parameters on springback in V-die and U-die bending processes. Gawade Sharad et al. [8] investigated the effect of sheet thickness on springback by FEA and experimental method for U bending and their results are compared. Wenjuan Liu et al. [9] used neural network and genetic algorithm to predict the springback in U shape bending. Aysun Egrisogut Tiryaki et al. [10] developed neural network prediction model for wipe bending process, using data obtained from FEA results. Ozgur Tekaslan et al. [11] studied effect of different parameters on springback of stainless steel sheet metal in V bending dies. W. L. Xu [12] studied the effect of number of integration points, blank mesh size, and punch velocity on springback.

Earlier study has mainly focused on the springback for components without hole. The comparative study of effect of orientation on the springback for components with hole and without hole is done in this paper. The sheets of material IS513EDD with thickness of 0.8 mm, 1.0 mm and 2.0 mm are used for forming the U shape components. The components are formed in U shape along rolling direction, $45^0$ to rolling direction and $90^0$ to rolling direction for all sheet thickness, with hole and without hole Springback is measured for components with hole and without hole and the results are compared for all the formed up components.

## 2. MATERIAL PROPERTIES

The material used for the forming of U shaped component is IS513EDD. This material is selected because it is an anisotropic material and is very widely used in an automobile industry for forming of the components of vehicle body. The material properties for this material are listed as below in table 1.

**Table 1 Material Properties for IS513EDD**

| Sr. No. | Material | Yield Strength (MPa) | Ultimate Tensile Strength (MPa) | Strength Coefficient K (MPa) | n | $r_0$ | $r_{45}$ | $r_{90}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | IS513EDD | 151 | 279.2 | 501 | 0.2415 | 1.8 | 1.11 | 1.81 |

## 3. EXPMENTAL PROCEDURE

Initially the sheets with thickness 0.8 mm, 1.0 mm and 2.0 mm of the material IS513EDD are cut along rolling direction, $45^0$ to rolling direction and perpendicular to the rolling direction as shown in figure 1. The dimensions of blanks are: length = 270 mm and width = 75 mm with sheet thickness of 0.8 mm, 1 mm and 2 mm. The shearing machine is used to cut the sheets as per required dimensions and along the required direction.

The schematic for U bending is shown in figure 2. The sheet is placed on die surface. With movement of punch in the downward direction, initially blank holder holds the blank and then further movement of punch presses the sheet to be formed into desired shape. The gap between die and punch is maintained equal to sheet thickness plus 10% of sheet thickness [1, 2, 3 and 4]. The punch is removed as soon as bending operation is finished.

Figure 3 shows the U shape component formed without holes and figure 4 shows the U shape component formed with holes in it. The blank sheets are pressed on 50 ton mechanical press machine to form the component into desired shape. The other parameters are as below.

Die corner radius (R) = 2 mm.

Sheet thickness ( t) = 0.8 mm, 1.0 mm and 2.0 mm.

Punch corner Radius ( r ) = 2 mm.
R/t ratio = 2.


