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AN EXPERIMENTAL STUDY TO DEVELOP ALUMINUM CORROSION RESISTANCE IN ACIDIC SOLUTION BY DIFFERENT RATIOS OF ADDITIVE ELEMENTS

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Abstract: In this work the corrosion behavior of aluminum alloy includes copper with different ratio is investigated by immersing the specimens in acidic solution (HCL& H_2SO_4) with concentration (5%,10%) then put in furnace at three temperature degree(40,60.80)C^0 and holding for (30)minutes the results showed that increased in (Cu) at alloy contain leads to increase in weight losses while when fixed cupper ratio and increased (Ni) at alloy contain the weight losses decrease .corrosion rate of studied alloy increase in(HCL) solution more than(H_2SO_4) .

Key words: *Pitting corrosion; Heat treatment; Aluminum alloys.*

دراسة عملية لتحسين مقاومة تأكل الالمنيوم في المحاليل الحامضية باضافة عناصر بنسب مختلفة

الخلاصة :- في هذا العمل سلوك التاكل لسبيكه المنيوم تحتوي على نسب وزنيه مختلفه من النحاس تم دراستها بواسطه غمرها بمحلول حامض الهيدروكلوريك و الكبريتيك و بتركيز (5%-10%) ثم وضعها في الفرن بثلاث درجات حراريه (40-60-80 مئويه) و تركها لمدة نصف ساعه . النتائج اوضحت ان زيادة النحاس في محتوى السبيكه تؤدي الى زياده فقدان الوزن في حين عند بتثبيت نسبه النحاس و زياده نسبه النيكل في محتوى السبيكه الفقدان في الوزن يقل . بينت الدراسه ان معدل التاكل للسبيكه المدروسه يزداد في محلول حامض الهيدروكلوريك اعلى بكثير من حامض الكبريتيك

1. Introduction

Due to its economic and technical importance aluminum is used in industrial applications like reflectors, buildings, airspace, decorative products, and aircraft and architectural. It has an excellent corrosion resistance and its surface bonded by oxide Film so it's used as one of the primary metals of commerce, if it destroyed it reforms directly in most environments.[1]Aluminum alloys are used in the automotive industry due to its relatively high strength-to-weight ratio.

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An 2xxx series is one the interesting families of Al alloys. It is well known that copper added to Al generally made it harder, stronger and more resistances to fatigue and creep and machinability. On the other hand, the increase in Cu content decrease resistance to corrosion and, in special constituted and material state; stress corrosion susceptibility the microstructure of hypoeutectic Al-Cu alloys can play an important role in both its mechanical and corrosion behavior. These alloys have microstructures of Al-rich α-phase and Al_2Cu intermetallic particles[2]

AA EL Maghraby (2010) studied the effect of immersing aluminum with 2M hydrochloric acid solution containing 100 ppm optimum KIO_3 dose, adsorbed film formed on the surface of aluminum improve its morphology, due to the marked layer enrichment of Al- surface by inhibitor components. Detailed studies were carried out to see the effect of oxygen in the process of inhibition. [1]

Wislei R OsRorio (2009) investigated the behavior of electrochemical of hypoeutectic Al-Cu alloys when immersed in sulphate and chloride ions solutions, respectively. The influence of Al_2Cu associated to the dendrite arm spacing on the general corrosion resistance of such alloys is analyzed. In 0.5 M sulphuric acid and 0.5 NaCl with temperature of 25 ±C It was found that corrosion in NaCl solution is increased as the Cu content increased while in h2so4 solution similar corrosion rates for the three different[2]

Z.szklarska (2008) studied the behavior of AA6061 aliminum when immersed in aqueous solution of NaCl and effects of chloride (Cl^-) ion concentration using measurements of weight loss, it was found that the corrosion dependent on the pH and chloride concentration of solution. In acidic or slightly neutral solutions [3]

Soha Talal(2010) studied the effect of some factors (acid concentration, solution temperature and inhibitor addition) on the corrosion properties of Al-Cu alloy in solutions of HCl, $H_3PO_4$and H_2SO_4 by using chemical (hydrogen evolution, HE, and Weight Loss, WL) the obtained data revealed that the corrosion rate of the studied alloy increases as both acid concentration and solution temperature increase [4]

Ahmed Y. Musa (2011) studied the evaluation and Protection from corrosion to the AL-alloys by using an organic coatings and inhibitors .Many industrial applications and corrosion prevention methods for different Al alloys are carried out [5] .

