A Study on Partial Discharge and Bubble Behavior in Oil Gap on Oil-impregnated Paper Insulation System.

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ABSTRACT

The deterioration has been confirmed in the survey of removed self-contained oil-filled cable joints, in which some faults occurred recently in Japan. From viewpoints of understanding its deterioration mechanism and the establishment of its diagnosis method, we investigated partial discharge (PD) signal, light emission of PD and visible image nearby the PD source on the oil-impregnated paper insulation system with an oil gap. Light emission of PD was observed by a high-speed camera combined with an image intensifier. PD signal was measured by a high-frequency CT. The visible image of the oil gap and PD induced bubbles in the gap were observed with LED lighting and a camera. They were observed simultaneously. As the result, it was confirmed that bubbles were generated near the place where the light emission of PD was observed both at AC and switching impulse voltages application. In addition, it was confirmed that, under the application of AC voltage just above PD inception voltage, bubbles and the repetition rate of PD increased, and phase resolved partial discharge patterns changed to the typical pattern when PD occurs in a void in a solid insulation.

KEYWORDS

Self-contained fluid-filled cable; Oil-impregnated paper insulation; Partial discharge; Bubble.

INTRODUCTION

Underground power cables which are one of the most important power equipment have been introduced in power grids up to 500 kV. In Japan, self-contained oil-filled (SCOF) cables (also called “self-contained fluid-filled (SCFF) cables”) account for a quarter of underground power cables, and about 60 % of them have been operated for more than 30 years [1]. Therefore, it is important to understand and maintain their performance.

It had been expected that the electrical insulation performance of SCOF cables hardly deteriorates as long as they were in normal service. However, the deterioration has been confirmed in the survey of removed SCOF cable joints, in which some faults occurred recently in Japan [1][2]. Thus, understanding its deterioration mechanism and the establishment of its diagnosis method are required for the stable operation of highly aged SCOF cable system. From this viewpoint, we investigated partial discharge (PD) signal, light emission of PD and visible image nearby the PD source on the oil-impregnated paper insulation system with an oil gap as a PD source.

EXPERIMENTAL SYSTEM

Fig. 1 shows the experimental circuit for observing PD signal, light emission of PD, and visible image under AC and switching impulse voltages application. This is composed of AC voltage source, a switching impulse voltage generator, a voltage divider (Nissin pulse electronics, EP-100K, divider ratio: 5000:1, frequency band: DC~50 MHz), a test sample, a high-frequency CT (HFCT) (Prodyn, I-125-1HF, frequency band: 120 kHz~600 MHz), a digital oscilloscope (Tektronix, DPO3054, frequency band: DC~500 MHz, sampling rate: 2.5 GS/s), a high-speed camera (nac Image Technology, MEMRECAM Q1v, frame rate: 8000 fps, effective pixels: 640×480 pixels), an image intensifier (Hamamatsu Photonics, C6654, luminous gain: 4.0×10^{6} (lm/m^2)/lx), a camera for visible image observation (Omron Sentech, STC-MCS43U3V (527 fps) at AC voltage application, STC-MCE132U3V (60 fps) at switching impulse voltage application). The values of C1, L1, R1, R2 and C2 on the switching impulse voltage generator are 16.7 nF, 1.8 mH, 20 kΩ, 140 kΩ and 4.3 nF, respectively. HFCT was attached on the ground wire of the test sample. A ground wire of the sample of the same structure as the test sample was passed through the same HFCT but in the opposite direction, in order to cancel a charging current when a switching impulse voltage was applied to the test sample. Light emission of PD was observed by the high-speed camera combined with the image intensifier.