Analysis of Insulation Materials of Cable Systems by Method of Partial Discharges

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***Abstract*-The paper is deal with detection and estimation of level of the partial discharges (PD) in insulating materials of technical systems. Theoretical consideration of processes and mechanisms of electric breakdown in insulating materials is fulfilled. Comparison of characteristics of PD is executed at different types of electric breakdown allowing to allocate and identify different types of defects and by that to establish characteristics of a working condition of high-voltage insulating materials. Practical application of a technique of diagnosing of technical condition, insulating materials under operating conditions and identifications of malfunctions of the cable systems (CS) on the basis of the PD method is represented.**

Keywords*- *Insulating Materials; Cable System; PD Method

I. INTRODUCTION

The problem of formation and development of the partial discharges (PD) in isolation of the high-voltage equipment in the conditions of its operation represents a great interest as for the personnel operating the equipment, and for developers of the equipment and researchers of electric isolation. PD constitute a big danger to insulation because of its fast destruction in local zones and the subsequent breakdown of insulating intervals. Previously, intensive researches has been conducted, in Germany, the USA, Japan and in some other countries, for the purpose of development and deployment of effective nondestructive methods of diagnostics of insulating materials of technical systems under operating conditions [1, 2]. The weakest links in cable systems are insulating materials (OIP- paper oil insulation, polyethylene (PE), viped polyethylene (VPE). Thus this study aims to develop a physical principle of determining defects in insulating materials by the PD method. We can allocate the following types of aging and destruction of electrical insulation of power cable lines (PCL): thermal aging, electric treeings, and water treeings. The sequence and interrelation of the processes causing electric aging and breakdown of isolation, is shown in Fig. 1.

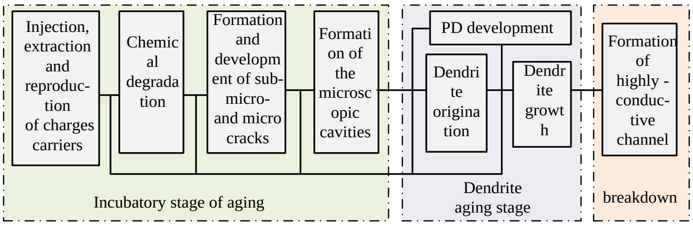

Fig. 1 Algorithm of electric aging and isolation breakdown

II. STATEMENT OF THE PROBLEM

The study focuses on the development and deployment of methods and devices allowing to carry out diagnostics with insulating materials for cable systems by nondestructive control methods with forecasting of a residual resource. Development of methods for the measurement of PD gives the ability to detect defects at an early stage of their occurrence, monitor their development, current status and potential for further exploitation of cable systems [3]. The most effective methods are:

• Measurement and estimation of the PD parameters and identification of their concentration places in order to predict future damage of insulation materials;

• Measurement and analysis of the return voltage parameters used for insulation materials in use.

In this paper we consider the solution of the following issues:

• A theoretical analysis of the processes and mechanisms of electrical breakdown in insulation;

• Application of the technique of diagnosing insulation materials under operating conditions and identification of the failures of cable systems on the basis of the PD and the analysis of their results.

III. CHARACTERISTICS OF PARTIAL DISCHARGES IN INSULATING MATERIALS

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PD can be considered as partial electric breakdown in the insulation of technical systems that occurs in the gas and water inclusions within the insulation, whereby forming a space between the conductor and the screen, Fig. 2 [4, 5].

The main danger PD due to the following factors:

• The inability to detect by conventional tests high DC voltage;

• Risk of a rapid transition to a state of breakdown and, consequently;

• The creation of an emergency on the cable.

PD could usually destroy the cable insulation. Complete destruction of the PC L takes from several hours to several years. PD characteristics depend on the type, size and location of the defect, an insulating material [4, 5], the applied voltage, temperature of the cable, as well as change over time.

Fig. 2 Insulation layer of paper-impregnated material with treeings

A. Formation of Partial Discharges

To identify patterns in the development of PD in gas inclusions, let us define PD characteristics involved in the destruction of the insulation materials, Fig. 3a, where C_i – gas inclusion capacity, C_b – insulation capacity in series with a gas inclusion, C_a – capacity of the rest of the insulation, R – channel resistance in the gas inclusion.

Condition of PD in the inclusion in the annex to the isolation voltage $U = U_m sin\omega t$

$$U = \mathrm{U_{PD}} = \frac{\mathrm{U_{i.br}}}{\sqrt{2}} \frac{\mathrm{C_b} + \mathrm{C_i}}{\mathrm{C_b}}, \tag{1}$$

where

$$\mathrm{C}_b = \frac{\varepsilon_0 \varepsilon_{\text{rи}} \mathrm{S_i}}{\mathrm{d} - \delta}, \mathrm{C_i} = \frac{\varepsilon_0 \varepsilon_{\mathrm{ri}} \mathrm{S_i}}{\mathrm{d} - \delta}, \tag{2}$$

$U_{i.br}$ – break down gas inclusion voltage, δ – the size of gas inclusion, t – insulation thickness, S_i – gas inclusion area, ε_{ri}, ε_{ra} the relative dielectric constant of the medium and inclusions. After substituting C_i, C_b into Eq. (1), taking into account that $\delta \gg d$ and inhomogeneity of the electric field isolation, obtain

$$\mathrm{U_{PD}} = \frac{\mathrm{U_{i.br}}}{\sqrt{2}} \frac{\varepsilon_{\mathrm{rv}}}{\varepsilon_{\mathrm{ra}}} \frac{\mathrm{d}}{\delta \mathrm{K_i}} \tag{3}$$

where K_i – electric field inhomogeneity factor in isolation, which is the ratio of maximum tension E_{max} to the average intensity E_{mean} in the insulating gap.

