Solution of Electromagnetic Field Distribution Around the 22 kV Poles Embedded with Bird-barrier

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Abstract — **This paper deals with the solution of electromagnetic field distribution in the vicinity of 22 kV poles equipped with the bird barriers. However, in some cases, these barriers serve as birds' habitats. Bird barriers are mostly electrically and magnetically non-conductive. However, due to the weather conditions, the material properties of these barriers are changed. For the purpose of this paper, appropriate anti-bird barriers have been selected that have been placed in a high-polluted area. Due to pollution, electric and magnetic properties on the surface had changed. Since pollution was an electrically conductive material, it also affected the distribution of electrical and magnetic fields. Therefore, this paper presents the results of simulations of the distribution of electric and magnetic fields around 22 kV poles fitted with bird barriers, considering a high degree of pollution of the avi-barrier.**

Keywords: electric pole; bird barrier; 22 kV power line; electromagnetic field; electric intensity; magnetic induction

I. Introduction

This article analyzes and describes the electromagnetic field distribution around console of the 22 kV pole. The main initiative for the solution of the subject matter was the fact that the placement of bird barriers in areas with a high degree of contamination and pollution can affect the distribution of the electric and magnetic fields around the pole. A dirty barrier is essentially a high-ohmic load, and for a given high-voltage power line it is like a short-circuited turn. Pollution affects the change in the distribution of the electromagnetic field and it is therefore necessary to consider this change, which can affect eg. higher power losses, higher corona rates at the edges or edges of the soiled barrier, higher safety requirements for live work on these poles and the like.

For this reason, this article describes a computer simulation in the ANSYS Workbench environment of the electromagnetic field distribution around the 22 kV pole console. The simulation results for different barrier types were evaluated and compared.

II. Analysis of the Distribution of the Electromagnetic Field Around the HV Poles, Before and After Equipping the Bird-Barrier

A. *Analysis of magnetic field distribution*

The 22 kV pole, together with its base and conductor fasteners, eventually grounding cables, is the element of the support points that form the external power lines. Their shape, height, construction and material depend mainly on the voltage level and the number of systems. An iron-concrete pole of 22 kV power line with horizontal conductor arrangement was considered in this paper (Fig. 1).

Figure 1. View of considered (real) 22 kV pole

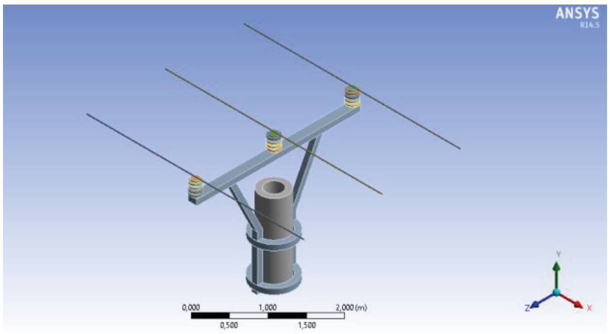

Figure 2. View of a modeled 22 kV pole

The following material constants listed in Table I [20–24] were used to simulate the magnetic field distribution. Pollution represents continuous solid contamination of 1 mm thickness and with electric and magnetic properties mentioned in Table I.

TABLE I. MATERIAL CONSTANTS FOR MAGETIC FIELD

Material	Relative magnetic permeability [–]	Electric resistivity [Ω/m]
Concrete	1,0013	400
Copper	0,99999	$1{,}75.10^{-8}$
Plastic (PVC)	1	1.10^{14}
Porcelain	1	1.10^{13}
Air	1,0000003	1.10^{11}
Iron	50	$1{,}3.10^{-7}$
Pollution	1,0006	34,84

Additional data were needed to be set up in the ANSYS Workbench, like current load of the conductors. Since the most unfavorable state was sought in this analysis, a full load of phase conductors, ie 300 A, was considered.

The simulations were performed on a server where the ANSYS software license was installed (12-core processor, 96 GB RAM). The calculation was quite fast (meshing about 4 hours (mesh size 1 cm), calculation of magnetic induction distribution, or electrical intensity: about 3 hours).