**Figure 1 Samples Cut Along Rolling Direction, $45^0$ to Rolling Direction and $90^0$ to Rolling Direction.**

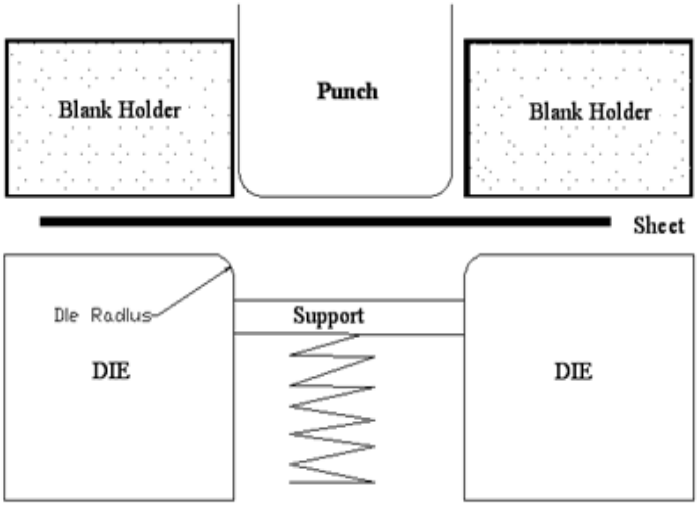


**Figure 2 Schematic of U Bending**

**Figure 3 U Shape Component Formed without Holes.**


**Figure 4 U Shape Component Formed with Holes**

## 4. RESULT AND DISCUSSION

### a. Effect of Orientation on Springback wihout Hole in Component

So as to obtain the effect of orientation during forming on springback, blanks are cut along rolling direction, $45^0$ to rolling direction and perpendicular to rolling direction for sheet thickness of 0.8 mm, 1.0 mm and 2.0 mm as discussed in section 3 and are formed in U shape by using mechanical press. These components formed in U shape are free of any holes as shown in figure 3. The springback is measured for these components and is tabulated in table 2. The graph of springback vs. orientation is plotted on graph as shown in figure 5.

**Table 2 Springback for Component Formed Along Different Orientations for Sheets Without Hole.**

| Orientation | Springback for sheet thickness - 0.8 mm | Springback for sheet thickness - 1.0 mm | Springback for sheet thickness - 2.0 mm |
|---|---|---|---|
| $0^0$ to rolling | 1.051 | 0.762 | 0.597 |
| $45^0$ to rolling | 1.102 | 0.805 | 0.661 |
| $90^0$ to rolling | 1.184 | 0.975 | 0.728 |

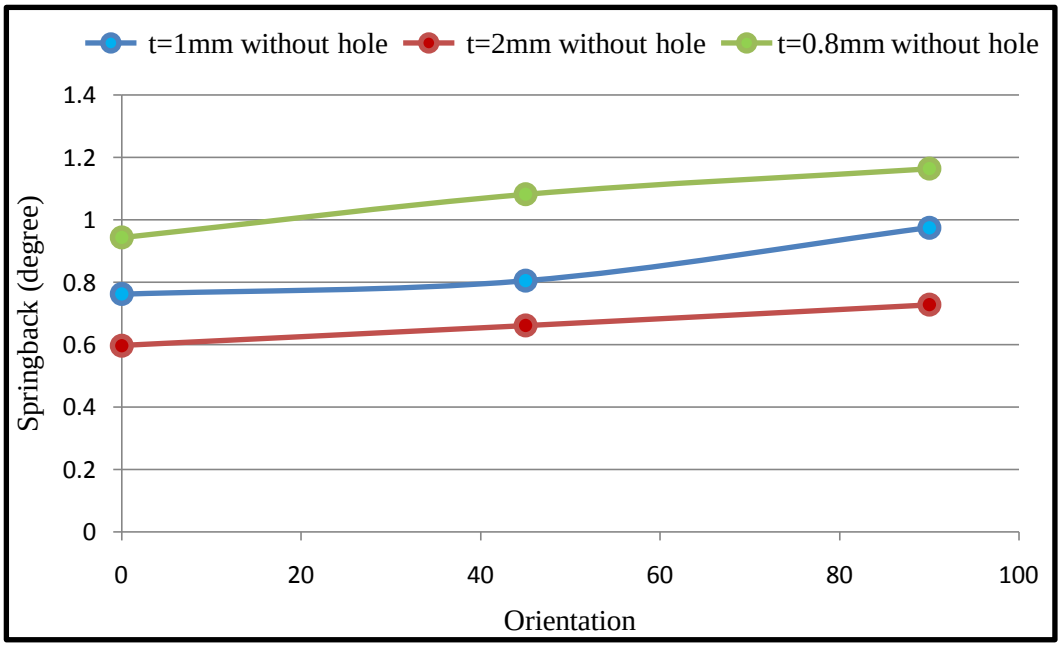


**Figure 5 Effect of orientation on springback for various sheet thicknesses for IS513EDD for component without hole.**

It is clearly seen from the figure 5 that for component without hole, the springback is minimum along the rolling direction and it is maximum along $90^0$ to rolling direction. These results for component without hole are in agreement with earlier published results [7]. Along the rolling direction the springback is minimum because along rolling direction elongation of grains is more as compared to perpendicular to rolling direction. Due to elongation in grains, yield strength is reduced. With decrease in yield strength springback decreases and therefore along the rolling direction the springback is less as compared with $90^0$ to rolling direction.

