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PARTIAL DISCHARGE CHARACTERISTICS IN VOLTAGE AGEING OF PET FOIL

1. Introduction

The effects of partial discharge (p.d.)acting on the solid dielectric can be divided into two different processes. The first of them causes the structural degradations which are irreversible. Such known phenomena like erosion and treeing are examples of this kind of p.d.-acting effects. In the second process the electrical effects of p.d.-acting appear but without the structural changes in the material. However the breakdown of the dielectric is also possible in this kind of p.d.-acting as the result of charge diffusion. The investigations of the second kind of p.d.-acting on the polyethylene-terephtalate foil (PET) are presented in this paper. In the preceding papers the phenomena of self-extinction of p.d.-in the models of laminated insulating systems Epoxtermtype have been described [1,2]. The interpretation of this phenomenon as the result of space-charge formation from the discharge source and the change of electric field, has been there given. However, it is further needed to investigate the possibility of natural p.d. regeneration and the influence of the main component of insulating structure i.e. polyester foil (PET).

In this paper the results of the investigations of periodically repeated overvoltages on PET in the model with thin air-layer are presented.

2. Experiments

The PET foil, 10 μm thickness, placed in a test chamber, was attacked

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by p.d. from an air-layer(50 μm thickness and 1240 mm^2 area)contacting to this foil. Partial discharges were incepted at sinusoidal overvoltages while the value and duration of these overvoltages were variable. The overvoltages with the value of U_v were applied. As the U_v the following products of the partial inception voltages U_o for new (unattacked by p.d.) foil were taken: U_v = 1,5 U_o, U_v = 2 U_o, U_v = 3 U_o. The overvoltage timeprogram was as follows: 10 s: $U < U_o$, 1s: U_v = 3 U_o. The overvoltage duration was varied from 10 ms up to some tens of hours. P.d. intensity i.e. the charge distributions n = f(Q) and time-interval-distributions n = f(t) were next measured. The channel width in the pulse height analysis was k_A = 2,4 pC and in the time analysis was Δt = 200μs. As the partial discharge inception voltage U_o was assumed this value at which the p.d. frequency was equal 50 s^{-1}. The partial discharge intensity in samples of foil, which had been aged by overvoltage acting, was measured at the test voltage of 1,5 U_o.

3. Results

a) Overvoltage acting

Examples of pulse height distributions in new foil samples (before the overvoltages acting) (1) and after overvoltages acting (2) are presented in the Fig.1.

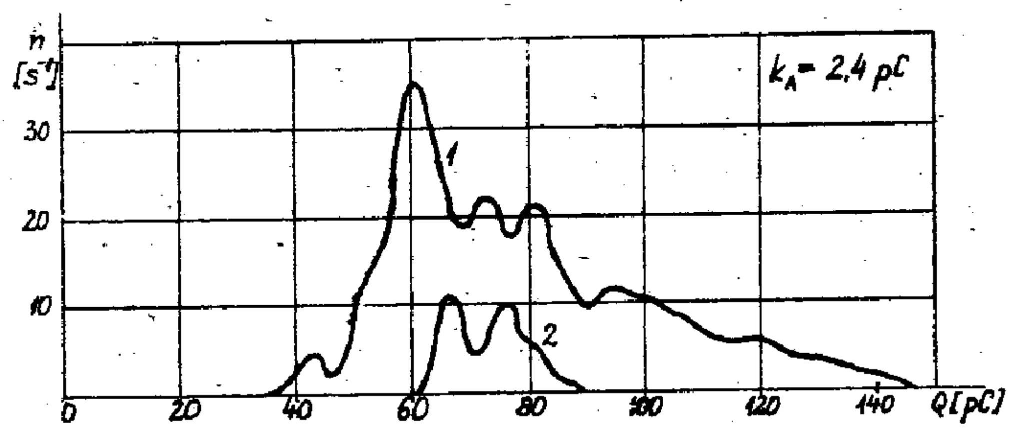

Fig.1. PD-pulse-height distributions at 1,5 U_o
1 - before, 2 - after the overvoltages acting, U_v = 3 U_o, 15 min

There are given the p.d. distributions after 15 minutes acting of the overvoltages $U_v = 3\ U_0$.

It has been found, that after the action of such defined overvoltages the apparent charge Q, p.d. frequency N_v and p.d. inception voltage U_0 are changed (see Fig. 2).

