Comparative Analysis on partial Discharge Inception Voltage in Interfacial Void Models with Different Materials for AC XLPE Cable Joints

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ABSTRACT

Interface problems in XLPE HV cable joint has been constantly raised. Although numerous studies for partial discharges in the joint have been reported, more detailed research is needed to examine basic mechanism in the occurrence of partial discharge. This paper conducted basic research on PDIV (Partial Discharge Inception Voltage) according to the kinds of materials regarding interfacial void likely to occur at AC XLPE cable joint. For the purpose, an experiment on partial discharge was carried out not only for the electrode-contact interfacial voids with EPDM-semiconductor and various metal electrodes but also the interfacial void between XLPE-EPDM insulation. In addition, breakdown voltages by using Paschen's law were calculated for these interfacial voids. Experimental PDIV values and calculated breakdown voltage values tended to be quite identical regarding metal electrodes. However, the case for EPDM-semiconductor was slightly deviated from the general tendency, which was assumed to result from the effect of carbon black clusters in the EPDM-semiconductor.

KEYWORDS

Cable joint, interfacial void, XLPE, EPDM, Work Function, PDIV, Paschen's law

INTRODUCTION

Failures for AC XLPE high voltage transmission cable systems generally occur in joints connecting cables. One of the causes in the failure of cable joints is partial discharges due to the presence of void defects at cable joint interfaces, which can lead to electrical trees and dielectric breakdown. In general, PMJ (Pre-Moulded Joint) and PJ (Pre-Fabricated Joint) are mainly used. The former uses highly elastic LSR (Liquid Silicone Rubber) and the interfacial pressure between XLPE and rubber maintains with the elasticity of LSR. The latter uses the stress cone made of EPDM rubber in which the interfacial pressure maintains with springs.

However, voids can be presented in the interfaces between rubber insulation and XLPE as well as between semiconducting rubber and XLPE due to site operations in both cases. If void defects are found in the joint interface, the degradation by partial discharges and electrical trees can occur, and dielectric breakdown can take place. Although many studies on interfacial partial discharges have been performed, most of them focused on the deterioration properties and detection techniques of partial discharges. There is little basic research on the properties of occurring partial discharges.

The present study is intended to interface void model to be able to occur at joint interface of AC XLPE extra-high voltage transmission cable. The basic properties for the occurrence of partial discharge was analysed using different electrode materials. To do this, we analysed PDIV according to electrode materials assessed by using electrodes of various materials such as copper, aluminium, stainless steel, and brass. Also, theoretical approach was carried out using Paschen's law with secondary electron emission in accordance with work functions of electrode materials.

EXPERIMENT

The regions where the interfacial voids can occur in a XLPE cable joint were illustrated in Figure 1. The red dotted line refers to an area of interfacial void between XLPE insulation and EPDM rubber insulation. The blue dotted line is an interface composed of EPDM-semiconductor and XLPE insulation. Voids can be generally formed in the above both interfaces due to uneven surface or pressure imbalance between insulations. This study produced the model that simulated two areas and assessed partial discharge on interfacial voids. For the experiment of a blue dotted area, that is the interfacial void between XLPE and semiconducting rubber, a variety of electrode materials were used such as EPDM-semiconductor, copper, aluminium, stainless steel, and brass.

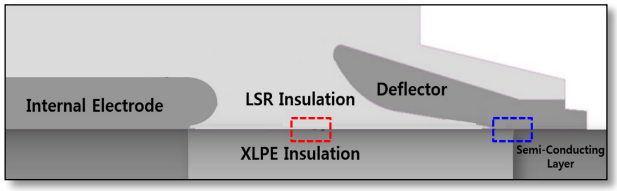

Fig. 1. Concept of XLPE cable joint interface

Specimen preparation

Types of interfacial void model used in this study are shown in Table 1. As mentioned above, the experiment was carried out on the interfacial void models between the XLPE and EPDM rubber insulation and the interfacial void model between XLPE insulation and EPDM-semiconductor. Furthermore, the experiment was performed on the model using different metal electrodes instead of EPDM-semiconducting shield for the analysis of the partial discharge occurrence properties.

The thickness of insulation substances such as XLPE and EPDM were 1mm, respectively. A cylindrical void with 6mm diameters in 1mm-thick XLPE sheet were prepared for the partial discharge experiment. All materials used in this experiment were actually used in producing actual cables and joints. After applying lubricants between each XLPE sample and semiconducting rubber thinly, samples were made by pressing with 1bar. For each types of electrode, 10 samples were produced and the measured PDIV values were statistically treated with Weibull analysis.