Effect of Heat Treatment on The Hydroformability of CuZn 35 Sheet Metal

Ali H. Alhelli
Mechanical Eng. Dep.
Al-Nahrain University
dr.alialhelli@gmail.com

Abdul Hakeem Amer S.Salim
Mechanical Eng. Dep.
Al-Nahrain University
eng.nah.hakeem60@gmail.com

Abstract

Sheet metal forming becomes a research topic for its widely using in the industrial field, these researches seeking for a better specifications of the products with low cost of production processes using available raw materials. In this work the sheet metal used is CuZn35 1mm thick. This sheet metal formed by a process named hydroforming process using a square shaped die to form the sheet metal according to its cavity by the pressure of the hydraulic which must be in direct contact with the surface of the sheet metal. Tests had been made for this sheet metal and for the final product for the as received specimen and for the heat treated one which shows the improvement of the formability of this sheet metal.

1. Introduction

Formability is defined as the ability of transformation of the sheet metal into a desired shape without fracture or localized thinning [1], in hydroforming process the hydraulic will act as a punch to force the sheet metal to take the shape of the die cavity .Many parameters affect the sheet metal Formability Fig. (1) Summarizes theses Parameters influencing the formability, one of these is the heat treatment process.

2. Annealing

It is the heat treatment process used to increase the formability of the sheet metal by elimination the cold working effect [3]. Two heat treatment procedure were chosen for the CuZn 35 used which they are shown in table 1

3. Experimental Work

Major objective of the experimental work is to find the forming limit diagram for the Brass CuZn35 for the as received specimen and for the heat treated one. Fig.2 illustrate a schedule of the experimental work.

Chemical composition for this sheet was carried out in the central organization for standardization and quality control as detailed below in the table 2

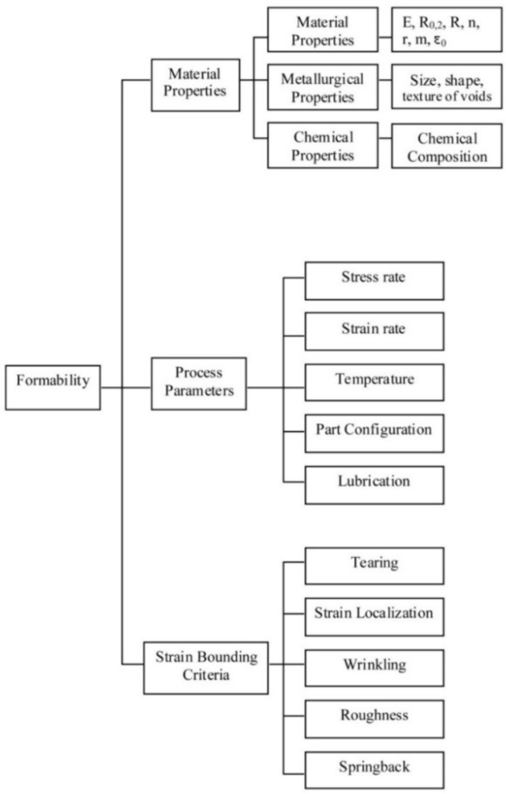

Figure 1: Parameters influencing sheet metal formability [2].

Table 1: Heat treatment procedure of CuZn35 [3]

CuZn35	**CuZn1**	**As received sheet.**
	CuZn2	**650℃ → cooled in iced water.**
	CuZn3	**600℃ → one hour holding time → cooled in iced water.**

