Influence of Electric Field Distribution along the Line Post and Pin Post Insulator due to Lightning Strike

Pramuk Unahalekhaka and Karun Sirichunchuen

Abstract— *This paper presents a simulation of electric field distribution along the insulator in case of lightning strike to the wires on top and at the side of line post type 57-2 TIS .1077 and pin post type 56/57-2 TIS.1251 by using Finite Element Analysis Program and ATP-EMTP program. The insulators were used in 22 kV distribution system of Provincial Electricity Authority (PEA) in case of a lightning strike on a pole directly. The model took the lightning surge current 10/350μs at **20**kA, **40**kA, and **80**kA respectively. The simulation results found that all surface area of line post insulator was distributed by electric field and partial surface area of pin post insulator which was distributed by electric field in case of installation the distribution line on the top and at the side of insulation. Therefore, the installation of distribution line on the top of insulation along straight path or the installation of distribution line at the side of insulation along curve path should be used suitable for the installation by pin post insulator.*

Keywords— **Electric Field, Pin post Type Insulator, Line Post Type Insulator, Finite Element, ATP-EMTP, lightning strike.**

1. INTRODUCTION

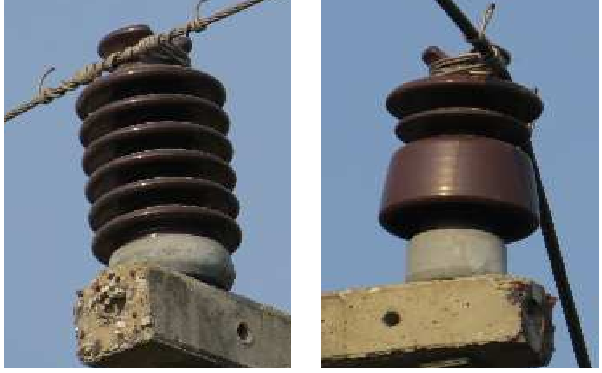
Nowadays, the power system at 22 kV of the provincial electricity authority (PEA) is a distribution system by using the overhead power line insulators for supporting and holding the space of the distribution lines steadily. The insulators selected were applied for distribution system based on the IEC 60815 standard, as shown in Fig 1.

Poles Installation for the distribution line on the curved road were equipped with beside of insulator for supporting the tension weight of the distribution lines as shown in Fig 2. Line post and pin post insulators are applied for the distribution system in PEA. They are installed on distribution overhead line on the poles and outdoors area, where the insulators are damaged by the lightning strike on the ground wire. The dropped voltage occurred was higher than the resistance and flashover occurred from the resulting in the loss of stability of the power distribution system.

From the reasons mentioned above, this research focused on the simulation electric field of line post insulators and pin post insulators in the crisis conditions by ATP-EMTP program. In addition, it could be analyzed the distribution of the electric field by the Finite Element Analysis program. The data obtained from this study was used for considering and planning the selection of insulators for distribution system installation properly and efficiently. It was able to protect against the loss of stability of the distribution system.

a) Line post Insulator b) Pin post Insulator

Fig. 1. Clamping to hold the power lines on the top insulators.



a) Line post Insulator b) Pin post Insulator

Fig. 2. Clamping to hold the power line at the side of insulators.

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2. LINE POST AND PIN POST INSULATORS

Porcelain insulator, line post insulator and pin post insulator were used in the power distribution systems 22 kV and 33 kV, which were made of the clay and coated with a coating including the base of the insulators is the casted iron. This paper was to simulate the dielectric insulators as line post type CLASS ANSI 57-2 and pin post type CLASS ANSI 56 / 57-2 in distribution system 22 kV as shown in Fig 3. In the technical data is shown in Table 1.

a) Line post Insulator b) Pin post Insulator

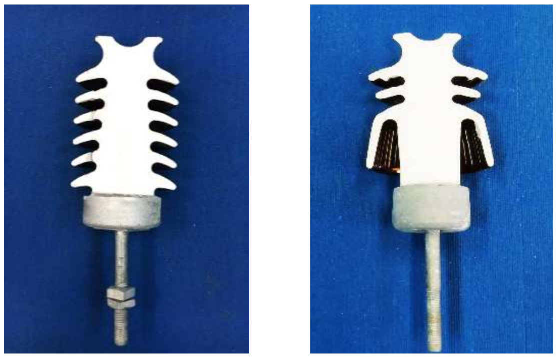
Fig. 3. The Characteristics of Insulators

