EFFECT OF COMPOSITE ASSISTANT SHED ON THE FLASHOVER PERFORMANCE OF ICE-COVERED STATION POST INSULATORS

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Abstract: In order to analyze the effect of Composite Assistant Shed (CAS) on icing flashover characteristics of post insulators，some characteristics of energized 500kV post insulators with and without CAS were studied by icing test in a large-scale artificial climate chamber. The difference of appearance of ice，flashover voltage，envelopment of leakage current and discharge path between post insulators with CAS and without ones were presented and analyzed in this paper. Test results demonstrated that the CAS can decelerate icicle developing on the insulators and the sheds will not been bridged by icicle, which result in discharge path mainly along to the icicle and air gaps. Due to the composite antipollution shed, on the condition of seriously iced and polluted, the flashover voltage of 500kV station post insulators is higher than the maximum running phase to earth voltage, which is distinctly higher than normal post insulators.

Keywords: Icing, Post insulators, Composite Antipollution Shed, Flashover, Leakage Current

1. INTRODUCTION

In the present work, icing flashover characteristics of energized 500kV post insulators with and without Composite Assistant Shed (CAS) were studied by icing test in a large-scale artificial climate chamber. The difference of appearance of ice， flashover voltage，envelopment of leakage current and discharge path between post insulators with CAS and without ones were presented and analyzed.

2. RESULTS AND DISCUSSION

The insulator with and without CAS are iced in same conditions. The icing state was shown in figure 1. The tested insulator without CAS was almost bridged by icicle except the high voltage end where has a higher electric field strength and local arc generated. But the insulator with CAS hardly bridged because the CAS increases the bridging distance between sheds, which effectively hindered ice bridging. At the same time, the porcelain sheds was less iced because freezing water was kept out by CAS, and the icicle just generated on the edge of CAS. On the effect of electric field, icicle is rather than vertical development but bending towards or outwards the insulator. Due to the difference of icing state, discharge path on normal post insulator and the post insulator with CAS were different, which were also shown in figure1. In normal post insulator was initialed from the metal flange and developed on the ice surface continuously till flashover. But on the iced post insulator with CAS, local arc firstly generated on the lower surface of CAS and Air gap discharge and ice surface discharge were con-existed. Once arcs connected and formatted a through path, the flashover occurred. Figure2 shows the results for insulators without and with CAS on the condition of SDD=0.1mg/cm^2 and NSDD=0.5mg/cm^2. $U_{50\%}$ can be calculated to be 207.9 kV, and the relative standard deviation is 7.3%. The $U_{50\%}$ for insulator with CAS is 328.9kV, which is 58% higher than the result of the normal post insulator.

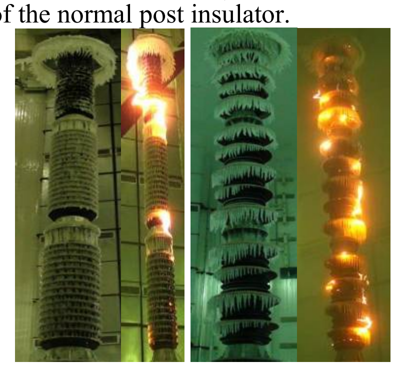

Figure 1. Icing state and discharge path on insulators with and without CAS

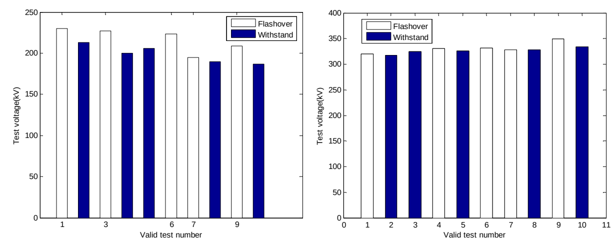

Figure2 Test results for post insulator without and with CAS

Influenced by the ice surface status especially the melting water conductivity, the leakage current increased faster but wave up and down frequently on the normal post insulator. On the other hand, because the ice surface with melting water film has a higher conductivity, the peak values of leakage current before flashover on the normal post insulator is larger than that value of post insulator with CAS.

