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Erosion Corrosion behaviors of Various Metals at different variable

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Abstract

Erosion corrosion process is considered one of the main problems to which too ls, machine parts and equipment are subjected and which operate in fluidized media. Solid particles strike them because of fluid motion at different speeds and varying time periods. Erosion corrosion system was made according to ASTM Specification. Circular test samples were made in diameter 15 mm and length of 50 mm from Al alloy 6061-T6 and Free Cut Brass 360 and polymer. Erosion corrosion test was made using weight loss method in sea water and Tigris river water at 500, 400 and 300 rpm for 1, 2, 3, 4.5.6 hrs. From the results reached, it is found that with increase in time, the erosion corrosion rate increases for both mediums because of the effect of medium components such as chlorine and oxygen for a certain period. When the time period increases, it decreases because the oxygen dissolved in water is used up which is responsible for corrosion. Also a protective is formed from the remnants of corrosion process. Moreover, it is found when speed increases, corrosion rate decreases due to speed prevent ion from summing at electrods.
Key Words: Erosion corrosion, Al alloy 6061-T6 , Free Cut Brass 360, ID, Sea water, Tigris River water

1. Introduction

Erosion corrosion is considered one of the main types of corrosion. It is local corrosion resulting from the mechanical effect and the electrochemical nature of the corrosion medium. It involves dissolution of the metal at the surface in the form of dissolved ions. These ions form overhead corrosion products which drift away from the metal surface. An example of this is the corrosion which takes place in the pipes of a heat exchanger. The products which deal with water or the vapor bubbles explode on the metal surface or corrosion may happen because of the media movement on the surface of metals. [1,2]. Erosion corrosion may increase as a result of faulty operation for example the accumulation of deposits at pipe junctions which delay flow of water causing local turbulence or flow at high speed which leads to erosion corrosion. Corrosion accompanies erosion causes high rate of picking. The main mechanism of corrosion is resulting from the turbulent flow of gas, steam ,liquid , bubble collapse causing voids or a hollow space.The factors that effect on erosion corrosion are the nature of metal or alloy in terms of hardness, chemical composition, liquid velocity , nature of flow, and design. The corrosive media which cause corrosion by erosion are gases, dissolved solutions, organic materials and molten metals. Solid materials suspended in a liquid are considered catalytic to erosion corrosion .The parts which are subject to erosion corrosion are pipes of heat exchangers, turbine blades, sewers covers, and instruments which are open to spray and ship, boat and so on [3] many researches study the subject such as:-**Zuhair Talib Khleef** [4] studied the effect of heat treatment and cold forming on erosion corrosion behavior of (Al-2Cu-2Mg) alloy in (1M) of (NaCl) at room temperature and cold forming at ratio 15-18 %. It was found that with increase in cold forming, erosion corrosion rate increases. **Sundews Mohamed Norrie[5]** Studies the advance resistance for the medium carbon steel to erosion corrosion by coated with electro less nickel plating using acid bath (Hydrogen number Ph = 4.5) which carry out at deferent temperature (70,75,80,85,90°C) to get deferent precipitation rate of coating. She designed device and manufactured in agreement with[ASTM (G73)] with certain adjustment , erosion corrosion was done using sodium chloride(3.5wt %) Nacl solution as sea water purged with CO_2 gas as the corrosive media and 1wt % silica sand was added as slurry to that media. Weight losses method was used and corrosion rate was calculated, it was found that corrosion rate decrease with increase value of hardness which increase at increase temperature of coating solution. And also study the effect of heat treatment which carry out at temperature (300,400,500,700,800°C for coated specimens .the result show that corrosion rate decrease at increase heat treatment temperature. The best result was established at temperature 800°C **Kharia Salman Hassan[6]** studying the influence of shot peening time which carry out at times ((15, 30, 45) min on corrosion behaviors of AA 6061-T6 in aqueous solutions . Such as 3 .5% NaCl solution and tap water. Corrosion rate was calculated using tafel equation. 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**. carroll a. smith [7]**, Studied the velocity impact on the corrosion of metals in sea water, the corrosion of metals in sea water may be supposed as the result of interaction between the characteristic of the metals involved and the properties of the surroundings. He clears that the velocity of the corroding media is an important factor in all forms of corrosion and he observed that by using Hydrofoil craft we can determined the range of water velocities and are normally subjected to times of inactivity interrupted by times of high stress and velocity

and found those metals which stand up well to 90 knots speeds commonly pit and corrode during lazy times, threatening the service of the vehicle. Materials well suited to static exposure are severely attacked by erosion corrosion, cavitation, and the stripping of protective oxide films at high speeds, in this paper the impact of many parameters such as type of metals, time, media and velocity were actualizing.