With a voltage $U < U_{PD}$ PD in isolation is absent, hence the higher the voltage U_{PD} the higher the permissible duration of exposure to insulation working voltage.

Development of PD in time is influenced by voltage $U = U_m sin\omega t$, Fig. 3b. At time $= 0$ $U_i < U_{i.br}$, therefore there are no discharges, and the voltage is turned on power $U = U_m sin\omega t$.

At time t_1 when $U_i = U_{i.br}$ PD occurs. In this capacity would be C_i shunt resistance R of the discharge channel, the voltage on C_i rapidly declines. When it drops to a value of extinction voltage $U_{i.e}$ discharge to include quenched. At $t > t_1$

$$u_i = \frac{\mathrm{C}_b}{\mathrm{C}_b + \mathrm{C}_i} U_m \sin \omega t - (U_{i.br} - U_{i.e}) \tag{4}$$

This voltage is valid up to $t = t_2$, when U_i again reaches $U_{i.br}$ and a second PD would be. After the extinction of the second PD voltage is turned on until $t = t_3$ is given by

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$$u_i = \frac{\mathrm{C}_b}{\mathrm{C}_b + \mathrm{C}_i} U_m \sin \omega t - 2(U_{i.br} - U_{i.e}) \tag{5}$$

Thus we obtain a graph of voltage U in the gas inclusion, Fig. 3b, where each voltage U_i jump corresponds to a single PD.

In each half-cycle in the gas inclusion, PD arise with some regularity. If there are several insulation gas inclusions of various size and arrangement, that following frequency is equal to

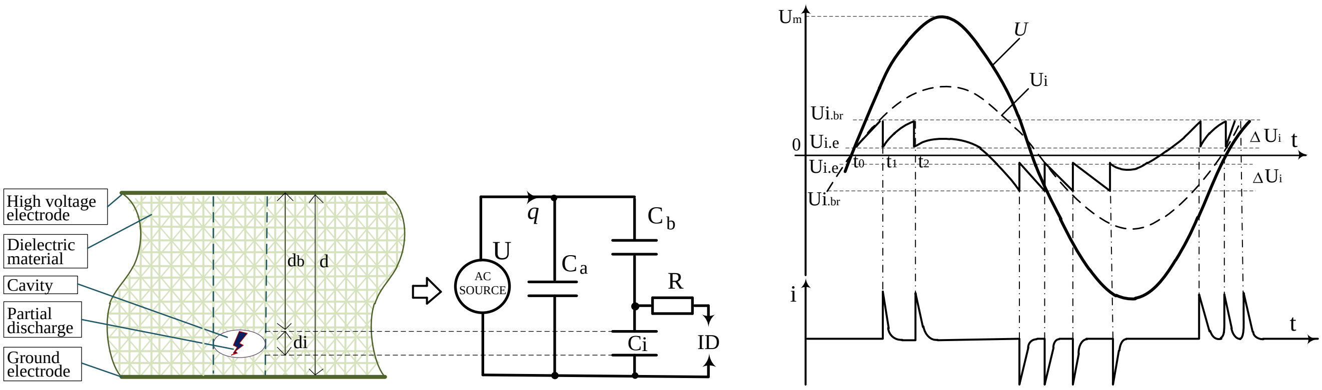
$$n_f = 4f \sum_{i=1}^{i=k} \frac{U - \eta U_{PDi}}{U_{PDi}(1-\eta)}, \tag{6}$$

where U_{PDi} – Voltage appearance in PD i–inclusion, k – the number of inclusions in isolation, where $\eta = U_{i.e} / U_{i.br} = 0{,}5 – 0{,}8$.

At $U \geq U_{PD}$ in gas inclusions PD are being arising and damping and energy W_{PD} dissipates in its channel, part of which is going to the destruction of the insulation. Average thickness of PD is determined as

$$P_{PD} = n_f W_{PD} \tag{7}$$

Therefore, with the increasing of U the number of PD per unit time and the power increase, respectively, the electrical insulation aging rate increases, and the service life reduces.



a) b)

Fig. 3 PD insulation: (a) Investigated insulating material and its equivalent electrical circuit at the time originating of PD by inclusion and (b) Voltage and current diagrams on inclusion of the insulation with PD

If $C_a \gg C_b$, and $\mathrm{C}_i >> C_b$ that $C_e \approx C_i$, and charge q passing through the inclusion, at which appears and disappears PD, is

$$q = (C_i + C_b)(U_{i.br} - U_{i.e}) = (C_i + C_b)\Delta U_b \; where \; U_{i.br} - U_{i.e} = \Delta U_i \tag{8}$$

Passing through the area of the development PD (including) a specific charge q leads to a change in voltage across the electrodes on the outer insulation on ΔU_x.