### *b. Effect of Orientation on Springback with Hole in Component*

So as to study an effect of orientation during forming on springback, for components with hole, the hole of diameter 12 mm is punched into the blanks cut along rolling direction, $45^0$ to rolling direction and perpendicular to rolling direction for all blanks of 0.8 mm, 1.0 mm and 2.0 mm thickness. Then these blanks with 12 mm hole are formed into U shape component by using a mechanical press. The measurement of is done adjacent to hole, by measuring final dimensions of the component adjacent to the hole with the help of digital vernier. The measured values of springback are listed in table 3 and are plotted as shown in figure 6.

**Table 3 Springback for Component Formed Along Different Orientations for Component with Hole**

| Orientation | Springback for sheet thickness - 0.8 mm | Springback for sheet thickness - 1.0 mm | Springback for sheet thickness - 2.0 mm |
|---|---|---|---|
| $0^0$ to rolling | 0.965 | 0.723 | 0.544 |
| $45^0$ to rolling | 1.025 | 0.743 | 0.585 |
| $90^0$ to rolling | 1.112 | 0.924 | 0.677 |

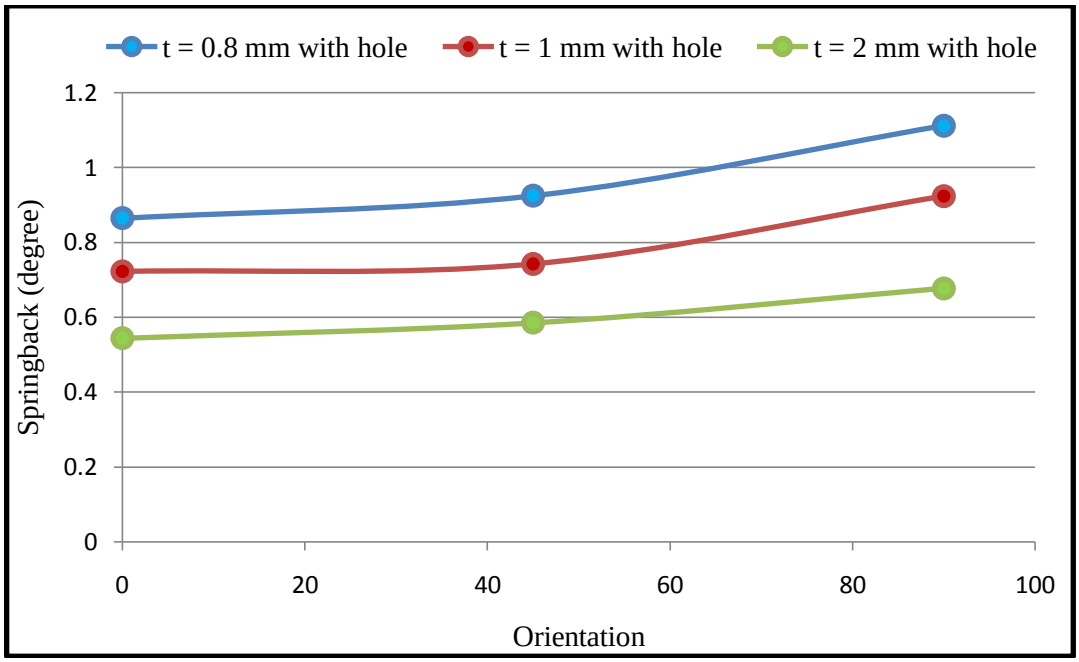


**Figure 6 Effect of orientation on springback for various sheet thicknesses for component with hole.**

It is clearly seen from the figure 6 that for component with hole, the springback is minimum along the rolling direction and it is maximum along $90^0$ to rolling direction. The pattern is very similar to that of component without hole.

