An Investigation of Thermal Ratings for High Voltage Cable Crossings through the use of 3D Finite Element Analysis

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Abstract - With the growing complexity of underground cable systems, cable crossings are inevitably found in urban areas in power distribution systems or sometimes even in transmission systems. It is critical to accurately rate such cables because dangerously high temperatures can occur at crossing points, resulting in premature aging of cable insulation and potentially cable failures. The only existing explicit method for rating cable crossings is IEC 60287 [1], which is analytical and makes a number of simplifying assumptions like constant surrounding ambient conditions. With improvements in computational power, 3D models based on Finite Element Analysis (FEA) become viable for rating crossing cables. This provides an alternative method to assess these problems using a more detailed cable representation and realistic environmental modelling. In addition, it allows the accuracy of the existing analytical method to be assessed.

With the eventual aim of examining the accuracy of IEC 60287 for rating cable crossings, FEA models have been developed to allow a detailed comparison to the analytical calculation. Due to the complexity of the crossing structure, firstly two 400kV single XLPE cables crossing at right angles have been modelled. A sensitivity analysis on model parameters (for instance buried depth, cable spacing, crossing angle and cable length) has been conducted and compared against IEC 60287 to gain confidence of the modelling process. By extension of the modelling techniques developed for the single cables crossing case, a 3D FEA model of two directly buried three-phase cable circuits crossing has been created. Each circuit is horizontal in flat formation and the model is solved for various crossing angles and vertical spacings. The results of IEC 60287 is are compared against 3D FEA model with various ground boundary conditions and temperature-dependent ac conductor resistance, both of which have been suggested in previous work as main reasons accounting for the conservatism of the analytical method [2][3].

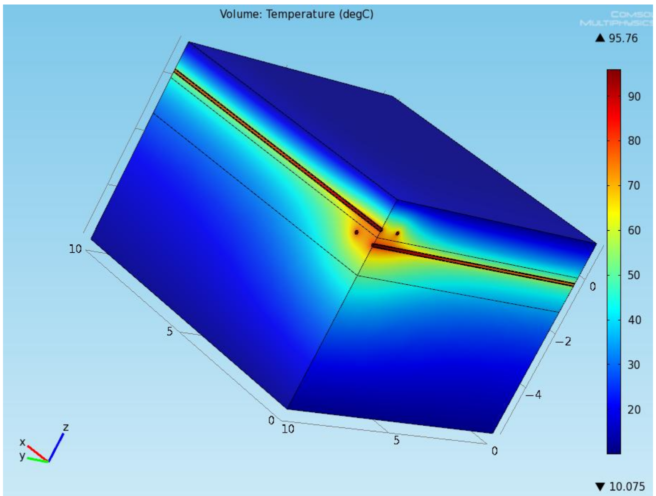

Figure 1: volume temperature profile of two three-phase cable circuits crossing at 90^0

[1] BS IEC 60287-3-3:2007, “Electric cables – Calculation of the current rating”, *Electrotechnical committee: British Standards Board*,2007

[2] D.J. Swaffield, P.L.Lewin and S.J.Sutton, “Methods for rating directly buried high voltage cable circuits”, *IET Gener. Transm. Distrib*, vol. 2, no. 3, pp393-401,May2008

[3] P.L. Lewin, J.E. Theed, A.E. Davies and S.T. Larsen, “Method for rating power cables buried in surface troughs”, *IEE Proc. Gener. Transm. Distrib*, vol. 146, no. 4, pp.360-364,1999