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EXPERIMENTAL INVESTIGATION ON DIELECTRIC PROPERTIES OF 1512L INSULATOR USING FINITE ELEMENT ANALYSIS (FEM)

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Abstract

In this work, a study on a cap and pin insulator (1512L) is proposed to evaluate the distribution of the electric field and the potential along the insulator under different conditions. A computational and experimental study for the examination of a real insulators model is assessed. Tests on contaminated insulators in the laboratory under the suggested conditions have been carried out. Finite element methods (FEM) have been employed in the numerical analysis to assess the electrical properties of the insulator under the suggested contamination profiles, including potential and electric field. The study proposed in this paper provides an effective and practical tool for analysis and enhance the dielectric properties of the studied insulator.

Keywords: insulator, pollution, electric field, experimental, simulation FEM.

1. INTRODUCTION

Today, electricity plays a vital role in the evolution and industrial progress and economic development of countries. Therefore, it is necessary to always ensure a better balance between energy production and increased demand. This is why an interesting part of its importance is associated with the network, mainly high voltage lines [1]. Under normal operating conditions, high voltage insulators are quickly covered with different types of pollutants. In addition to maintaining and functioning at the service voltage, the insulators also need to withstand a variety of environmental constraints. Pollution of insulating surfaces is a primary problem in the failure of insulation performance of high-voltage structures (substations and lines). The polluted agents are transported and carried with the help of the wind and deposited on the insulating surfaces of the insulators. Various polluting deposits will be more or less conductive, and this in the presence of humidity. This consequently results in a reduction in the withstand voltage through the insulator. The arc originates on the surface of the insulator and can propagate and grow, resulting in total flashover of the insulator [2,3]. As a result, in order to comprehend how pollution affects the insulator, one must be aware of how the electric potential and field are distributed. Arc initiation and propagation are greatly influenced by the repartition of the electric field along the insulator, that is dependent upon a number of parameters [4]. An area with a lot of localized electrical tension is when an arc first begins. Numerous theoretical and practical studies have been conducted to examine the effect of the pollution distribution's non-uniformity on insulators' flashover voltage. Certain investigations' findings are incongruous [5, 6].

In this work, the effects of pollution on the behavior of insulators are studied. Experiments were carried out to examine the performance of an insulator with uniform and non-uniform contamination of the insulator surface.

This paper presents the results from this experimental study.

The primary goal of this research is to simulate the potential and the electric field repartition along a glass insulator (1512L) insulator, under different conditions: polluted and clean. The research proposes a study of three scenarios, in which different levels of tension and conductivities are applied.

Firstly, a single polluted insulator is taken by applying a minimal voltage. Then, 3 attached (polluted) sheds are studied by applying an average voltage. Finally we take a chain of polluted insulators by applying a high voltage. Based on the finite element approach, the Comsol multiphysics tool, is utilised to carry out the various simulations.

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2. EXPERIMENTAL TESTS

2.1 Description of samples

The glass insulator with a cap and pin (1512L) was selected to study the repartition of potential and electric field with and without pollution. This type of insulator has been extensively tested and used in various applications, demonstrating its ability to withstand harsh environmental conditions, high voltage levels, and mechanical stresses. Additionally, the Cap and pin 1512L insulator is cost-effective compared to other types of insulators, making it a practical choice for make studies where budget constraints may be a concern. Its simple design also makes it easy to install and maintain, reducing downtime and operational costs. Details of parameters of the chosen model are illustrated in Table 1, and the photograph is given in Fig. 1.

Table 1. Insulator parameter of 1512L insulator

Parameter	Value (mm)
Creepage distance	292
Flashover distance considered in the air	230
Insulator's Cap	244
Insulator's Pin	125

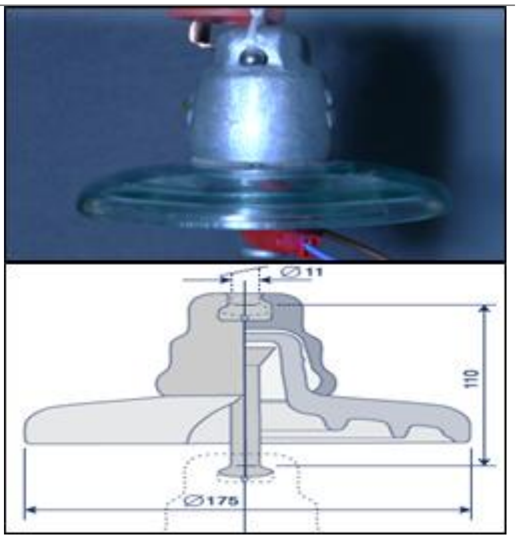

Fig. 1. Dimensional characteristics of the insulator designed Cap and Pin insulator

2.2. Preparation of simple

Sodium chloride NaCl, 20 g/l of kaolin, and distilled water made up the solution used to investigate the impact of the pollution on the insulator. In this study, light and heavy pollution levels are represented by equivalent salt deposition densities (ESDDs) of 0.01 and 0.1 mg/cm2, respectively.

