*(JZS)Journal of Zankoy Sulaimani, September 2007, 9 (1) Part A {31-41}*

گۆڤاری زانكۆی سلێمانی ئەیلول ٢٠٠٧ بەرگ ٩(١) ژمارە(١) بەشی A لاپەرە {٤١-٣١}

# Effect of Cold Work on the Precipitation Process in Aluminum Alloy 6063

**Sheirko Shakir Fettah, Omer Salih Mahmood**
College of engineering. University of Sulaimani, Kurdistan Region/Iraq

***Shawnim R. Jalal Rojbeyani**
College of engineering. University of Salahadine, Kurdistan Region/Iraq

## Abstract

Aluminum alloys can be strengthened by cold or hot working due to interaction between precipitates and dislocations. The alloy 6063 was deformed (2, 5, 10, 15 and 20) % after water quenching, and artificially aged at different aging temperatures (160, 180 and 200) °C for various periods of time (0.5, 5, 10, 50 and 100) hours. The results showed a considerable improvement in yield and tensile strength with an increasing level of prestrain. Generally aging temperature of 160 °C gave the best increase of yield and tensile strength, but these were decreased with increasing aging temperature i.e. (180 and 200) °C at a given level of prestrain.

The peak aging time that improves the mechanical properties decreased with an increasing aging temperature. The alloy of 20 % deformation and aged at 160 °C for 10 hours developed maximum (yield, tensile strength and hardness) values compared with all other conditions involved, because the density of dislocation tangles which improved (yield and tensile) strength increased with increasing degree of prestrain.

The 6xxx aluminum alloys are readily welded by most types of welding processes, but with severe local softening in the heat-affected zone (HAZ) where the hardness reduces to about half that of the parent metal.

**Keywords:-** cold work, precipitation, heat-treatment, microstructure, aluminum alloy 6063, mechanical properties.

## Introduction

The 6000 aluminum alloys are heat treatable, and have moderately high strength coupled with excellent corrosion resistance. They are readily welded. Today Al-Mg-Si-Cu alloys are widely used as sheet materials for various automotive details, including the car body. These alloys are subjected to quenching and aging in order to achieve higher strength. The precipitation-hardening response depends on the temperature of aging, the degree of deformation and the composition [1-4].

Aluminum alloys can be strengthened by mechanical (cold and hot) working.

This causes microscopic defects and strain in the aluminum crystals, which make it more difficult for the slip planes to move [5&6]. Precipitation may significantly increase hardness and tensile strength of the Al-Mg-Si alloys depending on precipitate structure, size and distribution [7].

---

*Email:-shawnim100@yahoo.com

**Cited From her M.Sc.Thesis.**

Some aluminum alloys and tempers approach or surpass the strength of commonly used automotive steels, for example, automotive aluminum alloys achieve tensile strength of 310 MPa for alloy 6061-T6 and 290 MPa for 6063-T832[8-11].

After cold deformation step, the material goes through heat treatment in order to develop a fine homogeneous distribution of hardening precipitates [9&12]. Most of aluminum alloys can be arc welded as readily as steel, using gas–shielded processes.

Aluminum can be alloyed with a number of different elements, (Cu, Si, Mg, Mn, and Zn) to provide improved strength, corrosion resistance and general weldability [6, 13&14].The precipitation sequence in the Al-Mg-Si alloy is generally accepted to be [1, 6, 11&15]:

$$\alpha \rightarrow \text{GP zones1} \rightarrow \text{GP zones2 } (\beta'') \rightarrow \beta' \rightarrow \beta$$

Where:

$\alpha$: is a supersaturated solid solution (ssss).

**GP** zones: are generally considered spherical clusters with unknown structure.

$\beta''$: are fine needle-shaped zones along [100] Al, with a monoclinic structure (coherent precipitate).

$\beta'$: are rod-shaped precipitates [100] Al, having a hexagonal crystal structure (semi- coherent precipitate). And

$\beta$ : are usually ($Mg_2Si$) platelets on [100] of Al, having f.c.c. structure (incoherent precipitate).

Figure (1) indicates kinds and formation of precipitates. The formations of solute clusters were first proposed by Pashley et al [11].

