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Partial discharge analysis using energy patterns

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ABSTRACT

Partial Discharge detection is an important tool for diagnosis of High Voltage insulation systems. The Phase Resolved Partial Discharge (PRPD) data obtained from Partial Discharge (PD) detectors is used to construct the energy versus phase angle plots called as Energy Patterns. The energy patterns in case of three types of discharges viz. delamination, void and slot discharges for High Voltage rotating machines are discussed in this paper. The energy patterns are correlated with tan δ measurements.

1. Introduction

Electrical discharges occurring in the insulation or at the interface of insulation which do not completely bridge the gap between the electrodes are called as partial discharges. Partial Discharges (PDs) slowly degrade the insulation and may ultimately lead to insulation breakdown [1]. During the occurrence of PD, energy in several forms like electrical energy, thermal energy, mechanical energy, acoustic energy etc. are emitted from the PD site. PD detection and identification is carried out using one or more of these energy forms. For example, single and multiple sources of PD can be identified using optical energy radiated from the source of PD [2]. Electrical PD is generally measured by detectors which measure the apparent charge (Q), repetition rate and number of pulses (N) with respect to the voltage magnitude (V) and phase angle ($Ø$). Study of variations in Q and N for changes in V and Ø reveals different aspects about the PD phenomena.

Different patterns like pulse sequence analysis [3], pulse height analysis [4,5] and Phase resolved Partial Discharge (PRPD) patterns [6–9] are used in electrical PD detection & analysis. PRPD pattern is considered as the robust method for PD identification. The PRPD pattern is generally plotted as a variation of charge Q at every phase angle and number of occurrence per phase angle. It is extensively used in PD identification using electrical energy. Some other patterns documented by Contin et al. [10] and Krivda [11] can be used to analyze PD in different ways.

The correlation of PD apparent charge distribution and PD energy distribution is used to study stochastic behavior of PD and physical processes causing degradation [12]. Xin et al. [13] has applied statistical methods and Neural Networks on energy distribution through discharges observed in case of ball-disk, needle-disk and corona discharge to identify the type of PD. Electrical tree growth in epoxy resin is studied using PD energy dissipation [14]. Tang et al. [15] has proposed PD source location in transformers on the basis of time difference of the energy accumulation curves of multiple signals using UHF PD measuring system. Modeling of power transformer and wavelet packet analysis is used to locate PD in transformer winding with the help of impulse current test [16]. The effect of variation in frequency of applied voltage on the PD inception voltage for different insulation samples is studied using integrated charge and energy measurement [17].

The literature survey shows that the energy and PRPD are used for identification of PD. This paper tries to construct energy patterns using PRPD data obtained from electrical PD detector. In PRPD patterns detected by any PD detector, the magnitude of Q versus $Ø$ is plotted and N is also indicated for a given number of cycles. Thus data obtained from PD detectors contain plot of N & Q for phase angle between 0° and 360°. Using this data, the energy dissipated in the partial discharge is computed for each phase angle. This is then plotted as the phase resolved partial discharge in terms of energy using Eq. (2). The energy versus phase angle plot is thus a modified PRPD plot in terms of Energy. Construction of energy patterns is an attempt to combine the information of Q, N, voltage magnitude & phase angle.

The motivation for using the energy as a parameter stems from the fact that the dissipation energy in Joules could be used to

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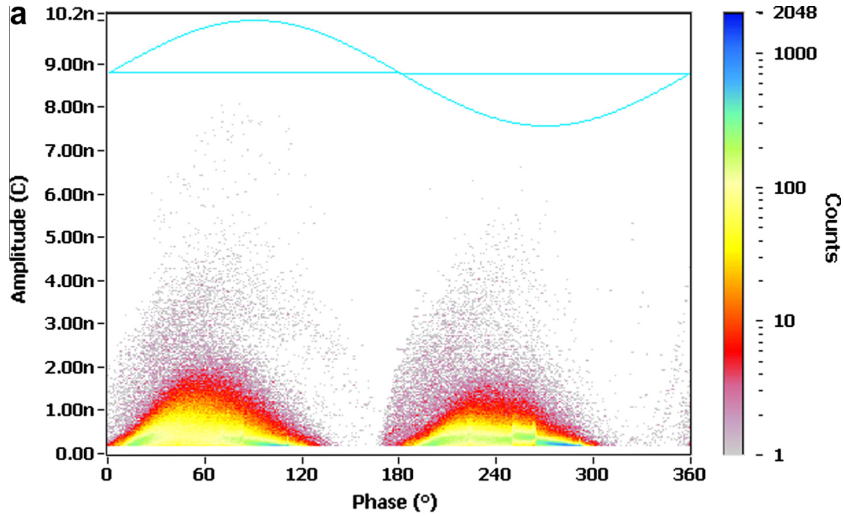

Fig. 1a. PRPD pattern for delamination at 3 kV.

