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Effect Of Annealing On The Forming Ability For Brass Sheet

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Abstract:

This research deals with the effect of annealing on the cold forming of brass sheet. In this research two methods were chosen one of them is an experimental work and the other is a numerical work .The material used is brass sheet. Sets of specimens are prepared and treated to perform the tests which include tensile test، forming process and the microscopic examination. The forming is performed in the cold state for blanks using a die with a hemispherical punch to produce drawn parts like cups. These parts are varying in their depths according to the condition of heat treatment (annealing). It was noticed from the experimental results that the annealing at temperature (600℃) has the major effect on the forming ability of the sheet; also using two steps of cold forming with intermediate annealing at the mentioned temperature can produce deeper drawn part as compared with that obtained by one stage. A numerical simulation had been made for the forming process using finite element method (FEM) the commercial software (ANSYS9) to confirm the experimental work The numerical results shows an agreement with the experimental results.

Key words: *Brass, deep drawing, Annealing, experimental, numerical analysis.*

تأثير التلدين على قابلية التشكيل لصفيحة من البراص

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الخلاصة:

البحث يتضمن دراسة تأثير إجراء التلدين على التشكيل البارد لصفيحة من البراص .في هذا البحث اختيرت طريقتين أحداهما عملي والأخرى رقمي حيث تم تهيئة مجموعة من النماذج ومن ثم إجراء التلدين وذلك لاستخدامها في اختبارات شملت اختبار الشد وعملية التشكيل البارد بالإضافة للفحص ألمجهري.استخدم في التشكيل على البارد قالب مع خرامة نصف كروية لإنتاج أجزاء مسحوبة وهذه الأجزاء تتباين فيما بينها في العمق تبعا لظروف التعامل الحراري المستخدمة(التلدين) حيث لوحظ من النتائج العملية أن إجراء التلدين بدرجة (600)°م له التأثير الأعظم على قابلية

التشكيل مقارنة بالنماذج الملدنة الأخرى كما تبين أن إجراء التشكيل البارد على مرحلتين بينهما يتم إجراء التلدين بدرجة حرارة (600)°م ينتج نماذج بعمق اكبر من النموذج الذي ينتج بمرحلة واحدة. أما الجزء الثاني من البحث فقد تضمن إجراء محاكاة نظرية باستخدام برنامج رقمي وذلك لأجل مقارنة النتائج العملية المستحصلة من الاختبارات مع النتائج المستحصلة من المحاكاة النظرية حيث لوحظ أن النتائج المستحصلة من المحاكاة النظرية بالبرنامج تتفق مع النتائج العملية .

1. Introduction:

The metal forming involves the reshaping of metals while still in the solid state. By taking advantage of the plasticity of certain metals, the forming process makes it possible to move a metal solid from its current shape to the desired form. Generally, metal forming operations can be categorized as hot, cold or warm working processes. The temperatures involved in these processes are varying from metal to metal. Hot working involves deforming a metal at temperature above its recrystallization temperature, (usually at temperatures higher than 60% of its melting point). Cold forming is performed at temperature below the recrystallization temperature. Warm working is performed at intermediate temperatures between those of recrystallization and cold-working .Cold worked metals are hard and strong, but their ductility is reduced, they have become relatively brittle as a result of the forming process.

We say that the material is work hardened or strain hardened [1] .The strain hardening is represented by the exponent (n) in the flow stress equation which approximates the relation of true stress and strain during plastic deformation of a metal. This value plays a crucial role in sheet metal forming, the larger the exponent the more the material can elongate before necking [2] and can be calculated using the relation of true values of stress and strain as below:

$$\sigma = k.\ \varepsilon \wedge n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 1$$

Where

σ: True stress

k: Strength coefficient

ε :True strain

n: Strain hardening exponent.

Formability is usually defined as the ability of sheet metal to undergo shape stretching without necking or tearing and the forming limit diagram(FLD) can be used to compare the formability of different metals [3] .The Deep drawing is considered one of the most popular metal forming methods available to manufacturer [4]. When cold worked metals are heated, recrystallization occurs .i.e. new grains forms and grows to consume the cold worked portion. The new grains have fewer dislocations and the original properties are restored so by controlling the processes of deformation and heat treatment we are able to process the material to in a useable shape yet still improve and control the properties [5].