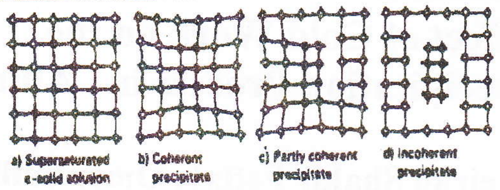

**Figure (1) Kinds and formation of precipitates** (6 &16-17)

| *chemical composition % of AA 6063 | | | | | |
|---|---|---|---|---|---|
| Mn | Mg | Cu | Fe | Si | Al |
| 0.0099 | 0.4247 | 0.005 | 0.2123 | 0.564 | Rem. |

## Experimental work

### 1. Material

The material used in this investigation was wrought aluminum alloy (6063).

The chemical composition of this alloy is given in Table (1).

**Table (1) The chemical composition of AA 6063**

### 2. Specimen preparation for different heat treatment

Specimens of (50x22x7) mm of wrought aluminum alloy (6063) were prepared by cutting them from plates. These were then solution heat treated at 540 °C for a sufficient time of 30min.

After that, subsequently water quenched to room temperature, (rapid cooling), and stabilized for 24 hours. Some of the as quenched samples were given (2, 5, 10, 15 and 20) % prestrain in compression by using (Compression machine model 55806 wfi wykham).

### 3. Aging process

Aging treatment began for prestrained (cold-deformed) specimens by two steps:

### 3.1 Natural aging

Carried out for some deformed specimens at room temperature (the specimens were stored more than six months at room temperature).

### 3.2 Artificial aging

Artificial aging was performed for specimens at elevated temperatures (160, 180 and 200) °C, for various lengths of time (0.5, 5, 10, 50 and 100) hours.

### 4. Hardness Measurements

Brinell hardness measurements were carried out on the ground and polished samples. With a 15.6 kg direct load applied for 10s. At least six approximately equally spaced measurements were taken for each sample (which were solutionized, deformed and polished) to ensure representative results.

### 5. Tensile Testing

The tensile test specimens were machined from the samples of hardness testing according to the ASTM A 370 standard with a gauge length of (16mm) and (4mm) diameter. Tensile tests were performed at room temperature by using a (MT 3037 Universal Testing Machine, Treco-Stockholm, Sweden) at a strain rate of (0.036 $s^{-1}$). The ultimate tensile strength σu and 0.2 % offset proof yield strength ($\sigma_Y$) and percentage elongation El % (ε) was accurately determined by using two specimens for each condition.

### 6. Specimens' preparation for photography

The specimens after grinding polished using a diamond past of (1, 1/4) μm for (2-3) minutes successively and then etched chemically according to (ASTM)[18] standard .After etching process, samples were prepared for photography process and were examined by optical microscope.

### 7. Specimen preparation for welding process

Samples of good mechanical properties were taken to welding process. by (metal manual arc welding). Welding has been done with filler type (4047A) and composition of filler as shown in Table (2).

## Results and discussion

### Tensile results

Table (3) shows the values of yield strength ($\sigma_y$), ultimate tensile strength (σu) of (as-annealed and quenched) specimens of aluminum alloy 6063. It can be observed that the ($\sigma_y$, $\sigma_u$) strength and HB of as-annealed and quenched condition had an increase of appreciatively (25.8) % in $\sigma_y$, (28.1) % in $\sigma_u$ and (57.1) % in HB, respectively for as-quenched sample over that of as-annealed material.

Because the quenched specimens consisted mainly of widely spaced dislocations which were pinned by solute cluster or GP zones which were formed during quenching [9].

**Table (2) the chemical composition of filler material (4047A)**

| Chemical composition % of filler material (4047A) | | | | | | |
|---|---|---|---|---|---|---|
| Mn | Mg | Cu | Fe | Zn | Si | Al |
| 0.15 | 0.10 | 0.30 | 0.60 | 0.20 | 12.0 | Rem |

**Table (3) Mechanical properties of aluminum alloy 6063 at as- annealed and quenched condition**

| Alloy condition | $\sigma_Y$ (MPa) | $\sigma_u$ (MPa) | Ductility ε % | Brinell Hardness $HB_{2.5}$ |
|---|---|---|---|---|
| annealed | 143 | 167 | 40 | 28 |
| Quenched | 180 | 214 | 24 | 44 |

