METHOD OF AUTOMATIC SIGNALING OF THE CRITICAL AL_2O_3 MINIMUM CONCENTRATION IN THE ELECTROLYTE

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Metoda are ca scop un control continuu, cu sesizare în regim automat a funcționării dispozitivelor de dozare alumină şi spargere crustă la cuvele de electroliză modernizate pentru obținerea aluminiului electrolitic.

Principiul metodei are la bază un control continuu al variației concentrației de alumină din electrolit cu sesizarea atingerii unor praguri critice minime ce conduc la apariția efectelor anodice.

Metoda are rolul de a stabili eventualele diferențe între un grafic standard impus de variație a pseudo-rezistenței şi graficul de variație real a acesteia în timpul funcționării cuvei. În cazul în care între cele două grafice se constată apariția unor diferențe, ce se situează peste pragurile maxime prestabilite, se atenționează prin alarmă acustică şi mesaj la calculatoarele de cuvă, apariția unei defecțiuni la dispozitivele de alimentare cu alumină.

The method targets a continuous control, with automatic signaling of the alumina feeding and crust breaking during the operation at the upgraded pots for the electrolytic aluminum production.

The method is based on a continuous control of the alumina concentration variation in the electrolyte by seizing the attainment of minimum critical thresholds which lead to the anode effects occurrence.

The method aims to establish the eventual differences between a preset standard chart of pot pseudo-resistance variation and its real variation chart during pot operation. When some differences between the two charts are noticed, situated over the preset maximum thresholds, an acoustic signal is given and message to the process computer is sent to inform about the occurrence of a fault at the alumina feeding devices.

Keywords: alumina feeding, anode effect, electrolyte

1. Introduction

The present devices operation monitoring methods, currently used at the world level at the electrolysis pots for electrolytic aluminum production, which are fitted with central punctiform feeding, use mainly electric sensors for stroke seizing only for the crust breaking plungers [1].

These electric sensors have the following disadvantages:

- low reliability, mainly due to the environmental conditions in the electrolysis potrooms, which lead to frequent false alarms which usually are caused by the deterioration of the electrical contacts.

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- clogging up of the alumina chargers or eventual lack of alumina in the pot hoppers can not be seized and, in these cases, the premature occurrence of the anode effects can not be avoided.
- the occurrence of the premature anode effects can also occur due to the tendency of electrolyte supersaturation in alumina, especially when the alumina solubility is low, which leads to the generation of alumina hills in the feeding holes area, without being noticed by the plungers stroke sensors.
- the purchase price for these type of plungers, additionally fitted with stroke sensors, is higher compared with the same type of plungers without stroke sensors.

The proposed method aims at a continuous control of the alumina concentration fluctuation in the electrolyte by signaling the achievement of the minimum critical thresholds which lead to the occurrence of the premature anode effects [2].

2. Principle of the method:

When a fault appears in alumina feeding, an accelerated drop of $\%Al_2O_3$ in the electrolyte is registered, with fast fluctuations of the pot pseudo-resistance which leads to the occurrence of the anode effects if the fault is not noticed and the failure is not corrected in due time (10-20 minutes) [3-4].

The method is based on an algorithm of continuous monitoring of the pot pseudo-resistance fluctuation during the alumina feeding periods, by a sequence of stages:

- calculation of the weighted average values of the pot pseudo-resistance at preset periods of 5-10 minutes per minute starting since the moment of occurrence of an anode effect tendency.
- calculation of the pot pseudo-resistance increasing slope versus the reference value registered at the moment of the anode effect tendency occurrence as well as versus the value registered in the previous cycle and their comparison with the preset critical values.

Practically, the algorithm achieves a continuous comparison of a preset imposed standard chart, for a normal variation of the pot pseudo-resistance, with its pseudo- resistance variation in real time. When sensitive variations between two charts are noticed, based on some preset imposed thresholds, the occurrence of some failures in the pot feeding with alumina is admitted [5-8].

