THE IMPACT OF CORROSION ON (Cu_37 Zn) ALLOYS WELDED BY OXY- ACETYLENE WITH THREE TYPES OF FILLER RODS BY WEIGHT LOSSES METHOD

Assistant Lecturer: Aysha Shawkat Hasan, Commission of Technical Education , Technical College, Fuel & Energy Eng. Department

Email: eng_aysha@yahoo.com

Received 1 April 2015 Accepted 27 August 2015

ABSTRACT

Brass is alloys of copper consisting mainly of copper and zinc, and it is welded in the same general manner as copper, but because of the peculiar properties of the alloying metals zinc, it is that must receive certain variation in welding. And because of viral application as structural materials in industries, in this work the weight losses method used to study the general corrosion behavior of α – Brass (Cu – 37 Zn) alloy weldments were welded by Oxygen – Acetylene mixture with three types of filler rods, α – Brass, $\alpha - \beta$ Brass and Tin – brass in sulfuric acid and sodium hydroxide solution at room–temperature (298k),where also the microstructure of these weldments before and after corrosion was studied. The results obtained shows that the acidic medium is more aggressive than alkaline medium for the three weldments and the total corrosion rate for three types of weldments in acidic medium was (0.085155 MPY) which was more than from alkaline medium total corrosion rate (0.030745MPY) for the same wldments, it is also found that longer exposure time to corrosion medium, leads to a lower corrosion rate while weight loss is still increasing.

Keywords: corrosion, brass weldments, filler rods, alkaline medium, acidic medium, Oxygen – Acetylene welding.

تاثير التاكل على سبائك ((النحاس – 37 الزنك) الملحومة بالاوكسجين- استيلين باستخدام ثلاثة انواع من قضبان الحشو بطريقة الفقدان في الوزن

مدرس مساعد: عائشة شوكت حسن، هيئة التعليم التقني، الكلية التقنية، قسم هندسة الوقود والطاقة.

المقدمة

البراص هواحد سبائك النحاس يتكون أساسا من النحاس والزنك، وطريقة لحامه بنفس طريقة لحام النحاس، ولكن اضافة الزنك يكسبه خصائص غريبة في عملية اللحام. وبسبب التطبيقات المختلفة كمعادن هيكلية في الصناعات، فقد تم في هذا البحث استخدام طريقة الفقدان في الوزن لدراسة سلوك التآكل العام لملحومات سبيكة الفا براص (النحاس – 37 الزنك) والملحومة بخليط الأكسجين - الأسيتيلين باستخدام ثلاثة أنواع من قضبان حشو، الفا براص، الفا بيتا براص والقصدير – براص في محلول حامض الكبريتيك ومحلول هيدروكسيد الصوديوم عند درجة حرارة (298كلفن)، كما ايضا" لقد تم دراسة البنية المجهرية لهذه الملحومات قبل وبعد التاكل. ولقد تبين من النتائج المستحصل عليها أن الاوساط الحامضية هي الأكثر تاثيرا" من الأوساط القاعدية للملحومات الثلاثة ومعدل التاكل الكلي للملحومات الثلاثة في الوسط الحامضي كان (0.085155 MPY) الذي هو اكبر من

معدل التاكل الكلي في الوسط القاعدي للمحلومات ذاتها ليبلغ قيمته (0.030745MPY) ، ووجد أيضاً أنه كلما كان زمن التعرض لوسط التآكل أطول كان معدل التآكل أقل مع بقاء استمرار الزيادة في فقدان الوزن.

كلمات رئيسية: تاكل، ملحومات البراص، قضبان الحشو، وسط قاعدي، وسط حامضي،لحام الاوكسجين-الاستيلين.

