

MEASURING LOCALIZED CORROSION USING THE WIRE BEAM ELECTRODE METHOD

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An electrochemically integrated multi-electrode system, namely the wire beam electrode (WBE),¹⁻⁸ has been developed into a means of measuring the thermodynamics and kinetics of localized corrosion and other heterogeneous electrochemical processes. The WBE is an array of mini-electrodes (namely wires) that are insulated from each other with a thin insulating layer. The working surface of the WBE is electrochemically-integrated by coupling all the terminals of the wires in the solid phase and by closely packing all the wires in the solid/electrolyte interface. This electrochemical integration minimizes the influence of the insulating layer on electron and ion movements and thus the working surface of a WBE effectively could simulate a conventional one-piece electrode surface in electrochemical behavior. The aim of this development is to extend the fundamental electrochemical theories and methods that are based on an ideally uniform electrode surface to heterogeneous electrode surfaces. This paper describes a typical localized corrosion experiment for illustrating the theory and applications of the WBE method in the measurement of localized corrosion.

Figure 1 shows an experimental set-up where a WBE made from 100 identical mild steel wires is totally immersed in a corrosive electrolyte containing 0.017 M sodium chloride and 0.008 M sodium carbonate⁹ under static conditions at 20 °C to allow corrosion to occur.

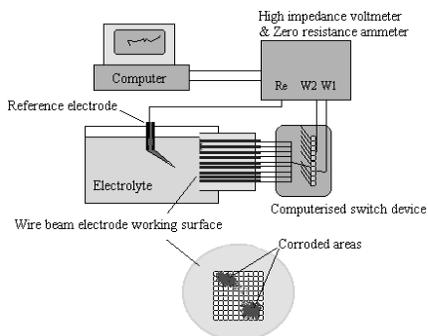


Figure 1. An experimental set-up using a WBE

The distribution of corrosion potential over the WBE surface was obtained by measuring the open circuit potential of each wire (E_k for the wire k) against an Ag/AgCl reference electrode. The terminals of wires in the electrode were temporarily disconnected from the WBE system and connected in sequence to an automatic zero resistance ammeter (autoZRA) using a computer controlled automatic switch device. In this work, E_k^0 value was arbitrarily set to equal the E_k measured after the wire k was disconnected from the WBE system for 1 second - to allow the disappearance of Ohmic drop and overpotential without major changes in surface mini-environment. The autoZRA was also connected in sequence between a chosen individual wire terminal and all other terminals shorted together using the computer controlled automatic switch to measure galvanic currents flowing between each individual wire and the wire beam system. Equations developed previously^{1,3} were applied to determine local corrosion rates, using the measured

potential and current (or noise resistance)³ data. A corrosion map of the type as shown in Figure 2 was produced, illustrating the instantaneous corrosion dissolution rates and their distribution at the particular point in time.

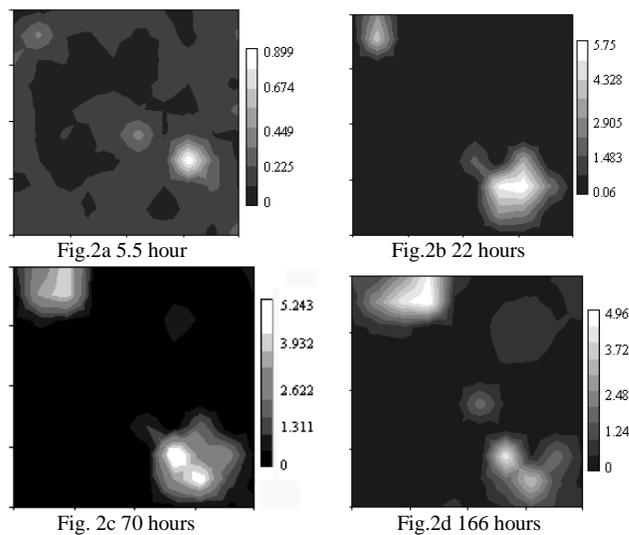


Figure 2. Corrosion rate distribution maps (in mm/y).

Instantaneous corrosion rate maps such as those shown in Figure 2 were used to determine total corrosion depths over the whole experimental period. This was achieved by summing up the corrosion depths over various periods of exposure to give a cumulative result. Figure 3 shows such calculated corrosion depth distribution map (Fig. 3a) together with a microscopically observed corrosion depth map (Fig. 3b) and a photo of the corroded WBE surface (Fig.3c) after exposed to corrosive environment for 406 hours. The calculated total corrosion depths correlate quantitatively with the microscopically observed corrosion depths and the photo of the corroded WBE. This result confirms the accuracy of the corrosion measurement method.

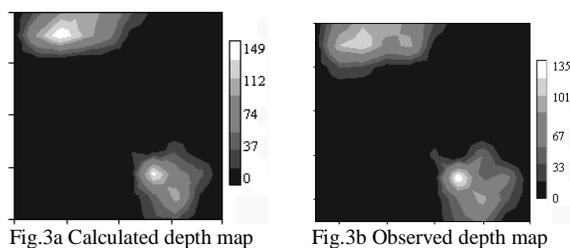


Figure 3. Corrosion depth distribution maps (in μm) and corroded WBE photo.

Fig.3c Photo of corroded WBE

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