2. Experimental Part

It includes making erosion corrosion test apparatus according to ASTM standard shown in Fig (1). The programmed machine tools including a lathe and milling machine were used to make the parts.

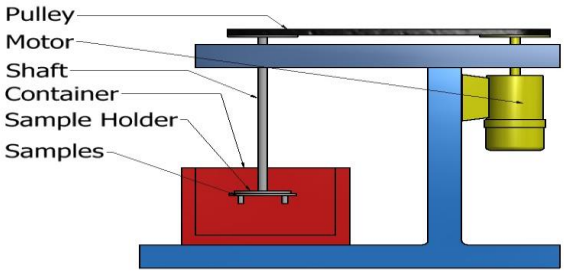

Figure (1) Assembly of erosion system

3. Metal Tests

Al alloy 6061-T6 was selected for test because it is widely used in engineering applications such as automobile parts and ships and Free Cut Brass 360ID used in making screws for joining automatic machine parts, valves and fluid flow measuring instruments and so on. The chemical analysis of the metals used is shown in Tables (1) and (2) also polymer which have many applications in industry is used.

The test was carried out in the following steps

1-The samples were washed with diluted HCL in 10% concentration after which they were dried with an electric drier.

2-Every sample was weighed with a sensitive electronic balance type (Sartorius) with accuracy (0.0001) mg. The measurement results were recorded.

Table (1) The chemical analysis of Al alloy 6061- T6

Eleme -Wt%	Cr	Fe	Cu	Mg	Mn	Si	Zn	AL
Meas-value	0.13	0.28	0.13	1.01	0.00	0.58	0.03	Rem
Slan-value [8]	0.04 - 0.35	Max 0.7	0.15-0.4	0.8 - 1.2	Max 0.15	0.4 - 0.8	0.25	Rem

Table (2) The chemical analysis of Free Cut Brass 360, ID

Wt%	Cu	Pb	Mn	Ni	Bi	Zn	Sn	Fe	Se
Meas u	59. 9	2.61	0.0 3	0.3 7	0.0 0	36.95	0.0 1	0.3 4	0.0 2
Slan d-value [8]	60 - 61	2.5-3.5	-	=	-	Rem	-	0.3 5	-

4. Manufacturing.Erosion.Corrosion Test Samples

A number of erosion corrosion test samples were made from selected metals (according to ASTM standard). They were 15 mm in diameter and 50 mm in length.

4.1 Categorization Test Samples

After the test samples were made, they were classified and encoded as shown in Table (3).

.Table (3) Encoding test samples

Group symbol	Status
A	Samples from Al alloy 6061-T6
B	Samples from Free Cut Brass 360,
C	Samples from polymer

5.1 Preparation of corrosive media.

The following media were used;

1-Laboratory sea water ,35gm of NaCl was added to 1liter of distilled water, making sure that NaCl dissolves completely before the samples were immersed.

2-Water from Tigris River, a sample of Tigris River was taken from some distance from the bank. Chemical and physical analyses were conducted in the Water Treatment Department and the results are shown in Table (4).

Table (4) The result of chemical and physical analyses.

Properties	Laboratory sea water	.Water from Tigris River
Calcium mg/L	260	120
mg/L $(Cl)^{-}$	1596	38
mg/L Mg^{+2}	32.3	25.54
Mg/L Ca^{+2}	104.4	50.23
PH	5.99	8.53
Electrical Conductivity	775	486

Corrosion tests were carried out on the samples listed in Table (3) as follows, they were immersed completely for length 20 mm in selected media after they suspended vertically in the system tank using a holder made for this purpose Fig. (2). The tank was closed tightly so that the process was carried out in a closed atmosphere to prevent

oxygen in air from dissolving in the corrosive medium. All corrosion tests were carried out on at room temperature during the time specified for each test, that is, 1, 2, 3, 4, 5, 6 hrs. The device was rotating at 500m/min. At the end of exposure time, the samples were taken out, washed with alcohol, and weighed after the test. The experiments were repeated after the time was fixed (2) hrs. and the speed was changed to 300.400m/min.

