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A NEW APPROACH FOR OPTIMAL DESIGN OF CORONA RING

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INTRODUCTION

Polymeric insulators are largely used in electrical systems. However, these equipment still present serious problems, mainly related to their polymeric material layer. When the polymer is exposed to intense electric fields, insulation failure and loss of hydrophobicity may occur.

These problems are caused due to non-uniform electric field distribution along the insulator, which tends to intensify the electric field on the sheds near to the phase terminal. Non-uniform electric field distribution can be minimized using suitable corona rings.

Since a corona ring is a very simple component, many manufacturers use empirical design criteria for its design process. However, the design of a corona ring involves a large number of variables, which makes it inappropriate to employ an empirical process.

As an example of that problem, issues involving bad corona rings design were found out at 230 kV transmissions lines of a Brazilian energy company. Insulators have presented failures after only 5 years of use, such as core tracking and fiberglass mechanical rupture. The company's suspicion was that the corona ring provided by the manufacturer was ill-designed.

After some study, the author [1] proposed a new corona ring design for the company. The author could improve the component's performance, despite no optimization method was used.

If any optimization method is applied, a better design could be achieved. With that in mind, the goal of this research is to employ several optimization methods in order to determine the optimal corona ring design for the case.

MATERIALS AND METHODS

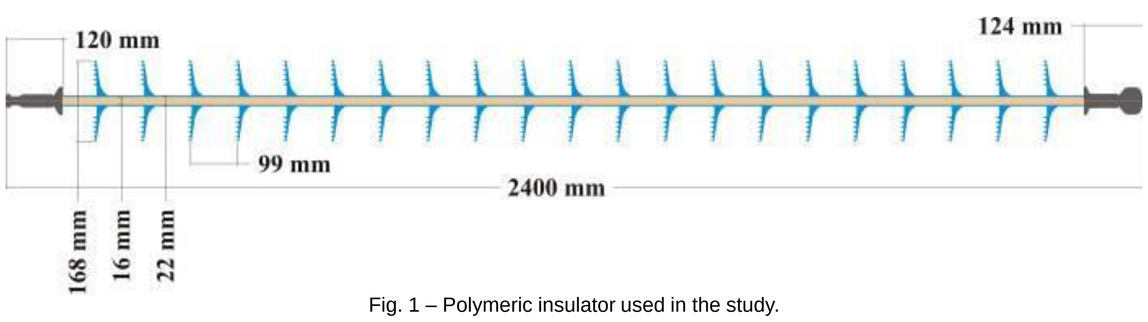

Fig. 1 – Polymeric insulator used in the study.

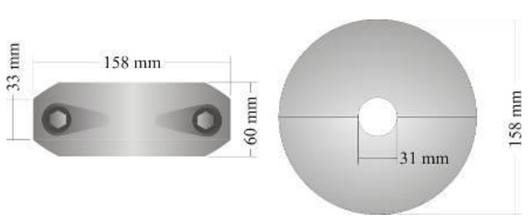

Fig. 2 – Manufacturer's corona ring.

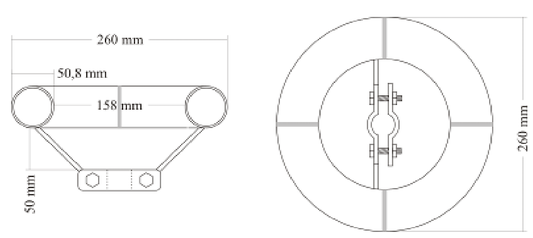

Fig. 3 – Corona ring proposed by author [1].

The methodology utilized in this study consists in perform electric field simulations using a software based in the Finite Element Method (FEM). The simulation provides the maximum value of electric field on the insulator, which is the variable to be minimized.

Then, the three optimization methods are applied to minimize the electric field value. To do that, a corona ring, with variable dimensions, is included in the simulation. The dimensions (a), (b) and (c), showed in Fig. 4, change into a pre-defined range, according with the optimization method in use. The optimization process is summarized in Fig. 5.

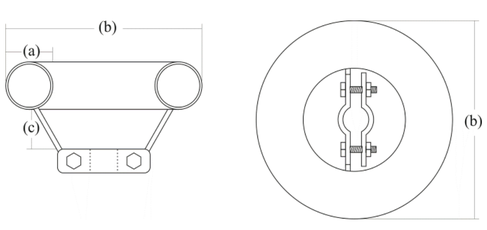

Fig. 4 – Corona ring with variable dimensions.

TABLE I. CORONA RING CONSTRAINTS.

Dimension	Minimum Value	Maximum Value
(a)	10 mm	100 mm
(b)	10.77 mm	400 mm
(c)	37 mm	323.4 mm

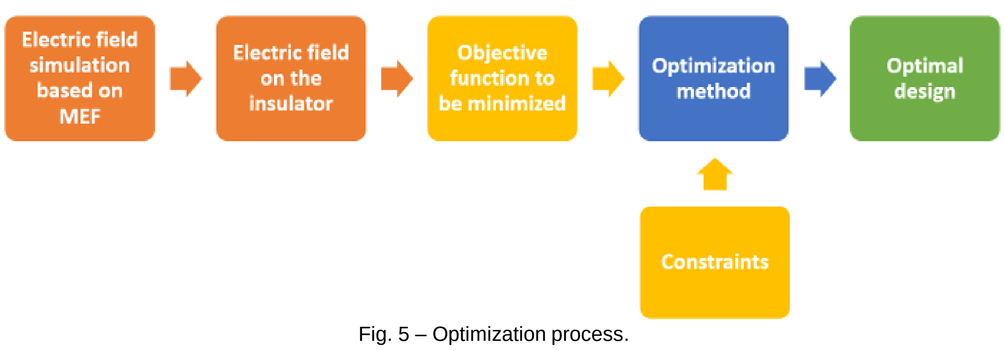

Fig. 5 – Optimization process.

