A NOVEL COMPOSITE INSULATOR WITH LIGHTNING PROTECTION AND ICING FLASHOVER PREVENTION

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Abstract: A novel composite insulator with lightning protection and icing flashover prevention is presented and designed. It consists of the insulation part and the lightning protection part. Electric field simulations are performed and prove the feasibility of the novel composite insulator design.

1. INTRODUCTION

Serious lightning or icing often causes flashover on the insulators and probably results in a tripping accident. Current measures just have the single function of icing flashover prevention or lightning protection [1-2].

2. PRINCIPLE OF NOVEL COMPOSITE INSULATOR

A novel composite insulator with lightning protection and icing flashover prevention is presented. It consists of the insulation part and the lightning protection part, shown in Fig. 1.

3. DESIGN OF NOVEL COMPOSITE INSULATOR

The novel composite insulator with the rated voltage of 220 kV and the nominal discharge current of 10 kA for the lightning protection part is designed, whose requirements are shown in Table 1. Circular metal oxide varistors with high potential gradient are adopted to shorten the total length. Several sheds are enlarged to 300 mm to roof the small sheds and prevent icing flashover.

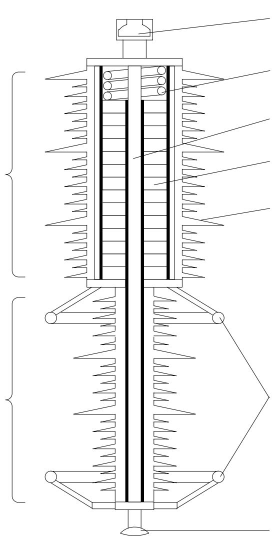

Figure 1: Schematic of the novel composite insulator

Table 1: Requirements of the Design.

Parameter		Value
Entire insulator	Rated voltage (kV)	220
	Specified mechanical load (kN)	100
	Power frequency withstanding voltage (kV)	≮370
	50% breakdown voltage under lightning impulse (kV)	≯960
Insulation part	Lightning impulse withstanding voltage (kV)	≮850
	Specific creepage distance (mm/kV)	≮17
Lightning protection part	Nominal discharge current (kA)	10
	2 ms rectangular current impulse (A)	600
	4/10 μs high current impulse (kA)	100
	Reference voltage under 1 mA DC (kV)	≮320
	Specific creepage distance (mm/kV)	≮17

4. ELECTRIC FIELD SIMULATION

Electric field simulations are performed. Simulation results show that the insulation part withstands almost 75% of the whole phase voltage, and the electric field strength of the insulation part is much higher than that of the lightning protection part. The highest electric field strength along the surface of the insulation part and on the surface of the grading ring is about 484 V/mm and 1900 V/mm respectively. All these electric field strength values can meet the insulation demands.

5. CONCLUSION

A novel composite insulator with lightning protection and icing flashover prevention is presented and designed. Simulation results show that all the electric field strength values meet the demands of the design.

6. REFERENCES

[1] Xiao-nan Wang, Hong-jun Yang, Zhao-feng Wu, and Ying Zhou, "Study on a new anti-ice-flashover compound insulator," Hubei Electric Power, vol. 34, no. 2, pp. 41–43, 2010 (in Chinese).

[2] Jun-bo Deng, Qiu-quan Deng, and Wei Shi, "Application of line MOA to reduce the tripping rate due to shield failure on 500kV transmission line," Insulators and Surge Arresters, no. 2, pp. 25–27, 2002 (in Chinese).

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***Abstract*—Serious lightning or icing often causes flashover on the insulators and probably results in a tripping accident. A novel composite insulator with lightning protection and icing flashover prevention is presented. It consists of the insulation part and the lightning protection part. The novel composite insulator with the rated voltage of 220 kV and the nominal discharge current of 10 kA for the lightning protection part is designed. Circular metal oxide varistors with high potential gradient are adopted to restrain of the lightning overvoltage. Several sheds are enlarged to roof the small sheds and prevent icing flashover. Electric field simulations are performed and show that all the electric field strength values meet the insulation demands and prove the feasibility of the novel composite insulator design.**

Keywords-composite insulator; lightning protection; icing flashover; metal oxide varistor

I. Introduction

Lightning and icing are natural phenomena. Both of them could have bad influences on the power transmission lines and even cause flashover on the insulators, probably resulting in tripping accidents. With the development of the electric grid construction, many power transmission lines are built even in the areas with complicated topography and cold climate. When confronted with the atrocious weather in these areas, tripping accidents are very easy to occur because of serious lightning or icing. Measures are taken to prevent the insulators from flashover. Compound insulators with enlarged sheds and spacing are developed to improve the ice-flashover voltage and to prevent the ice-flashover fault [1]. Besides the traditional measures of setting overhead ground wires and decreasing the grounding resistance of support, line metal oxide surge arresters are applied to reduce the tripping rate of transmission lines in the areas with intense lightning, high soil resistivity, and complicated topography [2-3]. Yet, these measures just have the single function of icing flashover prevention or lightning protection. There isn't an electrical product that can combine the above both functions.