Deep drawing is most effective with ductile metals, such as aluminum, brass, copper, and mild steel and the brasses comprise the useful alloys of copper and zinc and constitute one of the most important groups of non ferrous engineering alloys. The alpha phase of brass is quite soft and ductile at room temperature and for this reason this phase is considered as good cold workable alloy [6].

In this field W.Ozgowicz determined the influence of rycrystallization temperature on the microstructure and the mechanical properties of brass subjected to cold deformation in the process of rolling under various degree of strain and he found that annealing in range (400-650)°c is effective also he noticed that the hardness drops with decreasing cold rolling reduction and with rising the temperature of annealing [7] also the cold rolled brass strip is considered an ideal for deep drawing and the cartridge brass is a typical example of a deep drawn parts[8] .

The aim of this research is to make a cold forming of brass blanks using die with hemispherical punch to produce drawn parts of brass at different condition of annealing. Also the work is done numerically using commercial software program (ANSYS) to confirm the experimental results.

2. Experimental work:

The experimental work includes: specimen preparation, annealing process, microscopic examination, tensile tests and the forming process. In the beginning tensile specimens are prepared according to standard specification (which includes dimensions as 50*12.5*1 mm). The other specimens (blanks) which is related to the forming process have dimensions equal to (100*100*1mm) are prepared also. Then annealing is done for the specimens and the blanks using electric muffle furnace. The annealing is done at different selected temperatures between(400°C and 600°C) with soaking time about(15) minute . Microscopic examination is used for the annealed and the as received (un- annealed) brasses using optical microscope type (Karl Kolb).The specimens are grinded, polished and etched using acidic ferric chloride. A digital camera is used for taking pictures for the microstructures of the annealed and the as received specimens. About the mechanical testing, the tensile test is performed for all specimens using a tensile testing machine of capacity up to (50) KN. The results of such a test is useful in construction of the stress strain curves of the specimen the to determine the mechanical properties which is considered as an input values for the theoretical work by Ansys program. The forming is performed for the blanks to produce different drawn parts of brass. In this process a blank is stretched into the desired part shape. A punch pushes downward on the blank, forcing it into a die cavity, the forces applied to the blank cause it to plastically deform into a drawn part-shaped part. Deep drawing is most effective with ductile metals, such as aluminum, brass, copper, and mild steel. Examples of parts formed with deep drawing include automotive bodies and fuel tanks, cans, and cups. The blank is clamped down by the blank holder over the die, which has a cavity in the shape of the part. The movement of the punch is usually hydraulically powered to apply enough force to the blank. Both the die is made from tool steel or carbon steel. The process of drawing sometimes occurs in a series of operations, called draw reductions. After a part is completely drawn, the punch and blank holder can be raised and the part removed from the die. This process is repeated for all blanks **Figure (1a &1b)** explains this process.

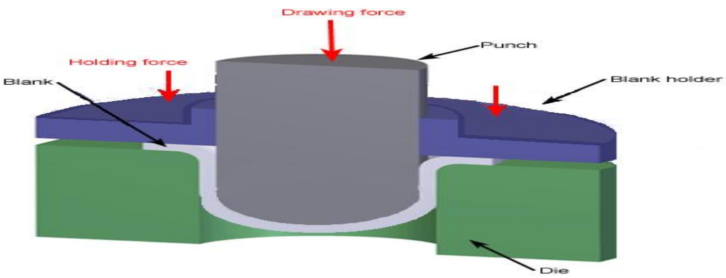


Fig. (1-a): principle of deep drawing

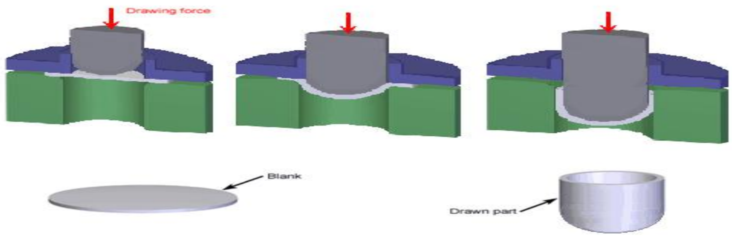


Fig. (1-b): Dep drawing process sequence)

