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論　文　内　容　要　旨

報告番号	甲　先　第　314　号	氏　名	WEN TAO
学位論文題目	Research on Discharge Characteristics of SF_6 Gas with and without Insulator Under Impulse Voltages with Different Waveform Parameters (異なる衝撃電圧パラメータにおけるSF_6と碍子の放電特性に関する研究)		

内容要旨

Gas-insulated metal-enclosed switchgear (GIS) may suffer various forms of impulse voltage in operation, including impulses with fast wavefront or short wavetail, and especially very fast transient overvoltage (VFTO), due to the complicated structure of GIS substation. Meanwhile, lightning impulse waveform is widely used in the impulse withstand voltage test to detect the defects in the GIS. The impulse voltage waveform parameters have great influence on the SF_6 discharge characteristics. But the oscillating impulse voltage is often used to study the influence of the wavefront time and the wavetail time parameters on the discharge characteristics. The waveform parameters are complex and have interact influence. Therefore, it is necessary to extract the characteristic parameters of the impulse voltage waveform, and systematically study the effects of single characteristic parameter influence on the discharge characteristics of SF_6 gas with and without insulator.

The platform of SF_6 discharge characteristics under multi-parameter impulses was established in Chapter 2. The experimental platform can generate a double exponential impulse voltage with wavefront time of 0.08 μs ~ 23.5 μs and wavetail time of 1.5 μs to 50 μs, VFTO with single oscillating frequency up to 8.1 MHz and rise time to 49 ns, an oscillating LI with wavefront time of 10 μs and oscillating frequency of 25 kHz. A conical voltage sensor was designed to accurately measure MV-level steep pulses with a rise time of less than 7 ns. Different kinds of GIS typical defect structures were used to study the insulation characteristics of SF_6. The 50% discharge voltage was obtained by the up-and-down method.

The discharge characteristics of SF_6 gas under impulse voltages with different waveform parameters, including VFTO, were studied in Chapter 3. The breakdown voltage for VFTO or standard LI in positive polarity is higher than that in negative polarity and the breakdown voltage of VFTO could be lower than that of standard LI at high gas pressure. The breakdown voltage of insulator under VFTO or standard LI in negative polarity is higher than that in positive polarity and the breakdown voltage of defective insulator under VFTO could be lower than that under LI by 8%. The 50% $U_{50\%}$-p curve shows the polarity reversion phenomenon, which can be explained by the migration and diffusion of space charges. The critical pressure of polarity reversion may increase with the increase of electric field inhomogeneity. The impulse waveform parameters have little influence on the breakdown characteristics of a sound GIS system, but have

significant influence on the breakdown characteristics of GIS system with defects. With the rise of gas pressure, the hump phenomenon occurs in the $U_{50\%}$-P curves. With the increase of impulse wave front time, the 50% breakdown voltages change significantly and the $U_{50\%}$-T_f curves tend to be U-shaped. The bigger the electric field factor f is, the more obvious the U-shaped trend is. The 50% breakdown voltages decrease significantly with the increase of impulse wave tail time. With the wavetail time increases, the discharge voltage gradually decreases, which could be explained by the area method.

The discharge characteristics of SF_6 gas under impulse votlages with wide range wavefront time were studied in Chapter 4. The insulation defects detecting effectiveness of oscillating LI with long T_f around 10 μs is lower than that of standard LI. According to the voltage-time characteristic, it can be inferred that the T_f plays an important role in the insulation defect detecting effectiveness. With T_f increases, the 50% breakdown voltages for rod-plane gaps have an increased trend. The V-t curves of rod-plane gap under short T_f and long T_f present an opposite trend. The V-t curve shows a U-shaped in a wide range of t_b. The gap distance (or field nonuniformity factor) influences the shape of V-t curve. With the gap distance increase, the flat part of the curve and the mouth of the U-shaped V-t curve become narrower. The 50% flashover voltage of the insulator with surface conductive defects increases with the increase of wavefront time, which is similiar with the results of gas gap. The effect of T_f is the effect of the slope of impulse dU/dt essentially. SF_6 gaps with a higher field nonuniformity factor f are more sensitive to dU/dt, also to T_f. Corona stabilization effect is not just in relationship with the rise rate of impulse, but also with electrode structure and gas pressure. The critical dU/dt for corona stabilization is calculated for different rod-plane gaps.

The effect of electrode structure on discharge characteristics was researched in Chapter 5. The electrode structure has a great influence on the discharge characteristics. For the GIS bus with a conductive protrusion, the shielding effect of the bus on the defect changes the electric field distribution of the gap, so that the $U_{50\%}$-T_f curves no longer show the U-shaped as the rod-plane electrode. The 50% discharge voltage of the bus with needle increases with wavefront time increase. The field simulation results also show that with the increase of the needle length, the field nonuniformity factor increases.

The on-site standard lightning impulse test technology was studied in Chapter 6. A new fully enclosed and compact standard LI generator with low inductance has been developed, using SF_6 gas as the insulating medium and incorporating novel structural design of the switch capacitor integration unit. Using the developed gene rator, an on-site standard LI test for 1100 kV GIS was successfully carried out in a UHV substation. One circuit breaker and its accessories were connected as the load for each test.