THE INFLUENCE OF THE ELECTRIC FIELD ON THE POZISTOR PROPERTIES OF THE ELECTROTECHNICAL GLASSYPLASTIC ON THE BASE OF THE EPOXIDO-CASE RESIN

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The peculiarities of the pozistor effect in the electrotechnical pressmaterial of PET type have been investigated. The influence of the electrical discharges on the pozistor characteristics of the epoxido-case pressmaterial has been studied, the coefficients of PTCR, PTK$_\varepsilon$, T_n, ΔT_n and their stability have been defined. It is shown, that at the moderate modes of influence (9kV, 5h), the values of PTCR and PTK$_\varepsilon$ increase, but values of T_n and ΔT_n decrease, and in the mode of 11kV, 5h the two regions of $\varepsilon_k(T)$ are observed on the dependence ε_k at the temperatures from 360-390K and 395-425K. It is proposed, that the first dispersion region $\varepsilon_k(T)$ connects with the before hardness processes, and second region probably is caused by the different oxygenocontaining groups, appearing at the influence of the electric discharges and their interaction with fillers in the PET samples.

The results of the investigation show, that the probability of the regulation of pozistor properties of elements, prepared from the pressmaterial of PET type by the way of influence of electric discharges and γ-radiations, and change of content and type of fillers, takes place.

INTRODUCTION

The glassyplastic materials (GM) on the base of fenoloformaldegide and epoxido-case resins, fulfilled by fiber and dispersion fillers are widely used in the electrotechnical devices, in radioelectronic equipments and e.t.c. The GM structure introduces the heterogeneous systems from fillers and polymer matrix (binding) with special building of the division boundaries between them and character structural defects [1]. For the directed change of the structure and electrophysical properties, they are often subjected to the electrodischarge modification [2,3]. At the influnce of the electric field on the GM the anomaly temperature dependency of the specific electric resistance ρ_v of pressmaterial of PET type in the temperature interval 373-500K [3] was observed. On the dependence $\rho_v(T)$ the val4ues ρ_v increase on 2-3 orders at the temperature growth till 500K, beginning from T=363K. However, the reasons, regularity and mechanism of the observable high value of the positive temperature coefficient of resistance (PTCR) of the samples of PET type haven't been investigated. It is shown, that materials with high value of PTCR are called pozistor [3]. The distinctive peculiarities of the pozistor properties of materials are the temperature interval ΔT_n, at which the high values of PTCR and reversible change of ρ_v stay without change. In the dependence on the material composition, the pozistors should have the big sensitivity, small innertionness and cost. The ceramics on the base of $BaTiO_3$ with the addition of glass in the quantity 1-5 mass.% [5] correspond to these demands. However, the pozistor properties i.e. the increase of ρ_v at the increase of T slowly depends on the applied voltage. The polymer composites have pozistor properties also, for example, on the base of polypropilen and CTS-19 [4], but the moderation of the reversibility ρ_v in the wide temperature interval is character for them.

It is need to note, that the creation of phase-boundary potential barrier, controlled by the composite dielectric constant ε_k [4,5] is the main reason of acquisition of pozistor effect by heterogeneous system.

In the case of the epoxidal glassyplastics, the value ε_k will be depended on the type of hardener and character of the influence of the electric field and discharges. On our opinion, these questions did not describe enough. Moreover, in the set of cases, the pozistor application in its capacity of the thermoregulators, fire netificators and thermogauges and e.t.c. demands the definite security at their detail geometrical sizes. These demands are possible for the compositional GM after the electrofield influences or the modification of their structure by the change of the ratio of the fillers and binding in them.

The aim of the given paper is the studying of the peculiarities of the influence of electric field and discharges (ED) on the pozistor properties of glassyplastic materials.

