Dalia Mohamed Gomaa. "Experimental and Numerical Modeling for Corrosion of Carbon Steel in 5% NaCl Carbonated Water for Oil Industries" . University of Technology Materials Engineering Department.PHD. Under Supervision: Dr. Rana A. Anaee, Dr. Ali H.Jawad .2012. .162p.

Abstract

This thesis includes electrochemical study of low carbon steel in 5% NaCl solution in absence and presence of CO_2 gas at three rates 9, 21 and 30 ml/min. under static and dynamic conditions at 200 L/h at temperature range of (298 – 328 K) using potentistat at scan rate 3 $mV.sec^{-1}$. Mathematical model was achieved to compare the theoretical and experimental results. In addition, attempts were made to inhibit sweet corrosion at only 21 ml/min CO_2 using diphenylamine with three concentrations $1x10^{-4}$, $1x10^{-3}$ and $1x10^{-2}$ M under static and dynamic conditions. The results revealed that:

1- Under static conditions, the corrosion potentials (E_{corr}) shift generally toward noble direction in the presence of CO_2 gas; this means that the corrosion reaction is then expected to be less spontaneous, while the corrosion current densities (i_{corr}) became higher than those of the case in the absence of CO_2.

2- Under flow condition, the comparison between the absence and presence of CO_2, can be seen that the E_{corr} at 9 and 30 ml/min rate shifted toward noble direction, while at 21 ml/min shifted toward active direction. The results of i_{corr} showed shifting corrosion current densities toward higher values at 9 and 21 ml/min of CO_2 and toward less values at 30 ml/min except at 298K due to the formation of $FeCO_3$ scale. On the

other hand, at 21 ml/min the highest values of i_{corr} can be seen this means highest values of corrosion rate in addition to obtaining different anodic curve.

3- The data of corrosion rates measarements indicated that the presence of CO_2 gas at the three flow rates increases the corrosion rates in comparison with the case of CO_2 absence under static conditions except one case. While under flow conditions, the presence of 9 and 21 ml/min. CO_2 increases the corrosion rates, while the presence of 30 ml/min. CO_2 decreases the rate except at 298K.

4- Cyclic polarization measurements indicate that there are no hysteresis loops that can be appear to resisted localized corrosion. It is also observed that the reverse scan curves meet the forward scan curve along the passive range.

5- Three dimensional results show the effect of temperature and corrosion potential on the corrosion current density and corrosion rate for all experimental cases.

6- The corrosion rate was correlated with E_{corr}, i_{corr} and physical properties, obtained correlation gave correlation coefficient and standard error is 0.9929 and 0.00011 respectively.

$$C_R = \frac{{R_{co2}}^2}{\Delta P^2} B_1 \left\{ \left[\frac{g}{\Delta P^{5 {R co_2}^2}}\right]^{B_2} \left[[\Delta P^2 \, i_{corr}]\right]^{B_3} [E_{corr}]^{B_4} \left[\frac{bc}{ba}\right]^{B_5} \left[\frac{DP\ \Delta P}{{R_{co2}}^2 \ \rho co_2}\right]^{B_6} \left[\frac{DP\mu \ co_2}{R co_2 \ \rho co_2}\right]^{B_7} \left[\frac{DP^4 T \ CP}{R co_2}\right]^{B_8} \right\}$$

The following mathematical model was derived to estimate the correlation rate of CO_2.

$$R_{co2} = \frac{\pi \rho g R^2}{2\mu} \left[\frac{R^2}{4} - \frac{1}{2}(1 + lnR)\right]$$

7- Comparison between observed and predicated values shows the good agreement for both results under experimental conditions.

8- Under static condition, in general the presence of diphenylamine shifts the corrosion potentials toward active direction in the presence of CO_2.

9- Under flow conditions, all corrosion potential values shift to noble direction and the corrosion current density values became less. This result indicates the inhibited action of diphenylamine.

10- The data of protection efficiency P% under static conditions, in the absence of CO_2, indicate that $1x10^{-4}$M of inhibitor gave the best inhibition, but under static conditions in the presence of CO_2, $1x10^{-2}$M of inhibitor was the best concentration to corrosion inhibition. Under flow condition in the absence and presence of CO_2, different behavior can be seen that is dependent on temperature and concentration of inhibitor.

11- Cyclic polarization test shows a very narrow hysteresis loop, it indicates no pitting corrosion.

Keywords : CO_2 corrosion , corrosion inhibition, corrosion under static conditions, corrosion under flow conditions, Mathematical model.