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A Detailed Experimental Study and Evaluation of Springback under Stretch Bending Process

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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 holder force, friction, lubrication etc..These process parameters have to be determined for the optimum forming conditions 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 metals 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 aluminum alloys.

The aim of this paper is to give a better understanding of the springback and its effect in various sheet metals forming process such as expansion and restreint deep drawing in the cup drawing process, by varying radius die, lubricant for two commercially available materials e.g. galvanized steel and Aluminum sheet. To achieve these goals experiments were carried out and compared with other results. The original of our purpose consist on tests which are ensured by adapting a **U**-type stretching-bending device on a tensile testing machine, where we studied and quantified the variation of the springback.

***Keywords*—**Deep drawing, Expansion, Restreint deep drawing, Springback.

I. Introduction

DEEP drawing process for stamping sheets into cup-shaped articles without failure or failure or excessive localized thinning. At the same time, the deep drawing mainly used for large scale manufactory e.g in the mechanical constructor of automobile, aeronautics, domestic appliance and in packaging industry. 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 force [7]. 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 [1], [2].

The Springback is a significant problem in the sheet metal forming process [8]. When the tools are released after the stage of forming, the product springs out behind; because of the action of the internal stresses. The precise prediction of the springback of product is increasingly significant for the design of the tools and for compensation because of the higher ratio of the yield stress to the elastic modulus [3].

Currently, there is much effort to evaluate or to decrease the springback. With regard to the evaluation of the springback, several techniques were used. Moreover, the use of steel and aluminum alloys in the car industry and aviation poses every day the problem of the springback. The determination in advance of the quantity of the springback allows consequently the design and manufacture of the tool.

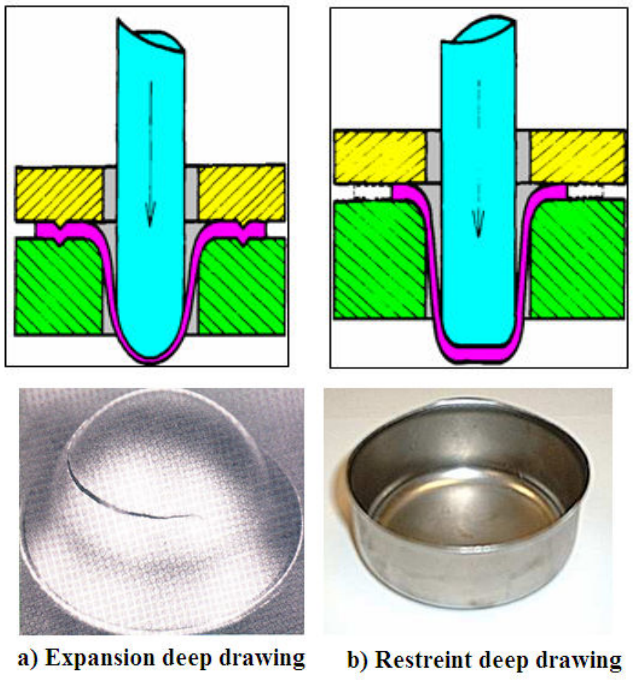

Fig. 1 Deep drawing process [4]-[6] (a) Expansion deep drawing (b) Restreint deep drawing

Fig. 1 illustrates the expansion and the restreint 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 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. Expansion deep drawing occurs when the metal between the die and the blank holder is blocked, which prevent the metal flow during this test. These lead at the end of the test a decrease in thickness. Restreint deep drawing occurs when the

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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.

II. Experimental Study

To measure the springback, a new experimental apparatus was built especially for deep drawing (different from that built and used in [2]) in our laboratory (LPMMM, Setif, Algeria) to incorporate a number of new features that were motivated by theoretical analysis. The tests are ensured by adapting the device of stretch-bending on the tensile testing machine and by using a displacement sensor of the type SOLARTRON C53 [+/- 10 mm] which crosses the opening of the die and is put in contact with the spacemen, which allows the recording of any displacement (see Fig. 2). These tests are carried out on specimens where are treated differently.

