The Study of the effect of natural aging on some mechanical properties of (Al-Cu) & (Al-Zn) alloys

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Abstract

The aim of this study is to notice the effect of natural aging on the new alloys and the evaluation of new Al-alloys which consists of the elements of (Zr) & (Te) with an amount of 0.2% for each additive & its comparison with alloy without additive for abase Al-alloy, then measuring their hardness & ultimate tensile strength :

1.As a function of artificial aging temperature at (130^{o}C) and natural aging(15 years) for wrought (Al-Cu) & (Al-Zn) alloys.

2. For corrosion specimen & oxidation specimen at (300 ^{o}C) for wrought and cast alloys with & without additive impurities , so noticed that the effect of natural aging for (15) years **(MSc specimen project-1992)** on wrought specimen (AL-Zn) alloy is clear and has high rate of both hardness & ultimate tensile strength .This is due to natural aging which leads to precipitate impurities .They resist the movement of dislocation due to high stability alloys , high hardness & high tensile strength, for (Al-Zn) wrought alloy is more than (Al-Cu)wrought alloy .So oxidation specimen test for (Al-Cu) specimen shows high hardness & tensile strength for wrought specimen in a comparison of cast specimen due to special thermo-mechanical treatment but corrosion specimen test for(Al-Cu)cast specimen has high hardness & high tensile strength due to the changes in heat treatment . But (Al-Zn) wrought specimen for both oxidation and corrosion tests have hardness & tensile strength which are less than cast specimen for the same alloy.

Introduction

There are eight elements which are added to Aluminum in different ratios to production of Al-alloys, to has different properties (strength, ductility, conductivity and corrosion resistance), Al alloys can be which classified into[1, 2, 3, 4,5,6]:

1.wrought alloys

2.casting alloys

The first type were produced by rolling, extrusion drawing and forging, and the second type were produced by casting operations. Aluminum-copper alloys contain elements like (Mg, Mn, Si, Ni, Ti, Cu, Zn, Fe, Cr, Zr) to improve the mechanical properties [7,8,9,10]. Aluminum-Zinc alloys has high strength & high corrosion resistance due to present (Zr) element [3,8,11,13], and adding (Cr) element leads to the improve stress corrosion strength [12].Aging the Aluminum alloy by natural temperature improve the mechanical properties of (tensile strength& hardness) [14,15]. Aluminum alloy is very active when exposed to a source of oxygen, it reacts to form a thin transparent oxide film over the whole of the exposed alloy surface. This film controls the rate of corrosion and protects the substrate metal allowing the production of long life components in aluminum alloys, if the film is damaged and cant be repaired corrosion rate of the substrate occurred very rapidly [16].

Heat treatment

The term "heat treatment" for Aluminum alloys is frequently restricted to the specific operations employed to increase strength and hardness for wrought and cast alloys. These

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usually are referred to as the "heat-treatable" alloys to distinguish them from those alloys in which no significant strengthening can be achieved by heating and cooling. Heat treatment occurred to increase the strength of Aluminum alloys and can be classified as:-

1-Homogenising
2- Solution heat treatment
3- Quenching
4-Age hardening

Age Hardening

Age hardening has occurred at[17,18] :

(1)-Room temperature (natural aging).

(2)-Artificial temperature (artificial aging).

In some alloys, sufficient precipitation occurs in a few days at room temperature to yield stable products with properties that are adequate for many applications. These alloys sometimes are heat treated to increase strength and hardness in wrought and cast alloys due to the nucleation Guinier-Preston zone[19,20] Other alloys with slow precipitation reactions at room temperature are always heat treated before being used. In some alloys, notably those of the 2000 series, cold working of freshly quenched materials greatly increase its response to later precipitation treatment. The artificial ageing or precipitation heat treatments are low temperature long time processes. As with solution treatment, accurate temperature control and spatial variation temperatures are critical to the process [21].

Mechanical properties

The mechanical properties may be considered as one of the most important properties of a material for most applications, generally dealing with materials requires information about their mechanical behaviour and how this behaviour can be measured by mechanical tests e.g. tensile, hardness…etc[22].

