STUDY OF THE PITTING CORROSION FOR SHOT PEENING 6061-T6ALUMINUM ALLOY IN SEA WATER

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ABSTRACT :-

This paper aims to clear some influential parameters, like shape and size of shot-peening on pitting corrosion for aluminum alloy 6061-T6. Many specimens were prepared for corrosion test with dimensions of (15*15*3) mm according to ASTM G71-31 and these specimens were categorized into four group having symbols (A,B,C,D). Three of these groups were shot peened using different ball sizes. Group B shot by steel ball having diameter 1.25 mm while group C shot by steel ball with diameter 2.75 mm. Steel cylinder with diameter of 2.75 mm and length 3mm was to shot another specimens. Shot time was fixed of (10) min. Many tests have been carried out to measure the surface roughness, Vickers hardness ,residual stresses. SEM micrograph for all specimens . **Corrosion** test was done by cyclic electrochemical methods for all specimens in environments of 3.5% NaCl solution . The Corrosion value has calculated by using Tafel equation. Results obtained show that shot peening contribute in decreasing corrosion rate comparing with base metal and shot peening using steel ball give low corrosion rate than cylinder steel due to plastic deformation causes by cylinder steel and steel ball having diameter 2.75 give the best result due to residual stress .

Key word:- Aluminum alloy, Shot peening, Surface roughness, Residual stresses, Pitting corrosion.

دراسة تاثير قذف سبيكة الالمنيوم 6061-T6 بكرات معدنية على التأكل النقري في ماء البحر

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الخلاصة :-

تناولت الدراسة تأثير بعض متغيرات القذف بكرات فولاذية من القطر والشكل على سلوك التآكل لسبيكة ألمنيوم ذات المتانة المتوسطة.6061-T6 صنعت عدد من عينات اختبارالتآكل بابعاد (15*15*3) ملم وفق المواصفة القياسية ASTM-G71-31.صنفت هذه العينات الى اربعة مجاميع باحرف (A,B,C,D) تعرضت ثلاثة مجاميع وهي عينات المجموعة B الى القذف بكرات فولاذية قطرها 1.25 ملم وعينات المجموعة C قذفت بكرات فولاذية قطرها 2.75ملم لبيان تأثير قطر الكرة على سلوك التآكل اما عينات المجموعة D فقد قذفت بأسطوانات فولاذية طولها 3 ملم وقطرها 2.75ملم لبيان تأثير شكل أداة القذف على سلوك التآكل مع تثبيت الزمن10د قيقة لكافة عمليات القذف . تم قياس الخشونة السطحية ، الصلادة ، الاجهادات الضغطية المتولدة كما اجري اختبار التآكل الكهروكيماوي على مجاميع العينات في محلول ماء البحر 3.5% NaCL وتم تسجيل النتائج القرائية من جهد وتيار بطريقة تافل. واستخدمت معادلة تافل لحساب معدل التآكل. أظهرت النتائج إن زيادة قطر الكرة ساهم في تقليل معدل التاكل نتيجة زيادة في الاجهادات الضغطية المتولدة جراء القذف .

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INTRODUCTION

Applications of medium strength heat treatable aluminum alloys which denoted as 6xxx are largely used in structures of aerospace and automotive because of their particular mechanical properties, corrosion resistance and formability so that shapes can be obtained from simple to complex profiles by extrusion .The regular strengthening for this alloy are work hardening and precipitation hardening, Mostafa [2012], Curiel [2009]