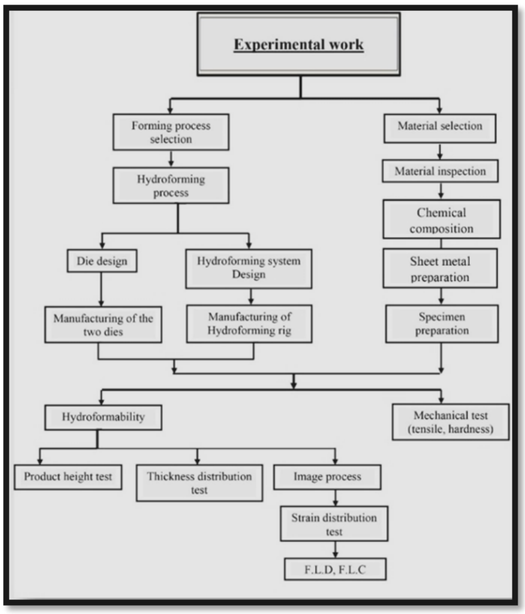

Figure 2 : Flow chart for the stages of the experimental work

Table 2: Chemical composition of CuZn35

Zn %	**35**	**Sn %**	**0.005**	**P %**	**0.003**
Fe %	**0.027**	**N %**	**0.005**	**Cr%**	**0.004**
S %	**0.006**	**AS %**	**0.004**	**Ag %**	**0.004**
Cu %	**0.004**	**Bi %**	**0.004**	**Cd %**	**0.001**
Others	**0.001**	**Cu %**	**Remain**	**AL%**	**0.003**
Mn%	**0.005**	**Ag %**	**0.011**	**Sb %**	**0.003**

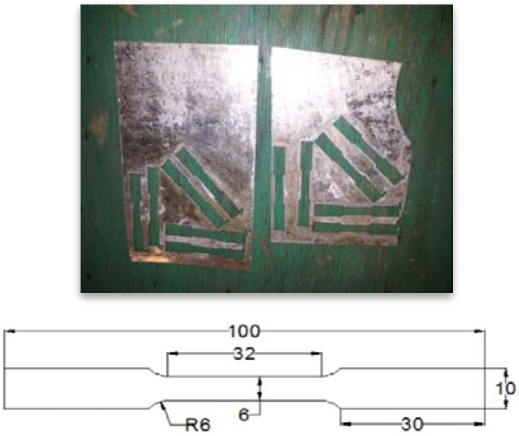

Figure 3: Specimen cut with different rolling directions and standard tensile test dimensions (mm).

These sheets were prepared for the tensile test shown in Fig.3 above.

They were also prepared for the formation with the square shaped die by designing a new special one for this work as shown in. Fig.4 manufactured and assembled withe the hydraulic system designed for this purpose to form the sheet according to the cavity of the die by the pressure of the hydraulic which is supplied by electric hydraulic pump and Controlled by pressure and throttling valves as shown Fig.5,6

To study and measure the strain levels for these deformed specimens an image process had been used to obtain the minor and major strain by printing a grid of pattern with known diameter circles on the surface of the undeformed specimen. See Fig.7,

After the deformation the new axes of these circles can be measured by a digital camera and programmed software prepared for this work [4] to obtain the minor and major strain in order to get the forming limit diagram (F.L.D) and the forming limit curve (F.L.C) which they are a good representation of the formability of the sheet metal see Fig.8, 9

Thickness distribution had been calculated by taking several points over the surface of the deformed specimens on the cross section of the specimen passing throw the center point and on the diagonal cross section to cover most of the surface of the deformed specimen see Fig.10

