DETERMINATION OF ELECTROPHYSICAL CHARACTERISTICS OF MULTI-ELECTRODE COMPOSITE ELECTRIC HEATERS DESIGNED FOR AGROINDUSTRIAL COMPLEX

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ABSTRACT

The process of engineering and manufacturing the production lot of low-temperature multi-electrode composite electric heaters (LTMCEH) *МКЭ-1* designed for the agroindustrial complex demands solving the problem of stability of the electrophysical characteristics.

Keywords: multy-electrode, polymer, composite, heater, resistivity, conductivity.

I. INTRODUCTION

A number of experiments and tests, including certification tests, have been conducted thereto in order to determine the ways of upgrading the manufactured product, as well as extending the product range and launching batch production. Production lot specimens were tested on the basis of *The Altai Standardization, Metrology and Certification Centre;* a number of electrophysical characteristics of the composite material (CM) and CM articles has been determined and tests have been conducted with regard to compliance with the requirements of GOST R MEK 335-1-94 *Safety of Household and Other Similar Electrical Devices.*

II. RESEARCH OBJECTIVES

The objectives of the research were experiments aimed at gaining deeper insight of the processes taking place in the conducting layer of the eclectic heater, including determination of the dependency of the volume resistivity upon the current magnitude under different operating modes of MCEH.

III. METHODS AND SUBJECTS OF THE RESEARCH

The subjects of the research were electrical heaters *МКЭ-1* by the size of 200x135x10 mm, with a various makeup of the electro conductive composite material, including the marks of technical carbon (TC) and its concentration in the conducting phase. Two specimens containing technical carbon of *П-234, П-324* and *П-514* marks have been picked out of each 100-pieces lot.

According to [1], the voltage-current characteristics of the composite materials under research are of linear character within the given voltage range and are subordinate to the Ohm's law, which corresponds to the dependency determined in [2] for the TC-filled polymers:

$$I = c \cdot U^n,$$

c, n are constants, where *n*=1. In this case the conductivity is due to direct contact between the TC particles, forming a continuous spatial pattern, in the polymer matrix.

Electrophysical methods have been employed to obtain the results of the LTMCEH conductive phase research. To determine the voltage-current characteristic, the test specimen was connected to a source of current, and the voltage drop value was measured 10 seconds afterwards. The measurements have been taken within the range from 1 mcA to 50 mcA of the impressed current. To determine the dependency of the volume resistivity upon the value of the alternating voltage on condition that the heater temperature is equal to that of the ambient air, alternating voltage has been applied to the heater and the value of the through-passing current was measured 30 seconds after activating the LTMCEH. The measurements have been taken within the range from 10 V to 200 V of the impressed current.

To determine the dependency of the volume resistivity upon the time in the process of heating of *МКЭ-1,* the measurements have been taken in 1 minute. *МКЭ-1* reaches the operating condition (i.e. the working temperature is obtained on the surface) in 30 minutes after activating. During the conducting of the experiments the following equipment was applied: source of current *В1-13*, audio-signal generator *ГЗ-118*, voltage amplifier *УМ-16*, voltmeter *Щ301-1В1-13*.

IV. RESULTS

The results of measuring the voltage-current characteristics of the LTMCEH specimens are performed in Table 1 in the graphic chart (Figure 1).

The results of measuring the dependency of the volume resistivity upon the time in the process of

heating the LTMCEH specimens are performed in Table 3
in the graphic chart (Figure 3).

