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Effect of Pre-Tension on the Springback Behavior of the Yellow Brass

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K E Y W O R D S

Brass 65-35; pretension; orientation; springback

A B S T R A C T

Springback forecasting of sheet formation is constantly remarkable problem in the métier, due to their influence the great in the definitive shape of the product. Study presents effects of pretension in tow rolling direction (0, 45 degree) on the springback behavior of the (Brass 65-35) sheet under V-die bending by an experimental. The pretension ranges from five different pretensions levels starting from 11% to 55% from total strain in each rolling direction by increment of 11%. used in punching that was performed at a constant deformation velocity of (5 mm/min) then bent on a 90° V-shaped die for the springback evaluation. The results from experiment indicate that the springback increase with pretension ratio and the springback in 45 degree is higher in rolling direction.

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1. Introduction

Sheet formation metal process is one of the main manufacturing processes in métier. An implement tiptop performance, tiptop productivity also low cost is important drive behind the evolution of the Sheet formation metal technology and mainly cold forming during the automotive section [1]. The sheet metal bending takeover a role is very important in the manufacturing industry. With the industry has evolved, the size of the products being created gets smaller and tolerances on them obtain compact. the geometrical precision of a bent piece is critical in determination the quality of the product [2]. Bending is one of the most common metal forming technology to produce structural stamping parts in production of car, ship structure and home apparatus manufacturing, One of the uttermost significant sheet metal bending operations is (V–Die) bending [3]. Component shape accuracy control, after unloading the elastic recovery causes the spring-forward or the so-called springback phenomenon in which the bend radius of any bending sheet increases after removed the bending moment. The accurate prediction of springback after bending unloading is the key. to the tool design, operation control, and precision estimate concerning portion geometry [4]. Brass an alloy in the main include of zinc (Zn) and copper (Cu), is wide used in diverse manufacturing due to of their superior formability, strength to weight ratio,as well elevated corrosion resistance, and ductility. Auto manufacturing is without fail in need of swift and strong automotive piece consequence it is feasible to production various parts and manufactured for automobile implementation using the brass alloy. moreover high strength brass alloy contains some additional elements such as manganese, iron, tin, these elements take shape a brittle amidst metallic compound in it, which raise the strength but decrease the ductility and machinability in industrialization of any piece in manufacturing, the ductility and machinability plays a main role. On the other side, the mechanical properties like strength and ductility in the metallic are affected by crystallite size and its apportionment [5]. Lower punch angle is creating higher springback as compared to higher punch angle and the residual stresses in pre bend strip showed more impact on springback as compared to flat strip [6]. The springback decreases with the increase in the punch velocity [7]. The springback is lower with an increase in the depth of compression and Young's modulus and increasing thickness or decreasing the bending angle. The binders can be used to reduce springback effect and also helps to distribute the stress evenly [8]. Springback reduces with decrease of punch radius and increase of sheet thickness [9]. springback decreased with thickness of the sheet metal increased whereas it was increased with increasing punch tip radii [3] when the punch angle, die opening and sheet width increases springback effect decreases [10].Spring back effect minimized by finding the appropriate loading conditions that applied to the punch but cannot be eliminated fully [11].

2. Experimental Procedures

I. Material Selection

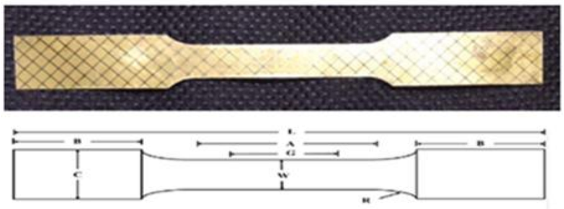
In this work, the Brass 65-35 sheet material with sheet thickness 0.7 mm was used in this work. It is called yellow brass C26800 according to (ASM) American Society of Metals this material is selected because of its excellent cold workability, when bending or spinning is required with fair strength and widespread usage in the industry [12]. Firstly, it is necessary to know the Material Characterization of it by testing chemical composition; Table 1 lists the results of the chemical test carried out at the Specialized Institute for Engineering Industries in Iraq, with the (ASM) characterization.

