THE POLARIZATION STEEL BEHAVIOR IN REFINERY INDUSTRIAL WATERS IN THE ABSENCE AND THE PRESENCE OF THE INCOR AN INHIBITOR

Eva Trîmbițașu*, V. Brânzoi, Florina Brânzoi and S. Neagoe

abstract: This paper presents a study concerning the carbon steel OL 37, W4541 and W4571 alloys corrosion speed variation in "reflux water V_1", in the presence and the absence of the INCOR AN inhibitor. Tests were made to study the bias curves using the static potential method and the evaluation of corrosion's kinetic parameters (I_{cor}, E_{cor}) by the extrapolation of Tafel curves.

Introduction

The petroleum industry is one of the main domains in which the corrosion generates severe problems in economic strategies and in security issues 50÷70% of the refinery plants' and chemical industry installations' maintenance expenses are referenced to the corrosion.

The most important corrosion type in oil processing plants is the electrochemical one, which appears because of the fact that the equipment metal is in direct contact with electrolytic conductive corrosive media.

The main characteristics of this corrosion form are given by passing electrical charge through metal-electrolyte phase limit. In fact, electrochemical corrosion represents a redox process, which takes place on the interface metal-solution with electrons transfer through metal and ions through solution [1].

The metal's nature and the corrosive medium's characteristics are the main factors that influence the speed and the type of the electrochemical corrosion [2-3].

A metal that corrodes freely generates a particular potential between its surface and its ions in the solution. Using an external circuit we can alter this potential which will determine a change in the metal's corrosion state. The electronic device used in the external circuit maintains the potential at a constant level or facilitates its variation in the desired direction [4,5].

If the electrode's potential is altered using a step-by-step external circuit (25÷30mV) to anode or cathode, we are talking about potentiostatic technique.

In the potentiodynamic method, the electrode's potential varies continuously and the charge is recorded periodically or continuously.

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* Oil-Gas University Ploiesti, Bd. Bucuresti 39, 2000, Ploiesti

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In the present study we used the potentiostatic technique to test the anode and cathode bias curves of the OL 37 steel, W4541 and W4571 alloys in "water reflux V_1" in the presence and the absence of INCOR AN inhibitor.

Experimental part

The metallic compositions tested in this study (OL 37, W4541, and W4571) took shape of cylindrical test bars with inside thread used to attach them to the sustain-support. The cylindrical shape was preferred because of its large surface and low number of edges (known as more fallible in corrosion). The reference electrode was calomel-saturated, and the auxiliary electrode was a platinum board.

The corrosive medium, "reflux water V_1", was sampled from DAV plant- PETROBRAZI refinery Ploiesti, being analytically described in (Table 1).

Table 1. Analytical characterization of the corrosive medium.

No	Sample type	Conductivity (mS)	pH	Chemical composition (ppm)				
				Cl^-	NH_4^+	S^{2-}	Fe^{2+}	Na^+
1	Reflux water V_1	0.94	4.5	5.48	0	6.35	2.32	81

ICERP SA Ploiesti produced the INCOR AN amines based. A very important aspect for the corrosion speed's decrease is maintaining the pH close to the optimal value (5.5÷6.5) inside the top of the distillation tower. To accomplish this, we used neutralizing inhibitors.

While studying the INCOR AN's efficiency in "reflux water V_1" we drew the bias curves for OL 37, W4541 and W4571 at the temperature of 60^{o}C, in the presence and the absence of INCOR AN inhibitor.

The starting point in drawing the cathode and anode curves was the mixed potential of the stationary state, which, as for every other potential, was measured corresponding to the calomel-saturated electrode**.**

Results and discussions

Here are presented the OL 37 steel polarization curves in reflux water, at the temperature level of 30^{o}C (Fig. 1) and 60^{o}C (Fig. 2) in the absence of the inhibitor. Observing the evolution of the curves, it is easily concluded that at the temperature of 30^{o}C, the corrosion speed is a little bit lower than the level recorded at 60^{o}C.