We made to improve the corrosion resistance for this alloy using mechanical surface hardening such as shot peening (SP which is regarded as cold working process intend to improve the fatigue strength results from heavy elastic and plastic deformation in the surface then improve fatigue characteristics by strain hardening because of inducing favorable compressive residual stresses. Compressive surface residual stress is a layer produced by shot peening method include pelting a surface with spherical shots or beads in a large magnitude at the surface (typically about 75%of yield strength), and depth of compression (typically about 0.25 mm) .The compressed grains under the surface layer try to return the surface layer to its first shape by production a hemisphere of cold-worked metal highly compression stressed as show in (Fig. 1), Uroš [2011] and Markovina [1991]. compressive residual stresses was measured using different methods such as X-ray diffraction which was consider the most accurate and best developed method. XRD consider as a linear elastic technique since the residual stress in the material can be evaluated from strain obtained in the crystal-lattice . Many advantages can be achieved from XRD when compared to the other mechanical methods, or the non-linear-elastic-ultrasonic or magnetic methods , Roko and Branko [2008].Many factors on the process of "shot-peening" such as shape and size of shooting particles, peening period , velocity of particles flow , pressure of air used in the peening process , separated distance between the material surface and shooting nozzle, geometry of the shooting nozzle like angle, length and diameter of nozzle, concentration of shooting particles and working surface. Some factors dealt as constant and some factors dealt as variable should be calculated, Wan [2010] . **Marine** corrosion confront a perennial problem in moving vessel , ports and anything kept in the sea water or presented to sea ambience for interval of Corrosion time which is simply defined as dissolving of the metal atoms to ions when the metal undergo to sea ambience. The main reason of the metal corrosion is the contact between the material surface and the sea ambience , so to avoid the corrosion attack this contact should be prevented .Aluminum shows good corrosion resistance in sea ambience because of the oxide film formed on the aluminum surface when exposed to sea ambience this phenomena great large area of application for the aluminum in the sea ambience . Corrosion has clear effect in economics and safety. Apparently corrosion cannot be prevented, but it can be reduced to a lower magnitude and different techniques have been used to lowered corrosion. many techniques and methods have been improved to conflict corrosion efficiency are continually being sought after as a result of exorbitant amount spent on corrosion annually, Kharia [2015].

Many of studies have been investigated on alloy such as ;-

RokoMarkovina[2008] who showed the "influence of shot peening parameters on the" fatigue "properties of aluminum" alloys 2024-T3, like nozzle angle and peening distance, the obtained results clear that the careful selection of shot-peening parameters lead to the escalation of material properties.

W.B. **Wan Nik**[2010] take aluminum alloys AA6063 which exposed to aqueous corrosion in salt spray room and normal seawater container. The electrochemical behavior of aluminum alloys was implemented with various inhibitor concentrations, applying electrochemical potential dynamic reactivation (EPR)).He carried out the morphology study to monitor the development of thin film on the specimen using

Scanning Electron Microscopy (SEM). EIS data exhibited that the mechanism of corrosion depends on inhibitor concentration .

Kharia Salman Hassan[2015]take the shot peening time influence on corrosion behaviors of AA 6061-T6 in aqueous solutions. The shot peening process using steel ball have diameter 2.75 mm at the variable shot peening time (15, 30, 45) minute and corrosion test by tafel extrapolation method was carried out on shot and un shot corrosion specimens in different media as 3 .5% NaCl solution and tap water. The obtained results shows a favorable influence of shot peening (SP) treatment on corrosion resistance as induced compressive residual stresses lead to increase hardening of layer surface and decreasing in corrosion rate .
In this paper was actualize the effect of (size, shape)parameters on corrosion rate for aluminum alloys 6061-T6- in 3.5% NaCl.

EXPERIMENTAL PROCEDURE

We take aluminum alloy6061-T6to study pitting corrosion after shot peening because it has many applications such as mass structures of aerospace and automotive .The chemical compositions of the alloys was investigated by (Thermo ARL 3460 optical Emission spectrometer).and tabulated in Table (1).

After that we prepared many corrosion test specimens from plate alloy by the dimensions of (15*15*3)mm according to ASTM (G71-31) and these specimens are classified to groups in agreement with shot peening size, shape .The base metal takes symbol (A) and symbol(B)give for group specimens shots using steel ball has diameters 1.25 mm ,symbol (C) include group specimens was shots using steel ball has diameters2.75mm, to show size effects on corrosion rate the last groups take symbol (D) for specimens which shots using steel cylinder in a diameter of 2.75 mm and length 3mm. instead of a steel ball to show the effect of shape on corrosions rate .Shot peened treatment from all sides using an air-blast machine "tumbles control model (STB –OB) machine No. 03008 05" types was carried out on all specimens who referred above. To avoid media collision , the angle of nozzle inclination was shifted by 10° with regard to the vertical axis. A constant specimen distance was maintained , "from a nozzle of around 120 mm". shot velocity is 42 m/ min. shot peening time was ten minute for each groups and by using SEM photo was taken for surface shot peening Fig.(2), Fig.(3) and Fig.(4) show the inclusions of shot peening.