Abdulkareem Mohammed et.al. (2011). carried out an experimental study by heating the specimens of Al-alloys type 7020 from (100to500) C° for two periods of holding time (one hour and two hours) with using Polarization technique to study the effects of microstructures on their electrochemical behavior in 3.5% NaCl solution. The results show that increasing temperatures of heating caused the appearance of pitting corrosion on the precipitated phase [6].

H. T. NAEEM (2014) studied the corrosion resistance of two types of alloys (aluminum based alloys and Al-alloys with nickel) .Several processes are applied for the (Al-Zn-Mg-Cu) alloys and (Al-Zn-Mg-Cu-0.5%Ni) alloys were homogenized, aged then retrogressed and re aged; also, extruded there after heat treated. Then samples after different treatments were subjected to corrosive media (acidic: 1.0M HCl) using weight loss method to evaluate their corrosion resistance [7]

Aminu D.et.al (2015) applied weight loss technique to study corrosion behaviour of some metals in different acid solutions.(In 0.5 – 3.0 M of solutions of HCl, H2SO4, and HNO3) for an exposure period of 100 minutes (at 20 minutes interval). Corrosion rate in

metals followed this order: zinc > galvanized iron > copper >, while it followed this order: HNO3 > H2SO4 > HCl. It has been obtained that concentration increase leads to increase in rate of corrosion. [8]

Kharia Salman Hassan et.al (2015) studied the time of shot peening on corrosion behavior of many prepared specimens from (AA 6061-T6) in aqueous solutions with the dimensions of (15*15*3) mm according to ASTM G71-31. Using steel ball have diameter 2.75 mm to shot peening with time at (15, 30, 45) min. The series of experimental techniques have been conducted to evaluate many properties of the alloys like hardness, surface residual stresses, microstructure and surface roughness. Corrosion test by tafel extrapolation method was carried out on shot and un shot corrosion specimens in different media as3.5% NaCl solution and tap water Corrosion rate was calculated using tafel equation. [9]

2.Theoretical Part

Percentage rate of loss in weight (corrosion) at 40℃ temperature

$$=\frac{W_0 - W_{40}}{W_0} \times 100... \quad (1)$$

Where:-

List of symbols

symbol	weight	Temperature
W_0	original	Room temp
W_{40}	Weight at	40℃
W_{60}	Weight at	60 ℃
W_{80}	Weight at	80℃

