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Self-Consistent Multi-arcs Dynamic Model for High Voltage Polluted Insulators

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ABSTRACT

This paper presents a self-consistent multi-arcs dynamic model for high voltage polluted insulator under impulse voltage. This model is an improvement of that one developed for single arc; it is based on an electrical equivalent circuit consisting of a series of different partial arcs and residual layer resistance. It takes into account the configuration of insulator, applied voltage polarity and the instantaneous changes of discharges parameters. The proposed model enables to compute the flashover voltage and leakage current and to show the influence of dry bands on the voltage distribution along the surface and furthermore on the electrical performance of polluted insulator. It is validated using a simple plane model in the case of uniform and non-uniform polluted bands. The computed flashover voltage and leakage current are found in good agreement with those measured experimentally.

Index Terms - **Self-consistent multi-arcs dynamic model, high voltage polluted insulators, impulse voltage, flashover voltage, leakage current.**

1 INTRODUCTION

MANY mathematical and physical models have been proposed to explain the mechanism and predict the flashover voltage of polluted insulators [1-4]. As far as models for predicting the flashover voltage of polluted insulators are concerned, both static [1, 5] and dynamic [6-8] mathematical models have been developed to simulate flashover on polluted insulators. The static models are based on Obenaus's model, the flashover of insulator being assumed to an arc in series with a residual resistance consisting of the polluted layer unabridged by the arc. Based on arc constants and pollution conductivity, one can get the characteristics of the arc at its critical length that leads to flashover. While the dynamic model adopts a dynamic approach based on the physical processes constituting the phenomena; the arc is considered as a time-dependent impedance and the flashover process is simulated by a steps development. This model can be used to predict the critical flashover voltage and leakage current, arc velocity and flashover time [8]. To simplify the study, both static and dynamic models assume that there is a single dominant arc on insulator surface whereas a large number of investigations carried out in field and in laboratory showed that several local discharges would take place on the insulator surface in the same time [9-11]. Indeed, when a contaminated and wetted insulator is submitted to a voltage, a resistive leakage current arises; this latter is generally many orders of magnitude higher than the capacitive one that flows through the dry insulator surface. The leakage current leads to the evaporation (Joule effect) of humidity and the formation of multiple thin dry bands on the insulator surface at the edges of which the electric field will be enhanced. When the field reaches a critical value that is the ionization electric field of surrounding ambient air, arcs discharges occur. The formation and development of these partial arcs lead, under specific conditions, to the flashover of the insulator surface.

Many attempts have been made to improve the existing models by introducing the multi-arcs concept [10, 12] to predict roughly the critical characteristics of polluted insulators. Most of these models relate to DC or AC voltage whereas there are only few models for flashover under impulse voltages (switching or lightning voltages); this being of great interest for sizing/design the transmission lines. Lighting is the most severe constraints to which are exposed insulators even under light pollution conditions. The lightning impulse voltage used for tests in laboratory is the standard wave-shape 1.2/50 µs (according to IEC 60060).

The main purpose of this paper is the developing of a multi-arcs model for predicting the behavior of polluted insulator under impulse voltage and to investigate the influence of the pollution configuration, the voltage polarity and the resistivity of the pollutant on the flashover voltage and the leakage current.

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