INTRODUCTION

Copper and its alloys are widely used in many industrial fields, especially in marine applications, external constructions as roofs, facades and claddings. the superior properties of copper and its alloys may be attributed to beneficial, physical, mechanical and corrosion resistance properties. Brass have various industrial applications and economic importance due to resistance against corrosion [1-5]. Copper alloys in which zinc is the major alloying element are generally called Brasses. Some Copper – Zinc alloys have other common or trade names, such as commercial Bronze, Muntz metal, Manganese Bronze and low – fuming Bronze, Other elements are occasionally added to Brasses to enhance particular mechanical or corrosion characteristics. Addition of Zinc to copper decrease the melting temperature, the density, the electrical and thermal conductivity, and the modulus of elasticity, Zinc addition increase the strength, hardness, ductility, and the coefficient of thermal expansion. The color of Brass changes with increasing Zinc content from reddish to gold to alight gold and filler metal may depend on matching the Brass color when joint appearance is important. Most Brasses are single – phase, solid solution, Copper – Zinc alloys with good room – temperature ductility. Brasses containing about 36 percent or more Zinc have two microstructure phase designated alpha and beta. Copper and most Copper alloys are readily soldered with commercial solders. Most Copper alloys are easily fluxed, except for those containing elements which from refractory oxides. (e.g., Beryllium, Aluminum, Silicon or Chromium). Special fluxes are required to remove refractory oxides that from on the surface of these alloys [6]. Because of the high corrosion resistance of the brass it is widely applied as structural materials in industries. For the brass, the conventional fusion welding has some obvious limitations. During the fusion welding, the evaporation and melting loss of a large amount of Zn element resulted in the failure of welded joint due to lower steam point of Zn which is (907 ^{o}C)[4]. The alloying metal Zn is greatly affected by the high temp of the flame, unless proper precautions are taken. These metals will combine with the oxygen and pass off as white vapor, and leave a weld of different composition and color [7]. The alloying metal Zn is greatly affected by the high temp of the flame, unless proper precautions are taken. These metals will combine with the oxygen and pass off as white vapor, and leave a weld of different composition and color [8].It is sometimes difficult to determine why welds corrode; however, one or more of the following factors often are implicated: Weldment design, Fabrication technique, Welding practice, Welding sequence, Moisture contamination, Organic or inorganic chemical species, Oxide film and scale, Weld slag and spatter, Incomplete weld penetration or fusion, Porosity, Cracks (crevices), High residual stresses, Improper choice of filler metal, Final surface finish [5].

The researcher Nooredeen Fathalla Soulyman (2005) studied the general corrosion behavior of α – Brass (Cu – 37 Zn) alloy weldments in sulfuric acid and sodium hydroxide solution at room– temperature (298k) by using the electrochemical cell corrosion test method[9]. Ashok Kumar , R. Shukla and A Venk at chalam (2013) studied Copper Aluminum metals and Brass alloy in the form of 8 x 6 x 0.3 cm strips under different medium is undertaken and study reveals that corrosion rate increases in the following order Al > Fe > Cu > Brass and for the medium in which the corrosion takes place in the order of HNO3 >H3PO4 > H2SO4 > HCl > CH3COOH [2]. W.F. Savage , E.F. Nippes and T.W. Miller (2013) studied the partially melted regions of gas tungsten – are welds made in a 70 Cu – 30 Ni [10].

And because of viral application as structural materials in industries, in this work the general corrosion behavior of α – Brass (Cu – 37 Zn) alloy weldments in sulfuric acid and sodium hydroxide solution at room–temperature (298k), also the microstructure of these weldments before and after corrosion was studied for the specimens α–Brass (Cu – 37 Zn) alloys were welded by Oxygen – Acetylene mixture with three types of filler rods, α – Brass, α – β Brass and Tin – brass by weight losses method.

EXPERIMENTAL

Materials

Different Samples of α – Brass alloys were used in this work. The brass is a Copper –30Zinc which shown the chemical composition of it in table (1), having mainly alpha phase structure in the heat treated condition with a fine dispersion of lead particles. It has excellent machinability, good cold forming properties, with a high resistance to dezincification [11]. Different welding filler rods used in this work, the principle types of the filler rods shown in table (2).

EQUIPMENT AND EXPERIMENTAL

The following machines and equipment were used :

1. Saw bar.
2. Electrical Furnace for preparing samples for welding process.
3. Oxy – Acetylene welding machine.
4. (α – Brass) weldments
5. Three types of filler rods (Cu – 30 Zn), (Cu – 40 Zn) and Tin – Brass.
6. Milling machines.
7. Sensitive balance device (four digits).
8. Sulfuric acidic concentrated solution (H_2SO_4).
9. Sodium hydroxide solution (NaOH).
10. Distilled water with PH=7.4.
11. PH meter.

THE PREPARATION OF SPECIMENS FOR WELDING PURPOSE

The preparation samples for welding purpose was done by the following steps:

A. Cutting the Samples

1. The samples cut from the plate of Brass with dimension (250mm) length and (122mm) width by saw bar.
2. The edge of the sample were chamfered by milling machine with grove angle (70°) .

3. Cleaning the samples by alcohol from oils and grease .
4. Fixing the samples by back strip to preparing them for welding[12] .

