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An Investigation of Corrosion Behavior at Weld Interface in SA 213 and SA 387 FWTPET Joints

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Abstract: **Friction welding of tube to tube plate using an external tool (FWTPET) is a solid state welding process used for joining tube to tube plate of either similar or dissimilar materials with metallurgical properties. In the present study, FWTPET has been used to weld SA 213 tube with SA 387 tube plate and the corrosion behaviour at weld interface has been analyzed and the weld interface is found to have increased in corrosion resistance value due to the influence of the grain refinement after the welding process. Hence, the present investigation is carried out to analysis the corrosion behaviour at weld interface in the presence and absence of corrosion inhibitor Sodium Potassium Tartrate (SPT) with well water in friction welded dissimilar joints of SA 213 tube and SA 387 tube plate joints and the results are presented.**

Index Terms— **FWTPET, Weld Interface, SPT, Corrosion Resistance**

I. INTRODUCTION

Corrosion is the destructive attack of a metal and its properties by chemical reaction with its environment. The rate of electrochemical reaction is limited by physical or chemical factors. Hence, an electrochemical reaction is said to be polarized [1][2]. Metals that normally fall victim to corrosion will sometimes exhibit passivity to corrosion. Most metals used in the construction of facilities are subject to corrosion. This is due to the high energy content of the elements in metallic form. The corrosion rate for iron as a function of pH. In the range of pH 4 to pH 10, the corrosion rate of iron is relatively independent of the pH of the solution. For pH values above about pH 10, the corrosion rate is observed to fall as pH is increased. This is believed to be due to an increase in the rate of the reaction of oxygen with $Fe(OH)_2$ in the oxide layer to form the more protective Fe_2O_3. Heat treatment is the process of heating and cooling of material to change the material's physical and mechanical properties without changing the original shape and size. Heats Treatment is often associated with increasing the strength of the material, but it can also be used to alter certain manufacturability objectives such as improve mach inability, formability, restore ductility etc. High carbon steels are particularly suitable for heat treatment, since carbon steel respond well to heat treatment and the commercial use of steels exceeds that of any other material.

The process of friction welding of tube to tube plate using an external tool (FWTPET) was invented in the year 2006 [3].Friction welding is a solid state welding process which produces welds due to the compressive force contact of work pieces which are either rotating or moving relative to one another. Heat is produced due to the friction which dis-places material plastically from the faying surfaces. FWTPET is capable of welding tube to tube plate of similar or dissimilar metals and is capable of producing good quality leak proof weld joints. In this work, experimental investigation of FWTPET has been carried out with backing block arrangement[4].Friction welding is a versatile process, suitable for producing a wide variety of components in industries such as light and heavy automotive, electrical, chemical and civil engineering. These components include air bag canisters, axle cases and tubes, drive axial shafts, drill pipes, diesel injectors, gear hubs, cluster gears, electrical connectors, hydraulic piston rods and cylinders, pump shafts, swivel pins, track rollers, turbochargers, bi-metallic valve engines, steering shafts, air brake push rod assemblies, universal joint yoke.

The aim of this Paper is to investi-gate the corrosion behaviour at weld in-terface in the presence and absence of corrosion inhibitor Sodium Potassium Tartrate (SPT) with well water in friction welded dissimilar joints of SA 213 tube and SA 387 tube plate joints and the

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results are presented.

II. MATERIALS AND METHODS

Seamless ferritic and Austenitic alloy grade materials such as SA 213 and SA 387 were taken for this research as tube and tube plate respectively. Their chemical composition of tube is showed below Table 2.1 and Table 2.2.

