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The Effect of Hold Time on the Spring Back Phenomenon in a V- Dies Bending Process

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ABSTRACT

Bending process is the one important process in the sheet metal forming in many industries, the main problem of bending process is the spring back phenomenon which is happens after removing the punch. This research involves theoretical and experimental study of the effect of holding time on spring back value of sheet material in V-bending die with 90^0, with different rolling direction and different holding time (0,10,20,30) min. (Al –Si) alloy having the thickness of (2 mm) were employed as the work pieces material for all experiments. The results revealed that as the hold time increases, the spring back decrease and spring back ratio increases.

تأثير زمن التثبيت على ظاهرة الرجوعية عند الحني بقوالب بشكل حرف v

الخلاصة

الحني من العمليات المهمة في تشكيل الصفائح المعدنية في التطبيقات الصناعية العديدة والمشكلة الرئيسية في عملية الحني هو حصول ظاهرة الرجوعية الحاصلة في المعدن بعد ازالة حمل المكبس بعد الانتهاء من عملية التشكيل. يهدف هذا البحث الى دراسة نظرية وعملية لتاثير زمن التثبيت على قيمة الرجوعية للصفائح المعدنية عند حنيها بقوالب V بزاوية مقدارها 90 درجة وباتجاهية درفلة مختلفة وبزمن تثبيت متغير مقداره (0,10,20,30) دقيقة. جميع التجارب اجريت على سبيكة (المنيوم – سليكون) بسمك 2 ملم . ووجد ان لزمن التثبيت تأثير كبير على ظاهرة الرجوعية حيث بزيادة زمن التثبيت تقل الرجوعية للمعدن ويزداد معامل الرجوعية.

INTRODUCTION

Spring-back is a common phenomenon that occurs in sheet metal bending after unloading due to elastic recovery. When the bending process is removed at the end of deformation operation elastic energy remains in the bent parts causing if to recover partially to word its original shape this elastic recovery is called spring back. It could be defined in terms of spring-back ratio K_s (the ratio between the produced and desired bend angles). Various efforts were made to analyze the spring-back phenomenon analytically, experimentally, and numerically for different shapes, and process and material parameters [1- 3] . Most of the analytical studies focused on V- die bending. Previous studies [4- 6] conducted on spring-back in V-bending showed that the spring back was influenced by the bend radius, punch speed and punch angle and also a few important literatures are briefly discussed here. Wang et. al. [7], reported mathematical models for plain-strain sheet bending to predict spring back,

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bendability, strain and stress distributions and the maximum loads on the punch and the die. Vin et. al. [8] reported, 'three section' model for air V-bending. The material behavior was described by the Swift's equation and the change of Young's modulus under deformation was addressed. Gau and Kinzel [9], investigated the influence of Bauschinger effect on spring back in sheet metal forming. Inamdar and Raval et. al. [10] ,reported the simulation program for the prediction of punch travel to bend the plate at desired angle, gap formation under the punch and spring back in V-bending process. Mori [11], proposed to control the spring-back of the V bended part by utilizing CNC servo press to reduce the sheet thickness at bend angle. Yoshida [12], studied a crash forming method to reduce spring-back of the part made of high strength steel sheet. Yanagimoto,j.Oyamada [13],studied the effect of many parameters on spring back phenomenon at worm and hot condition and study the effect of hold time at this condition, he founded that the spring back decrees with increase of hold time. Zhu L, Beaudoin [14], presents outline of a simple bending test to study relaxation at stress levels the evolution of stress and development of plastic strain with time are assessed through a simple analysis of spring back and the micro plastic processes that lead to permanent deformation of the bent metal are well characterized by a model developed by Garmestani and Hart. In recent research has been considered the different parameters which affected on spring back phenomenon.

This research aimed to study the effect of hold time on spring back value and spring back ratio at room temperature.

BASIC THEORIES OF SPRING BACK

Since all materials have two zones of deformation, the elasticity zone and the plastic deformation zone is followed by some elastic recovery after bending when the load is removed. In bending, this recovery of elasticity called spring back, which can easily observe by bending a piece of sheet metal. Spring-back phenomenon is shown in Fig.(1) the final bent radius is larger than before the process. Spring-back occurs not only in flat sheets or plate, but also rod and bar with any cross-section [15] [16].