Critical sinusoidal was determined by processing some data sets for the pot pseudo-resistance evolution areas prior to the anode effect occurrence.

The program signals all situations in which a pot presents the risks for the immediate occurrence of an anode effect:

- blockage of the pneumatic charger-plunger;
- empty alumina hopper;
- alumina hill generation;
- alumina through displacement.

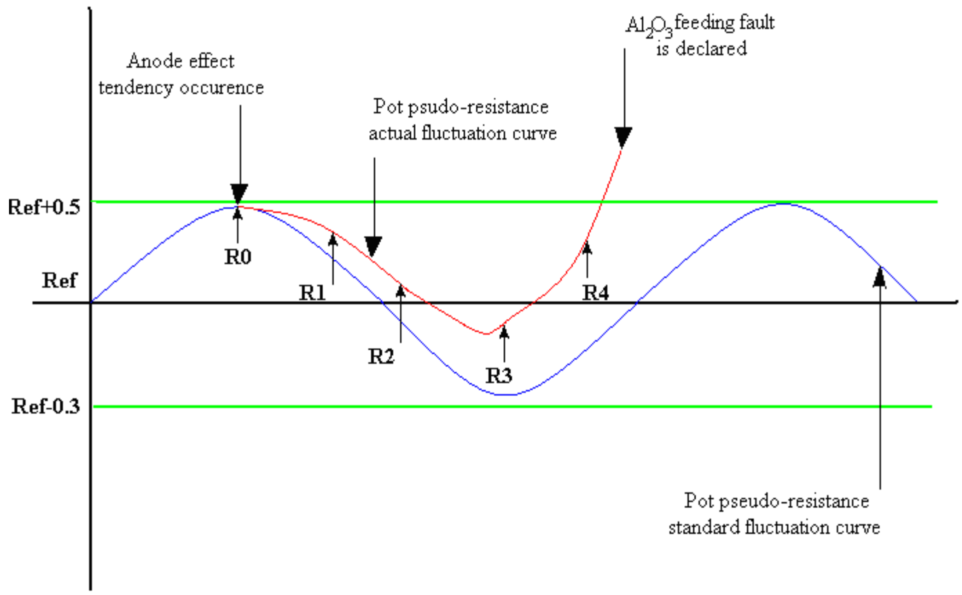

Fig. 1 Critical sinusoidal

At the preset periods of 5-10 minutes, the weighted average values of the following pot parameters are calculated:

- the weighted average value per minute of the pot pseudo-resistance starting since the moment of occurrence of each anode effect tendency until the moment of a new tendency of the anode effect. (R_0, R_1, R_2, R_3…R_n);
- duration of the last slow feeding phase (DRLE).

The increasing slopes of the pot pseudo-resistance are calculated for the ultra-rapid and rapid feeding periods, according to the ratios (1), (2):

$$R_i\text{-}R_0=\Delta R_{0,i} \quad (1)$$

$$R_{i-1}\text{-}R_i=\Delta R_{i-1,i} \quad (2)$$

where:

R_0 - value of the weighted average resistance per minute since the moment of the occurrence of an anode effect tendency.

R_i - value of the weighted average resistance per one minute achieved at preset cycles

R_{i-1} - value of the weighted average resistance per one minute achieved in the previous cycle

At each cycle, the cumulated increases of the pot pseudo-resistance are calculated since the moment of the occurrence of the last anode effect tendency by checking the conditions of signaling the failure in alumina feeding, according to the ratios (3), (4), (5).

$$R_{i-1} - R_i > p_1 \quad (3)$$

$$R_i - R_0 > p_2 \quad (4)$$

$$p_1 > p_2 * k_2 \quad (5)$$

where:

p_1- preset critical value of the increasing slopes of the pot pseudo-resistance weighted average values with values in the range 0.008-0.012 μΩ/min

p_2 – preset critical value of the increasing slopes of the pot pseudo-resistance weighted average values with values in the range 0.02-0.04 μΩ/min.
k_2.- preset minimum increase coefficient of the slope p_1 against p_2, with values in the range 1.4-1.8 (dimensionless).