Table 1. Technical data of line post and pin post Insulators

Class ANSI	56/57-2	57-2
Leakage distance min.	534 mm	559 mm
Protected leakage distance min.	267 mm	241 mm
Cantilever strength	12.5 kN	12.5 kN
Cantilever proof load	5 kN	5 kN
Low-frequency dry flashover	110 kV	110 kV
Low-frequency wet flashover	80 kV	85 kV
Critical- impulse flashover, positive	180 kV	180 kV
Critical- impulse flashover, negative	205 kV	205 kV
Low-frequency test voltage, rms to ground	22 kV	22 kV
Maximum RIV at 1000 kHz	100 µV	100 µV

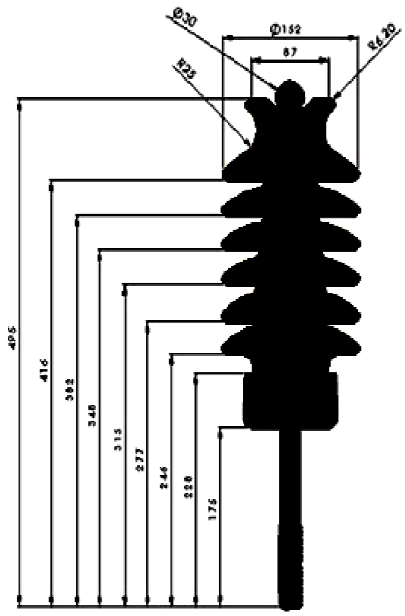
3. ELECTRIC FIELD MODELING

Modeling of dielectric insulators used the data of the spatial dimension and leaking stage of insulator that was in the modeling of the two types in order to measure the dimensional with the cutting a half way as shown in Fig 4. Also, it applied for modeling in 3D Programs and the scale of the completed model was 1:1 as shown in Fig 5.

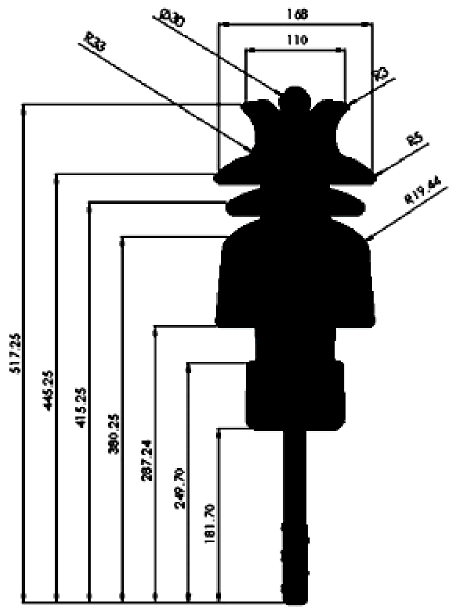


a) Line post Insulator b) Pin post Insulator

Fig. 4. Finding the dimensions size of insulators.



a) Line post Insulator



b) Pin post Insulator

Fig. 5. Insulators model.

4. SIMULATION OF IMPULSE VOLTAGE

The simulation of the ATP-EMTP program was considered the surge voltage happened at the distribution line. Due to the lightning strike on the overhead ground wire (OHGW) of the power distribution system. The lightning surge current is 10/350 µs that could be shown in 20 kA, 40 kA and 80 kA. The fig 6 was shown as the waveforms currents lightning at 80 kA and the lightning surge voltage up to 495 kV was shown in Fig 7. The results of simulation as shown in Table 2.

Table 2. Lightning surge voltage at distribution line.

Lightning surge current (kA)	Lightning surge voltage (kV)
20	137
40	256
80	495

This research is to study of the distribution of the electric field on the insulators surface of line post insulator and pin post insulator by using the Finite Element Analysis Program, which defined the parameters for modeling. It could comprise the electrical permittivity of the material (Relative permittivity) and a density electric charge spatial (Conductivity) according to Table 2. From simulation a lightning surge voltage occurred at the distribution line were 137 kV, 256 kV, and 495 kV. Also each segment was divided from the intensity electric field on the surface of a dielectric insulator as shown in Fig 8.