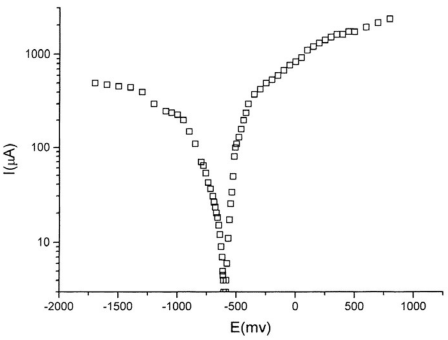

Fig. 1: *Polarization curve for OL 37 steel at 30°C in reflux water.*

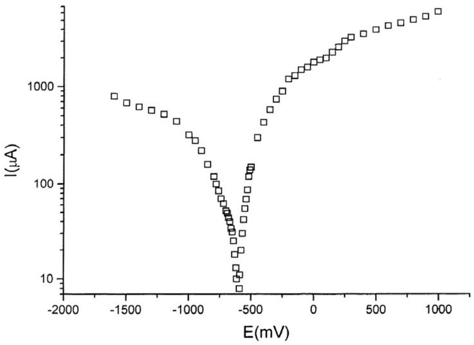

Fig. 2: *Polarization curve for OL 37 steel at 60°C in reflux water.*

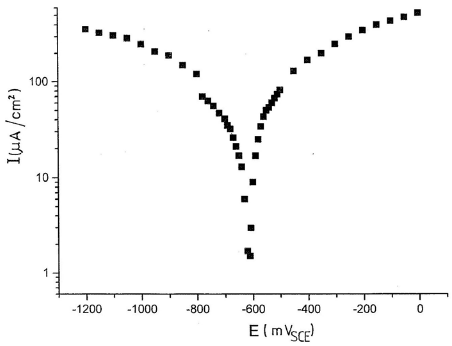

Fig. 3: *Polarization curve for OL 37 steel at 60°C in reflux water in the presence of INCOR AN 500ppm.*

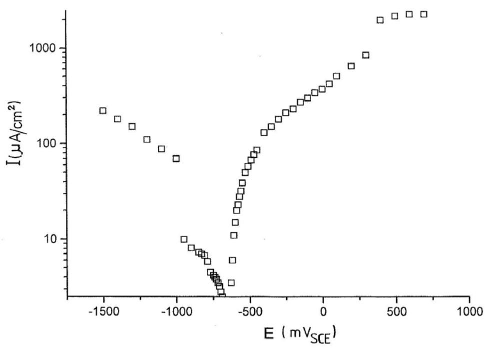

Fig. 4: *Polarization curve for OL 37 steel at 60°C in reflux water in the presence of INCOR AN 1000ppm.*

We also presented the OL 37 steel polarization curves in the presence of INCOR AN corrosion inhibitor, 500ppm concentration (Fig. 3) and 1.000ppm (Fig. 4). The curves analisys reflects a maximum point of protection efficincy at 60°C and 500ppm.

The study on the alloyed steels W4541 and W4571, implies the recording of polarization curves at 30 and 60oC respectively, in the absence of the inhibitor, in reflux water (Figs. 5, 6, 9 and 10). Analising the curves, we can clearly see that the corrosion speed is higher at 60oC, for both observed steels. Furthermore, at 60oC, the W4571 steel records a higher corrosion speed.

The action of the INCOR AN inhibitor at 500ppm and 1.000ppm and 60°C is graphically presented in Figs. 7, 8, 11 and 12. Observing these items, it is noted that the corrosion speed is lower when the concentration level of the inhibitor reaches 500ppm. In the same time, the W4571 steel's corrosion speed is lower than W4541`s.

