Development of XLPE nano-composite used for HVDC ±250kV cable system compatible with LCC and VSC

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Since 1960s, XLPE has been widely used for electric power cable insulation ascribed to its relatively preferred technical advantages, such as high breakdown strength, excellent thermal and mechanical properties. However, its use for DC power transmission cable has not been remarkably accepted considering the decrease in breakdown strength during the operation and the accumulation of space charge. Since the latter could enhance the local electric field distribution inside the cable insulation system, it has been suggested to introduce nanoparticles into XLPE for being pertinently suppressed.

In Korea, XLPE Nano-composite has been developed after several years' research works for HVDC ±250kV cable system compatible with LCC & VSC type. Since 2009, the related research work has been followed: the synthesis and surface treatment of nanoparticles and manufacturing process of Nano-composite XLPE has been successfully developed for the application to HVDC transmission cable. For this purpose, several numbers of tests have been carried out with the specially designed specimens fabricated with developed Nano-composite XLPE: DC volume resistivity, space charge accumulations, dielectric breakdown strengths, impulse breakdown and superimposed impulse. In addition, space charge accumulation in model cable has been also carefully investigated.

The prototype DC XLPE shows very low level of space charge accumulation with homo-charge characteristics and noticeably low field enhancement below 120%. DC volume resistivity is measured over 1017□cm at room temperature and 1015□cm at 90oC under the 20kV/mm and particularly less dependency on temperature is confirmed; one of the most important characteristics for DC transmission. Besides, other technical requirements for the mass production such as long-period extrusion have been satisfied, by which long cable system with minimum number of joints could be realizable. A model cable has been fabricated by using the developed compound and then put into the fundamental tests: DC Breakdown and Impulse breakdown. Moreover, space charge measuring devices for model cable are developed; however, further investigation is being conducted to be implemented to the real size cable.

Based on the above empirical results, ±250kV XLPE cable system for LCC has been designed and manufactured at Donghae plant of LS Cable & System. And then, relevant tests have been carried out according to CIGRE TB 496 LCC protocol: load cycle, polarity reversal, superimposed switching and lightning impulse over the DC, and finally subsequent DC. These tests for the qualification have been carried out at KEPCO Gochang Test yard, entitled as KOLAS (Korea Laboratory Accreditation Scheme). In addition, after fulfilling the required tests for LCC cable, the tested cable has been again put into test according to the recommended additional process of CIGRE TB 496, such as superimposed lightning impulse test, which is required for VSC. More research works are currently being carried out for the improvement of electrical properties for the purpose of the higher voltage grade beyond ±250kV.

Key words

Nano-composite; XLPE; HVDC; Cable System; Cigre TB 496; LCC & VSC; KOLAS