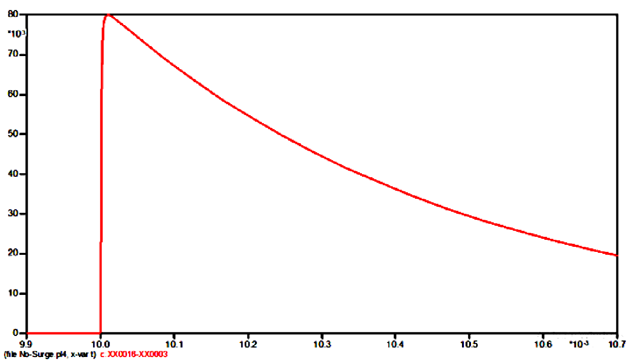


Fig. 6. Lightning surge currents at 10/350 µs, 80 kA.

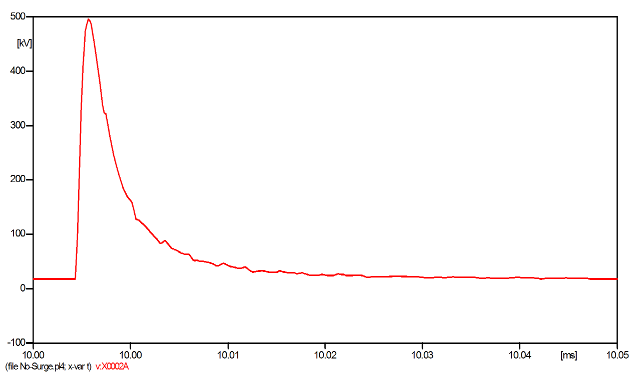


Fig.7. Lightning surge voltage at 10/350 µs, 80 kA.

Table 2. Parameters used in the simulation

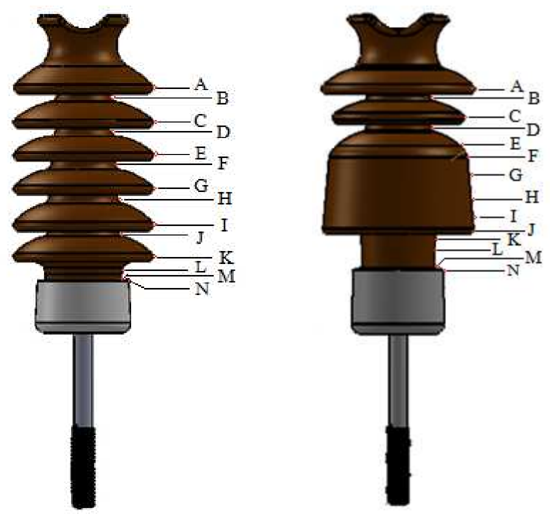
Material	Parameters	
	Relative permittivity ε_r	Conductivity σ (*s/cm*)
Porcelain	5.7	$1x10^{-14}$
Cast iron	1	$1.12x10^{7}$
Cement	4.5	$1x10^{7}$
Nut	1	$1.12x10^{7}$
Aluminium	1	$3.56x10^{7}$

5. SIMULATION AND RESULTS

From the modeling results, an electric field distribution in 3D figure was on the surface of dielectric of line post insulator and pin post insulator in the conditions of a lightning surge voltage as 135 kV, 256, and 495 kV, which distribution line insulator was mounted on the insulators and the electrical cable at the side of insulator.

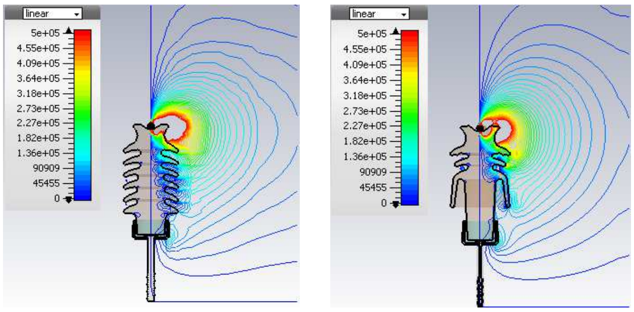
5.1 The electrical cable clamped to hold on the top insulator