Fig.(2), (3)and (4) SEM photo for all specimens after shot(marked area at higher magnification) computerized Lab XRD-6000 shimadzu X-ray diffraction meter was used to measure the strain in the crystal lattice from the on-side and the value of the strain was implemented in brag law to calculated compressive residual stress in the material, the residual stress results which obtained from device are shown in Table (2), and Figs.(5) ,(6),(7)and (8) which gives the relation between Psi (degree) represented the specimen location and its incline with the axis and 2 Theta (degree) which represented the strain. The average value of the free surface roughness , which was measured at the surface area of specimen (A) and peened area for specimens (B,C,D) indicated by the parameter (R_a μm) which is the center-line average of adjacent peaks results are shown in Table (2).

CORROSION TEST

Electrochemical cyclic polarization method was implemented for corrosion test using a Wenking Mlab multi channels potent dynamic and SCI-Mlab corrosion measuring system from Bank Electroniks-Intelligent control GmbH , Germany2007 as shown in Fig.(9) Cell current readings were taken. The sweep was taken from and (+250 -1000 mv) for cyclic relative to (OCP) . Scan rate defines the speed of the potential sweep in mV/sec and it's taken (10 mv) . In this range the current density versus voltage curve is almost nearly linear. In this test aluminum alloy 6061 –T6 shot peened and without shot samples were used as working electrode (WE), a saturated calomel electrode immersed in the solution was used as reference

All samples which were prepared for corrosion test were immersed in laboratory sodium chloride solution of 3.5% NaCl with pH of 6.75 to determine corrosion Parameters, such as corrosion potential ($E_{corr,}E_{pit}$) and corrosion current (I_{corr},I_{pit} at each time . These parameters were used to evaluate the corrosion rate according to Tafel equation as shown below, Annual Book of ASTMSTANDARDS [2004].The obtained result was listed in Table (3) and Fig.(10).optical microscope was used to take photo for all specimens after corrosion test as shown in Fig.(11)

C.R (m.p.y) = 0.13 * Icorr * eq.wt / ρ (1)

Where

(m.p.y) refers to mille-inches per year

(Icorr) is the corrosion current density (μA/cm2)

(Eq.wt) refers to equivalent weight of the corroding species,

DISCUSSION

Table(2) and Figs.(5,6,7,8) include compressive residual stresses result producing by shot peening at 10 min give positive influence and contributed in increased hardening and surface roughness compared with base metal specimens (A) and SEM photo graph in Figs.(2,3,4) enhance the result showing surface shot density and this have reversed effect on corrosion rate Table (3) and the photo graph in Fig .(12)show that for specimens(B, C, D) comparing with specimens (A) in same table due to this layer act as oxide film productive in aluminum and its alloys when aluminum react with dissolve oxygen to form it. Reducing corrosion rate in specimens**(B)** which bombarding a surface with spherical has diameter 1.25mmcreate residual stress less than specimens (C) which bombarding by spherical has diameter 2.75 mm create large residual stress and this is reverse on corrosion rate we see decrease in it in specimens (C) which give the best result and this is show the effect of size shot peening tool on corrosion behavior but when we bombarding specimens (D) cylinder having diameter 2.75 mm we see inverse effect of increasing in corrosion rate due to increasing surface roughness although increasing in residual stress Fig. (10,11) clear cyclic polarization curves of the un-shot and shot specimens. The specimens (B,C,D) did not have an apparent passive region; instead, the current increased quickly showing the occurrence of pitting. Epit is not clearly visible. The show hysteresis loop did not close in the reverse scan, but its size indicates a great tendency to pitting and crevice corrosion.

CONCLUSIONS

1-.The results showed that shot peening can be applied to increase the corrosion resistance of the aluminum alloy under optimum conditions

2- compressive residual stresses produced by shot peening process at tow variable was contributed in improving corrosion resistance of the Al- Alloy 6061-T6.

2-aluminum alloys 6061-T6 has high corrosion rate due to the alloy elements.

3- shot peeing at ball in diameter 2.75 mm was contributed in improvement in corrosion rate due to intense comparatives residuals stresses .