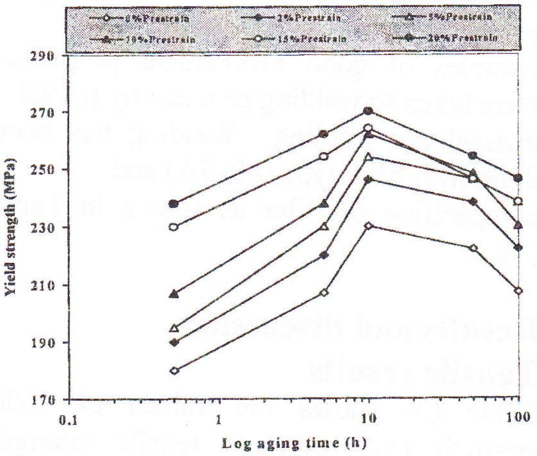

**Figure (2) Variation of yield strength with aging time at 160°C**

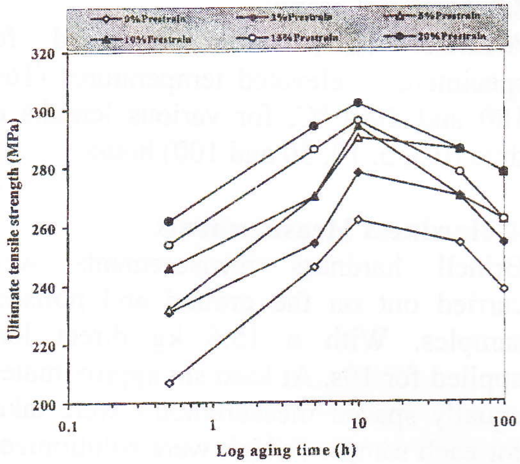

**Figure (3) Variation of ultimate tensile strength with aging time at 160°C**

Figure (2) shows the variation of yield strength ($\sigma_y$) as a function of aging time (0.5, 5, 10, 50 and 100) hours at 160 °C for various levels of prestrain (0, 2, 5, 10, 15 and 20) %.

It can be seen that as aging time increased at each level of prestrain, the ($\sigma_y$) increased to its peak at the (10) hours of aging time, after which it decreased with further aging time (over aging).

This can be attributed to an increase in dislocation density due to prestraining which piled up in tangles, hence increasing the ($\sigma_y$) strength of material.

The deformation after quenching increases the strength, this may correspond with the increasing fineness of the β" precipitates, which thus serve as more efficient obstacles preventing the movement of dislocations.

The significant increase in the strength after deformation is obviously due to work hardening which also reaches a maximum at 20 % of prestrain and this agrees with Eskiu results [19]. Prior strain will enhance the nucleation and early growth stages of semi-coherent intermediate phase precipitation [20].

The time to reach peak (yield and tensile) strength of aged alloy at (160) °C occurred after (10) hours, as shown in Figures (2&3).

Figure (3) shows the variation of ultimate tensile strength ($\sigma_u$) as a function of aging time (0.5, 5, 10, 50 and 100) hours at 160°C for various levels of prestrain.

The same trend of strength increased with an increasing level of prestrain as discussed in Fig. (1).

Figure (4) shows a fall in percentage elongation (El %) to fracture with aging time at (160) °C for various lengths of time, it was observed during aging of up to (50h) after which the rate of reduction decreased due to over aging. Also, at the aging time corresponding to peak ($\sigma_y$) of material, the El % generally decreased with an increasing level of prestrain.

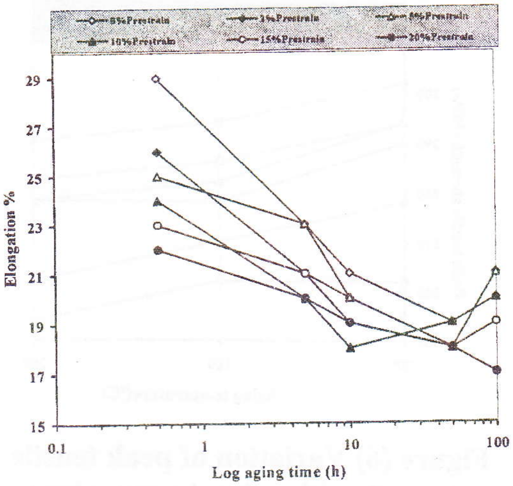

**Figure (4) Variation of elongation % with aging time at 160°C**

The essential reason of the decrease in ductility (El %), in the deformed and aged alloys may be attributed to the hindering of dislocation mobility as a result of their pinning by β′ precipitates, but the essential increase in ductility (El %) in the deformed and aged alloys after 50 hours due to over aging.

