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Protection of overhead transmission lines from lightning strike

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Abstract :*transmission lines are shielded with protective wires to overcome various kinds of sudden upsurge of high voltage.the aim of the article is to determine the probability of direct lightning strikes in overhead lines with protected wires for different model configurations with the help of experiments. The experimental results have allowed to refute the hypothesis of the absence of direct impacts in protected wires of overhead lines. The studies conducted suggest that lightning defeat of overhead lines with protected wires is substantially lower than that traditional lines.*
Keywords : *lightning protection, a direct lightning strike,*

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I. Electrical network, protected wire, large-scale model.Creation oflarge-scale model.

Research and development of methods and devices that would prevent burnout wires during overvoltage effects, today in ukraine are in demand due to the fact that the technical policy in the field of electricity provides large-scale use of protected wiring in new construction and reconstruction of power lines. In this regard, a group of specialists from the national technical university "kharkiv polytechnic institute" in cooperation with the firm "sicam ukraine" started to study the possibility of increasing lines with lightning-proof protected wire.

II. Introduction

One of the main causes of accidents and violations in the distribution networks are a storm surge on overhead lines, causing the pulse overlap destruction of insulators, causing arcing fault, the concomitant damage to equipment outages and lines. However, the rules in force did not provide any special protection against lightning surges overhead lines with bare wires with voltage up to 20 kv, except in cases of protection of individual points of overhead lines or weakened insulation with high requirements for reliability.

This state-of-lightning protection of distribution overhead line was the result of historically established recognition of the inevitability of their storm outages and damage due to the lack of effective and affordable technology. However, with the beginning of mass use in distribution overhead line conductors protected arose the need for mandatory technical measures to lightning protection.

The peculiarity of the problem of lightning protection protected overhead lines is that in the absence of special measures, when lightning insulator overlapping lines, followed by the breakdown of the solid insulation of the wire, which is formed with a high probability of commercial frequency arc is not able to move through the wire (as in bare wires) and burning at the site of the breakdown of the insulation off until the line [1.3]. This can cause damage to wire insulation, damaged insulators and line wire burnout, as evidenced by experience in operating lines with insulated wires. Because lines with bare wires exposed arc electrodynamic forces able to move one of its ends along the wire, the factor of wire damage due to thermal effects of the arc was not significant and does not affect the formation of the concept of lightning protection of overhead lines. In the case of insulated overhead wires to prevent burnout becomes the main condition in determining the need for mandatory application of any lightning protection measures. [2]

Some literature suggests that the probability of a direct blow to the wire insulated overhead line missing. To test this hypothesis, we performed experimental studies the probability of a lightning strike in the wire insulated overhead line for different conditions.

In the laboratory of ultra-high voltage of the department "electric power transmission" of the national technical university "kharkiv polytechnic institute" was established allowing the large-scale model to simulate overhead line with bare wires or protected. This model makes it possible to perform experiments to determine the probability of a direct lightning strike to insulated overhead line and overhead lines for different geometrical parameters of lines. As a source of high-voltage pulse voltage generator used (gpv), with a maximum voltage of 2.4 mv.

One of the main issues in experimental studies of lightning protection of various objects is the question of compliance with the conditions of discharge between a cloud and the earth (lightning) and in the laboratory between.

One such condition is the choice of the form of exposure voltage. Previously, for the initiation of the spark discharge in the air gap used the standardized international electrotechnical commission (iec) lightning overvoltage impulse 1.5 / 40 ms (the length of the of impulse front of 1.5 microseconds pulse length - the time from the beginning of the pulse until the voltage reaches half the maximum value - 40 ms). Currently, the standard form of the pulse slightly changed (1.2 / 50 s) that does not change the fact.

In addition to lightning characteristic zigzag channel, due to its stepwise development, and random direction of each stage at a low average discharge voltage - the order of 15 kv / m. To play the random nature of the direction of the discharge in the laboratory must be possible to obtain a lower average discharge voltage, which provides a stepwise development of the spark channel with a sufficiently large with respect to the length of the discharge gap length of the stage leader and therefore the direction of the development of accidental discharge. From this viewpoint justified application of positive polarity voltage pulse with a gently sloping front, at which the average discharge voltage in a sharply nonuniform field (such as rod-plane) decreases rapidly with increasing length of the gap. When negative polarity average discharge voltage for a period of rod - plane much more. For short periods (2 - 3 m) of the discharge voltage in the negative polarity voltage (to 1000 kv / m) is more than twice the discharge voltage at the positive polarity (400 kv / m). [4]

In accordance with the method of choice scale modeling height orientation laboratory spark can be determined based on the fact that the height of the orientation of lightning at heights of targets up to 30 meters of 5hl [5]. Therefore, the height of the orientation of a laboratory spark defined as:

$H_м=5h_л/30=1{,}3$ м (1)

Where$h_м$ - model height of suspension wires;

$H_л$ - height of the point of suspension wires

general view of the model is shown in figure 2.