The flashover voltage values shown in this work are the mean of 10 tests made again for every instance in order to achieve an accurate investigation. Insulator tests and Experimental results are presented in fig. 2 and table 3 respectively.

2.3. Experimental setup and Methodology

In the present work, the behavior of real and experimental model of the insulator is evaluated. The samples were previously immersed in NaCl saline solutions of different conductivity level. An experimental setups was used in the present work: flashover tests. The impact of the conductivity and the distribution of pollution on the behavior of the high voltage insulator cap and pin, artificially polluted is described. The following sections will give details of the experimental procedure.

Fig. 3 illustrates the common assembly chart of the test setup. Transformer 120 kV provides the DC test voltage. It also provides a control panel, a smoothing capacitor, a damping resistor, and a high-voltage diode D for half-wave rectification. A digital measuring instrument records the flashover voltage, an experiment cell, between the resistive voltage divider and the protective resistor is a suspension insulator [7].

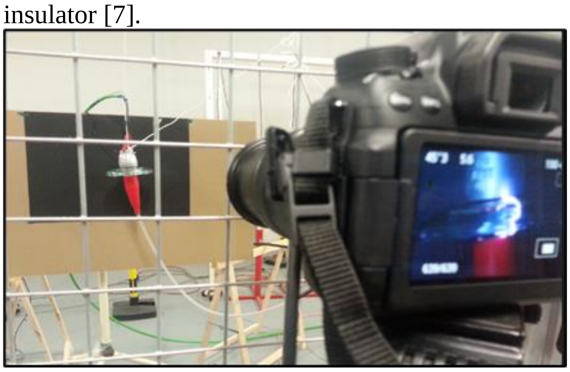

Fig. 2. Insulator test

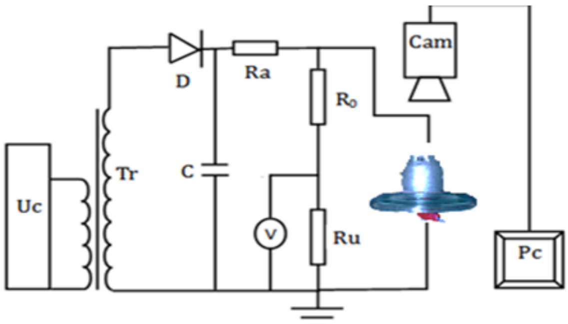

Fig. 3. The measurement's circuit diagram

2.4. Flashover study

A specific setup was designed in order to perform DC flashover tests of the samples. As illustrated in Fig. 2, the flashover test setup is constituted of the insulator sample placed between two identical stainless-steel electrodes. The high voltage electrode is connected to a DC generator and the other electrode is grounded. The electrodes are fixed to a support. The voltage is applied until the flashover occurs. The effect of the pollution on the behavior of the insulator (real model) studied. A leakage current has been observed to be produced by applying a minimal voltage between the electrodes. Fig. 4 illustates the commencement of arcs.

Table 3. Experimental values

Insulator type	Surface conductivity σ_P(μS)	U_{cm}(kV)
D=175mm H=110mm	10	17.0
	15	16.2
	20	15.1
	25	14.3
	30	12.8
	35	10.4
	40	10.1
	45	9.7
	50	9.0
	55	8.6

A leakage current has been observed to be produced by applying a minimal voltage between the electrodes. Fig. 4 illustates the commencement of arcs. Due to the Joule effect, the solution of salt evaporates where the high voltage electrode is located due to the high current density, creating a dry area. Variations in leakage current and voltage flashover were monitored during the experimental investigations. In summary, the width, position and conductivity of the contaminating layer affect the flashover.

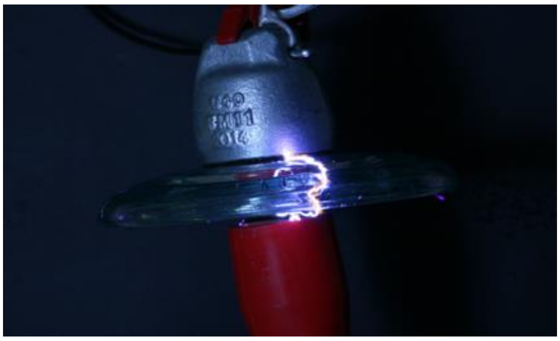

Fig. 4. Flashover observed for experimental polluted insulator

3. SIMULATION MODEL

To carry out this study, an insulator profile was designed. This profile contains the characteristics shown in Table 1 and the geometry illustrated in Fig. 1. The electrical parameters of materials are shown in Table 4.

The distribution of the electric field on an insulator surface is frequently studied using the finite element technique (FEM). Triangular or quadrilateral elements define the surface of a zone-applied FEM. When it comes to calculation speed and accuracy, the FEM offers significant benefits. Refer to the following sources for a thorough description on how to compute the field distribution using FEM [9, 10]. Researchers at government laboratories and engineering firms alike have come to adopt commercial finite element analysis packages, such as COMSOL multiphysics. Therefore, COMSOL multiphysics is employed for FEM analysis.

