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Determination of optimal parameters for the technological process of polling of copper wire with alloy POS-61

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Abstract

The development of the technique for the manufacture of round copper wire coated with "tin-lead" alloy is considered. The optimal parameters such as the temperature of the "tin-lead" alloy melt, the linear speed for tinning of the wire with a round copper alloy and the diameter of the diamond die were determined. The test results of the experimental wire samples are presented.

Keywords

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Key findings

- The round copper wire coated with POS 61 alloy is used as shielding elements in cable and wire products.
- According to the results of tests the optimal technological process parameters of tinning the wire are determined.
- During the tests it turned out that 8 samples of experimental round copper wire meet the established requirements 075-11-2019-047-TT on consumer properties.

1. Introduction

The most important factor in ensuring and increasing an organisation's competitiveness is the development of innovative products with parameters that are ahead of existing consumer requirements at the time of market entry [1]. The developed products, according to their characteristics, must satisfy the consumers, needs in terms of the required and the desired parameters, thus forming the necessary “quality profile” [2].

Chuvashkabel Plant JSC is not an exception. The plant management and personnel are focused on the production of innovative and high technology products [3], in particular, wire with unique characteristics used as braiding in cable products for various purposes.

This research is focused on round copper wire coated with POS-61 alloy. This wire is used as a shield in cable and wire products. The developed tinning technology must provide the wire with characteristics indicated in Table 1. Round copper wire samples with POS-61 coating are considered to have passed the tests if their indicators meet the requirements specified in Table 1.

The controlled parameters of the POS-61 coated round copper wire also include the appearance: the wire should have a smooth surface and a continuous coating along the entire wire length.

Table 1 List of required parameters for the round copper wire coated with POS-61.

Options	Values
Wire diameter, mm	$0.12^{+0.005}_{-0.003}$ $0.15^{+0.005}_{-0.003}$ $0.20^{+0.005}_{-0.003}$ $0.30^{+0.007}_{-0.005}$
Coating thickness, microns	$1.0^{+0.2}_{-0.5}$
Tensile strength wire, N/mm²	Not less 196
Elongation at break, %	0.12 mm – 10–25%; 0.15 mm – 10–25%; 0.20 mm – 10–25%; 0.30 mm – 15–30%
Resistivity, Ohm·m·10^{-6}	No more 0.0180

2. Materials and Methods

Research tests were carried out on 36 samples with a total weight of 50.4 kg and five parallel measurements for each wire sample.

During the tests, five experimental wire samples with a length of at least 1000 mm were taken from each wire batch. During the tests, we were guided by the following documents:

– preliminary technological documentation PBMI.05171.00002;
– route map 075-11-2019-047-1.2.1-MK;
– program and test procedure E PBMI.00002 PM2;
– act of making experimental samples.

Each experimental sample of a round copper wire with a POS-61 coating was obtained under various technological modes of coating the wire MT 0.12, MT 0.15, MT 0.20 and MT 0.30 with the solder made of the POS-61 alloy.

The production of high quality round copper wire coated with various alloys, including POS-61, is provided by:

– the correct choice of wire grade as a raw material;
– the correct choice of alloy (solder), which will be applied to the base, depending on the purpose, design features and materials used;
– the optimal flux choice [4], which is designed to remove the oxide film from the surfaces of wire and alloy (solder), to protect the surface of wires and solder (alloy) from oxidation during the alloy (solder) deposition and to reduce the surface tension of the straightened alloy (solder) at the boundary metal – alloy (solder) – flux;
– the surfaces, high-quality preparation of the base metal and alloy (cleaning, preliminary tinning);
– temperature control, speed and time of alloy (solder) deposition on the base;
– absence of foreign impurities and foreign inclusions in the alloy and the flux [5–6].

3. Results and Discussion

Chuvashkabel Plant JSC proposed to produce experimental wire samples to determine the optimal parameters of the technological mode of manufacturing round copper wire coated with POS-61 alloy.

As mentioned above, it is based on variations in the temperature of the POS-61 alloy melt, linear velocity, diamond wire diameter and flux grades (Table 2).

Table 2 Technological modes of obtaining the round copper wire with POS-61 coating.

Nominal diameter of copper wire, mm	Melt temperature, °C	Linear speed, m/min	Diamond die diameter, mm
$0.12^{+0.005}_{-0.003}$	185	110	0.187
$0.15^{+0.005}_{-0.003}$	215	125	0.238
$0.20^{+0.005}_{-0.003}$	245	140	0.385
$0.30^{+0.007}_{-0.005}$			

Table 3 shows an example, which is one of the variations in the manufacturing modes of round copper wire with a POS-61 coating, used as a braid in cable products for various purposes.

Table 4 shows the tests results of an experimental prototype of a round copper wire with a POS-61 coating, manufactured with the parameters of the technological mode indicated in Table 3.

Based on the 36 experimental sample results of the studies performed, obtained at different parameters of the tinning technological process, it is proposed to use the following optimal modes:

– first mode: melt temperature – 185±5 °C, linear speed – 110±5 m/min;
– second mode: melt temperature – 215±5 °C, linear speed – 125±5 m/min.

The first mode allows increasing the productivity of manufacturing of the round copper wire coated with pure tin or POS61 alloy at lower power consumption.

The second mode allows obtaining a better quality solder coating with a narrow range of variation in the coating thickness and wire diameter.

Table 3 Modes of manufacturing the experimental samples of round copper wire with POS-61 coating at a temperature of 395 °C.

No. wire sample	Diameter of copper wire, mm	Melt temperature POS-61, °C	Linear speed, m / min	Diamond die diameter, mm
E-MT-0.15- POS-61-31	$0.15^{+0.005}_{-0.003}$	215±5	110±5	0.238

Table 4 Test results of an experimental sample of POS-61 E-MT-0.15-POS61-31 coated round copper wire.

Options	Meaning and tolerances	Sample test results				
		No. 1	No. 2	No. 3	No. 4	No. 5
Diameter of wire, mm	$0.15^{+0.005}_{-0.003}$	0.156	0.155	0.156	0.156	0.156
Quality and continuity of the coating	the solution should be lighter than the control	Correct	Correct	Correct	Correct	Correct
Coating thickness, microns	$1.0^{+0.2}_{-0.5}$	1.1	1.0	1.2	1.1	1.0
Tensile strength of wire, N/mm²	not less 196	215	210	210	215	220
Elongation at break, %	20^{+5}_{-10}	23	22	22	23	24
Specific resistance, Ohm·m·10^{-6}, no more	0.0180	0.01725	0.01714	0.01722	0.01716	0.01715

4. Conclusions

Thus, during the tests, it turned out that 8 samples of experimental round copper wire with coatings POS61 E-MT-0.12-POS61-12, E-MT-0.12-POS61-14, E-MT-0.15-POS61-30, E-MT-0.15-POS61-32, E-MT-0.20-POS61-48, E-MT-0.20-POS61-50, E-MT-0.30-POS61-66 and E-MT-0.30-POS61-68 met the established requirements 075-11-2019-047-TT of consumer properties.

Supplementary materials

No supplementary materials are available.

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Conflict of interest

The authors declare no conflict of interest.

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