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Corrosion resistance of normalizing heat treatment of carbon steel ck45 in sea water at different velocities

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Abstract :

*The effect of, normalizing heat treatment on corrosion resistance of carbon steel DIN CK45 is investigated. Test specimens (1.5*1.5*0.3) Cm were manufactured according to ASTM G71-30 Heat treatments (Quenching, and normalizing were performed by heating the specimens in electrical furnace to 850 ° C and cooling in water for quenching and by air for normalizing microstructure were examined by optical microscope*
Corrosion tests were investigated by electrochemical potential state cell in prepared salt water (sea water) amulti velocities (1, 2, and 3) m/min where the test specimen represents the positive electrode (anode) pole. Tafle equation was adopted to calculate the corrosion rate.

The obtained results show that the heat treatment improves the corrosion resistance by increasing the combination of iron with carbon reducing by that the combination of iron with oxygen which produces rust.
Increasing velocity of the media (sea water) contributed in decreasing the corrosion rate because of reducing the assembling of ions on cathode pole

Keyword: Heat treatment, Carbon Steel CK45, Corrosion Resistance. Velocity of sea water_

مقاومة التآكل للفولاذ الكاربونىCK45 البحر بسرع مختلفه المعل حراريا بواسطة المعادله

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الخلاصة :

تم دراسة تأثير المعاملة الحرارية التقسية والمعادلة على مقاومة التآكل لفولاذ كربوني DIN CK45 حيث تم تصنيع عينات اختبار التآكل بأبعاد (1.5*1.5*0.3) سم وفق مواصفة ASTM G 71-30 أجريت المعاملة الحرارية من تقسية ومعادلة في فرن كهربائي عند درجة حرارة 850 م° لمدة ساعة ثم التبريد في الماء للعينات المقساة والتبريد بالهواء للعينات المعادلة تم إجراء فحص البنية المجهرية باستخدام المجهر الضوئي وكذلك تم إجراء اختبار التآكل بواسطة جهاز المجهاد الساكن باستخدام المحلول الملحي (ماء البحر) وعند عدة سرع هي(1،2،3) متر/ الدقيقة اذ مثلت العينات القطب الموجب وتم حساب معدل التآكل بطريقة تافل ومن النتائج التي تم الحصول عليها وجد تحسن في مقاومة التآكل بالنسبة للعينات التي أجريت لها عملية معادلة وكذلك العينات المقساة بسبب الأطوار التي تم الحصول عليها وتجانسها وكذلك وجد تحسن في معدل التآكل عند زيادة السرعة ودورها في تقليل تجمع ايونات التآكل.

Introduction :

Rates most metals are in its nature unstable and have the tendency to react with their environments to form a chemical compound to get a more stable state. Medium carbon steel is particularly used in most structural shapes such shafts, gears, dies to cast light metals [1] .

Corrosion resistance of steels is strongly connected to their microstructure obtained after heat treatments that are generally performed in order to achieve good mechanical properties. For that, there is currently a strong interest in the effect of the heat treatment on the corrosion resistance which is affected by the changes in the microstructure [2].

Corrosion can be defined as the destruction of a metal by chemical or electrochemical reaction with its environment. In cooling systems, corrosion causes two basic problems. The first and most obvious is the failure of equipment with the resultant cost of replacement and plant downtime. The second is decreased plant efficiency due to loss of heat transfer.

Corrosion occurs at the anode, where metal dissolves. Often, this is separated by a physical distance from the cathode, where a reduction reaction takes place. An electrical potential difference exists between these sites, and current flows through the solution from the anode to the cathode. This is accompanied by the flow of electrons from the anode to the cathode through the metal. Ted

Corrosion behavior of metals in sea water is affected by many environmental factors such as water temperature, dissolved oxygen content and velocity

The effect of water velocity on metals corrosion behavior has got a great interest by researchers, Kamilia Gruskevica [7]study the effect of water velocity on corrosion resistance of steel pipes finding that the corrosion resistance decreased in low or medium flow media by a percentage between 20-50% than rapid flow.

The effect of heat treatment on the microstructure and mechanical properties was, investigated by M.B. Ndaliman (2006) [3] study this under two different quenching medias (water and palm oil) achieving that best proprieties in strength and hardness in water is better than palm oil.

Adnan Calic (2009) [4] shows that in different cooling rate ,different microstructure can be obtained and improved it by varying the cooling rate .Thus, heat treatment is used to obtain desired proprieties of such as improving the toughness, ductility or removing the residual stresses, etc.

