An Investigation on corrosion parameters in SA 213 TUBE and SA387 tube plate in FWTPET with absence and presence of Inhibitor

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Abstract- Corrosion is the destructive attack of a metal and its properties by chemical or electrochemical reaction with its environment. The importance of corrosion studies is threefold includes conservation, improved safety and economic losses. The structural deterioration of all metallic mains is due to the external corrosion which is included by environmental and operation conditions. It is necessary to remember that the choice of material depends on many factors, including corrosion resistance, cost, fabricability, strength. Complete corrosion resistance is almost all media can be achieved by the use of glass, but it is not practical. The corrosion resistance of the material is the most important properties in most engineering applications. In this investigation, FWTPET process has been carried to achieve high-quality leak-proof joints. SA 213 tube and SA 387 tube plate are dissimilar material joined using by FWTPET process of interference fit with backing block. Polarization study and AC impedance spectra have been used to investigate the corrosion parameters of the material system immersed in well water in the absence and presence of the inhibitor Sodium Potassium Tartrate (SPT) and the result shows the increase of corrosion resistance in the materials.

Index Terms- SA 213 tube; SA 387 tube plate; FWTPET; SPT

I. INTRODUCTION

Corrosion of metal is of great practical interest because metals are widely used in the oil, gas and offshore environments for pipelines, flow-lines, down-hole tubular equipments; well heads. Corrosion inhibition is being extensively employed in minimizing metallic wastage of engineering materials in service [1]. Metallic material constitutes a great part of construction material elements in industries, agricultural equipment, medical services, process and allied industries. In these industries, the metallic material as a result of interaction with its environment loses its integrity over a period of time [2].Corrosion control is an important activity of technical, economical and environmental importance. Thus, the search for efficient corrosion inhibitors has become a necessity to secure metallic materials against unmitigated degradation. The presence of corrosion inhibitors in the cleaning and pickling solutions is very important to keep the surface of steel intact. For this reason, many researches were conducted to study its corrosion properties and to find out suitable chemical compounds to be used as corrosion inhibitors for it in acidic solutions [3].The process of friction welding of tube to tube plate using an external tool (FWTPET) was invented in the year 2006[4]. FWTPET 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 displaces material plastically from the faying surfaces. The aim of the present work is to join two dissimilar materials SA 213 tube and SA387 tube plate using FWTPET. The corrosion parameters are investigated by using the techniques Polarization study and AC impedance spectra. The process is carried out in two cases; in the first case the material system is investigated by immersed in well water in the absence of SPT and in the second case the material system is investigated in the absence of SPT. The result shows that in the presence of SPT, the corrosion resistance of the welded metal system immersed in well water increases. Also reveals that SA 213 and SA387 FWTPET joint show good grain structure and due to the fine refinement of grains it exhibits better corrosion resistance.

II. EXPERIMENTAL

A. Preparation of Work piece:

Seamless ferritic and Austenitic alloy grade materials such as SA 213 and SA 387 are taken for this research as tube and tube plate respectively. The experiment has been conducted using 6 mm thickness SA 387 tube plate and cut into the required sizes (50 mm x 50 mm) square block with center drill. Similarly, SA 213 steel tube of outer diameter 20.5 mm, inner diameter 16 mm and length 30 mm have been cut into required size. The metals are welded by FWTPET and the welded work piece is used for the investigation of corrosion parameters by immersing the piece into well water with the presence and absence of SPT.

B. 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.

C. Analysis of Potentiodynamic Polarization Curves

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 (Icorr) decreases.

D. Preparation of Sodium Potassium Tartrate

1 g of sodium potassium tartrate is dissolved in double distilled water and made up to 100 ml in a standard measuring flask. 1 ml of this solution was diluted to 100 ml to get 100 ppm of sodium potassium tartrate.

III. RESULTS AND DISCUSSION

A. *Analysis of Potentiodynamic Polarization Curves in SA 213 Tube*

The formation of protective film on the metal surface during corrosion inhibition process is confirmed by polarization study. The corrosion current value (Icorr) decreases if a protective film is formed on the metal surface. The Potentiodynamic polarization curves of Tube metal immersed in well water in the absence and presence of inhibitor are investigated. When Tube metal is immersed in well water the corrosion potential value is -389 mV vs SCE. When 100 ppm of SPT is added to the above system the corrosion potential shifted to the negative side -477 mV vs SCE. This indicates that the cathodic reaction is controlled predominantly.

