TEMPERATURE EFFECT ON PIT DEPTH AND MORPHOLOGY OF ALUMINUM ALLOY AISI 1080, IN THE RANGE (293-353)K, AT 0.5N NACL SOLUTION.[+]

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Abstract:-

Aluminum alloy type AISI 1080 was tested in 0.5N NaCl solution, using simple immersion test for 120 hr., at temperatures 293K, 313K, 323K, and 353k respectively. After immersion test the maximum pit depth was calculated at each test temperature. The results show that pit depth increases as the temperature of the solution increases.

The pit depth tend to increase rapidly starting from 293K (pit depth of 3 micron) up to 12 micron at 333K ,then steadily raise up to 15 micron at 353k. This may be related to temperature rise that causes change in oxide hydration also this temperature rise affect chloride ion absorption in the passive layer.

Corrosion rate in Mil Per Year (MPY) was also tested for the same alloy at the same solution concentration and temperatures. Results indicate corrosion rate decrease as the temperature increases. This is attributed to the increase in chemical reaction rate as the temperature rise, also it affect pit growth and nucleation. According to MPY results alloy AISI 1080 have excellent general corrosion resistance.

Scanning Electron Microscope (SEM) was also used to study the attacked alloy surfaces after immersion, in 0.5 NaCl solution at the above temperatures. Results reviled crystallographic nature of the attacked alloy surface.

المستخلص :-

في محلول ملحي AISI 1080 تم في هذا البحث أجراء أختبار الغمر البسيط لعينات من سبيكة الالمنيوم نــوع 293K, 3K,١3 3K,٣31 3K ,٥3 وعند الدرجات الحراريه)N 0.5 بتركيز(NaCl

تم بعد أختبار الغمر البسيط حساب أقص عمق للنقر عند كل الدرجات الحراريه المذكوره اعلاه وبالتتابع لمدة خمسة أيام اي ١٢٠ ساعة. تبين بأن عمق النقر يتزايد بصوره مطرده بزيادة درجة الحراره حيث كان عمق النقر عند درجة (٣ مايكرون) وصولاً الى (١٢ مايكرون) عند درجة حراره K ٣٣٣ ثم يتزايد ببطئ وحتى درجة k ٣٥٣ .

أن هذا يمكن ان يعزى التغيير الحاصل في تميؤ الاكاسيد في منطقة الخمود و التي تتغير بتغير درجة الحراره مسببا تغيير في أمتصاص ايون الكلوريد في تلك المنطقه.تم أيضاً في هذا البحث قياس معدل التأكل العام للعينات مقاساً بـMil Per Year(MPY) وعند نفس الدرجات الحراريه المذكوره وعند نفس الدرجات الحراريه المذكوره اعلاه ونفس تركيزالمحلول حيث وجد بأن قيمة معدل النأكل العام تتناقص مع ارتفاع درجة الحرارة.

أن هذا السلوك يمكن أن يكون بتأثير كل من درجة الحرلرة التي تعجل التفاعلات الكينياويه بصوره عامه وكذلك فأن ارتفاع درجة الحراره يؤدي الى زيادة معدل التخليق ونمو النقر،ولكن السبكه تبقى ذات مقاومه ممتازه للتاكل العام في المدى الحراري المذكور اعلاه. ولدراسة طبيعة السطوح المتاكله لنفس السبيكه تم استخدام المجهر الالكتروني

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الماسح Scanning Electron Microscope (SEM) وبعد أختبار الغمر اي بعد ١٢٠ ساعه وفي نفس ضروف المحلول حيث نبين بأن التاكل ذو طبيعه كريستلوغرافيه(crystallographic nature).

Introduction:-

The passive layer of alloys resulted due to the formation of condensed phase of continuous oxide layer on the alloy, and the stability of this passive layer depends upon the chemical and electrical properties of this passive film [1, 2].

For aluminum alloys amorphous layer of Al_2O_3 of not more than several nanometers formed spontaneously in regions where water is thermodynamically stable [2].

The structure, composition, and thickness of the passive film rely on multifactor as the nature of the solution, its composition, temperature, and current [2, 3].

