Drawing of the Optimal Geometry of Electrochemical Cells

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Despite a large amount of research devoted to the improvement of electrochemical engineering methods this last few years there is still no answer to one of the most basic problem: how to determine the geometry of an electrochemical cell necessary to apply a given current distribution on the specified geometry of an electrode ? Even though this problem has been pointed out few decades ago and its practical interest is obvious, there is no mention of a theoretical method to define straightforwardly an electrochemical cell from the shape of the electrode and from the current density distribution applied on its surface. In this work, a numerical approach is presented, which provides approximate solutions in two dimensions; the mathematical solution is expressed as an analytical function tailored to the profile of the electrode to be electrochemically treated. The electrical potential and the stream function distributions can be interpreted as the result of the superposition of elementary sources and eddies of current originating from a finite number of points. Mathematically the potential distribution is expressed by a finite series of complex logarithm functions.

$$\omega = \frac{1}{\kappa} \sum_{i=1}^{N/2} \alpha_i \ln\left(z - z_i\right)$$

ω : complex potential,
α_i: complex current,
z_i: location of the current source,
N: number of current sources,
κ: conductivity of the electrolyte.

To illustrate the applicability of this method the problems of uniform plating on convex and concave shaped electrodes are solved. The results give the optimal shapes and positions of shields and of counter electrodes as shown on figure N° 1.

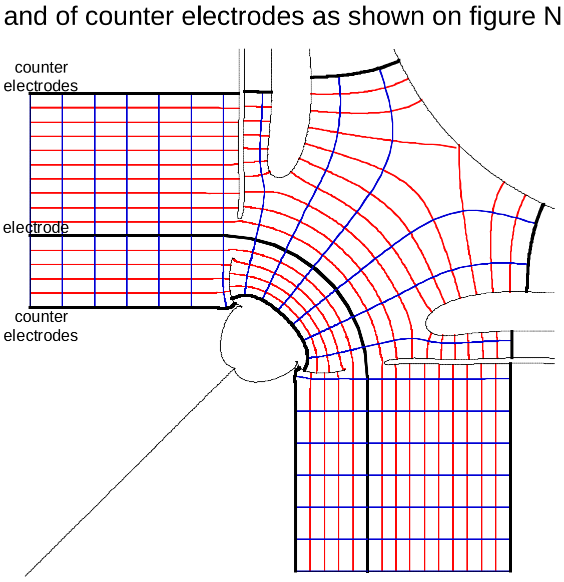

Figure N° 1: The appropriate shapes and positions of shields and counter electrodes are defined both for a convex and a concave equipotential electrode with a uniform current distribution.

The accuracy of the calculations depend on the degree of discretisation of the electrode and can be arbitrarily improved with a refinement of the condition of current density distribution on the electrode.

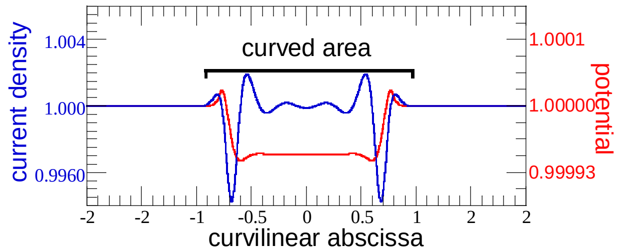

Figure N° 2: The conditions of uniform potential and uniform current distribution are checked with a limited accuracy.

The solutions indicate that the use of auxiliary electrodes is not optimal and that conforming counter-electrodes have a limited scope of application. Appropriately shaped shields and counter electrodes are accurate enough to performed uniform current distribution on convex and concave shaped electrodes.