Insulator String Design Optimization using Non-linear Optimization Techniques

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Abstract: Insulator strings are widely used in high voltage transmission lines to mechanically support the line and electrical insulator fixed between line and the tower. Corona discharges may cause a complete failure of an insulator string due to the high intensity of electric field. Applying a corona ring on insulator string is an important approach to decrease the effect of corona. This work analyzed the effect of the dimensions of the corona ring and optimized using non-linear optimization techniques. From the results obtained, parameters of the corona ring were very important in the maximum reduction of the electric field. Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) were used as the optimization techniques to derive the objective function between the maximum electric field and corona ring dimensions.

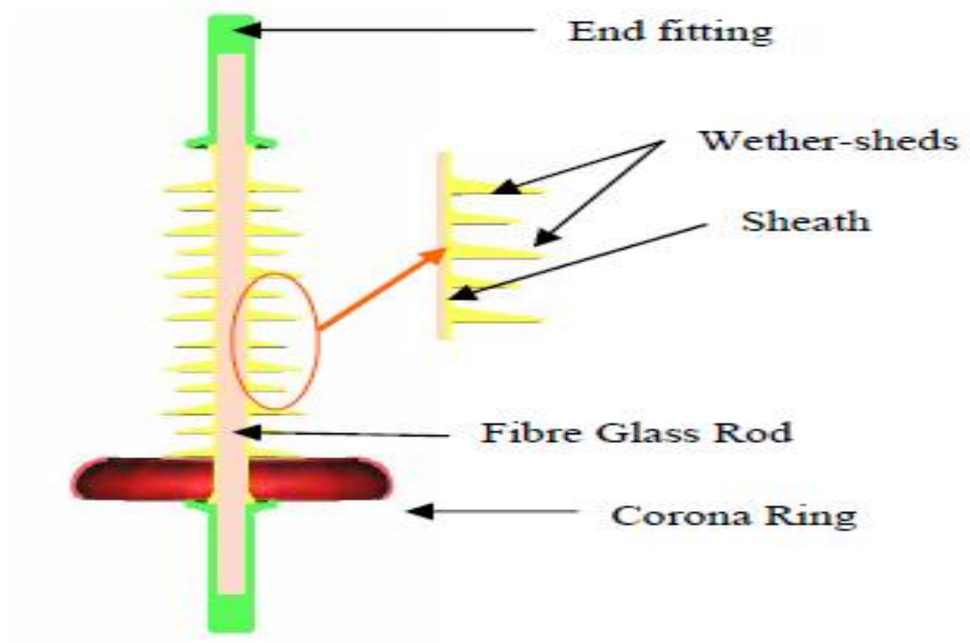

Figure 1. Components of a high voltage insulator

Introduction: Non-ceramic insulators are now extensively used in power systems for all voltage ratings and due to the great voltage level, there is high intensity of the electric field over the equipment. The calculation of electric field distribution on insulator is very important for the maintenance and operating the transmission lines. The exact dimensions of the corona ring are important to determine the optimum position of the rings along the insulator string.
The corona ring model consists of diameter of the ring (R), the tube radius (r) and the height of the ring (H). The approach of applying the corona ring design is by keeping two variables constant and changing the third variable. Figure 2 shows the three different dimensions corona ring model.