Table 4. Electrical parameters of materials

Material	Relative electric permittivity εr	Conductivity σ(S/m)
Glass	4,2	0
Iron	1000	$5{,}9.10^{7}$
Cement	15,00	1.10^{-4}
Steel	1000	$5{,}9.10^{7}$
Air	1.00	0

The 2D computational problem is selected for the current simulation, and electric currents are the chosen type. The electric field equations and Maxwell's formula for the symmetrical situation are represented in equations (1) and (2) [8].

$$E = -\nabla U \tag{1}$$

$$\nabla E = \frac{\rho}{\varepsilon} \tag{2}$$

Combining the continuity formula in use today with Ohm's law and Maxwell's equation, as shown by (3) and (4), respectively:

$$\nabla J = \frac{\delta \rho}{\delta t} \tag{3}$$

$$J = \sigma E \tag{4}$$

We note:
U : The electrical potential (V)
E : The electric field(V/m)
ε : The dielectric material's permittivity
ρ: The density of charges (C/m^3)
J : Current density(A/m^2)
σ : The electric conductivity

4. RESULTS AND DISCUSSION

4.1. Clean insulator modeling

Everywhere the system exits, a boundary condition is necessary. The insulators string that has an applied voltage in the first pin and a ground voltage in the third cap can be used to set up this boundary condition [9]. A broad interpretation was given based on mathematical model of the effect of pollution on the insulator's surface. Comsol has been used to model and simulate a clean cap and pin insulator as illustrated in fig. 5. One crucial phase in the simulation process that has a direct impact on the correctness of the computational results is meshing. In order to reduce the error computation, a meshing analysis is therefore necessary (fig. 6). Where greater accuracy is needed, the essential areas of the insulators have a higher mesh density.

Two boundaries have been established for the models: the pin, which represents the location of the electric potential, and the addition of 20 kV of voltage for each insulator in the chain. The final insulator's cap, which serves as the ground, is the second barrier. For this case, we took the following scenarios as boundary conditions:

Scenario 01: we take a single clean insulator (one shed) by applying a voltage of 10KV.
Scenario 02: we take 3 sheds attached (small chain) by applying a voltage of 30 kV.

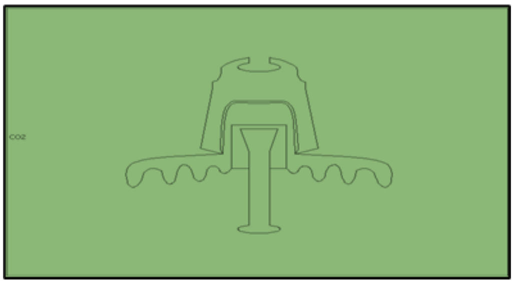

Fig. 5. Clean insulator developed by COMSOL

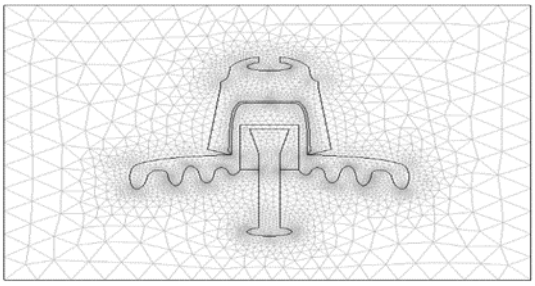

Fig.6. Finite element mesh of the studied model

A Cap and pin insulator with a single shed has been successfully modeled and simulated in Comsol. The simulation results were described and interpreted subsequently. In Fig. 7, the simulation results for the equipotential lines of a clean insulator are shown. Based on these findings, it is evident that the voltage repartition is not uniform and that the most concentrated area is in around the HT electrode while that close to the earth electrode, the voltage is practically zero.

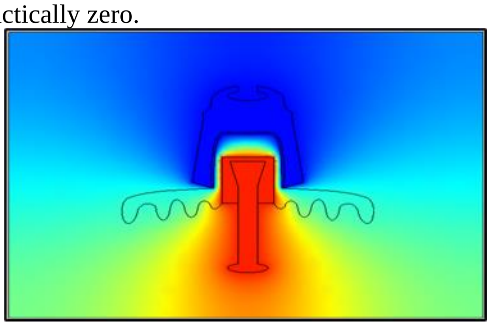

Fig. 7. Potential distribution for the insulator in the clean case

From Figs 8 and 9, it can be noticed that the electric field becomes stronger and condensed near the HT electrode (pin), while it weakens near the ground electrode (cap). Additionally, the ground electrode is where the electric field lines diverge from the HT electrode. Changes in the density of leakage current through the insulator's surface under clean conditions can generate flashover voltage. Due to geometry, the field and longitudinal current density at the surface of an insulator are always inhomogeneous. The current density, which is dependent on the insulator's shape, is largest in the cylinder area, the rod-shaped area. An enhanced electric field combined with a high current density causes a greater loss of power. [11, 12].