A close look at the Table (4) shows that at 160 °C there was an increase of approximately (6.9, 10.4, 13.9, 14.7 and 17.3) % in yield strength ($\sigma_y$), respectively for (2, 5, 10, 15 and 20) % prestrain over that of the unstrained material. The corresponding tensile strength ($\sigma_u$) increases were (6.1, 10.6, 12.2, 12.2 and 15.2) % respectively. For the 180 °C aging temperature, the increases in yield strength ($\sigma_y$) were (1.7, 4.2, 9.3, 11.01 and 13.5) % respectively. While the corresponding percentage increases in tensile strength ($\sigma_u$) were (3, 6.1, 9.1, 10 and 10.6) % respectively. For the 200 °C aging temperature, the increases in yield strength ($\sigma_y$) were (4.3, 5.2, 13.1, 14.9 and 15.7) % respectively. While the corresponding percentage increases in tensile strength were (3.1, 9.4, 9.4, 11 and 14.1) % respectively.

The peak value of yield and tensile strength results for various levels of prestrain at different aging temperatures (160, 180 and 200) °C are summarized in table (4). Peak aging times ($t_p$) for aging temperatures are (10, 5 and 5) hours, respectively. The variation of peak yield and tensile strength with aging time was presented in both Figures (5) and (6), respectively.

**Table (4) Variation of peaks ($\sigma_y$, $\sigma_u$ and HB) with various levels of prestrain, aging temperatures and peak times ($t_p$)**

| Peak properties for prestrain % | Aging temperature 160°C & Peak times(10)h | | | Aging temperature 180°C & Peak times(5)h | | | Aging temperature 200°C & Peak times(5)h | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\sigma_Y$ (MP) | $\sigma_u$ (MP) | $HB_{2.5}$ | $\sigma_Y$ (MP) | $\sigma_u$ (MP) | $HB_{2.5}$ | $\sigma_Y$ (MP) | $\sigma_u$ (MP) | $HB_{2.5}$ |
| 0 | 230 | 262 | 72 | 236 | 262 | 76 | 228 | 254 | 70 |
| 2 | 246 | 278 | 80 | 240 | 270 | 71 | 238 | 262 | 73 |
| 5 | 254 | 290 | 70 | 246 | 278 | 74 | 240 | 278 | 72 |
| 10 | 262 | 294 | 76 | 258 | 282 | 76 | 258 | 278 | 73 |
| 15 | 264 | 294 | 87 | 262 | 286 | 79 | 262 | 282 | 79 |
| 20 | 270 | 302 | 100 | 268 | 294 | 93 | 264 | 290 | 77 |

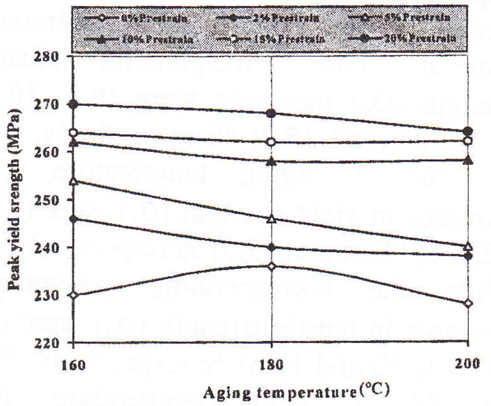

Figure (5) Variation of peak yield strength with aging temperature

In Figure (5) it can be observed that the (0 %) prestrain condition shows an increase in yield strength ($\sigma_y$) from (160 to 180) °C and a decrease beyond that.

On the whole, there was a general decrease in the peak value of yield strength ($\sigma_y$) with the increasing of temperature.

It can be observed that the aging temperature had slightly affected on the yield strength value ($\sigma_y$) of the undeformed samples when compared to the deformed samples. This decrease of ($\sigma_y$) with the increase of aging temperature is attributed to over aging.

Figure (6) shows a decrease in the peak value of the tensile strength ($\sigma_u$) from (160 to 200) °C for all prestrain conditions this decrease of ($\sigma_u$) with increasing of aging temperature attributed to over aging. The T6 condition procedure was varied slightly throughout changing the aging temperature (160, 180, and 200) °C and improves the ductility by (1-2) % without change in strength.