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II. Principle of Novel Composite Insulator

A novel composite insulator is presented in this paper. This novel composite insulator can substitute common composite insulators and can realize the functions of both lightning protection and icing flashover prevention. Moreover, this novel composite insulator is easy to install, without changing the structure of support.

The structure of the novel composite insulator is shown in Fig. 1. An entire core throughout the insulator is used to suspend the transmission line and can hold heavy load. The core has two functional parts, one is the insulation part and the other is the lightning protection part.

The insulation part of the core acts as a normal insulator, which withstands most of the operating voltage when the power system is in normal status. A pair of grading rings is fixed on two terminals of the insulation part to uniformize the electric field distribution.

The lightning protection part of the core is mounted with

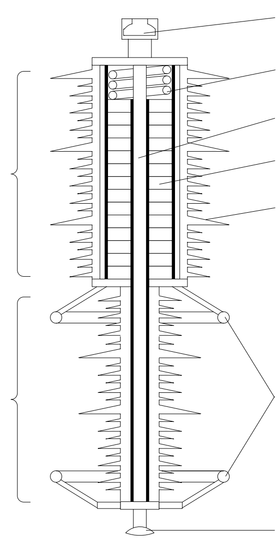

Figure 1. Schematic of the novel composite insulator.

the circular metal oxide varistors. A specially designed mechanism in the insulator can tightly press the metal oxide varistors. If a strong lightning strikes on the transmission line, the overvoltage will cause the air breakdown between the grading rings on the insulation part. Then the whole overvoltage will fall almost on the lightning protection part and the nonlinear performance of metal oxide varistors will take effect, resulting in the restraint of the overvoltage. This will prevent the insulators from a flashover and avoid a tripping accident of power transmission lines.

The whole insulator is covered with the silicone rubber housing and sheds, with the diameter and the spacing of some sheds are enlarged. During a cold icing season, the large sheds can roof the small sheds, so as to prolong the time of ice-bridging the sheds, increasing the difficulty of icing flashover and decreasing the probability of tripping accidents.

III. Design of Novel Composite Insulator

The novel composite insulator with the rated voltage of 220 kV for the whole insulator and the nominal discharge current of 10 kA for the lightning protection part is designed. Combining the functions of both a common composite insulator and a common line metal oxide surge arrester, this novel composite insulator is designed according to both standards of them [4-5]. The requirements of the design are shown in Table I.

TABLE I. Requirements of the Design

Parameter		Value
Entire insulator	Rated voltage (kV)	220
	Specified mechanical load (kN)	100
	Power frequency withstanding voltage (kV)	≮370
	50% breakdown voltage under lightning impulse (kV)	≯960
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According to the practical conditions of the site where the experimental sample insulators will be installed, the length of the novel composite insulator is required not longer than 2.5 meters. This length is longer than that of common composite insulators, but shorter than that of common line metal oxide surge arresters. Thus the common metal oxide varistors cannot meet the demand of the design. Instead, high potential gradient metal oxide varistors must be adopted to shorten the designed length of lightning protection part.

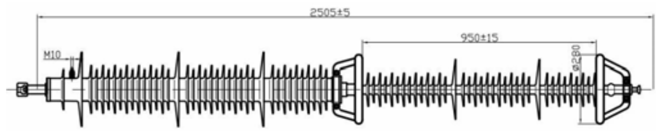


Figure 2. Design of the novel composite insulator.

The design of the novel composite insulator is shown in Fig. 2. As can be seen from Fig. 2, the length of the entire insulator is 2500 mm and the spacing between two grading rings is 950 mm. The diameter of several bigger sheds is enlarged to 300 mm.

IV. Electric Field Simulation

Based on the above design and dimensions of the real electric equipments, an electric field simulation model is established, including the novel insulator, the support, and the transmission line, as shown in Fig. 3.

Applying a DC 200 kV to the phase transmission line, which is equal to the probable maximum of the phase voltage in the 220 kV power system, we can calculate the electric field under the highest operation voltage.

The voltage distribution along the surface of the novel composite insulator is shown in Fig. 4. In Fig. 4, the zero point of distance represents the high voltage terminal, i.e. the voltage of transmission line. Fig. 4 (a) shows the voltage distribution of the insulation part and Fig. 4 (b) shows that of the lightning protection part. It can be seen from the Fig. 4 that the insulation part withstands almost 75% of the whole phase voltage and the lightning protection part withstands nearly 25% of the whole phase voltage.

