Mechanism of capture of ionic impurities from electrolytes, based on a bipolar cell of oscillating porous electrodes, spaced by the equilibrium distances

Roberto Perez M. [a]

[a] *Departamento de Ingenieria Metalurgica Universidad de Santiago de Chile Av. Bernardo O´Higgins 3363Casilla 10233, SantiagoChile*

Summary: This work proposes the use of electrochemical cells (bipolar or series) like mechanism recuperate of impurities and noble species, from contaminated or impoverished electrolytes. The treated fluid circulates through porous or perforated electrodes of compound material. In order to produce successive, selective deposits of the different chemical substances, these electrodes are located spaced by specific distances. Different prototypes of electrodes were elaborated starting from a conductive base material with small dielectric zones, which can have their origin in ceramic particles or pores. The rate and selectivity of capture was related to the porosity and nature of the base of the electrode, quantified by the size, geometry, average density and distribution of the dielectric zones in the conductive matrix of the electrode.
The longitudinal coordinates of each electrode are determined by means of the plainer of the electric field, which appears between the terminal electrodes, anode and cathode, polarized by an external source of tension. Using methods of finite mathematics the map of the equipotential lines was simulated and the location exact of each electrode so that by effect of his polarization it extracts a single chemical species was found. The type and the number of electrodes of the cell filter are determined by the time of residence required by the fluid to process, in order to obtain an appropriate deposit based on the volumetric flow, the composition and concentration of impurities and noble species.

Keywords: bipolar cells, vortices, probability of capture, free concentration

1. Introduction

When disturbing electro magnetically the interphase electrode electrolyte, a zone where the probability of capture of an ionic species is significantly greater than the one of others is generated. A conduct of stochastic nature for the dynamics of electro winning is proposed. Defining a variable which we will call free concentration of the chemical species and the geometry of the electric field the location of the electrode collector where the probability of extracting it is greater is determined. The nature of the material of the electrodes formed by conductive and dielectric phases, creates internal borders with local accumulations of electric charges in them, these internal condensers activated electro magnetically behave like vortices (where the relations space-time of the field do not respond to the classic architecture of the relations of

Maxwell), since they are generalized probability distributions that control the energy transfer.
The experimental verification of this mechanism was made using a multifactor design considering the electrical resistance equivalent of a cell, probability of capture, selectivity of the capture and effect of the perforations on the time of capture.

2. Objectives

1. The aim of this project is the analysis of the cell bipolar series as a mechanism selective recuperator of impurities and valuable species from solutions electrolytes and the influence of oscillating porous electrodes in the rate and selectivity of this capture.
2. To develop a dynamic model of the electric field in the electrolyte, and its modification by the presence of intermediate electrodes, in a certain configuration and the change in the composition and concentration of the electrolyte through the filter.

3. Procedure

A cell with stainless steel electrodes of different size was used, with an industrial electrolyte of electro-refining and electro-winning of copper, with perforations of variable form and size, different flows and temperatures. The position of the electrodes was adjusted with graduated bars of distribution on which it hung the electrodes, that oscillating mechanically to subsonic frequencies improving the selectivity of the deposit.
The experimental design is based on a multifactor adjustment, of the variables voltage of cell, adjustment of distances interelectrodes, mechanical porosity of the electrode and vibrations. Each factor is applied in three levels. As the probability that characterizes the equivalent ionic concentration is not know, the use of classic techniques is not feasible (normal Distribution) to analyze the dispersion in the results. Therefore a number of repetitions with non-parametric analysis will be required. Then, samples pilots closed at random, with a minimum number of 10 repetitions have to be made in order to get the density function from the histogram of frequencies.

4. Scheme of the cell serie prototype

The plant is composed by two metallic plates as a terminal electrodes (anode and cathode) connected to the poles positive and negative of a source of electrical tension. These electrodes are submerged in a cell filled with the electrolyte. The cell is part of a electrolytic circuit. Between the terminal electrodes, isolated electrodes are located as a set the metallic plates, interspaced at variable distances according to the different species that are desired to retain. When the isolated electrodes are polarized generate in each one of them the potential of dynamic equilibrium of the individual species, allowing the selectivity. Each plant, depending on the type and volume of the electrolyte to treat, the species to recover, and the electrical tension to apply, will have an own configuration of distances inter-electrodes, that from now on we will call pattern of the plant. The conclusions that can be obtained from this idealization could

be applicated to the industrial plants, considering the corresponding projection of the scaling-up of the plant.
The intermediate electrodes will be permeable to the passage of the electrolyte which implies that each one has pores or perforations to allow the passage of the electrolyte. The form and size of the perforations have to be calculated in relation to the nature of the electrolyte to be treated, temperature, composition, concentration, and others.
The cell has different chamber by which it is circulating the electrolyte becoming impoverished gradually as the species are extracted. The geometry of the perforated electrodes (shape, size and distribution of the holes) generates different level of turbulence, which determines of thickness of the boundary limit and the contact time between the species and the electrodes. Consequently, the optimal recovery of each species will be controlled by the local conditions on the bipolar electrodes. With the simulator algorithm, based on the geometry of the electrodes and the flow conditions the rate of recovery of each species will be estimated.
The size of the cell as well as the length between the terminal electrodes and the electrode area will be function basically of the number of different chemical species to capture, its concentration and the volume of the electrolyte to be treated; which determines the number of intermediate electrodes by each chemical species to extract and the magnitude of the electrical tension applied.

5. Conclusions

The first experiences gave the expected results, the electrodes were polarized by means of an electric field in the cell series through the electrolyte from the connected terminal electrodes to the source. The deposits were smooth and even in same bipolar electrodes, which demonstrates that the current density is distributed in an uneven form on the surface of the different plates. The masses deposited of copper in each sub cell are determined by the distance of the electrodes with respect to the cathode, getting a smaller deposit as this one increases. The theory proposes that the deposits had to be equal in each cathode since the current had to be equal in each sub cell due to the configuration in series. Nevertheless, the experiences validated the presence of losses of current through the electrolyte, this last was demonstrates with the application of the law (law of Faraday).

References

Peréz Roberto The Thermodynamic Equations of the Electromagnetic Field *IEE Proceedings Electric Power Applications,* 2002.