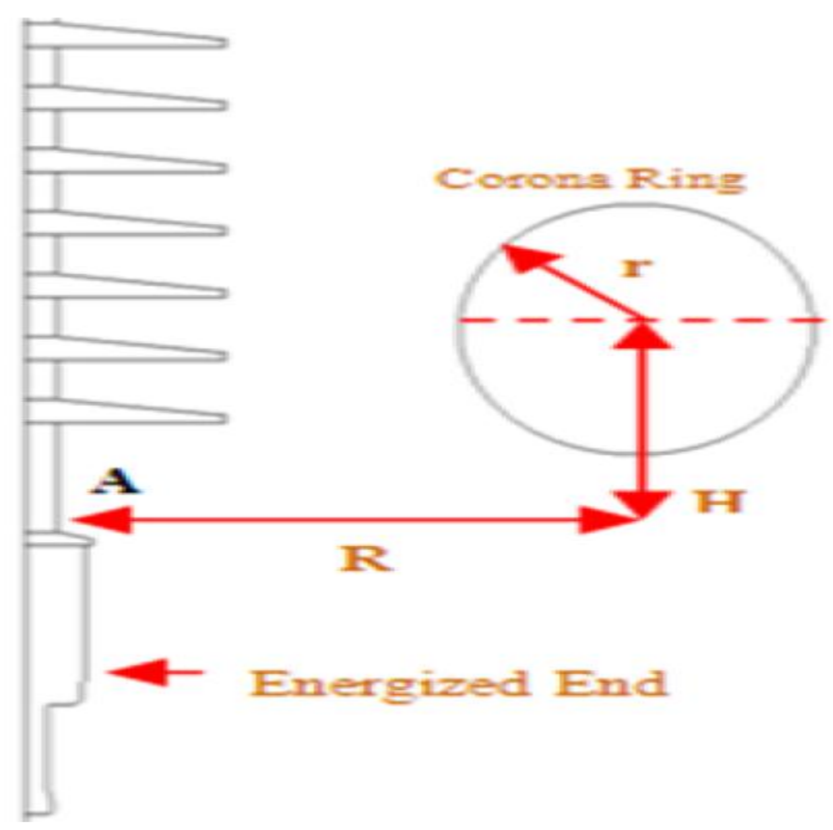

Figure 2. 2-D model of corona ring around the energized end

Objectives:
1. To develop a model of a non-ceramic insulator with and without corona ring using finite element analysis (FEA) method.
2. To obtain the electric field distribution on the surface of non-ceramic insulator.
3. To investigate the effect of different parameters of corona ring on the electric field distribution.
4. To design a corona ring using optimization techniques.

Methodology: Simulation was done using COMSOL Multiphysics software. The corona ring design was optimized using non-linear techniques, GA and PSO.

Results: Figure 3 shows the electric field distribution without corona ring while Figure 4 shows the electric field distribution with corona ring. Figure 5 shows the comparison graph of electric field distribution with and without corona ring. Table 1 shows the comparison of the electric field magnitude between with and without corona ring.