II. Material properties

The mechanical properties of the sheet are determined by performing to Tensile Test in beginning specimens were cut from the sheet and made according to ASTM (American society for testing of materials) standard E-8M specification [13]. As shown in Figure 1. The specimens were fixed carefully by the gripper, on universal testing machine WDW model (200E) electromechanical load frame with mechanical grips having maximum test force (200 KN) as shown in Figure 2. it has been done in the University of Technology-production engineering and metallurgy, strength of material laboratory, after that it loaded until fracture occurred under cross head speed 5 mm/min as showing in Figure 3-a. six tensile specimens tested with two degree of rolling direction [0°, 45°] degrees by three sample in each direction in order to take the average values to reduce the errors obtain from measurements as showing in Figure 3-b.

Table1: chemical composition and the ASM for Brass 65-35

Element	chemical composition	ASM
Zn%	35.23	35
Pb%	0.007	0
Mn%	0.00	0
Sn%	0.001	0
P%	0.007	0
Si%	0.001	0
Fe%	0.021	0
Ni%	0.001	0
Al%	0.002	0
Cu%	64.7	65



Nominal length	Dimensions (mm)
Gage length (G)	50 ± 0.10
Width (w)	12.5 ± 0.05
Thickness (T)	5
Radius of fillet (R)	12.5
Overall length (L)	200
Length of reduced section (A)	57
Length of grip section (B)	50
Width of grip section (C)	20

Figure 1: Dimensions of tensile specimen

Figure 2: Universal testing machine WDW model (200E) electromechanical load frame with mechanical grips

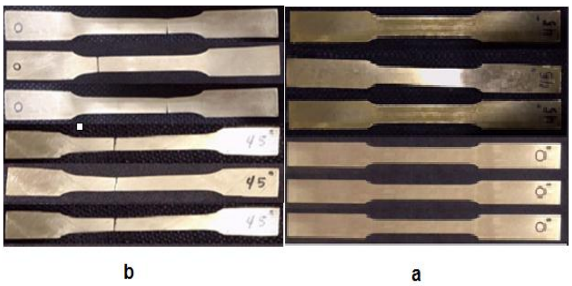


Figure 3: Tensile specimens (a) before test (b) after test

Table 2 includes the mechanical Properties obtained from tensile testing in two directions Rolling (0°) Diagonal (45°) and the Mechanical Properties of yellow brass (C26800) as ASTM E-8 M.

Table 2: The mechanical properties of brass in two directions

Property	YS (MPa)	UTS (MPa)	TE (%)
Rolling (0°)	86	293	61
Diagonal (45°)	52	245	64
ASM	97	317	65

YS: Yield Strength, UTS: Ultimate Tensile Strength and TE: Total tensile elongation (%).

III. springback test samples

Evaluation of the springback amount by implementing a sequence of experiments was the base of this work. To perform the experimental work, the testes should fit the punch and die with an apt clearance. The specimen should be a rectangular sheet of (50) mm of length and (100) mm of width, as shown in Figure 4. Twenty specimen were made for each direction.

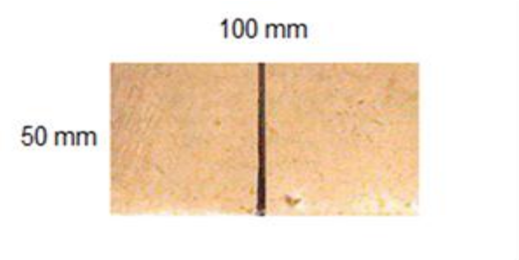


Figure 4: Dimension of specimens springback

IV. Dies used

This study examined V-die bending tool, which was designed and manufactured according to the standard specifications and consisted of two sections (punch, and general die) both of them formed from (CK45). The first one is the general die, which is called lower die of opened type 90° angle in bottom bending. It has a rectangular shape of (99×108) mm and the high (48) mm and with bending depth about (19) mm and opening die (40) mm. the second one is the upper die, which is called the punch having 90° angle as shown in Figure 5.

V. pre-tension

Five different pre-tension levels were used starting from 11% to 55% from the total strain in each rolling direction by increment of 11% used in punching that was performed at a constant deformation rate of (5 mm/min) and then unloaded at the same deformation rate as shown in Figure 6.

