Electric Field Calculations for AC and DC Applications of Water Controlled Cable Termination

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Abstract

The computation of electric field strength is the state-of-the-art technique for designing and optimizing High-Voltage (HV) equipment. In this research, the equipment under analysis is Cable Termination (CaTr) which is used to apply high-voltage (75 kV - 800 kV AC) on the cable to be tested (Figure 1). The CaTr is based on the principle of linear electric field control using deionised water with a specific and controlled conductivity [1]. The CaTr model under analysis has been already manufactured by HIGHVOLT for rated Alternating Current (AC) voltages from 75 kV to 800 kV for testing cables with diameters across the outer semi conducting layer up to 160 mm. However, with the recent focus of the power industry on High-Voltage Direct Current (HVDC), the design and subsequent testing of HV equipment for the application of HVDC voltages are inevitable [3]. This forms the underlying motivation for carrying out the presented investigations for analyzing the already designed AC CaTr for its application towards testing HVDC cables (350 kV DC), thus working towards feasibility electric field studies and nuances of the CaTr model for the application of both AC and DC voltages using COMSOL Multiphysics®.

The electrical conductivity and permittivity characterizes the material properties which are subsequently realized by solving parts of Maxwell equations. The challenge hereby lies in understanding the physical effects of electric field distribution in case of AC and DC voltages and subsequently simulating them. The AC electric field distribution is mainly influenced by geometry and permittivity, whereas the DC electric field distribution, under steady state conditions, is influenced by electrical conductivity (σ) and space charge accumulation [2], [3]. These influencing factors of DC are in turn strongly governed by temperature (T) and electric field (E) at a particular instant i.e. $\sigma = f(T,E)$. This encourages the further understanding of temperature distribution, in addition to the electric field strength. By using COMSOL Multiphysics® software, we discuss the above challenges by implementing the necessary parameters in Electric Currents 'ec' and Heat Transfer 'ht' Physics.

Results: The determination of electric field strength is the main intention. With appropriate boundary conditions for simulation, the electric field transition between AC and DC [3] shall be demonstrated using COMSOL Multiphysics®. The results achieved till today (Figure 2) are in agreement with the actual physical effects encountered, hence subsequent attempts to couple the two physics ('ec' and 'ht') shall be made. Additionally, though trivial, the transient phenomenon in the event of a flashover in the test object, i.e. cable, shall be attempted.

The technical adaptability of a modeling and simulation tool has been demonstrated in the area of high-voltage equipment design and optimization. Such methodology is supportive in updating and meeting the state-of-the-art requirements of the power industry. Especially in HV engineering, where the recent trend of increasing voltage levels and simultaneously decreasing device sizes pushes the boundaries of technology, which in our case is the present shift of technology from AC to DC.

Reference

[1] Dr. Ralf Pietsch et al. Optimised cable end termination system with water conditioning unit, XIIIth International Symposium on High Voltage Engineering, Netherlands 2003, Smit (ed.) ISBN 90-77017-79-8

[2] Alexander Eigner, Developments in Stress Control Systems in HV Cable Accessories, INMR World Congress 8-11 September 2013, Vancouver Canada

[3] Dr. Ralf Pietsch, On-site testing of extruded AC and DC cables above 36 kV and up to 500 kV - Some thoughts about the physics behind it, standards and test techniques, 2012 CIGRE Canada Conference, Montreal, Quebec, September 24-26, 2012

Figures used in the abstract

Figure 1: The Cable Termination (CaTr)- Right and CaTr System being used in high-voltage AC test system- Left.

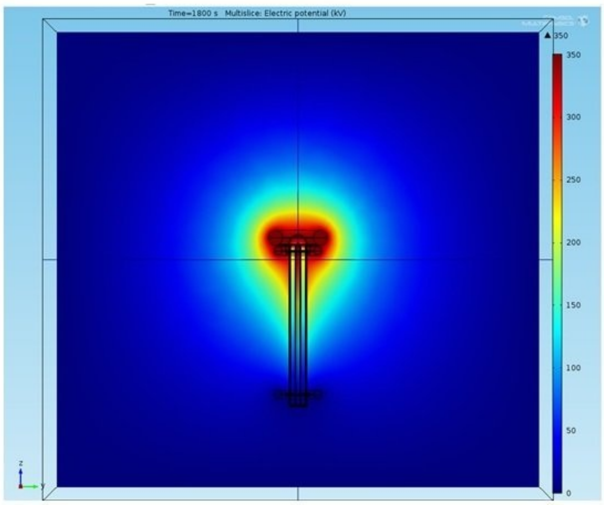

Figure 2: Electric Potential plot for the applied 350 kV D.C.