3. Results and Discussion:

Based on the monitoring of the main parameters, preceding the anode effect occurrence, the following was noticed:
- the anode effect increasing slope, for a pot with %Al_2O_3, in the normal limits of 2-3%, ranges in values between 16-18μΩ/min and has a duration of an alumina underfeeding phase sensible equal with the phase of rapid alumina feeding;
- an increasing slope below 15μΩ/min (correlated with a high duration of the last two underfeeding phases) indicates a pot operation at %Al_2O_3 over 3-4%, which requires the operator to decrease the alumina feeding rate (Kalim decrease) in order to reduce the risk of alumina deposits on the cathode;
- an increasing slope over 20μΩ/min indicates a pot operation at %Al_2O_3 below 2%, which would require the operator to increase the alumina feeding rate (Kalim decrease). It can be ascertained in these cases that a pot can also operate at %Al_2O_3 (below 2%), without entering in an anode effect, provided a technological work, which frequently leads to the anode effect occurrence, (anode replacement, tapping, command for downward movement) is not performed.

Under these circumstances, the calculation of the anode effect tendency is disturbed and the pot computer notices the following tendency of the anode effect (with performance of alumina over-feeding operation) with delay, which can lead to the anode effect occurrence.

The analysis of the data obtained at the pots with anode effect have shown that the evolution of the following parameters can pre- signalize a rate of alumina feeding below or over the pot normal consumption, respectively:
- evolution of the last three increasing slopes at the anode effect tendency;
- evolution of the alumina under-feeding duration (slow feeding) related to the last three tendencies of anode effect;
- the lower the duration between the last anode effect tendency and the anode effect occurrence, the higher the increasing slope at the last tendency (Fig.2).

For a certain duration of underfeeding, there is a critical increasing slope of the tendency, which can pre-signalize the anode effect occurrence.

It is ascertained, that for the pots with the last increase of the tendency higher than 25μΩ, the duration up to the anode effect is exponentially decreasing.

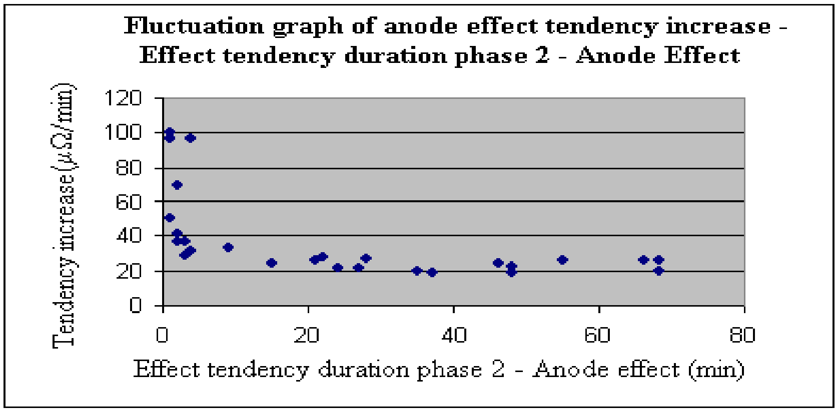

Fig. 2 Fluctuation graph of anode effect tendency increase – Effect tendency duration phase 2 – Anode Effect

The analysis of the evolution of the TE_2 increasing (for the last four consecutive TE_2) ascertains a sensitive different evolution of the pots which have experienced AE (at approx. 3-30 min after TE_4) and the pots with normal operation without EA (the average values TE_4-TE_1 are achieved for a number of 30 pots from each potline) Fig.3, Table no.1.