Table 1- *МКЭ-1* voltage-current characteristics

I, мА \ U, V	45,5м.s. ТС П514	52,5м.s. ТС П514	48 м.s. ТС П324	52,5 м.s. ТС П324	45м.s. ТС П234	52,5м.s. ТС П234
0,001	0,015	0,005	0,007	0,017	0,018	0,004
0,002	0,029	0,009	0,012	0,030	0,034	0,009
0,003	0,043	0,013	0,018	0,045	0,050	0,013
0,004	0,056	0,017	0,024	0,059	0,066	0,018
0,005	0,070	0,021	0,030	0,073	0,082	0,022
0,006	0,084	0,026	0,036	0,087	0,098	0,027
0,007	0,098	0,030	0,042	0,100	0,114	0,031
0,008	0,110	0,034	0,048	0,115	0,130	0,036
0,009	0,125	0,039	0,054	0,131	0,144	0,040
0,01	0,137	0,043	0,059	0,136	0,156	0,045
0,02	0,255	0,082	0,118	0,228	0,267	0,089
0,03	0,340	0,121	0,177	0,290	0,367	0,134
0,04	0,400	0,156	0,234	0,368	0,460	0,179
0,05	0,430	0,192	0,289	0,420	0,550	0,224
0,06	0,470	0,226	0,339	0,470	0,630	0,269
0,07	0,505	0,260	0,380	0,515	0,710	0,314
0,08	0,540	0,294	0,420	0,557	0,779	0,359
0,09	0,560	0,327	0,460	0,595	0,843	0,403
0,1	0,590	0,360	0,490	0,625	0,896	0,448
0,2	0,900	0,639	0,800	0,961	1,380	0,897
0,3	1,100	0,875	1,070	1,220	1,840	1,340
0,4	1,260	1,070	1,300	1,460	2,270	1,790
0,5	1,450	1,240	1,530	1,700	2,690	2,240
0,6	1,630	1,433	1,750	1,920	3,070	2,690
0,7	1,800	1,619	1,960	2,140	3,490	3,140
0,8	1,960	1,799	2,170	2,360	3,900	3,580
0,9	2,160	1,964	2,370	2,570	4,300	4,030
1	2,270	2,120	2,550	2,780	4,700	4,480
2	3,900	3,850	4,400	4,900	8,700	8,940
3	5,400	5,480	6,300	6,920	12,630	13,370
4	6,800	7,090	8,200	8,920	16,570	17,810
5	8,200	8,640	10,050	10,880	20,500	22,230
6	9,600	10,190	11,800	12,760	24,200	26,650
7	11,000	11,660	13,650	14,670	28,300	31,060
8	12,400	13,180	15,480	16,560	32,200	35,470
9	13,800	14,700	17,300	18,450	36,030	39,880
10	15,150	16,210	19,100	20,330	39,970	44,290
20	29,400	31,400	37,200	39,030	78,730	88,330
25	35,800	38,740	46,260	48,180	98,190	110,300
30	42,550	46,130	55,200	57,250		
35	49,550	53,490	64,150	66,340		
40	55,900	60,820	73,140	75,400		
45	62,500	68,140	82,040	84,410		
50				93,460		

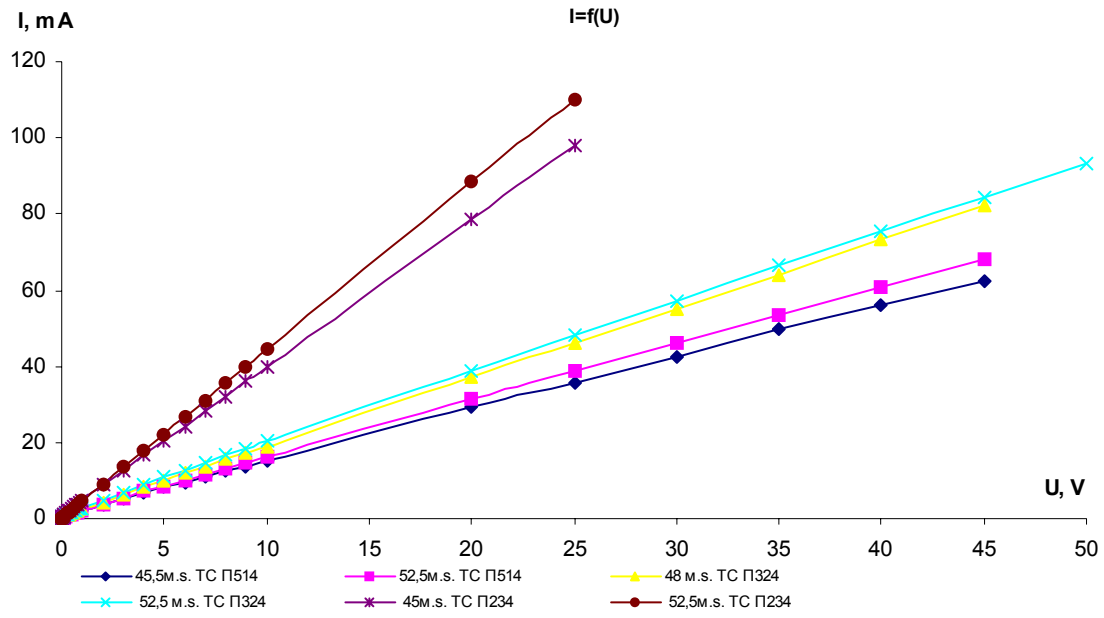

Figure 1 – *МКЭ-1* voltage-current characteristics

Table 2 -The dependency of the *МКЭ-1* volume resistivity upon the alternating voltage

