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Effect of Chloride Ions on the Corrosion of Welded Low Carbon Steel

GAMAL K. GOMMA

Chemistry Department, Faculty of Education
Kafr El-Sheikh, A. R. Egypt

A studies on corrosion of welded and unwelded low carbon steel (0.05%C) in 6% NaCl medium by means of steady-state potential, cathodic polarisation, weight-loss measurements and linear polarisation methods. Welded carbon steel corrode more than unwelded, the corrosion rate is very small due to the presence of chromium. Corrosion of welded low carbon steel is due to the attack which takes place at the welded portion than the base metal.

INTRODUCTION

Many studies have been made on the corrosion of metals in chloride medium[1–5]. Corrosion of welded low carbon steel in chloride media are limited[6,7]. The corrosion of welded and unwelded low carbon steel (0.05%C) have been undertaken in 6% sodium chloride solution to find out the nature of corrosion process.

EXPERIMENTAL

For welded low carbon steel (0.05%C), the sample were cut into two pieces and then joined by electrical arc welding. For unwelded low carbon steel, 2 mm thickness was used. The testing specimens were cut into pieces 3 cm × 1.5 cm with the help of a shearing machine and the edges smoothed. They were abraded into uniform surfaces with the help of a grinding machine and finally ground with 150, 300, 400 and 600 grades emery papers. For polarisation study the working electrode, soldered with insulated copper wire and after proper surface preparation, was coated thoroughly with epoxy resin keeping 1 cm^2 surface area exposed for corrosion. Platinum wire was used as an auxiliary electrode and a dip type calomel electrode was used as reference electrode (SCE). Polarisation was done by a power supply with a potentiometer connected in circuit. The current was calculated by using a variable resistance and an avometer. Potentials were measured by a BAY potentiometer against SCE. Steady corrosion potentials for cathodic polarisation were established between 2–3 hrs. Several runs were taken for each set of experiments for welded and unwelded electrodes.

For weight-loss tests the welded and unwelded specimens were cut as rectangular sheets (3 × 1.5 × 0.2 cm).

The composition of the specimens used is (0.05 C, 15.3 Cr, 1.4 Mn, 0.025 S).

A solution of 6% NaCl (E. Merck) was used without deaeration.

RESULTS AND DISCUSSION

The corrosion potential ($E_{corr.}$) from polarisation measurements and the relative corrosion rate by the linear polarisation method, and also from weight-loss technique for welded and unwelded low carbon steel specimens, are collected in Table 1.

TABLE 1

CORROSION RATE AND CORROSION POTENTIAL FOR WELDED AND UNWELDED SPECIMENS OF LOW CARBON STEEL (0.05%C)

Specimen	$E_{corr.}$	$i_{corr.}$ Am/cm^2	Weight-loss measurements (mg. cm.$^{-2}$ day^{-1})	dW/dt by linear-polarisation (mg. cm.$^{-2}$ sec^{-1})
Unwelded	−350	68×10^{-6}	0.23	1.70×10^{-5}
Welded	−360	71×10^{-6}	0.31	1.79×10^{-5}

Rate of corrosion can be calculated by linear polarisation method thus:

$$i_{corr,} = 0.029/\text{Slope Am/cm}^2$$

$$dE/dt = i_{corr.} \times \frac{\text{Atomic weight}}{\text{Valency} \times \text{farady}} \text{ mg. cm.}^{-2} \text{ sec}^{-1}$$

From Table 1 it can be seen that the rate of corrosion of unwelded low carbon steel is very small. This is probably due to the presence of chromium, which forms a very thin stable oxide Cr_2O_3 on the surface which inhibits further corrosion attack.

Arc welding is the best method for welding, this is due to the fact that there is relatively better homogeneity and less impurities and less inclusions on the metal surface than that of gas welding. It was found that the corrosion rate of cooled steel is more than the rate of corrosion of hot steel in chloride medium[8]. This may be due to an increase in dislocation density and residual stresses during the cold working process, resulting in a substantial increase in strain energy in the lattice. Again strain hardening does not occur in hot working metals since the processing temperature provides necessary thermal activation for dynamic recovery and recrystallisation in the alloy[9].

From Table 1, it can be seen that the corrosion potential determined by open-circuit measurement ($E_{corr.}$) is more anodic in case of unwelded low carbon steel. The corrosion rate is limited, this may be due to the localised corrosion resistance character of low carbon steel and also because of the presence of chromium in it and also by the fact that all the chromium present is in the solid solution and the steel has a single phase structure.

From optical microscopic studies it is revealed that the preferential corrosion attack like pit formation takes place at the welded portions of the metal surface than at the base metal[8].

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