Electrical and Thermal Evaluation of Nanofiller-Applied Insulation Materials for EHV Cable

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ABSTRACT

Replacing existing overhead power transmission lines with underground lines is in high demand in Korea due to the benefits of improved reliability, enhancing the urban landscape and environment. The voltage levels for underground power transmission lines are HV and EHV, and efforts have been made to compactify the cables. This study evaluated a nanocomposite with magnesia nanofillers applied to the insulation materials to develop a EHV class power cable with reduced insulation thickness.

KEYWORDS

Underground cable, EHV cable, Nano-filler, AC breakdown strength, Magnesia

INTRODUCTION

Underground power transmission lines have the effect of improving the reliability of electricity supply and improving urban landscape and the environment. It has been applied to center of major city and some necessary sections. Recently, in Korea, there has been an increasing social demand to replace existing overhead power transmission lines with underground ones due to environmental reasons and increasing complaints.

In addition, long-distance power cables are required to reduce the number of joints, which account for 39 [%] of accidents during the operation of underground cables [1]. Method to make it longer is to reduce the thickness of the power cable. If the thickness of the cable is reduced, there is an effect of increasing the maximum length of the cable on one drum, and convenience can be secured during construction.

For EHV underground transmission systems in Korea, the insulation thickness of underground cables has been maintained at 27mm since its introduction in 2003. This study aims to select suitable insulation materials for the development of power cables with a thickness reduce by applying nanofillers to the insulation material and examining their electrical and thermal properties according to the nanofiller content.

EHV CABLE WITH NANO FILLERS APPLIED

The power cable used in underground power transmission lines consists of a conductor and an insulation layer, which forms a concentric structure with (internal semiconductive layer, insulation layer and external semiconductive layer) a triple insulation core. In addition, it is composed of a metal shielding layer for cable protection and a polymer-based sheath layer. Figure 1 shows a cross-section of the underground power cable. In this paper, the electrical and thermal characteristics of the insulation material among the insulation materials of the power cable were examined.

The most important requirement for the insulation layer is breakdown strength. And crosslinking properties and heat resistance are required for long-term reliability. XLPE (cross-linked polyethylene), which has excellent electrical insulation and heat resistance properties, is the most widely used insulation material for EHV cables. If the insulation thickness of a EHV cable is reduced 11 [%], the electric field strength in the XLPE insulation layer increases by about 10 [%].

Fig. 1 Configuration of cable

Table 1 Testing specimens.

Nano Filler : MgO		Insulation type			
		LDPE	XLPE	XLPE -H	XLPE -H, A/O
Filler content [wt.%]	0.83	A	A-X	A-XH	A-XHO
	1.25	B	B-X	B-XH	B-XHO
	2	C	C-X	C-XH	C-XHO

Table 2 Testing condtion of short-term AC BD test.

Material of electrode	Stainless steel
Electrode system type	Sphere to sphere
Diameter of sphere electrode	20 [mm]
Applied voltage	AC, 1 [kV/s]
Maximum voltage	100 [kV]
Specimen size	50 x 50 [mm]
Specimen thick	0.485~0.515 [mm]