The methods of decreasing the influencing factors on the results of cable insulation control carried out with the complex methods

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Abstract: - This paper presents a complex method of cable insulation control which consists in measuring of the cable insulation capacity per unit length in strong electric field. The analysis of the factors influencing the results of controls is carried out, the methods to decrease the influence of these factors was offered.

Key-Words: - Insulation, cable, breakdown, capacity per unit length, spark testing, test voltage.

1 Introduction

Insulation is required constructive element of electrical cables and wires. It is used for preventing of electrical contact between conducting cable parts, providing able transfer characteristics, reliable transmission path, protecting of cable wire from mechanical influence and another negative conditions. Thus, to provide reliable transition path the high-quality cable insulation control for the whole of cable.

In the current regulatory documentation two methods of control such as spark testing [1] and measuring of cable insulation capacity per unit length [2] is described.

The first method consists in passing of controlled cable through the spark tester electrode with high test voltage. If insulation defect is passing through the controlled area the breakdown is occurred. That is registered with the automatics [3].

In the second method the cable insulation capacity per unit length is measured with the special cylindrical electrode. This electrode is immersed in water of cooling bath and the controlled cable is passing through the electrode. The water of cooling bath provides an electrical contact between the measuring electrode and cable insulation surface. If insulation defect is passing through the controlled area the insulation capacity per unit length is changing.

Both of these methods can not allow registration all type of insulation defects separately [4,5], thus new complex method of cable insulation control is offered. This method is combination of these two methods that allow increasing the quality of control.

2 The Complex Method of Control

In this new method of in-process control the high alternating test voltage is applied to the cable insulation surface with the bead chain electrode and the cable insulation capacity per unit length is measured at once. The value of test voltage is selected according to the insulation thickness and material as for the spark testing [3,6]. Thus, the insulation defects is registered with changing of the cable insulation capacity per unit length and occurrence of electrical breakdown.

3 The Purposes of the Research

Increasing of measurement accuracy during the manufacture allows you to register an insulation defects on the intermediate not on the final stage of cable manufacture. Defect registration on the intermediate stage of cable manufacture allows operator to avoid mass spoilage due to changing the process conditions at time. Different parameters of technological process affect the results of electrical capacity measurements with complex method of control. The purpose of this paper is determination of factors affecting electrical capacity measurement and evaluation of its influences. To enhance quality of control the methods to decrease the factors influences is offered.

4 The Theoretical Model of the Complex Method

The complex method is carried out with applying of a high test voltage to a cable insulation surface

(Figure 1). Electrical contact between the electrode and cable insulation surface is provided by high-intensity sliding discharges occurring in strong electric field. An applied alternative test voltage allows measuring of insulation impedance per unit length.

In this case a cable is represented two concentric cylinders. Electrical capacity of controlled cable insulation area can be calculated with known formulae for cylindrical capacitor [7]. In practice the measured electrical capacity of cable insulation area differs from theoretically calculated because of sliding discharges which are extend controlled area. Thus, the controlled area *L* (Figure 1) is longer than length of electrode applying the test voltage.

5 The Method Influencing on the Control Results

Developing complex method of control it is necessary to consider the influence of different factors such as test voltage parameters, value of electric field intensity, material, temperature of insulation, state of insulation surface, process conditions of production line.

5.1 The Effect of Test Voltage Parameters

The value of test voltage for spark testing is significantly more than the running voltage regulated by russian and international documentations [1, 3, 8, 9] in accordance with insulation thickness and material. When the high test voltage is applied to the surface, a sliding discharge is occurred. The length of a sliding discharge can be calculated with empirical Tepler’s formulae [10]:

$$l_{ск} = k \cdot C^2 \cdot U^5 \sqrt[4]{\frac{dU}{dt}}$$

Where *k* is the empirically determinated factor, *C* is specific surface capacity.

The length of controlled area depends on the length of a sliding discharge. To define the influence of a value and a frequency of high test voltage on the increasing of the controlled area length (Δl) the experiment was carried out (Figure 2). According to the data obtained it can be noted that increasing of the test voltage value and frequency leads to increasing of value Δl.

To decrease the influence of these factors the software of the device will measure an electrical capacity for the equivalent length of controlled area, which is more than real.

