International Journal of Mechanical, Industrial and Aerospace Sciences
ISSN: 2517-9950
Vol:7, No:1, 2013

An Experimental Study and Influence of BHF and Die Radius in Deep Drawing Process on the Springback

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Abstract**—**A lot of research made during these last 15 years showed that the quantification of the springback has a significant role in the industry of sheet metal forming. These studies were made with the objective of finding techniques and methods to minimize or completely avoid this permanent physical variation. 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. The aim of this paper is to study experimentally the influence of the blank holder force BHF and the radius of curvature of the die on the springback and their influence on the strain in various zone of specimen.

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 according to displacement.

Keywords**—**Blank holder force, Deep-Drawing, Die radius, Forming, Springback.

I. Introduction

SPRINGBACK is a significant problem in the sheet metal forming process. When the tools are released after the stage of forming, the product springs out behind, because of the action of the internal stresses. In many cases the deviation of form is too large and the compensation of the springback is necessary [1]. 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 [2].

Currently, there is much effort to evaluate or to decrease the springback. With regard to the evaluation of the springback, several techniques were used. The springback was studied by Claes Arwidson [3] by measuring the variation of the transverse distance from the opening. Sun [4] measured it according to the direction of displacement of the punch. Other authors [5]-[6]-[7] evaluated the springback through the deviation Δθ measured on the extremities of specimen.

In our study, the springback is given by the difference between the depth at the end of drawing *hc* and that measured after unloading *hd*

II. Experimental Part

The main aim is to obtain the variation of the springback versus die radius and blank holder force. These latter specimens underwent the same treatments as the specimens deformed to a U shape.

A. Springback Tests

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. 3).

The measurement technique of the springback is schematized in Fig. 1 and Fig. 2. The device used in our tests is designed and made in our laboratory (LPMMM, Setif, Algeria). These tests are carried out on specimens which are treated differently. The objective of these tests is to quantify the variation of the springback according to the depth of drawing, showing the influence of the factors mentioned before. The specimen were cut parallel to the direction of rolling (θ = 0). They are machined starting from a plane sheet and they have the form and the dimensions indicated in Fig.3. The springback Δh is evaluated in terms of the drawing depth h_d.

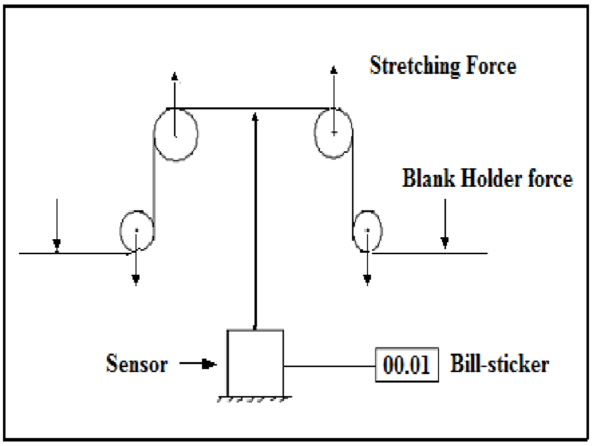

Fig. 1 Diagram explaining the principal test

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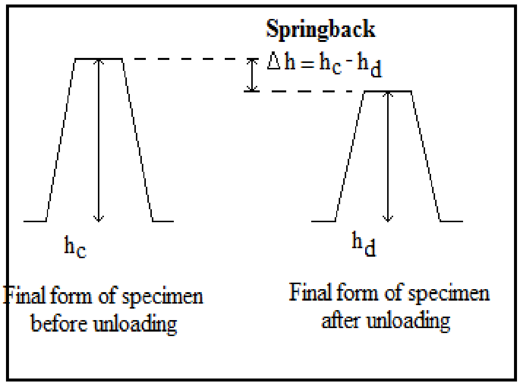

