Security Operation of Arrester with Series Gap under Power Frequency

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***Abstract*—In an effort to protect the transmission system from lightning, many types of arresters are used along transmission lines, paralleled with insulators usually. Regarding the protecting capability of an insulator, together with its tolerance ability of voltage, the arresters could be designed with gaps, and designed to discharge when lightning happens. Electric field concentration happens before a discharge occurs, and in other words, it is one of the causes of flashover or discharges. This paper aims at study the electric field distribution of an arrester with gap before discharges happen.

Keywords-arrester; discharge; electric field; frequency

I. INTRODUCTION

The insulator installed between the conductor and the transmission tower is designed to avoid the short circuit between them, which works well when the voltage of conductor doesn't exceed the amplitude of temporary over-voltage and switching over-voltage. That is to say, the insulation parameters of a insulator are high enough to prevent temporary over-voltage and switching over-voltage., especially in transmission systems lower then 330kV[1]. In consequence, to protect insulators from lightning damage by means of leading lightning current flow through itself is what an arrester should ensure. But one disadvantage appears that the residual voltage of an arrester after a lightning current flow through it might cause damage to the device paralleled with it. Therefore arrester with a series gap is designed to avoid that situation.

II. PARAMETER CALCULATION

A. Maximum Power Frequency Phase Voltage

First, let the rated operating voltage of a transmission system is $\mathrm{U_n}$, then the possible temporary over-voltage might reach 1.15 times rated voltage. Furthermore, for phase voltage the maximum power frequency phase voltage $\mathrm{U_p}$ could reach:

$$\mathrm{U_p} = \frac{1.15 \times \mathrm{U_n}}{\sqrt{3}}$$

B. Internal Gas Gap capacitance

Considering that the gas gap is like cylinder, which means the electric field between these two electrodes is slightly uneven field, the capacitance could be approximately calculated as a plate capacitance. Since the relative dielectric constant of air is 1.00058, and the vacuum dielectric constant is $8.85 \times 10^{-12}\mathrm{F/m}$, the relative capacitance of a gas gap can be calculated as:

$$\mathrm{C_{gas\ gap}} = \frac{8.85 \times 10^{-12} \times 1.00058 \times \text{Area of Electrodes}}{\mathrm{d}}$$

III. SECURITY COMPUTATION

A. Finite Element Method

Finite Element Method is a numerical solution of differential equation based on weighted residual method Law. In order to build the differential equations of the arrester model, mesh subdivision should be carried out. The mesh here is selected as free triangular mesh, considering the original shape of arrester devices.

B. Numerical Results

The field distribution before discharge is computed based on the possible discharging voltage. For instance, the discharging voltage of a 35kV gapped arrester under power frequency is suggested no less than 82kV, referring to *JB/T 10497-2005 Polymeric Housed Metal Oxide Surge Arresters with Series Gap for AC Electric Power Transmission Line.* Under this voltage the most severe electric field concentration on electrodes occurs at high voltage end, on the corner of the electrode, while the most severe electric field concentration on polymeric material occurs also at high voltage end, on the tip of the first shed. For detail value, Table 1 is available showing the accurate results.

TABLE I. ELECTRICAL FIELD BEFORE DISCHARGE

	Location			
	Electrode	***Silicone Shed***	***Insulation Rod***	***Epoxy Tube***
Maximum field strength/(kV/cm)	22.14	18.72	8.61	5.79

REFERENCES

[1] Bunov P, Klingbeil L, Schubert M, et al. Transmission line arresters application for control of switching overvoltages on 500-kV transmission line[C]// T&D Conference and Exposition, 2014 IEEE PES. IEEE, 2014:1-5.