5.2 The Effect of State of Insulation Surface

To evaluate the length of the controlled area it is necessary to consider the influence of talc (only for rubber insulation) and moisture on the surface of the cable insulation products as well.

During research of the effect of talc on the control results it was analyzed relevant literature in which the authors solved a similar task [11, 12]. It has been found that talc (in the absence of moisture) has no significant influence on the processes occurring during the control in strong electric fields. Thus, the influence of this factor can be neglected.

Reducing the influence of wet insulation surface on the length of controlled area is possible to produce with software. The cable insulation surface becomes wet after extrusion line. At this stage of production insulation is deposited on wire by an extruder, after which the cable passes through the cooling bath. After the cooling bath a spark testing is provided. Devices for cable insulation control are

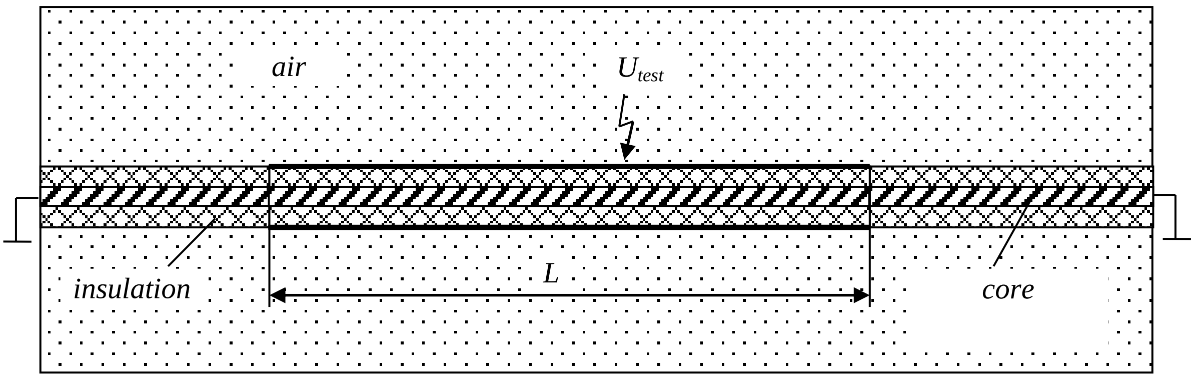

Fig. 1 Theoretical model of control

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also placed at other stages of the cable products manufacture for intermediate and output tests such as wire layup, etc. [13], at which the surface of the cable insulation stays dry. It has been experimentally proved that the increase of the controlled area for dry and wet insulation differ in two times at the same test voltage and electrode length. Thus, for quality recording of insulation capacity per unit length the expected state of insulation (dry or wet) have to be pointed in software.

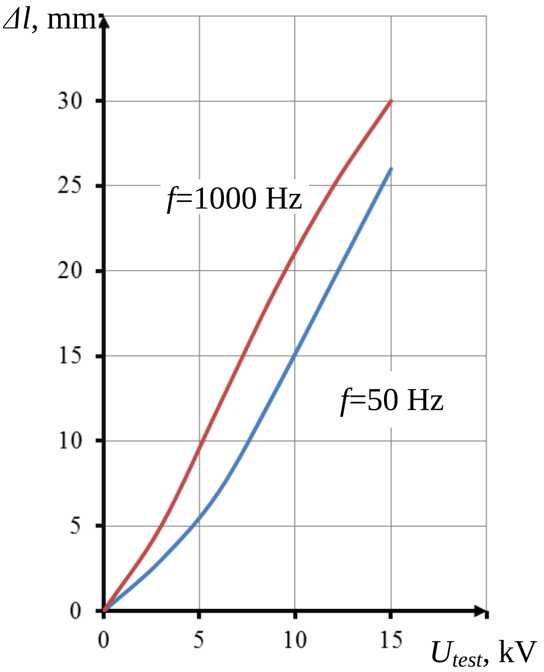

Fig. 2 Dependence of the length of the sliding discharge from the value the test voltage for different values of frequency

5.3 The Effect Value of Electric Field Intensity

The main materials used as cable insulation are polymeric materials such as polyvinyl chloride (PVC), polyethylene (PE), fluoroplastic. These materials are linear dielectrics [14] in other words their dielectric permittivity is constant and independent of the electric field in which they are located, so the affect of this factor can be neglected.