B. Preheating the Samples

Preheating the specimens results in the rapid conduction of heat from the weld joint in to the surrounding base metal due to its relative high thermal conductivity. This makes achieving fusion and weld penetration difficult [1].Heating the samples in electric furnace to (200-300) ^{o}C and preparing the samples for welding, the most common method to counteract the effects of thermal conductivity and which is used in this work. The second steps followed to finish the welding operation by Oxy – Acetylene, and the flame which its properties shown in table (3) were:

Maintain root gap between two joint parts in limits of (3mm) to obtain good penetration for welding metals, the distance between the internal core of welding flame and the specimen welded is (3-6) mm, the flat position welding process by back hand technique was used with low oxidation flame[8] and finally a suitable flux used, to dissolve any oxidation and to give a film or protecting to the fused material to prevent oxidation [11].

CORROSION TESTS

The following steps were followed to prepare the specimen[13], for studying the corrosion behavior of the weldments:

A. Weld Zone Preparing

- Cutting the weld zone by cutting tools with dimensions of (1x1) cm^3.
- Grinding them using wet grinding (120, 220, 240, 320, 400, 600) to prevent the increase of temperature, which will change the compositions of the materials.
- Polishing specimens by Aluminum Oxides with diamond and paste.
- Washing specimens by distilled water and degreased with ethanol and dried [8].
- Weighing them by sensitive balance with four digits accuracy to fixing the initial weight for the specimens.

B. Corrosion Medium

After prepare the specimens for the weld zone, the specimens marked to recognize one from another and make hole (2mm) in each specimens to hung by tungsten wire immersion in selected medium in backer with (1000 mm) capacity. Two mediums used to corrosion tests in this work:

- **Acidic Medium**

Three Samples of weldments, which were welded by brass (Cu–30Zn), brass (Cu–40Zn) and (Tin – Brass) filler rods were immersions in H_2SO_4 solution with purity of 98% and PH= 2.

- **Alkaline Medium**

Three samples of weldments, which were welded by brass (Cu–30Zn), brass (Cu – 40 Zn) and (Tin – Brass) filler rods were immersions in NaOH solution with purity of 96% and PH = 12.

C. Intervals Of Corrosion Test

The Corrosion test were done in 5 days (120 hours):

First interval: for 1 day, 24 hour.

Second interval: for 2 day, 48 hour.

Third interval: for 3 day, 72 hour.

Fourth interval: for 4 day, 96 hour.

Fifth interval: for 5 day, 120 hour.

D. Calculation Of Corrosion Rates

1. After the corrosion tests finished the samples taken from the corrosion mediums and cleaned from the oxidation layers which caused from the corrosion and by using smooth brush and then immersed in (HCL) and then washed and dried and weighing the samples. The previous steps was followed at the end of each interval for corrosion to know the difference of weight between the before and after the corrosion. The loss of weight was used to know the corrosion, and the formula for calculating the corrosion rate is[14]:

$$\text{Corrosion rates (Miles per year)} = 534\ W / DAT \qquad (1)$$

Where

534 : Constant.

W : weight loss in mg .

D : density of specimen in $g/cm^3 = 8.379\ g/cm^2$

A : area of specimen in Sq. in = 0.396

T:exposure time hour.

2. Total corrosion rates (Cr_T) also calculated from the equation (1) by substitute instead of (W) the difference between the initial weight and the last weight, and instead of the time the total exposure time to corrosion medium which was (120hr).

RESULTS AND DISCUSSIONS

The General Behavior of Corrosion And The Corrosion Rates for The Weldments:

1. The general Corrosion behavior for (α – Brass) (Cu – 37 Zn) alloy weldments by three different filler rods was obviously shown from figure(1).The corrosion rate is increasing with high percentage until the time reaches to (3hr) then its start, to decrease sharply with increasing the period of exposure until the time reaches to (20hr) and the decreasing continue but in slowly shape. With increasing time of corrosion the corrosion rate decrease

until it be there is no corrosion or it at zero and this result was for the three different weldments but with different percentages.

The maximum total corrosion rate done in (Cu–40Zn) weldments which equal to (0.002775MPY), and minimum total corrosion rate was done in (Cu–30Zn) weldments which equal to (0.000075 MPY), as shown in figure(2), referring to studies and researchers in [9]. The possible reason for this because the (Cu-40Zn) weldment has the maximum content of zinc (40 %), and Zinc tend to oxidize due to its electrode potential (-0.76V), and the corrosion of (Tin – Brass) weldment (Cu –39 Zn –1Sn) is less than the first one due to the percentage of Zinc (39 %) and Tin (1 %), and since the Tin's electrode potential is (+0.15 Volt), this weldment was less active. And the minimum corrosion which done in the (Cu – 30 Zn) weldment was due to the (30 %) of Zinc content. The chemical equation of elements in the weldments with sulfuric acid is:

$$M + H_2SO_4 \rightleftharpoons MSO_4 + H_2 \qquad \text{where M is Zn, Sn \& Cu.}$$