Table 2.1 Chemical composition of SA 387 tube plate

E	Mn	Cr	Mo	Va	Ti	Fe
Wt%	0.75	1.55	0.38	0.041	0.087	96.7

Table 2.2 Chemical composition of SA 213 tube

E	Mn	Cr	Mo	Ni	Cop	Ti	Fe
Wt%	0.51	1.46	0.42	0.046	0.044	0.090	97.1

2.1 FWTPET process

Seamless ferritic and Austenitic alloy are the grade material which is gen-erally used in boilers. Here, SA 213 as tube material and SA387 tube plate mate-rial. An external tool and boiler material tube and plate (SA213 & SA387) is fixed to a fixture designed for the experiment and the fixture in turn is held with the help of chuck of a center lathe and the tool is attached to the tail stuck of the lathe through a drill chalk. The material must be polished with some grade emery for better welding results. The tool was lowered while in rotation, and heat was generated on account of friction when the shoulder touches the plate. The tempera-ture generated in this process was ap-proximately in the range of 0.6 – 0.7 times the melting point of the material. At this temperature, the plasticized metal flows towards the center of the tool axis, and further metal flow was restricted by the cylindrical pin. There by pressure was developed at the interface between the tube and the plate. Thus, metallurgical bonding takes place between the tube and the plate. Backing block is used to pro-vide support for the tube to tube plate assembly and to restrict the deformation of plate during welding due to axial load. The using of backing block in the FWTPET process to leads as a defect free welding joint, higher strength and less distortion.

Fig 2.1 FWTPET machine (Developed In-house)

Fig.2.2 welding process

2.2 Analysis of Corrosion Resistance

Corrosion resistance of weld interface is investigated by immersed in well water in the absence and presence of Sodium Potassium Tartrate (SPT). Polarization study and AC impedance spectra have been used to investigate the Corrosion resistance of weld interface.

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Fig.2.3. SA213 & SA387 Test sample

III. RESULTS AND DISCUSSIONS

3.1. Analysis of Potentiodynamic Polarization

Polarization study has been used to confirm the formation of protective film formed on the metal surface during corrosion inhibition process. If a protective film is formed on the metal surface, the corrosion current value (I_{corr}) decreases.

Table 3.1.Corrosion parameters of weld interface metal system immersed in well water in the absence and presence of inhibitor, (SPT)

System	E_{corr} mV vs SCE	b_c mV/ decade	b_a mV/ decade	LPR ohm cm^2	I_{corr} A/cm^2
Well water	-475	251	222	25373314	2.041 x 10^{-9}
Well water + SPT 100 ppm	-482	212	202	11051239	4.118 x 10^{-9}

The potentiodynamic polarization curves of weld interface metal immersed in well water in the absence and presence of inhibitor are shown in Fig 3.1. As per the corrosion parameter values shown in the table 3.1,When the weld interface metal was immersed in well water the corrosion potential was -475 mV vs SCE. When 100 ppm of SPT was added to the above system the corrosion potential shifted to the cathodic side, -482 mV vs SCE. This indicates that the cathodic reaction is controlled predominantly. The inhibitor system functions as mixed type of inhibitor controlling both anodic reaction and cathodic reaction to an equal extent. The LPR value decreases from 25373314 $ohmcm^2$ 11051239 $ohmcm^2$; the corrosion current increases from 2.041 x $10^{-9}A/cm^2$ to 4.118 x $10^{-9}A/cm^2$. By the addition of SPT the corrosion resistance of weld interface metal system in well water decreases.

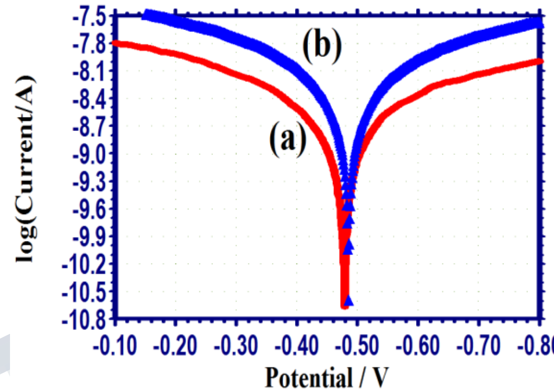

Fig.3.1 Polarization curves of weld interface metal system immersed in various test solutions (a) Well water (b) Well water + SPT 100 ppm

3.2. Analysis of AC Impedance Spectra

AC impedance spectra have been used to confirm the formation of protective film on the metal surface. If a protective film is formed on the metal surface, charge transfer resistance (R_t) increases; double layer capacitance value (C_{dl}) decreases. Impedance value increases. The weld interface metal system is immersed in well water in the absence and presence of SPT. The parameters R_t and C_{dl} derived from Nyquist plots. The impedance value derived from Bode plots.