Ultimate Tensile Strength

Tensile Strength of the material is the value of load applied to break the specimen at constant strain rate, it can be expressed by:

$$\text{Ultimate Tensile Strength} = \frac{\text{Maximum tensile load}}{\text{Original cross-section area}}$$

and it is usually expressed in (N/mm^2),so it is a very important test which gives an indication of the strength of the material and toughness as represented by the area under the stress-strain curve and gives an indication of the energy that the material can absorb before fracture[5,15,23,24,25,26].

Vickers hardness

The hardness is defined as the mechanical property of a metal which is able to resist penetration & scratching by harder bodies which investigated specimens had been carried out by using Vickers hardness instrument .Vickers hardness number was measured according to the following equation[15,27]:

$$Hv = 1.8544 \times P/ (dav)^2 \qquad [Kg/mm^2]\text{---------}(1)$$

Where:

P: The amount of the load placed on the specimen.

dav: The average of diameter.

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EXPERIMENTAL WORK

This work included evaluation of (Al-Cu) & (Al-Zn) alloys which are chemically analysed by using atomic emission spectrum photometer.The chemical compositions of alloys is listed in Table (1) .

Table (1) The chemical composition of alloys [28].

Alloy	**ELEMENTS %**											
	Cu	**Mg**	**Mn**	**Si**	**Zn**	**Fe**	**Cr**	**Ni**	**Cd**	**Zr**	**Te**	**Al**
2024w	5.11	1.307	0.544	0.146	0.100	0.311	0.037	0.004	0.004	-	-	**Rest**
2024c1	5.11	1.307	0.544	0.146	0.100	0.311	0.037	0.004	0.004	-	-	**Rest**
2024c2	5.11	1.307	0.544	0.146	0.100	0.311	0.037	0.004	0.004	0.2	-	**Rest**
2024c3	5.11	1.307	0.544	0.146	0.100	0.311	0.037	0.004	0.004	0.2	0.2	**Rest**
7075w	1.396	1.608	0.043	0.097	5.308	0.315	0.185	0.069	0.002	-	-	**Rest**
7075c1	1.396	1.608	0.043	0.097	5.308	0.315	0.185	0.069	0.002	-	-	**Rest**
7075c2	1.396	1.608	0.043	0.097	5.308	0.315	0.185	0.069	0.002	0.2	-	**Rest**
7075c3	1.396	1.608	0.043	0.097	5.308	0.315	0.185	0.069	0.002	0.2	0.2	**Rest**

Heat treatment

Alloys under investigation were artificial aging before natural aging , as shown in Table (2).

Table (2) Conditions of Heat Treatment of Alloys (28).

Alloy Code	Condition
2024 W 7075 W	homg. at 550ºC for 18 hrs + Q + S.H.T at 500ºCfor 1hr + Q + artificial aging at 130ºC for different time +natural aging for 15 years(MSc specimen project-992).
Oxidation sample at(300ºC) 2024 W,7075 W, 2024(C1,C2,C3) 7075(C1,C2,C3)	homg. at 550ºC for 18 hrs + Q + S.H.T at 500ºC for 1hr + Q + natural aging for 15 years.
Corrosion sample 2024 W,7075 W, 2024(C1,C2,C3) 7075(C1,C2,C3)	homg. at 550ºC for 18 hrs + Q + S.H.T at 500ºC for 1hr + Q + natural aging for 15 years.

Where:

C : Casting
W : Wrought
homg : homogenize
S.H.T : Solution Heat Treatment
Q : Quenching

Ultimate Tensile strength

The maximum tensile stress for specimens which were artificially aging at (130°C) for (0.5-30) hrs.& naturally aged for 15 years and corrosion & oxidation specimens were estimated. In this test(5-10)
readings for each sample were taking under a load of 10 kg by using MIC 10 "Krautkamer" Agfa NDT GmbH.