The ratio between the apparent charge PD q_{PD} and practical charge q has the form

$$q_{PD} = \Delta U_x C_e = \Delta U_i C_b = q \frac{C_b}{C_i + C_b} \tag{9}$$

If inclusion has a form of the layer extended across power lines of a field, it is convenient to carry C_b and C_i capacities to a surface unit of inclusion. Then the Eq. (9) can be presented as follows:

$$q_{PD} = q \frac{\frac{\varepsilon_b}{d - d_i}}{\frac{\varepsilon_b}{d - d_i} + \frac{\varepsilon_i}{d_b}} = \frac{q}{1 + \frac{\varepsilon_i}{\varepsilon_b}\left(\frac{d}{d_i} - 1\right)} \tag{10}$$

From a formula Eq. (10) follows that the seeming charge of PD decreases with increase in thickness of dielectric d.

Occurrence of each PD unit leads to the release of energy to the object of insulation W_{PD}. This energy is partly used for the destruction of the insulation. If the capacity, $C_a \gg C_b$, that

$$W_{\text{ч.р}} = \frac{C_b + C_i}{2}\left(U^2_{U_{i.br}} - U^2_{i.e}\right) \tag{11}$$

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Considering that the $\Delta U_x \ll U$, after transformations we obtain $W_{PD} \approx \Delta u_x C_x u$.

Strict examination, taking into account the redistribution of the electric field energy between tanks C_a, C_b and C_i in PD, gives expression

$$W_{PD} = \frac{\Delta u_x C_x}{\sqrt{2}} U_{PD}(1+\eta) \quad (12)$$

To measure of the intensity of a single PD we can use apparent charge PD $q = \Delta u_x C_x$, then

$$W_{PD} = \frac{qU_{PD}}{\sqrt{2}}(1+\eta). \quad (13)$$

Quantitative characteristics of an intensity of single PD are defined.

B. PD Integral Characteristics

Integrated quantitative characteristics are: average current I_{PD}, average power P_{PD}:

$$I = \frac{1}{T}[|q_1| + |q_2| + |q_3| + \cdots + |q_m|] \quad (14)$$

If all of the charges have the same value $|q_{PD}|$, then

$$I_{PD} = n_{PD} q_{PD} \quad (15)$$

If the charges are significantly different in magnitude, then

$$I_{PD} = \sum_{i=0}^{k} \frac{|q_{PD(i+1)}| + |q_{PD\,i}|}{2}(\eta_{i+1} - \eta_i) \quad (16)$$

where q_{PDi} – i-th level of apparent charge; η_i – following frequency of PD, which apparent charge exceeds i-y level (to $i = 0$ value there corresponds following frequency $n = 0$). When determining average current of I_{PD} by formula Eq. (3) the number of levels k of an apparent charge is recommended to choose not less than four (at which initial level has to correspond to $i = 0$), at adjustment of levels no more than through 20dB.

Discharge power as a result of PD is:

$$P = \frac{1}{T}[q_1.U_1 + q_2.U_2 + q_3 U_3 + \cdots + q_m.U_m] \quad (17)$$

where $U_1, U_2, \ldots U_m$ – values of voltage on isolation at the moments of discharges.

If the main quantity of PD arises close to amplitude of the enclosed voltage of U_m, then P_{PD} will be defined as

$$P_{PD} = I_{PD} U_m \quad (18)$$

If all of the charges have the same energy W_{PD}, power P_{PD} is equal to:

$$P_{PD} = \eta_{PD} W_{PD} \quad (19)$$

If the charges are significantly different, then

$$P_{PD} = \sum_{i=1}^{k} \frac{W_{PD(i+1)} + W_{PDi}}{2}(\eta_{i+1} - \eta_i) \quad (20)$$

where W_{PDi}– th energy level.

The square D_{PD} parameter determines the size of charges in isolation as a result of PD in one second.

$$D_{PD} = \sum_{i=0}^{k} \frac{q^2_{\text{ЧР}(i+1)} + q_i^2}{2}(n_{i+1} - n_i), \quad (21)$$

where q_{PDi} – i-y level of a square of a charge; n_i – following frequency of PD, which square of a charge exceeds i-y level (to value $i = 0$ there corresponds following frequency $n = 0$).

Square velocity in the time interval T is given by:

$$D = \frac{1}{T}[q_1^2 + q_2^2 + q_3^2 + \cdots + q_m^2] \quad (22)$$

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PDI intensity determines the power of the PD and is an integral characteristic:

$$I_{PD} = \frac{1}{\mathrm{T}} \sum_{1}^{\mathrm{k}} \mathrm{Q}_{02\mathrm{i}} \cdot \mathrm{U}_{\mathrm{x}}, \tag{23}$$

where Q_{02i} – amplitude Q_{02} i – th PD, for the period T; U_x – value change in voltage on the plates of the object under PD.