He compared this study with literature survey as, (Bangor and Sachdev, 1982) [5] show that oil quenching produce ferrite-martensits phases and thin film of retained austenite. By slow air cooling the results in a large amount in retained austenite in addition to the ferrite and martensite . on the other hand with the applied cooling rate increasing the transformed structure evolve s from granular bainite, lower bainite, self tempred martensite, to finally martensite without self-tempering (Qiao etal,m2009) [6] .Among them, self-tempered martensite obtained in the transformed specimens cooled with of 25-80 C/min, The aim of this paper is to examine the effect of phases which obtained by heat treatment of medium carbon steel CK 45 at different velocities on solution corrosion resistance .

Experimental Work :

Metal selection:

medium carbon steel CK45 according to DIN specification were chosen because of its wide range of engineering applications such as shafts, molds, connecting rods and its chemical analysis indicated in **table (1)** which was conducted by ARL Spectrometer.

Table (1) Chemical analysis of used metal CK45

wt%	C	Si	Mn	P	S	Cr	Mo	Ni
Standard Value	0.4-0.5	0.4	0.5-0.8	0.035	0.035	0.4	0.1	0.04
Actual Value	0.42	0.02	0.573	0.002	0.002	0.051	0.018	0.077

Fabrication of specimens:

test specimens for corrosion test were fabricated as (1.5*1.5*3) cm according to the ASTM G 71-30.

The test specimens were categorized into groups as shown in the **Table (2).**

Table (2) categorization of test specimens

Specimen symbol	Condition of specimens
A	Base metal
B	Heating at850°Cfor0.5hour and cooling in water (Quenching)
c	Heating at 850 °C for 0,5 hour and air cooling

Heat Treatment :

the heat treatments were performed on the specimens shown in **Table (2).** the process consist of heating the specimens of symbols (B, C,) to 850°C for 0.5 hour and water cooling., then Samples (C) were preheated to850°C for (0.5 hour then air cooling

Tests and examination :

Microstructure test : The specimens groups showed in table (2), the specimens were prepared for microstructure as follows:

Grinding by SiCemery paper of grades 120,350,500,800.

They were polished with cloth and alumina Al_2O_3 solution.

Aqueous treatment using Nital Solution composed of 2% nitric acid and 98% methyl alcohol.

Optical examination of samples was performed using optical microscope equipped with camera and connected to a computer. The microstructure is shown in **Figure (1).**

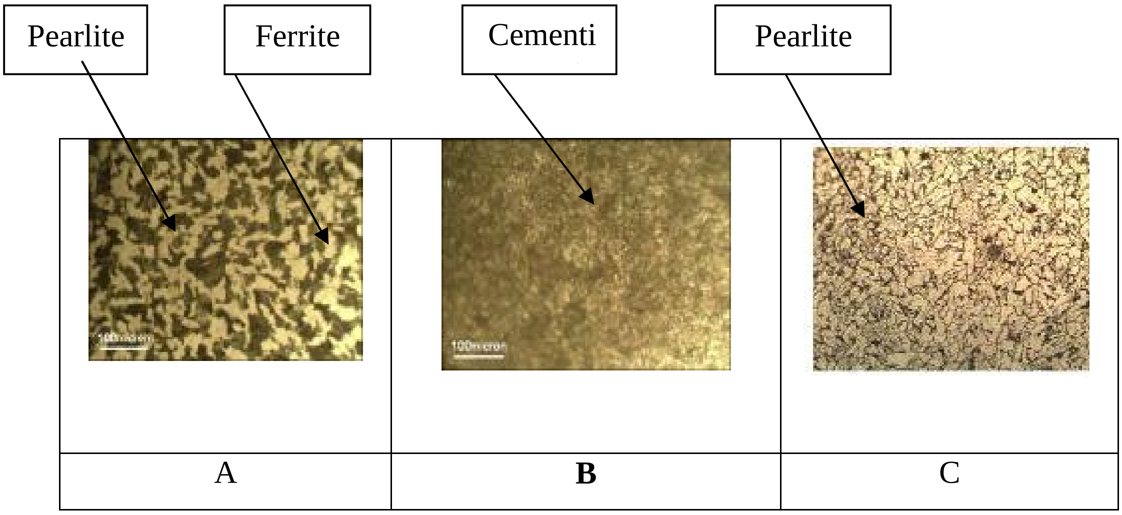

Fig. (1) Microstructure of test specimens

Electrochemical Tests :

The prepared specimen is fixed with in the holder the reference electrode was fixed about (1 mm) apart from the surface of the specimen to be tested. The reference electrode used in this study was Saturated Calomel Electrode (SCE). The auxiliary electrode used in the electrochemical was platinum type. The specimen holder (working electrode) , together with the reference and auxiliary electrode were inserted in their respective position in the electrochemical cell used for this purpose than can fit all these electrodes as shown in **Figure (2).**