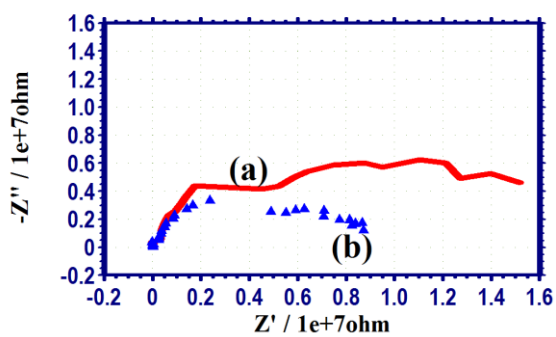

Fig.3.2. (Nyquist Plots). AC Impedance spectra of weld interface metal system immersed in (a) Well water (b) Well water + SPT 100 ppm

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Table.3.2. AC impedance parameters

System	R_t ohm cm^2	C_{dl} F/ cm^2	Impedance Log(z/ohm)
Well water	15350000	3.132x 10^{-13}	7.200
Well water + SPT 100 ppm	8846000	5.540 x 10^{-13}	6.940

From the table 3.2, it is observed that when 100 ppm of SPT is added to well water the charge transfers resistance (R_t) decreases from 15350000 Ω cm^2 to 8846000 Ω cm^2. The C_{dl} value increases from 3.132×10^{-13} F/cm^2 to 5.540×10^{-13} F/cm^2. The impedance value decreases from 7.200 to 6.940.

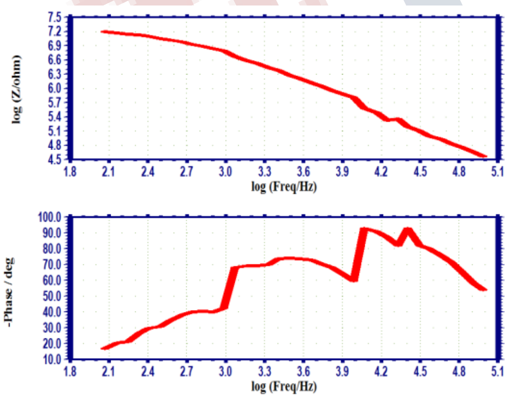

Fig. 3.3. AC Impedance spectra weld interface metal system immersed in Well water (Bode plots)

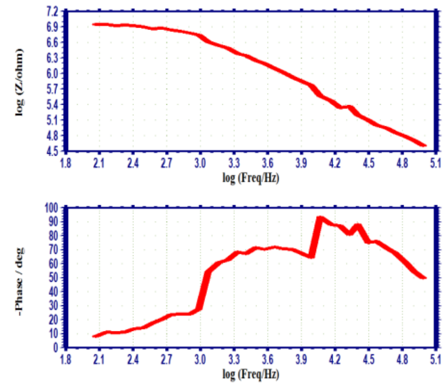

Fig.3.4. AC Impedance spectra of weld interface metal system immersed in Well water + SPT (100 ppm) (Bode plots)

These results lead to the conclusion that the protective film formed on the metal surface is not stable. It is broken by the aggressive ions present in well water. Thus AC impedance spectra lead to the conclusion that in presence of SPT, the corrosion resistance of weld interface metal system decreases.

IV.CONCLUSION

At the weld interface, the results appear to closely follow the Hall–Petch relationship in the corrosion current densities vs recrystallized grain size. While increasing the grain size up to ∼168 μm, the corrosion rate increases due to less grain boundary volume and accordingly less dense passive layer. The grains are refined; the refinement is occurred in the joint interface and simultaneously increases the hardness value and strength of the FWTPET joint of SA 213 tube to SA 387 tube plate. While increasing the grain size, up to ∼168 μm, the corrosion rate increases due to less grain boundary volume hence, the metallurgical property changes and also increases the corrosion resistance at the interface of the joint. When the corrosion resistances increase, degradation is reduced at the weld interface of FWTPET process.