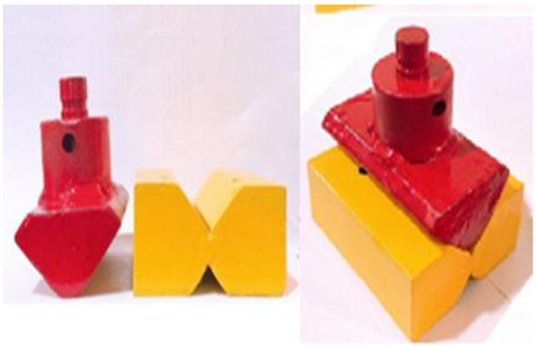


Figure 5: Shape of Die and Punch

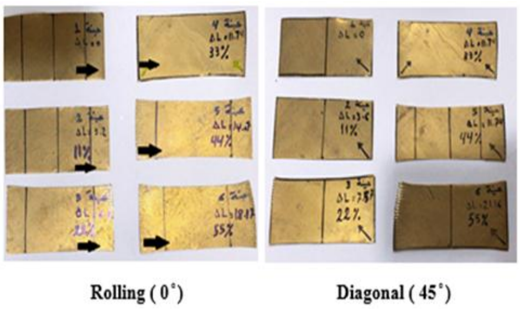


Figure 6: Five different pre-tension levels in two directions

VI .Experimental bending device

Again, the universal testing machine type (WDW-200E) was used in the experimental work for the specimens in bending which was standard with wedge-shaped stretching attached, compression and bending, as show in Figure 7.

The bending tests were performed at a 25 mm/min deformation speed, before that, the die and punch were loaded, the precision of the displacement rate ≥ 0.01 m / min. at the begining three specimens for each direction were bent to take the average values of them in order to reduce the errors obtained from the measurements. Then, bending 30 specimen that were pre-tensioned with five different levels of two directions at a rate of 15 specimen per direction in the same groove, where the specimens without tension were bent as shown in Figure 8.

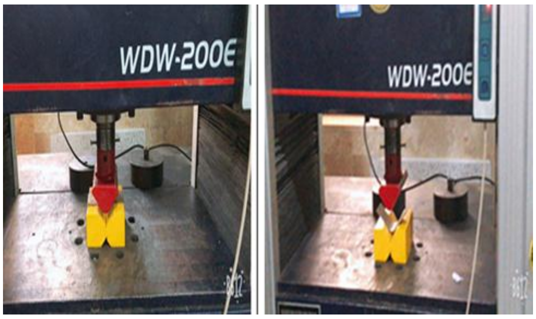


Figure 7: Bending device

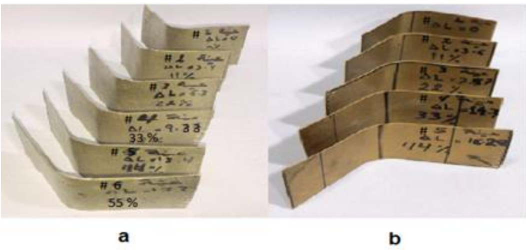


Figure 8: Bending the sample (a) in rolling direction (b) diaconal.

VII. Springback measured

After fixing the punch and die in the device and placing the sample on the die, the punch is moved down and contacted the sheet. As the punch proceeds downward, the plate is drawn through the opening in the die, after raising the load and the tools are takeaway the outer radius of the workpiece is less in amount, the difference between the sheet angle and punch angle is measured. This is the value of springback, as shown in Figure 9. The springback angle (Δα) was measured by a Mitutoyo 187-907, tool universal bevel protractor with a magnifying glass for was used the precise reading of angles on sample features or setting angle on machine tools hardened stainless steel construction that has blade length 150 mm. A high precision angle gauge was used for the accurate measurement of all angles, as showing in Figure 10.

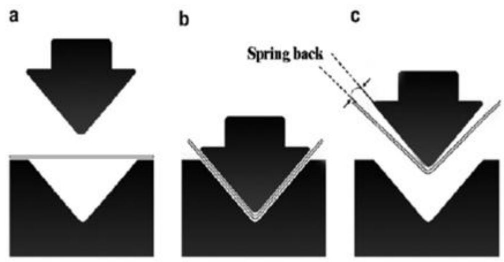


Figure 9: Illustration the springback in V- die.