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Vickers hardness

For specimens which were artificially aging at (130°C) for (0.5-30) hrs.& naturally aged for (15) years and corrosion and oxidation specimena ,had their hardness measured after natural aging for (15) years.The hardness test of the investigated specimens had been carried out by using Vickers hardness instrument, The Vickers hardness tester type [TOKYO TESTING MACHINE MFG CO., LTD].In this test (5-10)readings for each sample were taken and the average of the diagonals of indentation was calculated in equation (1).

Table (3) Represents values of hardness & ultimate tensile strength for dry and wet corrosion specimen of Al-Cu & Al-Zn alloys

Alloy Code	Vickers hardness Kg/mm²		Ultimate tensile strength (N/mm²)	
	corrosion	oxidation 300 ºC	corrosion	oxidation 300 ºC
2024 **W**	110	145	350	425
2024**C1**	133	111	518	395
2024**C2**	98	100	320	365
2024**C3**	121	92	465	330
7075 **W**	105	115	338	355
7075**C1**	98	118	357	380
7075**C2**	100	135	385	450
7075**C3**	111	86	430	331

RESULTS & DISCUSSION

This section involves the results of the present experimental work with its discussion concerning the effect of additives on the mechanical properties (hardness, Ultimate tensile strength) and the effect of aging at room temperature (natural aging) for (15) years on the Vickers hardness& Ultimate tensile strength for wrought and cast (Al-Cu) , (Al-Zn) alloys. Fig. (1) shows the relationship between the hardness and the aging time for the wrought (Al-Zn) alloy at two aging temperatures (130°C & room temperature for 15 years) , the behaviour of this alloy was noticed to be similar, where three peaks of Vickers hardness appeared because new phases are precipitated through the aging temperature process (29), two represented the minor values (57,68-80,85) kg/mm^2 and the other was the major(122, 136) kg/mm^2 for the alloys at(130°C & R.T. for 15 years) respectively. Fig. (2) shows the relationship between the hardness and the aging time for the wrought (Al-Cu) alloy at two aging temperatures (130°C & R.T. for 15 years) , the behaviour of this alloy was noticed to be similar too, where three peaks of Vickers hardness have appeared because new phases are precipitated through aging operation, two represented the minor values (40,71-63,84) kg/mm^2 and the others the major(102, 125) kg/mm^2 for the alloys at(130°C & R.T. for 15 years) respectively. Fig.(3) shows the relationship between the Ultimate tensile strength and the aging time for the wrought (Al-Cu) & (Al-Zn) alloys at two aging temperatures (130°C & R.T. for 15 years).The alloy (Al-Zn) recorded higher average Ultimate tensile strength than(Al-Cu) alloy ; this means that the hardness& Ultimate tensile strength increased for(Al-Zn) which is more than (Al-Cu) alloys due to alloying and heat treatment[14]. This change in hardness can be explained as follows, during natural aging GP zones enriched in (Cu, Mg) and (Zn, Mg) lead to precipitate the phases (Al_2CuMg) for (Al-Cu) and ($MgZn_2$)for (Al-Zn) alloys respectively[30,31], and some other phases produced as a result of the addition. This change takes place because of the increase in the temperature which accelerated precipitation by diffusion[29,32]. The addition was resisting the movement of dislocation due to high hardness[33,34] in figs(1,2) which noticed that high peak of hardness to appear because of artificial aging of (130ºC) accelerated precipitation by diffusion and this allowed for high peak of hardness to appear. In addition more than two hardness peaks were shown for both artificial & natural aging because of new (Gurnier-Preston) zone forming during the aging operation which represented precipitation phase from the supersaturated solid solution [29]. Fig.(3)shows the relation between ultimate tensile strength & aging time for wrought (Al-Cu) and (Al-Zn) alloys, after artificial(130°C) and natural aging for (15 years).It is noticed that the behaviour of alloys are to be nearly similar, but the rate of ultimate tensile

