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Effect of Pre-Tension and Orientation on the Springback Behavior of the Sheet Brass 65-35

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Abstract

One of the most important phenomenon that occurs in sheet metal forming processes is the spring-back, which causes several geometrical alterations in the parts. The accurate prediction of springback after bending unloading is the key to the tool design, operation control, and precision estimate concerning the part geometry. This study investigated experimentally the effect of pretension in three rolling direction (0, 90, 45 degree) on the springback behavior of the yellow brass, sheet under V shape bending die. The pre-tension ranges from five different levels starting of 11% to 55% from the total strain in each rolling direction by regular increase of 11 %, then bent on a V-die 90 degree for the springback estimate. From experiment the results revealat that the springback increment with increase pretension ratio and the springback in 45° rolling direction is considerable than the sbringback in 90° rolling direction and the springback in 90° is greater than the sbringback in 0° rolling direction.

Keywords: *Pretension, orientation, springback, Brass 65-35.*

1. Introduction

Sheet-metal forming processes (SMFP) can be divided into two groups: cutting processes and plastic deformation processes. The advantage of the sheet metal parts that the material has a high yield strength (Yσ) and a high elastic modulus (E), so that the parts created can be tough to have a good strength-to-weight ratio. A large number of techniques used to make sheet metal parts. One of the most widely applied metals forming operation is bending. By this technology, materials can be processed with various cross sections (sheet metal, bars, rods, pipes, wires. However, bending of sheet metal) most frequently used in industrial practice. First of all is in the car and ship building industry, there are different types of metal bending operations, one of the uttermost significant sheet metal bending operations is the (V–Die) bending [1]. Statement of the closing shape of the part after unloading (loading taken away) is a actual problem In manufacturing operation, In further, is necessary to design suitable tooling so as to lessen the effect of elastic recovery or springback (SB) in sheet bending which is a widespread phenomenon in (SMFP), which leads to some geometrical changes in the parts [2]. After completing the bending process of the punch, the material attempts to return to its original state due to the elastic stresses occurring in the deformation zone of sheet metal but it cannot return due to the permanent plastic deformation. Therefore, the sheet metal opens backwards slightly and reveals the spring back [3]. Brass an alloy mainly include zinc (Zn) and copper (Cu), is wide used in diverse manufacturing due 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 [4]. In the past years, oversize of numerical and theoretical studies to foretell the (SB) characteristics of sheet metal had been carried out. Investigated experimental and numerical the effect of dwell time on springback value of sheet material in V shape bending with different rolling direction and holding time in work pieces material [5]. Springback reduces with increase in yield stress (Yσ), compression depth, strain hardening (n), Young's modulus (E) and increasing thickness or decreasing the bending angle and The binders can be used to reduce springback effect and also helps to distribute the stress evenly [6]. Investigated a die angle optimization method for reduce of (SB) in Sheet metal bending operation in a (V-bending) die [7]. Studied the effect of orientation and widths of the bending parallel, to the rolling direction on the slab. Then extended the variation quasi-static parameter with different punch velocities in two steel materials [8]. Presented the evaluated springback effect under various thicknesses and angles and using finite element method (FEM) for (SB) statement of arbitrary form [9]. Studied the effect of three parameters (punch angle, die opening and sheet width) on springback in sheet metal V-bending of steel sheet and determine the contribution of each process parameters towards springback effect [10]. Introduced the cold-forming process using explicit dynamic (FEM) and discussed the effect of thickness and curvature on springback of hull sheets was [11]. Performed study and compare the spring back effect of two materials (AMS 5504 & Aluminum alloy) also investigated the causes for spring back effect and its remedial factors. So using finite element method in ANSYS software to approximation process is carried out [12]. It should be note that the previous research above studies the effect of many parameters on sbringback. The objective of present work is to know the behavior of the phenomenon of sbringback in case the sample used is predetermined in the pre-tension process in three rolling direction and their influence in the definitive shape of the product is positive or negative.