2. While the samples which immersion in the (NaOH) as alkaline medium the corrosion rate increasing with high percentage until the time reaches to (5hr) then decreasing sharply with increasing the period exposure until the time reaches to (20hr) and the decreasing continues but slowly. With increasing the time of corrosion, the corrosion rate decrease until it be there is no corrosion or it at zero and this result was for the (Cu –30Zn) weldments, and the same behavior for the another two weldments just the difference for the time reaches to the peak rate of corrosion was at (3hr) but with different percentages and this behaviors clearly show in figure(3).The total corrosion rate for three types of weldments with alkaline medium immersing can be seen in figure(4) which shows the maximum total corrosion rate in (Cu–30Zn) weldment with (0.00040833MPY) and minimum total corrosion rate in(Cu–40Zn) weldment with (0.00036667MPY). The chemical equation of elements in the weldments with alkaline is:

$$M + 2NaOH + 2H_2O \rightleftharpoons Na_2M(OH)_4 + H_2 \qquad \text{where M is Zn, Sn \& Cu.}$$

3. In general the total corrosion rate in acidic medium for weldments with three types of filler rods was more than from the specimens in alkaline medium as shown in figure(5)and the peak total corrosion rate was (0.085155MPY) in acidic medium, meanwhile in alkaline medium the peak total corrosion rate was (0.030745MPY) referring to the studies and researchers in [15], all these obviously shown in figure(6) which represents the compartive between two mediums for the total corrosion rate for specimens were used in this work.

4. The reason for the low corrosion rates with increased exposure to the medium of corrosion due to the slow time speed of Electrochemical interaction with continued exposure time due to form layers of membrane or remnants of corrosion on weldments surfaces hinder the continuation of the process of electrochemical corrosion, which leads to reduced rates with the continued erosion of time. And also because of depletion of dissolved oxygen in the medium of corrosion, that at the beginning electrochemical corrosion test interaction which happens quickly lead to a high erosion rates, but with the passage while less dissolved oxygen ratio, leading to increased the concentration of hydrogen ions that accumulate when the lift pole where interactions hinder corrosion, this is named polarization referring to studies and researchers in[5].

DISCUSSIONS

1. From The obtained results for the specimens were immersed in acidic medium its clearly show that the corrosion effort be more aggressive due to the following order of corrosion activity:

   Cu – 40 Zn > Tin – Brass > Cu – 30 Zn .

2. From The obtained results for the specimens were immersed in alkaline medium its clearly show that the corrosion effort be more aggressive due to the following order of corrosion activity:

   Cu – 30 Zn > Tin – Brass > Cu – 40 Zn

3. The corrosion rates in acidic medium were higher than the corrosion rates in alkaline medium.
4. The corrosion rate decreasing with increasing the interval of the corrosion due to the slow time speed of electrochemical interaction with continued exposure time due to form layers.

REFERENCES

[1] American Welding Society, 1992. Welding Copper and Copper Alloys , 550 N .W. Le Jeune Road , Miami , FL 33126.

[2] Ashok Kumar, R. Shukla and Venkatachalam, 2013. Studies of Corrosion and Electrochemical Behavior of Some Metals and Brass Alloy Under Different Medium, Rasayan Journal Chemistry, 6(1): 12-14.

[3] Billy, F., 1985. Engineering Material Hand Books, Translated by Dr.Hussein Baqir, Technical College, Baghdad, Iraq.

[4] China Machine press, Benjing, Welding Hand Book, 1992, 2: 469-471. Davis, J.R. and Associates, 2006. Corrosion of Weldments,

[5] Stephen C. D., 2003,Galvanic Corrosion ,University of Delaware, U. S. A.

[6] EL- Mahdy G.A. Amro K.F. Dyab, M. Ayman Atta, A. Hamad Al-Lohedam,2013. Brass Corrosion Under a Single Doplet of NaCl, International Journal of Electrochemical Science, 8:9858-9867.

[7] Rauf, A. and E. Mahdi 2012. Evaluating Corrosion Inhibitors with the Help of Electrochemical Measurements Including Electrochemical Frequency Modulation, International Journal of Electrochemical Science, 7: 4673-4685.

[8] Robert, J., M.E. Kehl, 1918, Oxy – Acetylene Welding Practice, Consulting Mechanical Engineering, American Technical Society, Chicago.

[9] Nooreldeen Fathalla Soulyman, 2005, Corrosion Behavior of Some Brass Welding in Different Medium, B .Sc. Thesis, Republic of Iraq, Ministry of Higher education and Scientific of Technical education Technical College / Baghdad.

