Spectrum of the Voltage Fluctuations in an Aluminium Electrolysis Cell

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The voltage of an aluminum electrolysis cell fluctuates due to the periodic character of gas bubble generation below the anode (1,2). A mathematical model was developed earlier (3) for the prediction of the value and fluctuations of the covering factor of the anode. In the model, bubbles are generated at the nodes of a virtual grid placed on the anode surface in a way that respects the mass balance and the random characteristics of the phenomenon. Results presented in this paper were all computed for 280 bubble nucleation sites (28 sites in the direction of the flow, 10 sites in the normal direction). The algorithm keeps track of each end every bubble from the nucleation through the individual growth, detachment and coalescence to the escape from below the anode. Besides the values of the covering factor, the simulation procedure computes also the mean liquid velocity in the two-phase layer.

The objective of the present work was to determine the influence of the periodic nature of the growth cycle, the bubble generation frequency and the detachment volume of the individual bubbles on the fluctuations of the cell voltage (covering factor) and on that of the fluid velocity. Results, computed for different anode geometries were compared as well.

As the bubbles grow, the gas covers a bigger and bigger portion of the anode bottom. When a bubble escapes, the covering factor decreases rapidly. In the initial period, when the bubble growth is controlled by diffusion through the porous anode, the diameter of the bubble increases about 400-600 times while its volume by a factor of 10^7-10^8. After the detachment the relative variation of the bubble size is smaller, the diameter increases about 20 times and the volume only about 500 times due to the flattening of the bubble. The escape of the big, flat, dominating bubbles causes the big fluctuations in the covering factor (see figure 1). When they escape in the lateral channels, the big bubbles sweep the anode bottom and also accelerate the two-phase layer (figure 2).

The character of the fluctuations varies with the shape of the anode. Below the anodes that are long in the direction of the movement of the two-phase layer the bubbles have more chance to grow big. In the case of wide anodes, the nearly simultaneous escape of several big bubbles in a random sequence can be superimposed which makes the individual big fluctuations invisible.

Figure 3 shows the growth of big bubbles by coalescence after the detachment from the nucleation site just to the point of escape from below the anode. The movement, collision and coalescence of these big bubbles produce strong, periodic phenomena that can dominate the spectrum, suppressing completely the frequency of the generation of individual bubbles, figure 4.

ACKNOWLEDGMENTS

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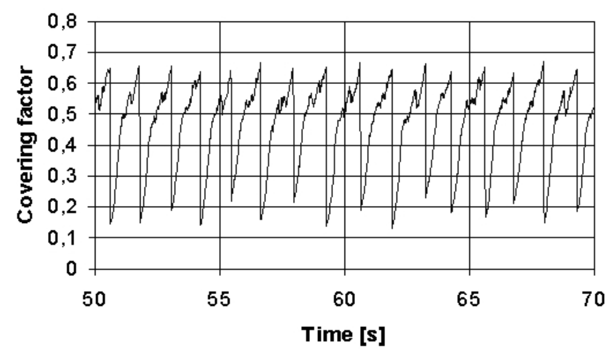

Figure 1 – Example of the computed fluctuation of the covering factor of the anode bottom.

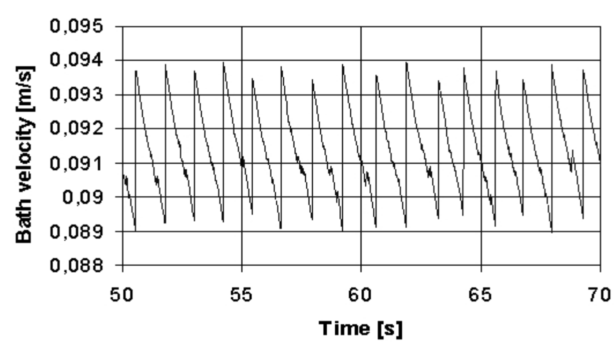

Figure 2 – Example of the computed fluctuation of the bath velocity in the bubble layer.

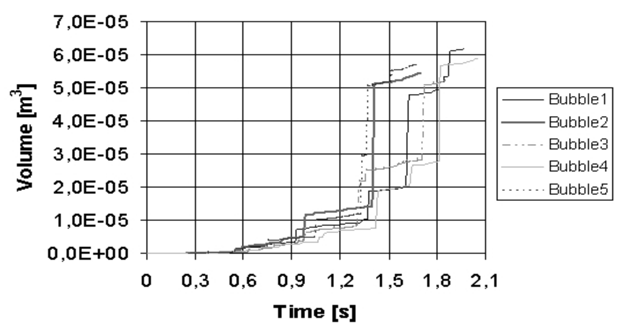

Figure 3 – Growth of big bubbles by coalescence.

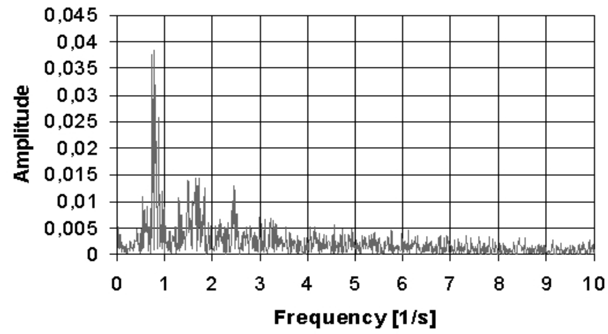

Figure 4 – Computed spectrum of the covering factor fluctuations. Frequency of the bubble generation is 4 Hz.