2. Experimental Equipments

2.1. Materials

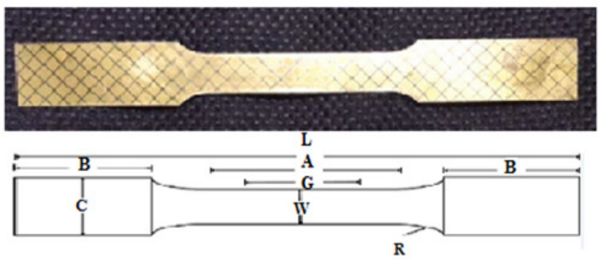
The yellow Brass Sheet Material was used in this work. It is called brass 65-35 (C26800) according to (ASM) American Society of Metallic, it has excellent cold workability and widespread usage in the industry [13]. With sheet thickness (0.7) mm, to know the material characterization of it must be testing Chemical composition, in Table (1) listed the results of the chemical composition carried out at the Specialized Institute for Engineering Industries in Iraq, with the ASM caracterization.

Table 1,
Chemical composition and the ASM for Brass 65-35.

Elements	EXP.	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

2.2. Material Properties

To determine the mechanical properties of the sheet must be performing to tensile test. the specimens were first cut from the sheet and then made according to ASTM (American Society for Testing of Materials) standard E-8M specification [14], as shown in fig. 1.



Nominal length	Dimensions (mm)
Gage length (G)	50 ± 0.10
Width (w)	12.5 ± 0.05
Thickness (T)	0.7
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

Fig. 1. Dimensions of tensile specimen.

As shown in fig. 2. The specimens were fixed carefully by the gripper, on universal testing machine WDW-200E, model (200E) electromechanical load frame with mechanical grips having maximum test force (200 KN) with accuracy of testing ±1% of indicated value, the relative error of displacement is ±5 %, and the speed range of cross beam is 0.1 mm/min ~ 500 mm/min, valid testing space 600 mm. This test was done in Strength of Materials laboratory in Department of Production Engineering and Metallurgy /University of Technology. Strength of Materials laboratory, under cross head speed 5 mm/min, the specimen it loaded until fracture occurred. Nine tensile specimens were tested in three directions (0°, 45°, 90°) by three samples in each direction in order to take the average values to reduce the errors obtained from the measurements, as shown in fig. 3.

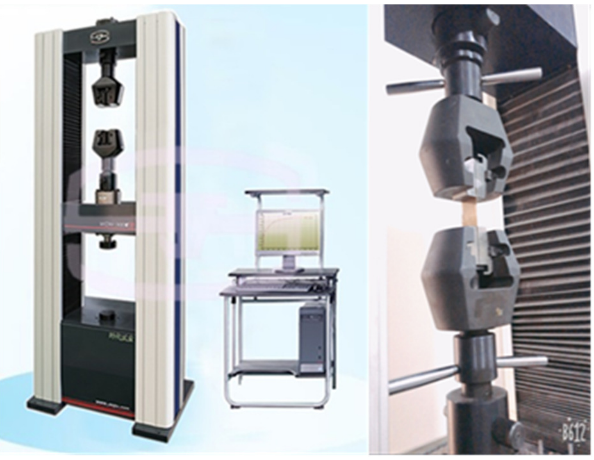
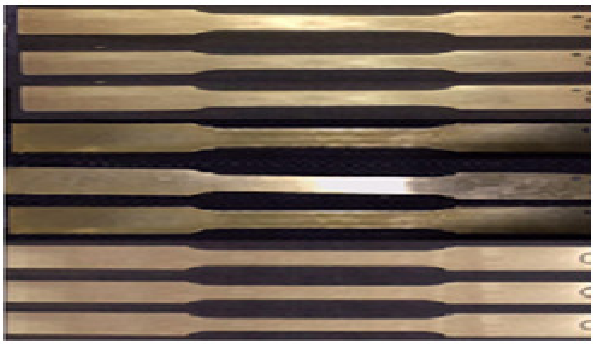


Fig. 2. universal testing machine WDW model 200E electromechanical load frame with mechanical grips.



a

b

Fig. 3. Tensile specimens (a) before test (b) after test The Mechanical Properties of it in three directions Rolling (0°), Diagonal (45°) and Transvers (90°).

