International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Volume 3, Issue 6 (November-December, 2015), PP. 226-232

EFFECT OF HEAT TREATMENT ON THE HYDROFORMABILITY OF 1060 AA 1MM THICK SHEET METAL

Dr. Ali H. Muhammed[1],Abdul Hakeem Amer S.Salim[2]
[1]Assistant Professor, [2]Student
Mechanical Engineering Department
AL-Nahrain University Baghdad-Iraq
[1]dr.alialhelli@gmail.com
[2]eng.nah.hakeem60@gmail.com

Abstract— **Sheet metal technologies are challenged especially by the improvement in the automotive industry in the last decades to fulfill the customer expectations, safety requirements and market competitions, new production technologies have been implemented [1]. In this work the sheet metal used is 1060AA 1mm thick Aluminum alloy usually used for its light weight, high corrosion resistant, easy to recyclables and high strength to weight ratio. This sheet metal is to be formed by hydroforming process which used the hydraulic pressure as a punch to force the sheet metal to take the shape of the die cavity and study the formability of this alloy under different heat treatment procedures.**

Keywords: **Automotive, aluminium, hydroforming.**

I. INTRODUCTION

Formability is defined as the ability of transformation of the sheet metal into a desired shape without fracture or localized thinning [2], in hydroforming process the hydraulic will act as a punch.Many parameters affect the sheet metal Formability Fig. (1) Summarizes theses. Parameters influencing the formability, one of these is the heat treatment process which called annealing.

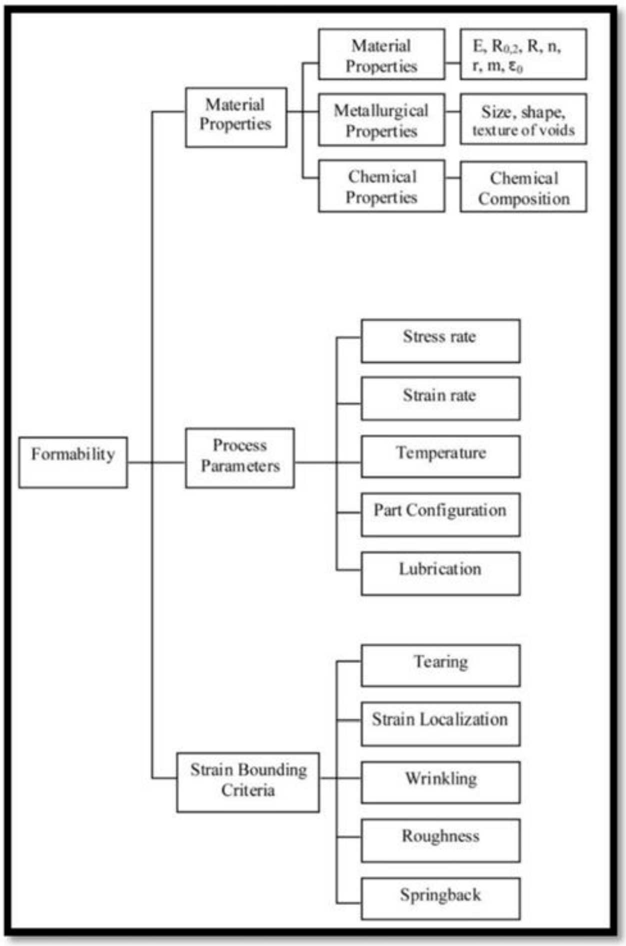


Figure 1 Parameters influencing sheet metal formability [3].

II. ANNEALING

It is the heat treatment process used to increase the formability of the sheet metal by elimination the cold working effect [4]. Two heat treatment procedure were chosen for the 1060AA 1mm thick used which they are shown in table 1.

Table 1 Heat treatment procedure of 1060AA [3]

1060AA 1mm	**AA1**	**As received sheet.**
	H.T.1 AA2	**530 (→ one hour holding time → cooled in iced water.**
	H.T.2 AA3	**530(→one hour holding time → cooled in iced water →150(→ two hour holding time → cooled in furnace.**

III. EXPERIMENTAL WORK

major objective of the experimental work is to find the forming limit diagram for the 1060AA 1mm thick for the as received specimen and for the heat treated one. Fig.2 illustrate a schedule of the experimental work.

