A Detailed Experimental Study of the Springback Anisotropy of Three Metals using the Stretching-Bending Process
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Abstract—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, 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. 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.

The main object in this paper was to study the effect of the anisotropy on the springback for three directions of rolling: 0°, 45° and 90°. At the same time, we highlighted the influence of three different metallic materials: Aluminum, Steel and Galvanized steel.

II. EXPERIMENTAL PART

The use of steel and aluminum alloys in the industry and aviation poses every day the problem of the springback. The main aim in this study is to evaluate the springback for three different directions: 0°, 45° and 90°. Moreover, through these tests, the effect of the three different metallic materials: Aluminum, Steel and Galvanized steel. We note that the average grain size was evaluated after observation of the microstructure of the small samples using an optical microscope. These latter specimens underwent the same treatments as the specimens deformed to a U shape.

A. Tensile Trial

The objective of the tensile trial is to characterize and analyze the effect of the three different metallic materials: Aluminum, Steel and Galvanized steel which are more used in industry applications. Moreover, these tests are ensured by the tensile testing machine (ZWCK).

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B. Springback Trials

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 spacers, which allows the recording of any displacement (see Fig. 4.). The measurement technique of the springback is schematized in Fig. 2 and Fig. 3. The device used in our tests is designed and made in our laboratory (LPMMM, Setif, Algeria). These tests are carried out on specimens whose 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 ($\theta = 0$). They are machined starting from a plane sheet and they have the form and the dimensions indicated in Fig. 3. The springback $\Delta h$ is evaluated in terms of the drawing depth $h_d$. 

III. RESULTS AND DISCUSSIONS

A. Effect of the Lubrication on the Springback

We noticed that the various curves presented in Fig. 4 take a decreasing form and that the springback increases with the reduction in the curvature radius of the die, which produces a strong stretch-bending and work hardening of the sheet. This observation was made by Samuel and Chan [2]-[11]. It was also noticed that the springback increases appreciably with the increase in coefficient of friction. Actually, the use of lubrication during forming is very important, because it causes a reduction in friction and facilitates the slip and the flow of sheet on the curved parts of the die, thus avoiding a localized work hardening and a higher springback. Indeed, a good lubrication decreases friction and reduces the springback.
Fig. 4 Effect of the lubrication and the curvature radius on the springback

As shown in Fig. 5, the depth deformation with lubrication is more important than without lubrication. Moreover, we can see that the deformation increase with decreasing the friction coefficient; because the lubrication uniformly distribute the deformation, thus, to carry the striction which is favorable for depth stamping.

Fig. 5 Effect of the lubrication and the depth deformation for galvanized steel, steel and aluminum alloys

B. Effect of the Deviation Rolling on the Springback

The springback was evaluated for deformation depth and various deviation of rolling. We noticed that the various curves presented in Fig. 7 take a decreasing form and that the springback increases with the decrease of depth deformation for three materials, which produces a strong stretch-bending and work hardening of the sheet. It also noticed that the
springback for galvanized steel is more important than for steel material, this is due to the zinc layer. Moreover, as shown in Fig. 7, for high angle of rolling, the springback decreases strongly with the increase of depth deformation. We can then conclude that the anisotropy on the springback has a much influence for all direction of rolling shown in our working test.

![Springback Graph](image_url)

**Fig. 7** Effect of the depth deformation and direction of rolling on the Springback

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 lubrication on the springback. A small thickness lead the necessity of increasing the blank holder force, else we can see the formation of folds. Moreover the deformation for galvanized steel is much smaller. It is also noticed that the springback decreases with the existence and the quality of the lubricant. Hence, we can say that in the presence of friction the springback is higher.

Furthermore, the springback decreases with the increase of deviation of rolling. Hence, we can say that the springback is more for galvanized steel than for steel and aluminum alloys. It is also noticed that for great sheet stretch-bending become for small radius of curvature, the springback is also higher. With the regard from the observations of all test carried out for three different materials, show that galvanized steel has an enormous springback during their forming than the others. Hence the mechanical treatment of materials has a great influence on this significant factor: springback. It was also shown the influence of the anisotropy on the springback for all direction of rolling which is in a good agreement to the results studied by Sun[6]. With regard to the tests carried out on aluminum, the results show that metals hardened initially deviation of rolling. Hence, we can say that the springback is higher.

REFERENCES