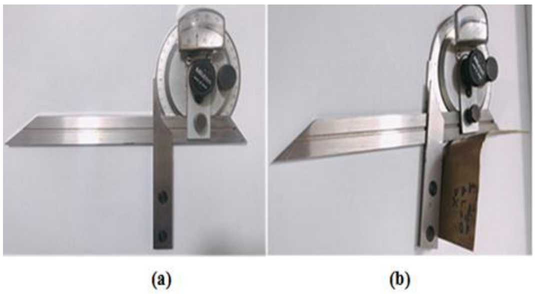


Figure 10: (a) Measuring device Mitutoyo 187-907 (b) the device while measuring the angle of the sample

To act the effect of process factor on the springback of the profile, the defined of springback angle ($\Delta\alpha$) can be calculate by the difference between the final bending angle αf and loading bending angle αi.

$$\Delta\alpha = \alpha_f - \alpha_i \qquad (1)$$

This can be seen through the Figure 11. in the otherwise the ratio of springback angle to the loading bending angle is called the springback ratio will the springback factor is defined by the ratio of the final bending angle and to the loading bending angle.

$$K = \alpha f / \alpha i \qquad (2)$$

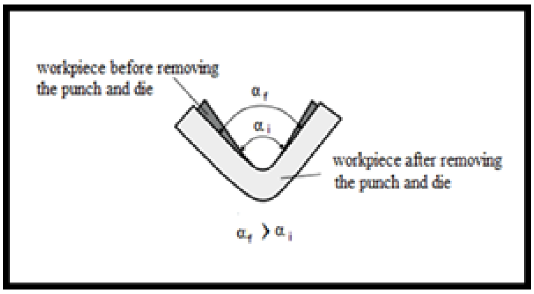


Figure 11: Illustrate the difference between final bending angle (αf) and loading bending angle (αi)

3. Results and Discussions

The main reason to Springback due to Bauchigner's influence, which authorize the material to follow dissimilar paths through loading and unloading cycles. Each of forming operation will take places in the plastic zone. Wherefore to estimate or to analyses spring back, nonlinear material properties, which will Accommodate stress strain relations in the nonlinear regions, are required [15]. Mensuration of springback can be defined as a difference between the angle of loading and unloading. The estimated values of springback and the calculated values of springback factor (Ks) and values of pre-tension were measured for each specimen in two directions as shown In Table 3.

Table 3: Bending angles before and after withdrawal of punch

Direction angle	Workpiece	pretention		Springback	Springback factor
		Percentage of total pre-tension	Change in length (ΔL) in mm		
0	1	0 %	0	8°	1.088
	2	11 %	3.11	11°	1.122
	3	22 %	6.2	13°	1.144
	4	33 %	9.3	15°	1.166
	5	44 %	12.4	17°	1.188
	6	55 %	15.5	19°	1.211
45	1	0 %	0	17°	1.188
	2	11 %	3.5	19°	1.211
	3	22 %	7.05	22°	1.244
	4	33 %	10.55	25°	1.277
	5	44 %	14.1	28°	1.311
	6	55 %	17.65	31°	1.344

The results show that the higher percentage of pre-tension has leaded to increase the Change in length (ΔL) and greater the springback factor so thus increasing the springback there were situations whereby the final bending angle becomes bigger. Figure 12 shows the effect of pretension on springback in rolling direction and at 45 degree on rolling direction respectively. SO, it is clear that the pre-tension is a positive relationship to the spring backs, i.e. the springback increases with the increase in pre-tension due to the increase of dislocation density that lead to the variation of mechanical behavior. Strain is as well play a big role in springback result where the increasing in number of strain hardening will raise the value of springback.