Taguchi Methods for Designing Experiments

The mechanical properties of yellow brass as (ASM) illustrated in table 2. While the relation between the true stress and true strain of brass sheet in three different directions is depicted in fig. 4.

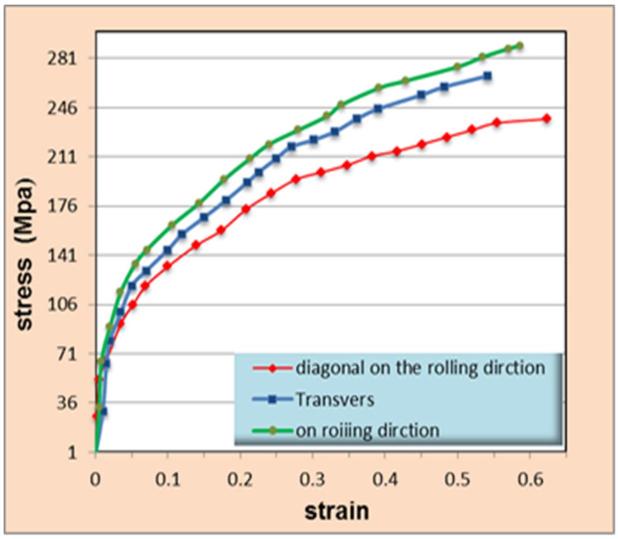


Fig. 4. True stress-strain curves of Brass 65-35 sheet in three different directions.

Table 2,
Mechanical properties of in three directions.

Property	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	%Elogation to Failure	Buissons ratio
Rolling (0°)	89	293	61	0.353
Diagonal(45°)	52	245	64	0.243
Transvers(90°)	64	270	55	0.239
ASM	97	317	65	0.355

2.3. Dies Used

This study examined V-die bending tool, which 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 height (48) mm with bending depth about (19) mm and opening die (40) mm. the second one is the upper die, which called the punch having 90° angle, as shown in fig. 5. The fixed velocity of the upper die is about (25) mm/min.

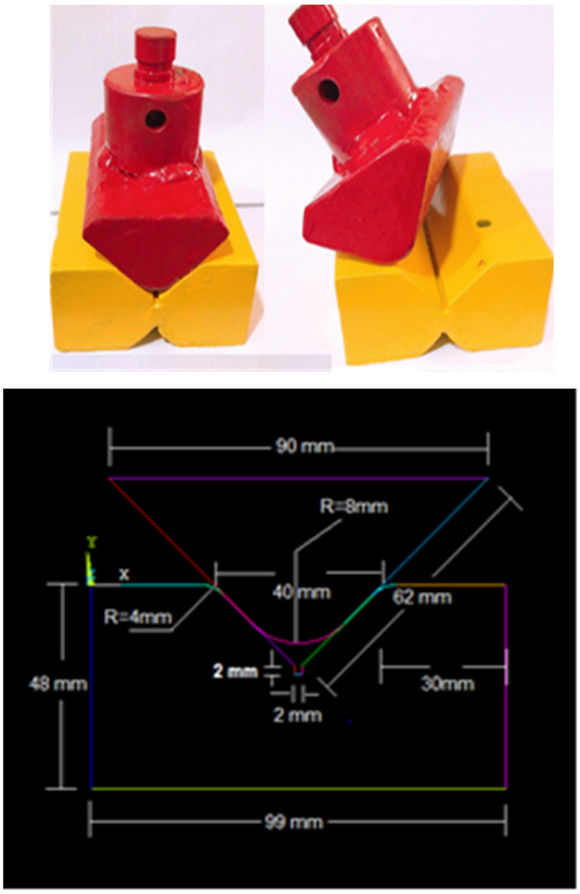


Fig. 5. The shape and dimension of Die and Punch.