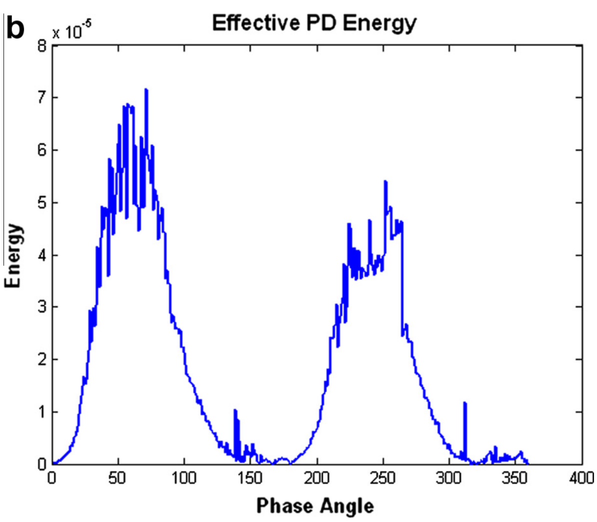

Fig. 1b. Energy plot for delamination at 3 kV.

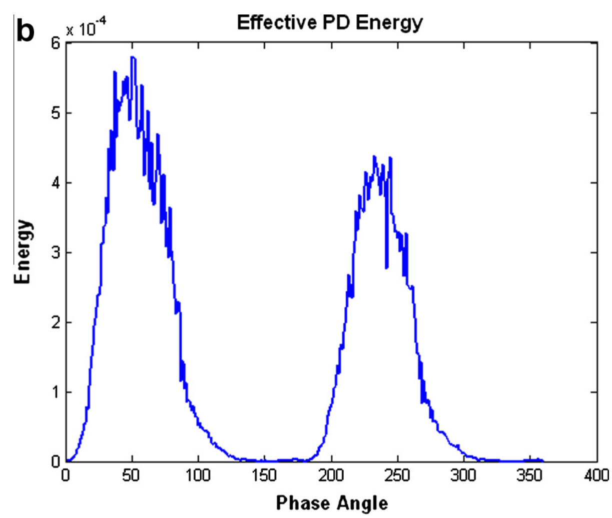

Fig. 2b. Energy plot for delamination at 4 kV.

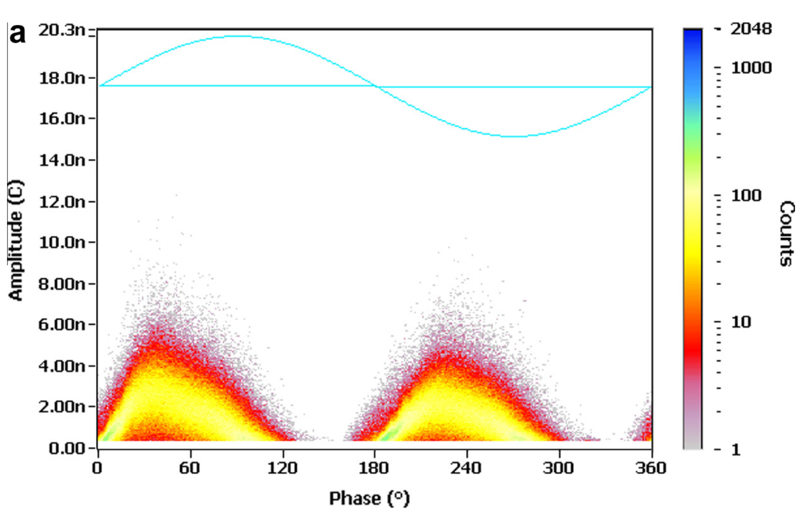

Fig. 2a. PRPD pattern for delamination at 4 kV.