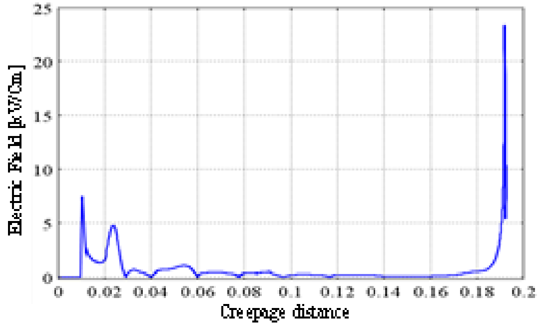

Fig. 8. Electric field evolution along the insulator

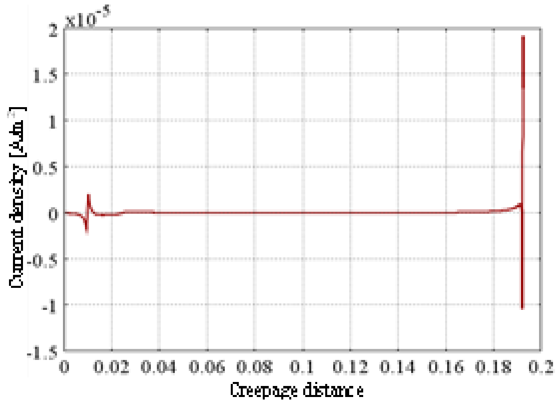

Fig. 9. Current density along the insulator in the clean condition

Now, Comsol has been used to model and simulate a cap and pin insulator with three sheds (30 kV) with success (Fig 10). Following was an explanation and interpretation of the simulation results.

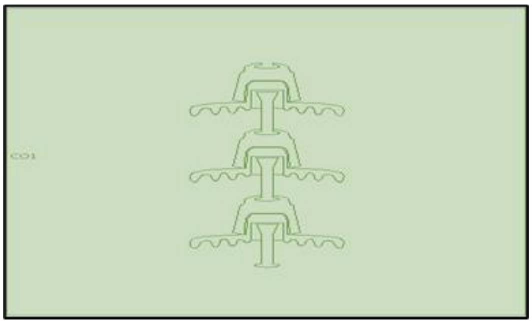

Fig. 10. Presentation of insulator string in the clean case

Fig. 11 illustrates the potential variation through the cap and pin insulator string. It can bed notice that the electric potential is important for the high voltage (HT) side then it starts to decrease as we move away towards the earth side. In the case of our model (three sheds), 30 kV is the highest possible value of the applied voltage. The voltage appeared increased next to the pin, on the HT side, then it decreased linearly as it moved away towards the 'earthed' cap, then the potential was canceled.

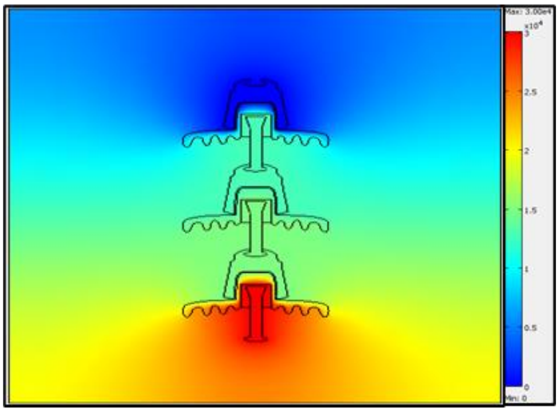

Fig. 11. Distribution of the potential for the insulator string in the clean case

For various applied voltages, the change in electric field with respect to leaking distance is assessed. There were three applied voltage levels taken into consideration. (10, 20, and 30 kV) in a clean condition.

From Figs 12 and 13, we can notice that the electric field becomes lower at the ground electrode in 3rd level (cap), while it is higher near the HT electrode in 1st level (pin). Additionally, the electric field lines disperse from the HT electrode to the earth's electrode. The change in current density linked to the chang in electric field or we notice that the current is low in ground level (cap) and begins to gradually rise in HT level (pin).

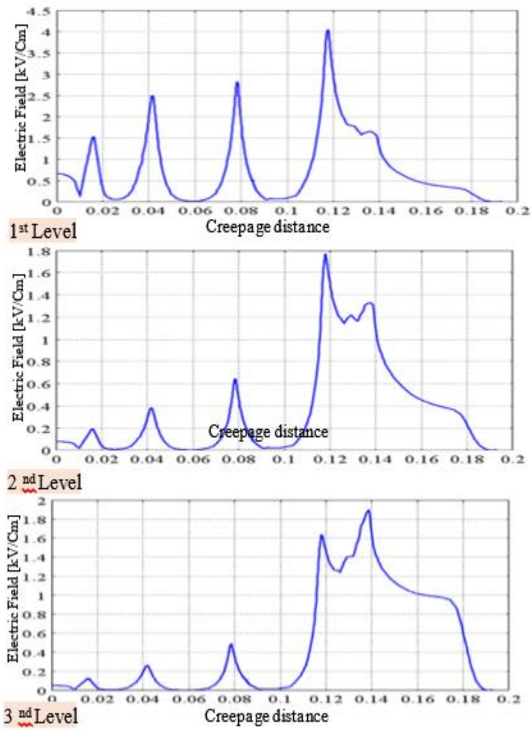

Fig. 12. Evolution of the electric field of the three applied voltage levels in the clean condition