EXPERIMENTAL PART

The samples from GM by the thickness of 500 mkm had been obtained by the thermopressing of two marks of pressmaterial – PET and MFE-1. The samples have been prepared from the pressmaterial of PET mark on the base of the epoxido-case resin UP-643, fillers – glassifiber and caoline. In the capacity of the accelerator of the hardness process was used the accelerator A-30-1,5. The second type of the samples had been prepared from the pressmaterial of MFE-1 mark on the base of melaninoformaldegide resin with the aminosilaxan AM-2 and fillers are glassyfiber and talc [3]. The pressing temperature at the pressure 150MPa for PET and MFE-1 was 423 and 453K, correspondingly. The degree of dispersion of the powder fillers wasn't higher than 10-15 mkm, and diameter of glassyfiber – 13 mkm.

The hardness of resin was under the external pressure action. Further the GM samples were subjected to the influence of the electric discharges on the technique [6] at the effective value of voltage on the electrodes – 9kV and 11kV during 5 hours. The dielectric measurements (ε, $tg\delta$) were carried out on the device E7-8 at the frequency 1kHc. The specific electric volume resistance of ρ_v was measured with the help of the teraohmeter EK6-13 at the direct-current voltage 100V. After the sample's standing under the voltage during 1 minute, the temperature dependencies of $\rho_v(T)$ have been fixed.

The PTCR and the temperature interval ΔT_n of existence of pozistor material properties were defined on the inclination of the dependencies of $\rho_v(T)$. The value of PTCR, i.e. the sensitivity coefficient to the temperature change of the sample is defined by the formulae:

$$PTCR = lg(\rho_v^1 - \rho_v^2) / T_2 - T_1 \qquad (1)$$

where ρ_v^1 and ρ_v^2 are specific electric resistances of the sample at the temperatures T_1 and T_2, correspondingly. From the dependency $\varepsilon_k(T)$ the degree of dispersion coefficient of pozistor was defined by the formulae:

$$PTK_\varepsilon = \varepsilon_k^2 - \varepsilon_k^1 / T_2 - T_1 \qquad (2)$$

where ε_k^1 and ε_k^2 are values of dielectric constant at T_1 and T_2, correspondingly. In the given case the value T_1 corresponds to the temperature of the increase beginning of ρ_v and ε_k, i.e. to the temperature of appearing of pozistor properties of T_n of PET type.

THE RESULTS AND THEIR DISCUSSION

The temperature dependences of $\rho_v(T)$ of PET samples before (curve1) and after the influence of the discharges at the voltage on the cell U_p=9kV (curve2) and 11kV (curve3) are given in the fig.1. It is seen, that with the temperature increase, ρ_v of all samples firstly decrease, going through the minimum at 373-383K, and further again begin to increase. Thus, till the temperature 440-450K, the PET samples have pozistor properties. From the fig.1 it is a followed, that the influence of the electric discharges in the air leads to the increase of the inclination on the line area of $\rho_v(T)$ dependence at the temperature interval of pozistor effect appearing. Moreover, this inclination becomes more significant (curve3) with the increase of the discharge power (U_p increase). The decrease of ρ_v of the initial state parts of the dependence $\rho_v(T)$ connect with the increase of the number of current carriers and the reason of the resistance increase probably can be as the before hardness processes, i.e. the additional structuring, so the formation of the potential barrier with the depth $\Delta\varphi$.

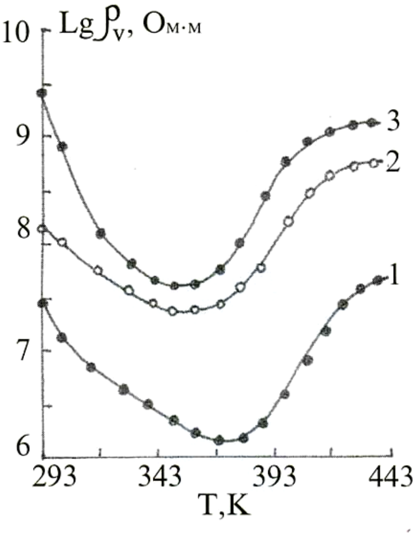

Fig.1. Temperature dependences of specific volume electric resistance ρ_v of PET pressmaterial samples; 1-initial, 2 and 3 after influence of discharges in the mode U_p=9kV, t=5 hours, U_p=11kV, t=5 hours, correspondingly.