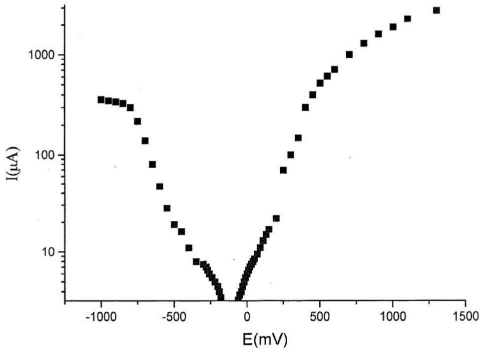

Fig. 5: *Polarization curve for W4541 alloy at 30^{o}C in reflux water.*

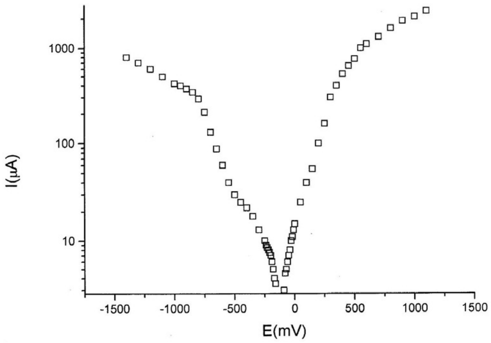

Fig. 6: *Polarization curve for W4541 alloy at 60^{o}C in reflux water.*

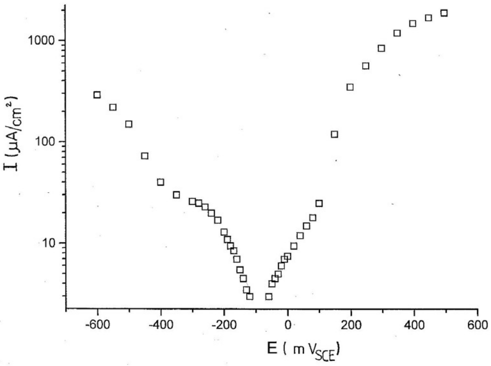

Fig. 7: *Polarization curve for W4541 alloy at 60^{o}C in reflux water in the presence of INCOR AN 500ppm.*

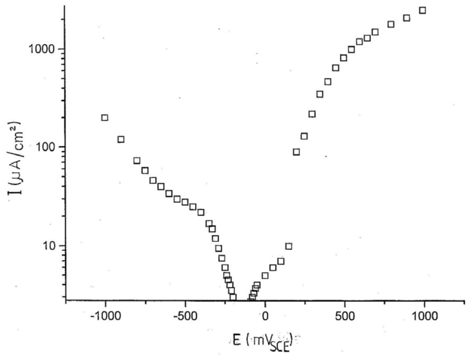

Fig. 8: *Polarization curve forW4541 alloy at 60^{o}C in reflux water in the presence of INCOR AN 1000ppm.*

