Interface Polarization Characteristics of Water-Tree Aged Cables based on Polarization and Depolarization Current Method

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ABSTRACT

In order to achieve the effective and fast condition diagnosis for water-tree aged XLPE cables, this paper investigates the variation of conduction current of water-tree aged cables during the polarization process, and compares the asymmetrical current between polarization and depolarization process. Cables samples were subjected to an accelerated water tree experiment. The cable samples with different water tree aging time were subjected to the PDC（Polarization and Depolarization Current） test, and were sliced around the pinholes to observe water tree morphology. According to the test results, the conduction current extracted from the PDC test presents a peak value for water-tree aged cables, and this peak becomes more obvious with the increase in deterioration of water-tree aged cables. The result shows the polarization process of water-tree aged cables is fast and the depolarization process is slow due to the nonlinear variation of relative dielectric constant and conductivity of water tree region, which leads to appearance of the conduction current peak. Asymmetry coefficient K is presented to show the asymmetrical interface polarization characteristics of water-tree aged cables and diagnose insulation performance of cables.

KEYWORDS

XLPE cables, water tree aging, insulation diagnosis, polarization and depolarization current, interface polarization

INTRODUCTION

Cross-linked polyethylene (XLPE) cables have been widely used in electric power transmission and distribution in cities and islands [1-2]. The water tree in XLPE cables will grow with the increase in service time due to the combined effects of electrical and environmental stresses, which is considered as the main reason for the insulation deterioration in the XLPE cables [3].

In recent years, the polarization and depolarization current (PDC) method has been widely used for insulation condition diagnosis of water-tree aged cables because of its convenience and abundant information. The literature found the relationship between characteristic parameters (e.g. relaxation time constants and peak of depolarization current) and water tree aging time in the PDC test [4]. Reference [5] found that the conductivity and the nonlinear factor of conductivity extracted from the short-time PDC test can diagnose deterioration degree in water-tree aged cables. The literature indicates mean values of dissipation factor calculated by depolarization current increase gradually during the aging process [6]. Many researchers have presented some valuable characteristic parameters to evaluate the insulation performance of water-tree aged cables. In fact, water tree includes many micro voids filled water, and the water in the voids and XLPE matrix material actually form an interface. For different water-tree aged cables, the interface polarization can present different behaviors, which can help further understand the water tree aging phenomenon. However, there is still a lack of detailed experimental data and a physical model to explain the effect of interface polarization of water-tree aged cables on the PDC test.

To understand the interface polarization characteristics of water-tree aged cables, the water-tree aged cables at different aging time will be obtained by accelerated water tree aging experiments, and the PDC test is also performed for these samples. Both the relative dielectric constant and the conductivity of water-tree aged cables will be analyzed.

EXPERIMENTAL SETUP

Water tree aging experimental setup

The cable(type: YJV22-3×95, 8.7/10 kV) is cut into 40 short samples with length of 0.5 m to perform the accelerated water tree aging experiments. Pinholes with depths of 3 mm were produced by the metal needle in the aging region in advance, which has a tip radius of 4.0±0.5 μm and a point angle of 17°±2°. According to the IEC/TS61956 standard, the experimental setup is shown in Fig. 1 for the water tree accelerated aging experiment.

Four groups of water tree cable samples were produced by the above method. Each group includes 10 samples. The four groups of water tree samples were subjected to the accelerated water tree aging for 30, 60, and 90 days, respectively. In order to evaluate the aging performance of the cable samples, each group samples will be subjected to the electrical performance test, and be sliced around the pinholes to observe water tree morphology.

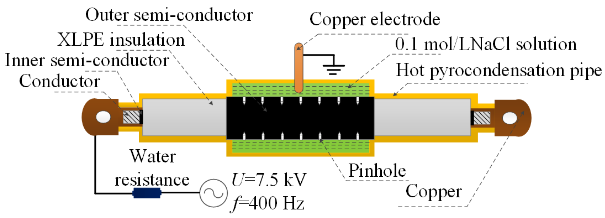

Fig. 1: Accelerated water tree tests of XLPE cables

PDC measurement

Fig. 2 shows the PDC measurement principle for the cable sample. The circuit includes a DC power supply, a high voltage switch, picoammeter, and a computer. When the polarization voltage is applied to the cable sample by setting the switch S to the position S1, the polarization current gradually decays to a stable value. After the finish the polarization process, the switch S switches to the position S2 to measure the depolarization current.