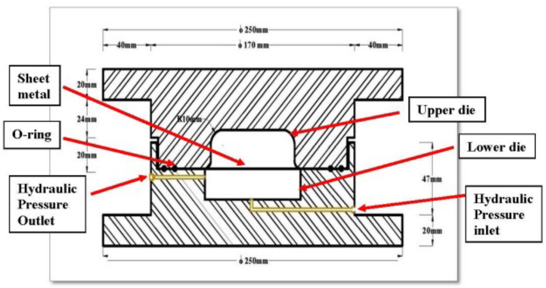

Figure 4: First step of the design of the two dies

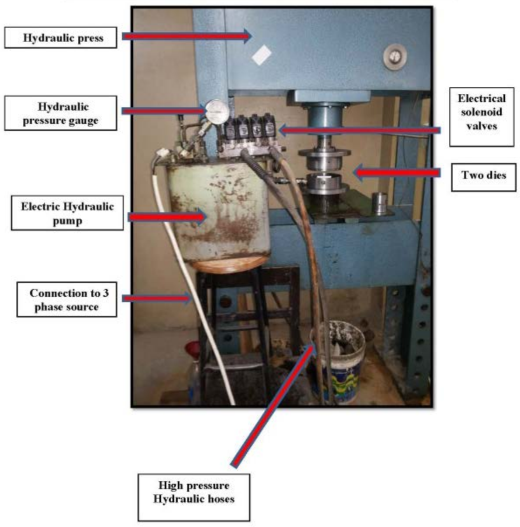

Figure5: Assembly of the two dies and the hydraulic system

Figure 6 : Final shape of the dies

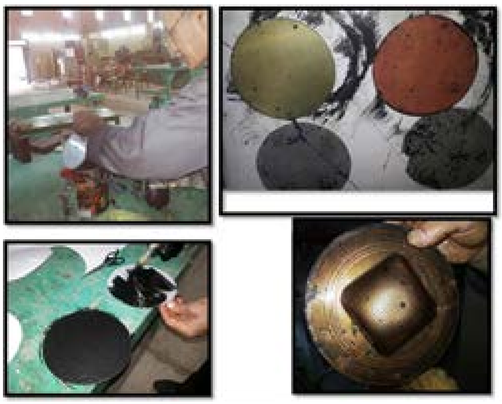

Figure7: Specimen before and after deformation showing the preparation of painting the grid pattern of circles with special metal paint

Figure8: The digital camera

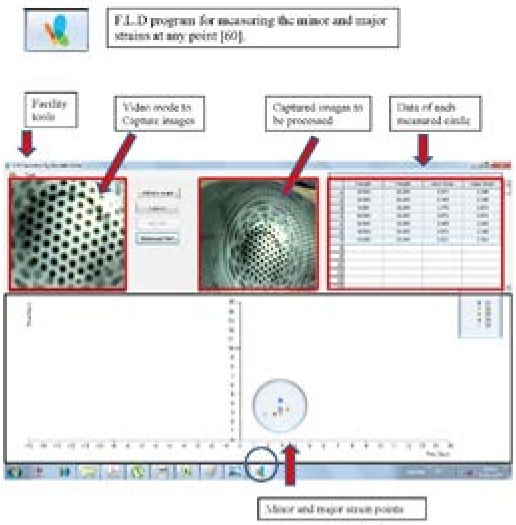

Figure 9: Designed software interface

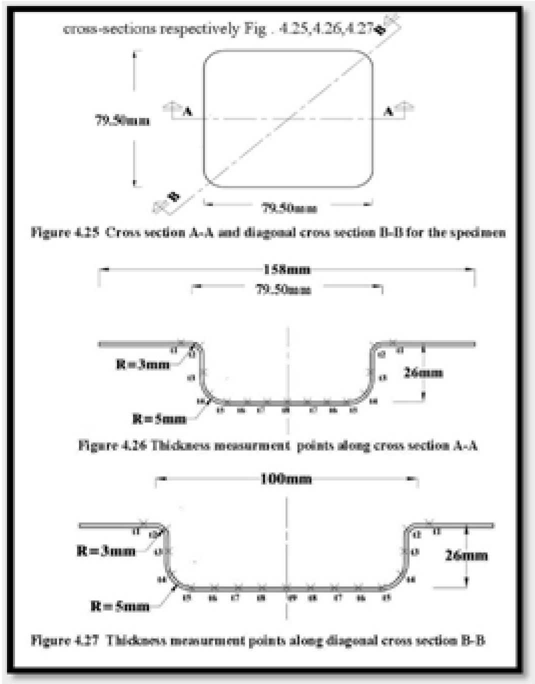

Figure 10: Thickness measurement points along diagonal cross section B-B

Maximum Product height had been measured for the as received specimen and for the heat treated ones.

4. Result and Discussion

Experimental results had been measured for Brass CuZn35 as an experimental material for the as received and heat treated specimens to see the effect of heat treatment on these results and on the hydroformability of this material.

1-Hardness test shows that the hardness of the as received Brass was 55 H.V. and (48,42) H.V for the other two heat treated specimens respectively, this decrease in the hardness result due to the increase within the grain size of these specimens by heat treatment [4].

