REDUCTION IN CURRENT CARRYING CAPACITY DUE TO CABLES CROSSING

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ASTRACT

In order to analyze more accurately their asset of cables and hence exploiting them to their thermal limit, utilities are increasingly switching from the conventional analytical methods, developed by Neher McGrath in the fifty's, to the numerical Finite Element Methods (FEM). Two dimensional (2D) FEM are well suited to analyze complex cable installations that can be located in any environment and that are subjected to any load conditions, provided that spatial configuration and ambient conditions remain unchanged along the cable route. In case of one cable system crosses another or a steam pipe, the problem becomes much more complex and a 3D FEM has to be used. This paper reports on a real life case where a distribution duct bank is crossing a transmission one and on the latter crossing a steam pipe. It outlines the derating impact on cables current carrying capacity with respect to the sections away from the crossing.

KEYWORDS

Cable ampacity, finite element, cable crossing

INTRODUCTION

Nowadays, complex electromagnetic, thermo-fluid, civil, aeronautical simulations, etc. are currently carried out using numerical finite element methods (FEM) due to their great accuracy in solving the various physical equations that describe these phenomena. In the field of cables current carrying capacity, the use of these methods is also picking up. The electrical utilities, which are conservatives by nature, have adopted since the fifties the Neher-McGrath analytical method [1]. This method employs a lot of simplifications and has its limitations. It cannot be used effectively for the analysis of complex configurations (extra large duct banks, duct banks crossing each other, cables crossing steam pipes, cables near buildings, cable splices, etc.). On the other hand, the FEM is more powerful and more versatile to handle these cases. In fact, FEM can handle any complex cable configuration in 2D or 3D, located in any environment and subjected to any load condition. In this paper, we will report on the use of FEM in analyzing the overheating of cables when crossing each other in one particular Hydro-Québec's installation and on another case when a transmission circuit is crossing a steam pipe. The theory behind the FEM can be found elsewhere [2-5] and will not be detailed in this paper.

CROSSING OF DUCT BANKS

At the request of Hydro-Québec and for other utilities based in US, we have analyzed recently several cases where duct banks are crossing each others. The latest one consists of a 25 kV distribution duct bank crossing a 230 kV transmission circuit. Figure 1 shows a sketch of this installation. The first step in solving the heat dissipation in this complex installation by FEM is to discretize (meshing) the domain into small elements (figure 2) over which we solve the Fourier partial differential equation:

$$\frac{\partial}{\partial x}\left(k_x\frac{\partial T}{\partial X}\right)+\frac{\partial}{\partial y}\left(k_y\frac{\partial T}{\partial Y}\right)+\frac{\partial}{\partial z}\left(k_z\frac{\partial T}{\partial Z}\right)+q=\rho c\frac{\partial T}{\partial \tau}$$

Where $\boldsymbol{k_x}$, $\boldsymbol{k_y}$, $\boldsymbol{k_z}$ are the anisotropic conductivities of the various materials present; $\boldsymbol{q}$ is the heat source or losses, $\boldsymbol{T}$ is the temperature, $\boldsymbol{\tau}$ is the time and $\boldsymbol{\rho}$ and $\boldsymbol{c}$ are the density and thermal capacity of the materials.

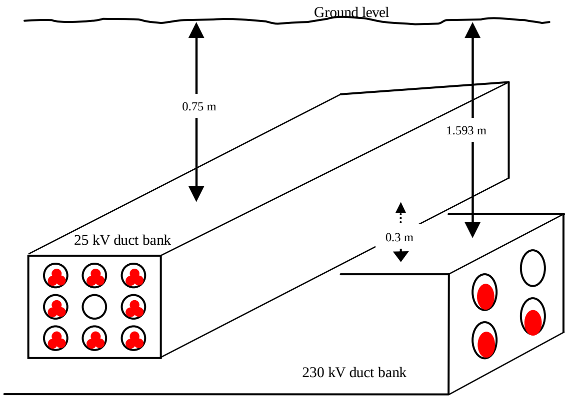

Fig.1: Sketch of the crossing

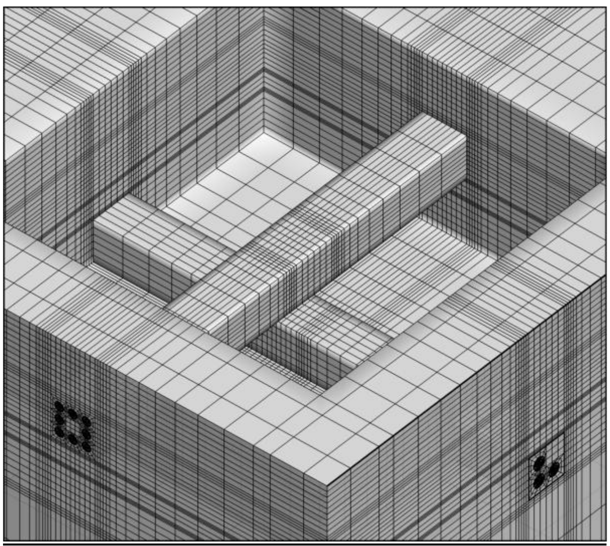

Fig.2: Finite element mesh of the crossing (part of the mesh is removed)

The boundary conditions set for this analysis are adiabatic: 10m below and 20 m on each side of duct banks. At the ground level, convective and radiative