The electric field strength distribution along the surface of the novel composite insulator is shown in Fig. 5. In Fig. 5, the zero point of distance also represents the high voltage terminal. Fig. 5 (a) shows the electric field strength

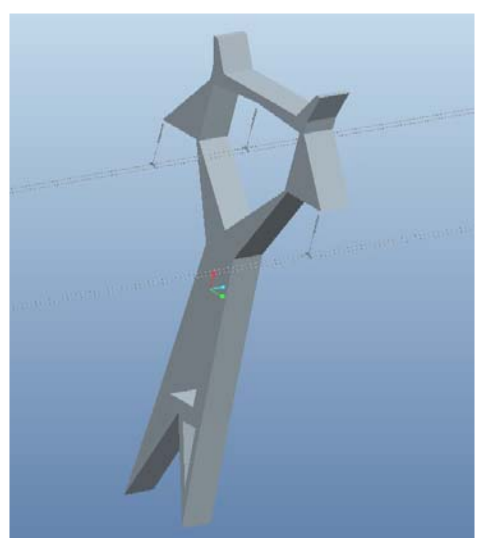
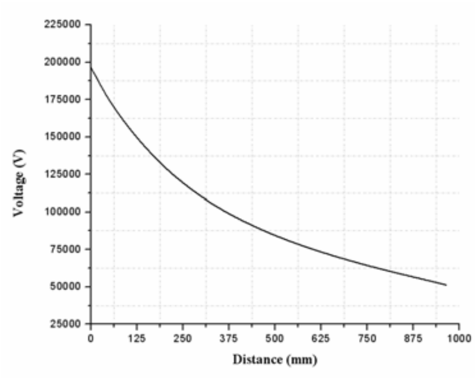
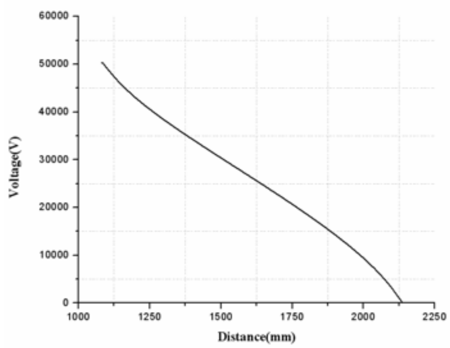


Figure 3. Model of electric field simulation.

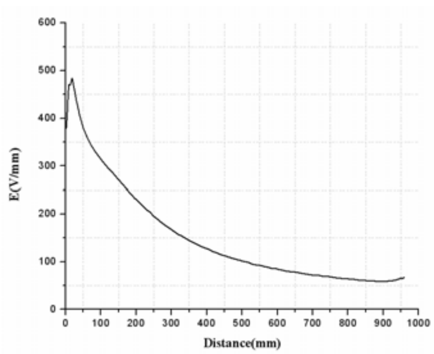


(a) Voltage distribution of the insulation part

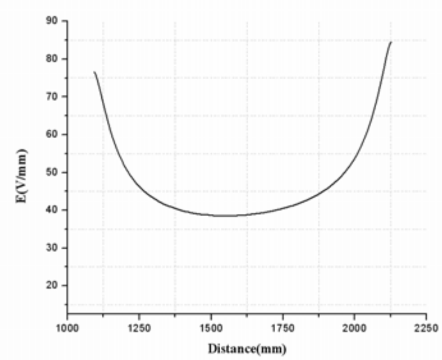


(b) Voltage distribution of the lightning protection part

Figure 4. Voltage distribution of the novel composite insulator.



(a) Voltage distribution of the insulation part



(b) Voltage distribution of the lightning protection part

Figure 5. Voltage distribution of the novel composite insulator.

distribution of the insulation part. In this part, the nearer from the transmission line, the higher the electric field strength is. Fig. 5 (b) shows the electric field strength distribution of the lightning protection part. In this part, the electric field strength distribution takes on a saddle shape. Comparing Fig. 5 (a) with Fig. 5 (b), we can see that the electric field strength of the insulation part is much higher than that of the lightning protection part. The highest electric field strength along the surface of the insulation part is about 484 V/mm. The highest electric field strength in the simulation model appears at the surface of the grading ring attached to the high voltage terminal, with the value of 1900 V/mm. All these electric field strength values won't cause the air breakdown, so the electric field strength distribution can meet the demands of the electric equipments and prove the feasibility of the novel composite insulator design.

V. CONCLUSION

1) A novel composite insulator is presented. This novel composite insulator can realize the functions of both lightning protection and icing flashover prevention.

2) The novel composite insulator with the rated voltage of 220 kV and the nominal discharge current of 10 kA for the lightning protection part is designed.

3) The electric field simulations show that the insulation part withstands almost 75% of the whole phase voltage, and the electric field strength of the insulation part is much higher than that of the lightning protection part. All the electric field strength values meet the insulation demands and prove the feasibility of the novel composite insulator design.

4) Sample novel composite insulators need to be fabricated and installed in real transmission lines to testify the practical effects in the next study.

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