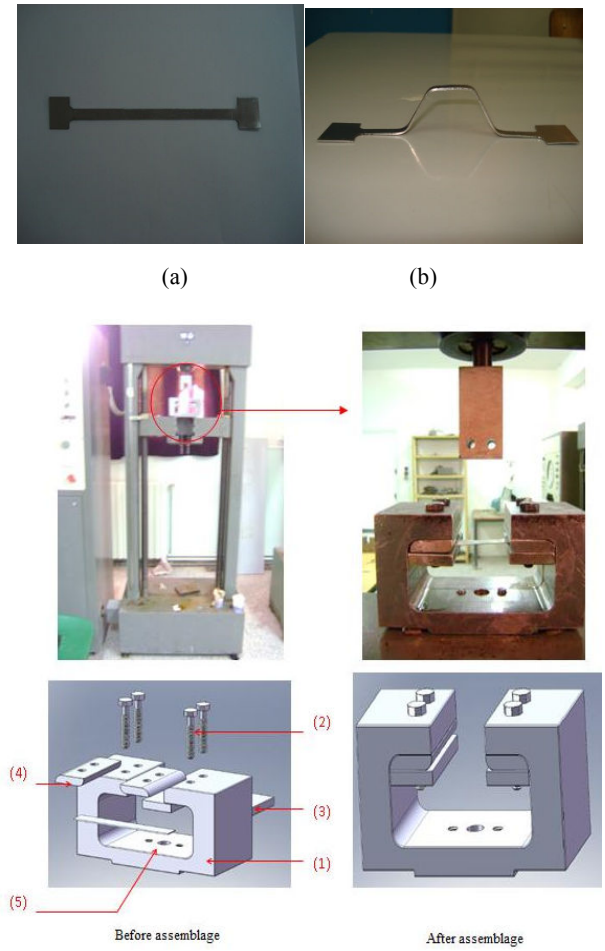


Fig. 2 Stretching -bending set-up (a) The initial shape of the specimen, working length=120mm (b) Form of specimen after deformation (c) Device of stretch-bending assembled on the tensile testing machine

Thus, the sequence measure of the springback consists of three 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 two values indicated in steps two and three as in

$$\Delta h = h_c - h_d \quad (1)$$

Furthermore, the punch depth is evaluated as the difference between two values indicated in steps one and two (see Fig. 3).

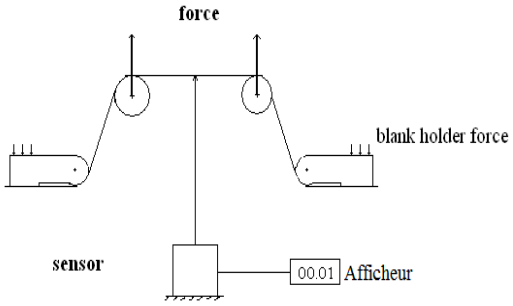
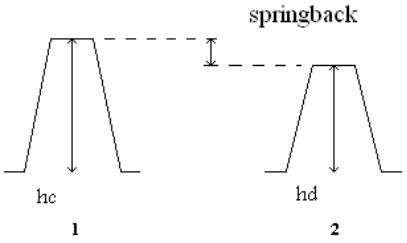


Fig. 3 (a) Diagram explaining the principal trial



1. Final form of specimen before unloading.
2. Final form of specimen after unloading.

Fig. 3 (b) Sequence measure of the springback

III. Results and Discussions

This study aims to investigate and measure the springback after restreint and expansion deep drawing processes for two kinds of materials (galvanized steel FeE280G and Aluminum sheet A1050 by varying punch thickness, radius die and lubricant (Grease, Golsa oil, Telfon). The use of lubricant between contact surfaces in the deep drawing process increase the draw-ability reduces tool wear and improves the product quality [5].