The electric field was distributed on the insulator surface and around the distribution lines mostly. Also, it could distribute through the base of insulator as shown in Fig 9. From the analyzing, the intensity electric field of the two types insulators, which was found that the increased lightning surge voltage in distribution lines towards the valuable of the electric field increased and spread on insulators mostly. The line post insulator was the maximum valuable in the electric field strength at the point B as 2.27 $x10^{6}$ V/m and minimum point L as 4.46 $x10^{5}$ V/m. For the pin post insulator was the maximum valuable of the electric field strength at the point B as $1.91x10^{6}$ V/m and minimum point I as 5.14 x105 V/m. In case of lightning surge voltage in distribution lines were distributed at 495 kV which was the maximum valuable in the electric field strength at each analyzed segment as shown in Fig 9c.



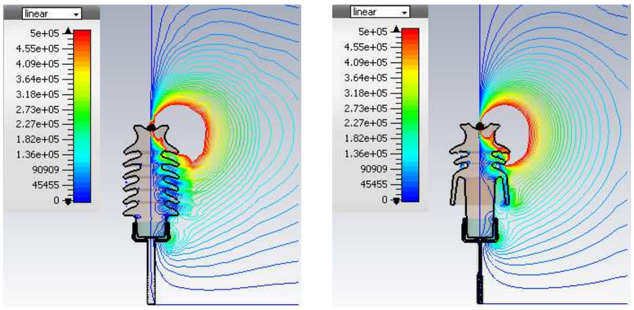
a) Line post Insulator b) Pin post Insulator

Fig. 8. Each segment the intensity electric field on the surface of a dielectric insulator.



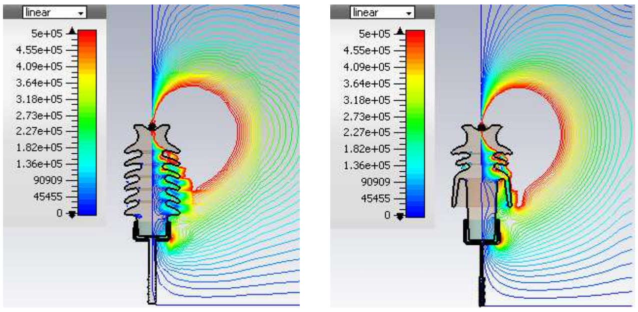
Line post Insulator Pin post Insulator

a) Lightning surge voltage at 137 kV



Line post Insulator Pin post Insulator

b) Lightning surge voltage at 256 kV



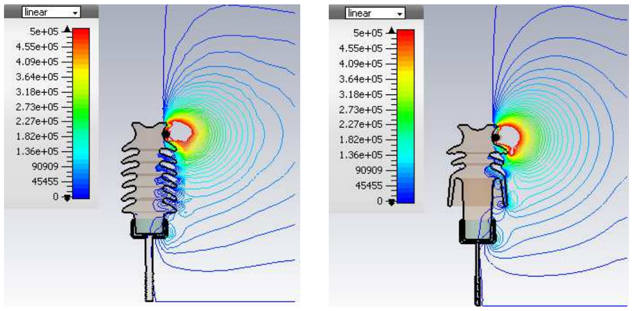
Line post Insulator Pin post Insulator

c) Lightning surge voltage at 495 kV

Fig. 9. Electric field contour with lightning surge voltage of distribution line on the top of insulator.

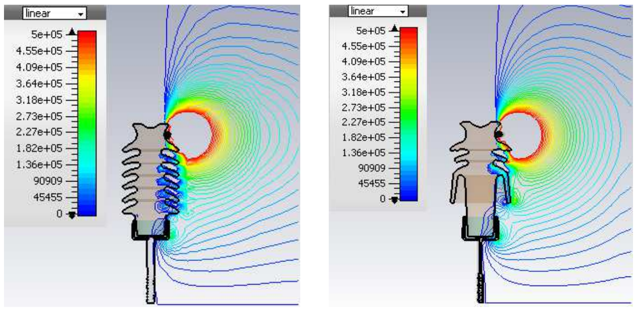
5.2 The electrical cable clamped to hold at the side of insulator.