C. Forecasting of Emergence Inclusion

With growth of voltage of isolation the numbers of inclusions, in which PD appear, increases that lead to stronger dependence of number of discharges in a second and PD power from tension, than on Eqs. (16), (19), (20) [6]. Distribution of ignition voltages of PD submits to the normal law with average $U_{i.b.a.}$ value and a mean square deviation $\sigma_{i.b.}$. Thus, density of probability of emergence of inclusions with tension of ignition of PD $U_{i.b.}$, it is equal to

$$f(U_{i.br}) = \frac{1}{\sqrt{2\pi}\sigma_{i.br}} exp\left[-\frac{(U_{i.br} - U_{i.br.a.})^2}{2\sigma^2_{U_{i.br}}}\right], \tag{24}$$

and the probability of emergence of inclusion with ignition voltage less $U_{i.br}$ makes

$$F(U_{i.b.}) = \frac{1}{\sqrt{2\pi}\sigma_{i.br}} \int_0^{U_{i.br}} exp\left(-\frac{(U_{i.br} - U_{i.br.m.})^2}{2\sigma^2_{i.br.}}\right) dU_{i.br.}, \tag{25}$$

Passing to the voltages on conclusions of the examined object, we have

$$U_{PD} = U_{i.br}/\eta; \quad = U_{i.br.m.}/\eta; \quad \sigma_{PD} = \sigma_{i.br.}/\eta; \tag{26}$$

And

$$F(U_{PD}) = \frac{1}{\sqrt{2\pi}\sigma_{PD}} \int_0^{U_{PD}} exp\left(-\frac{(U_{PD} - U_{PD.m.})^2}{2\sigma^2_{PD}}\right) dU_{PD}, \tag{27}$$

At a voltage, smaller voltage of initial PD $U_{i.}$, the probability of emergence of PD in inclusion has to be rather small. In the field of small probabilities dependence of *F(U)* and consequently, and dependences defined by it $n_{PD}(U)$ and $I_{PD}(U)$ have an appearance

$$\begin{gathered} F(U) = A_1(U/U_i)^{a_1} n_{PD} = n_{PD0}(U/U_i)^{a_1} = A_2 U^{a_1} = A'_2 E^{a_1}; \\ I_{PD} = I_{PD0}(U/U_i)^{a_1} = A_3 U^{a_1} = A'_3 E^{a_1}, \end{gathered} \tag{28}$$

where $a_1 = 4U_i/\sigma_{PD}$, n_{PD0} и I_{PD0} – number of PD current at PD by voltage U_i.

The accounting of statistical dispersion of ignition voltage of PD in separate inclusions leads to that the power of PD depends on voltage more strongly than on Eq. (10) [6]. As in this case PD in inclusions with the greatest voltage of ignition and consequently, possessing and the greatest energy, originate near amplitude of enclosed voltage, $P_{PD} \approx I_{PD} U_m$. Considering I_{PD} Eq. (28), we have

$$P_{\mathrm{PD}} = A_4 U^{a_1+1} = A_4 U^a = P_{\mathrm{PD0}}(U/U_i)^a = A'_4 E^a. \tag{29}$$

Thus, the accounting of statistical dispersion of voltage of ignition of PD in separate inclusions results in sedate dependence of power of PD on voltage. Value of an apparent charge is connected with the physical mechanism of development of charges. Initial PD with intensity to 10^{-12}–10^{-11} *Cl* at long influence of voltage cause aging of isolation and destruction. At further increase of voltage the apparent charge of single PD caused by change of physics of development of PD, for example, formation of a dendrite in firm isolation sharply increases in isolation. Such PD called critical are characterized by an apparent charge ~ 10^{-8}–10^{-7} *Cl* – for hardware and cable isolation Critical PD bring to more intensive destruction of isolation and their appearance sharply reduces term of service of cable system. These discharges have the degree dependence of characteristics of voltage in accordance with Eq. (29) [6], however the exponent has rather high values than for initial PD, and lies within 12–16.

D. Results of PD Modeling

If the given voltage reaches a certain value Ux, and voltage on the capacity of C_i exceeds voltage of breakdown of the defective $U_{i.b.a.}$, the capacity of C_b is shunted (Fig. 4). The exception of capacity of C_b from an equivalent circuit is accompanied by PD, the general capacity of studied system during emergence of the discharge increases. On the basis of known voltage on inclusion ΔU_x (12) and the electric capacity of C_i (1) the charge of PD q_{PD} is calculated (Fig. 4a). The increase in the extent of defect in this case conducts to reduction of the initial capacity C_a and increase in capacity of C_b that in turn leads to a voltage reduction on object at the time of the discharge C_i and to increase of size of an apparent charge q.