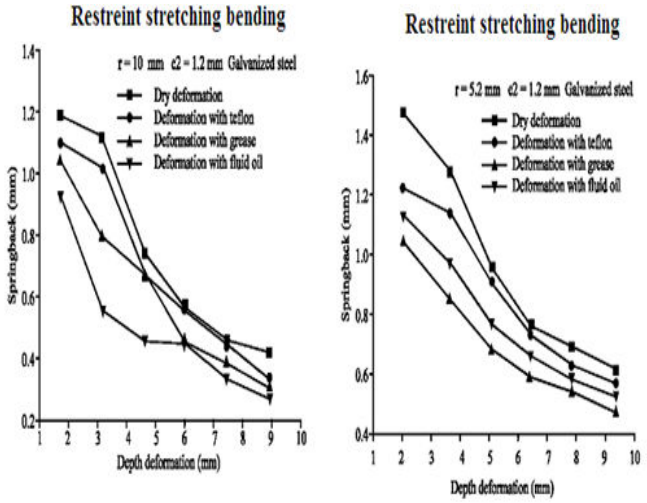


Fig. 4 Influence of die radius and lubricant for galvanized steel

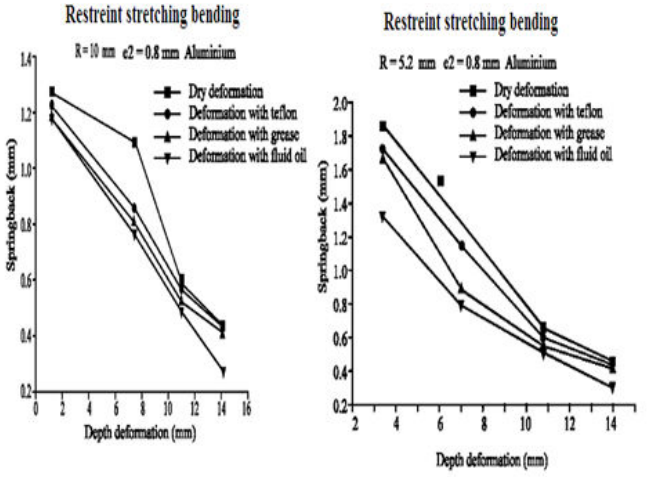


Fig. 5 Influence of die radius and lubricant for Aluminum

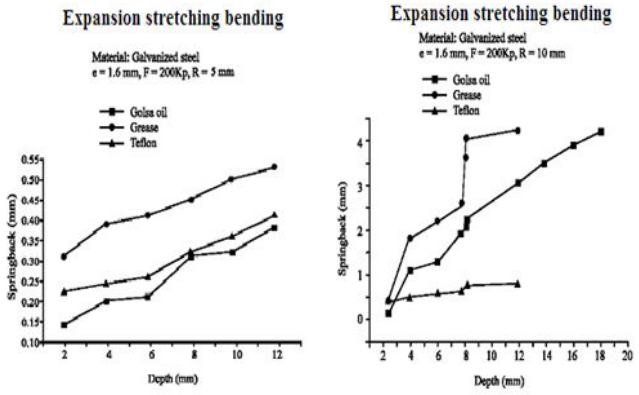


Fig. 6 Influence of die radius and lubricant on the springback for galvanized steel

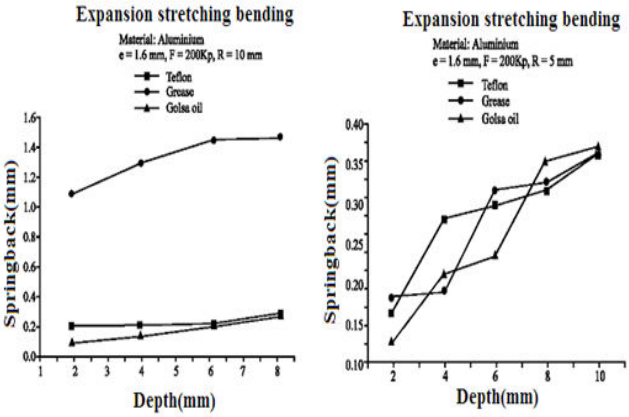


Fig. 7 Influence of die radius and lubricant on the springback for Aluminum

IV. Conclusion

In this work, an important characteristic which is a springback has been studied for two kinds of stretching drawing process: restreint and expansion. We have presented defaults where showed in this two process and many parameters influenced a springback.

Moreover, we have studied the effect of the lubricant type and the radius of the die on the springback for two most commercially materials eg galvanized steel and aluminum sheet.

The main conclusions, which can be made from the present study, are:

- For expansion deep drawing, the springback decreases rapidly with an increase of deformation (or a decrease of thickness);
- For the restreint 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.
- It was found that with increasing the thickness, this can be explained that the springback occurs significantly related to the yield strain level and by the elastic constraints delivery during the unloading.
- A large value of the deformation gives a little value of springback.
- The die plays a significant role through its curvature on the quality of forming. For great sheet stretch-bending because of small radius of curvature, the springback is also higher. With regard to the tests carried out on aluminum, the results show that metals hardened initiallyby tension has an enormous springback during their forming.

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