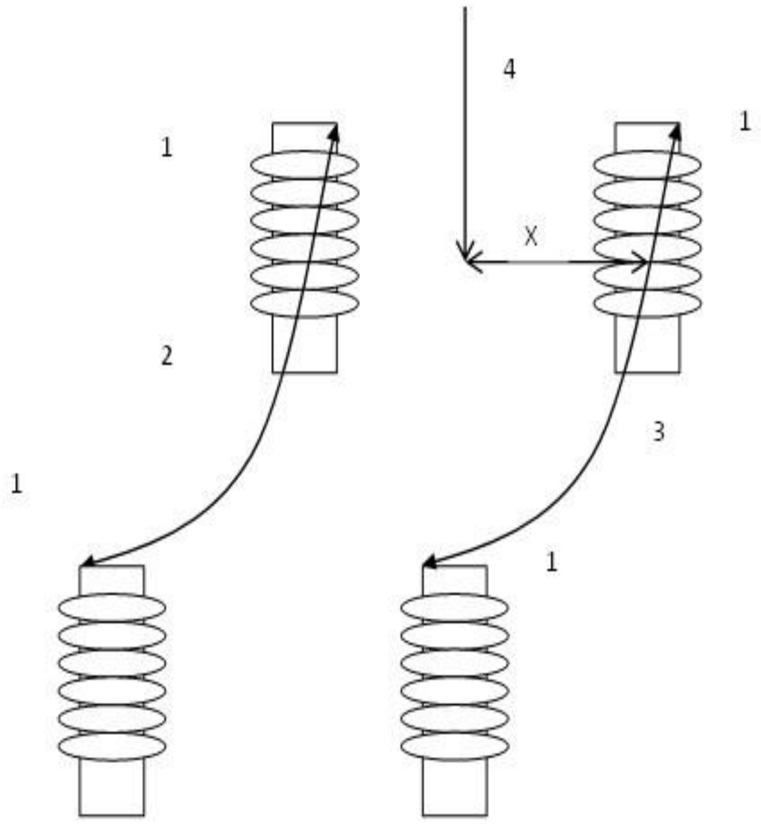

Fig. 2 general view of the model.

1 support insulator, 2 bare wire, secure the wire 3, 4 electrode simulating lightning, x distance from the electrode simulating lightning to secure the wire.

Whenthe location andelectrodes simulating lightning out of the plane models appear in the ground level, which confirms the correctness of the choice of the model parameters.

Iii.experimental research of lightning protection

A. **The first series of experiments**

fig. 4 general view of the model for thefirst series of experiments

In the first series of experiments was performed comparing the probability of a direct lightning strike to the wire for the lines on which both suspended and protected and bare wires. The model parameters were as follows: the electrode is at a height of 1.3 meters from the surface of the "earth", at a height of 20 cm from the "ground" were hung insulated and bare wire at a distance of 90 cm from each other, simulating lightning electrode sets strict middle between the wires. As a result of 100 tests all the bits have come to the bare wire. This result suggests elevated lines with lightningproof protected wire.

B. **The second series of experiments**

The second series of experiments was carried out on a similar model lines which are suspended and at the same time protected and bare wires. The main difference between this series of experiments was that simulates lightning electrode was placed at a distance of 30 cm and 60 cm protected from naked. This arrangement of electrodes simulating lightning allows you to explore the probability of a direct blow to the wire lines in case of a lightning channel in an arbitrary point in space. Parameters of the model have the same meanings as in the first series of experiments.

It holds four series of experiments, 100 in each of experiments, the results are as follows in two series of experiments, 70 beats had a bare wire and 30 beats protected, one 68 beats bare wire 32 and secured in the last 73 bare wire and 27 protected. The obtained results show that the probability of a direct blow to the protected wire is 30% of the total number of strokes.