2.4. Springback Test Samples

Evaluation of the springback amount by implementing a sequence of experiments was the base of this work. In order to perform the experimental work, the testes must be a rectangular platelet (50 x 100) mm, according to template user as shown in fig. 6.

2.5. Pre-Tension

The specimen was prepared following the rolling direction. Considering the maximum strain of 0.12 (where the local necking happens after this point) under the uniaxial tensile loading path, five pre-tension states are used of 11%, 22% , 33% , 44% , and 55% , from the total strain in each rolling direction with a steady increase of 11% were selected to assign on the samples. The punching performed at a constant deformation rate of (5 mm/min) and then unloaded at the same deformation rate, as shown in fig. 7.

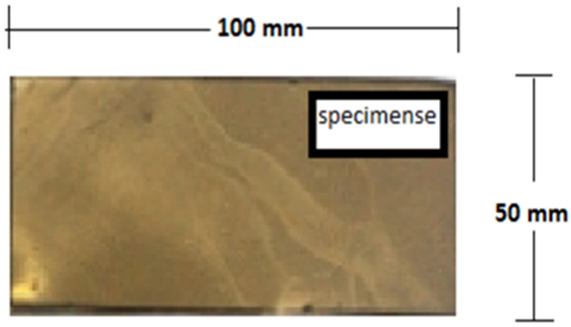


Fig. 6. Dimension of specimen's springback.

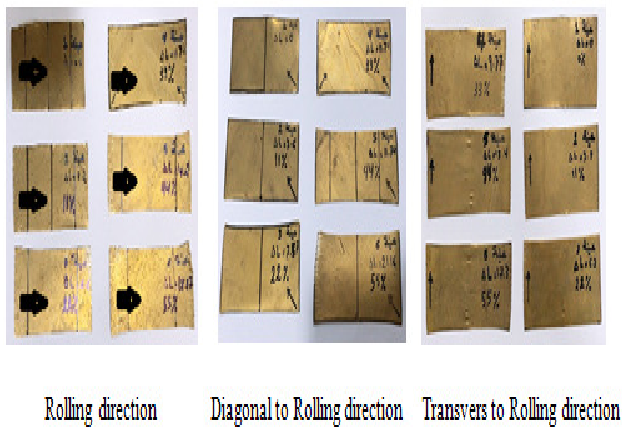


Fig. 7. Five different pre-tension levels used in three directions.

2.6. Experimental Bending Devices

Agene universal testing machine model WDW-200E was used in the experimental work for the specimens in bending which was standard with wedge-shaped stretching attached, compression and bending, with the user and other attached to the form, as shown in fig. 8.

The bending tests worked at a (25 mm/min) deformation speed, before that, the die and punch. In were loaded, the beginning, nine specimens without tension were bending at rate of three samples for each direction to tack the average values of them in order to reduce the errors obtained from the measurements. Then, bending 45 sample that were pre-tensioned with five different levels of three directions at a rate of 15 sample for each direction (0, 45, 90) degree in the same old groove, where the sample without tension were bent as shown in fig. 9.

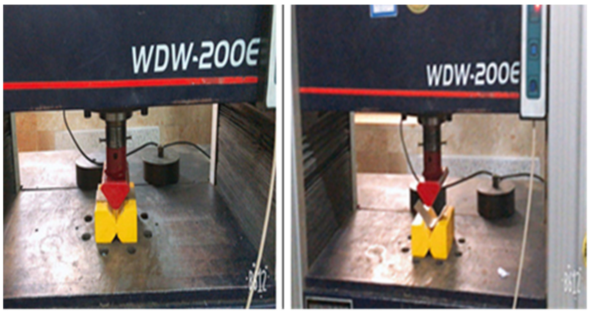


Fig. 8. Bending Device.

