INVESTIGATION OF THE LIFE CURVE FOR HIGH VOLTAGE CABLE INSULATION

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ABSTRACT

This paper covers test and visualisation methods related to electrical treeing resistance of power cable insulations. The unit was designed for investigation of electrical tree inception that allows to obtain the life curve for XLPEs, the example of such curve is presented.

KEYWORDS

Life curve; electrical tree; XLPE; threshold stress.

INTRODUCTION

The current situation in Russia is characterized with heavy increase in production and consumption of XLPE insulated power cables. Several cable plants mastered production of HV cables up to 220 kV. The appearance of new materials and technologies creates a demand also in the new test methods and analytical procedures.

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The main task is to provide high reliability and at the same time reasonable dimensioning of HV and EHV cables. Only analysis of insulation aging and breakdown mechanisms can give the solutions of this problem. It is known that inception and propagation of electrical trees (ET) considered to be the main reason of breakdown of HV insulation.

One of the ways in studying these processes is experimental plotting the insulation life curve, i.e. ET induction period vs. electric field stress dependency. As a rule small pieces of insulation with electrodes as sharp-pointed needles are used as test samples.

Comparatively not so many papers have been issued in this field. It can be explained by high cost and complexity of tests to be run.

We set the following tasks for our own tests, which claimed:

1) to provide test for material samples, manufactured under laboratory conditions and for samples of insulation cut out directly from the cables;
2) test duration should be limited only by practical reasons (for example cost), omitting disadvantages of equipment and approach employed;
3) a sufficient number of samples are to be tested simultaneously to provide acceptable productivity;
4) one should have the maximum spatial and time accuracy in measurement and the minimum susceptibility to noise of different origin.

We believe that the solutions of this tasks would give an opportunity to study the mechanisms of electrical aging and solve problems on material application and cable design.

We monitor the moment of tree inception by means of microscopic technique. This method is employed to establish ET inception when 10 samples are tested simultaneously with high voltage applied. The spatial resolution of approximately 1.5 μm is obtained. It permitted to record early electrical tree, provided pinpoint accuracy for the microelectrode delivery to the microscopic area of interest inside the sample, reliable and direct contact between microelectrode and material, preservation of residual mechanical stresses when necessary.

Within the framework of this method the tests are accomplished with more detailed sample analysis by means of microtoming, staining with specific dye, slice microscopy with large magnification for complimentary verification of tree inception, evaluation of ET dimensions and in case of its absence detection of microscopic degradation area (material oxidation due to electric field exposure) which precede ET inception.

We use the following method to obtain the life curve.

The samples are installed in testing cells then needle-shaped electrodes are inserted and HV is applied. The moment of every ET inception is recorded. Then samples are replaced with new ones which are tested under different voltages. We take time of tree inception in 50% of samples as the characteristic tree inception time at the given voltage [1], preferably not less than 5-6 values are to be recorded.

The test facility has the following principal units:

– optical system;
– optical system horizontal displacement mechanism;
– testing cells;
– devices for HV electrode insertion.

General scheme of the test facility is shown in Figure 1.

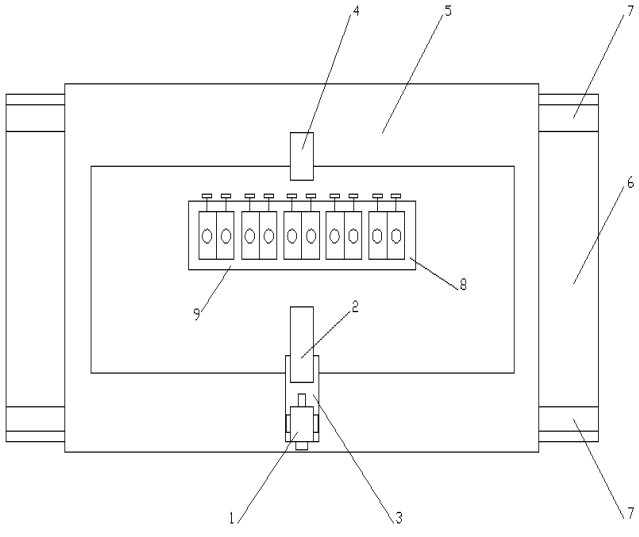

Fig. 1. Block diagram of the unit for plotting the life curves of XLPE insulations of HV and EHV cables