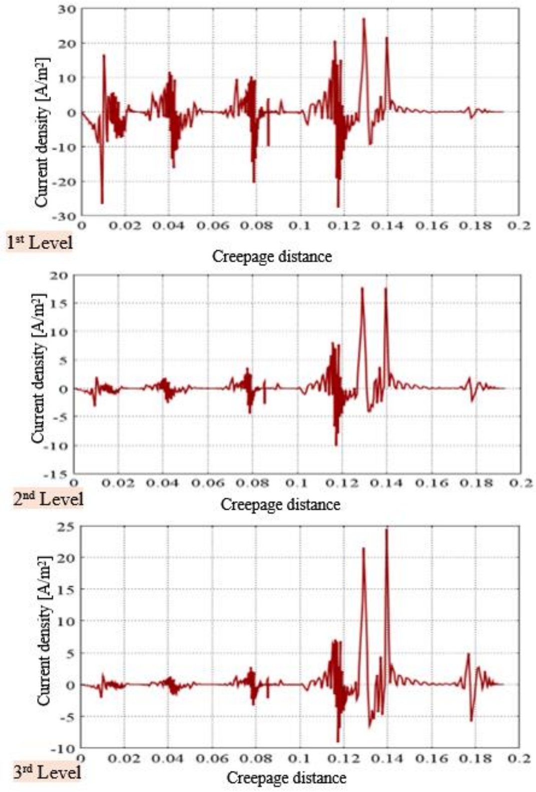

Fig. 13. Current density along the insulator string of the three applied voltage levels in the clean condition

4.2. Polluted insulator modeling

In this part, the distribution of voltage and electric field by applying a pollution layer on the surface of the insulator will be studied. The goal is to see the effect of different conductivities and contamination properties on the voltage distribution. To do this, we will present several comparison scenarios while comparing the results obtained with the clean state.

4.2.1. Non -Uniform Pollution

In this work, a non-uniform pollution layer was applied to the insulator's surface. The results of simulation are illustrated in figs : 14, 15 and 16.

The insulator leakage distance and non-uniformity of pollution have both been studied on the complete upper and lower surfaces. We notice that, as expected, the potentials have a maximum near the high voltage electrode and start to decrease until zero near the earth side.

Non-uniform pollution the upper and lower sides is linked with the flashover voltage around the insulator surface. It is commonly recognized that the position of the pollutants affects the electricfield intensity. The highest electric field stress was reported in the pollutant layer nearest the powered end [13, 14]. The non-unifomity between the upper and bottom surfaces may exist along the insulator length.

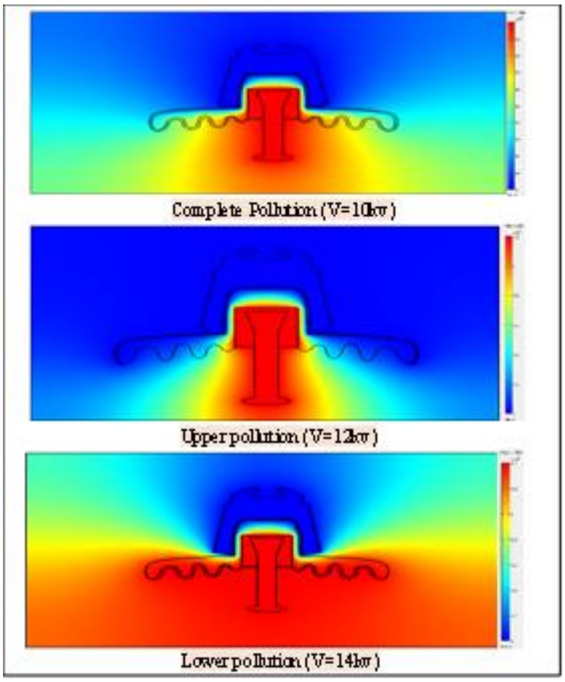

Fig. 14. Equipotential distribution in case of non-uniform pollution

Non-uniform pollution in the upper and lower sides is linked with the flashover voltage around the insulator surface. It is commonly recognized that the position of the pollutants affects the electric field intensity. The highest electric field stress was reported in the pollutant layer nearest the powered end [13,14]. The non-unifomity between the upper and bottom surfaces may exist along the insulator length. By considering the varying amounts of pollution in the various zones, this can be investigated.

