論文の内容の要旨

Propagation of Surface Leader Discharge in Atmospheric Air

（大気圧空気中における沿面リーダ放電の進展）

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Surface discharge is a kind of discharge propagates on the surface of insulators, including the interface of gas/solid insulation, liquid/solid insulation and gas/liquid insulation. The breakdown field of the surface discharge is relatively weak, for example, for the solid insulation, the breakdown field is about 1 MV/cm; for SF_6 at 5 atm., it is several 100 kV/cm; but for the spacer in SF_6 at 5 atm., it is only several 10 kV/cm. For high voltage apparatus with a solid-gas insulation system, insulator surface is the weakest part. At triple junction, where a gas, a solid dielectric, and a conductor coincide in one point; the electrical field stress is very high, the surface discharge occurs from there, first as streamer, and then into leader, finally flashover occurs, companying with ionization of gas molecule and light emission. After discharge, charge accumulates on the surface of insulator.

Compared with streamer, leader can develop over a longer distance with a lower potential gradient, and easy to lead to flashover of insulation. For designing highly reliable electric power apparatus, it is of great importance to clarify the mechanism of discharge propagation, the transformation process from streamer to leader, and the influence of the residual charge accumulated on the surface of the insulating material to the discharge propagation.

Many researchers have investigated the characteristics of the surface discharge propagation with different methods, including dust method, optical method and electrostatic probe method. Although surface discharge have been studied by many researchers for more than 100 years with all kinds of methods, but till now, the mechanism of surface discharge development is still not very clear.

The investigations have been performed in a cylindrical insulator configuration in atmospheric air. There are two ring electrodes and one rod back electrode. The distance between two ring electrodes is 300 mm. The diameter and the length of the rod back electrode are 29.6 mm and 600 mm, respectively. There is a 0.2 mm-thick PET (Polyethylene terephthalate, relative permittivity: 3.2 at 1MHz) film layer as the insulator between the pair of ring electrodes and the grounded back electrode. When the applied voltage is too high, the potential caused by residual charge will be very high and discharge will occur between the probe and the insulator surface. To reduce the surface potential, two-layer structure is designed. It can successfully reduce the surface potential after discharge, but not change the electrical distribution and charge distribution at the time of discharge.

One of pair ring electrodes is grounded and 1.2/50 μs standard lightning impulse voltage or 50Hz-ac voltage is applied to the other ring electrode so that a surface discharge occurs and propagates on the insulator surface. Two cameras are used to observe the discharge. One is a high speed video camera (Phantom, Vision Research Inc.), and the other is an ultra high speed framing and streak camera (Imacon 468, Hadland Photonics). Discharge current is measured through a Rogowski coil (Model 2877, Pearson Electronics, Inc., bandwidth: 200 MHz) and the voltage is measured by a high voltage divider (PR-100GL, Pulse Electronic Inc., bandwidth: 30 MHz). The waveforms are recorded by an oscilloscope (Trektronix 3053, bandwidth: 500 MHz).

The residual charge distributions of surface discharges are measured with an electrostatic probe (Trek 341B, measuring range: ±20kV), which utilizes a voltage feedback to the probe housing to null the electric field between the charged surface and the probe. With keeping 1mm air gap, the electrostatic probe moves in axial direction to the pipe and measures the surface voltage at every 0.25 mm. After measuring one line the pipe is rotated by 2 degree and the probe is moved back rescanning the surface.

With the two-layer structure pipe, the leader discharge propagation on clear insulator surface is studied. At first, the potential distribution is measured. And then, with electrical calculation and 2-dimensition Fast Fourier Transformation (FFT), the charge distribution and electrical field distribution are calculation are calculated. From these distributions, the propagation characteristics of the surface leader under positive/negative impulse voltage application are summarized.

The residual charge changes the electrical field distribution and strongly influences the propagation characteristics of the subsequent surface discharge. In this research, surface discharges on the PET film under impulse voltage application were observed by high speed cameras and measured by electrostatic probe. From the photographs and potential distribution figures, the influence of the residual charge to the propagation characteristics of surface discharge is studied. It is found that with the residual charge of the former discharge accumulated on the insulator pipe surface, the subsequent discharge propagation is greatly influenced, including the propagation pattern, velocity and distance.