[10] Savage, W.F., E.F. Nippes and T.W. Miller, 1976. Microsegregation in Partially Melted Regions of 70 Cu – 30 Ni Weldments, Welding Journal , July: pp: 181-187.

[11] Voortand F. George, 2004. ASM Metals Hand Book, ASM International Materials Collection Metallurgaphy and Microstructure.

[12] ASM hand book , 2004, Metallurgaphy and Microstructure, Volume(9), 107 .

[13] ASME, 2010. Specification of Welding Rod and Electrode, Part C.

[14] Velayutham K., U. Arumugham, B. Kumarugur-rubaran, P. Gopal, 2013. Evaluation of the Anti-Corrosive Coating on Railway Bogie Components, International Jounal of Engineering and Advanced Technology, 3(2): 2249-8958.

[15] Zhuo Yuan Chen, 2005, The Role of Particles on initial Atmospheric Corrosion of Copper and Zinc, Royal Insitute of Technology, Sweden, P(29).

Table 1: Chemical composition for the base metal (α – Brass)

Element	% Percentage	Element	% Percentage
Cu	62.68	Bi	o.o44
Al	0.00131	Sn	0.0043
Fe	0.156	Zn	37.07
Ni	0.00125	Mn	0.021
Pb	0.0106	Sb	0.002
Si	0.0031		

Table 2: Principle types of welding rods

Procedure	Type of filler rod	Chemical composition%
Oxy – Acetylene welding	R Cu – Zn	Cu - 30 Zn
	R Cu – Zn	Cu - 40 Zn
	R Cu – Zn – Sn	Cu -39 Zn – 1 Sn

Table 3: Cases of welding brass by oxy – acetylene[8]

Tip size	Plate thickness mm	Pressure kg/cm^3		Gas consumption L/ Min	
		O_2 min	C_2H_2 max	Min	Max
70	8.19	0.77	1.54	37.5	70