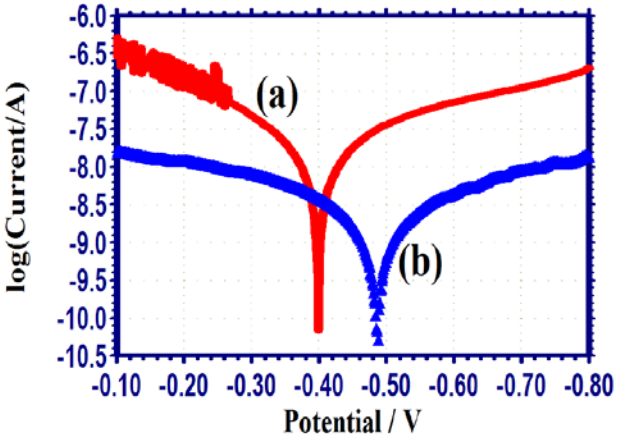

Figure 1: Polarization curves of Tube metal immersed in various test solutions

(a) Well water (b) Well water + SPT 100 ppm
(b)

Table 1: Corrosion parameters tube metal immersed in well water in the absence and presence of inhibitor, Sodium potassium tartrate (SPT) obtained from polarization study

System	Ecorr mV V SCE	ba mV/decade	bc mV/decade	LPR ohm cm^2	I_{corr} A/cm^2
Well water	-389	232	152	2726502	1.264 x 10-8
Well water + SPT 100 ppm	-477	219	201	23037226	0.246 x 10-8

The LPR value increases from 2726502 $ohmcm^2$ to 23037226 $ohmcm^2$; the corrosion current decreases from 1.264 x 10-8 A/cm^2 to 0.246 x 10-8 A/cm^2 shown in Table 1**.** Hence, polarization study confirms the formation of a protective film on the metal surface.

B. *Analysis of AC Impedance Spectra in SA 213 Tube*

The AC impedance parameters namely charge transfer resistance (R_t) and double layer capacitance (C_{dl}) derived from Nyquist plots are given in the table 2. It is observed that when the inhibitor (100 ppm of SPT) is added to well water the charge transfers resistance (R_t) increases from 12890000 Ω cm^2 to 20730000 Ω cm^2. The C_{dl} value decreases from 3.772x10 $-^{13}$ F/cm^2 to $2.89x10^{-13}$ F/cm^2. The impedance value increases from 6.906 to 7.12.

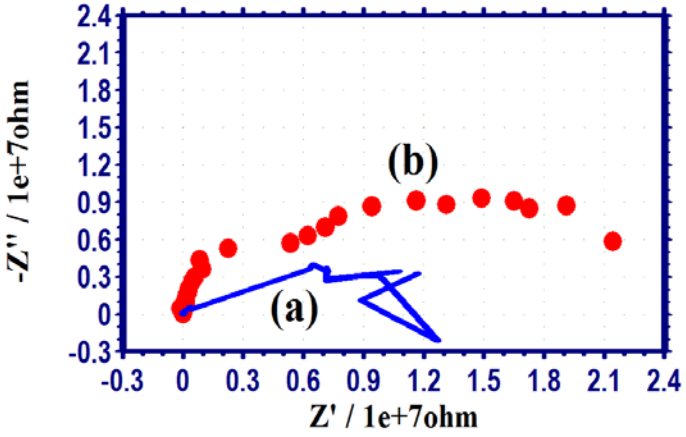

Figure 2: AC Impedance spectra of Tube metal (Nyquist Plots)
(a) Well water (b) Well water + SPT 100 ppm

Table 2: AC impedance parameters of Tube METAL IMMERSED in well water in the absence and sodium potassium tartrate (SPT) obtained by AC impedance spectra

System	R_t ohm cm^2	C_{dl} F/ cm^2	Impedance Log (z/ohm)
Well water	12890000	3.772x10 $-^{13}$	6.906
Well water + SPT 100 ppm	20730000	$2.89x10^{-13}$	7.12

These results lead to the conclusion that a protective film is formed on the metal surface. Electrochemical studies lead to the conclusion that in presence of sodium potassium tartrate (SPT), the corrosion resistance of Tube metal immersed in well water increases.

C. *Analysis of Potentiodynamic Polarization Curves in SA 387 Tube Plate*

When Tube Plate metal was immersed in well water the corrosion potential is -419 mV vs SCE. When 100 ppm of SPT is added to the above system the corrosion potential shifted to the anodic side, -401 mV vs SCE. This indicates that the anodic reaction is controlled predominantly. The LPR value increases

from 170710 ohmcm^2 to 243210 ohmcm^2; the corrosion current decreases from 2.067x10^{-7} A/cm^2 to 0.9989x10^{-7} A/cm^2.