Pole without bird barriers

In order to compare the magnetic induction values around the contaminated bird barrier, it was necessary to first calculate the magnetic field distribution around the 22 kV pole console without using an avi-barrier (Fig. 3).

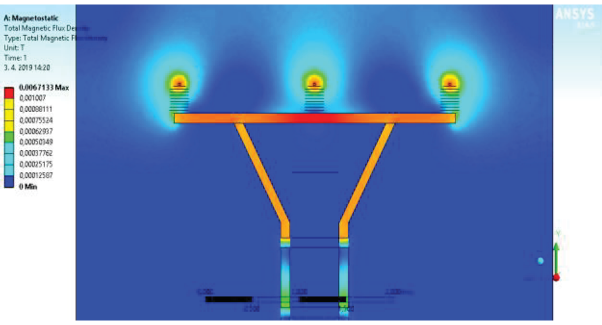

Figure 3. Magnetic field distribution around the 22 kV pole

The highest values of magnetic induction ***B*** are located in the center of the console because it is magnetized not only from the middle phase L_2, but also from the remaining (outer) phases L_1 and L_3 (Fig. 3). It can also be observed that, without the presence of bird barrier, and with a symmetrical load, the magnetic field is not deformed. The biggest influence on the magnetic field distribution is the metal pole console, which has relatively high relative permeability.

Pole with ridge bird barriers

Although there are no new ridge barriers at the moment, there are still plenty of poles where these ridge barriers are being installed. For this reason, these types of barriers were also considered in the simulations. The shape and fitting of the ridge barriers can be seen in Fig. 4.

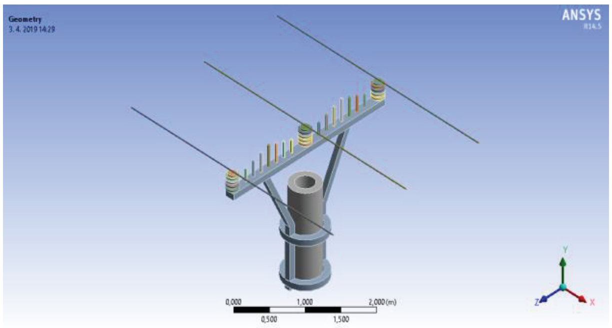

Figure 4. View of the 22 kV pole fitted with the ridge barriers

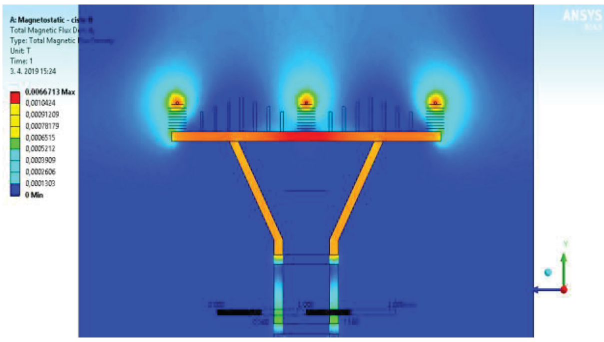

Figure 5. Magnetic field distribution around the 22 kV pole fitted with ridge barriers

The presence of ridge barriers does not have a significant effect on the magnetic field distribution (Fig. 5). This is due to the fact that these ridge barriers are made of a plastic material that has a relative magnetic permeability close to 1. For this reason, these ridges are very little magnetized. Furthermore, it is seen that the highest values of magnetic induction ***B*** are found on the carrier console, due to the fact that its relative permeability is high compared to other materials. It is also seen that the higest values of magnetic induction are located in the center of the console where the adjacent phases L_1 and L_3 are affected.

Since the barrier is relatively difficult to contaminate on its surface (from the top of the barrier, at the tips), the resulting magnetic field distribution, including contamination, was almost identical to the no-pollution variant.

