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Short communication

Volt–time characteristics of small airgaps with Hyperbolic model

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ABSTRACT

An experimental investigation of the volt–time characteristics of small airgaps is performed. A Hyperbolic model is proposed to account for the results. The constants of the model have a direct bearing on parameters of the Disruptive Effect model for breakdown with non-standard Lightning Impulses (LIs). Analyses with uniform and non-uniform electrodes show their effect on the Hyperbolic model parameters.

1. Introduction

The major proportion of failures in transformers are due to inter-turn and inter-disc winding insulation (oil and OIP) failures, where clearances are in the order of millimeters. Small voids in dry type resin cast transformers may lead to permanent failure in the near future. During transient conditions, these insulations can be stressed with non-standard impulse voltages of both unidirectional and bi-directional oscillating waveshapes. The inter-turn and inter-disc winding insulation failures are attributed to these oscillating voltages. There exists an analytical prediction procedure (Modified Disruptive Effect method) [2] to estimate the insulation strength of these non-standard waveshapes. This method serves as a measure of insulation strength under oscillating voltages and estimate the breakdown strength irrespective of the medium of the insulation and of the physical processes involved [1,2]. It is important to note that this method utilise volt–time characteristics to obtain the Disruptive Effect (DE) model parameters. To estimate the strength under non-standard waveshape, one should first estimate the experimental volt–time characteristics using the standard 1.2/50 μs impulse waveshape. If there exist an analytical prediction model to obtain the volt–time characteristics, then the efforts in doing experimentation could be minimized. One such model namely a Hyperbolic model based on the DE model parameters is proposed here. A basic study with this model on small airgaps of 1–6 mm gap distances is dealt here.

It is well known that the Disruptive Effect model [3] is an effective tool to estimate the strength under non-standard waveshape. It is stated that when the area under the impulse curve above the onset voltage is greater than critical value (DE^*) the breakdown takes place. This phenomenon is explained in the DE model [3], which states that the condition for sparkover at time 't_b' is given by Eq. (1).

$$DE^* = \int_0^{t_b} (U - U_0)\,dt \qquad (1)$$

where U_0 is the onset voltage, U is the applied voltage, DE^* is the critical Disruptive Effect area above the onset voltage U_0 and t_b is the time to breakdown.

When this area above the onset voltage (U_0) exceeds a critical value, the breakdown takes place. Based on this model, parameters (DE^*, U_0) are extracted from the standard 1.2/50 μs impulse volt–time characteristics.

2. Experimental volt–time characteristics

A MWB (Messwandler-Bau), 100 kV, 250 kJ impulse generator with fine voltage control facility is utilised for generating standard 1.2/50 μs impulse voltages. The test cell consists of uniform plane electrodes with the provision for minute gap adjustment. The uniformity in electrical field distributions is verified with the help of

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