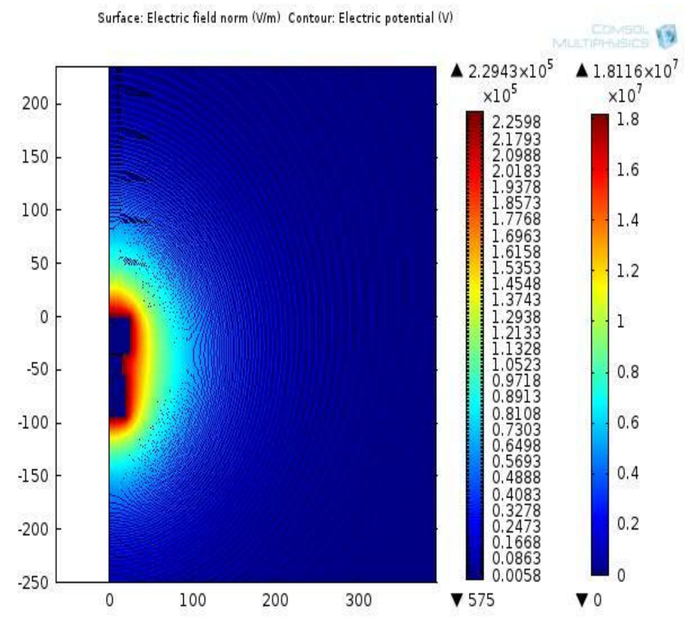

Figure 3. E.Field distribution without corona

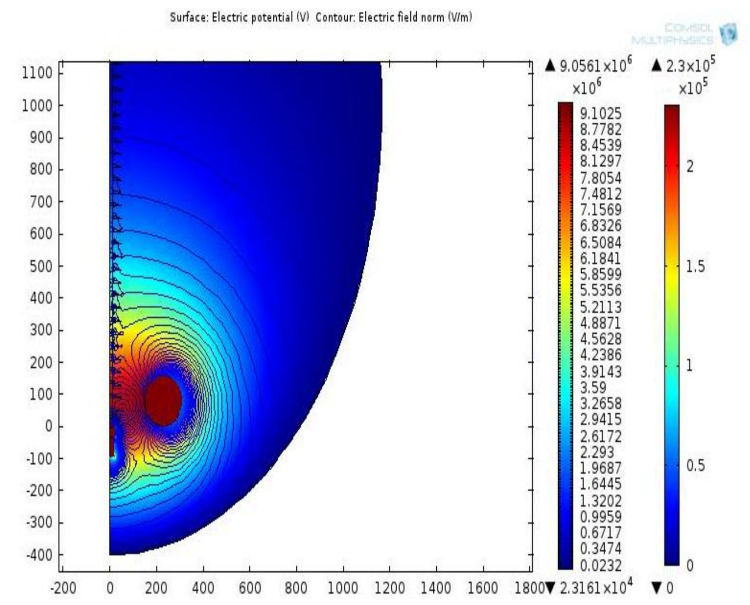

Figure 4. E.Field distribution with corona

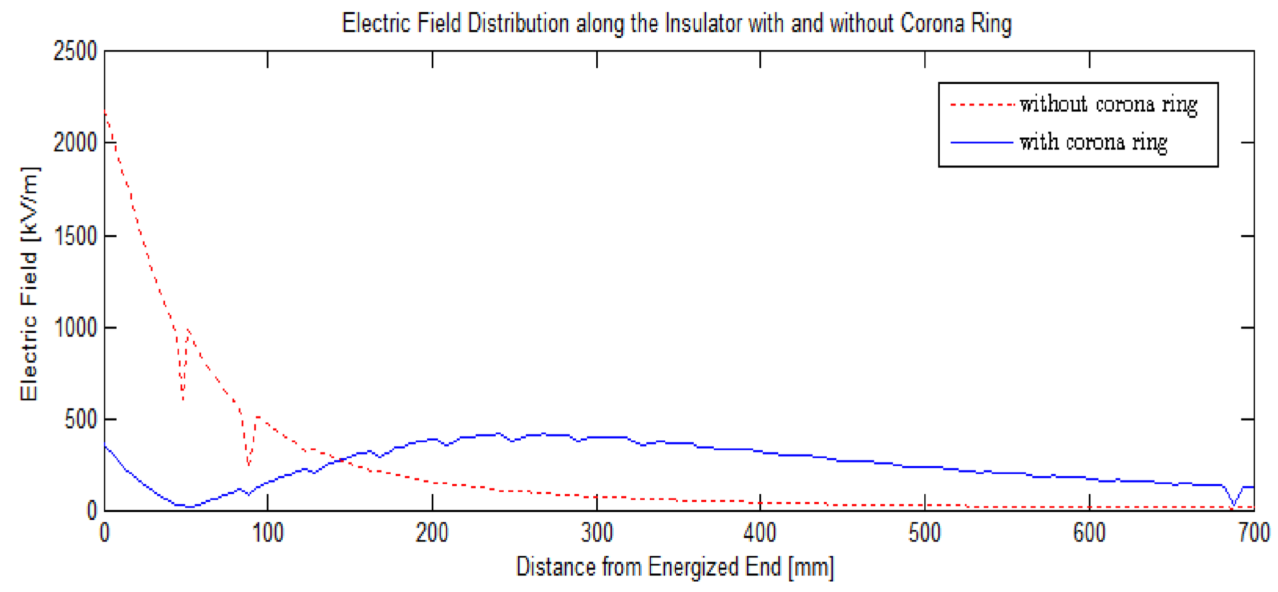

Figure 5. Electric Field distribution along the insulator with and without corona ring

Table 1. Comparison of the electric field magnitude between with and without corona

Without corona Ring [kV/m]	With corona ring using GA [kV/m]	With corona ring using PSO [kV/m]
783.6969924	7.90765	7.7075

Conclusions: The electric field magnitude in a corona ring has been successfully determined using COMSOL Multiphysics software. From comparison of the results, PSO yields a lower minimum electric field magnitude than GA.

References:
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