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Comparative Study of Springback for Expansion and Retreint Deep Drawing

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Abstract: The design of multi-stage deep drawing processes requires the evaluation of many process parameters such as the intermediate die geometry, the blank shape, the sheet thickness, the blank-holding force, friction, lubrication etc… These process parameters have to be determined for the optimum forming condition before the process design. In general sheet metal forming may involve stretching drawing or various combinations of these basic modes of deformation. It is important to determine the influence of the process variables in the design of sheet metal working process. Especially, the punch and die corner for deep drawing will affect the formability. At the same time the prediction of sheet metal's springback after deep drawing is an important issue to solve for the control of manufacturing processes. Nowadays, the importance of this problem increases because of the use of steel sheeting with high stress and also aluminium alloys. The aim of this study is to give a better understanding of the springback and its effect in various sheet metal forming process such as expansion and retreint deep drawing, by varying diameter die, lubricant for 2 commercially available materials e.g., galvanized steel and aluminium sheet. Expansion deep drawing occurs when the metal between the die and the blank holder is blocked, which prevent the metal flow during this test. This lead at the end of the test, a decrease in thickness. Retreint deep drawing occur when the metal between the die and the blank holder is not blocked, which permit the metal flow during this test and then obtaining final draw product with high thickness. To measure the springback, an experimental apparatus was built especially for deep drawing in our laboratory, to incorporate a number of new features that were motivated by the theoretical analysis. This apparatus was composed of the die and of a punch, which is adapted to traction machine Fu 1000e. A displacement detector pass through an opening under the die. This detector is bended at a recorder. The propose method can be further improved to determine and measure the springback. Thus, the sequence calculus of the springback consists of 3 steps. At the first step, we take the initial value on the recorder as reference, at the second step, we applied a load on the punch and we take then the final value of deformation. At the third step, we unload the punch and take also the residual value of deformation. The springback value is evaluated as the difference between 2 values indicated in steps two and three. Furthermore, the punch depth is evaluated as the difference between 2 values indicated in steps 1 and 2. For expansion deep drawing, the springback decreases rapidly with an increase of deformation (or a decrease of thickness), but the retreint deep drawing, the springback increases with an increase of thickness. As discussed previously, the magnitude of the springback is influenced by the amount of plastic deformation and unloading residual stresses.

Key words: Deep drawing, expansion, retreint deep drawing, springback, deformation, parameters

INTRODUCTION

Deep drawing is a process for stamping sheets into cup-shaped articles without failure or excessive localized thinning. At the same time, the deep drawing process mainly used for large scale manufacturing e.g., in the mechanical constructor of automobile, aeronautics, domestic appliance and in packaging industry. The design and control of a deep drawing process depend not only on the work piece interface but also on the mechanics of plastic deformation and the equipment used.

The deep drawing process consists to stain punched foil under punch effect, where the blank holder pressure keeps the sheet. The sheet stained under blank holding

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force. This last is one of the most important process variables controlling the sheet forming process for a given tool design. The blank holder controls metal flow from the blank holder region to the die cavity. It is, however, well known that advanced in process-control of the blank holder force can provide a more robust forming process, less sensitive to variations in the process (Moon *et al*., 2001).

$$\varepsilon = \varepsilon_e + \varepsilon_p \quad (1)$$

Thus, the elastic deformation is the first, it occurs under elastic threshold boundary. It is a reversible behaviour and generally linear for metals, thus, the elastic deformation is relatively low (au maximum 1% for metals with haute elasticity boundary. Beyond the elastic threshold boundary, we pass to plastic deformation, where the deformation becomes irreversible and has no linear behaviour. This is due to cold hammer phenomena, which force to increase the constraint.

$$\delta = f/s \quad (2)$$

At the last of deep drawing process, we can see the springback and permanent deformation (plastic). This gives the final shape of sheet.