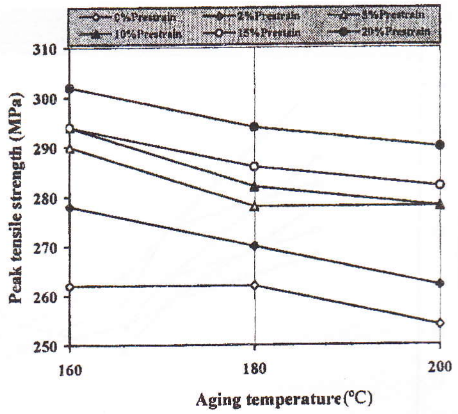

Figure (6) Variation of peak tensile strength with aging temperature

This result is consistent with the result of Bergsma [21]. Both Figures (5) and (6) show adequate strength of the material at (160 and 180) °C and decrease beyond that and this agrees with Quanioo's results [9]. Fig. (7) Shows the effect of various levels of prestrain at room temperature for specimens naturally aged for (6) months on strength (yield $\sigma_y$ and ultimate tensile $\sigma u$).

It can be seen that as percentage prestrain increased at room temperature the ($\sigma_y$, $\sigma_u$) increased, but lower than artificial aging results.

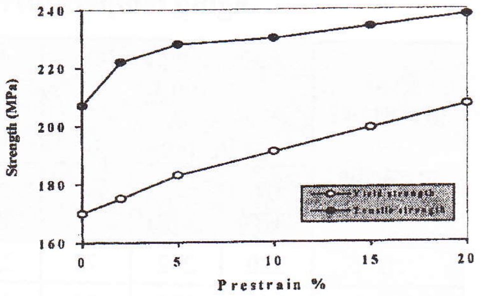

Figure (7) Variation of strength with prestrain % of specimens naturally aged for 6 months

Murayama and Hono[11] recently reported that clusters of Mg atoms are present in the as-quenched alloys, and separate clusters of (Mg, Si) atoms and their co-clusters evolve after long-term (natural aging) [11]. Natural aging (i.e. keeping the alloy at room temperature) enables the formation of GP zones. This GP zones precipitation occurs via the help of quenched-in vacancies which accelerate diffusion, which is very slow at this temperature.

**Brinell hardness results**

Figure (8) shows the variation of Brinell hardness (HB) with aging time at 160 °C for various levels of prestrain (0, 2, 5, 10, 15 and 20) %. The trend is similar to the results shown in Figures (3) and (4).

**Welding results**

Figure (9) shows the variation of brinell hardness (HB) as a function of distance from welded zone of specimens deformed for various levels of prestrain (0, 10, and 20) %, and aged at 160 °C for 10 hours after that metal arc welded. The HAZ (heat affected zone) can be divided into two regions (A and B) as indicated in the Fig. (9).

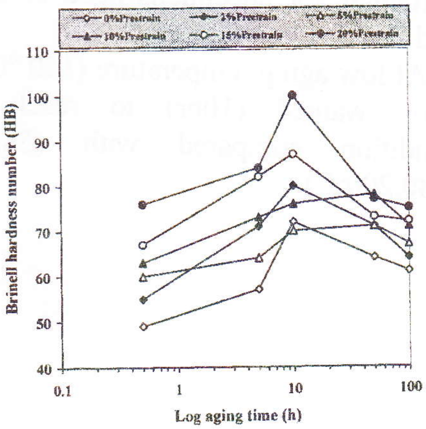

Figure (8) Variation of hardness (HB) as a function of aging time at 160°C

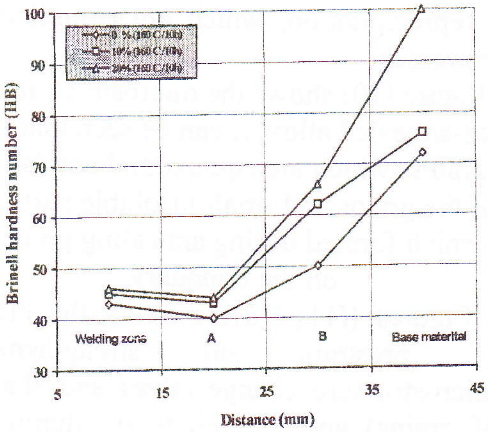

Figure (9) Variation of hardness (HB) with distance of specimens deformed and aged at 160°C

The hardness is a minimum at the boundary between the two regions point (A), and then rises steadily as we move out to point (B), beyond B; the heat of welding has negligible effect and full parent properties are assumed to apply.

The microstructure evolution of the Al-Mg-Si alloys during welding and, in particular, the reduction of hardness values in the HAZ can be attributed to the distribution of high temperature reached during welding in the HAZ.