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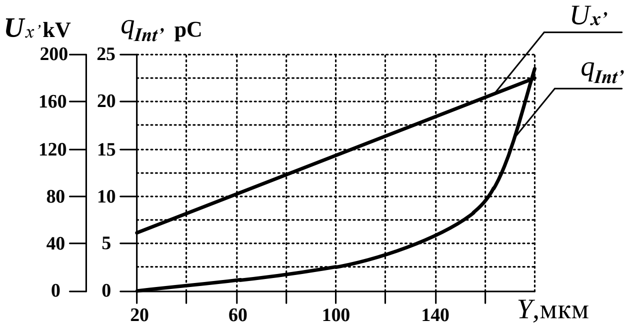
The dielectric permeability increasing of ε leads to decreasing of intensity of electric field in isolation. As a result, voltage of U_x decreases that causes redistribution of voltage in a parallel branch of an equivalent circuit and voltage increasing on the defective U_i area. In this case emergence of PD requires the smaller voltage, attached to object (Fig. 4b). The charge of the partial discharge q_{int} remains invariable, and the apparent charge q increases under the linear law (Fig. 4b).



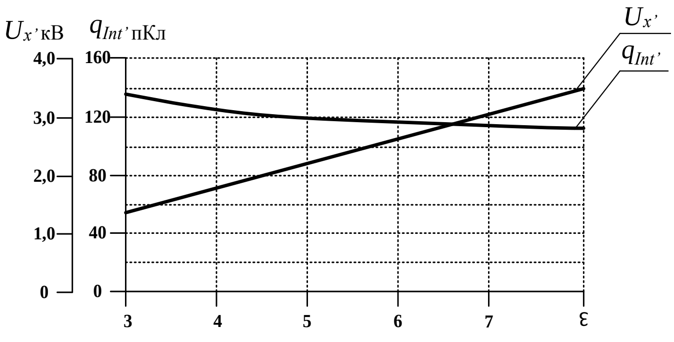


Fig. 4 Dependence schedule: (a) voltage of ignition of PD Ux and an apparent charge q from the extent of defect and voltage of ignition of PD Ux and (b) an apparent charge q from dielectric permeability of isolation ε

Voltage of ignition of the partial discharge U_x remains invariable, however with increase in depth of damage the size of a charge of the partial discharge q_{PD} and an apparent charge of q linearly increase [7], that is explained by linear increase in value of capacity of defect. Increase of a charge of the partial discharge q_{PD} is proved by proportional increase in capacity of C_i, owing to increase in the size X.

E. Development of Operational Insulation Defects

During operation the cable, impregnated with a viscous, due to repeated heating and cooling cycles, the emptiness is being formed in the insulating material. Deteriorated insulation value depending on the degree of cable capacitance residual deformation of the shell defined by the expression.

$$C = \frac{0{,}024 \cdot \varepsilon}{lg\frac{R}{r}}, \tag{30}$$

After repeated heating-cooling oil rosin compound due to permanent deformation cable sheath reaches this size, the next time that it is no longer heated expands. Then, in Eq. (29), the radius of conductor (r) can be taken the same, and the new value of radius isolation R' defined in accordance with the expression.

$$R' = R(1 + a \cdot \Delta t), \tag{31}$$

where ɑ - linear expansion coefficient is determined from the relation

$$1 + \beta \cdot \Delta t = (1 + a \cdot \Delta t)^3, \tag{32}$$

Δt - cable temperature change when it is heated.

From Eq. (30) and Eq. (31) the relative change in the capacitance of the cable at the highest-possible permanent deformation of cable sheathing is

$$\frac{C'}{C} = \frac{lg\frac{R}{r}}{lg\frac{R(1 + a \cdot \Delta t)}{r}}. \tag{33}$$

The expression Eq. (33) shows that the relative change of the capacitance value depends not only on the maximum temperature of the cable, but also on the cable diameter and the thickness of the paper insulation.

For cables with the same cross section 6 and 10 kV insulation thickness of 2.95 mm and 4 mm [2] the relative changes in capacitance of the cable at different thermal deformations were calculated, defined by the superheat temperature, Fig. 5.

Analysis of the obtained results shows that while taking into account the thermal deformation of the sheath of the cable and substitution treatment fluid, the capacitance of the cable drops to 0.47 from the initial capacity. The resulting value can be considered the maximum possible.

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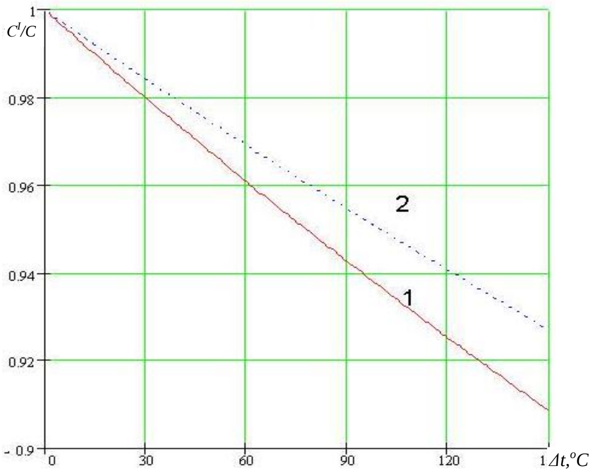