Fig. 2 Principal Measurements

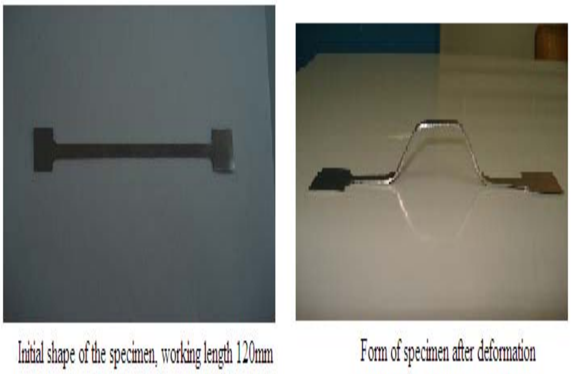

Fig. 3 (a) Form of specimen before and after unloading

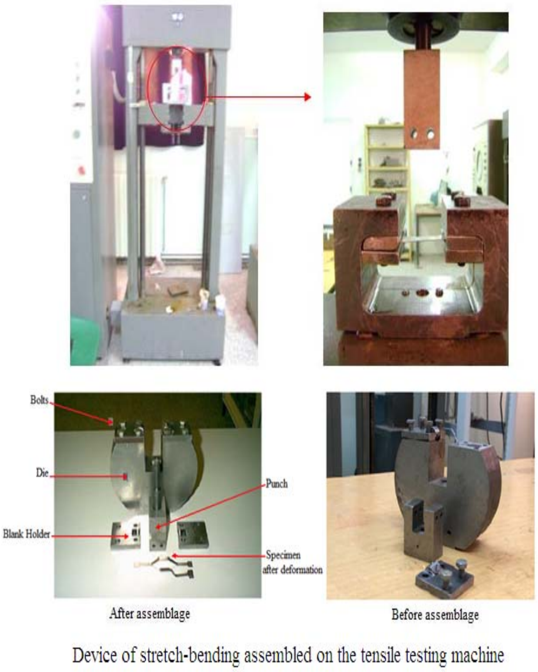

Fig. 3 (b) Stretching -bending set-up

III. Results and Interpretations

A. Effect of the Blank Holder Force BHF on Springback

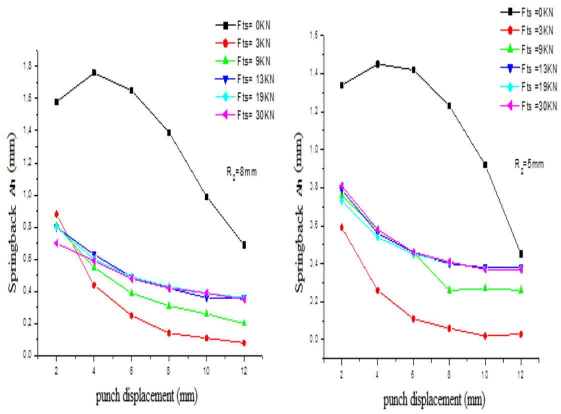

Fig. 4 Influence of *the blank holder force on the springback*

B. Effect of the Blank Holder Force BHF and the Radius of Curvature of the Die on Springback

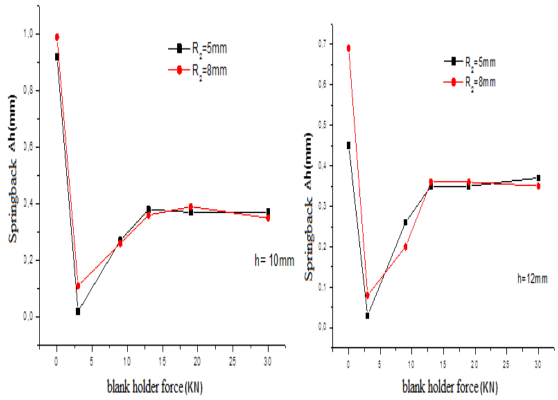

Fig. 5 Influence of the blank holder force and the radius of curvature of the die on the springback

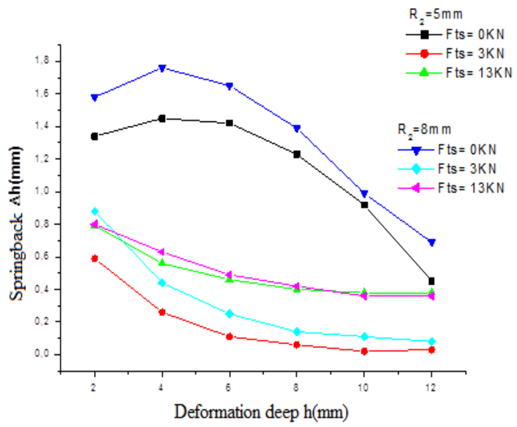

Fig. 6 Influence of the deformation deep on the springback variation

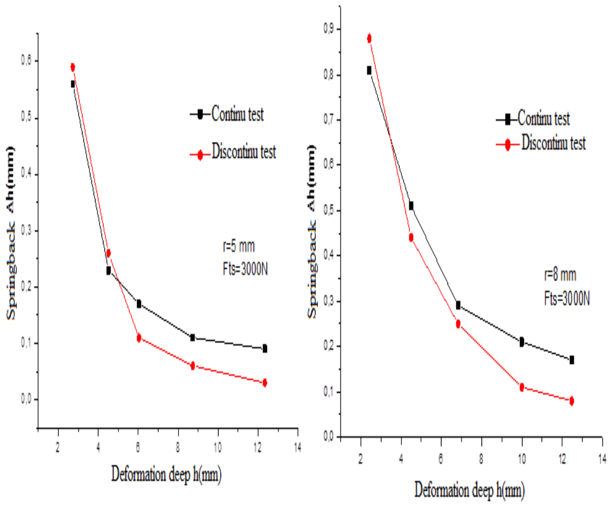

Fig. 7 Influence of the test continuity on the springback

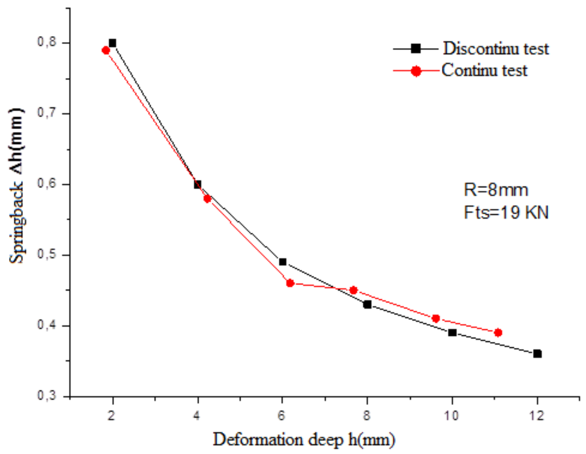

Fig. 8 Influence of the deformation deep on the springback for blank holder force F=19KN