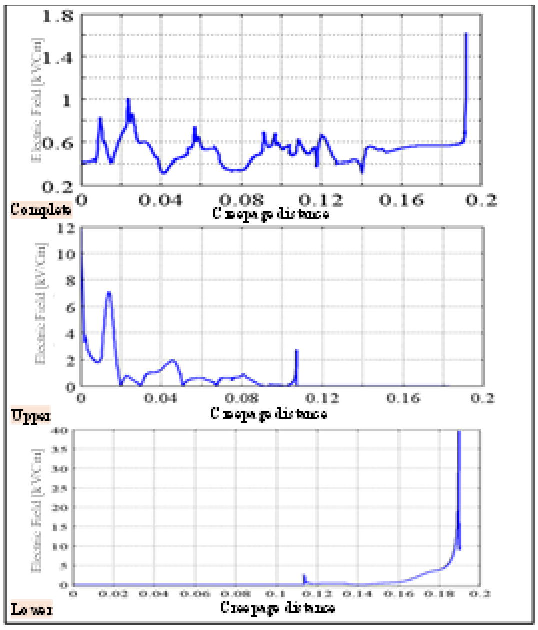

Fig. 15. Evolution of the electric field in case of non-uniform pollution

The voltage at which pollution flashover occurs is linked to the level of contamination and the degree of non-uniform contamination distribution on the insulator's upper and lower surfaces. The upper surface is usually less contaminated than the lower surface due to wind and rain's cleaning effects [8].

The field distribution along the creep age path is significantly altered by the existence of a pollution layer on the insulator's upper surface. The live-fitting-end (pin) area of the unit experiences the most stress when a homogenous pollution layer (uniform polluted state) is placed on it; yet, the amplitude of the electric field is comparable to that in a clean condition.

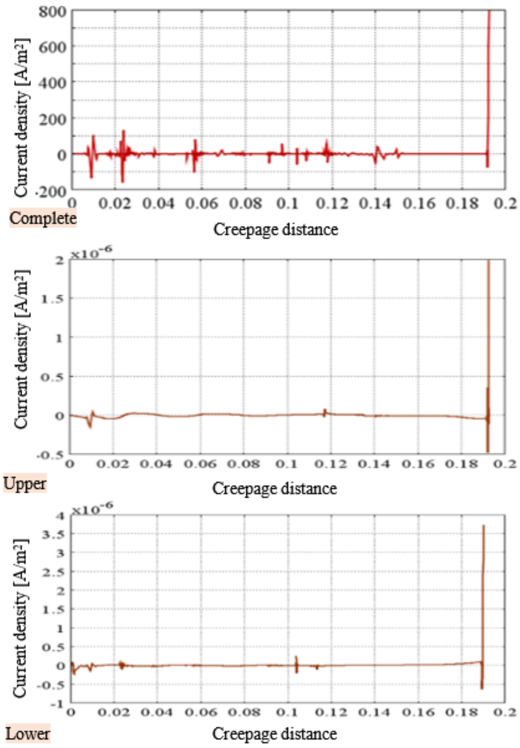

Fig. 16. Current density along the insulator in case of non-uniform pollution

The axial repartition of electric field and potential in the case of a polluted layer is as expected, the type of pollution strongly affects the potential distribution and makes it non-uniform, which means that the insulators are not subject to the same constraints as insulators which favor the appearance of flashovers and in polluted conditions. The variation of leakage current density along a non-uniform pollution layer on a cap and pin insulator, resulting an arcing voltage [13]. The degree of pollution severity and the salinity of the pollution determine the leakage current density that is generated to flow through the pollution layer and its magnitude.

4.2.2. Uniform Pollution

In outdoor applications, high voltage insulators are exposed to the atmosphere and a variety of contaminants. Consequently, the surfaces of outdoor insulators may become partially or completely polluted. The electric field and voltage distributions surrounding a clean insulator differ greatly from those around a surface contaminated to some extent or another. Thus, it is essential to comprehend how different kinds and levels of surface pollution impact the voltage distributions and electric field around an outside insulator. The pollution flashover that happens on high-voltage insulators is one of the biggest issues with power transmission lines. The modeling issues are just one of the many reasons why this is a highly complex topic [15, 16,17]. Now, we apply a uniform layer of pollution with a conductivity of (10µS, 30µS and 50µS) to the surface of the insulator. The funding obtained are illustrated in Figs: 17, 18 and 19.

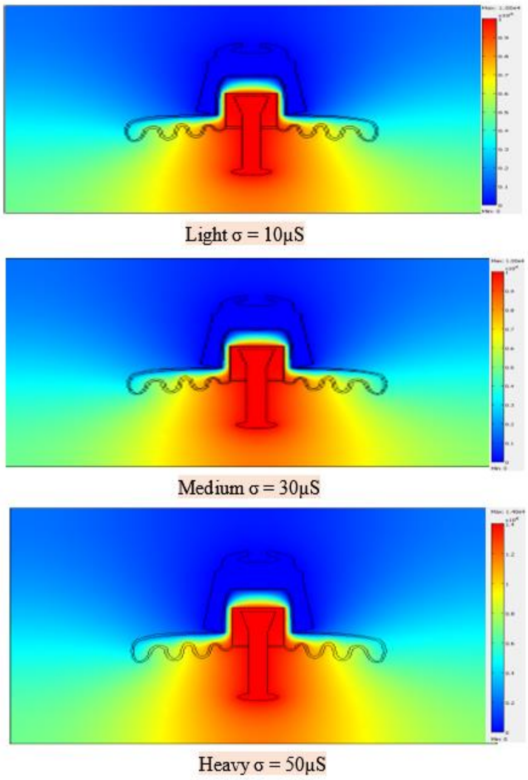

Fig. 17. Equipotential distribution in case of uniform pollution

From these figures, we notice the insulator's field distribution, With application of a voltage, the electric field distribution becomes significantly more uniform again. Additionally, the observed electric field peaks were successfully reduced when pollution application was carried out. It should be noted that the effect of NaCl appears as a uniform redistribution of the electric field, and as the pollution's conductivity rises, the flashover voltage decreases. The explanation that can be given to the results obtained is that, for all applied voltages, the highest conductivity seems to be that the leakage current increases in a non-linear way with the conductivity. We note that the conductivity affects the leakage current, so the current increases as the conductivity of the pollution increases.