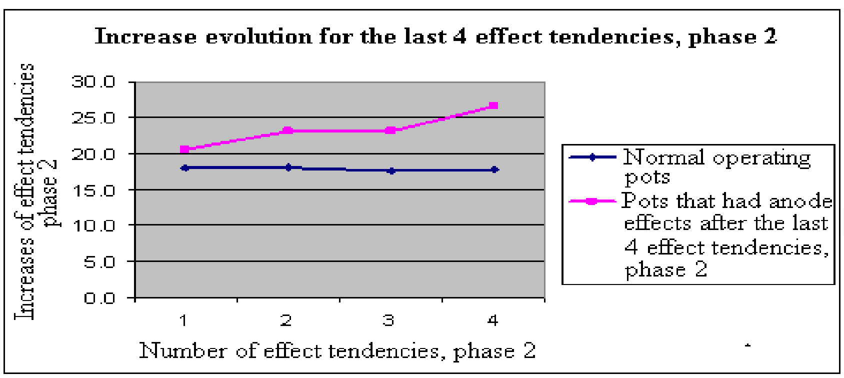

Fig. 3 Increase evolution for the last 4 effect tendencies, phase 2

Table 1

The average values TE_4-TE_1 are achieved for a number of 30 pots from each potline

Effect tendency increase phase 2 (µΩ/min)	TE_{i-3}	TE_{i-2}	TE_{i-1}	TE_i
Normal pots	18.1	18.1	17.6	17.7
Pots with AE	20.6	23.1	23.1	26.2

Based on the analysis of the last 4 durations (between those four consecutive TE_2), it is found out a sensitive different evolution of the pots, which have experienced AE (at 3-30 min after TE_4), and the pots with normal operation without AE (the average values are achieved for a number of 30 pots from each potline) Fig.4, Table no.2.

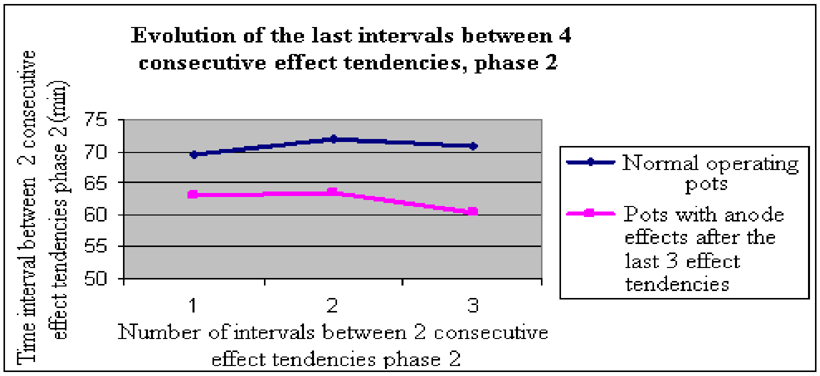

Fig. 4 Evolution of the last intervals between 4 consecutive effect tendencies, phase 2

Table 2

The analysis of the last 4 durations (between those four consecutive TE_2

Duration between two consecutive anode effect tendencies (min)	TE_{i-3} - TE_{i-2}	TE_{i-2} - TE_{i-1}	TE_{i-1} - TE_i
Normal pots	70.9	71.9	70.9
Pots with AE	63.1	63.5	60.3

The analysis of the data related to the pots with AE (occurred at 3-30 min since TE_2) indicates a good correlation, which would allow to establish an equation for determination of a critical increasing at TE_2 according to the duration between the last two TE_2, prior to the AE occurrence, Fig.5.