Table (1) Chemical components of alloy "6061- T6"

Elements wt%	Si	Fe	Cu	Mn	Mg	Cr	Zn	Al
Measured value	0.6	0.4	0.3	0.12	1.0	0.2	0.18	Rem.
Standered value *	0.4-0.8	Max 0.7	0.15-0.4	Max 0.15	0.8-1.2	0.04-0.35	Max 0.25	Rem.

*, Metals Handbook, Vol.2 [1990]

Table (2) Surface roughness and residual stress results

Symbol specimens	Residualstress(Mps)	Surface roughness(µm)
A	-18	0.008
B	-76.165	1.57
C	-140	2.23
D	-143.543	2.43

Table (3) corrosion obtained result for all grouped specimens

symbole	I_{pit}.[µA/cm^2]	E_{pitt}[mV]	Corrosion rate (M.p.y) =**0**.43 *i_{corr}
A	23.67	-906.7	10.178
B	0.4453	-1371	0.19
C	0.0228	-2024.0	0.0098
D	1.7	-1284.3	0.731

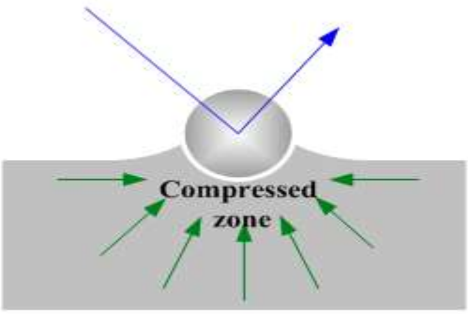


Fig (1) A dimple created by shot peening and the resulting compressive zone, Markovina [1991].

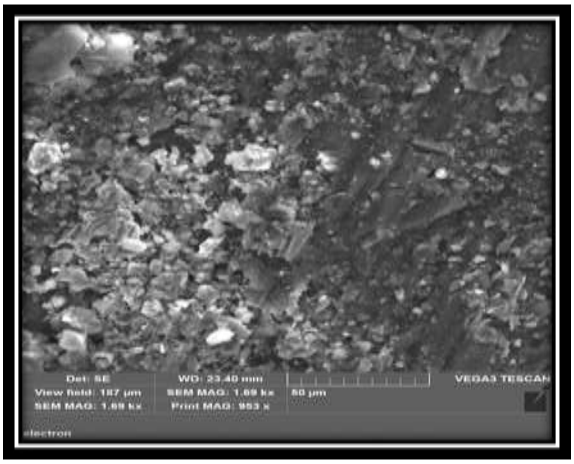


Fig.(2) SEM photograph for Specimens (B) after shot.

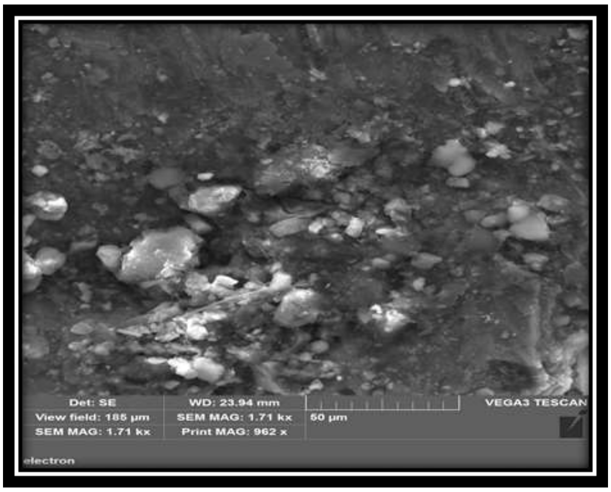
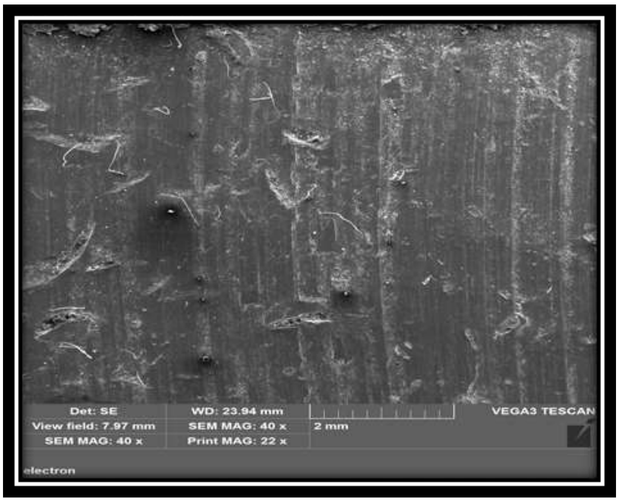


Fig.(3) SEM photograph for Specimens (C) after shot .