About the going of the before hardness processes testify the data on ε_k measurement and its temperature dependencies (fig.2). As it is seen from the fig.2 the ε_k values of PET samples significantly increase in the region of the pozistor effect appearing.

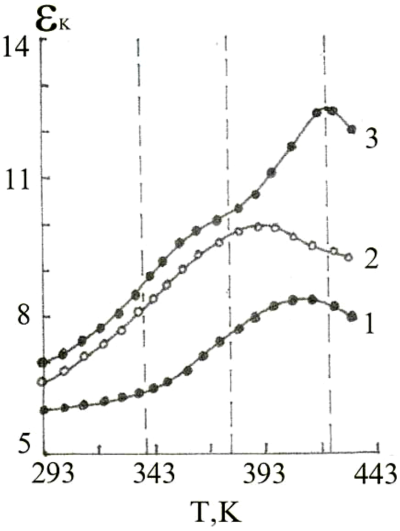

Fig.2. Temperature dependences of dielectric constant ε_k of PET pressmaterial samples: 1-initial, 2 and 3 after influence of discharges in the mode U_p=9kV, t=5 hours, U_p=11kV, t=5 hours, correspondingly.

The significant increase of ε_k takes place at the discharge influence (curve3), where the increase of the dielectric constant $\Delta\varepsilon_k$ is 5÷6. Moreover, it is need to note, that the increase of ε_k values with the temperature stops and the some decreases of ε_k, beginning from the temperature 420-430K, which testifies about the stop of the before hardness processes, are observed. As it is seen from the fig.2, the influence of the electric discharges leads to the increase of the temperature interval of the ε_k increase (curve3). The creations of the different oxygenocontaining groups can influence also on the electrophysical properties of PET at the stronger mode of discharge influence (U_p). These and other structural changes cause the increase of the value of the potential barrier $\Delta\varphi$ between matrix and PET pressmaterial fillers, which are the main reason of the pozistor effect appearing in them. Comparative studying of the $\rho_0(T)$ dependencies for MFE-1 samples before and after discharge influence shows that nonlinear dependence $\rho_v(T)$ in MFE-1 doesn't observed. This can be connected with the different composition of fillers in these glassymaterials MFE-1 has 40-50 mass.% of talc and calcium steorat. Thus, the properties mainly are caused by the presence of caoline in PET pressmaterial. At the preparation of PET the surface treated caoline of the following composition: SiO_2(45,4%), $Al_2O(3)$(38,8%), Ti_2O_3(1,5%) with the specific volume resistance $\rho_v=10^{15}$ Om·m and dielectric constant ε=2,6, was used. The values T_n, ΔT_n, PTCR and PTK_ε, changed under the influence of ED at 10-time cyclic heating-cooling of PET samples are presented in the table.

From the table it is followed, that PET pressmaterial has pozistor properties and ε_k dispersion also in the temperature interval 277-327K. At the moderate influence modes (9kV, 5h) the PTCR and PTK_ε values increase, but T_n and ΔT_n values decrease.

Moreover, in the mode 11kV, 5h, two region of ε_k at the temperatures from 360-390K and 395-425K (fig. 2, curve 3) are observed on the $\varepsilon_k(T)$ dependence.