Pitting corrosion may be defined as local dissolution as a result of passive film breakdown, causing formation of cavities when alloys are exposed to aqueous solutions containing aggressive anions, primarily chlorides.

Three modes of breakdown are chemical, electrical and ionic breakdown [2]. The breakdown starts from competition in the film/electrolyte interface between hydroxyl ions and aggressive anions [1].

In most cases the breakdown favorite sites are surface defect such as metallic inclusions of (Fe, Si, or Cu sites), or due to non-metallic inclusions in the alloy composition [٤, 5, 6].

It was also reported that all flaws in the oxide passive layer film when immersed in pitting conductive environment can be considered as potential pit sites. The mechanical flaws at the bases (which is free Al) possesses small area but of appreciable cathode/ anode effect [6, 7].

These small areas (pits) are corroded to sacrifice the largest metal surface causing sever attack [2, 3, 5, 7].

Some recent studies show the electrochemical behavior of different aluminum alloys [8, 9,10].This study includes other important information to the high purity alloy AISI 1080 such as pit morphology and pit depth.

Experimental Procedure:-

The chemical composition of the tested alloy in this research is shown in Table-1-. Disc aluminum specimens of one square cm area are prepared according to the standard procedure [11].

Solutions of 0.5N NaCl were prepared using high purity salt and deionised water. Electrical Water bath with automatic controller was used to regulate the bath temperature for the tests above 293K temperature (i.e.303K, 323K, and 353K).

Each spacemen was immersed in 0,5N NaCl solution at the specified temperature for 120 hr. continuously, and then washed thoroughly, dried and weighed before and after immersion. Therefore, calculating MPY according to the equation below:-

$$MPY = 534 / DAT ....[12].$$

Where W: Weight loss in mg.

D: density of the alloy used in gm/cm٣.

A: Surface area in square inch.

T: immersion tine duration in hrs.

Optical microscope type Univar was used to measure the maximum pit depth of each immersed specimen in microns. Focusing is performed in turn, i.e. on the surface of the specimen and on the bottom of the pitted surface, utilizing a calibrated wheel in the fine focus adjustment rack for the focusing process.

Then the maximum pit depth was recorded. Scanning Electron microscope type Joule was used to study pitted surface after immersion.

Table-1-Chemical Composition of the Tested Aluminum alloy AISI 1080.

% Element	Cu	Mg	Mn	Si	Zn	Fe	Ti	Al
	0.03	0.03	0.03	0.15	0.06	0.15	0.02	Rem.

Results and Discussion:-

The results of this study are indicated in Table-2-.In this table the corrosion rate MPy values decreases as the temperature of the solution increases. At the same time the temperature rise causes fast increase in maximum pit depth that is measured for the testes AISI 1080 aluminum alloy.

From Table -2- it could be noticed that the maximum pit depth increases as the temperature rises from 293K rapidly after the temperature exceeds 313K (almost doubled). Pit maximum depth is 12 micron at 333K. This means that handling aluminum alloy AISI 1080 at temperature that exceeds 333K should be considered carefully.

It was reported that changes in oxide hydration occur as temperature rises and that $Al(OH)_3$, and $Al_2O_3.3H_2O$ are formed if the solution temperature is below 333K.When the temperature exceeds 333k the oxide film formed are AlOOH, and Al_2O_3. H_2O.

Changes in the temperature and the oxide film hydration affect the passive layer and the adsorption of aggressive chloride anions [3,14].All the previous changes as temperature increases i.e. hydration of the oxides, and adsorption of Cl anions may explain the reason behind the sharp increase in maximum pit depth up to 333K temperature, followed by the slow increase in the depth when solution temperature is 353K.

Tabele-2- depicts also the general corrosion values measured in MPY.It shows that MPY values do not exceed 1.8 this means that AISI 1080 aluminum alloy is of excellent general corrosion resistance [12, 13].

Although MPY is an important measure for the penetration through the alloy depth [12], but in comparison with the maximum pit depth resulted in this study become of less importance.