3. Numerical analysis:

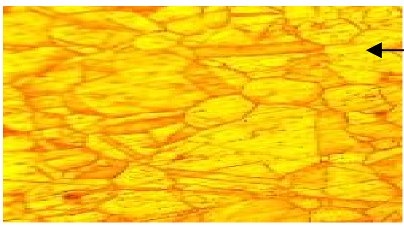
Also this work is performed numerically by simulation with (FEM) the commercial software (ANSYS9***)*** to confirm the experimental results. The simulation of the deformation process was carried out using FEM-Finite element method through the application of the program which is a general purpose finite element software and the element visco106, contact 171, used to model the punch, die, blank holder and the deformed brass sheet. The punch was gradually moved against the blank in order to achieve the required forming pressure, a conversions in the result was achieved with 4850 elements.

4. Analysis and Results:

The experimental results show that the annealing is very useful for the cold forming of brass, also increasing the annealing temperature upto (600)ºC affect on the forming ability of the blank. All the annealed specimens are considered better in forming as compared with the as received specimen, especially those annealed at (600°C) which give an improvement in the results of forming process equal to (32%) as compared with the as received blank and this percentage is calculated according to the increasing in the depth of the drawn part(cup).Also the other annealed blanks have a little effect on cold forming as compared with the blank which annealed at (600°C) .The number of deformation steps affect also on the forming ability of brass sheet .It was noticed that using double steps of cold forming with intermediate annealing can give a good results as compared with the results obtained by using single step under the same conditions of annealing that means using two steps of forming for annealed blank at (600°C/15 min.) with intermediate annealing at the same condition can produce deepest drawn part , so the improvement increased from (32%) to (70%) which is calculated using the difference in depth of the cup produced by cold forming that means it is calculated by this equation:

% improvement= {(new depth - original depth) / original depth}*100 %..........(2)

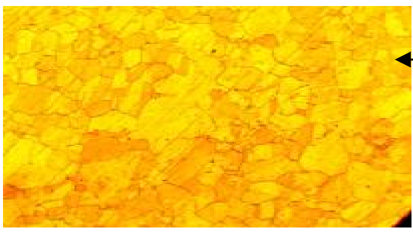
Where original depth means the depth of the cup for the as received specimen and this improvement is due to recrystallization process which occurs. This usually means holding the cold worked metal at a temperature above the recrystallization temperature for a period of time (15 minute) and by controlling the processes of deformation and heat treatment it was able to process the material into in a useable shape yet still improve and control the properties. **Figures (2 ,3 & 4)** shows the microstructures of the annealed brasses and the change in the shape of alpha grains is clear due to annealing and the equiaxed grains of alpha phase are very clear in **Figure (4)** which represents the microstructure of annealed brass at (600) °C.



Grains of alpha phase annealed at 400°C

160 X

Fig. (2): Microstructure of the annealed brass at 400°C



Grains of alpha phase annealed at 500°C

160X

Fig. (3): Microstructure of the annealed brass at 500°C

Equiaxed grains (recrystalized grains of alpha phase which annealed at 600°C)

160X

Fig. (4): Microstructure of the annealed brass at 600°C

Figures (5) represent the results of the tensile tests .It was noticed from **Figures (2,3 And 4)** that the strain values increasing for the annealed brasses as compared with the as received brass .This is due to the effect of annealing process through elimination of residual stresses and increasing the ductility so the strain of the annealed specimen exactly at (600ºC) have the highest value of strain as compared with those annealed at temperatures below (600ºC).**Figure (6**) represents the relation between true stress and true strain. **Figure (7)** represent the contour of stress distribution during process, **Figures (8&9)** explains the effect of annealing at different temperatures on the effective stress. It was noticed from these figures that the induced stresses generated during forming process are varies significantly with the annealing temperatures as compared with the as received specimen.