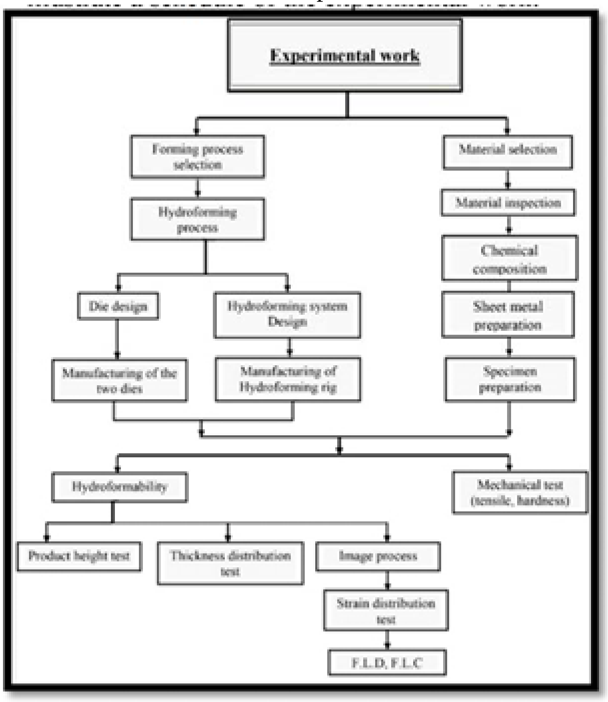


Figure 2 Flow chart for the stages of the experimental work

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

Table 2 chemical composition of 1060AA 1mm thick

Si %	0.066	Ti %	0.019	Na %	0.0005	Hg %	0.0005
Fe %	0.147	Be %	0.0001	Bi %	0.002	In %	0.0005
Cu %	0.009	Ca %	0.0001	Zr %	0.0005	Sb %	0.005
Mn %	0.001	Li %	0.0001	B %	0.003	P %	0.002
Mg %	0.0005	Pb %	0.002	Ga %	0.018	As %	0.004
Zn %	0.007	Sn %	0.0005	Cd %	0.0003	Ce %	0.001
Cr %	0.0001	Sr %	0.0001	Co %	0.0002	La %	0.0002
Ni %	0.002	V %	0.005	Ag %	0.0007	Al %	Remain

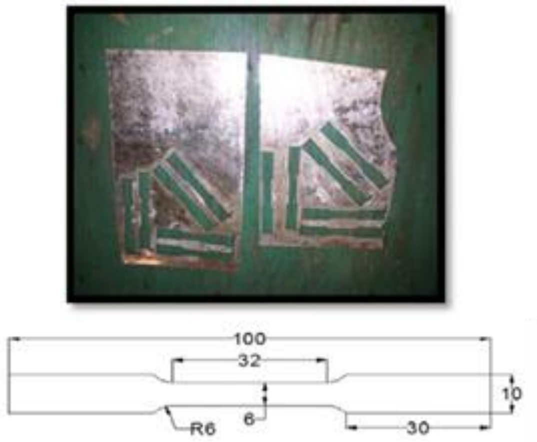


Figure 3 Specimen cut with different rolling directions and standard tensile test dimensions (mm).

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.