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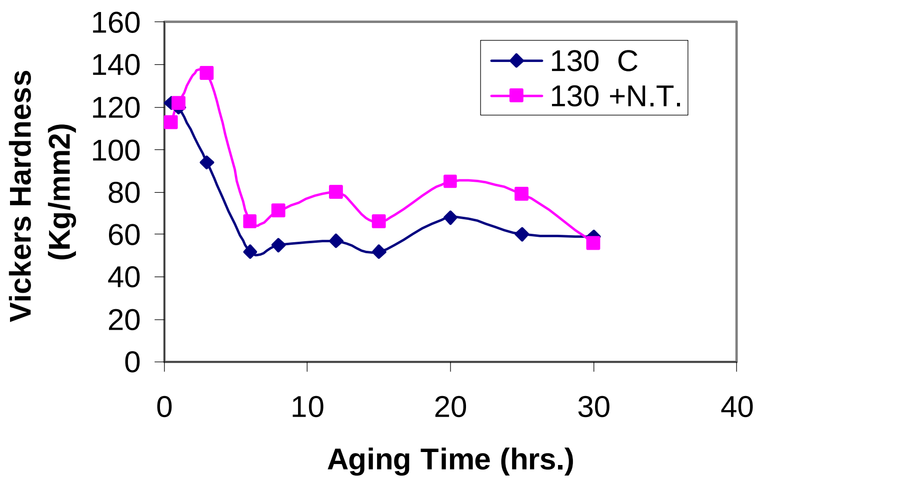
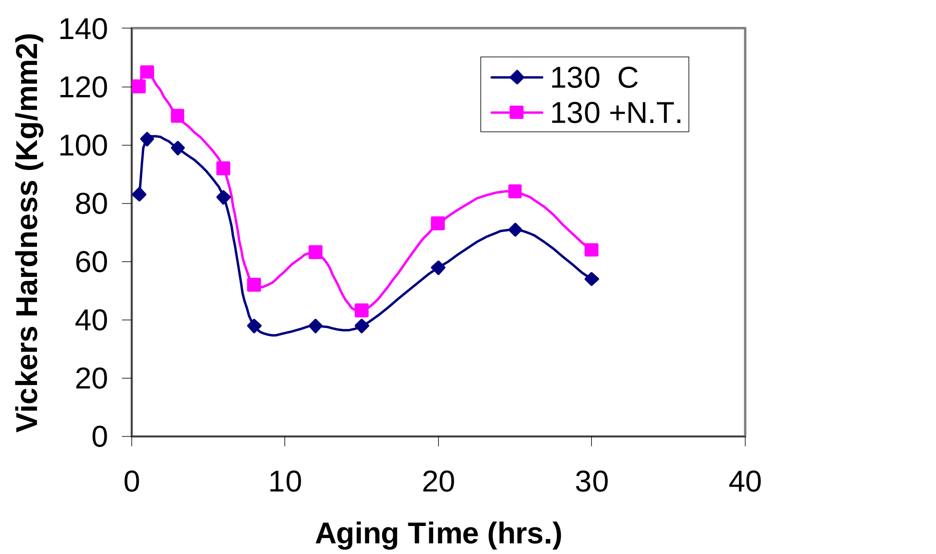
strength for (Al-Zn) alloy is greater than (Al-Cu) alloy, due to the effect of natural aging on the precipitation of ($MgZn_2$) phase and some other phases, which made the dislocation movement more difficult [33,34], or nucleation of super saturation solid solution, and the difference in the chemical composition on the (Al-Zn) alloy and contain strength impurities more than (Al-Cu), which lead to increasing strength, for the same reason that the rate of hardness & ultimate tensile strength for dry and wet corrosion specimen of (Al-Zn) alloy to be greater than (Al-Cu) alloy, which are shown in Table(3) [14,35,36].