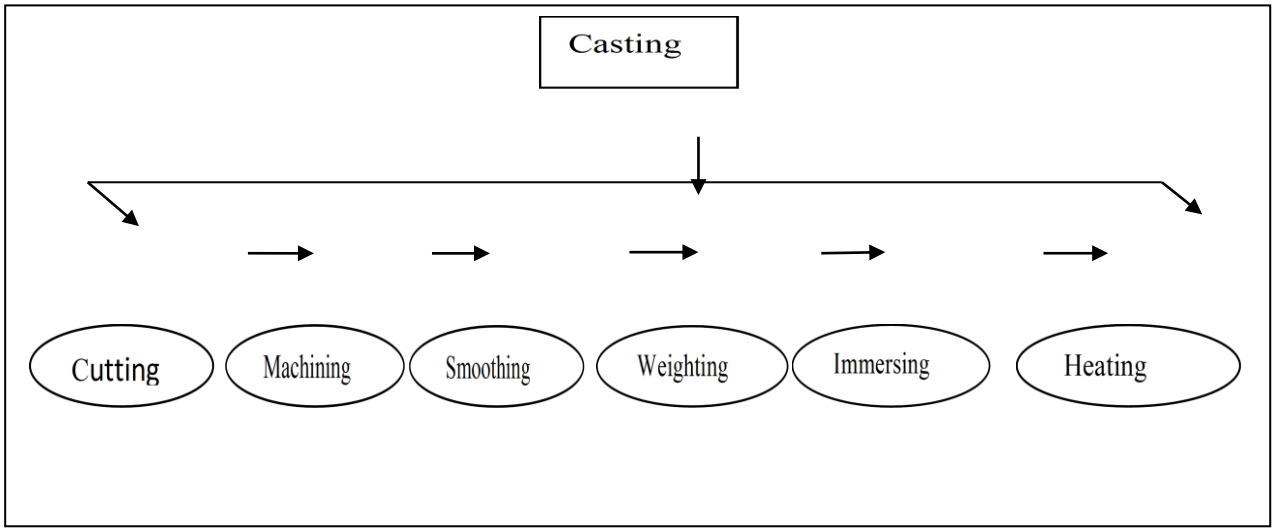
Alloys Preparation

The alloys were prepared by melting and casting in a permanent mold weight present of cast alloy showed in table(1) cast as referred in Fig(1)

Table 1.Chemical Component of alloys (done in the labs of Ministry of Science and Technology labs)

Base/AL	Model1	Model2	Model3	Model4	Model5	Model6
Mn	0.19*	0.1	0.11	0.13l	0.24	0.09l
Fe	0.43	0.472	0.37	0.45	0.39	0.37
Ni	0.00	0.52	0.09	0.45	0.07	0.63l
Cu	0.31	1.36	2.34	2.52	4.63	4.78
Zn	0.0	0.0	0.20	0.43	0.0	0.0
Weight(gm)	5.8	9.7	1.5	4.0	33.3	2.3

Figure1. The samples



Flow chart (1) shows the work procedure

Specimens were cut at same dimension for each model. Sharp edges are removed by smoothing with finer grades of SiC paper with water as a lubricant. The sample has been weighted by using digital balance before and after treatment , immersed in two types of acids(HCL& H_2SO_4) with two concentrations (5% & 10%) and then put in the furnace at three temperature grades (40, 60 & 80) ℃ the time of exposure for all samples was(30)minute.

3. Results and Discussion

The amount of weight losses due to immerse in acidic solution are shown in the tables below (2, 3,4,5&6)

Table 2.Percentage of losses in weight at concentration 5% HCL (gm)

Model	W_0	W_{40}	$W6_0$	W_{80}
1	5.8*	5.48	4.82	3.7
2	9.7	9.4	8.78	7.2
3	1.5	1.3	1.0	0.81
4	4.0	3.82	3.43	2.83
5	33.3	28.1	20.3	11.6
6	2.3	2.1	1.53	1.0

Table3. Percentage of losses in weight at concentration 5% HCL

Model	Cu	W_{40}	W_{60}	W_{80}
1	0.31	5.5	12	21
2	1.36	3.0	6.5	10
3	2.34	13	16	19.5
4	2.52	4.5	10	17
5	4.63	15	29	42
6	4.78	14	23	35

Table 4.Percentage of losses in weight at concentration 10%HCL(gm)

Model	W_0	W_{40}	$W6_0$	W_{80}
1	5.8	5.3	4.71	3.66l
2	9.7	8.5	6.77	5.7
3	1.5	1.18	0.8	0.31
4	4	3.3	2.37	1.46
5	33.3	26.18	14.2	2.65
6	2.3	1.65	1.2	0.52

Table 5. Percentage of losses in weight at concentration 10% HCL

Model	Cu	W_{40}	W_{60}	W_{80}
1	0.31	8	11	23
2	1.36	17	20	23
3	2.34	21	32	52
4	2.52	17	28	38
5	4.63	21	45	81
6	4.78	20	27	56

Table 6. Percentage of losses in weight in 5%HCL With effect of different Ni concentrations

Model	Cu	W_{40}	W_{60}	W_{80}
3	2.34	13	16	19.5
4	2.52	4.5	10	17
5	4.63	15	29	42
6	4.78	14	23	35