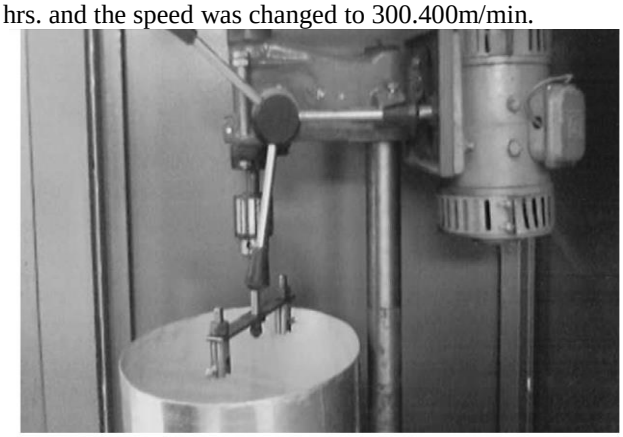

Figure (2) how the device works5.2

5.2 Calculating Corrosion Rate

Corrosion rate is decided using the main function, that is, loss in weight CR = (Δw/A) A during the test over the unit of surface exposed to corrosion (A) cm^2

CR: corrosion rate

Δw: weight loss in gm.

A; surface area exposed to corrosion (A)cm^2

T: time of exposure to corrosive medium measured in hours

Test results are shown in Tables (5, 6,7, 8,9 and10) and Fig (3, 4).

Table (5) Results corrosion test of Al alloy 6061-T6 in sea water with variable time.

Corrosion rate (g/cm^2hr)	Δwweight difference in gm	Weight after test in gm	Weight before test in gm	Time in hrs
0.0014	0.0100	26.8600	26.8700	1
0.0101	0.0709	26.7891	26.8600	2
0.0251	0.177	26.600	26.77	3
0.0326	0.23	26.770	7.00	4
0.0185	0.1309	27.6443	27.7752	5
0.0160	. 0.1104	27.6400	27.6504	6

Table(6)Results corrosion test of Al alloy 6061-T6 in Tigris river water with variable time

Corrosion rate (g/cm^2hr) in	ΔWweight difference in gm	Weight after test in gm	Weight before test in gm	Time in hrs.
0.0014	0.01	26.6000	26.6100	1
0.0028	0.02	26.7500	26.7700	2
0.0113	0.08	26.000	26.0800	3
0.0198	0.14	26.6100	26.75	4
0.0057	0.0400	26.6100	26.6500	5
0.0086	0.0620	26.6200	26.6820	6

Table (7) Results corrosion test of Free Cut Brass 360 in sea water with variable time

corrosion Rate (g/cm^2hr)	**ΔWweight difference in gm**	**Weight after test in gm**	**Weight before test in gm**	**Time in hrs**
0.0042	0.03	74.45	74.4800	1
0.0099	0.07	74.00	74.0700	2
0.0136	0.68	74.07	74.7500	3
0.0057	0.04	74.00	74.040	4
0.0028	0.0200	74.012	74.032	5
00	00	74.00	74.00	6

Table (8) Results corrosion test of Free Cut Brass 360 in Tigris water with variable time

Corrosion rate in (g/cm^2hr)	ΔWweight difference in gm	Weight after test in gm	Weight before test in gm	Time in hrs
0.0042	0.03	74.410	74.4400	1
0.0084	0.06	74.440	74.5000	2
0.0255	0.18	74.350	74.43	3
0.0297	0.21	74.230	74.44	4
0.0058	0.0410	74.220	74.2610	5
0.0028	0.0200	74.230	74.2500	6

Table (9) Results corrosion test of polymer (Teflon) in sea water with variable time

corrosion Rate (g/cm^2hr)	ΔWweight difference in gm	Weight after test in gm	Weight before test in gm	Time in hrs.
00	00	9.00	9.00	1
0.1118	0.79	8.9900	9.6000	2
0.0014	0.01	8.99	9.00	3
0.0283	0.2	8.800	9.00	4
0.0169	0.12	8.88	9.00	5
0.0028	0.02	8.8700	8.8900	6

