Control of the Microplasma Process in Electrolyte Solutions Based on STATISTICA Model

Valery N. Borikov, Oleg V. Stukach, Elena A. Popova

Tomsk Polytechnic University, Tomsk

***Abstract* — Modeling of microplasma oxidation process in the electrolyte solutions for various coverings is carried out by processing of experimental data in STATISTICA software. The prospecting analysis of experimental data is carried out. Hopelessness of linear model for the process is shown. The square-law models most precisely appropriate to experimental results are offered and proved. Sufficiency of models is checked up. The received models may be used for decision of a problem of control by microplasma oxidation process.**

***Index Terms* — Microplasma oxidation, modeling in STATISTICA, control of the microplasma process, square-law regression model.**

I. Introduction

The microplasma method of the metal surface processing is the most perspective among traditional electrochemical methods [1]. The method consists of processing of details in electrolytes by big density currents. During covering the local plasma charges are observed that is the basic characteristic of process. Many various factors, for example, time, temperature, the bath form, value and form of the input voltage etc are impact on microplasma oxidation. Influence of these factors continues to be studied. The received results are actively used in practice. Nevertheless, up to now the problem of control by process of the microplasma oxidation is not solved, that demands design of model for the process.

Dependence of a target current on the voltage on electrodes represents random process. Therefore in the given paper it was offered to use statistical software STATISTICA as one of the program complexes, capable to solve this problem. The software allows to carry out the prospecting analysis of the data and to choose the most

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suitable model for the process. In addition, there is an opportunity to check up sufficiency of model by various probability diagrams.

II. MODELING

Using measurement input and output signals of process, it is possible to design its model. Identification of the microplasma oxidation process we shall carry out in the following.

1. It in necessary to transform the data from a format of registration device (oscillograph with program control) to STATISTICA format.

2. It in necessary to carry out the prospecting analysis of the data by investigation of the basic statistics and process diagrams.

3. This step is design a regression model, estimate its adequacy and make conclusions on the opportunity of formation of control impacts based on the offered model.

4. We compare received models for different coverings that will allow to solve the identification problem.

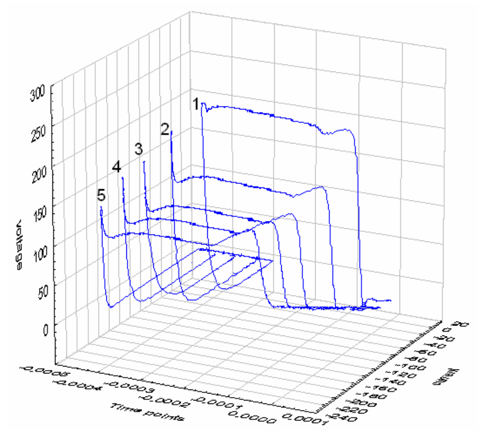

Fig. 1. The input and output signal form for the microplasma oxidation process vs time points

Experiment consists in the following. Three details of one form and size were serially processed in different electrolytes within five minutes. The form of voltage (input signal) and output current were measured by a digital oscillograph and fixed in 2500 time points. For the analysis the results measured with an interval in one minute were chosen. The signal form varied as processes in electrolyte [2]. Diagrams for one of solution are shown on Fig. 1. Axis X corresponds to time points, axis Y is the output current, axis Z is the input voltage. Digits on the diagram designate minutes, through which data were taken for the analysis.

Let's carry out the prospecting analysis of the data for formation of the assumption of function for the regression model. From Fig. 2 it is visible that the linear model may not be adequate to considered process. It is a large disorder of current and voltage from the prospective plane which have been carried out by a method of the least squares.

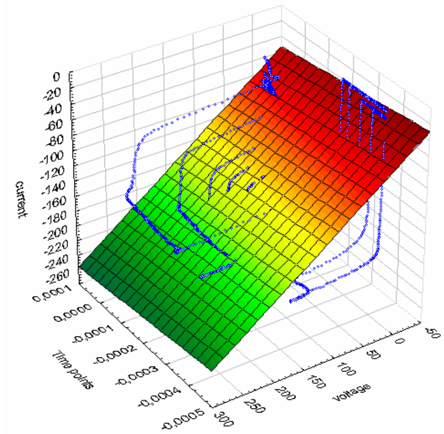

Fig. 2. The linearity assumption of the oxidation model

The square-law model (Fig. 3) designed in STATISTICA software for the considered process and its expression looks like more suitable:

$$I_{out}(t,U) = -79.808 - 1.2587 \cdot 10^5 t - 1.4558U + \\ + 1.1473 \cdot 10^8 t^2 + 1565.9918Ut + 0.0052U^2 + \varepsilon(t),$$

where ε(t) is a noise and errors of voltage measurement.

