Simulation Study on DC Electric Field of a Layer Type HVDC MI-PPLP Cable

Jaesang **HWANG**, Chaekyun **JUNG**, Jiwon **KANG**, Jungwook **WOO**, Jinwoo **PARK**, Jongchae **KIM**, Kyubum **KWON**, KEPCO, (South Korea), jshwang@kepco.co.kr, chaekyun@kepco.co.kr, jwkang3985@kepco.co.kr, mark.woo@kepco.co.kr, pjinw@kepco.co.kr, jongchae.kim@kepco.co.kr, kb.kwon@kepco.co.kr

Ik-Soo **KWON**, Bang-Wook **LEE**, Hanyang University, (South Korea), clanss@hanyang.ac.kr, bangwook@hanyang.ac.kr

ABSTRACT

The electric and thermal properties of HVDC MI-PPLP cable have recently been improved such as dielectric performance and the maximum allowable temperature. However, its dc electric field characteristics have not been fully investigated. As a lapped cable, its main insulating material is PPLP, which has a special composition of Kraft-PP film-Kraft. This prevents conventional dc electric field analysis for the bulk type model from being directly applied to HVDC MI-PPLP cable. Therefore, the layer structure should be considered for HVDC MI-PPLP cable. In this paper, we focused on the difference in the dc electric field properties between the bulk and layer type model, which were determined at a steady state and polarity reversal. From the simulation results of the layer type model, its dc electric field intensity was higher than the bulk type model, requiring serious consideration of how to model and analyse the dc electric field for the HVDC MI-PPLP cable.

KEYWORDS

DC electric field analysis, HVDC MI-PPLP cables, Layer structure, PPLP

INTRODUCTION

Long distance power transmission has been realized worldwide and a global super grid is no longer a dream. For interconnection between countries and continents, the HVDC cable is a core technology of long distance transmission that does not suffer from a capacitive current, dielectric losses, or sheath losses [1, 2]. Currently, HVDC cable has quickly developed than AC cables have in the past. Now, commercialization of higher voltage HVDC cables is an essential step toward a global super grid.

Conventional HVDC cable has been developed with mass impregnated (MI) cables and has been applied to submarine cables in the past 60 years [3]. Looking at the fault cases of HVDC MI cables, the main problems have occurred due to external mechanical damage and only rarely by internal breakdown. Therefore, HVDC MI cable is being recognized as one of the most reliable types of transmission lines. Recently, HVDC Mass Impregnated Polypropylene Laminated Paper (MI-PPLP) cable has been developed which meets the requirements of higher voltage and better capacity than HVDC MI cables [4].

HVDC MI-PPLP cable has been developed up to ±700 kV by Prysmian Group. The highest voltage level for a project using HVDC submarine MI-PPLP cable is a ±600kV HVDC Western Link [5]. In Korea, the ± 500 kV Bukdangjin-Goduk HVDC land cable project is being developed, and ±500 kV HVDC MI-PPLP will be applied in order to transmit a large scale transmission capacity. At present, HVDC MI-PPLP has no official operating cases around the world therefore, technical verification is required in terms of cable reliability.

HVDC MI-PPLP cable is a lapped cable and is classified of the same type as HVDC MI cable due to its non-draining properties. Its main insulation is PPLP with superior dielectric performance and improved thermal properties compared to Kraft paper, which is used for the main insulation of HVDC MI cables [6]. One layer of PPLP is composed of Kraft-PP (Polypropylene) film-Kraft. Thin PP film has a good dielectric performance compared to Kraft. Therefore, if PPLP had PP film sandwiched by Kraft paper on both sides, it would show greater breakdown strength. The main characteristics of HVDC MI and MI-PPLP cable are summarized in Table 1. The PPLP, which has a special composition of Kraft-PP film-Kraft, prevents conventional dc electric field analysis for the bulk type model from being directly applied to HVDC MI-PPLP cable. Therefore, the layer structure should be considered for HVDC MI-PPLP cable.

In this paper, firstly, the dc electric field regarding the effect of the temperature dependent coefficient and the electric field dependent coefficient was compared and analyzed. The conventional dc electric field simulation only considers the temperature dependent coefficient, but recently, various studies have shown that the electric field dependent coefficient also has an effect on the dc electric field, but not as much as the temperature dependent coefficient [7, 8].

Table 1: Characteristics of HVDC MI and MI-PPLP cable

HVDC Cable	MI (Kraft)	MI-PPLP
Insulation	Kraft	Main: PPLP Part: Kraft
Maximum operating temperature	55℃	85℃
Size / Weight	110-140 ㎜ / 30-60 ㎏	
Converter type	Both possible to VSC/LCC	
Space charge	No effective	
Advantage	·No problem for polarity reversal ·Non-draining (no pressure tank)	
Weakness	Long time for mass impregnation	
Development	500 kV (Nexans)	700 kV (Prysmian)
Commercialization	500 kV (SAPEI etc.)	600 kV (Western Link)