PREDICTION OF WELDED JOINT THINNING
BY THE METHOD OF POLARIZATION RESISTANCE

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The equivalent electric circuits for determining \( R_p \) in electrolytic cells with two dissimilar electrodes are investigated. For welded joints, we suggest a relation for estimating the corrosion rate in terms of \( R_p \) and describe the design of a solion for determining this rate in a local zone of a welded joint.

The method of polarization resistance (\( R_p \)) is basic for the diagnostics of welded joint thinning under general electrochemical corrosion [1 – 4].

To use this method for determining the rate of corrosion of welded constructions, one must first justify it for an electrochemical cell consisting of dissimilar electrodes and elaborate the design of a solion.

Measurement can be realized without destroying a construction if the corrosion process is localized in a certain zone of a welded joint (Fig. 1a). The space between the auxiliary (standard) electrode and the area around the joint is filled with an aggressive agent. The auxiliary electrode is made of a base metal whose polarization resistance \( R_{p2} \) in this solution is known; it is necessary establish the resistance \( R_p \) of the area around the joint and the expected thinning in it.

The electrochemical problem is to determine \( R_p \) in a cell with two dissimilar electrodes. The equivalent electric circuit of this cell (Fig. 2a) is represented by the series connection of the resistance \( R_p \) of the solution with two circuits, each of which is a parallel connection of the capacities \( C_1 \) or \( C_2 \) of the double layers on the boundaries of the joint (auxiliary electrode – electrolyte) with the series segment consisting of the polarization resistance \( R_{p1} \) of the area around the joint (or the polarization resistance \( R_{p2} \) of the auxiliary electrode) and the initial electromotive forces \( E_1 \) and \( E_2 \) of a corrosion sensor. At the first stage of measurement, \( R_p \) is compensated under alternating current. At the frequency 10 kHz (\( R_{pmin} = 5 \text{ Ohm}, \ C_n \geq 50 \mu \text{F})\), the circuits (\( R_p - E_n \)) can be regarded as shorted out. Further measurement is carried out under direct current and, thus, the circuits with \( C_1 \) and \( C_2 \) are switched off. After compensating the initial electromotive forces, we measure \( R_{p0} \).

Fig. 1. The scheme of corrosion localizing: (a) for similar electrodes; (b) for a developed auxiliary electrode; (c) for measurement on a welding edge.

Then the expected joint thinning $i_w$ (mm per year) in a local zone of the welded joint is given by the expression

$$i_w = \frac{K_1}{S(R_{p0} - R_{p2})},$$

where $K_1$ is a linear coefficient equal to 230 for iron in acid solutions and $S$ is the area of the local zone in cm$^2$.

Fig. 2. The equivalent electric circuit of the electrochemical cell: (a) with similar electrodes; (b) with a split electrode.

In the case where the kind of base metal is unknown or it is impossible to make an auxiliary electrode of a base metal (if we test foreign equipment), then the rate of corrosion of a local zone should be measured directly (see Fig. 1b).

The electrochemical problem can be formulated as follows: Determine the polarization resistance of the cell with dissimilar electrodes in the case where the areas of corrosion surfaces differ significantly (by 10 times or higher). In this case, the equivalent electrical circuit is similar to that considered above but with $R_{p2} \to 0$. The expected thinning of the welded joint is

$$i_w = \frac{K_1}{SR_{p0}}.$$