Researchers reported that the rate of pit nucleation and the rate of pit growth changes as the solution temperature increase in simple immersion test. As the temperature increased the rate of nucleated pits increased due to the ease of passive film breakdown. While the rate of pit growth decreases as a result of salt layer precipitated on the bottom of pit depth [3, 14].

These studies [3, 14] explained the reason of the resulted MPY value of 1.8 that is determined at 293K.When the solution temperature was increased, the reaction and relatively the corrosion products are increased causing the formation of the precipitated salts that may cover the pits' bottom. This causes the decease of MPY value at higher temperatures (MPY=0.8).

Scanning Electron Microscope results are shown in Fig.'s (1),(2),and (3) respectively. In these Figs' the pitting attack is obvious to be of crystallographic nature. This nature of the resulted pits is due to the non-disturbance of the propagated single tunnel [15]. Here the pit propagation is not disturbed due to the nature of the immersion test. Previous studies also indicated the crystallographic nature of different alloys composition, at various testing conditions [9, 10, 16]. And tunneling is a general mode of pit propagation for aluminum alloys in chloride solutions, irrespective of microscopic aspect of the attack [17].

Table-2-Results of this research

Temperature of the solution K.	Maximum Pit Depth Micron	Corrosion Rate MPY
293	3	1.8
313	7	1.4
333	12	0.8
353	15	0.84

Fig.(1)Propagated pits indicating tunneling mode for the tested Alloy AISI 1080.

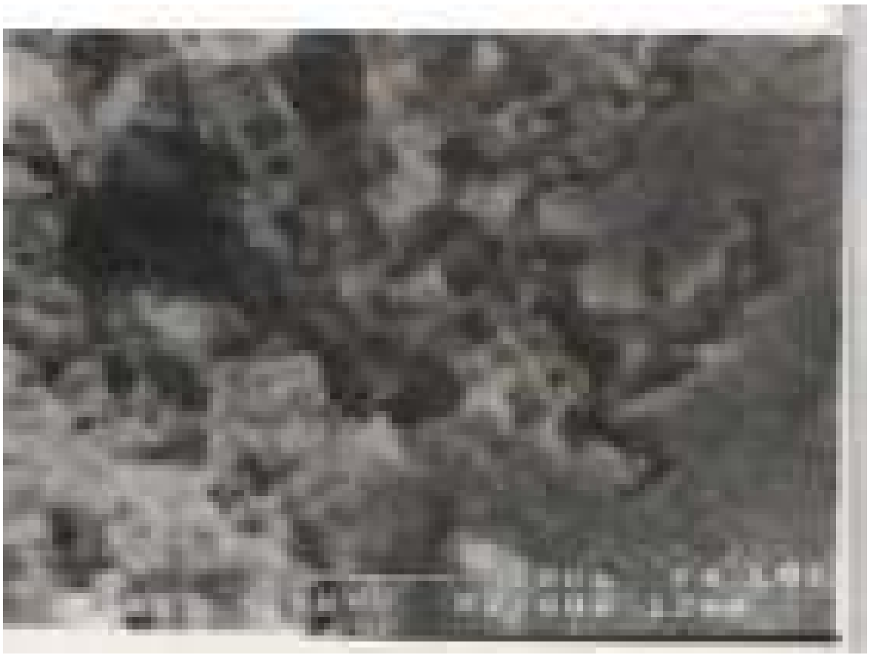

Fig.(2) Depicts the Crystallographic nature of the pitted surface, after 5 days of immersion.

Fig.(3)Shows the Propagated Pit of crystallographic nature propagation directions are normal and parallels to the surface.

Conclusions:-

1. AISI 1080 aluminum alloy have excellent general corrosion resistance in 0.5N NaCl solution, in the temperature range (293-353)K.But still cannot be used in conditions(at temperatures above 293K)due to the probability of alloy perforation after certain immersion duration.
2. MPY values decreases as the solution temperature increases up to 333K, then MPY slowly increase up to 353K temperature increase.
3. Maximum pit depth was 15 micron after 5 days of immersion at 353K,at 0.5N NaCl solution.
4. Pit morphology is of crystallographic nature.

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