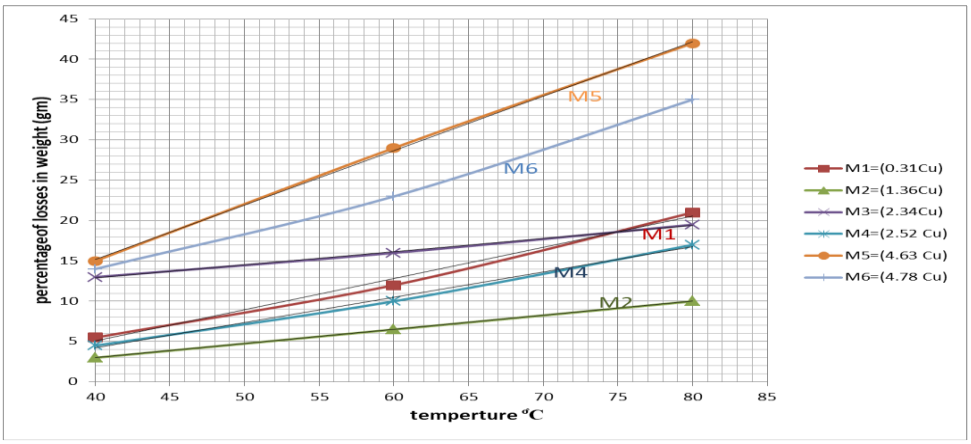


Fig 2. Relationship between percentage of losses in weight and temperature at 5% HCL

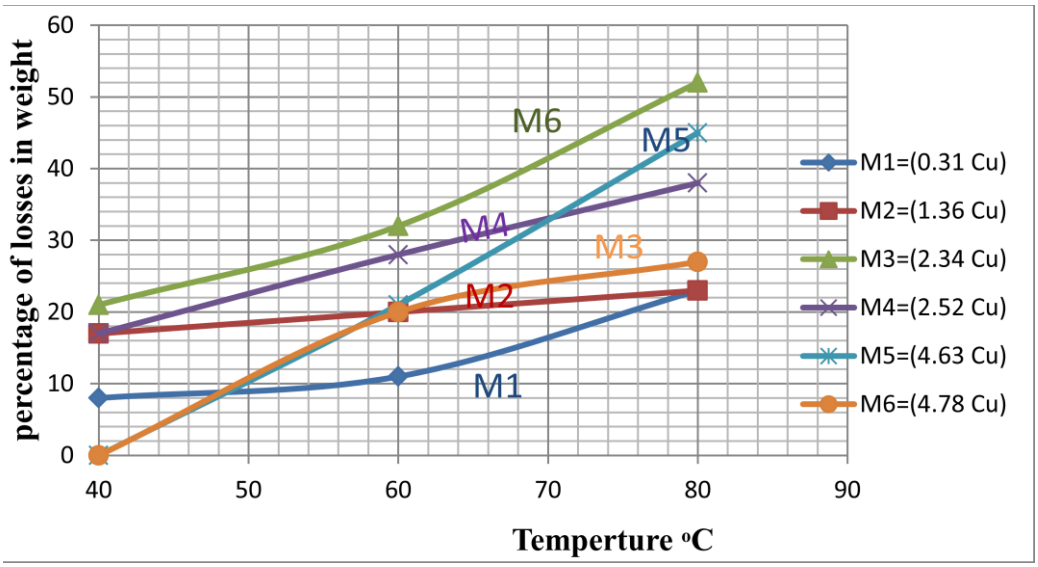


Fig 3. Relationship between percentage of losses in weight and temperature at 10% HCL