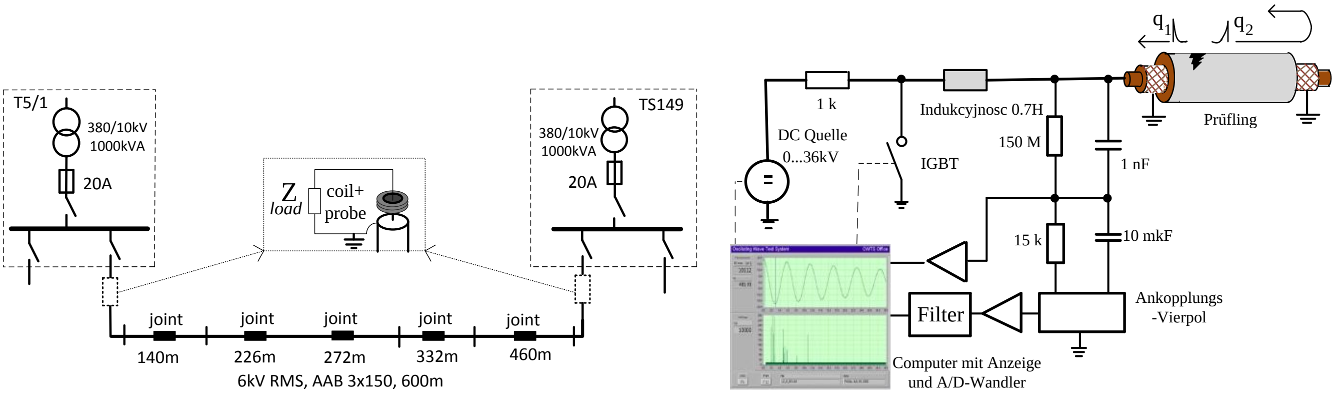
Fig. 5 Change in capacitance of the cable insulation material 1 - 6 kV cable, 2 - 10 kV cable

IV. METHODOLOGY

Integrated diagnostics of the insulating materials cable system [8] was held (Fig. 6a), and the level of PD has been measured by the diagnostic system OWTS M28, and relaxation current or return voltage measurement was performed using equipment CDS. Simplified diagram of the measurement system OWTS-28 [9] is shown in Fig. 6b, using damped AC voltage as a test, Fig. 6b. The system responds to overvoltage (100 to 800 Hz), created by PD (q1 and q2).

The essence of the method implementation is based on applying a high voltage to the cable line and the initiation of it for a few fractions of a second variable fading voltage (DAC) Fig. 6b, otherwise referred to as the damping, which is under the influence of defect sites in the cavities of the cable line and ignite PD. It creates the oscillatory tension which frequency of fluctuations is defined by inductance and capacity of object of tests according to the equation:

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \tag{34}$$



a) b)

Fig. 6 Connection diagram: (a) Power cable system plot and (b) block diagram of the diagnostic system OWTS PD

In the future, according to known or previously measured length of the cable line and guided by a certain velocity of propagation of electromagnetic pulse reflectometry method, local place of PD concentration will be determined [9].

V. RESULTS AND DISCUSSION

Analysis shows that the occurrence of PD signals strongly depends on the frequency of the test voltage and hence the voltage gradient. Fig. 7a, b, reflected the intensity of the PD at the test voltage 4 and 8 kV, resulting with amplitude of the PD at maximum about 466 and 6875pC respectively. So within the operating voltage in isolation, having no hazardous PD (Fig. 7a), under the overvoltage PD of very high intensity originate, creating a danger for insulation, Fig. 7b. The voltage of PD originating is below the level of the phase voltage, Fig. 7a and it shows that during operation of the cable the existing defects develop and grow to bigger (dangerous) size, Fig. 7b, which leads to the output of CL from operation mode.