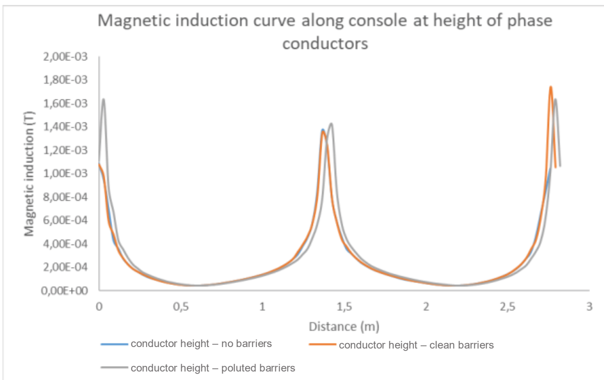

Figure 6. Comparison of the pole magnetic field and the magnetic field of the pole with ridge barriers at conductor height

Pole with bracket barrier against birds

The currently most widely used type of bird barrier used on 22 kV pole consoles is so-called bracket barrier. Its advantage, compared to other types of barriers, is that it allows the birds to short-time to sit on barrier, while electrically isolating the conductive parts from the possible contact of the bird with the conductor.

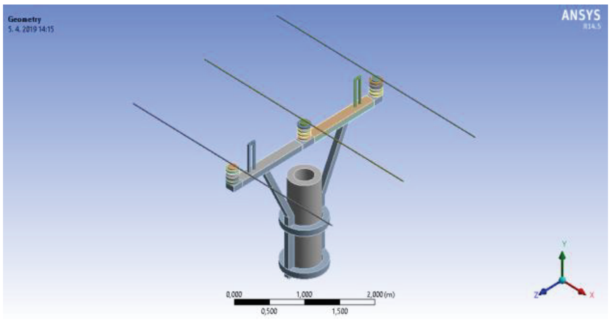

Figure 7. View of the 22 kV pole fitted with a bracket barrier

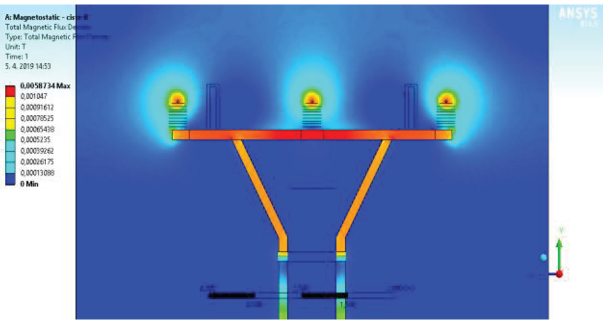

Figure 8. Magnetic field distribution around a 22 kV pole fitted with a bracket barrier

The largest values of magnetic induction appeared on the support metal console (Fig. 8). Thanks to the middle phase (L_2), a magnetic induction of 0.27 mT is induced on the surface of the bracket barrier. Based on the results of the simulation, it can be said that the presence of the bracket barrier itself does not affect the shape of the magnetic field, mainly because the bracket barrier is made of plastic material.

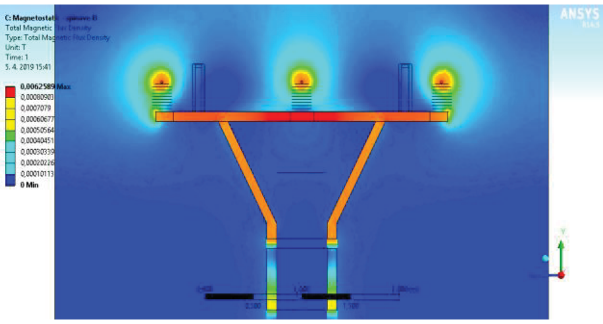

Figure 9. Magnetic field distribution around a 22 kV pole fitted with a bracket barrier and with pollution

The pollution caused an increase in the maximum magnetic induction value to 6.2 mT, because the electrical conductive contamination represented a quasi short-circuit turn (Fig. 9). As a result, magnetic induction values have increased in other locations around the console. This fact is due to the bracket barrier is fixed directly to the support console and also its top surface, which can become dirty, is quite large, therefore its influence on the magnetic field distribution is also greater than in other types of bird barriers.