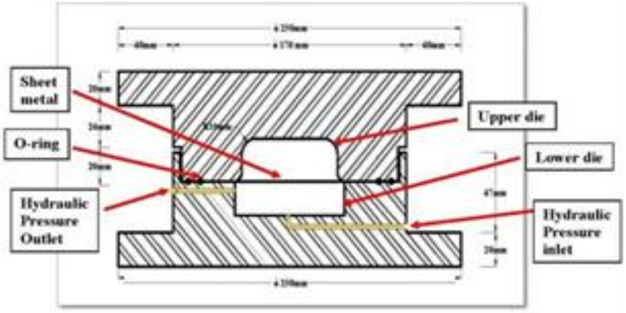


Figure 4 First step of the design of the two dies

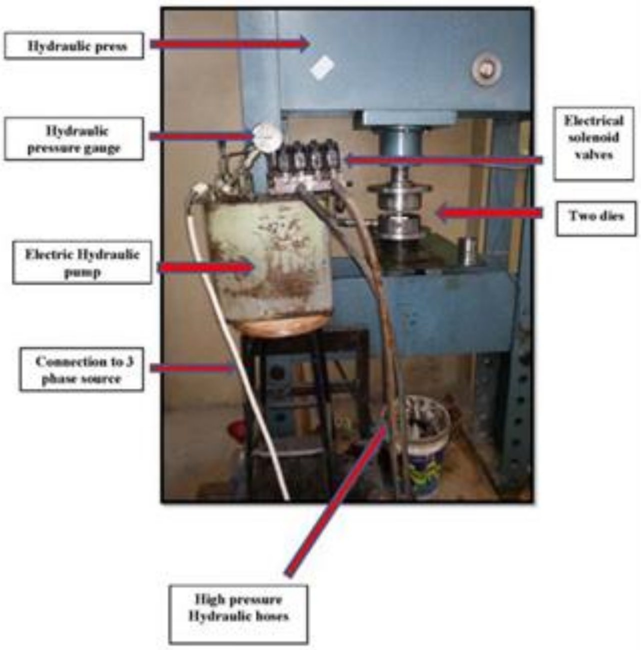


Figure 5 Assembly of the two dies and the hydraulic system

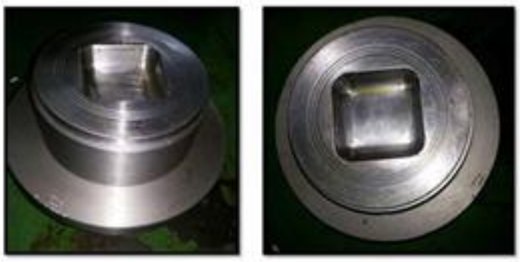


Figure 6 Final shape of the dies

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.

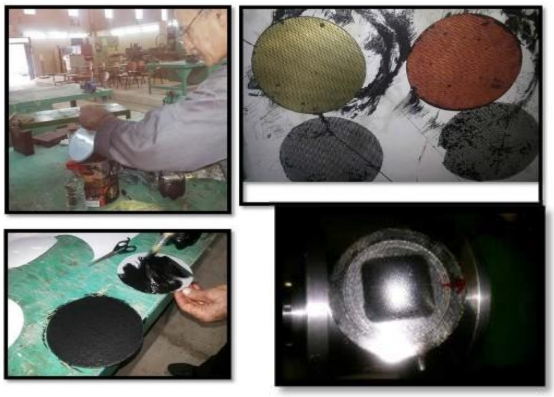


Figure 7 Specimen before and after deformation showing the preparation of painting the grid pattern of circles with special metal paint

and after the deformation the new axes of these circles can be measured by a digital camera and programed software prepared for this work [5] 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.

Figure 8 The digital camera

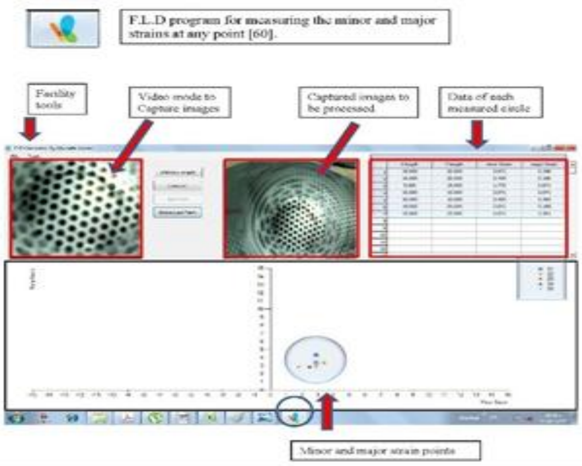


Figure 9 Designed software interface

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.