Fig(4) SEM photographg for Specimens (D) after shot.

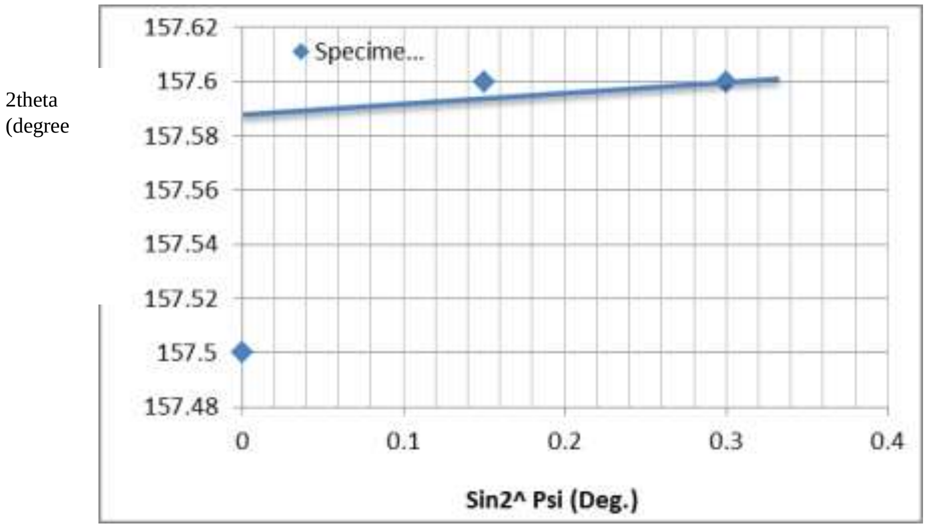


Fig.(5) . photo graph of residual stress for specimen A.

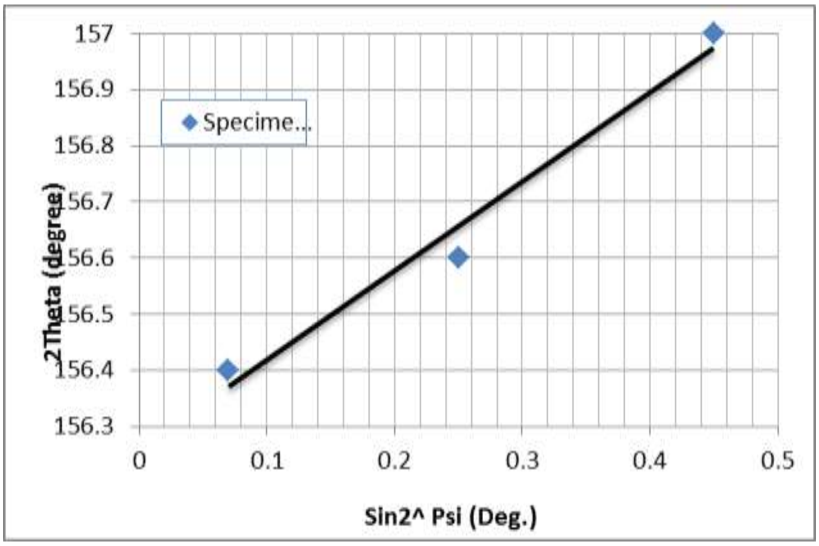


Fig.(6) . photo graph of residual stress for specimen B.

