INFLUENCE OF VOIDS WITHIN ELECTRIC FIELDS IN HVDC CABLES

Sebastián **GUTIÉRREZ**, Iñaki **SANCHO**, Luis **FONTÁN**, Jose MALUMBRES, CEIT and Tecnun (University of Navarra), San Sebastián, Spain, jsgutierrez@ceit.es, isancho@ceit.es, fontan@ceit.es, jamalumbres@ceit.es

ABSTRACT

This paper presents a new analytical expression to determine the inception voltage of Partial Discharges in HVDC cables depending on the shape, size and position of the cavities. This analytical expression has been verified for cylindrical cavities using a 2-D FE simulation model. The influence of the temperature has been analyzed and discussed.

KEYWORDS

HVDC, DC cables; PD; Partial discharges; Inception Voltage; voids;

INTRODUCTION

High voltage direct current cables (HVDC) has become more important in recent times, fundamentally due to their higher power transmission capacity over long distances. This type of technology is specially used for transmission over long distances in submarine cables. In addition, HVDC systems present economical, technical and environmental advantages compared to traditional HVAC systems [1]. Indeed, HVDC systems produce lower losses and offer the possibility of total control active power [2].

However, it is well known that the field distribution in DC cables is strongly influenced by the value of the electrical conductivity of the dielectric material used, whose value is highly dependent on temperature and electric field [3-5]. Moreover, it is well known that in high voltage cables the main cause of breakdown is the partial discharge (PD) in the internal gaseous cavities inside the insulation; as the dielectric breakdown strength is smaller in gaseous cavities than in the solid dielectric.

In fact, there are invariably a certain number of gaseous cavities within the dielectric material that appear during the manufacturing process, installation and operation; and can spread and grow according to the degree of aging of the cable under normal operating conditions (Figure 1). Therefore, it is important to predict the maximum voltage, called inception voltage, applied to the cables without having partial discharges. This will then prevent the propagation of defects and premature failure of the cables [5].

In AC cables, the maximum electric field is placed on the surface of the conductor, and the inception voltage limits depend on the maximum size of voids that exist on this surface. Nosseir [6] and Malik [7] established analytical expressions to predict the inception voltage in AC cables starting from the distribution of electric field in these cables. More recently, Blackburn [8] used a 2-D Finite Elements (FE) model for the simulation of the inception voltage in cables AC in presence of voids of different forms and sizes.

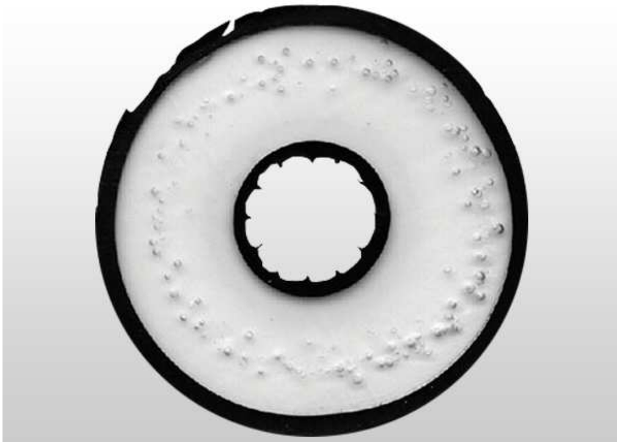

Figure 1: Voids formed on the surface of HVDC cable (Courtesy of M. Kurtz, Ontario Hydro Dobson Laboratories)

The same author studied the inception voltage in the presence of several voids close together and the distribution of electric field inside the void.

Unlike AC cables, DC cables present a field distribution strongly affected by the temperature gradient over the insulation. With high temperature gradients in the insulation this effect can reverse the form of the field to make it more intense in the sheath of the cable (Figure 2) [3]. In this situation, the sheath is the most critical point of the cable and determines the value of inception voltage depending on the size of voids.

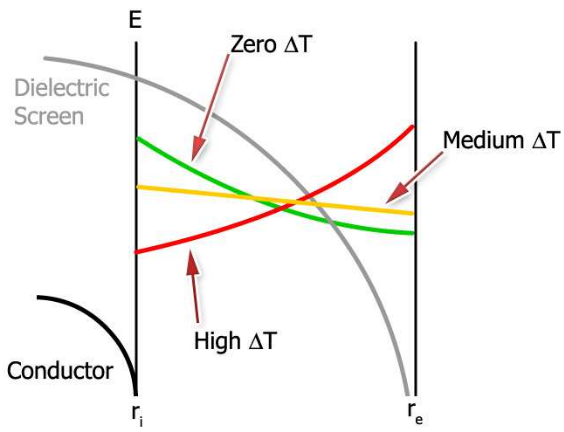

Figure 2: Field distribution in DC cables under effect of temperature of insulation

In this article a new analytical expression has been established to determine the inception voltage of PD in HVDC cables depending on the shape, size and position of the cavities. The verification of this formula for cylindrical cavities has been performed using a 2-D FE simulation model. Section I provides a review of the