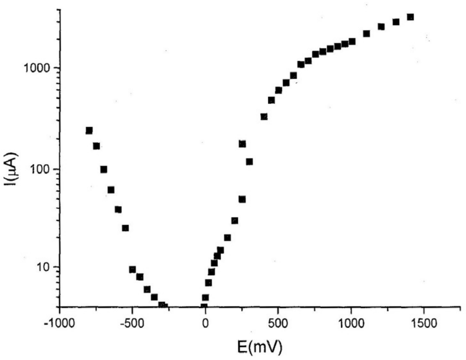

Fig. 9: *Polarization curve for W4571 alloy at 30^{o}C in reflux water.*

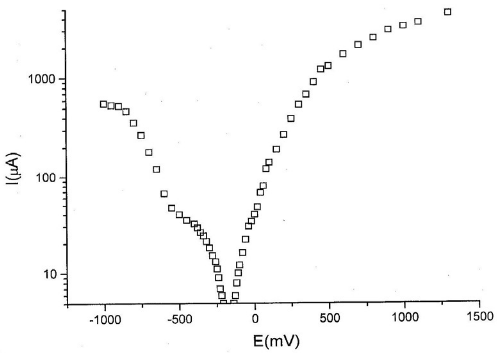

Fig. 10: *Polarization curve for W4571 alloy at 60^{o}C in reflux water.*

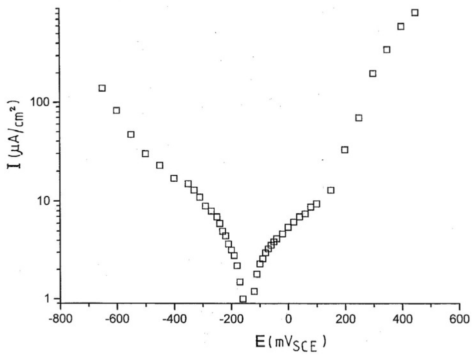

Fig. 11: *Polarization curve of W4571 alloy at 60°C, in the presence of INCOR AN 500ppm.*

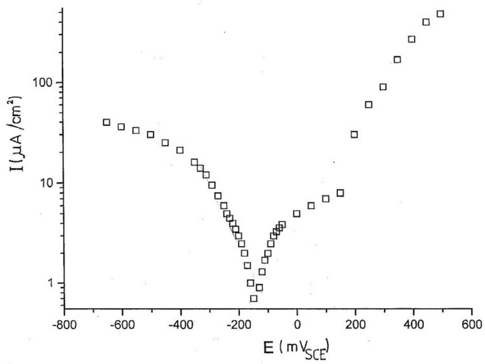

Fig. 12: *Polarization curve for W4571 alloy at 30°C in reflux water in the presence of INCOR AN 1000ppm.*

In Table 2 are presented the corrosion kinetical parameters, which were determined by Tafel curves extrapolation and which indicate that the presence of the INCOR AN inhibitor decreases dramatically the corrosion process. The corrosion speed (noted as *Rmpy* in Table 2) was calculated using the following formula:

$$Rmpy = 0.15\ ie/\rho$$

And it is expressed in miliinch/year, where: i = current density (μA/cm^2); e = chemical equivalent of the metal; ρ = metal's density (g/cm^3).

Table 2. Kinetic corrosion parameters in reflux water V_1 with INCOR AN 500 ppm inhibitor, temperature 60°C.

No.	Inhibitor type	Icor μA/cm^2	E_{cor} mV	R_{mpy} ie/ρ	P mm/year	Kg g/m^{2}h	E %
1	OL 37 Without inhibitor	21,50	-690	10,030	0,2546	0,2264	
2	OL37 INCOR AN	3,00	-650	1,400	0,0350	0,0320	81,25
3	W4571 Without inhibitor	3,20	-170	1,493	0,0380	0,0340	
4	W4571 INCOR AN	0,99	-140	0,462	0,0120	0,0100	69,06
5	W4541 Withthout inhibitor	3,10	-115	1,477	0,0370	0,0330	
6	W4541 INCOR AN	1,50	-100	0,700	0,0180	0,0160	51,60

Conclusions

Observing the bias curves, we noticed that, in contrast with the alloys, the OL 37 carbon steel did not present any transition active-passive until very high potentials.

Electrode's surface metalographical analysis after each measurement in "reflux water V_1" stressed that OL 37 steel corrodes uniformly not like the alloys that were attacked by pitting corrosion.

Consulting the presented bias curves it is also easily noted that, at low over voltage, the activation of OL 37 steel corrosion is controlled and using the extrapolation of Tafel curves it is possible to calculate the density of the corrosion current and the corrosion potential.

At higher over voltage, the corrosion process is under control for every type of diffusion. The shapes of the bias curves show the appearance of the limit diffusion currents.

Observing the presented data, it is stated that INCOR AN efficiency reaches a maximum level for OL 37 steel and minimal for W4541, but in any case, using this inhibitor will diminish the corrosive attack. The determined optimal inhibitor dose is 500ppm. The efficiency of the inhibitor (E%) is higher in the case of OL 37 steel (81,25%) than that recorded in the case of the alloyed steels (69.06%, 51.60% respectively).

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