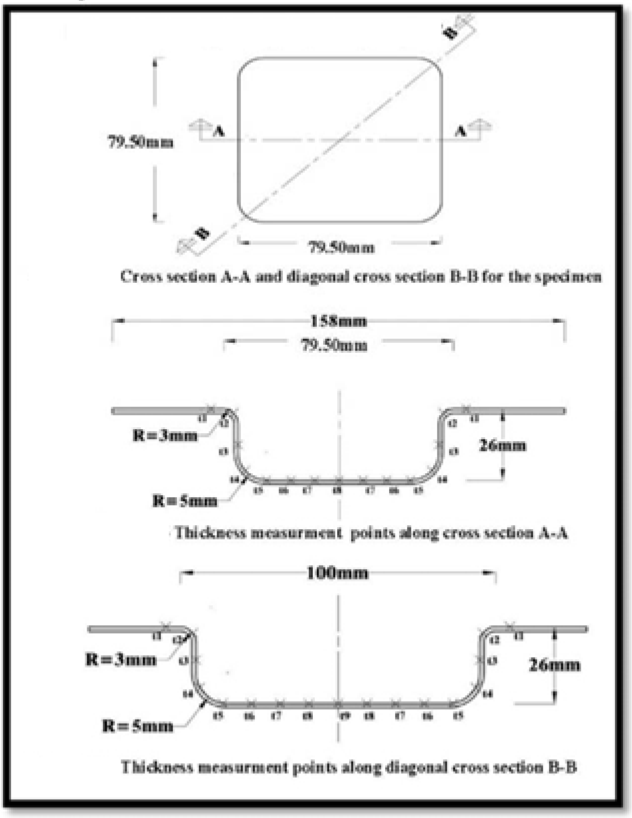


Figure 10 Thickness measurement points along diagonal cross section B-B

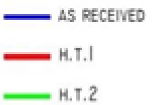
Maximum Product height had been measured for the as received specimen and for the heat treated ones.

IV. RESULT AND DISCUSSION

Experimental results had been measured for 1060AA 1mm thick 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 received1060AA was 28 H.V. and (20,15) 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 [5].

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



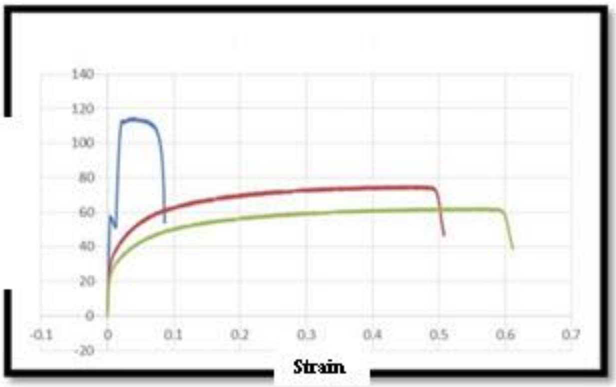


Figure 11 Stress-stain curves for 1060AA 1.00 mm thick 0° with rolling direction

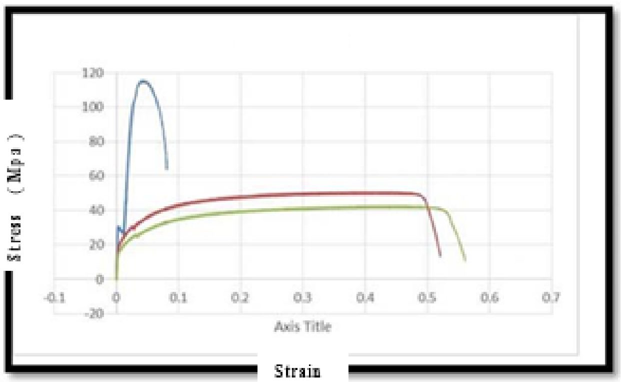


Figure 11 Stress-stain curves for 1060AA 1.00 mm thick 45° with rolling direction

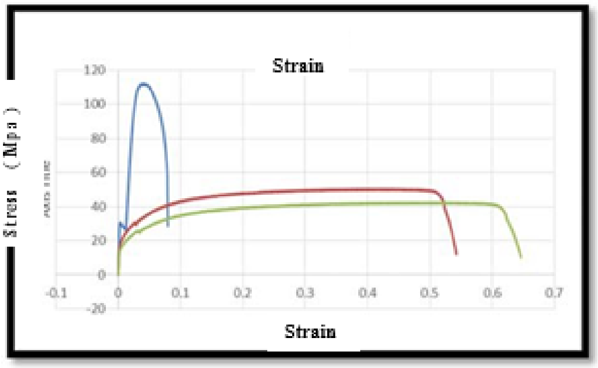


Figure 11 Stress-stain curves for 1060AA 1.00 mm thick 90° with rolling direction

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.