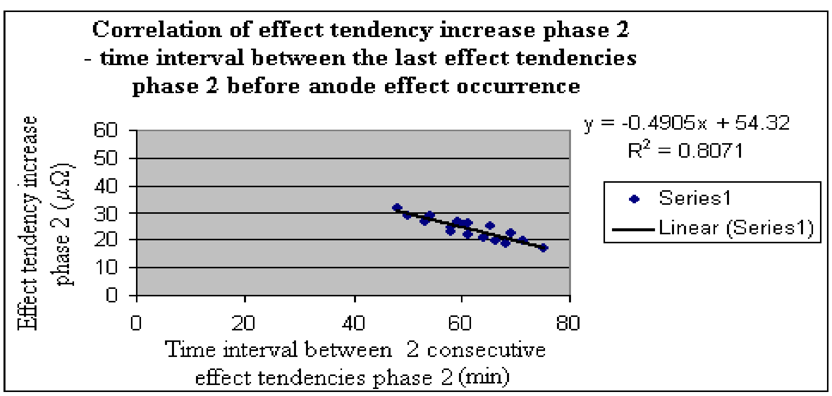

Fig. 5 Correlation of effect tendency increase phase 2 – time interval between the last effect tendencies phase 2 before anode effect occurrence

In Fig.6 and Fig.7, the evolution of the anode effects average in two electrolyses potrooms is presented, 9 months prior to the program use and their evolution during the following 9 months after the program implementation.

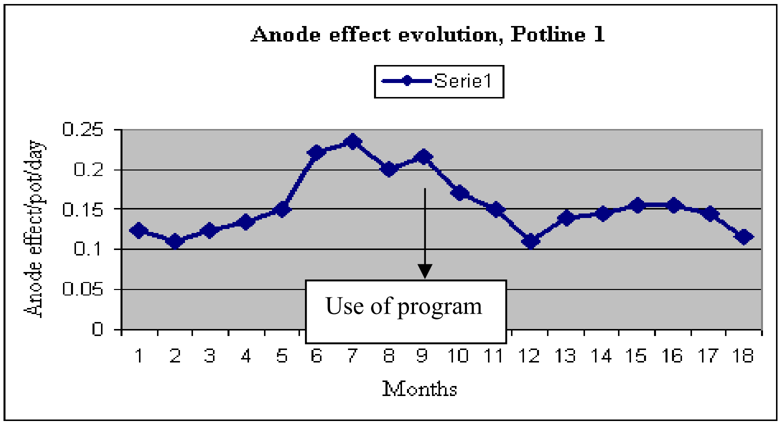

Fig. 6 Anode effect evolution, Potline 1

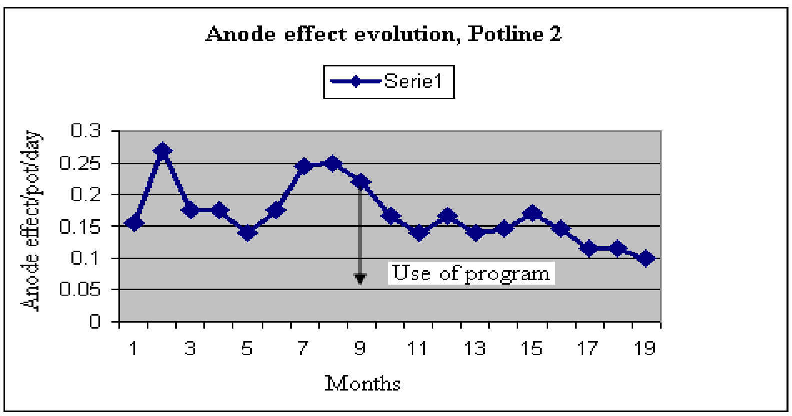

Fig. 7 Anode effect evolution, Potline 2

3. Conclusions

The initial implementation of the algorithm at the level of 15 electrolysis pots test group, followed by its implementation at the potlines level, has emphasized the following:
- signaling the mechanical failures at one of the alumina feeding device, of crust breaking charger-plunger type, was achieved by activation of a sound signal in the potline alongside with the display of the message “Pot no ….Failure in Al_2O_3 feeding” at each pot micro-calculator;
- signaling the mechanical failures was achieved by about 5-30 minutes prior to the anode effects occurrence, period which depends on the type of pot feeding in the moment of mechanic at failure occurrence (the pot can be in three feeding stages: overfeeding, rapid feeding or underfeeding with alumina);
- the average amount of anode effects decreased by approx. 40% and, inferentially, this had a positive impact on the achieved average voltage as well as on the efficiency.

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