U, V	ρv Ом*м					
	52,5м.s. ТС П234	45м.s.ТС П234	52,5м.s. ТС П324	48м.s. ТС П324	52,5м.s. ТС П514	45м.s ТС П514
10	12,27	12,54	15	15,34	29,35	30,68
50	9,811	10,61	13,13	13,45	28,13	30,32
100	9,375	10,29	12,47	13,26	26,79	30
150	9,289	10,13	12,33	13,13	26,72	29,4
200	9,28	10,2	12,47	13,25	26,68	29,47

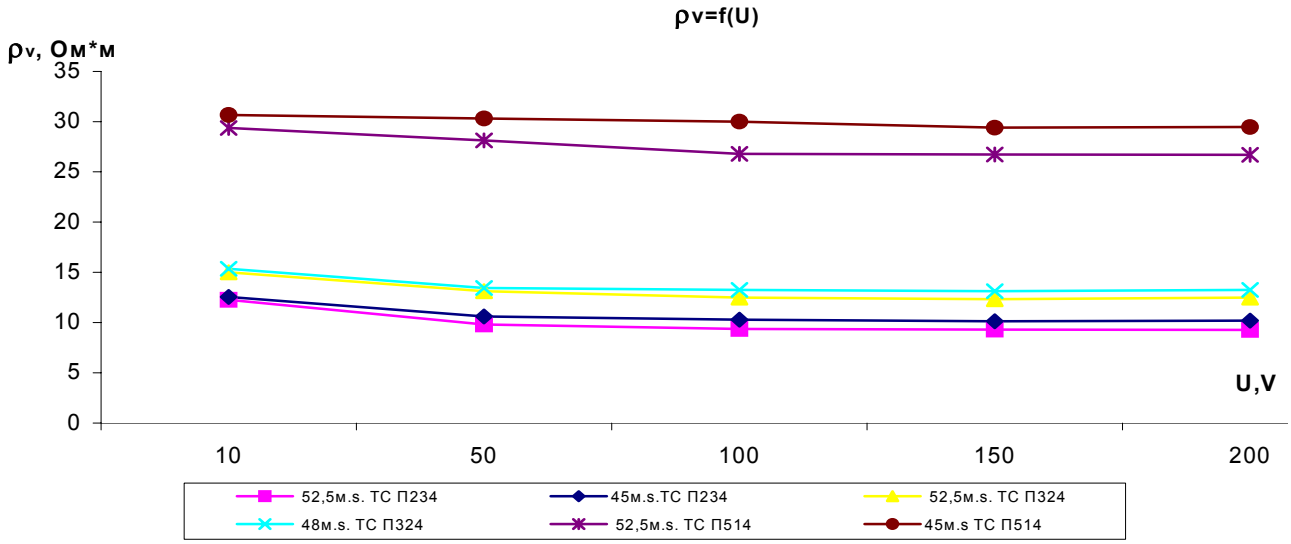

Figure 2 – The dependency of the *МКЭ-1* volume resistivity upon the alternating voltage

Table 3-The dependency of the volume resistivity of the *МКЭ-1* specimens upon the time in the process of heating