3. CONCLUSIONS

1) The CAS can effectively hinder icicle bridging insulator sheds. Consequently, air gap discharge and ice surface discharge were con-existed on the iced post insulator with CAS.

2) On the condition of SDD=0.1mg/cm^2 and NSDD=0.5mg/cm^2, the 50% withstand voltage of post insulator with CAS is 58% higher than that of normal post insulator.

3) On the same condition, the leakage current on the post insulator with CAS rose slower and more stable than that process on normal insulator, and the post insulator with CAS has a lower current before flashover.

Effect of Composite Assistant Shed on the Flashover Performance of Ice-covered Station Post Insulators

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***Abstract*—In order to analyze the effect of Composite Assistant Shed (CAS) on icing flashover characteristics of post insulators, performance of energized 500kV post insulators with and without CAS were studied by icing test in a large-scale artificial climate chamber. The difference of appearance of ice, flashover voltage, envelopment of leakage current and discharge path between post insulators with CAS and without ones were presented and analyzed in this paper. Test results demonstrated that the CAS can decelerate icicle developing on the insulators and the sheds will not been bridged by icicle, which result in discharge path mainly along to the icicle and air gaps. Due to the composite antipollution shed, on the condition of seriously iced and polluted, the flashover voltage of 500kV station post insulators is higher than the maximum running phase to earth voltage, which is distinctly higher than normal post insulators.**

Keywords- Icing; Post insulators;Composite Assitant Shed; Flashover; Leakage Current

I. INTRODUCTION

Insulator icing is one of the serious challenging problems for power transmission and substation equipment in cold regions, which decreases significantly the electrical performance of insulators, and sometimes, results in insulator flashover and power outages[1] [2]. Normally, the sheds distance of post insulator is shorter than the distance between two insulators in transmission lines, that results the post insulator may be easily bridged by icicle. So the icing problem is even serious for post insulators in heavy icing regions. However, at present, there are fewer studies on post insulator icing flashover performance, especially less on the anti-icing technology for post insulator [3][4][5][6].

In the present work, icing flashover characteristics of energized 500kV post insulators with and without Composite Antipollution Shed (CAS) were studied by icing test in a large-scale artificial climate chamber. The difference of appearance of ice， flashover voltage， envelopment of leakage current and discharge path between post insulators with CAS and without ones were presented and analyzed.

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II. TEST FACILITIES AND MODEL

Ice accretion and flashover tests were carried out in the artificial climate laboratory at the UHV AC test base of SGCC, which has a net space diameter of 20m and a net space height of 25m. The temperature can be reduced to -19 ℃ and the atmosphere pressure can reach to 0.05 MPa in this laboratory. There also configured a 3×500kV AC test transformer system and a 1000kV DC power resource. Assistant to these facilities, external insulator tests of AC or DC UHV on conditions of polluted, icing and low pressure can be achieved in this lab. The whole test system is shown in Figure 1. The bottom AC test transformer was used in this work, which has a rated output voltage of 500kV, and a rated output current of 10A.

Figure1. Artificial climate laboratory

The dimensions of the tested insulator are shown in Tab.1. The CAS were equipped on the porcelain sheds in the mode of "3+1", that means every three porcelain sheds bonding a CAS. In addition, the diameter of adjacent CAS are not the same, the bigger CAS has a outer diameter of 510mm and the smaller CAS has a outer diameter of 480mm, and their inner diameter are both 156 mm, the diameter of the post. The post insulators with CAS were shown in Figure 2.

Table1. Dimensions of the tested insulators, mm.

Parameters	Higher part	Middle part	Lower part
Height H	1500	1500	1400
Creep distance L	5525	5140	4455
Big shed diameter D1	300	320	346
Small shed diameter D0	270	290	315
Number of sheds	35	34	30
Post diameter d	156	175	213
Arc distance h	1250	1200	1050

(a) Higher part (b) Middle part (c) Lower part

Figure 2. Post insulators with CAS

To simulate the running state, the post insulator was equipped a grading ring as shown in figure3, and its dimension was shown in Table 2.