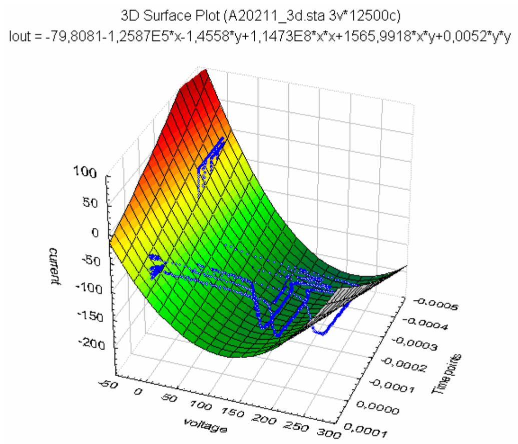

Fig. 3. The assumption about square-law model of the oxidation process

The assumption about square-law oxidation models confirm box and whisker diagrams for all measured values of current (Fig. 4) and voltage (Fig. 5). From diagrams it is visible that means of signals is changed at first time quickly, and then this change is slowed down. The maximal and minimal values of signal change the same. There are no unidirectional reasons influencing process, except for considered signals that symmetry of boxes and whiskers specifies.

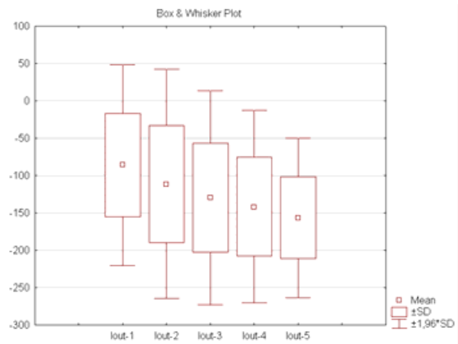

Fig. 4. Box and whisker for the output current of each measurement

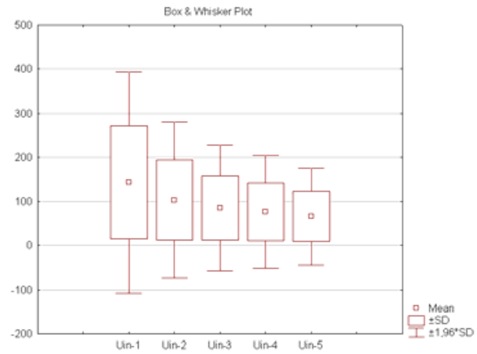

Fig. 5. Box and whisker for the input voltage

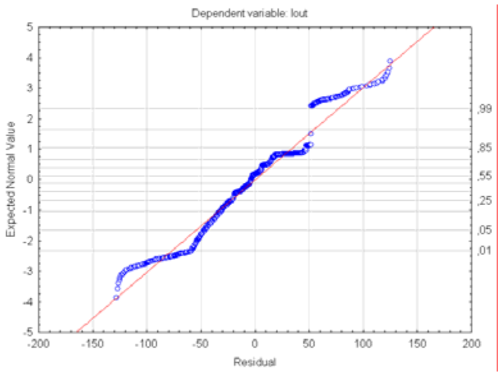

Fig. 6. Normal probability chart of residuals for square-law oxidation model

Let's carry out the regression analysis with module *Statistics/Advanced Linear/Nonlinear Models / General Regression Models*, having chosen a *Polynomial regression*. In result the following dependence is received:

$$I_{out}(t,U) = -48.393 - 1.8387U + 0.0057U^2 + \varepsilon(t)$$

It is visible that the coefficient at the voltage square in 100 times is less than coefficient at the linear component. For sufficiency checking of model we shall design a normal probability chart of the residuals. From Fig. 6 it is visible that the residuals lay on a line very well. It indicates a small error of decision.

Let's design model as a polynomial of the third order in module *Statistics/Advanced Linear/Nonlinear Models / Nonlinear Estimation*. As a result of good initial approximation choice we shall receive model:

$$I_{out}(t,U) = -44.295 - 3.024U + 0.0183U^2 + \varepsilon(t)$$

The coefficient at the voltage cube is appeared equal to zero. Thus, it proves a right choice of square-law model.

III. Discussion

Results of process modeling in various electrolytes testify a good repeatability of square-law model and essential distinctions in values of its coefficients.

For example, for different aluminium coverings the independent component varies in limits from 20 up to 80 that allow to effectively solve an identification problem of covering. Besides simplicity of square-law model gives a good opportunity of process control at obtaining the appropriate voltage form.

Exhaustion another classes of parametrical models and increase of their degree has given worse or not exceeding result.

It is visible from Fig. 4 and Fig. 5 that at values of current in comparison with voltage the disorder from a minimum up to a maximum for various times are much higher. It specifies complexity of the control problem which is precisely difficult for solving only as a result of obtaining of the necessary signal form.

References

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[2] A.I. Mamaev, V.N. Borikov, V.A. Mamaeva, T.I. Dorofeeva. The automatic method of the metals and alloys identification. Russia Patent No. 2005109471 (26.02.2006).