t,min	ρv, Ом*м					
	52,5м.s. ТС П234	45м.s.ТС П234	52,5м.s. ТС П324	48м.s. ТС П324	52,5м.s. ТС П514	45м.s ТС П514
1	10,479	10,224	12,867	12,700	25,853	29,610
2	10,479	10,224	12,867	12,752	25,853	29,631
3	10,526	10,339	12,982	12,867	26,055	30,016
4	11,028	10,454	13,097	12,982	26,123	30,048
5	11,076	10,569	13,212	13,097	26,123	30,300
6	11,138	10,683	13,326	13,212	26,190	30,800
7	11,242	10,798	13,306	13,326	26,258	31,199
8	11,282	10,913	13,298	13,441	26,325	31,920
9	11,330	11,028	13,489	13,556	26,393	32,073
10	11,475	11,143	13,574	13,671	26,460	32,511
11	11,535	11,258	13,659	13,786	26,528	32,866
12	11,806	11,373	13,745	13,901	26,595	33,082
13	11,837	11,488	13,830	14,016	26,663	33,013
14	11,816	11,603	13,915	14,131	26,730	33,527
15	11,848	11,718	14,001	14,246	26,798	33,750
16	11,825	11,833	14,086	14,361	26,865	33,900
17	11,862	11,948	14,171	14,476	26,933	33,458
18	11,851	12,062	14,257	14,590	27,000	33,700
19	11,782	12,177	14,342	14,705	27,068	33,700
20	12,000	12,292	14,427	14,820	27,608	34,272
21	11,994	12,407	14,513	14,935	27,878	34,272
22	11,980	12,522	14,598	15,050	28,215	34,000
23	11,938	12,637	14,683	15,120	28,688	34,126
24	12,090	12,752	14,768	15,188	28,620	33,787
25	11,965	12,867	14,854	15,323	28,755	33,803
26	11,977	12,982	14,939	15,728	29,160	33,757
27	12,192	13,097	15,024	15,728	29,363	33,772
28	12,110	13,144	15,110	15,795	29,363	33,765
29	12,327	13,114	15,195	15,795	29,430	33,802
30	12,326	13,171	15,280	15,863	29,578	33,822

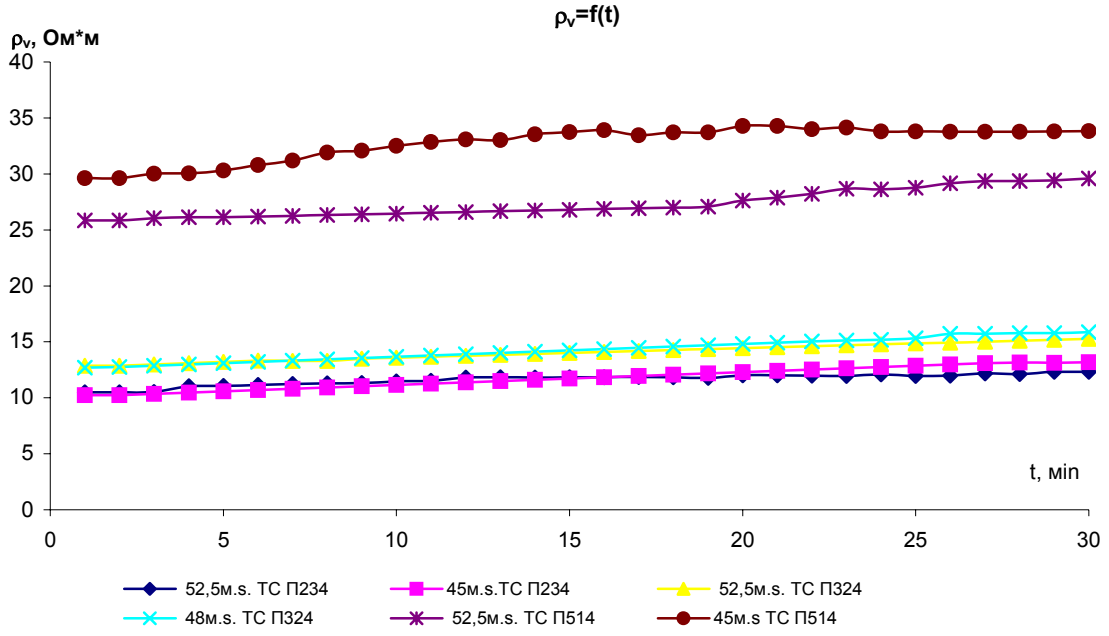

Figure 3 – The dependency of the volume resistivity of the *МКЭ-1* specimens upon the time in the process of heating

V. CONCLUSION

The experiment results have shown that for the support of the electrophysical characteristics stability, including the volume resistivity, the TC-marks *П-234* and *П-324* are to be picked out, the TC share should make not less than 52.5 mass shares with regard to the chosen methods of LTMCEH production [3].

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