The hardness distribution in the HAZ of the Al-Mg-Si alloys depends on the interplay between dislocation and

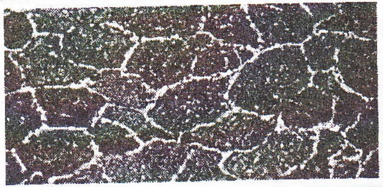

Figure (10) Microstructure of as-annealed material (100X) reprecipitation, which are complicated processes.

Figure (10) shows the microstructure of as-annealed alloy. It can be seen that the grains (which are equiaxed), boundaries of the grains and small insoluble particles which formed during annealing process on the boundary.

Figures ((11)-(13)) indicate the effect of prestrain on strengthening, microstructure change (sizes and shapes of grains) and precipitate of aluminum alloy 6063.

The grains are somewhat elongated gradually from2% Fig(12) to 15 % deformation Fig (13), it is clear that precipitated pellets are more numerous and have grown larger which signifies the faster precipitation kinetic (this structure gave the best mechanical properties).

Also, it can be seen the reduction in sizes of the deformed grains which increased with an increasing level of prestrain, and no change in sizes and shapes for unstrained specimens.

**Figure (11) Microstructure of as-quenched specimen 0 % and aged at 160 °C for 10 hours (100X).**

**Figure (12) Microstructure of specimen deformed 2 % and aged at 160 °C for 10 hours (100X)**

**Figure (13) Microstructure of specimen deformed 15 % and aged at 160 °C for 10 hours (100X)**

**Conclusions**

**1.** The dislocation density increases with the degree of prestrain and contributes to the strengthening of aluminum alloy 6063.

**2.** The peak yield strength, ultimate tensile strength and Brinell hardness of aluminum alloy 6063 decrease with an increasing of the aging temperature at fixed levels of prestrain.

**3.** At the times corresponding to peak yield strength, aluminum alloy 6063 showed a decrease in percentage elongation with increasing levels of prestrain.

**4.** In the heat affected zone (HAZ) hardness reduced to a minimum in particular for specimens aged at 160°C, and this due to over-aging

**5.** At low aging temperature (160 °C) this alloy wanted (10hr) to reach peak condition compared with (5hr) at (180,200°C).

## References

1- Dwight, J.B "*Aluminum Design and Construction*" E&FN Spon, **1999**. 1-14& 46-100.

2- Hedly, S.W, Das, S. and Miller, J.W "*Aluminum R&D Automotive uses*" The department of energy's role, March **2000**, 1-20

3- Cobden, R. Alcan and Banbury "*Aluminum: physical properties characteristics and alloys*" TALAT Lecture 1501, EAA, **1994,** 8-29.

4- Dorward, R.C and Bouvier, C. "A *rationalization of factors affecting strength, ductility and toughness of 6061 type Al-Mg-Si (Cu) alloys*" Material Science and Engineering, A 254 (**1998**),.33-44

5- The Aluminum Association, Inc "*Aluminum alloy Selection and Applications*" Washington, D.C. December **1998,** 11-13.

6- Polwer, I.J "*Light alloys Metallurgy of the light metals*" Edward Arnold.1989, pp .20-141

7- Missori, S. and Sili, A. "*Mechanical behaviors of 6082-T6 aluminum alloy weld*" *Metallurgical Science and Technology*, 18,.1, 13, **2000.**

8- Automotive and Light Truck Group Sponsors "*Aluminum: The corrosion Resistant Automotive Materials*" AT7-May **2001**, The Aluminum Association, Inc.. 2-6.

9- Quainoo, G.K, Yannacopoulos, S. and Gupta A.K. "*Strengthening characteristics of Aluminum Alloys 6111*" *Canadian Metallurgical Quarterly*, 2001, 40, 2,. 211-220.

10- Miao, W.F and Laughlin, D.E. "*Precipitation hardening in Aluminum Alloys 6022*" *Acta Metallurgical Inc. Script Materialia*,. **1999,** 40. 7,. 873-878.

11- Murayma, M. and Hono, K. "*Pre-Precipitate clusters and precipitation processes in Al-Mg-Si alloys*" *Acta Mater*, **1999**,47, 5, 1537-1548

12- Deschamps, A., Brechet, Y. and Guyot, P. "*Interactions between plasticity and precipitation*" 7th Seminar of the International Federation for Heat-treatments and surface engineering, Budapest, Hungary, **1999**.,1-9.