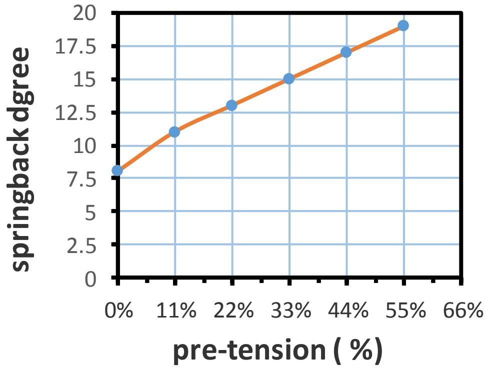


Figure 12-a: Variation of the measured spring back with pretension in rolling direction

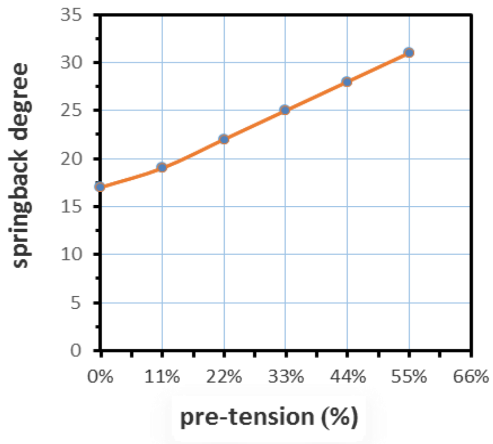


Figure 12-b: Variation of the measured spring back with pretension in 45 degree on rolling Direction

Figure 13 shows the comparison between the springback values calculated with various directions to the rolling at different pre-tensions, which, show that the springback is higher in 45 degree to the rolling direction than in rolling Direction.The pre-tension process has resulted in an increase in sample (ΔL) length from its original length as shown for each sample in Table 3. Figure 14 show the relation between the change in length and spring back Parallel (0º) and (45º) degrees to the rolling direction, respectively. Where, the change in length has a positive relationship to the spring back, i.e. the springback increases with increasing the change in length. Also. This leads to decrease the thickness, and the thickness has an inverse relationship with springback.

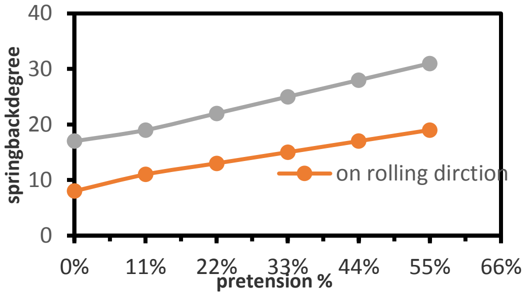


Figure 13: Variation of the measured spring back with pretension in two Directions

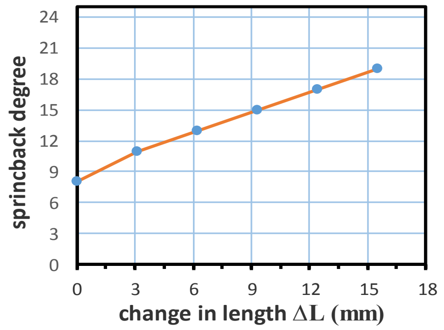


Figure 14-a: Variation of the measured spring back with change in length in rolling Direction

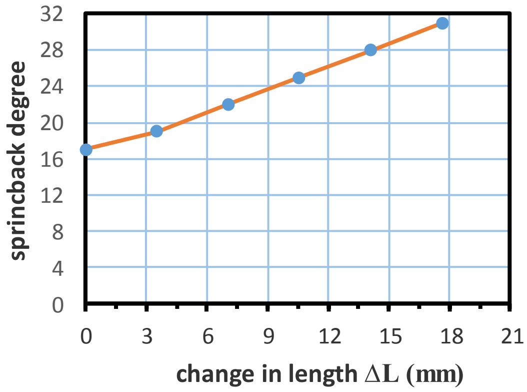


Figure 14-b: Variation of the measured spring back with change in length in 45 degree on rolling Direction

Figure 15 illustrates the comparisons between the springback degrees values calculated at various directions to the rolling and the different changes in length.Which, show that the springback is higher in 45 degree on rolling direction than in rolling direction. Due to the material is anisotropy, i.e. it has different properties (Yield Strength, Ultimate Tensile Strength and Total tensile elongation) in different directions Also, it has a great effect on the material properties, this corresponds to the source no. [8]. Where proved that "the springback decreases with increase in yield stress, strain hardening but it decreases with increase in Young's modulus and increasing thickness".