RESULTS AND DISCUSSION

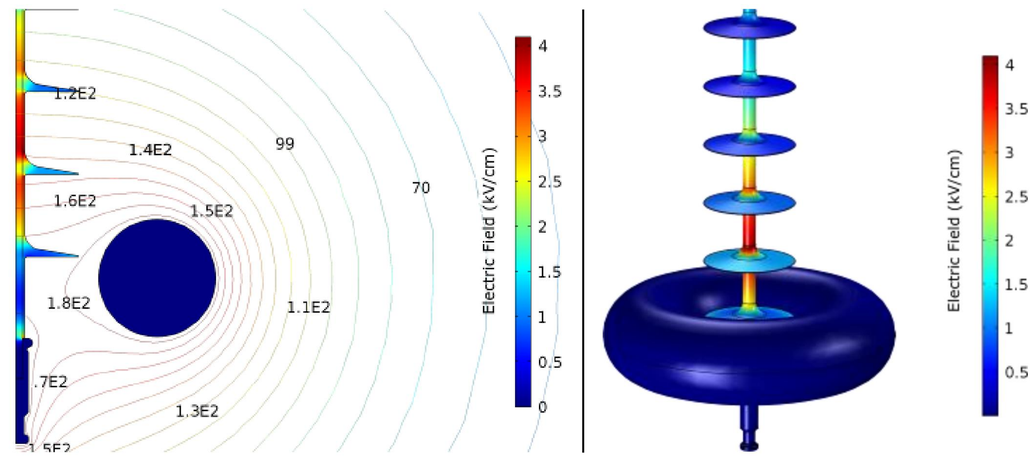

Fig. 6 – Electric field distribution for the optimized corona ring.

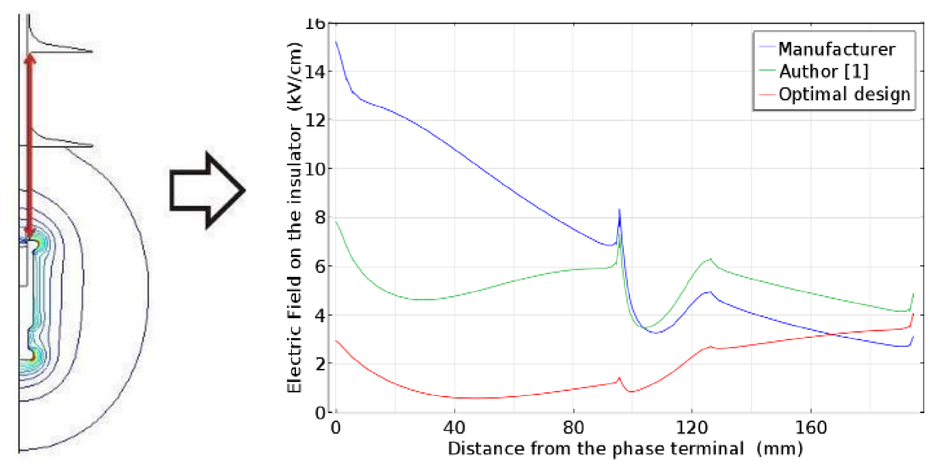

Fig. 7 – Electric field distribution for the optimized corona ring.

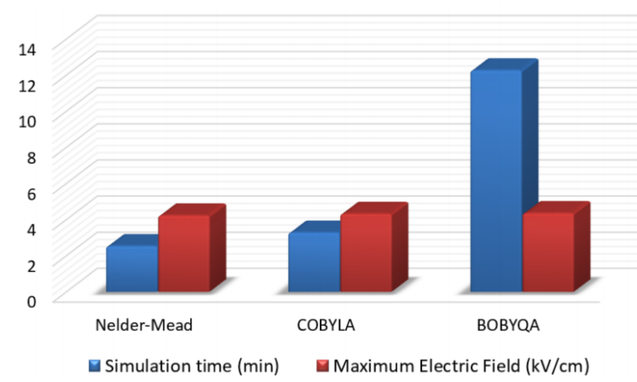

Fig. 8 – Performance of each optimization method.

CONCLUSION

A new approach for optimal design of corona rings was presented in this paper. Three different optimization methods and FEM based simulation were utilized together, in order to determine the optimal design of a corona ring.

The results showed that the electric field on the insulator was reduced about 80% when using the optimized ring. The Nelder-Mead method was found as the most suitable for the problem solution, due to its smaller computational effort.

The method presented in this paper, can be generalized to any insulators with different voltage levels. Moreover, the method has some advantages over other available methods, as discussed in the paper.

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