### *c. Comparison of Effect of Orientation on Springback for Component with Hole and wihout Hole.*

So as to investigate effect of presence of hole in the component, the springback are measured for component without hole and with hole. These results are listed in table 4 and are compared as shown in figure 7.

**Table 4 Springback Measurement for Component**

| Orientation | Springback for sheet thickness - 0.8 mm | | Springback for sheet thickness - 1.0 mm | | Springback for sheet thickness - 2.0 mm | |
|---|---|---|---|---|---|---|
| | Without hole | With hole | Without hole | With hole | Without hole | With hole |
| $0^0$ to rolling | 1.051 | 0.965 | 0.762 | 0.723 | 0.597 | 0.544 |
| $45^0$ to rolling | 1.102 | 1.025 | 0.805 | 0.743 | 0.661 | 0.585 |
| $90^0$ to rolling | 1.184 | 1.112 | 0.975 | 0.924 | 0.728 | 0.677 |

From figure 7 it is clear that along rolling direction the springback is minimum while for $90^0$ to rolling direction the springback is maximum for both the component with hole and without hole. But it is observed that springback has reduced for the components with hole for all the sheet thicknesses and for all orientations under consideration. This is because when we punch the hole in the blank, the material is removed and because of the removal of material, the residual stresses that are responsible for springback are reduced.

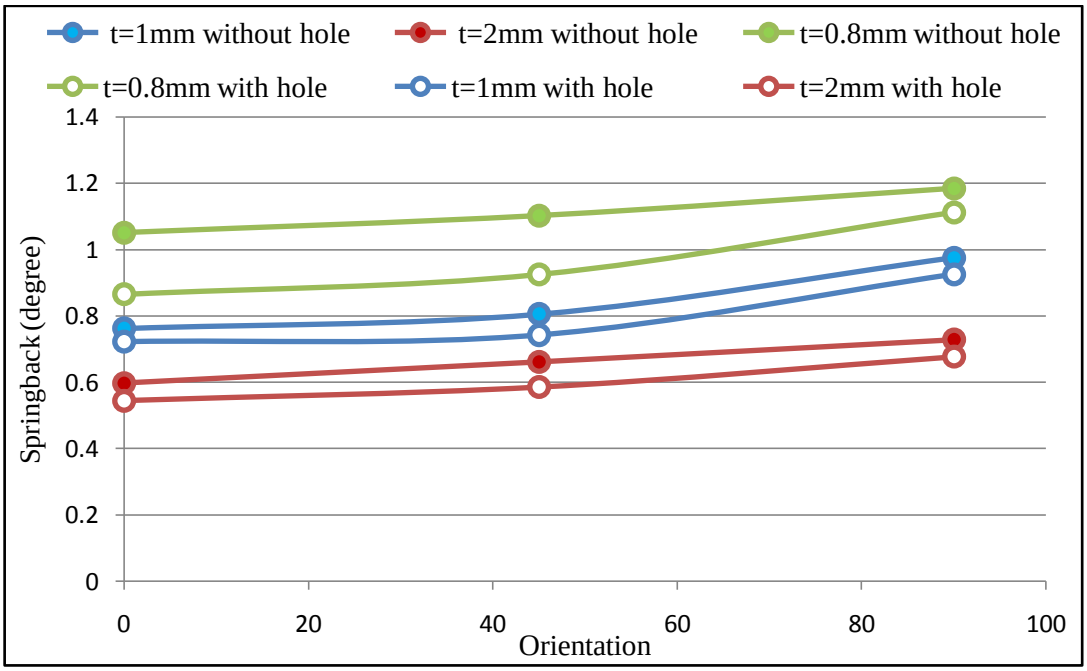


**Figure 7 Effect of orientation on springback for component without hole and with hole.**

## 5. CONCLUSION

Based on obtained results, following conclusions can be made.

1. The springback is minimum when component is formed along rolling direction (i.e. $0^0$ to rolling direction) and it is maximum when formed along perpendicular to rolling direction (i.e. $90^0$ to rolling direction) both for the component with hole and without hole.
2. It is observed that for the components with hole the springback is reduced as compared with the component without hole for all the components formed along rolling direction, $45^0$ to rolling direction and $90^0$ to rolling direction.

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