Spring back, defined as the increase in included angle of the bent part relative to the included angle of the forming tool after the tool is removed. This is illustrated in Fig. (1) and expressed :

Spring back = $\alpha_f - \alpha_b$, $K_s = \alpha_b / \alpha_f$ [16] Where :-

α_f = angle after spring back

α_b = angle of bending tool

K_s = spring back ratio

EXPERIMENTAL WORK

Material used

Aluminum alloy which the chemical composition is shown in Table (1) is used as a work piece with (2) mm thickness

Specimen preparation

The specimens for tensile test were manufactured according to ASTM [E8- 55] in different rolling direction (0, 45, and 90) degree [14]. And the specimens for spring back test were manufactured these specimens must fit the die and punch with a suitable clearance about (1mm) with a V-die. A rectangular sheet of 50 mm of width and 150 mm of length which cut in different direction, Parallel, perpendicular and (45) degrees to the rolling direction represent the three factors of the planar anisotropy.

Mechanical testing

1- **Tensile test**

The tests were run with INSTRON machine with velocity (50 mm/min) for different direction of rolling and mechanical properties shown in Table (2) which represent the true stress-strain curves of (Al – Si) alloy in three different directions of rolling.

1- **Spring back test**

Two parameters are used which effect on the spring back phenomenon, as follows: **Rolling direction** Parallel and perpendicular rolling direction and (45^0) represent the three factors of the planar anisotropy. And the other parameter is the **hold time**, different rang of hold time can be used as shown (0, 10, 20, 30) min. these tests done on V bending die with 90. A semi closed 90 V- die is designed and used to conduct bending process. The die assembly is installed on the comparison side of 100 KN testing machine (INSTRON MACHAIN) The V- die bending processes are conducted under constant force .The experimental setup for the V-die bending illustrated in fig.(2)

RESULTS AND DISCUSSION

Figures (3 to 10) show comparison between spring back and spring back ratio calculated with different rolling direction at different hold time. Figures (3-8) Shows the effect of hold time on spring back and spring back ratio. May be found that the hold time is linearly proportional to the spring back and spring back ratio and when the hold time increased the spring back is decreased and spring back ratio increase this related to the relaxation of material because, when a metal is deformed, hardening usually occurs to some extent and is caused by generation and rearrangement of dislocation sub-structures in the material. And Holding time causes lower degree of stress relaxation. After a certain holding time, some elastic strain is converted to plastic strain and the stress decreases [13] [14].so springs back reduce and spring back ratio increase in different direction of rolling, although the effect of rolling direction with hold time on spring back and spring back ratio shown in figure (9 and 10) from the experimental results due to that the metals give different flow strength in different directions in the plain of the sheet. Parallel (0^o), perpendicular (90^o) and (45^o) degrees to the rolling direction as shown in table (2), this mean that the material is anisotropy this has a great effect on the material properties therefore lower spring back found when rolling direction angle (90^o) than (45^o) and (0) direction . And may be found that decrease of spring back value when change for hold time from (0 to 30 min.) are 12%, 25% 37.5% respectively in rolling direction angle (90^o) , at (45^o) rolling direction found decrease spring back value 12% , 22% , 32% and at (0^o) rolling direction found decrease spring back value 9.3% , 14.6% and 26% respectively this different in values refer to the same reasons which illustrated previously .

CONCLUSIONS

The present work has reached the following conclusions:

1- The rolling direction has a greater effect of spring back and spring back ratio where the lower spring back found in rolling direction angle (90^o) than (45^o) and (0) direction.

2- The holding time has an affected on spring back and spring back ratio, when the holding time increases, spring back decreases and spring back ratio increases.

3- The lower effect of holding time found in rolling direction angle (90^o) than (45^o) and (0) direction.

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Table (1) The chemical composition for (Al- Si) Alloy.

element	Si	Fe	Cu	Mg	Zn	Cr	Ni	Pb	Mn	Al
%	0.6	0.19	0.01	0.0043	0.019	0.004	0.012	0.006	0.004	99.2

Table (2) The Mechanical Properties of (Al –Si) alloy in different directions.