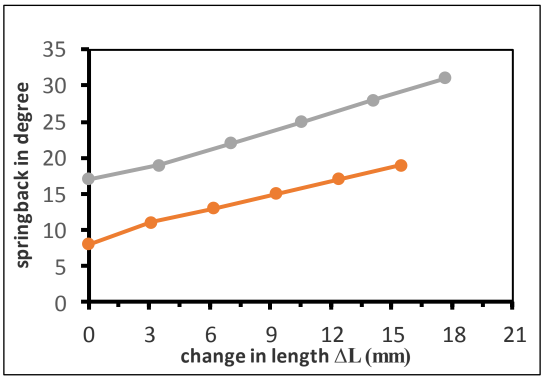


Figure 15: Variation of the measured spring back with change in two Directions

4. Conclusions

The present work has reached the following conclusions :

1. The pre-tension has a greater impact on spring back and spring back ratio, the springback increase with increasing pretension ratio and spring back ratio was increases so it has no positive effect on the springback compensation.
2. The change in length is important relation to the spring back i.e. the springback increasing with increase change in length .
3. High spring back angle and high spring back factor result when direction angle rolling (45º). while lower spring back angle and lower springback factor result when direction angle rolling is (0º). whereas the springback in (45º) more than double the angle of springpack in (0 º) and springback ratio more than (0.1) about the amount of springback factor in (0 º) Therefore direction angle rolling has a significant impact on springback and spring back ratio.

References

[1] A. Elsayed, M. Mohamed, M. Shazly and A. Hegazy, "An investigation and prediction of springback of sheet metals under cold forming condition," IOP Conf. Ser. Mater. Sci. Eng., vol. 280, no. 1, 2017.

[2] E. T. Akinlabi, K. Matlou and S. A. Akinlabi, "Characterising the effect of springback on mechanically formed steel plates," Lect. Notes Eng. Comput. Sci., vol. 1 LNECS, pp. 5–8, 2013.

[3] A. Ivaniševic, M. Milutinovi, B. Štrbac and P. Skakun, "Stress state and spring back in v-bending," J. Technol. Plast., vol. 39, no. 2, pp. 158–168, 2013.

[4] D.K. Leu and Z. W. Zhuang, "Springback prediction of the vee bending process for high-strength steel sheets," J. Mech. Sci. Technol., vol. 30, no. 3, 2016.

[5] J. S. Trivedi M, "Characterization of physical and structural properties of brass powder after biofield treatment," J. Powder Metall. Min., vol. 04 , 2015.

[6] S. B. Chikalthankar and G. D. Belurkar, "Factors affecting on springback in sheet metal bending: a review" Int. J. Eng. Adv. Technol., vol. 3, no. 4, 2014.

[7] M. Krinninger, D. Opritescu, R. Golle and W. Volk, "Experimental Investigation of the influence of punch velocity on the springback behavior and the flat length in free bending," Procedia CIRP, vol. 41, pp. 1066–1071, 2016.

[8] M. Arunkumar, "Design and analysis of a spring back effect in sheet metal forming," no. May 2016, pp. 0–7, 2018.

[9] T. Kartik and R. Rajesh, "Effect of punch radius and sheet thickness on spring-back in V-die bending," Adv. Nat. Appl. Sci., vol. 11, no. 8, pp. 178–184, 2017.

[10] R. D. Gedekar, S. R. Kulkarni, and M. B. Kavad, "Optimization of input process parameters affecting on springback effect in sheet metal 'V' bending process for CR2 grade steel sheet of IS 513-2008 material by using taguchi method," Int. Res. J. Eng. Technol., no. July, p. 381, 2008.

[11] Z. Yue, J. Qi, X. Zhao, H. Badreddine, J. Gao, and X. Chu, "Springback prediction of aluminum alloy sheet under changing loading paths with consideration of the influence of kinematic hardening and ductile damage," Metals (Basel)., vol. 8, no. 11, p. 950, 2018.

[12] V. Drossou-Agakidou. ASM handbook properties and selection: nonferrous alloys and special-purpose materials," Vol. 2, vol. 157, no. 7. 1998.

[13] W. Materials, R. Head, "Standard Test methods for tension testing of metallic materials," Designation: E-8,ASTM American Association State," vol. 88, 1989.