The Propagation Retardation of Electrical Tree in XLPE under Negative Impulse Superimposed AC Voltage

Kai **ZHOU**, Zerui **LI**, Shijia **CHEN**, Guangya **ZHU**, Yonglu **HUANG;** Sichuan University, Chengdu, China,
zhoukai_scu@163.com, lizeruiscu@163.com, lxcsj221@163.com, miyazhu_1989@126.com, huangyonglu_scu@163.com

ABSTRACT

The propagation retardation of electrical tree was found in XLPE under negative impulse superimposed AC voltage. To understand the effect mechanism, an electrical tree initiation experiment and a growth experiment were performed on XLPE sheet specimens. In initiation experiment, two different types of voltages (AC voltage superimposed negative impulse voltage and pure negative impulse voltage) were used to initiate electrical tree, and in propagation experiment four impulse stages were imposed to the tree initiated under AC voltage. Moreover, the propagation process of electrical tree was observed with a real-time microscopic observation platform. The propagation retardation phenomenon of electrical tree appeared after impulse stage. Further, an electric field simulation model was constructed to explain the propagation retardation of electrical tree under negative impulse superimposed AC voltage.

KEYWORDS

XLPE, electrical trees, Impulse Superimposed AC Voltage, grows retardation

INTRODUCTION

XLPE cables have been widely used in power transmission and distribution system due to superior electrical, mechanical, and thermal properties. However, some micro defect can be generated in the insulation layer inevitably during manufacturing, transportation, and installation process. When the cables in operation are subjected to lightning or operating voltage shock, the electrical tree can be initiated from the defect, which can further result in insulation breakdown [1]. Therefore, electrical tree is regarded as a main cause of XLPE insulation failure [2-4].

The literature found that the electrical tree morphology is significantly affected by the applied voltage type. Moreover, as the applied voltage changes, the initiation time and growth pattern of the branches will change [5]. Reference [6] reported the morphology of electrical branches in XLPE and its corresponding PD characteristics under different power frequency voltage, and the PD signals were used to characterize the growth stage of electrical branches. Reference [7] presented the relationship between the propagation characteristics and the microstructure of the tree branches under power frequency voltage. It also found that the channel wall of the tree branches are attached with nano-level carbon particles, which leads to further bifurcation and growth of the electrical branches. Reference [8] reported the tree initiation characteristics under impulse superimposed AC voltage, and found that the tree inception field intensity is related to the applied AC voltage and relative polarity. Although many researchers have observed the initiation and propagation characteristics of electrical trees, the properties of electrical tree propagation under impulse superimposed power frequency voltage are not thoroughly understood.

To further understand the influence of impulse superimposed power frequency voltage on propagation characteristics of electrical tree, an impulse superimposed power frequency voltage circuit was constructed, and the electrical tree propagation characteristics were recorded with a microscopic observation platform. Moreover, a simulation model was constructed according to the microscopic images. The propagation retardation of electrical tree was analysed based on the electric field distribution.

EXPERIMENTAL SETUP

Specimen Preparation

XLPE specimens peroxide cross-linked according to industrial standard were used in the electrical tree initiation and propagation experiment. Their electrical properties are similar to those of the industrial 10 kV cable insulation.

Fig. 1 shows the configuration of the specimens. The specimens were cut into cuboids with dimensions of 80 mm × 10 mm × 5 mm. A copper bar with dimensions of 100 mm ×3 mm ×5 mm was attached to the specimen as ground electrode. A steel needle with tip radius of 10±1 μm and point angle of 30° was thereafter slowly inserted at a temperature of 125 ℃ into each specimen, providing the separation between its tip and the ground electrode of 2 ± 0.2 mm as electrical tree propagation area.

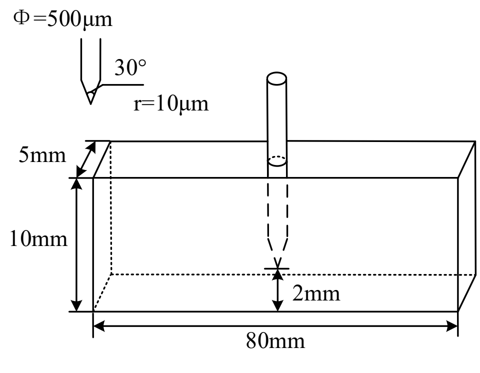

Fig. 1: Configuration of the specimens

Experimental Setup

The microscope based real-time digital imaging system was used to observe the propagation process of electrical branches as shown in Fig. 2. The specimen was kept in a test cell filled with transformer oil to avoid corona discharge and flashover.