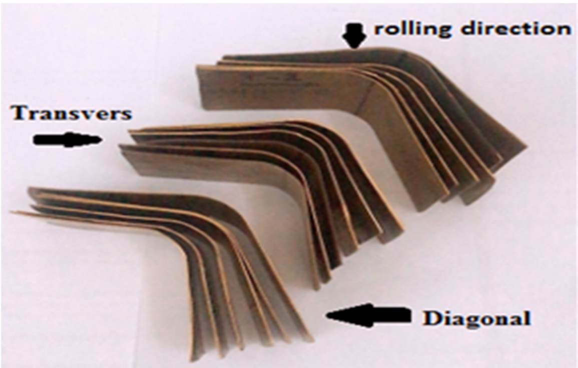


Fig. 9. Bending the Sample in Three Rolling Direction.

2.7. Springback Measured

The springback angle is the difference between sheet angle αf which formed after raising the load where the part tends to recover elastically after bending and its bend radius becomes larger when the tools are taken away the outer radius of the workpiece and punch angle αi or which called loading bending angle when punch / dies configuration in closed position, as shown in fig. 10.

$\Delta\alpha = \alpha f - \alpha i$ …(1)

Will the springback factor is defined by the ratio of the final bending angle and to the loading bending angle, in case K = 1, it is refers to no spring back (αi = αf) but if K = 0 it refers to that complete elastic recovery of the bent material takes place (αf = 0).

$K = \alpha f / \alpha I$ …(2)

By a Mitutoyo 187-907 tool universal bevel protractor with a magnifying glass was used for the precise reading of angles on workpiece 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 angle measurement of all angles, as shown in fig. 11.

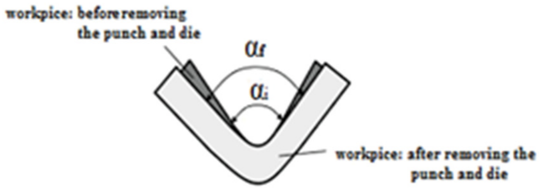


Fig. 10. Illustrate the difference between the final bending angle αf and loading bending angle αi.

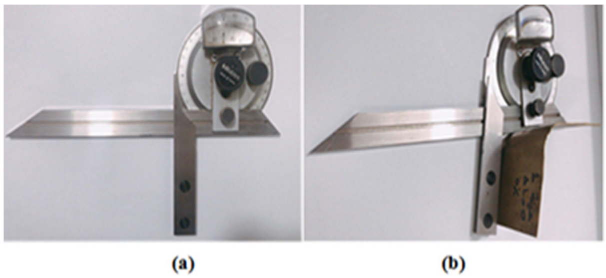


Fig. 11 – a. The measuring device Mitutoyo 187-907. (b) The device while measuring the angle of the sample.

3. Results and Discussions

Mensuration of springback can be defined as a difference between the angle after loading and after unloading. The measured values of springback and the calculated values of springback factor (Ks) and values of pre-tension were measured for each specimen for the two directions as shown In Table (3). 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. Fig. 12 show comparison between springback calculated with different direction to the rolling at different pre-tension. Where it is clear that the pre-tension is a positive relationship to the springbacks and spring backs factor, i.e. the springback increases with the increase in pre-tension. as well the springback is higher in 45 degree to the rolling direction than in 90 degree to the rolling direction, and the springback is higher in 90 degree to the rolling direction than in parallel rolling direction. The main reason to the springback due to increase of dislocation density, which lead to the variation of mechanical behavior. Strain is as well play big role in springback result, where the increasing in number of strain hardening will raise the value of springback due to Bauchigner's influence, which authorize the material to follow dissimilar route through (loading – unloading) cycles. Each of forming operation will happen in the plastic zone. wherefore to estimate or to analyses springback, nonlinear material attribute whose will adjust (stress - strain) relationship in the nonlinear region are indispensable [15].

