Lightning Striking Process Simulation and Its Effects

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Abstract—Lightning striking will threaten the safety of the society. This paper tries to present a panorama of lightning striking process and its effects on grounding devices. First the paper introduces the simulation on lightning striking process based on the leader propagation model and the fractal model, how the lightning fractal is initialized is discussed based on lightning observation and 3D simulation of corona discharge, the upward leader characteristics are studied by high voltage experiments. Then the lightning effects on grounding were introduced, the ionization discharge and arc discharge in soils around grounding devices will be presented, too, this will be very helpful for lightning protection.

Keywords-lightning striking; simulation; lightning effects

I. INTRODUCTION

Lightning striking will threaten the safety of the society. In the lightning protection of ground structures, a clearer understanding of the mechanism and dynamics of leader branching is needed to identify possible lightning strike locations as well as vulnerable parts of the protection systems. This paper tries to present a panorama of lightning striking process and its effects on grounding devices.

II. LIGHTNING STRIKING PROCESS SIMULATION

A. Simulation Models

The propagation-type models for analyzing lightning striking process are critically assessed. The main parameters of leader propagation-type models, including leader progression model and upward leader model, leader inception model, cloud potential, charge distribution in the leader channel, charge of upward leader, velocity of upward leader and downward leader, initial velocity of upward leader, and final jump model, are suggested to make this analysis model solid, and to provide a sensitivity analysis of transmission lines to lightning strikes. This work has been published as CIGRE Brochure 704[1].

B. Fractal Initialization of Lightning Leader

We start with the image analysis of a lightning leader process recorded with a high-speed camera and to show that the anode-directed streamer zone developed from space stems in front of a leader tip needs be smaller in size (<10m) to make branching more likely to occur. Then, we propose a kinetic model to describe the growth of the meter-scale streamer zone, which essentially states that the growth speed decreases as the streamer zone expands. The exponent in the kinetic model can be estimated by comparing the numerical and observational results. Based on the model, the streamer zone dynamics on the meter-scale differs from that of a single streamer in that the slowing down of the growth is accompanied by the recovery of the electric field at the discharge front, which may result in new bursts of streamers. This model, if further verified, could be the foundation of inferring the structure and dynamics of the streamer zone from the morphology of the leader channel, which would significantly advance the knowledge of the streamer zone in negative lightning leaders.

C. Upward Leader Study by High Voltage Experiments

The real-size experiments of 110 kV, 220 kV, 500 kV and 1000 kV transmission lines are carried out, and the ac operating voltage is considered.

Regarding the leader inception characteristics, for all the voltage levels, streamer inception time, discontinuous and continuous leader inception time all increase as the transient voltage amplitude becomes larger. And for leader development characteristics, both of the developing velocity and charge density are representing the increasing trend as the triggering phase degree increases.

During the leader developing process in detail, the leader velocity maintains on the basically same level when the leader is smaller than around 0.6m, and leader lengthens afterwards, the velocity increases as the length becomes larger. The leader charge per unit concentrates in the scope of 10-50 μC/m.

III. LIGHTNING EFFECTS ON GROUNDING

A. Soil Ionization under Lightning Impulse

The ionization discharge around the grounded electrodes under lightning impulses are very complicated, the ionization phenomenon will be introduced.

B. Soil Arc Discharge under Lightning Impulse

In uniform soil, the ionization channels are dense. If the soil is inhomogeneous, the ionization channels will be thin, especially for actual soil, it is very nonuniform, the soil ionization paths will be less and become arc discharge.

REFERENCES

[1] J. L. He, et al., “Evaluation of lightning shielding analysis for EHV and UHV transmission lines,” CIGRE Brochure 704, Dec. 2017.