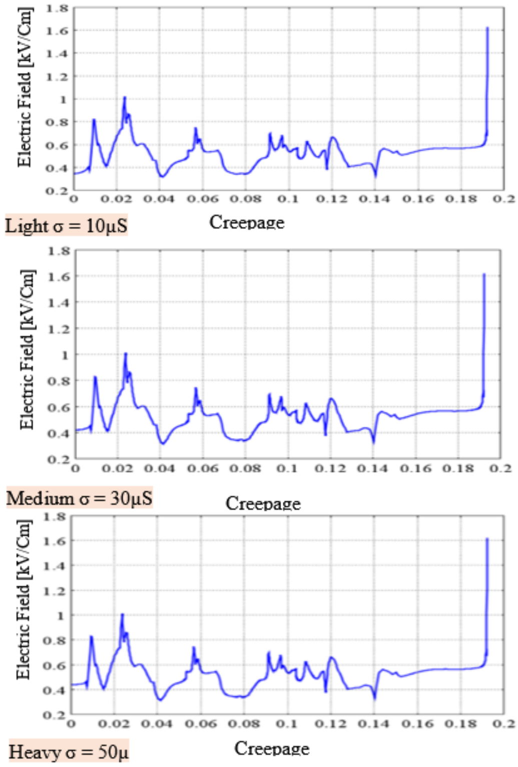

Fig. 18. Evolution of the electric field in situation of non-uniform pollution

It can be seen that for a rise in leakage current there will be an associated increase in the applied voltage for all conductivities.

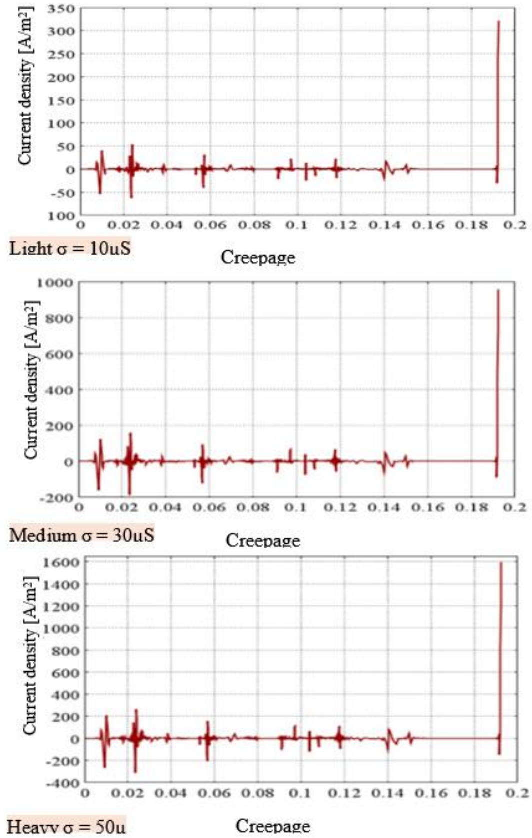

Fig. 19. Current density along the insulator in the uniform pollution condition

CONCLUSION

This paper developed and carried out an experimental insulator model (cap and pin 1512L) to assess the effects of the pollution layer on the insulator's performance. The flashover performance is examined and assessed using experimental, analytical and numerical analysis.

The non-uniform repartition of pollution has an impact on insulator flashover, according to the pollution performance studies carried out in this paper based on the flashover current flashover.

Two-dimensional models of the 1512L cap and pin insulator were made for this study; one model was a single insulator, and the other was a chain of three insulators with and without pollution. To evaluate how the analyzed variables affected the distribution of the electric field and electric potential, simulations of the models were created using COMSOL Multiphysics.

Simulations were performed to evaluate the impact of conductivity, pollution layer position on the distribution of the electric field through a cap and pin insulator. Based on the modeling results, it seems that the length and position of the pollution layer have a substantial influence on the electric field.

The electric field strength decreased and the potential distribution got closer to the linear state with an increase in pollution conductivity. The uniform condition closest to the data range may have higher electric field strength levels than non-uniform pollution created with random data. In non-uniform pollutions with two different conductivities on the upper and bottom surfaces, the electric field intensity decreased in the cap region as the upper pollution conductivity increased, whereas it decreased in the pin region as the bottom pollution conductivity increased. In this research, experimental measurement is carried out with inexpensive and simple measuring equipment that may be used in any high-voltage laboratory. The measurement process is also easily repeatable by other writers and is clearly stated. Based on the results, future work can be performed to make additional experimental studies to verify the accuracy of the simulation results. Extend the scope of the study to assess how additional environmental factors, including variations in humidity and temperature, affect the effectiveness of insulators. These recommendations can be applied and extended to other insulators of higher voltage class of the electrical power system.