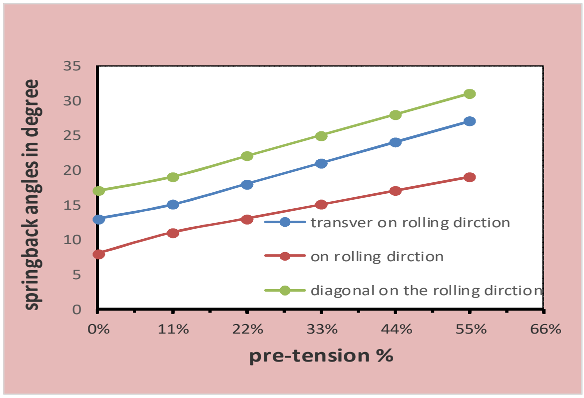


Fig. 12. Variation of the measured spring back with pre-tension in three directions.

The pre-tension process has resulted in an increase in sample length from its original length (ΔL) as shown for each sample in table 3.
Fig. 13 show the relation between the change in length and spring back in Parallel to rolling direction (0°), (45°) degrees to the rolling direction and (90°) respectively. Where, it is clear that the change in length has a positive relationship to the springback i.e. the springback increases with increasing change in length. This leads to decrease the thickness, and the thickness has an inverse relationship with springback.

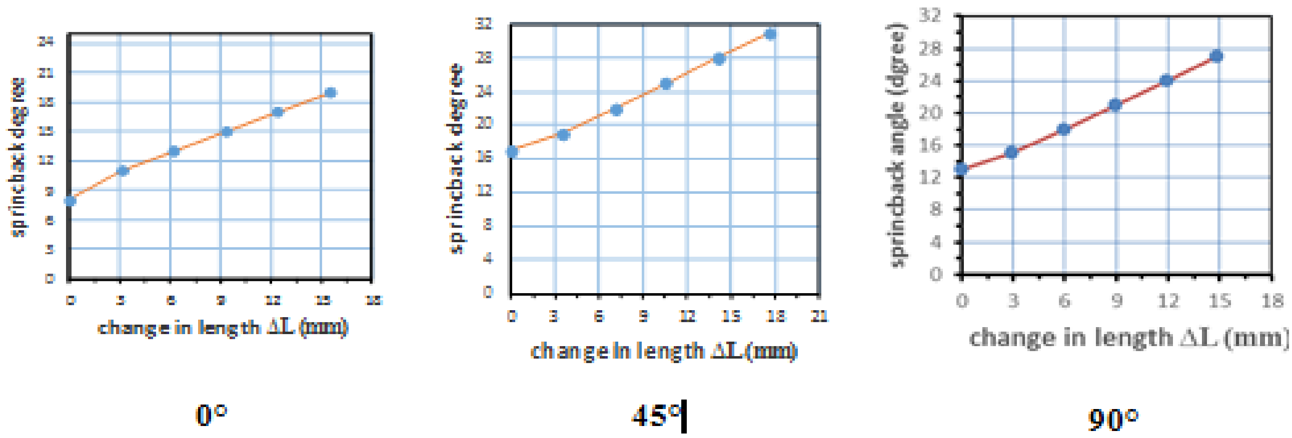


Fig. 13. Relation between the change in length and spring back in three rolling direction.

Fig. 14 show comparison between springback degrees calculated with different direction to the rolling at different change in length, which shows that the springback is higher in 45 degree to the rolling Direction than in (90°, 0°) to rolling Direction respectively. The sheet metal is defined as having planar anisotropy when that give various flow strengths in various directions in the plane of the plate so the yellow brass is anisotropy, perpendicular, diagonal and parallel to the rolling direction assimilate the three vectors of the planar anisotropy. i.e. has different properties (Yield Strength, Ultimate Tensile Strength and Total tensile elongation) in different direction and that it has a great effect on the material properties this corresponds to the source no. [7]. 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".