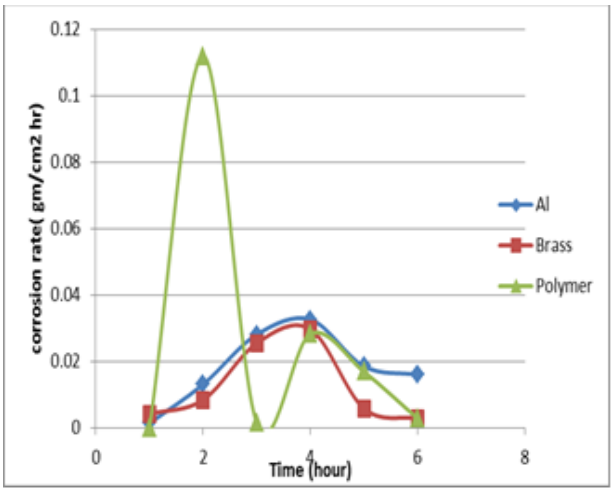

Figure (3) The relation between time and corrosion rate in sea water medium

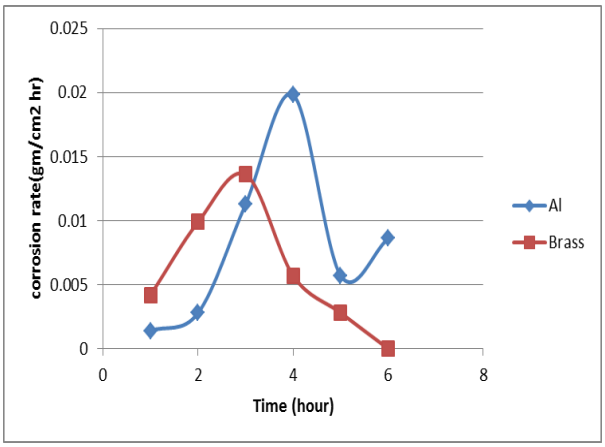

Figure (4) The relation between time and corrosion rate in Tigris river water medium.

Table (10) Results corrosion test of samples of group (A and B) in sea water with variable velocity.

Speed m/min	ΔW weight difference For sample (A) in gm	Corrosion ate of Sample (A) (g/cm^2hr)	ΔW Weight difference for sample(B) in gm	Corrosion ate of sample (B) (g/cm^2hr)
300	0.2	0.0283	0.2	0.0283
400	0.1	0.014	0.1	0.014
500	0.07	0.0101	0.06	0.0084

6. DISCUSSION

The main goal of this research is studying the effect of metal type, medium, velocity and time of exposure on corrosion rates. The research results are shown in Tables (5,6,7,8,9, and10) and Fig (3,4). The rotation speed of the medium was constant at 500 rpm .The results show the difference is due to metal because polymer (Teflon) gave the lowest and brass the highest because of the difference in electrical conductivity of the metal used as well as the medium used, Table (4) As regards the effect of medium type on corrosion rate, it was found the medium of sea water gave higher results than Tigris river water because sea water contains high concentration of chlorine ion, making sea water active in electro-chemical reactions. Moreover, chlorine helps to spread the reaction through most of the surface area through electrical conduction which characterizes these salts. It was also found the duration of exposure to corrosive medium has clear effect. The corrosion rate increases with duration for all media. The highest corrosion rate was at duration of (4) hours after which it begins to decrease. This was found at duration of (4) hours because electro-chemical reactions are slow and form deposits on the surface, hindering corrosion process and making it go slow. Also the amount of oxygen dissolved in the medium plays a role. At the beginning of the test there is a good amount of oxygen and the reaction takes place quickly, resulting in high corrosion rates. With passage of time, the amount of dissolved oxygen is reduced, resulting in increase in concentration of hydrogen ions which accumulate at the anode,

7. Conclusions

1-Corrosion rate in sea water is higher than that in Tigris river water

2-Corrosion rates decrease with increase in exposure to corrosive medium. In other words, the duration of immersion in a corrosive medium, the more resistant the metal becomes to corrosion and rusting

3- It has been that lowest corrosion rates take place when the metal is expoed to corrosive medium for six hours. In this research, the highest corrosion rates were obtained during 4-hour exposure.

4-When speed increases, corrosion rates are found to decrease because liquid motion plays a role in removing deposits from the surface which cause corrosion.

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