2-Tensile test result for the as received specimen and for the two other heat treated ones with different rolling directions as shown in Fig.11, 12, 13

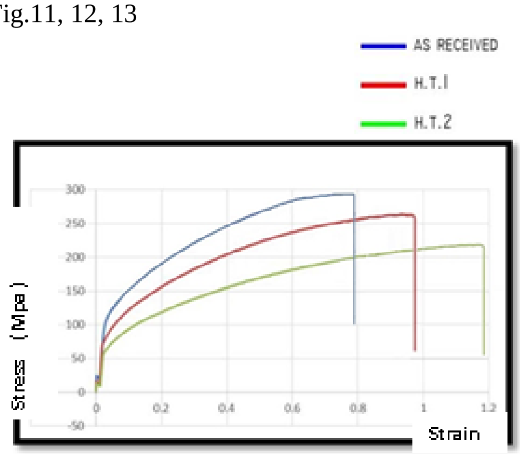

Figure 11: Stress-stain curves for CuZn35, 1.00 mm thick 0° with rolling direction

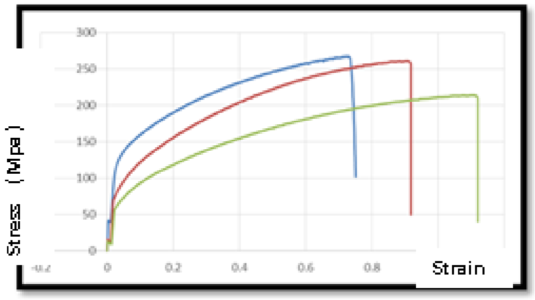

Figure 12: Stress-stain curves for CuZn35, 1.00 mm thick 45° with rolling direction

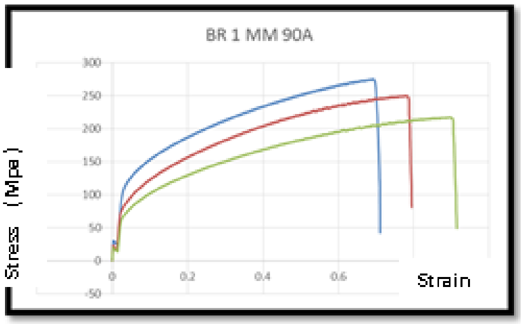

Figure 13: Strees-stain curves for CuZn35, 1.00 mm Thick 90° with rolling direction

These Figures are Stress-strain curves which shows an increase in the total percentage of elongation with each heat treatment for the three directions of rolling process (1-longtudinal with rolling direction, 2- 45° with rolling direction, 3- normal to rolling direction), table 3 show the result of total percentage of elongation for these specimens.

Stress-strain curves also shows a decrease with Ultimate tensile strength as shown in table 4

These two tables 3, 4 show an improvement in the ductility of this alloy with each heat treatment and the decrease in the ultimate tensile strength with heat treatment due to the changing in the mechanical properties.

Table3: Total percentage of elongation %

Specimen material	Total percentage of elongation %		
	As received	H.T.1	H.T.2
CuZn35, 0° with rolling direction	79	95	118
CuZn35, 45° with rolling direction	73	92	113
CuZn35, 90° with rolling direction	70	79	95

Table4: Ultimate tensile strength (Mpa)

Specimen material	Ultimate tensile strength (Mpa)		
	As received	H.T.1	H.T.2
CuZn35, 0° with rolling direction	290	260	220
CuZn35, 45° with rolling direction	270	255	215
CuZn35, 90° with rolling direction	260	250	215

3-Thickness distribution profile had been measured and plotted for the as received specimen and the other two heat treated ones at the points on cross section A-A and diagonal cross section B-B as shown in Fig.14, 15 which shows increase in the percentage of maximum thinning which they are 30% for the as received specimen and 40%, 50% for the other two heat treated specimens.