C. **The third series of experiments**

In the third series of experiments was performed comparing the probability of a direct lightning strike to the lines on which both suspended and protected and bare wires. The model parameters were similar to the first two experiments. A simulating lightning electrode was placed directly over a secure wire. It was performed 5 series of 100 trials each. In two of them the probability of a direct blow to the protected wire was 50% of the total number of strokes, in the following series of probability ranged from 47 - 51%.

D. **The fourth series of experiments**

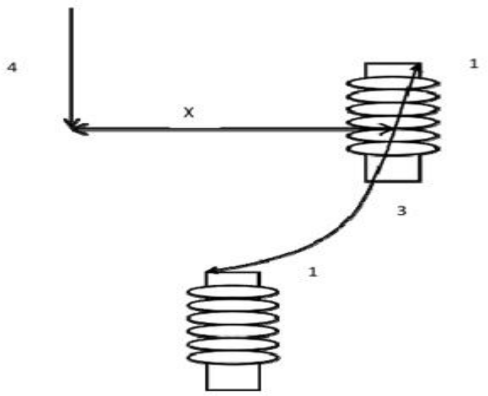

Fig. 3 general view of the model for thefourth series of experiments.

1 support insulator,, secure the wire 3, 4 electrode simulating lightning, x distance from the electrode simulating lightning to secure the wire.

The fourth series of experiments determined the probability of a lightning strike to secure the wire with equal distances from the wire to the electrode simulating lightning and from said electrode to the ground. Suspension height of the electrode and wires were the same as in previous experiments. There have been four series of 100 trials each. The probability of hitting a protected lead ranged from 26% to 32% of the total number of strokes.

E.the fifth series of experiments

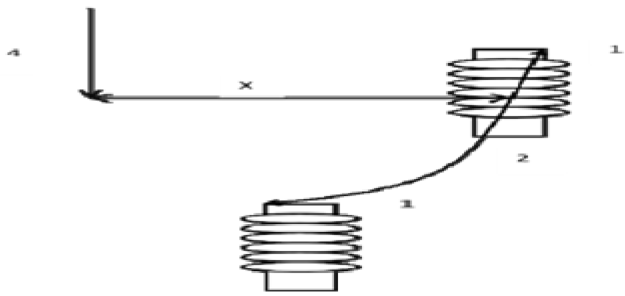

Fig. 4 general view of the model for the fifth series of experiments.

1 support insulator, 2 bare wire, 4 electrode simulating lightning, x distance from the electrode simulating lightning to secure the wire.

When the fifth series of experiments determined the probability of a lightning strike in the bare wire at equal distances from the wire to the electrode simulating lightning and from said electrode to the ground. Suspension height of the electrode and wires were the same as in previous experiments. There have been three series of 100 trials each. The probability of impact in bare wire ranged from 70% to 72% of the total number of strokes.

III. Experimental results

During experiments was found non-zero probability of hitting the protected wire, which rejects the hypothesis of the impossibility of a direct blow to a wire. Provided electrode arrangement simulating lightning strictly in the middle between the bare wire and protected, they were not recorded in the level of a protected model. In the case of the bias electrode simulating lightning in the direction of the protected wire increases the probability of its destruction.

If simulating lightning electrode is closer to the wire than to secure the bare (in the experience of the distance from the bare wire to the electrode axis is 70% of the total), protected by wire amazed with the probability of 30%. The most severe case, in terms of affection was a case of a wire electrode arrangement simulating lightning over a secure wire. Protected wire amazed with the probability of 50% when placing electrodes simulating lightning at equal distances from the protected wires and electrodes simulating lightning probability of hitting the wire is approximately 30%, and at the same configuration model for the bare wire likelihood of injury is 70%.

These results suggest that secure the wires will be exposed to direct lightning strikes twice as likely than naked.

This will significantly increase the estimated lightning-proof secure lines with wire. Based on the experimental data one can conclude that the grip region of the bare wire 3 times the capture zone covered conductor. This fact illustrates the significant reduction in the projected area at which the probability of direct lightning strikes in line with protected wires. Said area, along with the number of hours and length of storm line is used to calculate the number of direct lightning strikes in line npum. Its reduction leads to a proportional decrease in the estimated npum and consequently an increase in lightning-proof line with protected wires.

IV. Conclusions.

1. The results of the experiments allowed to refute the hypothesis of the absence of direct impacts in protected wire overhead lines.
2. The studies suggest that the susceptibility of a lightning defeat overhead lines with protected wires significantly lower susceptibility of traditional lightning defeat line performance.
3. The results indicate the need for further research in affection lightning defeat overhead lines to secure the wires.

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