Table

Pozistor characteristics	Before ED influence	After ED influence	
		9kV, 5h	11kV, 5h
T_n ,K	377	363	353
ΔT_n, K	50	40	45
PTCR, (Om·m·K^{-1})	$2\cdot10^{-3}$	$5\cdot10^{-3}$	$2{,}7\cdot10^{-3}$
PTK$_\varepsilon$, K^{-1}	$3{,}3\cdot10^{-2}$	$3{,}5\cdot10^{-2}$	$4{,}7\cdot10^{-2}$

If the first dispersion region $\varepsilon_k(T)$ connects especially with before hardness processes, then the second region is caused by different oxygenocontaining groups, forming at the ED influence and their interaction with fillers in PET samples. The comparison of the values, given in the table with the values of these values for the semiconductor and ceramic materials [5,9] shows, that some pozistor characteristics (T_n and PTK$_\varepsilon$) for PET is some worth in the comparison of the corresponding parameters of these materials. However, the PET is less energy capacious, the probabilities of pozistor properties by the way of ED and γ-radiations influence, change of content and type of fillers, takes place.

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EPOKSİD QƏTRAN ƏSASLI ELEKTROTEXNİKİ ŞÜŞƏ PLASTİKİN POZİSTOR XASSƏLƏRİNƏ ELEKTRİK SAHƏSİNİN TƏSİRİ

PET presmaterialında pozistor effektinin xüsusiyyətləri tədqiq edilmişdir.

Epoksid-novalak presmaterialının pozistor xarakteristikalarına elektrik boşalmalarının təsiri oyrənilmiş, PTKS, PTK$_\varepsilon$, T_n, ΔT_n əmsalları və onların stabilliyi təyin edilmisdir. Göstərilmişdir ki, mülayim təsir rejimlərində (9 kV, 5 saat) PTKS və PTK$_\varepsilon$ qiymətləri artır, T_n və ΔT_n qiymətləri isə azalır, 11 k, 5 saat rejimində isə $\varepsilon_k(T)$ asılılığında ε_k-nın 360-390 K və 395-425 K temperaturlarında iki oblastı müşahidə olunur. Fərz edilir ki, $\varepsilon_k(T)$ dispersiyasının birinci oblastı bərkimə prosesinin davam etməsi ilə bağlıdır, ikinci oblast isə çox güman ki, elektrik boşalmalarının təsiri zamanı müxtəlif oksigenli qrupların yaranması və onların PET nümunələrindəki doldurujularla qarşılıqlı təsirləri ilə əlaqədardır. Tədqiqatların nəticələri göstərir ki, PET presmaterialından hazırlanmış elementlərin pozistor xassələrini elektrik boşalmaları və γ-şüalanma ilə təsir etməklə, həmçinin doldurucuların miqdarlarını və tiplərini dəyişməklə nizamlamaq imkanı mövcuddur.

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ДЕЙСТВИЕ ЭЛЕКТРИЧЕСКОГО ПОЛЯ НА ПОЗИСТОРНЫЕ СВОЙСТВА СТЕКЛОПЛАСТИКА НА ОСНОВЕ ЭПОКСИДНО-НОВОЛАЧНОЙ СМОЛЫ

Исследованы особенности позисторного эффекта в электротехническом ПЭТ. Изучено влияние электрических разрядов на позисторные характеристики эпоксидно-новолачного прессматериала, определены коэффициенты ПТКС, ПТК$_\varepsilon$, T_n, ΔT_n и их стабильность. Показано,что при умеренных режимах воздействия (9 кВ, 5 ч) значения ПТКС и ПТК$_\varepsilon$ возрастают, а значения T_n и ΔT_n уменьшаются, а в режиме 11 кВ, 5 ч. на зависимости $\varepsilon_k(T)$ наблюдаются две области ε_k при температурах от 360-390 К и 395-425 К. Предполагается, что первая область дисперсии $\varepsilon_k(T)$ связана с процессами доотверждения, а вторая область, по-видимому, обусловлена различными кислородсодержащими группами, образующимися при воздействии электрических разрядов, и их взаимодействием с наполнителями в образцах ПЭТ. Результаты исследования показывают, что имеется возможность регулирования позисторных свойств элементов, изготовленных из прессматериала ПЭТ путем воздействия электрических разрядов и γ-излучений, а также изменением содержания и типа наполнителей.

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