The experimental set up used in the deep drawing operation is illustrate as follow:

A punch was inserted in load cell that was attached to an upper plate of the die. A blank holding force was applied to a blank through a blank holder. The blank holder force is one of the most important process variables controlling the sheet forming process for a given tool design. The blank holder force controls material flow from the blank holder region to the die cavity. As this study, the initial blank holder force was determined as the minimum force that could prevent the wrinkling of the blanks and was kept constant during the test.

The major objectives of this study are focused on finding the expansion and retreint deep drawing and springback in the cup drawing process. To achieve these goals, experiments were carried out and compared with other results.

DEEP DRAWING CASES

The aim of this study is to present and discuss the two types of stamping e.g., expansion and retreint deep drawing where the blank holder keep out or not keep out the creeping of sheet.

Expansion deep drawing: The deep drawing process occurs when the metal situated between the die and blank holder is blocked. It was characterised by

$$e_f < e_0,\ \varepsilon_3 < 0$$

where:

e_0 : Initial thickness of Flong

f_e : Final thickness final draw product

ε_3 : Deformation according to third direction.

Retreint deep drawing: Retreint deep drawing occurs when the metal situated between the die and the blank holder, flow from the blank holder region to die the cavity. It was characterised by

$$e_f < e_0,\ \varepsilon_3 = 0$$

Figure 1 and 2 illustrate the expansion and retreint deep drawing showing the punch, the die and a partially formed cup. The punch is on the down stroke and is just beginning to draw the sheet-metal blank into the die

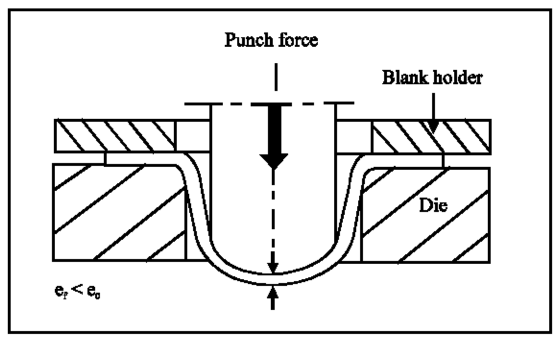

Fig. 1: Schematic drawing of expansion deep drawing process

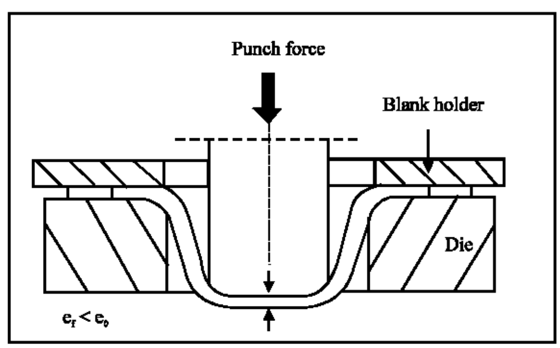

Fig. 2: Schematic drawing of retreint deep drawing process

cavity. If the blank size has been chosen correctly, the sheet will work harden sufficiently to overcome the combined strength of the remainder of the blank metal and friction between it and the blank holder and the part will be successfully made.

MATERIALS AND METHODS

The work materials are:

- Commercially available, FeE 280 G Galvanized steel, with a thickness of 1.25 mm is used for the blank material. Table 1 established mechanical properties of galvanized steel used for the experiments reported in the study.
- Commercially available, A1050 aluminium steel, with a thickness of 1.0 mm is used for the blank material. Table 2 established mechanical properties of aluminium sheet.

Tooling for the process and its operation: To achieve one of the aims of this research presented in this study, a lot of effort was made e.g., deep drawing apparatus, which was built to incorporate a number of new features that are motivated by the theoretical analysis Fig. 3. An especial effort was directed towards precise control of the blank holder position. Figure 3 shows the experimental set up used in the deep drawing operation. The first step consist to realise test-pieces in the shape of rod which are punched out from sheet with a length of 130 mm and a width of 6.0 mm with the help of shear which gives us directly samples.

