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 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.