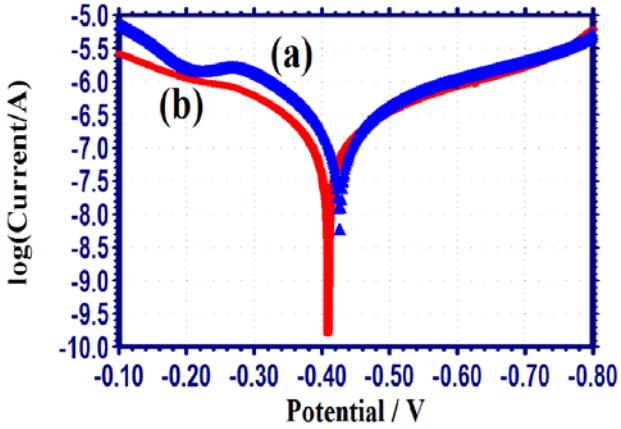

Figure 3: Polarization curves of Tube metal immersed in various test solutions
(a) Well water (b) Well water + SPT 100 ppm

Table 3: Corrosion parameters tube metal immersed in well water in the absence and presence of inhibitor, Sodium potassium tartrate (SPT) obtained from polarization study

System	Ecorr mV V SCE	ba mV/decade	bc mV/decade	LPR ohm cm^2	I_{corr} A/cm^2
Well water	-419	238	158	170710	2.067x10^{-7}
Well water + SPT 100 ppm	-401	226	208	243210	0.9989x10^{-7}

Hence, polarization study confirms the formation of a protective film on the metal surface.

D. Analysis of AC Impedance Spectra in SA 387 Tube

It is observed that when 100 ppm of SPT is added to well water the charge transfers resistance (R_t) increases from 102795912 Ω cm^2 to 139789509 Ω cm^2. The C_{dl} value decreases from 4.412x10 $^{-13}$ F/cm^2 to 3.202 x 10^{-13} F/cm^2. The impedance value increases from 4.1 to 4.432. These results lead to the conclusion that a protective film is formed on the metal surface.

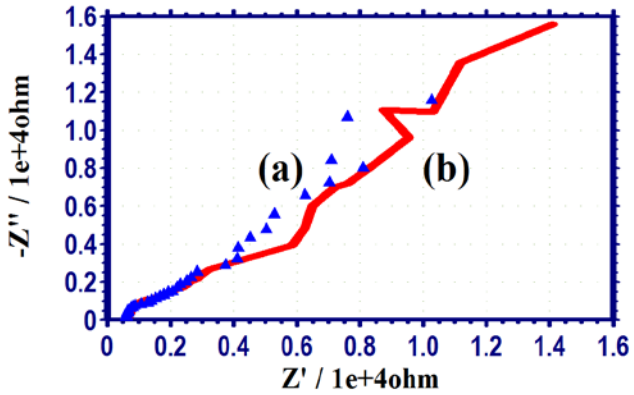

Figure 4: AC Impedance spectra of Tube metal (Nyquist Plots)
(a) Well water (b) Well water + SPT 100 ppm

Table 4: AC impedance parameters of SA 387 Tube METAL IMMERSED in well water in the absence and sodium potassium tartrate (SPT) obtained by AC impedance spectra

System	R_t ohm cm^2	C_{dl} F/ cm^2	Impedance Log(z/ohm)
Well water	102795912	4.412x10 $^{-13}$	4.1
Well water + SPT 100 ppm	139789509	3.202 x 10^{-13}	4.432

This result shows that in presence of sodium potassium tartrate (SPT), the corrosion resistance of Tube metal immersed in well water increases.

IV. CONCLUSION

The Investigated values of the polarization study confirm the increase in LPR values and the decreases in corrosion current in the presence of SPT; it clearly shows the formation of a protective film on the metal surface. By the AC impedance spectra parameters of Tube metal immersed in well water in the absence and presence of sodium potassium tartrate, the formation of protective film is confirmed with the increase in charge

transfer resistance, increase in Impedance value and decrease in capacitance value. The FWTPET metal joint corrosion parameter results showed that the SPT has excellent inhibition properties for the corrosion of SA 213 and SA 287 metal in aqueous medium and also concluded that the metals have good grain structures with good mechanical properties. The investigation concludes that SA 213 and SA 387 metals joints are suitable for the various industrial applications.

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