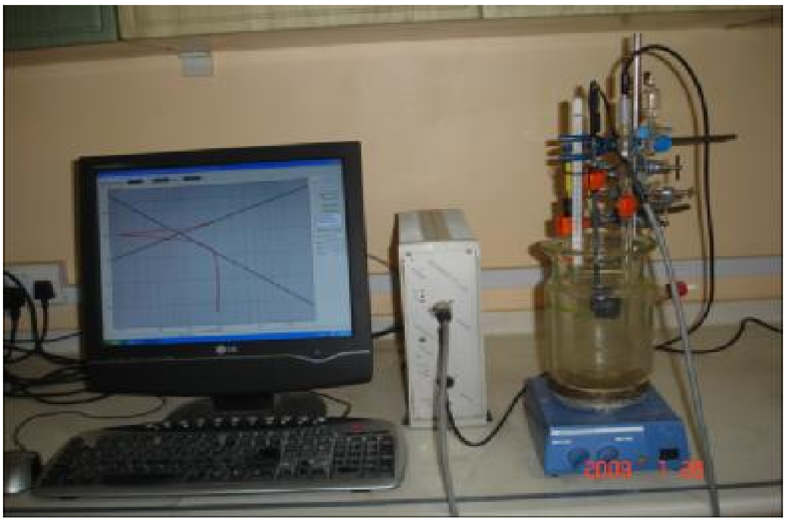

Fig. (2) the electrochemical corrosion unit

Constant potentials (anodic or catholic) can be imposed on the specimen, By using the potentiostat (Mlab200 of bank Eleck. Germany) . This potentiostat is able to induce a constant potentials ranging from (-1 + lv) the potentials of the standard reference electrode used in this study (SCE).

The potential difference between the working and reference electrode (WE – RE) and any current passing in the circuit of working electrode were auxiliary electrode can be measured by using the SCI Computer Software.

Any potential difference between the working and reference electrodes circuit can be automatically recorded using . The result and plots were recorded using window xp. The scan rate can be selected also.

Polarized resistance tests were used to obtain the micro cell corrosion rates . In the tests , cell current reading was taken during a short , slow sweep of the potential . The sweep was taken from (-100 to +100) mv relative to (OPC) .

Scan rate defines the speed of potential sweep in mv/sec. In this range the current density versus voltage curve is almost nearly linear . A linear data fitting of the standard model gives an estimate of the polarization resistance , which used to calculate the corrosion current density (lcorr) and corrosion rate .

The tests were performed by using a WENKING MLab multi channels and SCI MLab corrosion measuring system from Bank Electronics – Intelligent controls GmbH , Germany 2007 , as shown in **Figure (2)** . The result of electrochemical corrosions shown in **Table (3)** by using

Tafel Eq. ($C.R=0.13*l_{cor}*$ eq. Wt/d) [8] ---------------------- (1)

Corrosion rate (C.R) = $0.43* l_{cor}$

Where

mpy = milli – inchs per year

l_{cor} = corrosion current density (mA/cm^2)

d = density of corroding units (g/cm^3)

C.R= corrosion rate

wt.= weight

Results and Discussion

Fig. (1) Shows the microscopic tests specimens given in **table2**

Medium carbon steel as presented by specimens of groups (A, B, C, were specimen Aand C consist of

Ferrite and pearlite and the microstructure of the specimens groups (B) consist of cementite which forming with ferrite a matrix called martensitic in (B), These results agree with the results obtained by Adnan Calic [4] which study the effect of cooling rate on the microstructure. This microstructure has affected on the results of the corrosion behavior

See that in **Figure (3which re-presented** the relationship between the catholic and anodic behavior after polarization test, the corrosion results are shown in **Table (3)**

An increasing in corrosion rate of all specimens groups at velocity (1m/min) has been seen . This is because the ferrite which combined with the dissolved oxygen in sea water causes iron oxide which known as rust while this rate decreased as the velocity increased to (2 and 3) m/min, this is because the movement of the liquid prevents the formation of deposits and ions gathering on cathode pole where corrosion can easily develop

Corrosion rate for specimen (C) gives the best corrosion resistance because of the transformation of retuned Austanite by quenching to Cementite.

While specimen A (gives higher corrosion rate comparing with (C) because of the amount of ferrite which combine with oxygen to produced rust

Table (3) Corrosion test result for all specimens in table 2

Specimen	Velocity m/min	E core (m v)	I core mA/Cm^2	Corrosion rate(m.p y.)
A	1	-619.1	49.65	21.846
A	2	-627.4	36.28	15.96
A	3	-646.1	20.11	8.87
B	1	-579.7	32.15	14.46
B	2	-578	22.59	9.93
B	3	-559.7	20.17	8.874
C	1	-618	26.12	11.49
C	2	-610.5	22.31	9.81
C	3	-606.3	20.36	8.95

Conclusions :

1 - Quenching Heat treatment improves the corrosion resistance by increasing the combination of iron with carbon reducing by that the combination of iron with oxygen which produces rust.