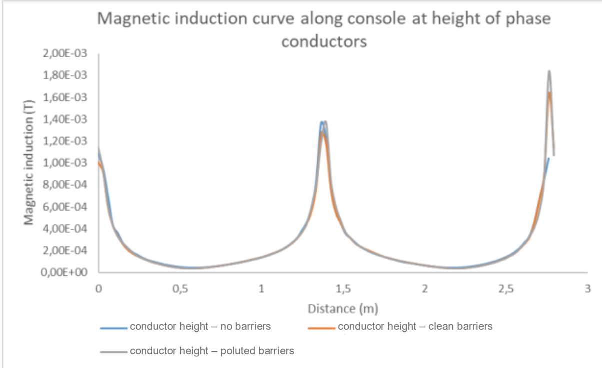

Figure 10. Comparison of magnetic field of pole without avi-barrier and fitted with bracket barrier at height of phase conductors

Pole with „H“-shape barrier against birds

Another protection against birds is the 4TECH „H“ barrier. The ZSE distribution company mainly uses this bird barrier, but it can also serve as an alternative to, for example, a bracket barrer or ridge barrier (Fig. 11).

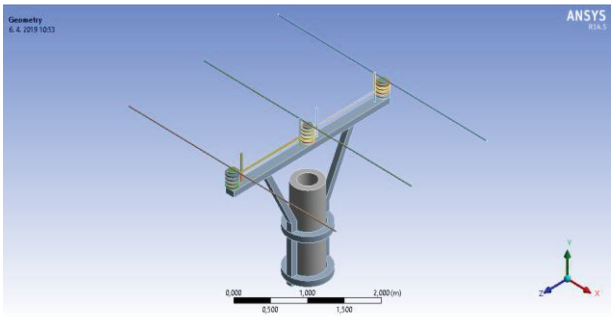

Figure 11. View of 22 kV pole fitted with avi-barrier of „H“-shape

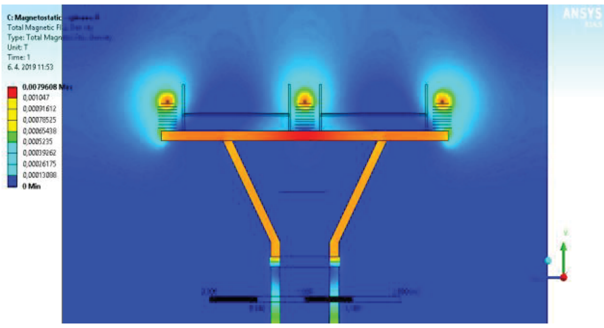

Figure 12. Magnetic field distribution around the 22 kV pole fitted with avi-barrier of „H“-shape and with pollution

From Fig. 12 it can be seen that if this barrier is contaminated, the maximum value of the magnetic induction rises to a value of nearly 8 mT, since the electrical conductive contamination represents a quasi short-circuit turn. Therefore, there is an increase in magnetic induction values. The shape of the magnetic field has not been greatly influenced by the fact that these barriers are made of plastic material and because the relative permeability of the pollution is in the range of paramagnetic substances.

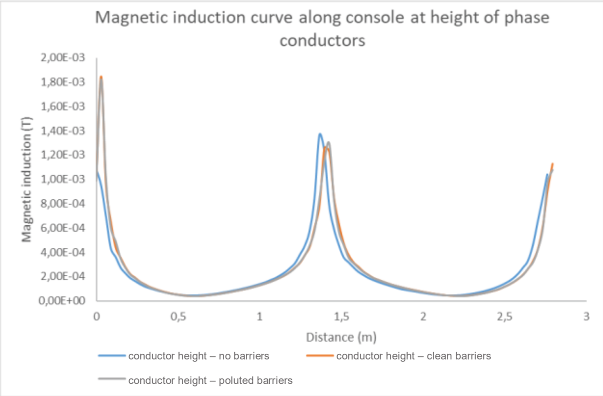

Figure 13. Comparison of magnetic field of pole without avi-barrier and fitted with „H“-shape barrier at height of phase conductors

B. Analysis of the electric field distribution

As mentioned above, the distribution of the electric field was solved separately in the ANSYS Workbench, not as a coupled field problem of electric and magnetic fields.