Figure(1) The relation between hardness & time



Figure(2) The relation between hardness & time



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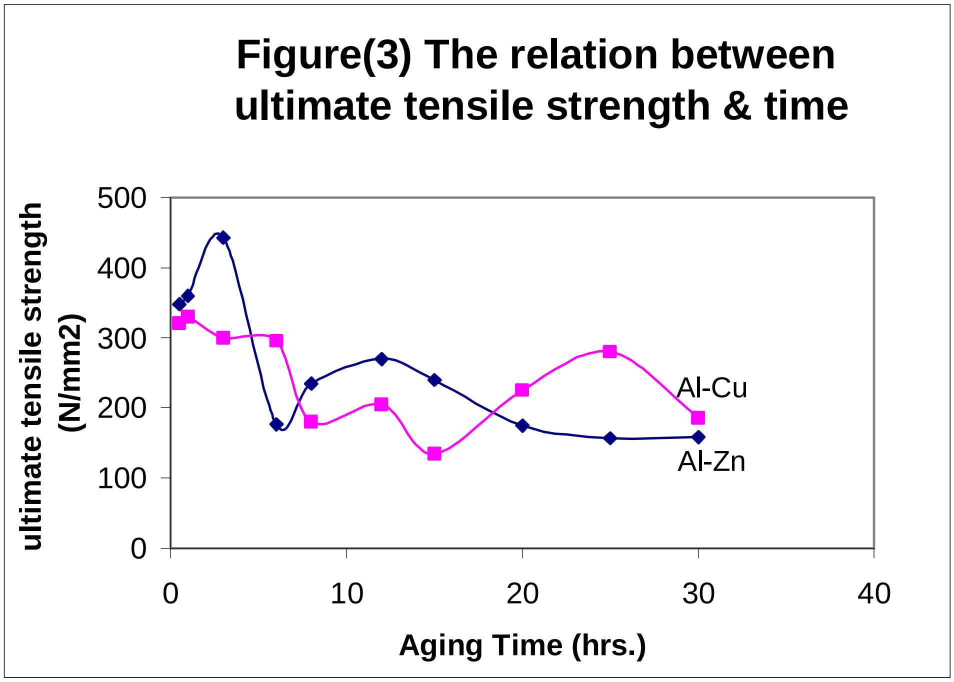

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دراسة تأثيرالتعتيق الطبيعي على بعض خصائص السبيكتين
Al-Cu & Al-Zn

صفاء عبد القادرصالح المطوري

هندسة المواد/كلية الهندسة/جامعة البصرة

الخلاصة

يهدف البحث الى دراسة تأثير التعتيق الطبيعي(15 سنة,عينات مشروع الماجستير) على سبائك المنيوم– نحاس و المنيوم– زنك المستخدمتين في صناعة الطائرات والمحضرتين سابقا" والمحتويتين على 0,2% من كل من الزركونيوم و التيليريوم وقياس الصلاده و مقاومة الشد كداله للتعتيق الصناعي(130 م) و التعتيق الطبيعي(15 سنة) ومقارنتها مع السبائك التي لاتحتوي على الاضافات,كذلك قياس الصلاده و مقاومة الشد للعينات المعرضه للتأكل الرطب والجاف (التأكسد عند 300 م) وللسبائك المشكله و المصبوبه, حيث يمكن ملاحظة ان معدلي الصلاده ومقاومة الشد لسبيكه المنيوم– زنك المسبوكه و المشكله اكبرمن سبيكة المنيوم– نحاس ويعزى ذلك لترسب الاضافات مع الشوائب الموجوده في السبيكةالاولى بين الانخلاعات واعاقتها عن الحركه مما ادى الى زيادة الخواص الميكانيكيه المقاسة وجعل السبيكه اكثر استقرارا" للخواص,اما سبيكه المنيوم– نحاس المشكله و المعرضه للتأكسد فنلاحظ ان معدل الصلاده و مقاومة الشد اكبر من قرينتها المسبوكه بسبب المعاملات الميكانو– حراريه للسبائك المشكله.اما سبيكه المنيوم– زنك المشكله و المعرضه للتأكل الرطب و الجاف فلها معدل صلاده و مقاومة شد اقل من السبائك المسبوكه ويعزى ذلك الى اختلاف المعاملات الحراريه بعد السباكه.

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