Table 2. Parameters of the grading ring, mm

Pipe Diameter	**Inner diameter**	**Outer diameter**	**Height**
50	590	690	260

Figure 3. Profile of the grading ring

To simulate the serious polluted and icing condition, insulator has an artificial contamination of SDD= 0.1mg/cm^2, NSDD= 0.5 mg/cm^2. The ambient temperature was around -10℃ and the conductivity of water was 100 $\mu s/cm$. The insulator was energized 80% of the rated phase to earth voltage (231kV) during ice accretion process.

III. RESULTS AND DISCUSSION

Icing State

To analyze the effect of composite assistant shed (CAS) on ice state, the insulator with and without CAS are iced in same conditions.

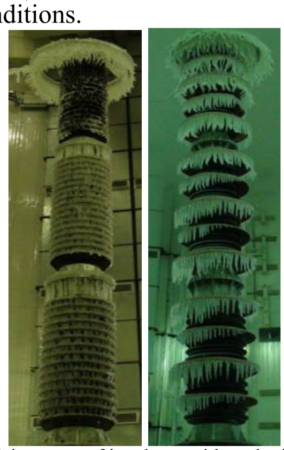


Figure 4. Icing state of insulator with and without CAS

The ice state was shown in figure 4. From the figure, the tested insulator without CAS was almost bridged by icicle except the high voltage end where has a higher electric field strength and local arc generated. But the insulator with CAS hardly bridged because the CAS increases the bridging distance between sheds, which effectively hindered ice bridging. At the same time, the porcelain sheds was less iced because freezing water was kept out by CAS, and the icicle just generated on the edge of CAS. On the effect of electric field, icicle is rather than vertical development but bending towards or outwards the insulator.

50% Withstand Voltage

Using the test procedures described in[7][8], the 50% withstand flashover voltage $U_{50\%}$ was determined by equation 1.

$$U_{50\%} = \frac{\sum (n_i U_i)}{N} \qquad (1)$$

Where U_i is the value of applied voltage; n_i is the number of tests at the same voltage level U_i, and N is the total number of useful tests.

Figure 5 shows the results for insulator without CAS. $U_{50\%}$ can be calculated to be 207.9 kV, and the relative standard deviation is 7.3%. The $U_{50\%}$ for insulator with CAS is 328.9kV, which is 58% higher than the result of the normal post insulator. Additionally, because the sheds were not be bridged by icicle as mentioned in previous, the discharge path mainly along the icicle and air gaps and the continues water film will not generated on the iced insulator. So, the flashover voltage is slightly influenced by ice surface resistance and the conductivity of melting water, which results the relative standard deviation of insulator with CAS (2.7%) is much lower than normal post insulator.

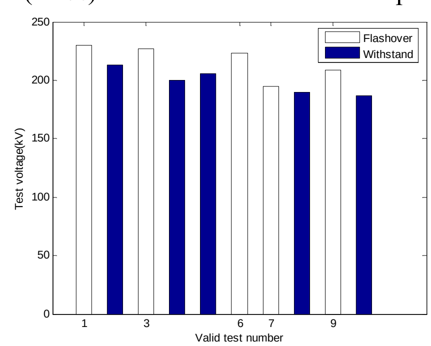


Figure 5. Test results for normal post insulator

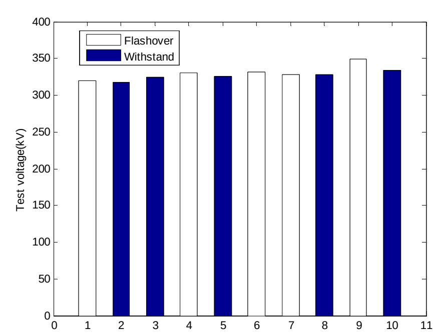
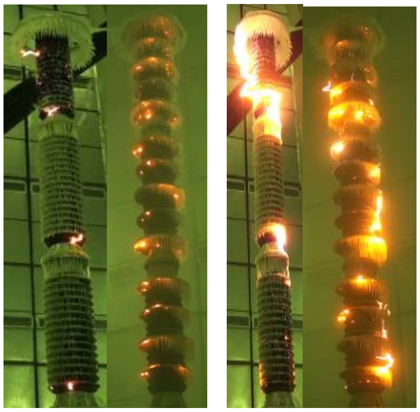


