3D Simulation of the Electric Field of Polymeric Insulators Under Adverse Conditions

D. F. Reis[1], E. J. da Silva[1], I. J. S. Lopes[1]

[1]Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil

Abstract

Recent studies report problems related to premature aging and degradation of high-voltage polymeric insulators. Corona activity, which is induced in areas of high electric field levels, is considered one of the leading causes of these problems. The insulator operation under adverse conditions including rain, fog, dew and pollution is affected by these key factors that modify the electric field until it reaches a level which is high enough to produce corona activity. Experimental investigation shows that a water droplet can be deformed when subjected to a given electric field intensity, which in turn distorts the field in the region between drop, air and insulator surface. The degree of distortion of the water drop produced by the influence of the electric field is influenced by the water conductivity. Therefore, pollution combined with a water drop can lead to degradation and premature aging of the insulator due to the high level of electric field. Inadequate insulator design and installation, and inadequate classification of the operating conditions and of standard policies aiming to specify the use of anti-corona rings equalization are potential causes that can lead to surface corona activity.

A thorough study of the electric field distribution in these insulators is extremely important for the preparation of a long lasting insulator design. Once one has achieved a reasonable optimized electric field distribution, one can plan and scale out a low cost product by mitigating the costs involved in poor material specification, increase the life expectance of the product due its better performance and system reliability. This evaluation of critical levels of voltage for starting the corona involves a complex physics, due to several factors that influence the distribution of the electric field. Simulations on static and quasi-static conditions and the three-dimensional modeling of the geometry of the insulators, water drops, towers and conductors, among other elements of the power system make the analysis more realistic and more practical results.

In this context, the COMSOL Multiphysics® software was chosen to perform the computational studies herein proposed. The Electric Currents (ec) interface of the AC/DC Module was used to evaluate the electric field distribution around high voltage polymeric insulators of 115 kV. The modeling of the transmission towers, conductors and insulators were designed at the core of native geometry. The electric field distortion and the water droplet conductivity were included in the model and compared with experiments conducted in a high voltage laboratory. Initially, a two-dimensional (2D) analysis including only the isolator was performed in order to understand the basic phenomenon and the reliability of the model, make mesh convergence analysis and get first physical numerical

results. Thereafter, a three-dimensional (3D) simulation study, including the other parts of the system, was performed using and compared with the 2D case to determine the influence of the system elements on the field distribution around the insulator and how the model should be assessed. The results are shown and discussed in this work.