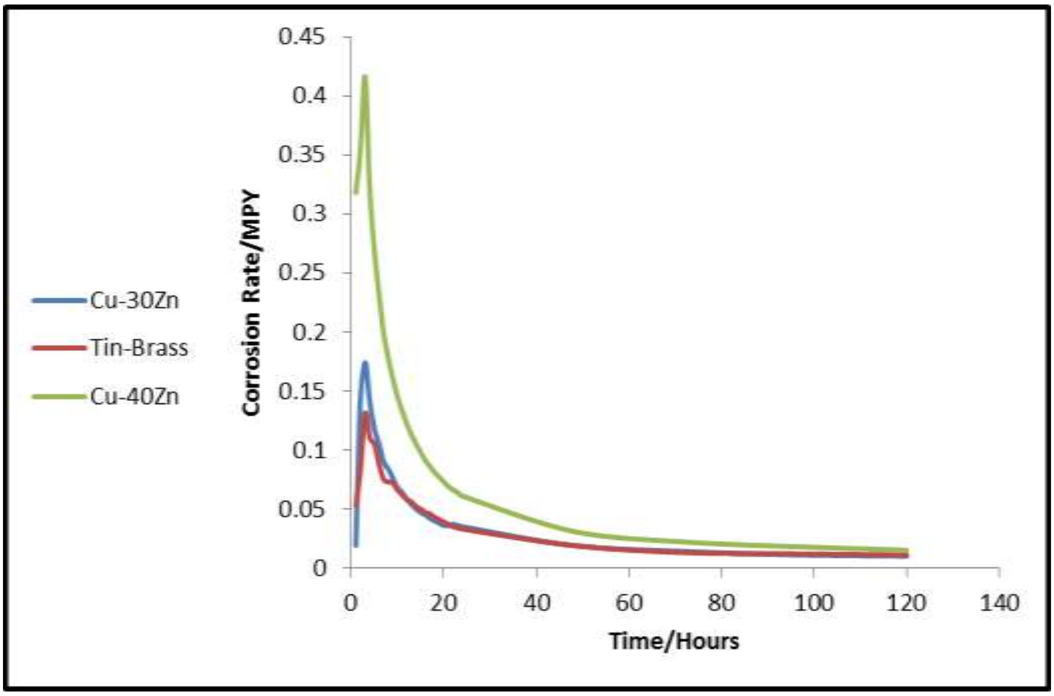

Figure (1) : Corrosion rate in sulfuric acid immersion for three filler rods

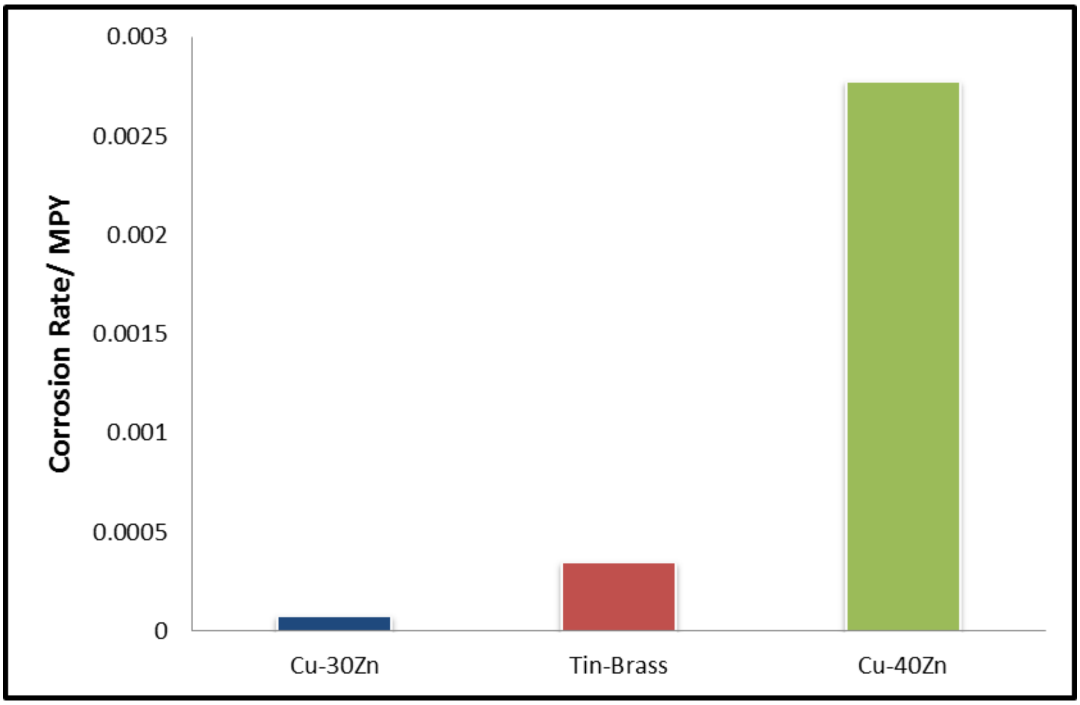

Figure (2): The total corrosion rates for three weldments immersed in acidic medium.