The electric field was distributed on the insulator surface and around the distribution lines mostly. Also it could distributed through the base of insulator as shown in Fig 10. From the analyzing, the intensity electric field of the two types insulators, which was found that the increased lightning surge voltage in distribution lines towards the valuable of the electric field increased and spread on insulators mostly. The line post insulator is the maximum valuable in the electric field strength at the point B as 2.21 x10^6 V/m and minimum point L as 4.27 x10^5 V/m. For the pin post insulator is the maximum valuable of the electric field strength at the point B as 2.54x10^6 V/m and minimum point M as 5.14 x10^5 V/m. In case of lightning surge voltage in distribution were distributed at 495 kV which was the maximum valuable in the electric field strength at each analyzed segment as shown in Fig 10c. From the results of simulation in the two types of insulator the electric field distribution were analyzed a segment near ground of line post insulator which was located between point K to M, which the electric field was distributed massively as shown in Fig 11a. The pin post insulator was located between point J to M, which the electric field was distributed less than of line post insulator massively because there was more air gap as shown in Fig 11b.



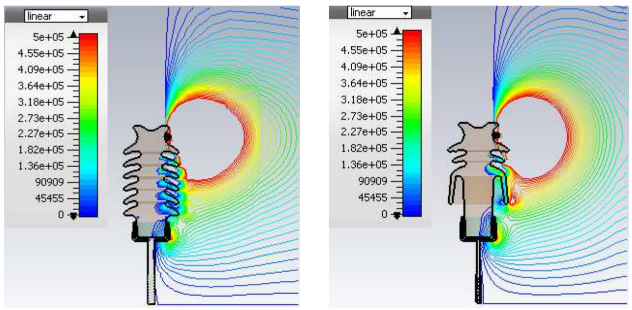
Line Post Insulator Pin post Insulator

a) Lightning surge voltage at 137 kV



Line Post Insulator Pin post Insulator

b) Lightning surge voltage at 256 kV



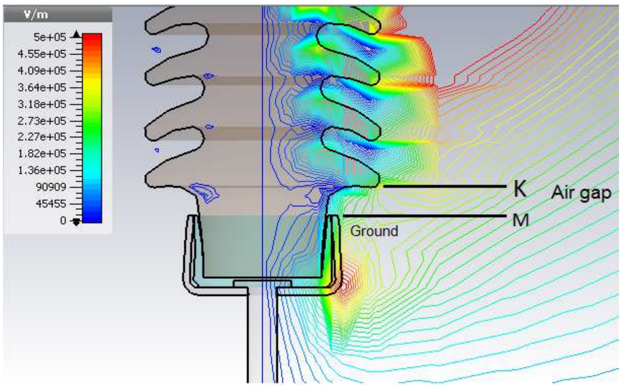
Line post Insulator Pin post Insulator

c) Lightning surge voltage at 495 kV

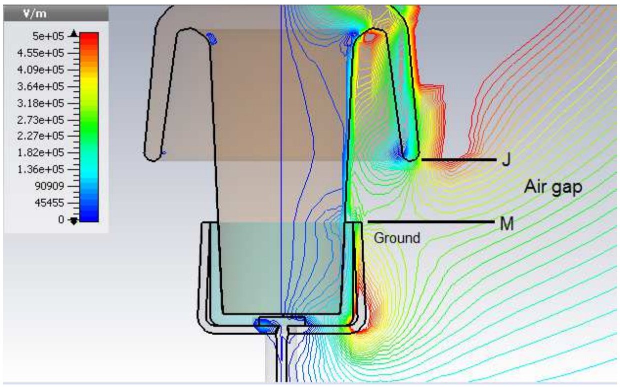
Fig. 10. Electric field contour with lightning surge voltage of distribution line at the side of insulator.

6. CONCLUSION

From the results of simulation, both of the line post type 57-2 insulator and pin post type 56/57-2 under-lightning surge voltage were analyzed the lightning surge currents at 10/350 μs by lightning currents 20 kA, 40 kA and 80 kA. The pin post insulator was analyzed that the distribution electric field was the most suitable for the installation of distribution line on the top of insulation along the straight path and at the side of insulation along curved path. Since an electric field distribution near the ground area was distributed at least and more the air gap. The chance of flashover and breakdown might be tougher than line post insulator.



a) Electric field Line post Insulator



b) Electric field Pin post Insulator

Fig. 11. The electric field near ground in case of voltage surge 495 kV.

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