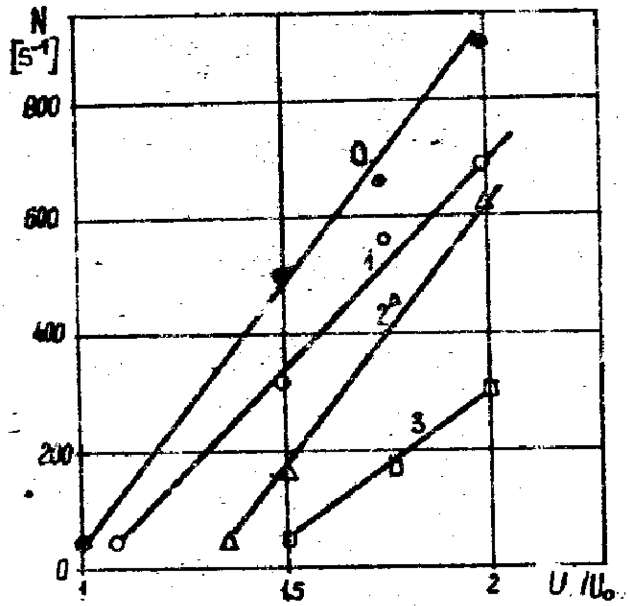

Fig.2. P.d. frequency vs. relative test voltage
0 - before overvoltage acting, $1{:}U_v/U_0 = 1{,}5$; $2{:}U_v/U_0 = 2$; $3{:}U_v/U_0 = 3$

P.d. inception voltage U_0^- increases and reaches now the value U_{0v}. The relative p.d. frequency N_v/N and relative inception voltage U_{0v}/U_0, which were measured at the test voltage of 1,5 U_0 after overvoltages acting according to the program as above, are presented vs. different values of U_v/U_0 in the Fig.3.

The time-distributions of p.d. pulse frequency were measured by the use of multichannel analyser (512 channels) operating in multi-scaler system.

The example of the time-distributions of p.d. frequency in a half-period of the sinusoidal test voltage is given in the Fig.4. while Δt = 200 μs is the time interval corresponding the phase angle φ.

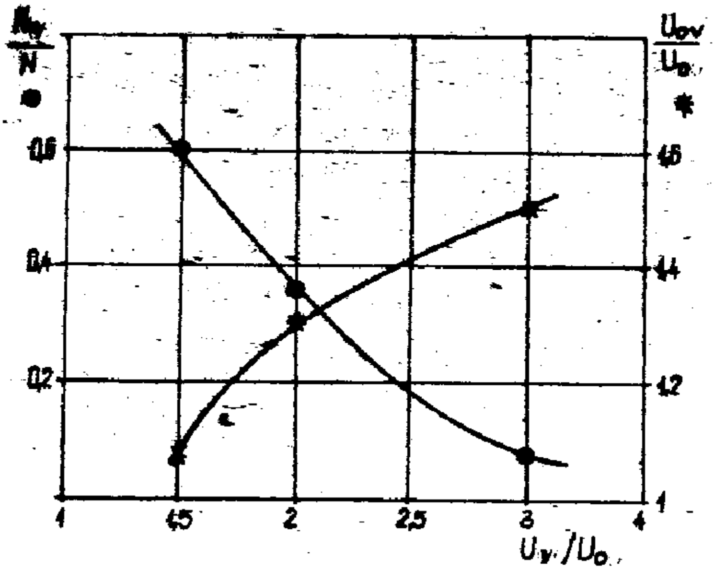

Fig.3. Relative p.d. frequency and relative p.d. inception voltage vs. overvoltages value