Property	**0 degrees**	**45 degrees**	**90 degrees**
Young's modulus	69 Gpa	69 Gpa	69 Gpa
Yield Strength	118 Mpa	130 Mpa	137 Mpa
Ultimate Tensile Strength	131 Mpa	142 Mpa	143 Mpa
% Elongation to Failure	6.2 %	3.8%	4.5%

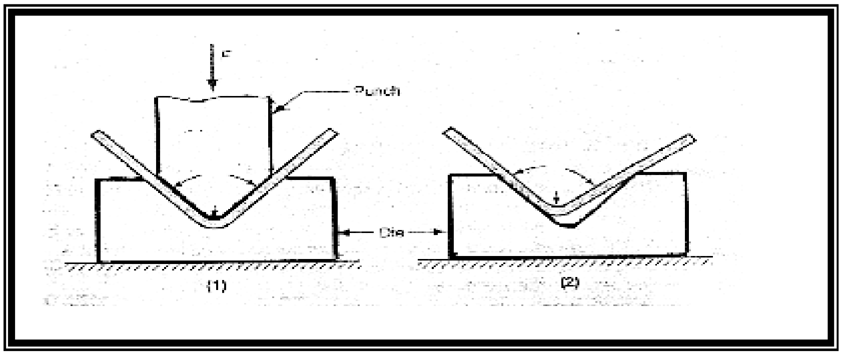
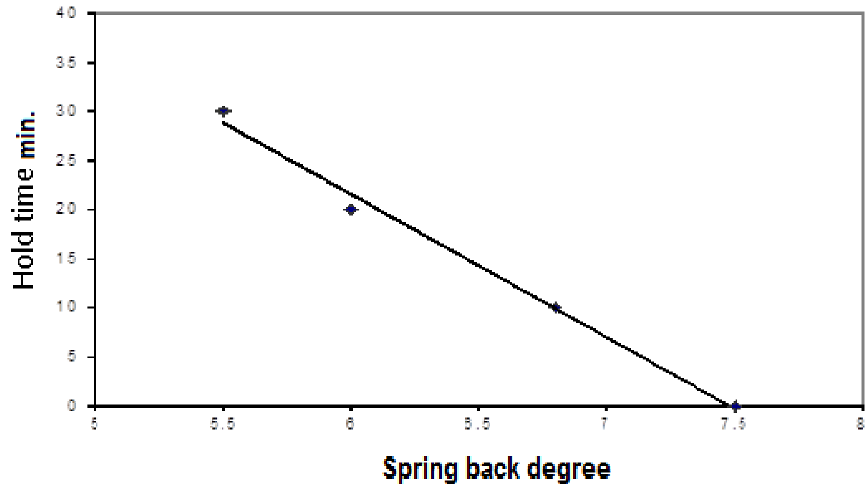


Figure (1) Spring-back in bending process [16].

Figure (2) The experimental setup for the V-die bending.



Figure(3) The relation between spring back and hold time at parallel rolling direction (0)^{o}.

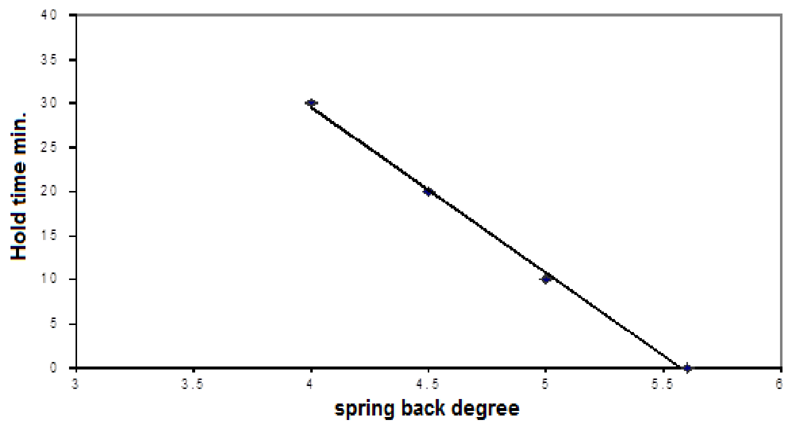


Figure (4) The relation between spring back and hold time at (45)^{o} direction.

