Observation of space charge accumulation in cable insulating materials at voltage polarity reversal

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Investigation of space charge accumulation process in cable insulating materials at voltage polarity reversal is carried out using PEA (pulsed electro-acoustic) measurement system. It is one of important research objects in HVDC (High Voltage DC) system because the polarity reversal is necessary to change a direction of current flow using a LCC (line commutated converter).

The space charge accumulation in the cable insulating material is said that it strongly affects the breakdown characteristics. However, while some space charge accumulation measurement results have been reported as the main reason of the breakdown of the insulating materials under a severe condition like more than 100kV/mm, there is no reports that the space charge accumulation directly affects to the breakdown or severe enhancement of the electric field under a relatively low stress close to the working voltage. On the other hand, many engineers have pointed out that the polarity reversal test on a conventional XLPE (cross-linked polyethylene) cable showed somehow dangerous results including the breakdown. However, there are few attempts for the measurement of space charge accumulation at the voltage polarity reversal because it is hard to apply a high voltage to the thick XLPE sample including some crosslinking by-products.

In a space charge measurement, a thin film like several hundred-micrometer-thick is preferably used to apply a high electric field to it. However, the crosslinking by-products easily volatile from such thin films and the measurement results on such sample is not reflect the actual condition of the material. That the reason why the space charge accumulation characteristics at the dangerous situation of the polarity reversal has not been investigated.

Authors have showed that such existence of the crosslinking by-products is important factor for the space charge accumulation strongly affecting the breakdown strength under high DC stress. In this report, we tried to measure the space charge accumulation process in a flesh XLPE sample including the crosslinking by-products and it was found that a huge amount of so called a packet like charge, which was enough to enhance the electric field significantly, generated at the polarity reversal of a relatively low DC stress. It enhanced the electric stress locally in the sample by almost twice of the applied average stress. Therefore, it must affect to the polarity reversal test for the actual products of the cable.

On the other hand, it is said that such a problem is not observed in a DC cable using a specially improved XLPE as the insulating layer. We also tried to measure the space charge accumulation characteristics in SXL-A, one of improved XLPE material using nano-composite technique, under the same polarity reversal condition which is applied to the conventional XLPE sample. As a result, we found that the packet-like charge was not observed in the sample. It means that such material is applicable to the HVDC system using the LCC.

Key words

HVDC cable, XLPE, Polarity reversal, Space charge, PEA method, Crosslinking by-products, Nano-composite