Behaviors of water tree propagation after accelerated aging under different polarity DC voltages

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HVDC XLPE cables have been widely used in new energy power generation, power supply dilatation in cities and island power transmission. Even though water trees under DC voltage propagate much slower than those under AC voltage, water-tree propagation under DC voltage can be accelerated in the presence of harmonics generated by non-linear converters. Different voltage polarity in bipolar HVDC systems can affect the space charge distribution and ion diffusion activity in XLPE insulation, which can further result in different growth characteristics of water trees.

To investigate the influence of DC voltage polarity on propagation behaviors of water trees in the presence of harmonics, water-tree growth behaviors in XLPE material were investigated by utilizing four rectified voltage waveforms (e.g., positive polarity half-wave and full-wave voltages, negative polarity half-wave and full-wave voltages) and a standard sinusoidal voltage waveform.

A water-tree accelerated aging experiment was performed on XLPE samples under the five different voltages respectively. An optical microscope was used to observe water-tree morphologies in the samples, and sizes of the water trees were also counted after 22 days of aging experiment.

Experimental results show that the morphologies and the sizes of water trees are strongly dependent on DC voltage polarity. Water trees under the positive polarity voltages are significantly shorter than those under the negative polarity voltages. Meanwhile, water-tree branches under the positive polarity voltages are more transparent and thinner than those under the negative polarity voltages.

According to the results, a possible mechanism based on different ion diffusion activity is proposed. The diffusion of hydrated ions in the material plays an important role during the process of water-tree aging. The flux of ions is different under different voltage polarity. As a result, the numbers of water molecules driven into the polymer are different, which can result in the difference of water-tree propagation characteristics.

Key words

XLPE; cables; water treeing; DC voltage; polarity; ion diffusion