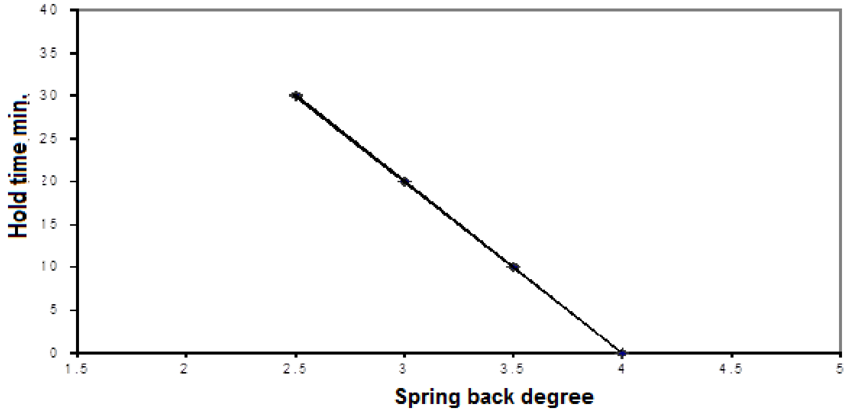


Figure (5) The relation between spring back and hold time at perpendicular rolling direction (90)°.

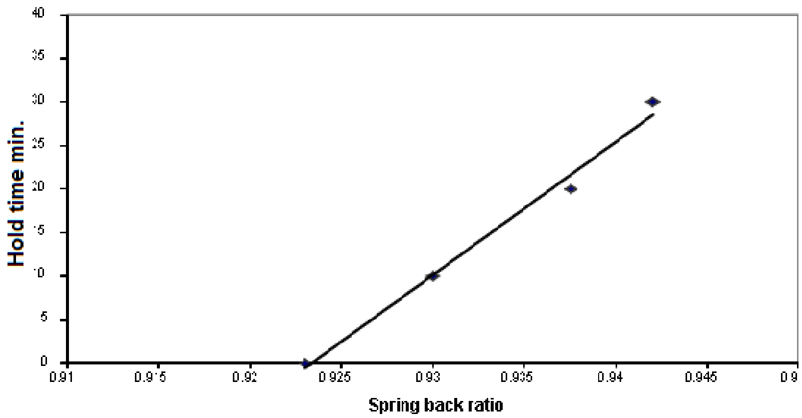


Figure (6) The relation between spring back ratio and hold time at parallel rolling direction (0)°.

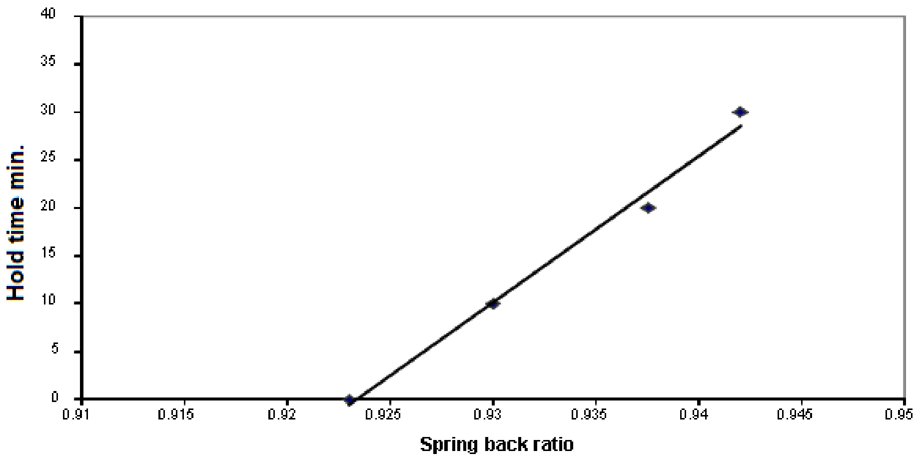


Figure (7) The relation between spring back ratio and hold time at (45)° direction.