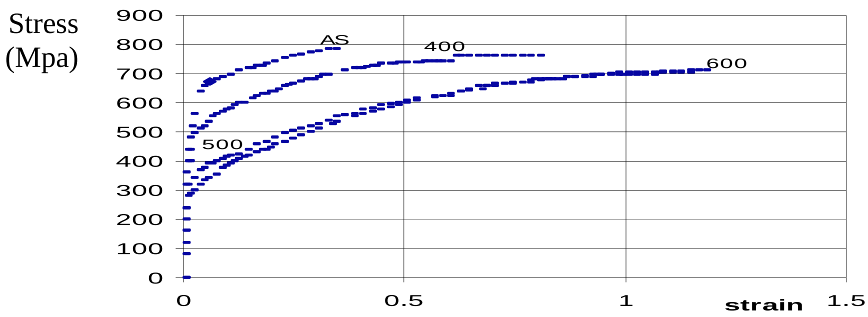


Fig. (5): Stress strain curve for experimental work

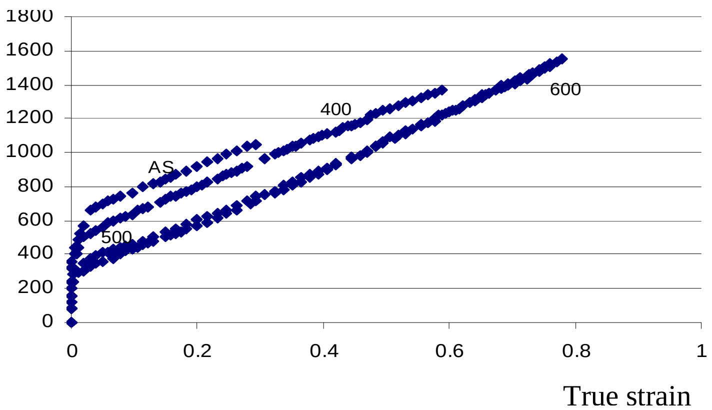


Fig. (6): True stress –true strain curve for experimental work

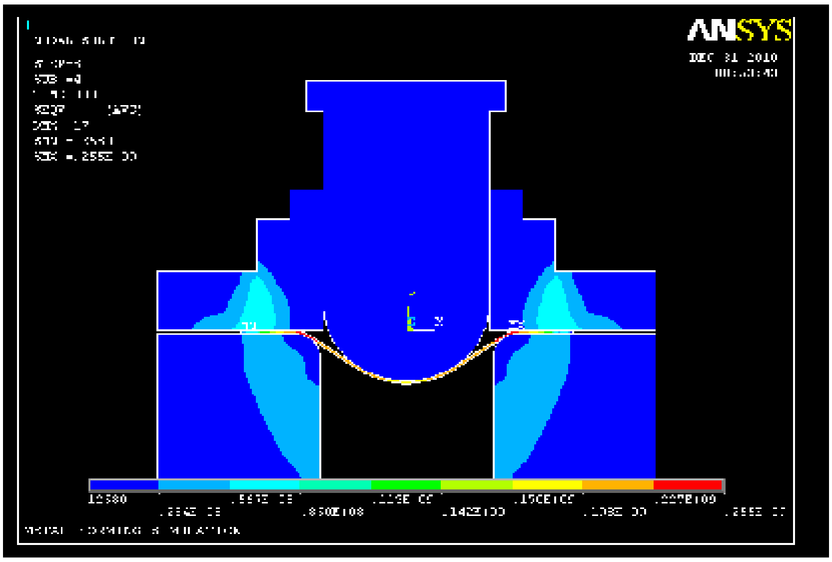


Fig. (7): Contour of stress distribution during process

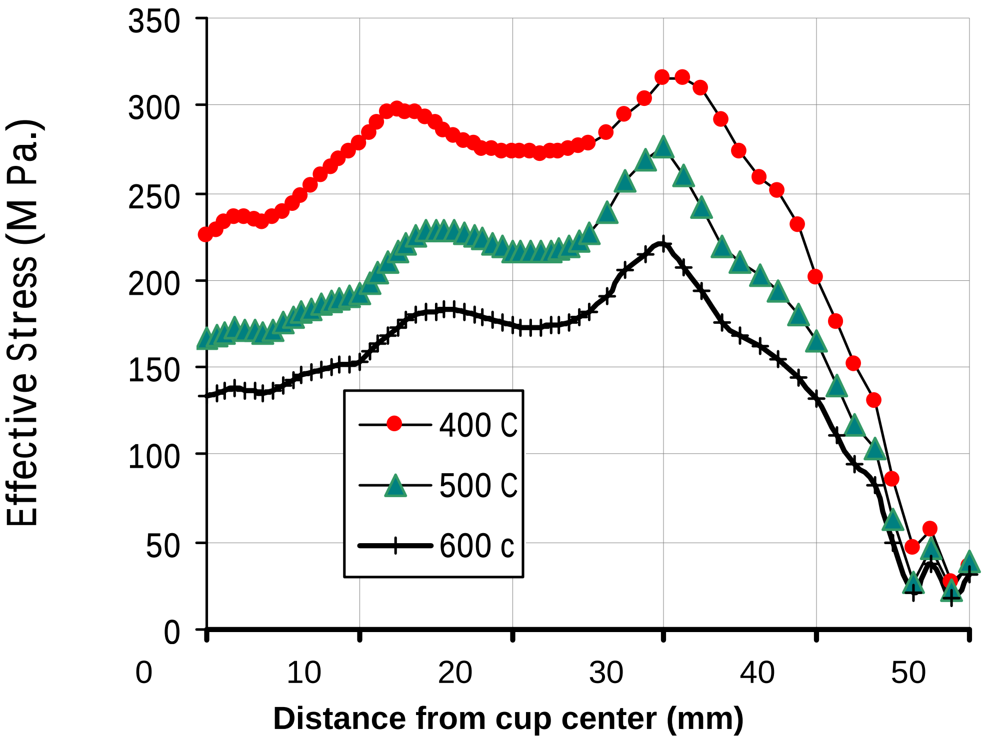


Fig. (8): Effect of annealing temperature on effective stress for annealed specimens

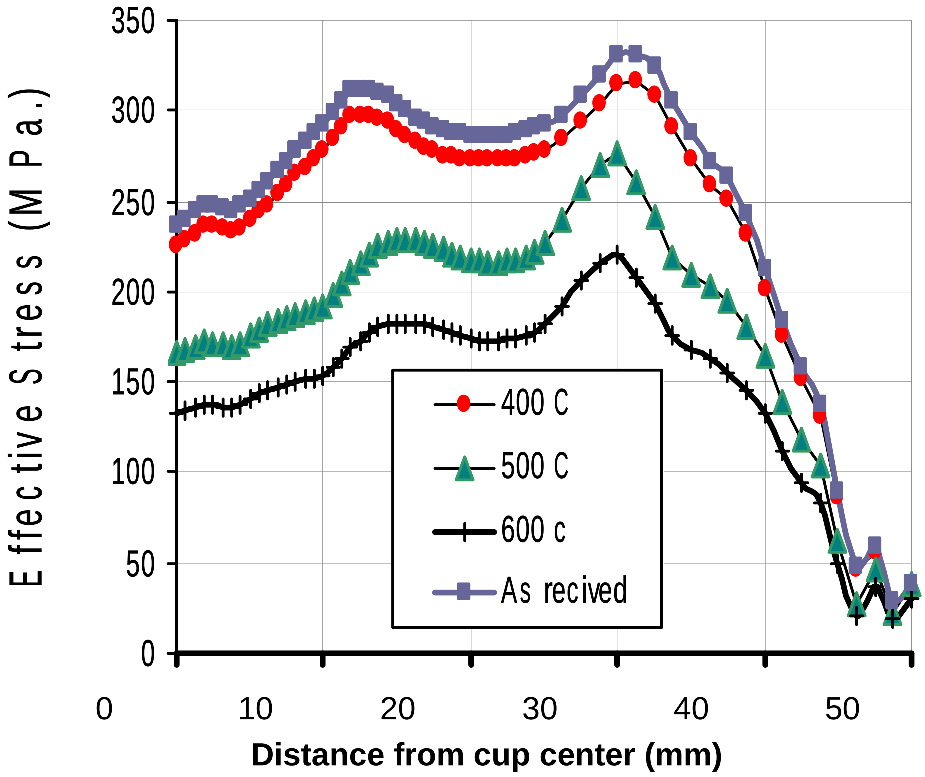


Fig. (9): Effect of annealing temperature on effective stress for all specimens

5. Conclusions:

1. The annealing temperature equal to (600°C) for approx.15 minutes improves the cold forming for all specimens.
2. Using two steps of cold forming with intermediate annealing at (600) ºC gives a better result as compared with using a single stage.
3. FEM method is considered a very useful in simulation of plastic deformation of brass sheet as a confirmation for the experimental results.

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