The material properties (electrical resistivity) of the respective pole components were selected according to Table I. Other input data in the simulations were values of the load. Since limit states were addressed for the purpose of this paper, a 100% phase conductor load (300 A) and a voltage of 23.6 kV were selected for the simulation.

The presentation of the results of the electric field will be in this paper in the form of graphs that were read on the selected curves (Fig. 14).

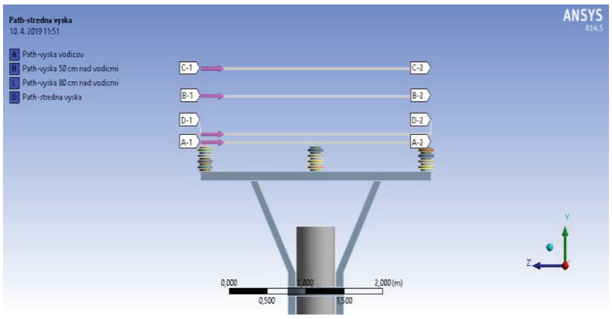

Figure 14. Curves along which the electric intensity was measured

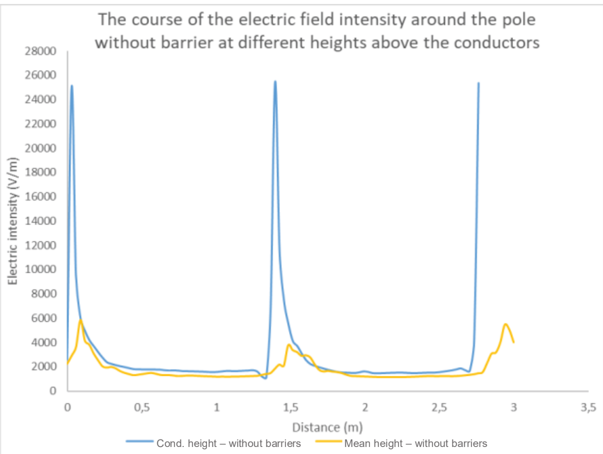

Figure 15. The course of the electric field intensity around the pole without barrier at different heights above the conductors

The graph in Fig. 15 shows that the highest values of the electric field intensity are at the hight of conductors (note: not inside the conductors, where $\boldsymbol{E} = 0$), where in the places where the phase conductors are located it reaches about 25 000 V/m. Furthermore, it can be seen that higher values are also in the middle. This mean height is needed to make further comparisons between individual bird barriers and to compare them at the same height. It can also be seen that the highest values occur around the phase conductors, with a value of about 6000 V/m. This rapid decrease in values was because the electric field intensity values are decreasing indirectly with the square of the distance from the source. It should be noted that the graph did not indicate values from inside the conductor and from near surroundings of the conductor (where the path curve passed through the conductors) because the values were oscilated, respectively, in the order of $1 \cdot 10^5$ V/m, what would lead to distortion of the graph and its visual opacity.

The following graphs show the results of electrical intensity courses around the selected types of avi-barriers.

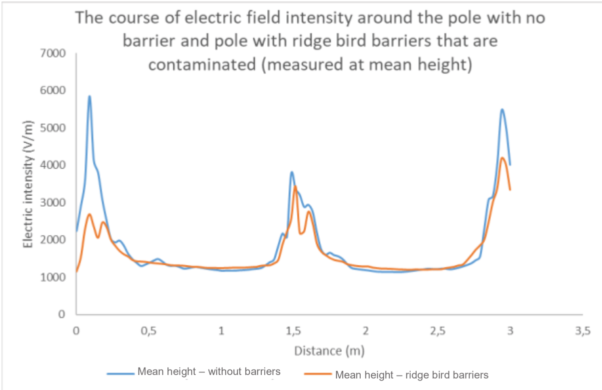

Figure 16. Comparison of the electric field intensity around the pole with no barrier and pole with ridge bird barriers that are contaminated