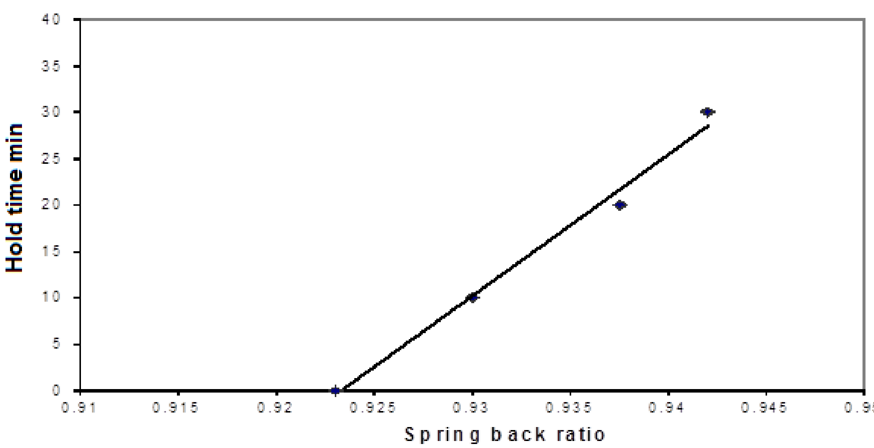
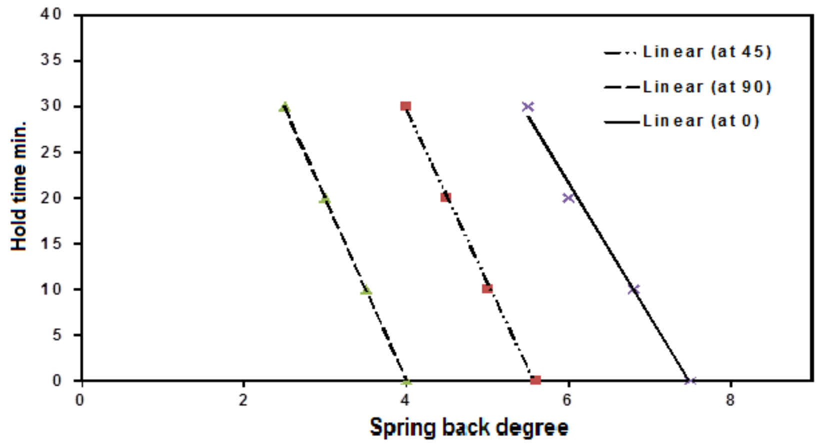


Figure (8) The relation between spring back ratio and hold time at perpendicular rolling direction (90)°.



Figure(9) The relation between spring back and hold time at different rolling direction.

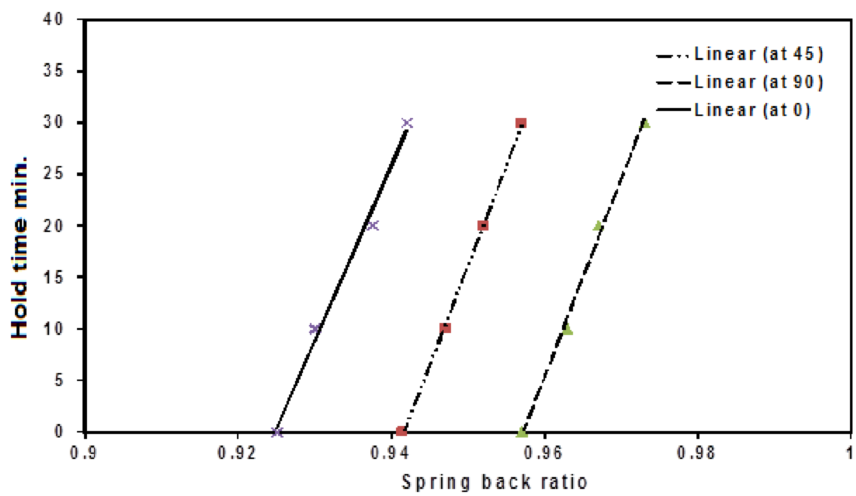


Figure (10) The relation between spring back ratio and hold time at different rolling direction.