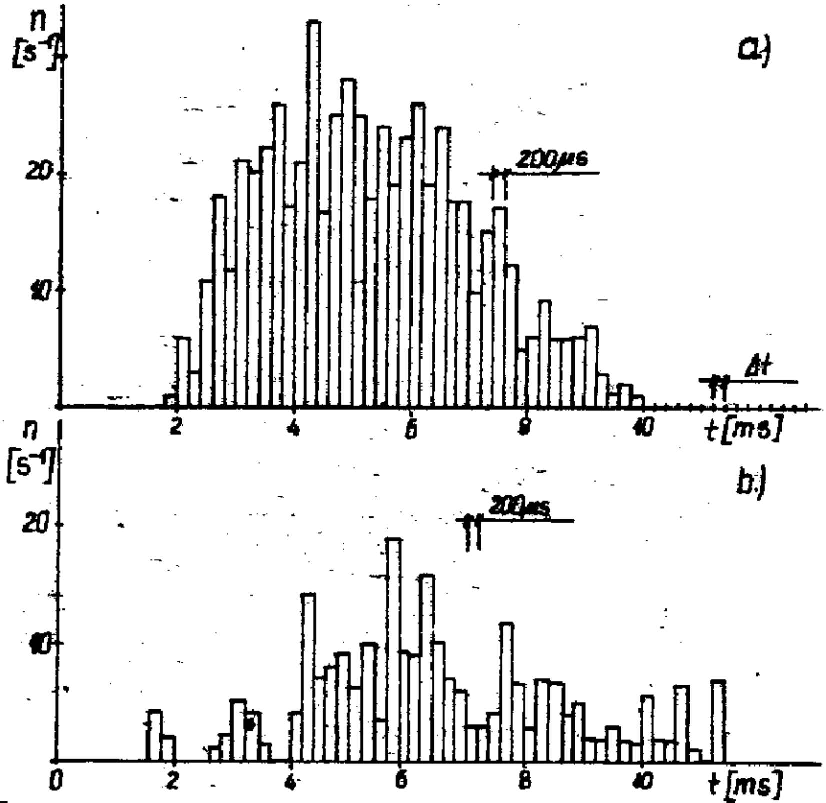

Fig.4. Time-interval-distributions

a - before, b - after overvoltages acting, U_v/U_o = 3, 15 min, U/U_o = 2

The p.d.-acting results in the self-extinction. The phase range of p.d.-acting greater than $\pi/2$ has been found. It is characteristic phenomenon for partial discharges in the internal cavities limited by polymeric materials, in which the space charge can be formed. Such a dependence of time distributions of p.d. frequency on the dielectric kind has been reported in [4]. The charge injection into the dielectric in one half-period of the test voltage, changes the conditions for p.d. inception in the second one.

The quantitative investigations of these effects correlated to the detection of trapped charges by TSDC is the purpose of further work.

b) Overvoltage duration

The influence of overvoltage duration on the change of the inception voltage was also investigated. The increase of U_{ov} up to approx. 1,5 U_o at the overvoltage acting of $U_v/U_o = 3$, is observed after a dozen or so minutes of the test duration. However it has been found that this U_{ov}-increase can appear even in a shorter time.

c) Regeneration of the initial conditions

The experimental results indicated that the disappearance of p.d. was not of the permanent character. After some hours of voltageloss-pause, the reversion of the foil to the initial stage has been found (see Fig.5).

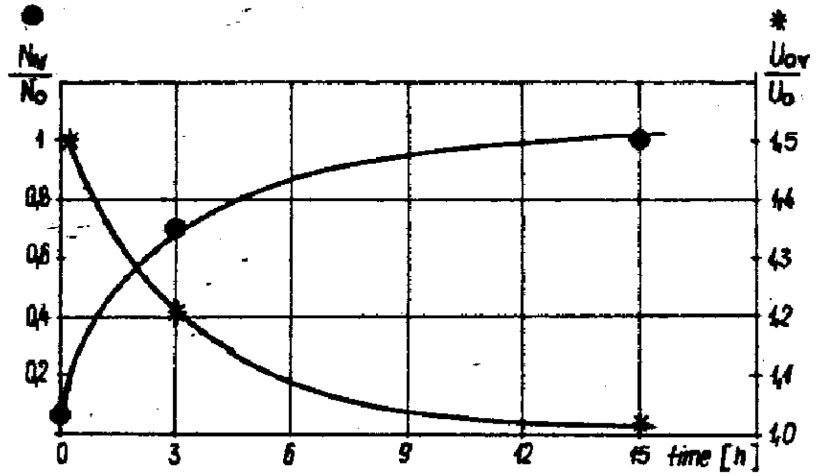

Fig.5. Relative p.d. frequency and relative p.d. inception voltage vs. voltageloss-time

4. Interpretation of results

The partial discharges in gas cavities in insulating systems can be the cause of charge trapping in the dielectric thus changing the electric field both in the gas space as in the solid dielectric. The field change depends on the surface charge density σ at the interface air/solid being the effect of partial discharges. The electric field stress in gas layer decreases approx. by the value of ΔE_g:

$$\Delta E_g = \frac{-\sigma}{\varepsilon_0 \left(\varepsilon \frac{g}{d} + 1\right)} \qquad (1)$$

while the electrical field stress in solid dielectric increases on the value of ΔE_s:

$$\Delta E_s = \frac{\sigma}{\varepsilon_0 \left(\varepsilon + \frac{d}{g}\right)} \qquad (2)$$

where: ε – dielectric constant of the solid dielectric,
d – solid dielectric thickness,
g – air space thickness.

The decrease of electric stress in the air space results in the increase of p.d. inception voltage and in the p.d. self-extinction as its consequence.

The time-relations of the space-and surface charge formation in the solid dielectric under the influence of p.d. action and resulting in the electric field changes are the objects of further investigations.

R e f e r e n c e s

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