13- Hand book "*Mechanical Engineers*" 2nd, John Wiley & Sons. Inc. 1998, pp. 45-57.

14- Higgins, R.A "*Engineering Metallurgy, Applied Physical Metallurgy*" Sixth Edition, Edward Arnold, **1998.** 175-178, 206-213, 206-428.

15- Jacobs, M. H "*Precipitation Hardening*" *TALAT Lecture1204*, EAA, **1999,** 3-20.

16- Cullister, William D.Jr. "*Materials Science and Engineering an Introduction*" John Wily & Sons, Inc, **1997**,. 363-364.

17- Henkel, Daniel P. and Pense, Alan W. "*Structure and Properties of Engineering Materials*" Mc Graw-Hill **2002**, 86-108.

18- Cerri, E. and Evangelista, E. "*Metallography of Aluminum alloys*" *EAA*, **1999**,3

19- Eskin, Dmitry G. and Kharakterova, Marina L. "*The effect of Silicon and Copper on the precipitation hardening of sheets of aluminum 6000 series alloys*" *Mater. Tehnol*, **2001**. 5-8.

20- Rack, H. J "*The Influence of strain upon precipitation in a light-purity 6061 AA*" *Material Science and Engineering*, 29, **1977**. 179-188.

21- Bergsma, S.C, Kassner, M.E, Li X. and Wall M.A. "*Strengthening in the new aluminum alloy 6069,*"*Material Science and Engineering* A 254, **1998**,.112-118.

# کاریگەری جێ فشاری پێشینه له سەرکرداری نیشاندن بۆ داڕشتەی ئەلەمنیۆمی ( ٦٠٦٣ )

**شیرکو شاکر فتاح و شونم رشید جلال و عمر صالح محمود**
**کولیجی ئه ندازیاری / زانکوی سلیمانی /هه ریمی کوردستان- عیراق**

## پوختـــــــه

کاریگەری جێ فشاری پێشینه له سەرکرداری نیشاندن بۆ داڕشتەی ئەلەمنیۆمی ( ٦٠٦٣ ) لەم لێکۆڵینەوەیەدا ئەنجام درا . چاککردنی سیفەتە میکانیەکان به هۆی چارە سەرە گەرمیە کانەوە ( Heat treatment ) دەکرێت ، لەڕاستیدا پتەوکردنی ئەم داڕشتەیە لەڕێگەی کارلێکی ( Dislocation ) وە دەبێت کە له ئەنجامی جێ فشاری پێشینه دروست دەبێت لەگەڵ ئەو وردیلە نیشتوانە ( $Mg_2Si$ ) کە دروست بوون لە ئەنجامی کاریگەری گەرمیەوە . بڕی جێ فشاری پێشینه بەڕێژەی ( ٢، ٥، ١٠، ١٥ وە ٢٠ ) ٪ بۆ داڕشتە کە کرا وە دواتر به هۆی چارە سەرە گەرمیە کانەوە لە چەند پلەیەکی گەرمی و کاتی جیاوازدا ( ١٦٠، ١٨٠ وە ٢٠٠ ) پلەی سەدی وە ( ٠,٥ ، ٥ ، ١٠ ، ٥٠ وە ١٠٠ ) کا ژێر ئەنجام درا .