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Author contributions: *K.BELHOUCHET is the primary author of the manuscript, and all authors gave their reviews and approval.*

Declaration of competing interest: *The authors note that no known competing financial interest or personal relationship may have had any effect on any of the work disclosed in this study.*

REFERENCES

1. Belhouchet K, Bayadi A, Bendib ME. Artificial neural networks and genetic algorithm modelling and zot of arc parameter in insulators flashover voltage and leakage current. International Journal of Computer Aided Engineering and Technology. 2019; 11(1): 1-13. https://doi.org/10.1504/IJCAET.2019.096708.
2. Douar MA, Mekhaldi A, Bouzidi MC. Flashover process and frequency analysis of the leakage current on insulator model under non-uniform pollution conditions. IEEE Trans. Dielectr. Electr. Insul. 2010; 17(4): 1284–1297. https://doi.org/10.1109/TDEI.2010.5539701.
3. Belhouchet K, Bayadi A, Belhouchet H, Romero M. Improvement of mechanical and dielectric properties of porcelain insulators using economic raw materials. Boletín de la SociedadEspañola de Cerámica y Vidrio 2019; 58(1): 28-37. https://doi.org/10.1016/j.bsecv.2018.05.004.
4. Belhouchet K, Bayadi A, Alti N, Ouchen L, Effects analysis of the pollution layer parameters on a high-voltage porcelain cylindrical insulator using response surface methodology. Diagnostyka 2021; 22(2): 21-28. https://doi.org/10.29354/diag/134114.
5. Ghiasi Z, Faghihi F, Shayegani-Akmal AA. et al. FEM analysis of electric field distribution for polymeric insulator under different configuration of non-uniform pollution. ElectrEng 2021; 103: 2799–2808. https://doi.org/10.1007/s00202-021-01252-2.
6. Mousa MI, Abdul-Malek Z, Mousa ZI. Leakage current based thermal modeling of glass disc insulator surface. IJEECS 2017; 6(3): 504–512. http://doi.org/10.11591/ijeecs.v6.i3.pp504-512.
7. Ouchen L, Bayadi A, and Boudissa R. Dynamic model to predict the characteristics of the electric arc around a polluted insulator. IET Sci.Meas.Technol. 2020; 14(1): 83–90. https://doi.org/10.1049/iet-smt.2019.0029.
8. Alti N, Bayadi A and Belhouchet K, Grading ring parameters optimization for 220 kV meta-oxide arrester using 3D-FEM method and bat algorithm. IET Sci. Meas. Technol 2021; 15(1): 14-24. https://doi.org/10.1049/smt2.12002.
9. Benguesmia H, M'ziou N, Boubakeur A. Simulation of the potential and electric field distribution on high voltage insulator using the finite element method. Diagnostyka 2018; 19(2): 41-52. http://dx.doi.org/10.29354/diag/86414.
10. Ghiasi Z, Faghihi F, Shayegani-Akmal AA. FEM analysis of electric field distribution for polymeric insulator under different configuration of non-uniform pollution. ElectrEng 2021; 103: 2799–2808. https://doi.org/10.1007/s00202-021-01252-2.
11. Ilomuanya CS, Farokhi S, Nekahi A. Electrical power dissipation on the surface of a ceramic insulator under pollution condition. in Proc. IEEE Conf. Electr. Insul. Dielectr. Phenomena (CEIDP) 2018; 199–202.
12. Albarracín R, Ardila-Rey JA, Mas'ud AA. On the use of monopole antennas for determining the effect of the enclosure of a power transformer tank in partial discharges electromagnetic propagation. Sensors 2016; 16(48): 1–18. http://dx.doi.org/10.3390/s16020148.
13. Boudissa R, Djafri S, Belaicha R. Effect of insulator shape on surface discharges and flashover under polluted conditions. IEEE Trans. Dielectr. Electr.

Insul. 2005; 12(3): 429–437. https://doi.org/10.1109/TDEI.2005.1453447.

14. Xu Y, Cheng J, Liu W, and Gao W, Evaluation of the UHF method based on the investigation of a partial discharge case in post insulators. IEEE Trans. Dielectr. Electr. Insul. 2017; 24(6): 3669–3676.
15. Salem AA, Abd-Rahman R, Al-Gailani SA, Kamarudin MS, Ahmad H, Salam Z. The leakage current components as a diagnostic tool to estimate contamination level on high voltage insulators' IEEE Access 2020; 8: 92514–92528. https://doi.org/10.1109/ACCESS.2020.2993630.
16. El-Shahat M, Anis H. Risk assessment of desert pollution on composite high voltage insulators. J. Adv. Res. 2014; 5(5): 569–576. https://doi.org/10.1016/j.jare.2013.07.008.

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