REFERENCE

[1]. H.H. Uhlig, "The cost of the corrosion to the united states," Chem.Eng. News, Vol 27. pp 2764. 1949.

[2].H.H. Uhlig, "The corrosion," Chem.Eng. News, Vol 29. No 6. pp 2764. 1950

[3].Muthukumaran S, "A process for friction welding tube to a tube sheet or plate by adopting an external tool", Indian patent Application No. 189/ KOL/ 06 filed on 07-03-2006, patent No.21744, granted on 26/03/2008 (2006).

[4].G.Vinoth kumar, S.Senthil kumaran, "Experimental Investigation on SA213 Tube SA387 Tube Plate using external tool Friction Welding Process by Without Backing Block" International Journal of Applied Engineering Research, Vol. 10 No.49 (2015) pp 622-629.

[5]. O. Bauer, O. Krohnke, S.Hirzel, Leipzig, and G. Masing, "Die corrosion metallischer werkstoffe'', Vol.1, p.240, 1936.

[6]. "Electro chemical techniques for corrosion," edited by R.Baboian, National Association of corrosion engineeres,Houston, Texas, 1977.

[7]. G.Skaperdas and H. Uhlig, Ind. Eng. Chem., Vol 34. pp 748. 1942.

[8]. B.F. Brown, J. Kruger and R. W. Staehle, "National Association of Corrosion Engineeres," Corros. Sci.,Vol.34. pp, 331. 1974.

[9]. C. chappell, J. Iron steel Inst., Vol. 85 pp 270. 1912

[10]. Corrosion Handbook, edited by H.H. Uhlig, pp 125-143, wiley, New York, 1948. [15]. J. Lamb and R. Eliassen, J. Am. Water works Assoc., Vol 46, pp 445. 1954.

[11]. L. Antropov, "Inhibitors of metallic Corrosion and the Phi-scale of potentials," First international congress on metallic corrosion, p. 147, Butterworths, London, 1961.

[12]. D.Brasher and A. Mercer, Brit. Corros. J., Vol.3. pp.120.1968.

[13]. A. A. El. Warraky and El. Meleigt, "Electrochemical and Spectroscopic Investigation of Synergestic Effects in Corosion Inhibition of Al Bronze Part 1-in Pure HCl," Journal of British Corrosion, Vol. 37, No. 4, 2000, pp.305-310

[14]. G. Berkt, A. Pinarbasi and C. Orgretir, "Benzimidazole-2- tione and Benzyoxazole-2-tione Derivatives as Corrosion Inhibitors for Al in HCl Acid," Anticorrosion, Methods and Materials, Vol. 51, No. 4, 2004, pp. 282-293.

[15]. E. Ebenso, P. C. Okafor and U. G. Eppe, "Studies on the Inhibition of Al Corrosion by 2-Acetylphenothiazine in Chloroacetic Acids," Anticorrosion, Methods and Ma- terials, Vol. 50, No. 6, 2003, pp. 414-421.

[16]. N. Kumpawat, A. Chaturvedi and R. K. Upadhyay, "Study on Corrosion Inhibition Efficiency of Stem Alka- loid Extract of Different Varieties of Holy Basil on Alu- minium in HCl Solution," Journal of the Korean Chemi- cal Society, Vol. 56, No. 4, 2012, pp. 1-5.

[17]. P. Sharma, R. K. Upadhyay, A. Chaturvedi and R. Parashar, "Study of Corrosion Inhibition Efficiency of Naturally Occurring Argenmone mexicana on Al in HCl Solution," Journal of Technical and Research in Chemistry, Vol. 5, No. 1, 2008, pp. 21-27.

[18]. T. P. Hoar and R. D. Holliday, "The Inhibition by Quino- lines and Thioureas of the Acid Dissolution of Mild Steel," Journal of Applied Chemistry, Vol. 3, No. 11, 1953, pp. 502-513

[19]. T. Sethi, A. Chaturvedi, R. K. Upadhyay and S. P. Mathur, "Inhibition Effect of Nitrogen Containing Ligands on Corrosion of Aluminium in Acid Media with and without KCl," Polish Journal of Chemistry, Vol. 82, No. 3, 2008, pp.591-598.

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