Table 3,
Experimental measurements of springback and springback factor.

Direction angle	Workpiece	Pretention: Percentage of total pre-tension	Pretention: Change in length (ΔL) in mm	Springback	Springback factor
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
90°	1	0 %	0	13°	1.44
	2	11 %	2.95	15°	1.17
	3	22 %	5.95	18°	1.2
	4	33 %	8.93	21°	1.23
	5	44 %	11.9	24°	1.27
	6	55 %	14.85	27°	1.3

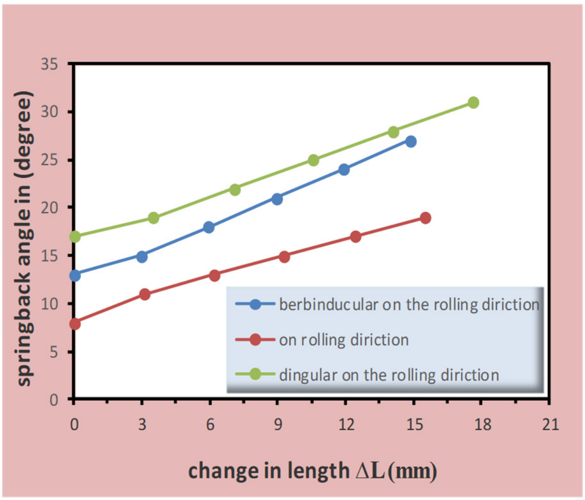


Fig. 14. Comparison between relations measured springback with change in length on three rolling Directions.

4. Conclusions

The present work has reached the following conclusions:

1. The pre-tension has a greater effect on the springback and springback factor, whereas the springback and springback ratio increase with the increase of pretension ratio so it has no positive effect on the springback compensation, and the pre-tension plays a remarkable role in the final sample geometry of the part.
2. The change in length is positive relationship to the spring back whereas the springback increase with the of increase change in length.
3. The orientation has a significant impact on the springback and springback factor. When the direction to the rolling angle is (45º), the spring back angle and spring back factor are higher than the (90º) for the direction to the rolling, while the lower spring back angle and lower springback factor resulted when the direction angle to the rolling is (0º).

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تأثير الشد المسبق واتجاهية المعدن على سلوك ظاهرة الرجوعية في صفيحة النحاس الاصفر

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الخلاصة

تعد ظاهرة الرجوعية احد اهم الظواهر التي تحدث في عمليات تشكيل الصفائح المعدنية والتي تسبب عدة تغييرات هندسية في الاجزاء. ان التنبؤ الدقيق للرجوعية بعد رفع الحمل بعملية الحني هي المفتاح لعدة التصميم والسيطره على العمليات والتخمين الدقيق فيما يتعلق بهندسة الاجزاء. تحرت هذه الدراسة بشكل تجريبي تأثير الشد المسبق بثلاثة اتجاهات (٠,٤٥,٩٠) درجة على اتجاه الدرفلة على سلوك ظاهرة الرجوعية في صفيحة النحاس الاصفر بعملية الحني في قالب شكل V ، تم الشد المسبق بخمسة مستويات مختلفة تبدأ من ١١% الى ٥٥% من قابلية الشد الكلي لكل اتجاه بزيادة منتظمة مقدارها ١١% ومن ثم تم حني العينات في قالب شكل V زاوية ٩٠ درجة لغرض تخمين الرجوعية ، اظهرت النتائج العملية ان الرجوعية تزداد بزيادة نسبة الشد وان الرجوعية بالاتجاه ٤٥ درجة على اتجاه الدرفلة اكبر بكثير من الرجوعية بالاتجاه ٩٠ درجة وان الرجوعية بالاتجاه ٩٠ درجة اكبر من الرجوعية بالاتجاه صفر على اتجاه الدرفلة.