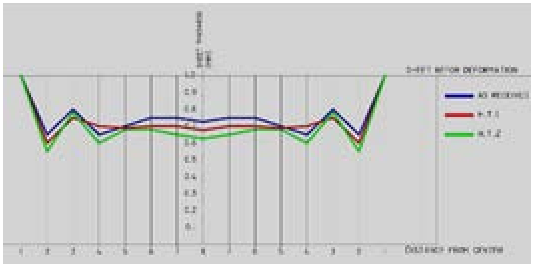

Figure 14 : Thickness distribution profile of specimen made of CuZn35 1.00 mm thick (cross section A-A)

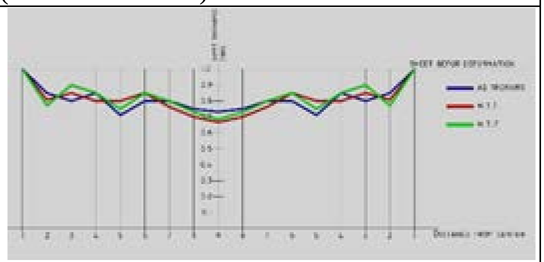

Figure 15: Thickness distribution profile of specimen made of CuZn35 1.00 mm thick (cross section B-B)

Table 5 shows the percentage of maximum thinning that happened in each specimen for different heat treatment, from which we can see the improvement of maximum thinning for each one by the annealing processes which means decrease in the width which leeds to increase in the strain levels due to annealing process

Table 5:Maximum thinning			
specimen	Maximum Thinning % as received	Maximum Thinning % H.T.1	Maximum Thinning % H.T.2
CuZn35	30	40	50

4- Forming limit diagram (F.L.D) and forming limit Curve (F.L.C) had been blotted for this material . By measuring the major and minor strain on points on the surface of the deformed specimen by using the image process which can cover most the surface of the deformed specimen.

Figs.16 and 17 show the (F.L.D) and (F.L.C) respectively which shows the increase in the formability for the heat treated specimen comparing with the as received one by increasing the strain values due to the change in the microstructure with annealing process as shown in table 6 which indicates the major and minor strain for the tension –tension region and tension – compression region.

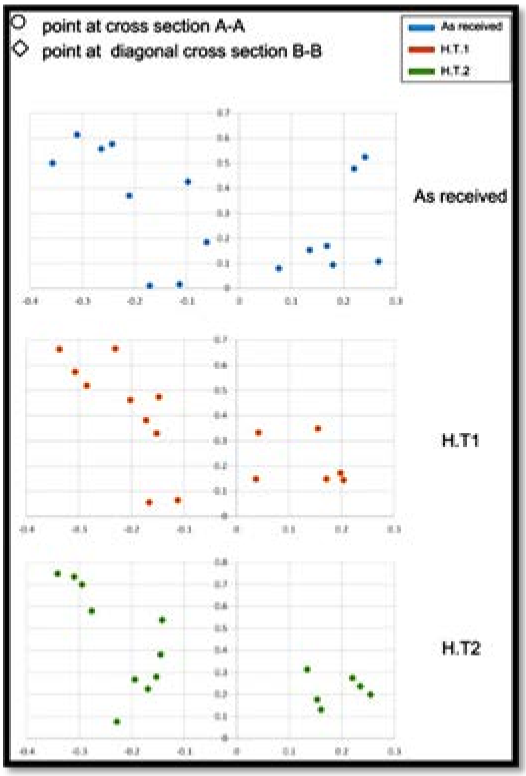

Figure 16 : Strain distribution of CuZn35, 1.0 mm thick

Table 6: Maximum minor strain and maximum major strain

Sheet metal	Tension-tension region		Tension-compression region	
	Max ϵ_1	Max ϵ_2	Max ϵ_1	Max ϵ_2
As received	0.53	0.26	0.61	0.36
H.T.1	0.57	0.21	0.67	0.34
H.T.2	0.67	0.27	0.75	0.35