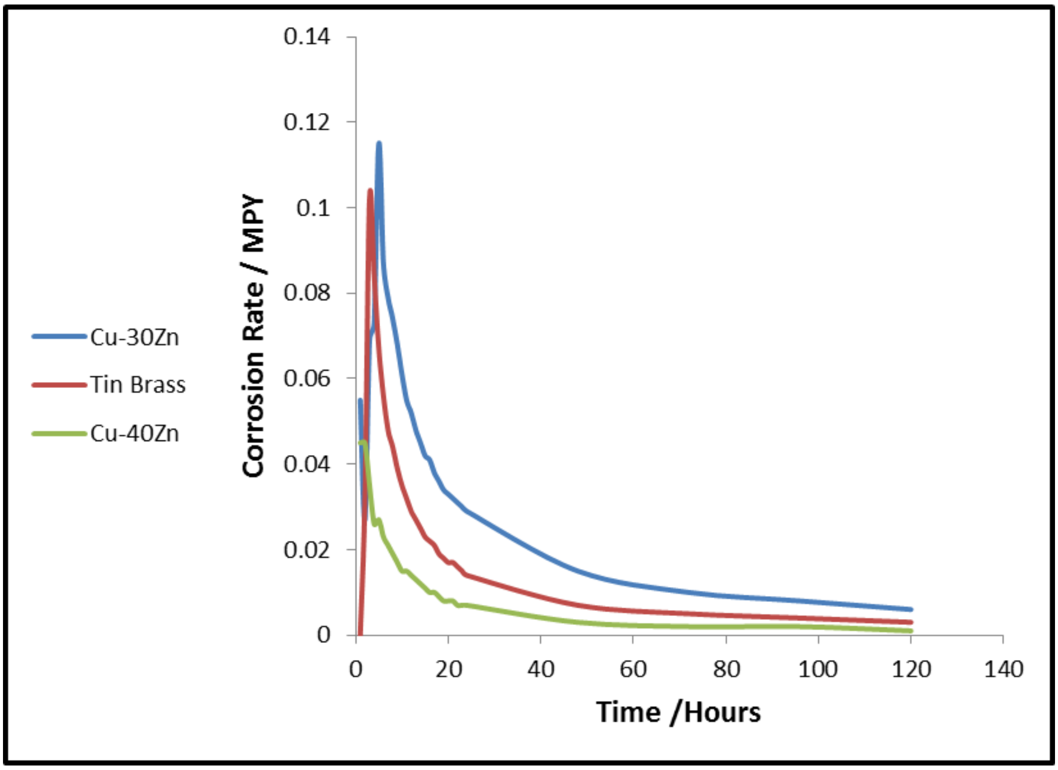

Figure (3): Corrosion rate in alkaline immersion for three filler rods

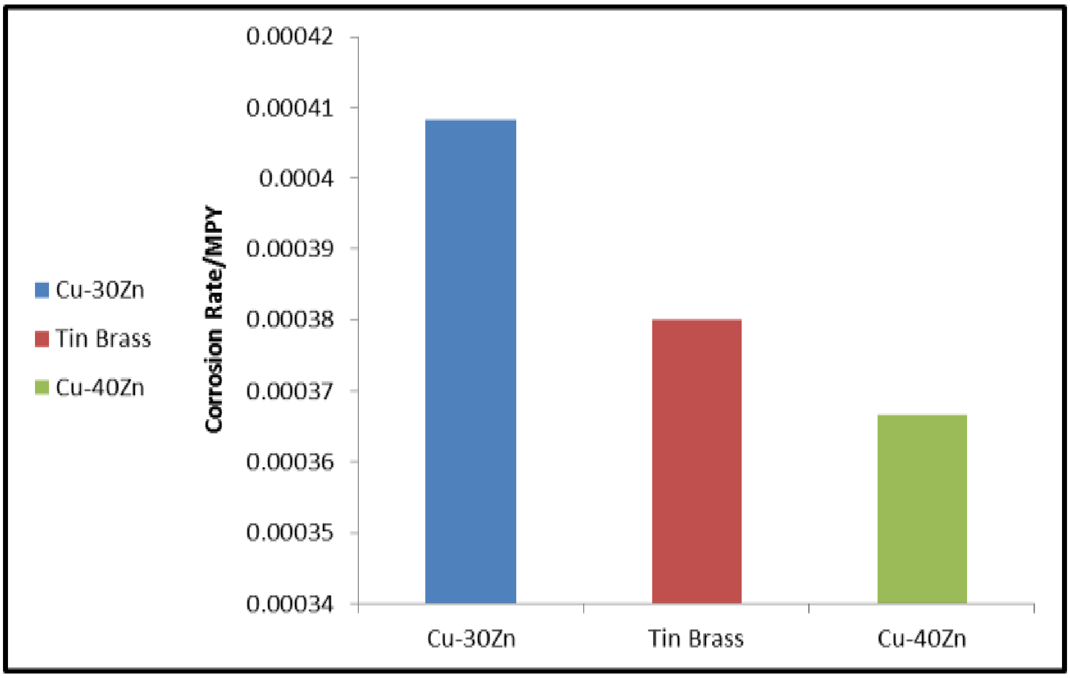

Figure (4): The total corrosion rates for three weldments immersed in alkaline medium.

