MODELING AND SIMULATION: OPTIMIZATION OF REACTOR GEOMETRIES WITH RESPECT TO A HOMOGENEOUS DEPOSIT PROFILE

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Optimization of the performance of electrochemical reactors is a very important topic to ensure an efficient and low cost technical process. In this contribution, a recently developed software [1] is applied to some technical important plating procedures (chromium plating of a steel cylinder, brass plating of a steel wire). The software is based on the so-called potential model, which follows from the complete transport equation under the condition of vanishing concentration gradients. Consequently, the applicability of the software is restricted to reactors with highly efficient stirring utilities.

Evidently - in the case of plating processes - the optimization has to be performed with respect to the homogeneity of the deposit profile (or, because of Faraday's law, with respect to a uniform current density along the cathode). Since the potential model yields the potential field *U(x,y,z)* and spatial current density distributions *J(x,y,z)* dependent on the electrode kinetics and on the reactor geometry, its numerical solution should allow for the optimization of reactor designs. The above-mentioned software offers fast numerical solutions of the potential model in two dimensions, i. e. one has to perform the simulation with a representative cut through the reactor (longitudinal section, cross-section) which yields the current density along the electrode intersecting curves.

As an example, Fig. 1 depicts the cross-section of an electrochemical reactor with a typical geometry used for chromium plating of large-scaled steel cylinders with diameters up to 1.2 meters. One can see, that a configuration with a ring of 6 rods acting as anodes causes a pronounced inhomogeneous cathodic current density distribution along the intersecting circle and, as a consequence, one can expect an inhomogeneous deposit profile. The results of a series of simulations for different numbers of anodes for a cylinder with a diameter of 496 mm and a fixed distance of 375 mm between the centres of the anodes and the centre of the cylinder are given in Fig. 2. One can see that the amplitude of the periodic current density fluctuations decreases exponentially with the number of anodes.

By performing the simulations with a longitudinal section, the optimization of the position and geometry of a current thieve will be presented which nearly completly suppresses the current density maxima at the edges of the cylinder .

In order to demonstrate the influence of the shape of the anode on the homogeneity of the deposit profile, a brass plating process of a steel wire will be presented , too.

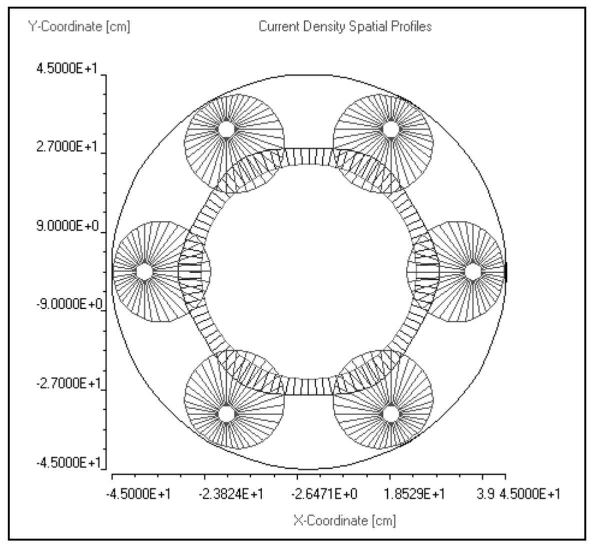

Fig. 1.: Cathodic current density fluctuations along an intersecting circle of the steel cylinder and current densities along the intersecting circles of six anodes in a cylindrical electrochemical reactor..

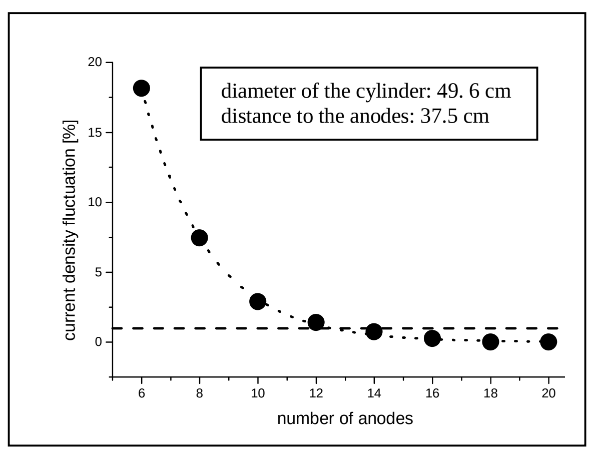

Fig. 2.: Relative current density fluctuations vs. number of anodes (dotted line: exponential fit; dashed line: 1 % relative current density fluctuation) for a defined distance between the centres of the anodes and the cylinder.

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[1] ElSy (see, www.elsca.com)