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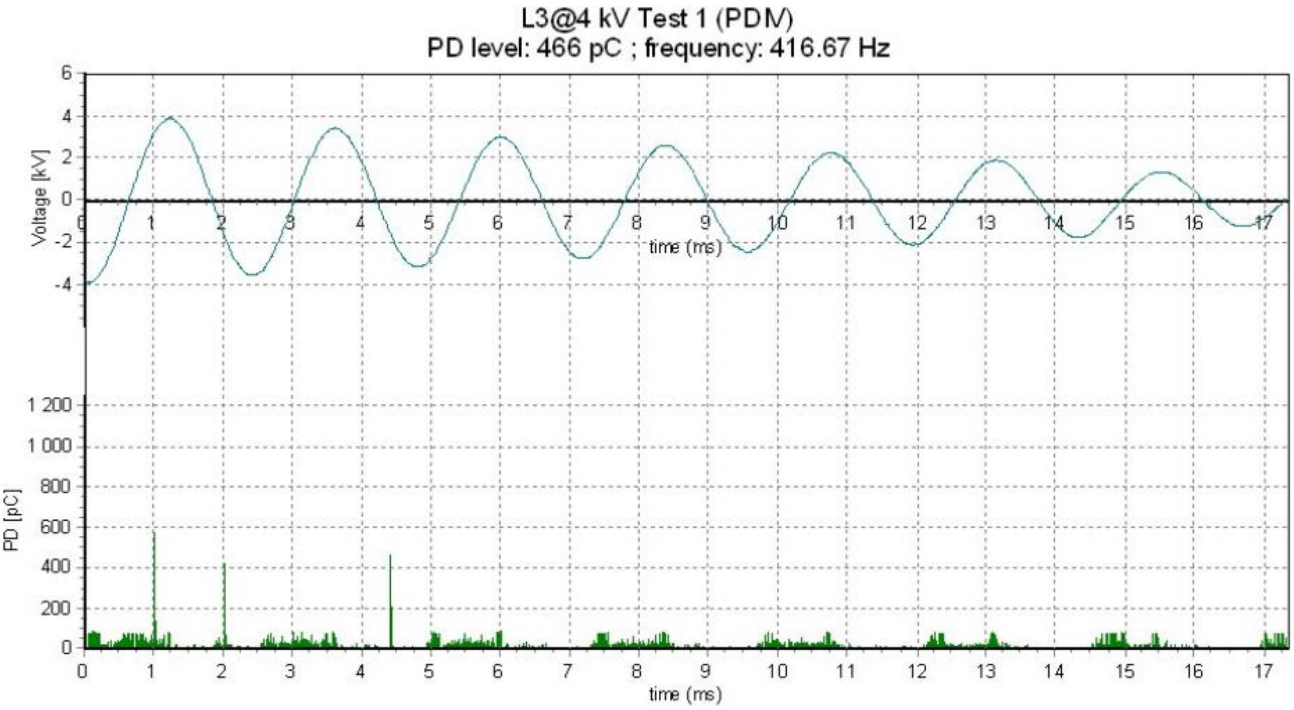

Fig. 7 a – test fading tension (DAC = 4, kV), U <Uo and PD family in cable system

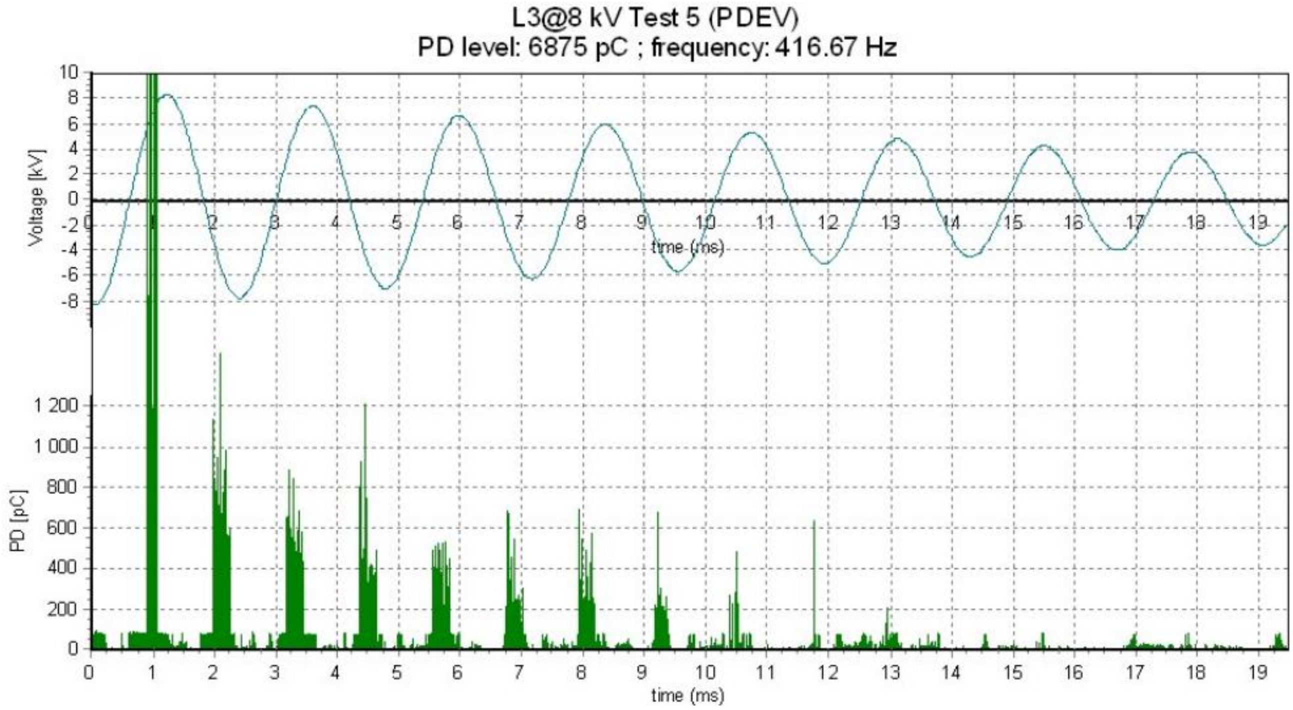

Fig. 7 b – test fading tension (DAC = 4, kV), Uo < U < 2Uo and PD family in cable system

Tension of emergence of PD is lower than level of the phase tension (PDVI=4 kV) it means that at the cable operation, defects available in it develop and grow to the dangerous sizes that lead to an exit of CL from work.