Table3 Total percentage of elongation %

Specimen material	Total percentage of elongation %		
	As received.	H.T.1	H.T.2
1060AA 1mm 0° with rolling direction	8	49	59
1060AA 1mm 45° with rolling direction	7	48	53
1060AA 1mm 90° with rolling direction	7	51	62

Stress-strain curves also shows a decrease with

Ultimate tensile strength as shown in table 4, below

Table4 Ultimate tensile strength (Mpa)

Specimen material	Ultimate tensile strength (Mpa)		
	As received.	H.T.1	H.T.2
1060AA 1mm 0° with rolling direction	118	75	60
1060AA 1mm 45° with rolling direction	117	50	42
1060AA 1mm 90° with rolling direction	116	50	42

These two tables 3,4 shows 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

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.

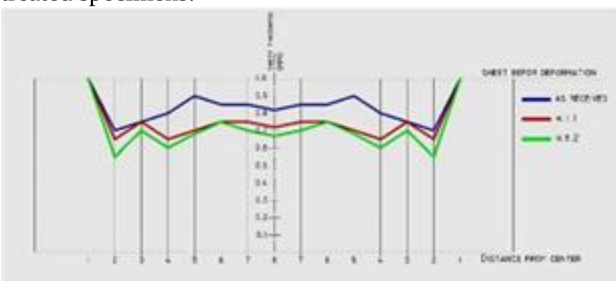
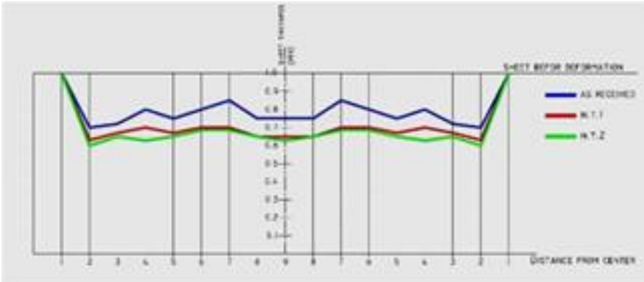


Figure 14 Thickness distribution profile of specimen made of 1060AA 1.00 mm thick (cross section A-A)



2- 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.

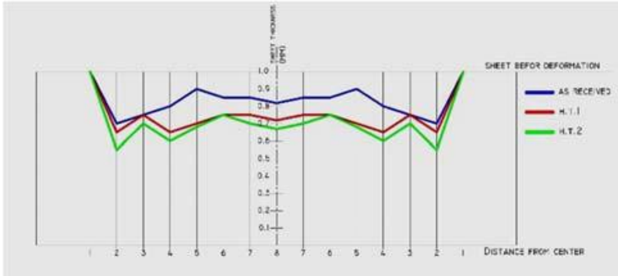


Figure 14 Thickness distribution profile of specimen made of 1060AA 1.00 mm thick (cross section A-A)

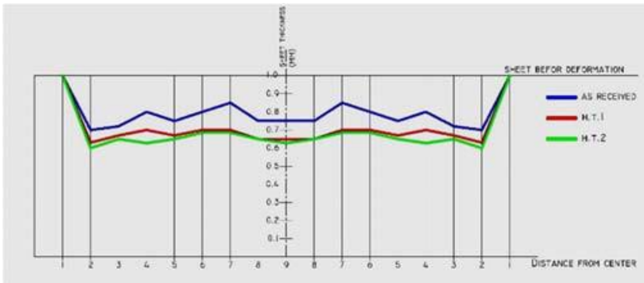


Figure 15 Thickness distribution profile of specimen made of 1060AA 1.00 mm thick (cross section B-B)

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
1060 AA	30	37	40

1- 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.

Fig.16, 17. Shows 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.