5.4 The Effect of Material and Temperature of Insulation

Cable insulation temperature is not constant at different stages of the cable manufacture and affects the dielectric constant (respectively, and capacity per unit length).

On leaving the extruder the temperature of the insulation is about 100°C, after passing through the cooling bath the insulation temperature is reduced to 40-50°C [15]. As mentioned before, the cable insulation control is carried out immediately after the stage of insulation depositing. At other stages of the cable manufacture, which contain spark testers, cable insulation heating is not provided. Thus, it is necessary to consider the temperature change in the range from 20 to 50°C.

The dependencies of the dielectric constant from temperature for some insulation materials is represented below (Figure 3, 4).

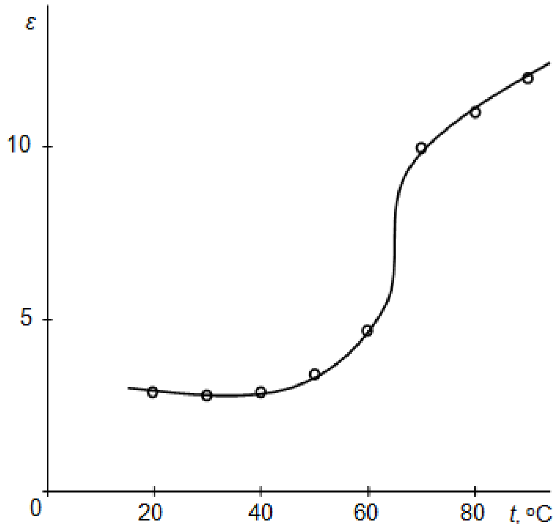

Fig.3 The dependence of the dielectric constant ε from the temperature for rubber insulation

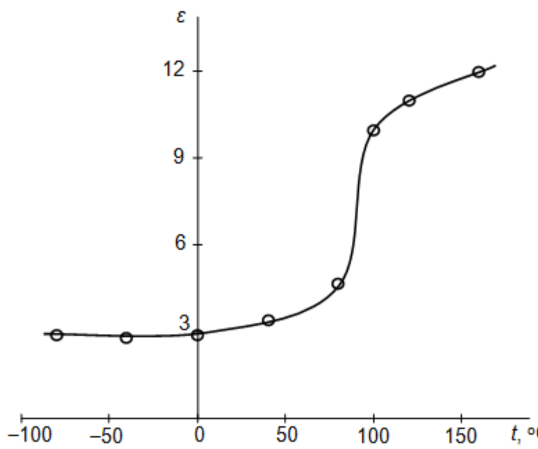

Fig.4 The dependence of the dielectric constant ε from the temperature for PVC insulation

Analyzing these dependences it can be noted that the temperature does not significantly affect the dielectric constant and, consequently, on the value of capacity per unit length, in the studied temperature range (20 – 50°C). Thus, the influence of this factor can be neglected.

5.5 The Effect of Process Conditions of Production Line

According to the technology of cable manufacture the cable is always in motion. Linear speed of production lines is determined according to the required operation mode. At high speed production lines the radial vibration of controlled object often occurs. It is also cause of noise in the measurement of cable insulation capacity per unit length. The maximum permissible deviation of the object from the central position is regulated by the normative document MD 16 14.640-88 in Russia and it is 10 mm. In practice, this deviation is 1..5 mm. To decrease the influence of this factor it is possible to use a digital filtering of the obtained measured signal. Filtration is advantageously carried out using a fast Fourier transform, which allows you to remove from the spectrum of low-frequency component of the received signal due to mechanical vibrations of the cable product.

6 Conclusion

In this paper it was found that such factors as the parameters of the test voltage, temperature, moisture and insulation material of cable products have a significant influence on the result of measurement of cable insulation electrical capacity per unit length. The effect of the electric field intensity and the presence of talc on the surface (for rubber insulation) on the measurement results were found to be insignificant and do not require detuning.

Using the proposed methods to reduce the influence of these factors will increase the accuracy of control. The proposed methods are software-based and do not lead to a complicated construction, and thus to a cost increasing.

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