This study aim to investigate the effect of springback for two kinds of materials e.g., galvanized steel and aluminium sheet by varying punch thickness, diameter die R = 5, R = 10 mm) and lubricant (grease, Golsa oil, Teflon). Before each experiment, both sides of the sheet were wiped in the lubricant. The presence of lubricant between contact surfaces in the deep drawing process increase the drawability, reduces tool wear and improves the product quality.

An analysis of 2 types of deep drawing operation. The first one is a retreint deep drawing where the samples used haven't heads, which permit to material to flow from the blank holder region to the die cavity. The second one, is the expansion deep drawing where the samples used have heads, which prevent the material flow during this test.

Equipments: Our deep drawing tests are carried out using a:

Table 1: Mechanical properites of galvanized steel

Designation	Re (Map)	Rm (Mpa)	A (%)
FeE280G	280	360	18-38

Table 2: Mechanical properites of aluminium sheet

Designation	Re (Mpa)	Rm (Mpa)	A (%)
A1050	30-40	70-90	40-30

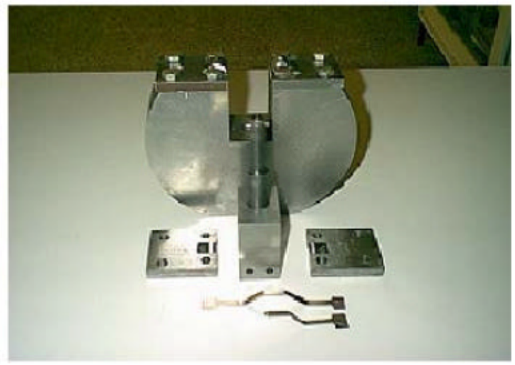

Fig. 3: Photograph of experimental apparatus

- Traction machine Fu1000e with maximum load 1Mp.
- Deep drawing apparatus adapted to traction machine developed in our laboratory.
- Displacement detector SOLARTRON AX/10/S±10 mm.

RESULTS AND DISCUSSION

It is important to measure the springback after retreint and expansion deep drawing processes as varying the thickness, the diameter die and the lubricants for galvanized steel and aluminium sheets. The determinate results were shown as follow (Fig. 4-5).

It was found that when the samples heads are removed, the material flow (for restraint deep drawing process), which cause an increase of thickness. Besides, the final thickness is greater than the initial $e_f > e_0$, then the springback values increase until a fixed threshold where become stable.

For expansion deep drawing case ($e_f < e_0$) the samples are used with heads, le material flow. This lead to a decrease of samples thickness with an increase of deformation (Taylor, 2003). In addition, the effect of materials was investigated in this study. Ours experimental results show that the springback values are then related linear to elastic deformation level for different materials (Slim *et al.*, 2005). Therefore, the lubrication is of great importance in sheet metal forming processes. The use of lubricant (between contact surfaces in deep drawing process) permit the deformation uniformity which

