Development of VSC DC 320kV XLPE cable system

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ABSTRACT

HVDC transmission systems have been employed all over the world for long-distance power transmission lines to interconnect power grids between the continents and for short distance between neighbour countries. Besides, the global market requires a HVDC power cable system with large power transmission capacity bringing about the economic benefits. In this paper, our development plan has been described in detail for HVDC XLPE cable system for various voltage ratings; insulation material at laboratory, miniature cable for the evaluation of characteristics and finally the design of full scaled power cable system including necessary joints. We started with developing ±80kV cable system in 2010 and then the necessary efforts will be continued for ±525kV for several years more. For this purpose, various materials have been employed for the cable insulation depending on the type of converters; Nano composite compound by adding Nano inorganic filler for LCC type and commercially available compound for VSC. LCC and VSC type full scaled cables have been developed for those four operating voltages such as ±80kV, ±150kV, ±250kV and ±320kV. Furthermore, the development of ±525kV for LCC and VSC types has been now undergoing and would require a couple of years more.

KEYWORDS

HVDC XLPE cable, Nano composite, LCC type, VSC type, VSC 320kV XLPE cable system, Type test, PQ test, CIGRE TB 496

INTRODUCTION

Ascribed to the technical advantages confirmed since last couple of decades, HVDC transmission systems have been employed all over the world for long-distance power transmission lines to interconnect power grids between the continents and for short distance between neighbor countries. Besides, the global market requires a HVDC power cable system with large power transmission capacity bringing about the economic benefits.

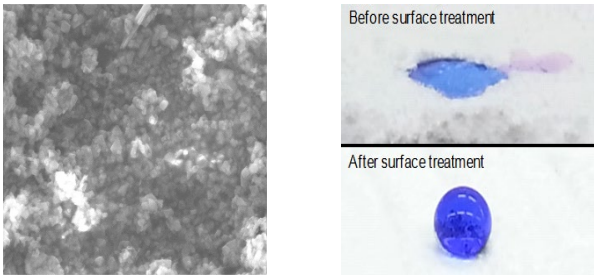
It has been conceived to develop new insulation materials suitable to meet the commercial goals. In this regards, HVDC material technology has been developed depending on the type of the converter station and cable system, for which related material researches have been carried out diversely. In order to avoid any unexpected service failure of HVDC power cable system, many a research have been conducted to find a solution enabling to decrease the space charge accumulation inside the cable system. And thus, the development of XLPE material has been mostly focused to obtain long term stability and relatively high transmission efficiency.

In this paper, our development plan has been described in detail for HVDC XLPE cable system for various voltage ratings; insulation material at laboratory, miniature cable for the evaluation of characteristics and finally the design of full scaled power cable system including necessary joints. We started with developing ±80kV cable system in 2010 and then the necessary efforts will be continued for ± 525kV for several years more. For this purpose, various materials have been employed for the cable insulation depending on the type of converters; Nano composite compound by adding Nano inorganic filler for LCC type and commercially available compound for VSC. It could be pointed out that our efforts have also extended to develop exclusively an optimized manufacturing process by which Nano composite XLPE could be obtained for the cable insulation by use of our own surface treated Nanoparticles. In this way, model cable has been fabricated using our compound before being put into the fundamental investigation: DC and impulse breakdown, Analysis of DC field distribution as a function of temperature up to 90 degree. Regarding LCC cable, our first ±80kV cable system has been developed and then related type test has been conducted according to CIGRE test recommendations (CIGRE TB 219). Our successful results based on the deep investigation pushed its first commercial service in 2013. In connection with VSC cable, our cable systems have been designed and manufactured for three operating voltages such as ±150kV, ±250kV and ±320kV; they have been all put under type test in accordance with CIGRE TB 496. In particular, ±250kV LCC cable system shows also satisfied results. Furthermore, the development of ±525kV for both types has been now undergoing and would require a couple of years more.

HVDC XLPE CABLE SYSTEM FOR LCC TYPE

Development of the HVDC XLPE materials (XLPE nano composite)

Many research works have been carried out to obtain relevant electrical properties of nano materials employable to HVDC cable insulation. Mostly, the surface of the inorganic nano material shows normally polarity, which requires surface modification when they are dispersed and mixed with host material such as nonpolar polyethylene in this case.



a) SEM **b) Presence of Water droplet**

Fig. 1: SEM and optic image of inorganic nano materials

In figure 1 (a), SEM image shows the inorganic nano material under our consideration. Figure 1 (b) shows the optical observation of the presence of water droplet on the