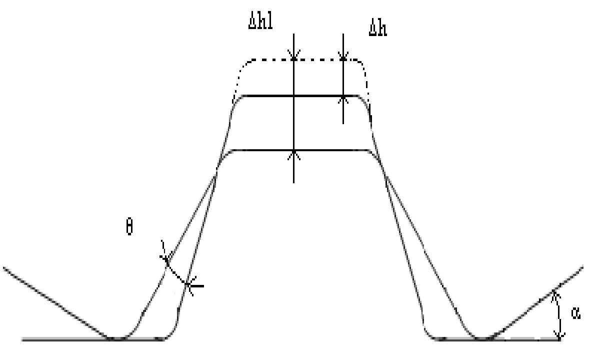

Fig. 9 (a) Representation of sringback variation Δh et Δh_1

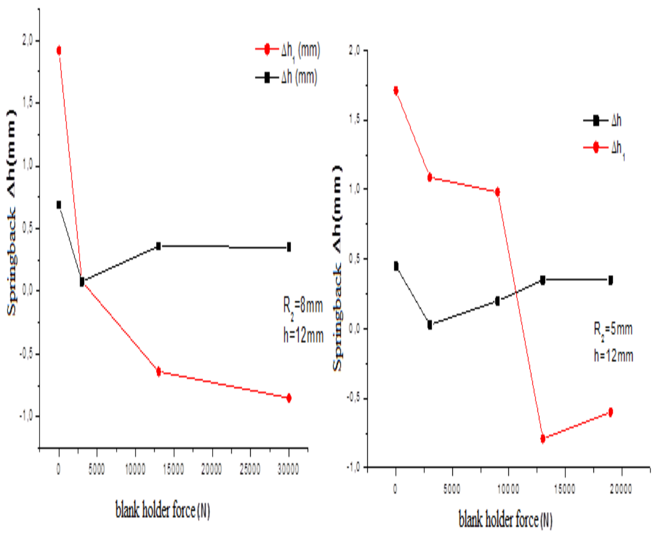

Fig. 9 (b) Influence of the blank holder force on the springback variation Δh and Δh_1

C. Measure of the Springback Angle

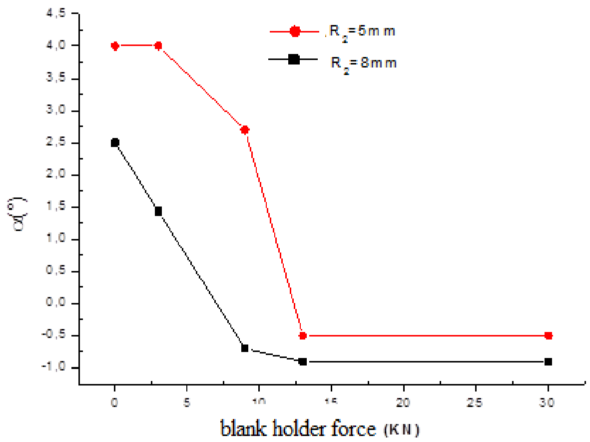

Fig. 10 Influence of the blank holder pressure on the springback angle (α)

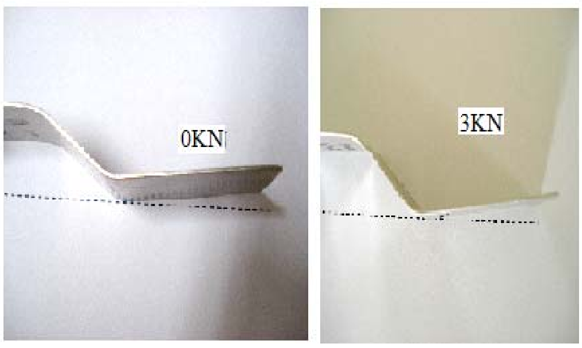

Fig. 11 Specimen after deformation

ISSN: 2517-9950
Vol:7, No:1, 2013

IV. Conclusion

In this work, we have studied important characteristics in deep drawing process which is a springback. We have presented defaults that are showed in this process and many parameters influenced a springback.

Moreover, we have studied the effect of the blank holder force and the radius of the die on the springback and all deformations of aluminum ε_1, ε_2, ε_3.

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

- It was found that with increasing the radius of the die, the springback increases.
- Another particular test was realized showing the effect of force caused by the blanck holder.
- With increasing the blanck holder force, a smaller increase of the springback, but when the presswork is zero, the springback is very important.
- The ration of radius curvature R_1/R_2 has an important effect on the springback, it has a value near to zero when R_1 equal to R_2.
- 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 initially by tension have an enormous springback during their forming.

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