دەتوانرێت بەهۆی زیاد کردنی بڕی جێ فشاری پێشینه سیفەتە میکانیکیەکان کە بەرگری هەریەکە لە ( Yield, tensile and hardness ) زیاد بکرێت ، لە ئەنجامی لێکۆڵنەوەکەدا دەرکەوت بەزیادبونی پلەکانی گەرمی ( Aging ) بۆ هەمان بڕە جێ فشاری پێشینه کاری پێچەوانە دەکاتە سەر سیفەتە میکانیکیەکان وە نرخیان دێتە خوارێ. بۆ بە دەست هێنانی سیفەتی نمونەیی لەماوەی کورت دا پێویستە کرداری ( Aging ) لە پلەی گەرمی بەرزدا بکرێت ، وە چاکترین سیفەتی میکانیکی بە دەست دێت لە داڕشتەی ئەلەمنیۆمی ٦٠٦٣ کاتێك بە بڕی ٢٠ ٪ جێ فشاری پێشینەی بۆ دەکرێت وە هەروەها ( Aging ) لە پلەی گەرمی ١٦٠ پلەی سەدی بۆ ماوەی ١٠ کا ژێر بە بەراورد کردنی لەگەڵ حالەتەکانی تری ئەم داڕشتەیە چونکە بە زیاد بونی بڕی جێ فشاری پێشینه دەبێتە هۆی زیاد بونی چڕی ( Dislocation ) وە تێك ئا لاندنیان کە ئەمەش دەبێتە هۆی پتەوبونی داڕشتەکە ، بەلام بە بەرز کردنەوەی پلەی گەرمی ( Aging ) دەبێتە هۆی والا بونی ئەم تێکئالاندنە وە کاریگەری ئەمەش ئەبێتە هۆی دابەزینی نرخی سیفەتە میکانیکیەکان . داڕشتەی ئەلەمنیۆمی ٦٠٦٣ بە هەموو ڕێگەکانی لکاندن دەتوانریت بلکێنرێت بەیەکەوە بەلام هەندێك لە سیفەتە میکانیکیەکان نرخیان دێتە خوارێ لە کاتی لکاندندا ئەوەش بە هۆی بەرز بونەوەی پلەی گەرمی دێت لە جێگەی لکاندنەکە . وە دابەزینەکە هەندێك جار دەگاتە نیوەی نرخەکان .

*(JZS)Journal of Zankoy Sulaimani, September 2007, 9 (1) Part A*

گۆڤاری زانكۆی سلیمانی ئەیلول ٢٠٠٧ بەرگ ٩(١) ژمارە(١)بەشی A

# تاثير التشكيل البارد على عملية الترسيب لسبيكة الألمنيوم (٦٠٦٣)

**شيركو شاكر فتاح و شونم رشيد جلال و عمر صالح محمود**

**كلية الهندسة /جامعة السليمانية/اقليم كردستان-العراق**

## الخلاصة

يتناول هذا البحث تاثير التشكيل البارد على عملية الترسيب لسبيكة الألمنيوم6063 والمستخدمة الان في صناعة ابدان السيارات نظرا لخفة وزنها و سهولة لحامها و تشكيلها هذا بالأضافة الى امكانية تحسين الخواص الميكانيكية لها عن طريق المعاملات الحرارية . ان زيادة صلادة هذه السبيكة تم عن طريق تفاعل الانخلاعات الناتجة من التشكيل البارد مع الدقائق المترسبة ($Mg_2Si$) و الناتجة من عملية الاصلاد بالتعتيق . تم تشكيل هذه السبيكة بعد عملية التقسية بنسب مختلفة (٢، ٥، ١٠ ، ١٥ و ٢٠ ) ٪، و بعد ذلك تمت عملية التعتيق عند درجات حرارية مختلفة (١٦٠، ١٨٠ و ٢٠٠ )م° ، و لازمان مختلفة ( ٢/١، ٥ ، ١٠ ، ٥٠ و١٠٠ ) ساعة. لقد بينت نتائج التجارب بان هناك تحسنا تدريجيا في الخواص الميكانيكية مثل مقاومة الشد ، اجهاد الخضوع و الصلادة مع زيادة نسبة التشكيل و تقل هذه الخواص مع زيادة درجة حرارة التعتيق و بنفس نسبة التشكيل ، و ان الزمن المطلوب للحصول على الخواص المثلى يقل مع زيادة درجة حرارة التعتيق.ان التشكيل بنسبة (٢٠ ٪) ثم التعتيق عند درجة حرارة (١٦٠ م° ) لمدة ١٠ ساعات ادى الحصول على افضل الخواص الميكانيكية مقارنة ببقية الحالات لان زيادة التشكيل يؤدي الى زيادة كثافة و تشابك الانخلاعات و بالتالي الى زيادة هذه الخواص . اما رفع درجة حرارة التعتيق فانه يؤدي الى تفكك هذا التشابك و بالتالي الى خفض الخواص الميكانيكية . سبيكة الألمنيوم (6063) يمكن لحامها باي طريقة كانت و لكن نلاحظ انخفاضا واضحا في الصلادة بين المنطقة الملحومة و المعدن الاصلي و قد تصل الى النصف تقريبا بسبب تعرض المعدن الى الحرارة العالية و التي تؤثر بدورها على تركيب الدقائق المترسبة في عملية الاصلاد.

---

*Received 26/7/2004 Excepted 22/10/2005.*

وەرگرتن لە ٢٠٠٤/٧/٢٦وە پەسەندكرا لە ٢٠٠٥/١٠/٢٢دا.