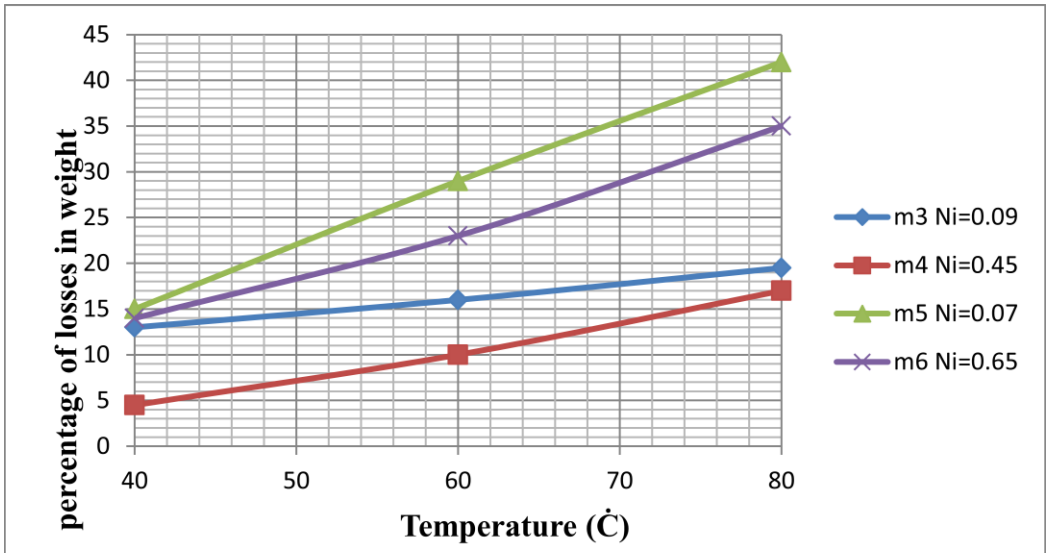


Fig 4. Relationship between ratio losses in weight and temperature at 5% HCLWith effect of different Ni concentration.

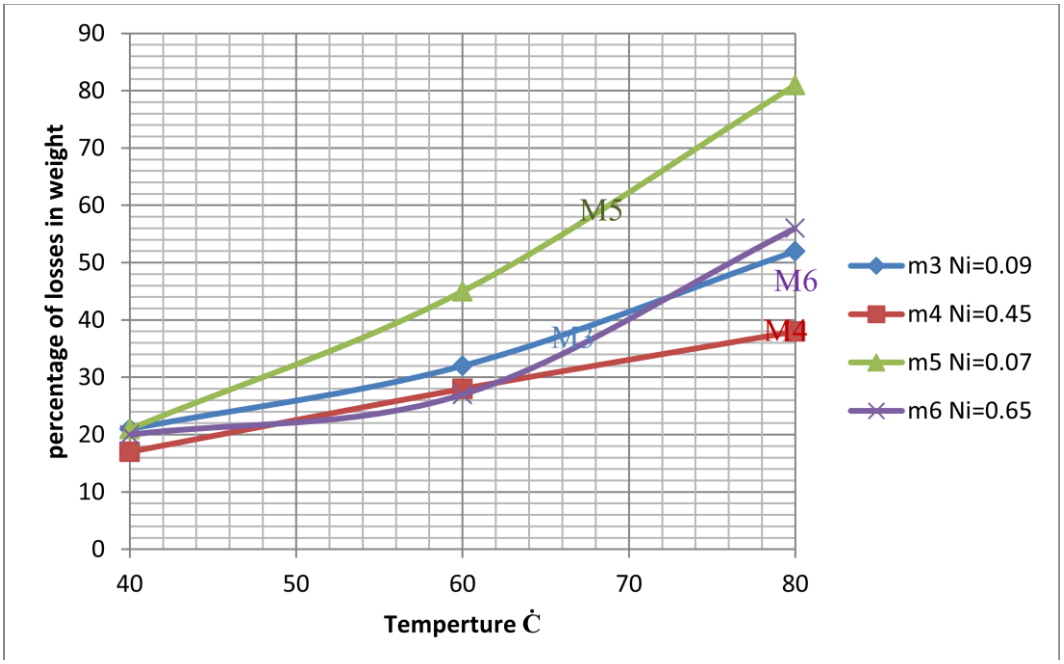


Fig 5. Relationship between percentage of losses in weight and temperature at 10 % HCL With effect of different Ni concentration.

From figures (2) & (3)it can be observed clearly that the increase in Cu concentration leads to increase in weight losses (corrosion rate). Pure aluminum have protective area at the surface (consist of aluminum oxide) but when this film exposed to acid or salt solution has been broken then (AL) solve in the hole that happen from pitting producing (H_2) and the corrosion caused by bad ventilation or non-homogenous in surface composition [10] From figures (4)& (5) it can be observed that when ratio of element(Ni) increase with fixed ratio of (Cu) decrease the corrosion rate.

4. Conclusions

HCL acid solution more effective on alloy due to (H_2) exist then (H_2SO_4) while (HNO_3) has no reaction. -
Increase in concentration of acid solution and temperature lead to increase in corrosion -Broken down the oxide film enhance the interaction between (Cl) and oxide this processes depend on composition of material, the presence and distribution of micro defect. -
Increase in (Cu) weight ratio in alloy contains causes an increase in corrosion rate

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