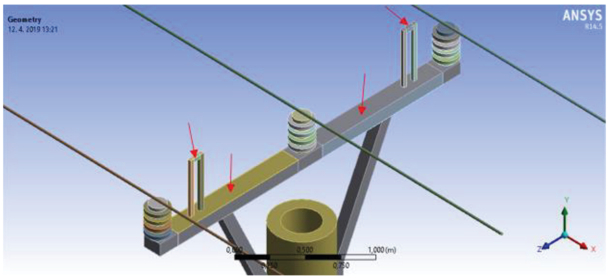

Figure 17. Detailed view of the sites where pollution was applied

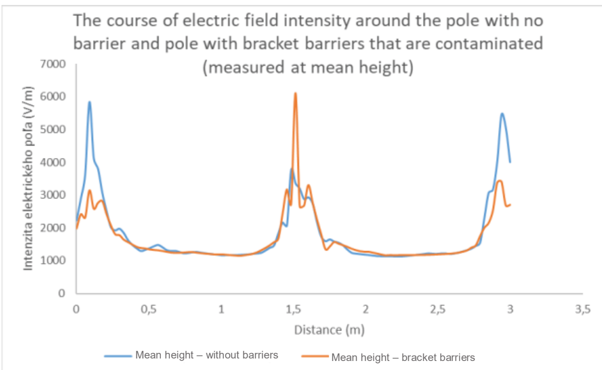

Figure 18. Comparison of the electric field intensity around the pole with no barrier and pole with bracket barriers that are contaminated

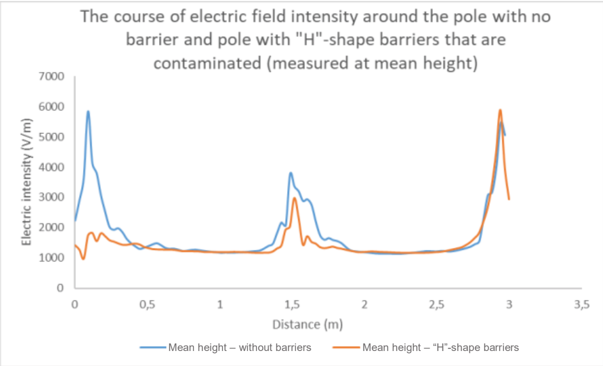

Figure 19. Comparison of the electric field intensity around the pole with no barrier and pole with „H"-shape barriers that are contaminated

From graphical dependence in Fig. 19 it can be seen that when the bird barrier is contaminated, the values of the electric field intensity at the conductor height decrease. As far as the electric field intensity in the middle height is concerned, the trend continues from the variant without pollution. The values of the electric field intensity at this height are comparable to those of a pole without barriers or even decrease below these values in some places. Exception is the location around the L_3 phase conductor. This trend is because the "path" curve along which the electric field intensity values are measured is high above the bird-placing where the bird barrier is polluted.

III. Conclusion

The aim of this paper was to analyze and describe the distribution of the electromagnetic field in the case of the application of a bird-barrier to the construction of 22 kV pole console. To compare the values, the EMF characteristic values were selected, namely the magnetic induction and the electrical intensity that are given in this paper.

It should be noted that, according to the simulated values, if the plastic material is used for barriers, their influence on the magnetic field is minimal. As far as the impact on the electric field is concerned, the electric field intensity values have increased mainly around the phase conductors. Therefore, it is also necessary to consider whether these elevated values can adversely affect birds in contact, and whether high electric field intensity can result in any injury or injury to birds and whether the operator cannot be compromised in the event of maintenance. Therefore, distribution system operators should address this issue, develop similar but more complex analyzes, complemented by real measurements and innovate bird-barriers so that their impact, whether on birds, distribution of electromagnetic fields or operators, is minimized.

Acknowledgement

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