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MEASUREMENT OF OVERGLAZE MICROWIRE RESISTANCE IN THE MANUFACTURING PROCESS

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Abstract **– The paper is dedicated to the solution of the problem of the quality control of overglaze microwire insulation in the technological operation of moulding. The model of the measured object in the operation of the resistive material molding is defined. To obtain the measurements exactitude the method of simulated resonance based on an impedance simulator and serial resonance circuit is offered to use. Also are presented the structure of the resistance meter realizing the method, the analysis of its operation.**

Keywords: *insulated wire, simulated resonance, impedance simulator*

1. INTRODUCTION

In the technological process of owerglaze microwire production frequently appears the problem of resistance control in the process of its molding [1]. The important requirement to used measuring equipment is the complete automation of measuring process and compatibility of equipment with an intelligent system used for control the technological process. As the microwire is covered by glass insulation, the continuous measurement of its resistance creates any difficulties in the technological process. The engineering problems in these technological operations consists in inaccessibility of one pole of the measured resistor for the galvanic contact with the measuring device, that does not allow applying to this purpose the traditional measuring methods and devices.

2. OBJECT OF MEASUREMENTS

As the resistive wire is covered with continuous isolation which destruction is inadmissible, one pole (or both poles) of measured resistance are inaccessible for galvanic connection to the measuring device. For formation of the closed measuring circuit, the additional elements can be used, such as the reel with a resistive material and capacitive contacts to a moving wire. As will be shown below, the object of measurement has the complex equivalent circuit containing active and reactive components of impedance.

In the technological operation of molding, it is necessary to control per-unit length resistance of the resistive wire. In this operation (Fig. 1, a) it is necessary to measure the resistance of a wire section made between two capacitive contacts C_1 and C_2.

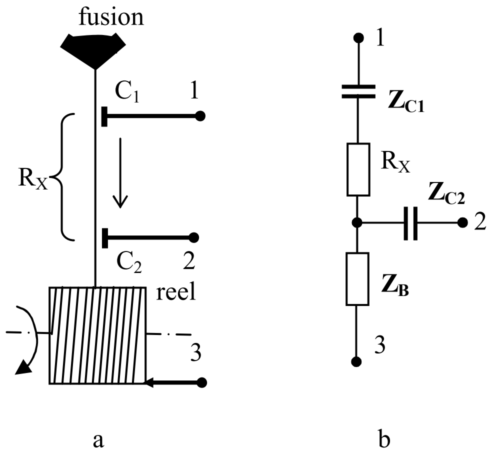

Fig. 1. Schematically representation of the process of microwire molding (a) and the equivalent circuit of measuring object (b)

For connection the measured resistance to the measuring device, the contacts 1, 2 and 3 can be used. The equivalent circuit of object of measurement (Fig. 1, b) contains the measured resistance R_X and the noninformative impedances of coupling elements $\mathbf{Z_{C1}}$, $\mathbf{Z_{C2}}$, $\mathbf{Z_B}$. During the moving of a wire, the resistance of these elements varies under the random law and, consequently, it is necessary to eliminate their influence on the result of measurement. The measuring device should ensure a measuring error of per-unit length resistance no more than 10 %.

The capacitive contacts represents a metal plates forming with a moving resistive wire capacity C, which value will vary on casual in limits 1- 10 pF. Its impedance is determined [1]:

$$Z_C = \left[r(j\omega C)^{-1}\right]^{0.5} \mathrm{cth}\left[(j\omega C\ L)^{0.5}\right] \approx \approx (j\omega C)^{-1} \qquad (1)$$

where: r - per-unit length resistance of a wire, ω - frequency of a signal, L - breadth of contact.

The impedance of the reel $\mathbf{Z_B}$ is formed from capacity of a metal frame of the reel with the resistive material, reeled on it, and sum resistance of a wire. The equivalent circuit of this element represents the structure with distributed parameters and its impedance is determined [1]:

$$\mathbf{Z}_B \approx \left[r(j\omega c)^{-1}\right]^{0.5} \mathrm{cth}\left[(j\omega rc)^{0.5} l\right] \approx \approx \left[r(2\omega c)^{-1}\right]^{0.5}(1+j) \quad (2)$$

where c - per-unit length capacity of a system "reel – wire", l – length of wire. This impedance also varies in accordance with a modification of an amount of a wire on the reel under the rather complex law.

As follows from above-stated, for precision measuring of resistance R_X, the measuring method and measuring device should ensure a high accuracy of measuring and complete elimination of connecting elements impedances of a measuring circuit. To the measuring equipment used in the said technological operations, the following requirements are presented:

- Low measuring error, depending on technological operation no more than 10 - 0,1 %;
- Continuous control of resistance without of a resistive wire insulation damage;
- Complete measurement process automation and possibility of measuring modules use in componence of the informational - measuring system for controlling by technological process at the plant.

To some of peculiar properties can obey only measuring equipment based on null method of resistance measurement, however the classical bridge and compensation meters of resistance by virtue of the specified measurement object features cannot be used to that end.

3. THE RESISTANCE METER

The essence of the measurement method [2] consists in continuous measurement of the resistance R_X of the wire section between two capacitive contacts, located on the distance L from each other.

The measuring circuit (Fig. 2) contains the generator G, feeding the measuring circuit by the current I_G, the impedance simulator SIM, reproducing on the input terminals the negative resistance R_{conv} equal on the module to the linear resistance of the measured wire, two capacitive contacts to the measured wire C_1 and C_2. The amplifier A and the functional null-device FNO supplied by zero-indicator NI are used for determining the state of the measuring circuit.

The process of measurement (Fig. 3) consists in the balancing of measuring circuit by regulating the resistance of the resistor R_M to the zero indication of null-indicator.

As it follows from vector diagram, in the state of the equilibrium:

$$I_G(R_X - K_{conv} \cdot R_M) = 0, \quad (3)$$

from where it follows:

$$R_X = K_{conv} \cdot R_M \quad (4)$$

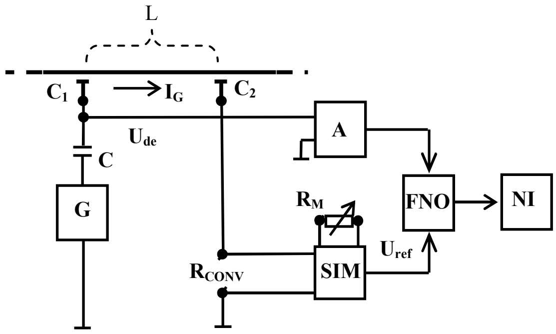

Fig. 2. The bloc – diagram of the resistance meter

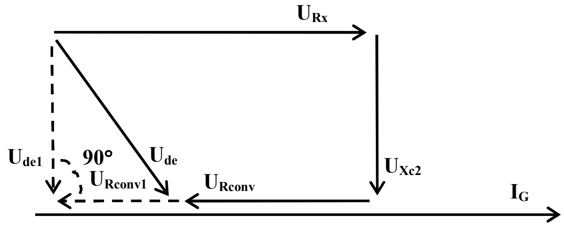

Fig. 3. The vector diagram of measuring process

The expression (4) presents the result of measurement. The linear resistance of microwire:

$$R_{linear} = R_X / L \quad (5)$$

As it follows from (4) and (5), the result of measurement is not depending on the impedance of contact elements C_1, C_2.

The presented above method may be used for the control of owerglaze microwire resistance during the process of its moulding with the view of this process automation and for control of the finished product quality

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