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Modelling electric treeing in XLPE insulation using electric field concepts

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Résumé

Nous avons élaboré une méthodologie pour concevoir un modelage de la croissance de l'arbre électrique dans l'isolation en polyéthylène à liaisons transversales (XLPE) en employant des concepts des champs électriques et de la probabilité. Les configurations de l'arbre ont été conçues à simulation numérique en tenant compte de la géométrie de l'électrode pointe-plane dans l'isolation XLPE. La stratégie du modelage est vérifiée en comparant des dimensions fractionnaires des configurations de l'arbre simulées et générées à titre expérimental. De plus, certains défauts comme des particules métalliques, des saillies, des vides etc. dans l'isolation XLPE à la géométrie pointe-plane ont été modélés. Cette approche de modelage semble être efficace dans la détection du type de défaut qui contribue à l'accroissement de l'arbre.

Abstract

Developed a methodology to model electrical tree growth in XLPE insulation by using electric field and probability concepts. Tree patterns have been numerically simulated considering point plane electrode geometry in XLPE insulation. The strategy of modelling is verified by comparing fractal dimensions of simulated and experimentally generated tree patterns. Also, certain defects like metallic particles, protrusions, voids etc. in XLPE insulation with needle plane geometry have been modelled. This modelling approach appears to be effective in sensing the type of defect that influences the tree growth.

Introduction

XLPE insulation employed in high voltage cables is well known for its excellent electrical and thermal properties. However, it has two serious disadvantages, viz., (i) poor resistance to partial discharges and (ii) not being a perfect non hygroscopic material. Inclusion of defects like voids, metallic & non-metallic impurities, sharp projections of semi- conducting layer into cable insulation of under ground power cables leads to stress concentration and hence partial discharges. These discharges result in localised breakdown of insulation due to a well known process called electrical treeing. The internal channels or paths thus generated propagate in the direction of applied field until complete failure of insulation takes place. Since these pre- breakdown channels bear striking similarity to a 'tree' in nature, they are called electrical trees.

Treeing consists of three stages, a) initiation, b) propagation and c) termination. Various mechanisms for tree initiation and propagation have been reviewed and presented by Bahder etal [1] and Eichhorn [2]. Extensive research is being carried-out, the world over, to study various aspects of the electrical treeing phenomenon in XLPE insulation employing different approaches. Mathematical modelling of electrical treeing is one among them.

Experimental work

The present study has been conducted on XLPE samples taken from a 132kV cable. Electrical trees were generated by employing single needle experiments as per ASTM-3756-79 [3]. XLPE samples of thickness of 3mm were considered. Stainless steel sewing needle was used as HV electrode