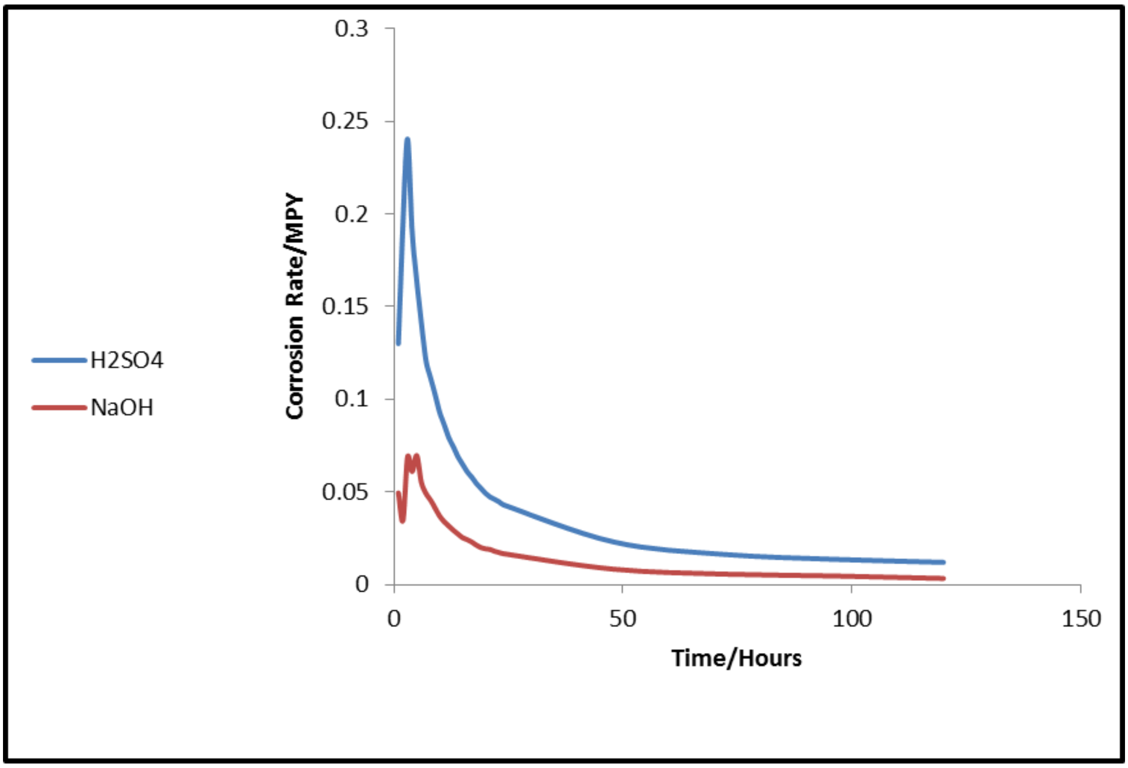

Figure (5): The comparative of the average corrosion rate for three types of weldments between two mediums.

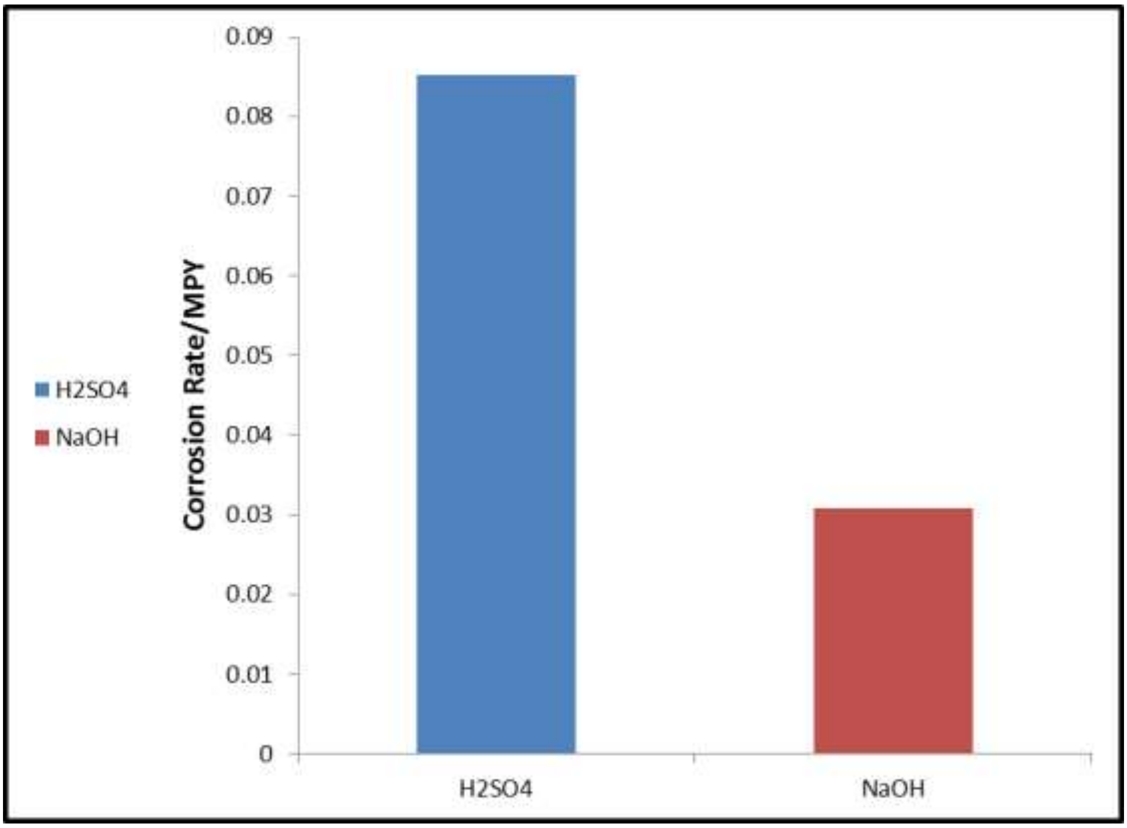

Figure (6): The comparative of the total average corrosion rate for three types of weldments between two mediums.