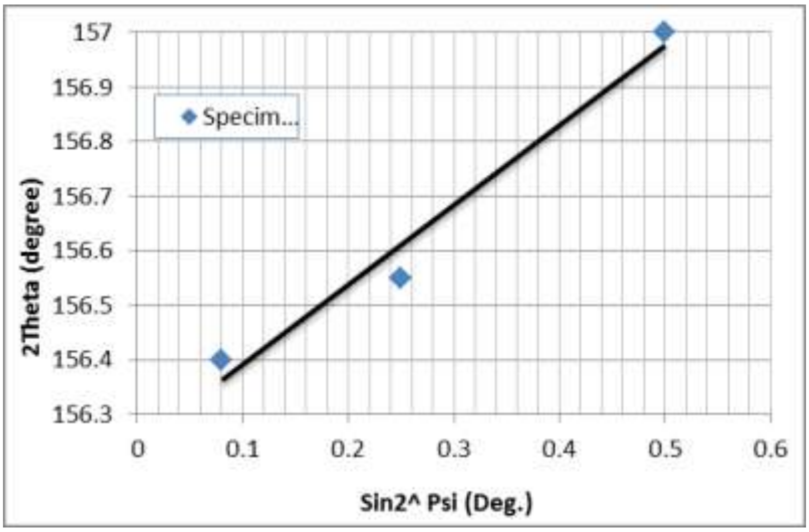


Fig.(7) . photo graph of residual stress for specimen C.

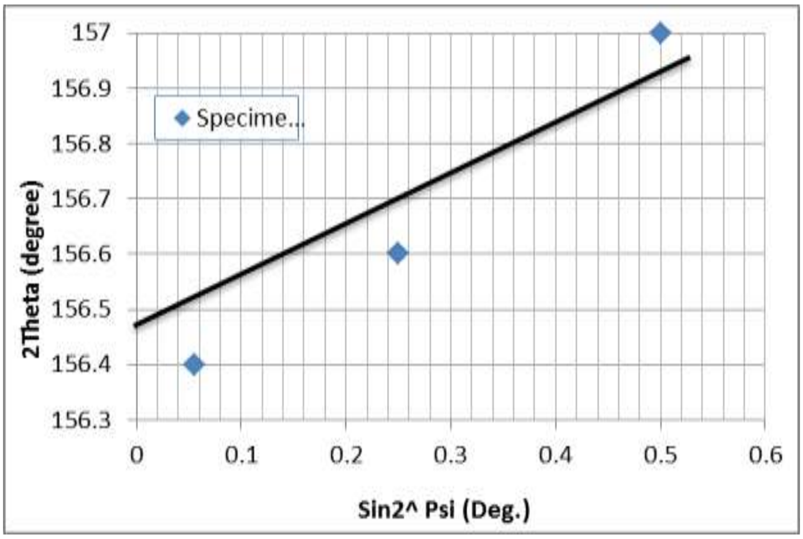
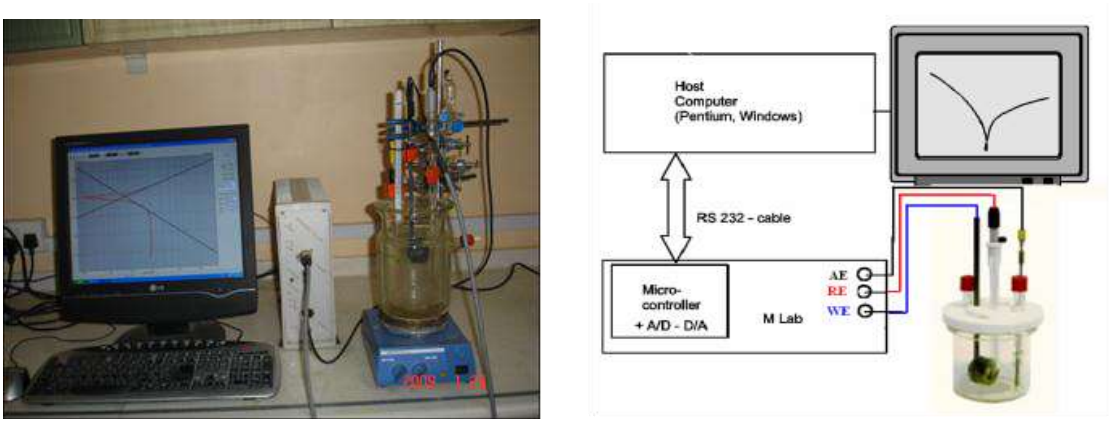


Fig.(8) . photo graph of residual stress for specimen D.



Fig(9) The unit used for electrochemical corrosion.