Compared with the method of [2], which allows to determine the breakdown of insulation already happened, the result of diagnosis by HDI method is a distribution map PD, Fig. 8, which are determined by the presence or absence of latent defects along the entire length of cable system (Fig. 6a). In other words, the PD method gives the possibility of ranking criteria state lines – “good”, “bad” or “critical” (Table 1). In Fig. 8 to a phase A, B, C there correspond L1, L2, L3 designations.

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TABLE 1 BOUNDARY VALUES AND PD TENDENCIES

CS element	Type	Value
Insulation	OIP- insulation	≤ 10.000pc
	PE / VPE-insulation	≤ 20pc
Joints	Oil insulation	≤ 10.000pc
	Epoxy pitch	≤ 5.000pc
	Silicon/EPR insulation	≤ 1.000pc
Terminations	Oil Termination	≤ 6.000pc
	Dry Termination	≤ 3.500pc
	Shrink-/Side-on Termination	≤ 250pc

Due to the method it is possible to determine the general state of the line as well as the specific defect locations, as well as forecasting the development of the defect and determine the costs associated with the planned renovation of the line, rather than an emergency.

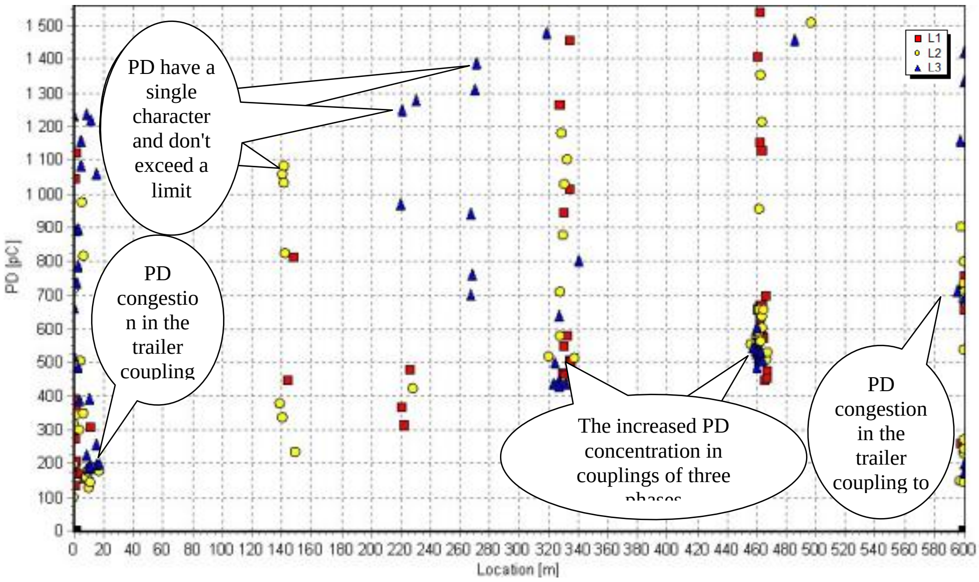

Fig. 8 Map of distribution and concentration of PD in isolation

PD sources detected testify to the presence of defects in the cable insulation. The study showed that at the mark around 330m, 460m, on all phases (L1, L2, L3), and terminations on both sides increased intensity of PD has been recorded (according to the Table 1).

Since the place PD detection coincides with the location of couplings, Fig. 6a, the cause of this defect may be due to a violation of the mounting technology of these joints. Thus periodic heating and cooling of cables with the paper isolation impregnated with an oil- rosin compound, leads to gradual replacement of liquid impregnation with air, emergence of air inclusions in isolation and deformation of a cover of a cable. It is resulted by decrease of capacity value of a vein of a cable in relation to a cover and other veins.

VI. CONCLUSIONS

Theoretical justification of processes and the mechanism of electric breakdown in insulating materials had been carried out. The mathematical model of quantitative and integrated characteristics of PD in insulating materials, and also forecasting of emergence of inclusion was studied.

On the basis of calculation of characteristics of PD, connection of change of ignition voltage of PD U_x and an apparent charge q from the extent of defect in isolation, and also changes of ignition voltage of PD U_x and an apparent charge q from dielectric permeability of isolation ε is established.

Research of development of operational defects of isolation showed that relative change of capacity value of an insulating cable material depends not only on the maximum value of temperature of a cable, but also on diameter of a cable and thickness of paper isolation.

The technique of diagnosing of insulating materials under operating conditions is given. The analysis of results showed that measurement of the PD parameters allows estimation the impact on insulating materials of various factors in a complex. PD is

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a measure of electric aging, and intensity of external influences which have impact on formation and development of defects of isolation.

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