Figure 6. Test results for post insulator with CAS

Discharge path and leakage current envelopment

The status of initial discharge and before flashover of iced post insulator with and without CAS was shown in Figure 7.



(a) 15 s before flashover (b) 0.02 s before flashover

Figure7. Discharge path of iced post insulator with and without CAS

From figure 7, discharge in normal post insulator was initialed from the metal flange. However, on the iced post insulator with CAS, local arc firstly generated on the lower surface of CAS because there has less ice and when the voltage is rising, the thermal effect of leakage change these positions into dry belts, which distorted the electric field and result local arc discharge as well as the influence of metal flange on normal post insulator. Besides, because sheds were bridged by icicle on the normal post insulator, the arc developed on the ice surface and elongated continuously till flashover. But on the post insulator with CAS, there exist many air gaps and arc generated on each gap but not continuous. Air gap discharge and ice surface discharge were con-existed. Once arcs connected and formatted a through path, the flashover occurred.

The difference of flashover process and discharge path directly influences the leakage current envelopment as shown in figure8 and figure 9. Influenced by the ice surface status especially the melting water conductivity, the leakage current increased faster but wave up and down frequently on the normal post insulator. On the other hand, because the ice surface with melting water film has a higher conductivity, the peak values of leakage current before flashover on the normal post insulator is larger than that value of post insulator with CAS, respectively recorded as 1400mA and 900mA.

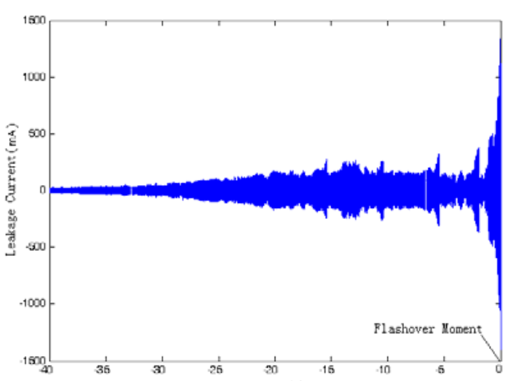


Figure 8 Leakage current envelopment of post insulator without CAS

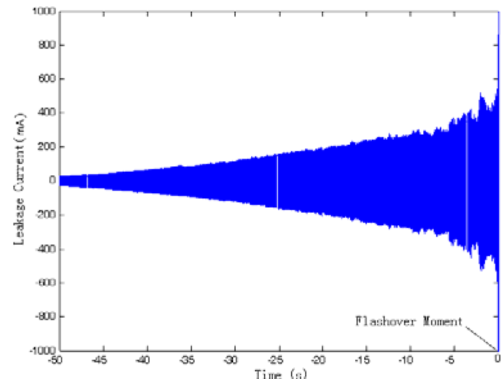


Figure9. Leakage current envelopment of post insulator with CAS

IV. CONCLUSIONS

Icing flashover characteristics including icing state, flashover voltage, discharge path and leakage current envelopment of 500kV post insulators with and without composite antipollution shed were compared and analyzed by test. Based on test results and analysis, following conclusions can be drawn:

1) The CAS can effectively hinder icicle bridging insulator sheds; consequently, air gap discharge and ice surface discharge were con-existed on the iced post insulator with CAS.

2) On the condition of SDD=0.1mg/cm^2 and NSDD=0.5mg/cm^2, the 50% withstand voltage of post insulator with CAS is 58% higher than that of normal post insulator.

3) On the same condition, the leakage current on the post insulator with CAS rose slower and more stable than that process on normal insulator, and the post insulator with CAS has a lower current before flashover.

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