Internal partial discharge in cavity of polyurethane

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Abstract

Parameters and time development of internal partial discharges in insulation material - polyurethane were studied. The internal defect was created by a needle, which was moved back by 1 mm in order to create an air filled cavity in addition to the microcavity at the tip of the needle. In the experiment polyurethane pattern was stressed by high AC voltage and parameters of the partial discharges until breakdown of insulation material were recorded. The discharge activity generated in the air cavity, the point of the greatest stress degrades gradually the insulation. This degradation is connected with growth of an electrical tree, which parameters are described. The apparent charge magnitude, voltage and the time of occurrence of each PD event were recorded by LDS- 6.

Keywords: Partial discharge; charge; polyurethane

1. Introduction

Polyurethanes, polyethylene, epoxy resins and other are new materials which have wide application as the insulation materials in electrical equipment, medium voltage cables, a power electronic or compound transformers [1, 2, 3, 4]. Electrical properties of polyurethane foam are investigated and are considered as an insulation material to replace SF6 and N2 inside hollow insulation systems to prevent internal flashover [5]. Healthy high-voltage insulation between two electrodes keeps the charge of opposite polarities from passing through the material. During normal operation, the electric field stress is uniformly distributed across the healthy insulation between the electrodes. However, when it has some defects (impurity, small gaps, bubbles (void) and other), there occurs a non-uniform
distribution of the electrical stress among the healthy and the defective insulation parts. This is due to different dielectric properties of the healthy and defective parts of insulation. Depending on the size and type of the defect, the partial discharge occurs at a certain level of the applied voltage. During this activity, the charges are able to penetrate through the material with the force provided by the high electric field strength. As time passes by, the discharge causes a significant degradation to the insulator [6, 7, 8, 9].

The partial discharge (PD) measurements have been widely used in the field of insulation diagnostics. The detection and continuous monitoring of the PD data can provide useful information regarding the insulation condition. The partial discharge measurements are performed with the help of Phase Resolved Partial Discharge Analyzer (PRPDA). This technique is used to analyze PDs with respect to the phase angle of the applied voltage [10]. The PD pattern recorded with the help of PRPDA can be used to recognize the insulation defects which are the root cause of partial discharges. It is believed that each type of PD mechanism has a unique set of statistical parameters like skewness, kurtosis and others parameters [10, 11, 12, 13]. The variations in PD pattern with respect to phase angle can be reflected by change in these statistical quantities which allow predicting insulation degradation [14]. Thus, it’s quite possible to devise an intelligent and automated insulation diagnostic system based on the quantification of the partial discharge signals.

2. Experiment

In our measurements we used one of the most popular electrical methods for the detection of the partial discharges. The measuring impedance LDM-5 (bandwidth 20 MHz, max. current 5 A, optional 50 A) was galvanic connected with measured object. At this configuration we can direct sensing current pulses of PDs which are superimposed on power supply. The test object (air cavity in polyurethane) presented as a $C_a$ was parallel connected to the coupling capacitor in series with the measuring impedance (Fig. 1a). PD pulses were recorded and analyzed by the PD detector - LDS-6. The calibration process was done using LDC-5 before each new measurement. At applied voltage 22 kV the maximum detectable PD level was 7 pC and this threshold level was used for rejection of background noises.

Polyurethane (PUR or PU) is a polymer composed of organic units joined by carbamate (urethane) links. These plastic polymers are made by combining a di- or polyisocyanate and polyols. Polyurethanes are used in a wide variety of applications to create all manner of consumer and industrial products that play a crucial role in making our lives more convenient, comfortable and environmentally friendly. Polyurethanes are used in the manufacture of rigid insulation panels, microcellular foam seals and gaskets, electrical potting compounds, high performance adhesives, surface coatings and surface sealants, synthetic fibers (e.g., Spandex), hard-plastic parts (e.g., for electronic instruments) etc. Because these materials are so versatile and known to be excellent insulators, they offer many solutions to the challenges of energy conservation and eco-design [15, 16].
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