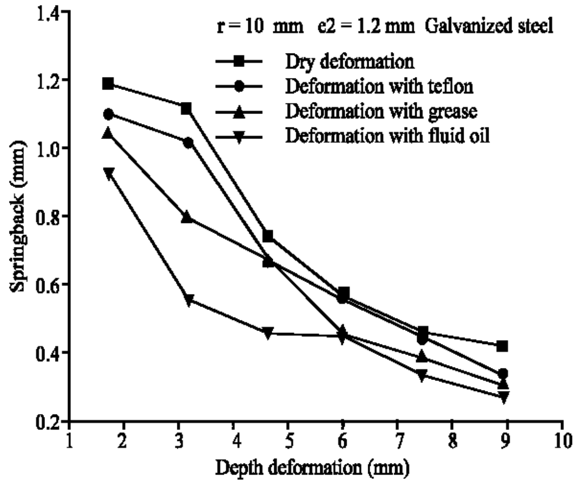

Fig. 4a: Springback curve as function of deformation depth for galvanized steel

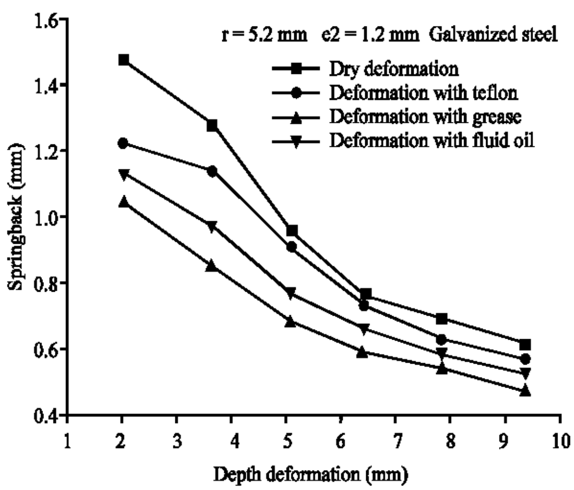

Fig. 4b: Springback curve as function of deformation depth for galvanized steel

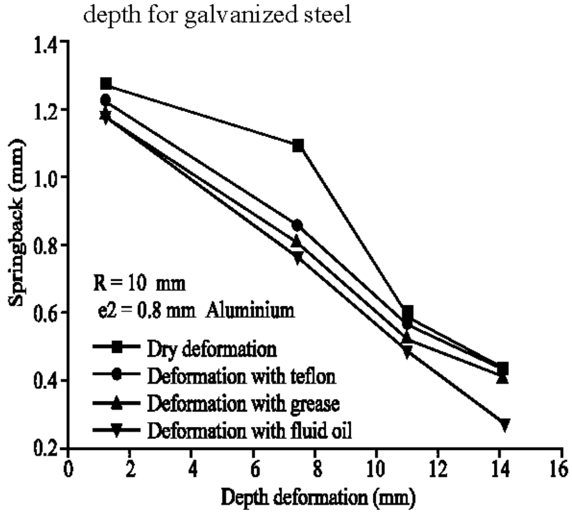

Fig. 4c: Springback curve as function of deformation depth for aluminium

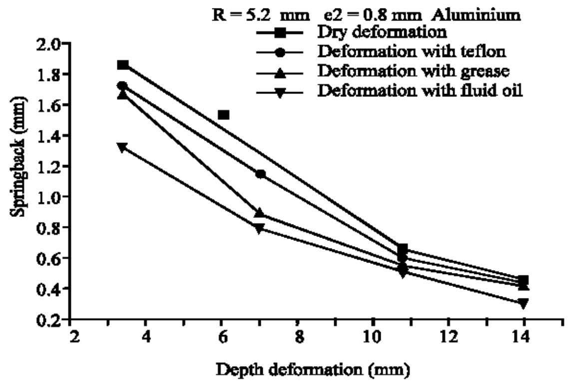

Fig. 4d: Springback curve as function of deformation depth for aluminium

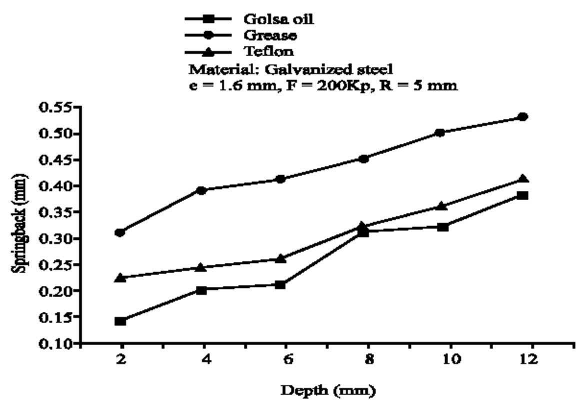

Fig. 5a: Springback curve as function of deformation depth for galvanized steel

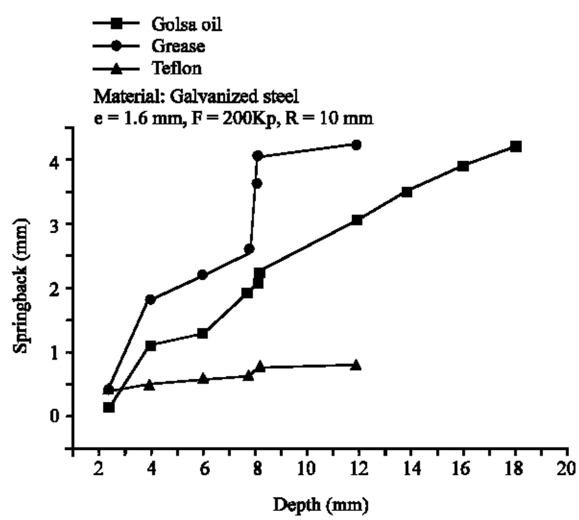

Fig. 5b: Springback curve as function of deformation depth for galvanized steel

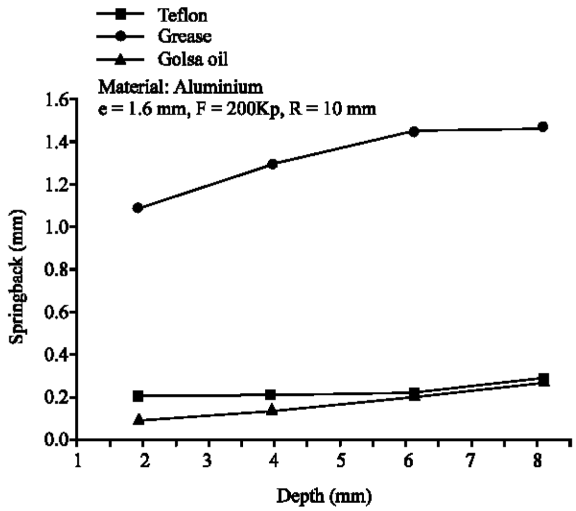

Fig. 5c: Springback curve as function of deformation depth for aluminium sheet

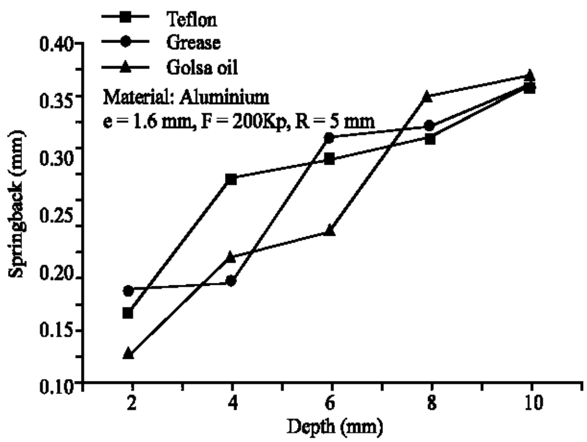

Fig. 5d: Springback curve as function of deformation depth for aluminium sheet

led to an increase of penetration thickness and of depth deep drawing, increases the drawbility, reduces tool wear and improves the product quality.

CONCLUSION

From the results of experiment analysis, some useful conclusions can be led as follows. In this study, 2 kinds of deep drawing tests i.e., (retreint and expansion) were conducted using especially developed apparatus. The materials used are galvanized steel FeE280G and aluminium sheets A1050. Our experimental results shows that the material types, the diameter Die and the lubricant type have no significant effect on springback curves. Furthermore, it was found that they're a significant difference between springback values for 2 deep drawing cases. For expansion deep drawing, the springback curves decrease but for retreint increases. Then the only parameter that makes the difference is the thickness of sheet. The determined results show that the springback increase with thickness increases. This can be explained that the springback occur significantly related to the yield strain level and by the elastic constraints delivery during the unloading.

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