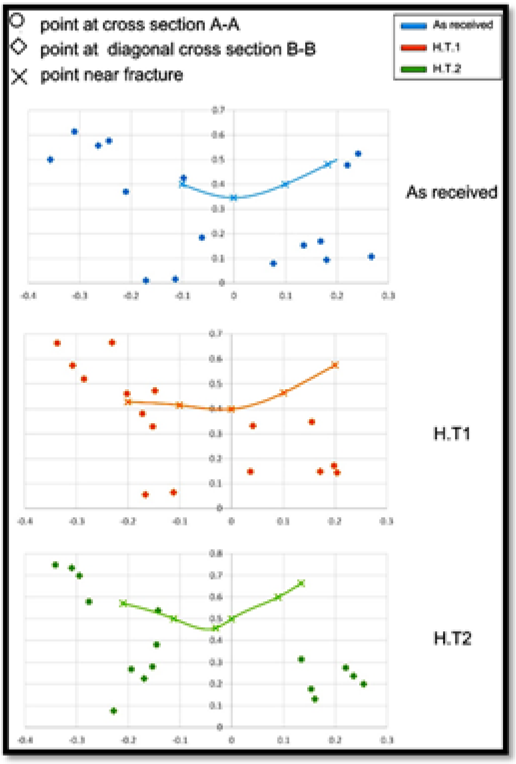

Figure 17: Forming limit curve of CuZn35, 1.00 mm thick.

5- Maximum product height which can be reached had been measured for the as received specimen and for the heat treated one. It was found 24mm for the as received specimen, 25mm for the first heat treatment and 26mm for the second heat Treatment which means an increase in the formability of this sheet metal with heat treatment.

From the above results it is obviously seen the formability can be improved by the heat treatment by decreasing the hardness, increasing in the ductility and increasing in the maximum thinning that can be reached due to the change in the microstructure of the material.

5.• References

[1] Fahrettin Ozturk, Murat Dilmec, Mevlut Turkoz, Remzi E. Ece, Huseyin S. Halkaci, "Grid Marking and Measurement Methods for Sheet Metal Formability",5th International Conference and Exhibition on Design and Production of MACHINES and DIES/MOLDS 18-21 JUNE, 2009 Pine Bay Hotel - Kusadasi, Aydin, TURKEY,pp.1.

[2] A. Wellendorf: Untersuchungen zum konventionellen und wirkmedien-basierten Umformen von komplexen Feinstblechbauteilen, Fakultat Maschinenbau Lehrstuhl fur Umformtechnik Promotionvortrag, Dortmund, 2004.

[3] Engineering metallurgy, part 1, applied physical metallurgy, sixth edition, Raymond Higgns.
[4] Mustafa Adnan Mustafa, "Numerical and Experimental Study of the Effect of the Effect of Forming Parameters on the Formability of CuZn30", Master thesis, Al-nahrain University, Mechanical Engineering dept. 2013.

تأثير المعاملات الحراريه على قابلية التشكيل بالهيدوليك لصفيحة البراص CuZn35

علي حسين محمد
قسم الهندسة الميكانيكية
جامعة النهرين

عبد الحكيم عامر سلمان
قسم الهندسة الميكانيكية
جامعة النهرين

الخلاصة

يعتبر مجال بحوث تشكيل الصفائح المعدنيه من المجالات الواسعة و اصبحت محط أنظار الباحثين و مادة ثريه للبحوث العديدة لما لها من استخدامات واسعة من الصناعة و الحياه العمليه ،ان هذه البحوث تهدف للحصول على مواصفات أفضل و كلف انتاج اقل باستخدام خامات معدنيه متوفره في هذه الدراسه ان الصفيحة المستخدمه هي (سبيكة البراصCuZn35) بسمك ا مليمتر . تم تشكيل هذة الصفيحة بطريقة التشكيل الهيدروليك باستخدام قالب ذو مقطع مربع حيث تم سحب الصفيحة لتجويف القالب بواسطة ضغط الهيدوليك حيث يكون تلامس مباشر بين الهيدروليك و سطح الصفيحة . تم اجراء العديد من الفحوصات للصفيحة المعدنيه و للمنتوج الاخير للسبيكة المستلمه بدون مكعالجات حراريه و كذلك للسبيكة المعالجة حرارياً و التي أظهرت تحسناً و اضحاً لقابلية التشكيل .