2- Normalizing at 850°C for 0.5 hour then cooling in air gives better results in corrosion resistance than quenching heat because of heomogenies in grain size.

3- Velocity contributed in decreasing the corrosion rate because of reducing the assembling of ions on cathode pole.

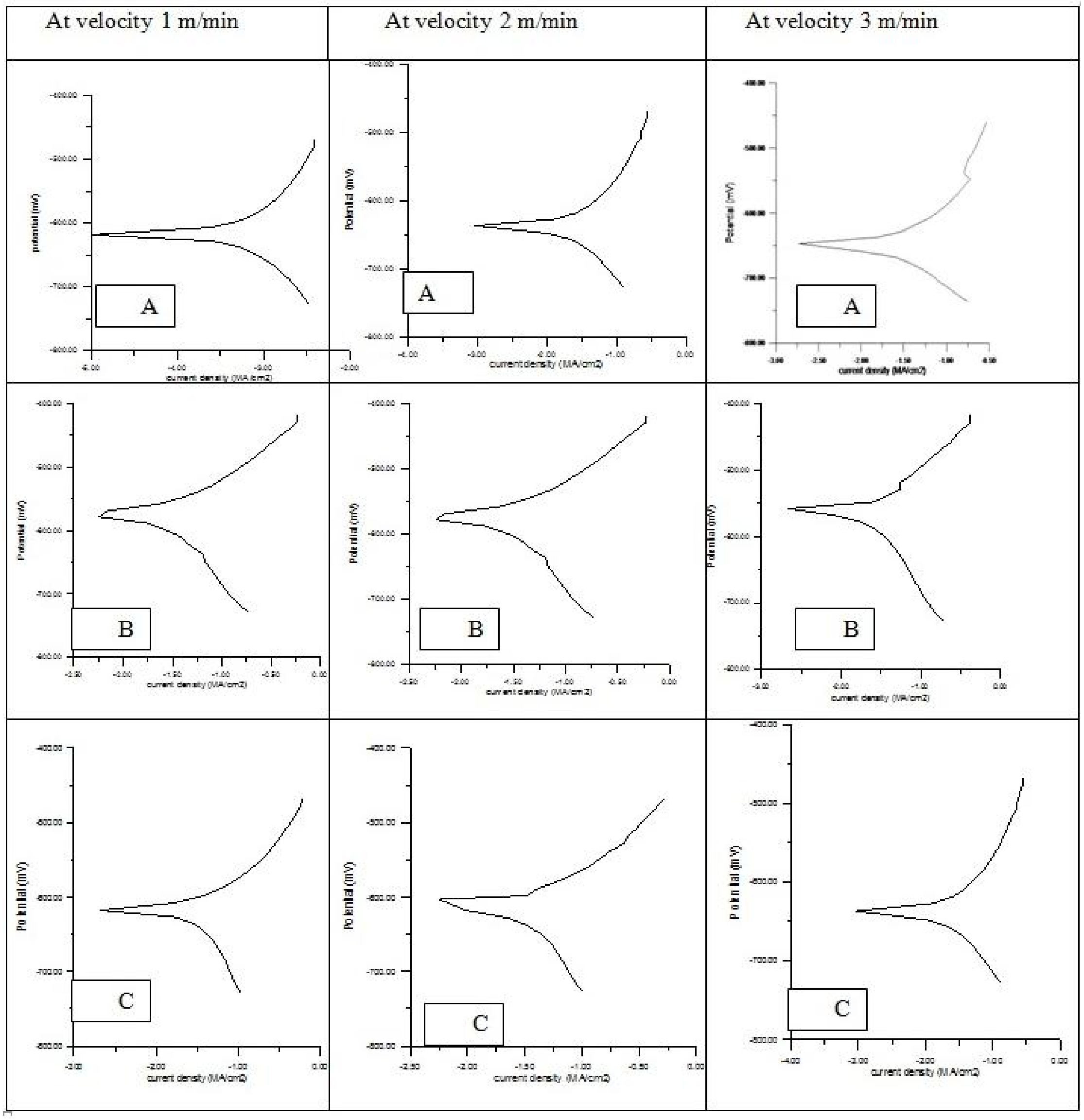

Fig.(3) the relationship between catholic and anodic behavior for all specimen in table 2

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