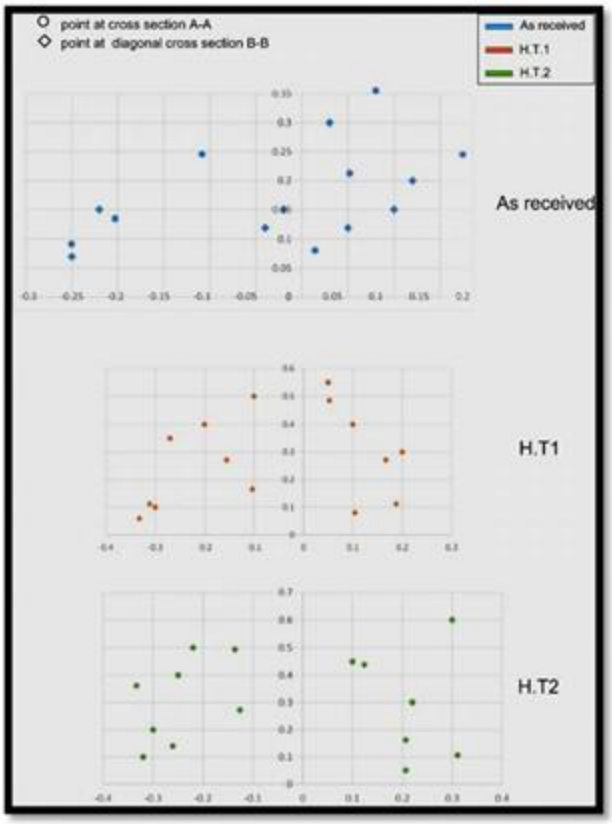


Figure 16 Strain distribution of 1060AA 1.0 mm thick

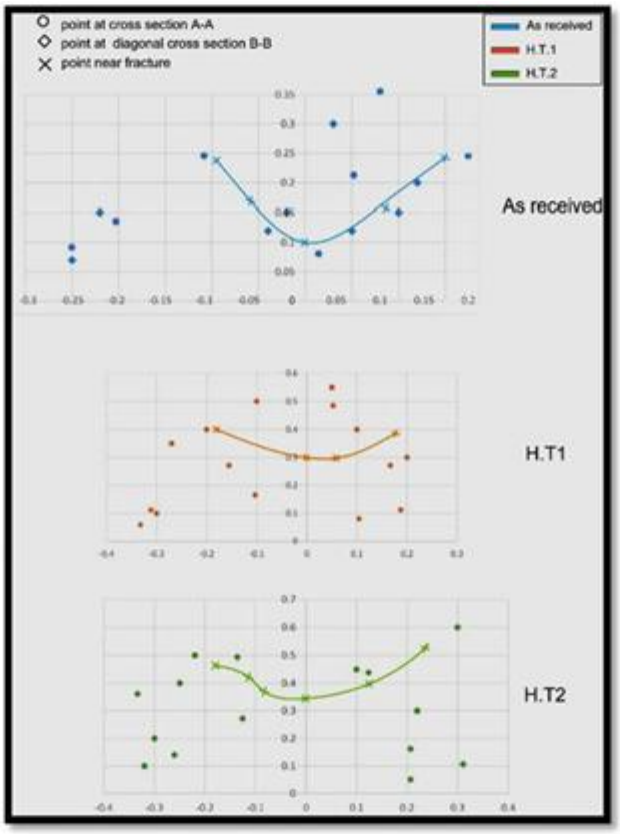


Figure 17 Forming limit curve of 1060AA 1.00 mm thick

Table 6 Maximum minor strain and maximum major strain

1060AA 1mm				
Sheet metal	Tension-tension region		Tension-compression region	
	Max $\in_1$	Max $\in_2$	Max $\in_1$	Max $\in_2$
As received	0.35	0.18	0.25	0.25
H.T.1	0.55	0.20	0.50	0.34
H.T.2	0.60	0.32	0.50	0.34

3- Maximum product height which can be reached had been measured for the as received specimen and for the heat treated one. It was found 13mm for the as received specimen, 24mm for the first heat treatment and 25mm 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.

V. REFERENCES

I. ERKAN ONDER, ASSESSMENT OF SHEET METAL FORMING PROCESSES BY NUMERICAL EXPERIMENTS

[2] 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.

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

[4] Engineering metallurgy, part 1, applied physical metallurgy, sixth edition, Raymond Higgns.

[5] 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.