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Volume effect partial discharge inception characteristics in high temperature superconducting cable

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Abstract: We discussed partial discharge (PD) inception characteristics of liquid nitrogen (LN₂) / polypropylene (PP) laminated paper composite insulation system for high temperature superconducting (HTS) cables. By electrical and optical measurements for PD inception characteristics, we found that initial PD generated between PP laminated paper layers, in addition to in butt gaps. From the experimental facts, we introduced statistical stressed liquid volume (SSLV) based on the discharge probability in both butt gaps and LN₂-filled thin layers between PP laminated papers. Finally, we could systematically analyze and evaluate the volume effect on PD inception electric field strength (PDIE) in HTS cables.

Keywords: High temperature superconducting cable, Partial discharge, Butt gap, Volume effect

1. Introduction

Application of superconducting power technology to electric power apparatus such as power cables will give rise to enhanced power supply efficiency and capacity. Research and development of high temperature superconducting (HTS) cables have brought about the rapid progress to the world [1-4].

In order to incorporate HTS cables into power systems for the next generation, the electrical insulation performance in cryogenic liquids and composite insulation system should be enhanced. Especially, liquid nitrogen (LN₂) / polypropylene (PP) laminated paper composite insulation system is expected to be the most promising system for the cold dielectric type HTS cables [5], where butt gaps between the laminated papers can be regarded as the weak points on the partial discharge (PD) generation leading to the reduction of electrical insulation performance and to the final breakdown. Furthermore, since the longer distance HTS cable may have the more weak points, the size or the

Résumé: Nous avons discuté les caractéristiques au début de décharge partielle (PD) du système isolateur composite au papier laminé d'azote liquide (LN₂)/ polypropylène (PP) pour les câbles supraconducteurs à haute température (HTS). Par les mesures électrique et optique pour les caractéristiques au début de PD, nous avons constaté la production de la PD initiale non seulement entre les couches du papier laminé de PP mais aussi dans les déjoints. D'après les faits expérimentaux, nous avons introduit le volume de liquide sous contrainte statistique (SSLV) basé sur la probabilité de décharge aussi bien dans les déjoints que dans les couches minces remplies de LN₂ entre les papiers laminés de PP. Finalement, nous avons pu analyser systématiquement et évaluer l'effet de volume sur l'intensité de champ électrique au début de PD (PDIE) dans les câbles HTS.

Mots clés: Câble supraconducteur à haute température, décharge partielle, déjoint, effet de volume

volume effect of PD inception characteristics should be taken into account for the practical insulation design of the HTS cables.

On the basis of the above background, we have been investigating the PD inception characteristics of LN₂/PP laminated paper composite insulation system [6,7]. In this paper, we discussed the PD inception characteristics of LN₂/PP laminated paper composite insulation system in terms of volume effect on PD inception electric field strength (PDIE). Electrical and optical measurements for PD inception characteristics brought about a universal expression for the volume effect on PDIE in the electrical insulation design of HTS cables.

2. Experimental setup

To investigate the volume effect on PDIE, we used two types of electrode systems; parallel plane electrode and coaxial cylindrical electrode, for LN₂/PP laminated paper composite insulation system.