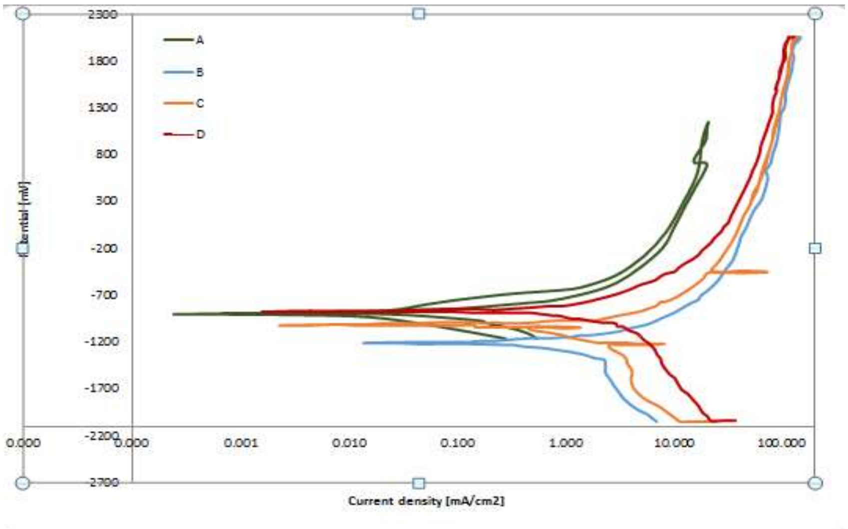


Fig.(10) Eelectrochemical polarization for all specimens.

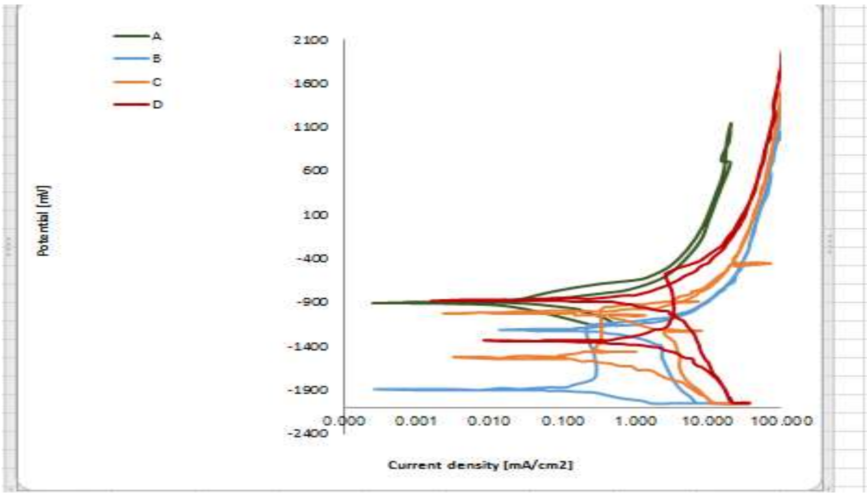
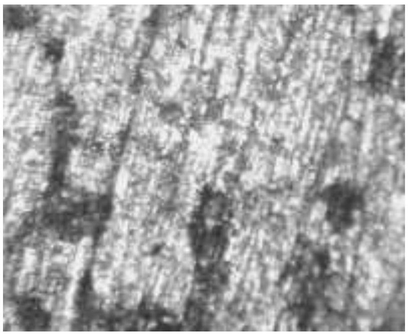
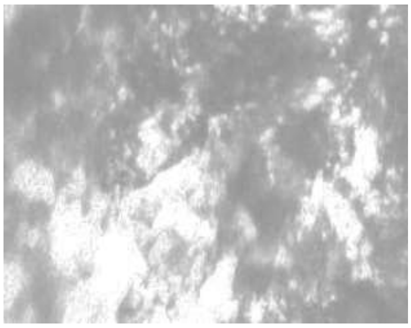
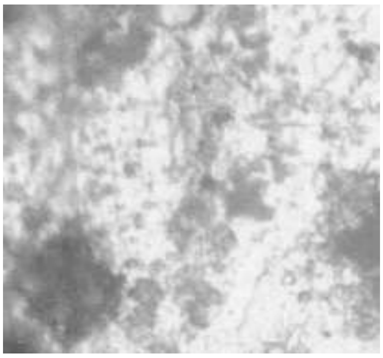


Fig .(11) cyclic polarization for all specimen.


(A)


(B)


(C)


(D)

Fig.(12) optecal photo after corrosions test .

Fig.(13) Shot peening machine

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