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Using the finite element method for complex cable ampacity calculations : A more accurate and much more flexible alternative to the conventional analytical methods

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Résumé

La majorité des compagnies d'électricité et des manufacturiers de câbles utilisent la norme CEI-287 basée sur la méthode analytique développée par Neher-McGrath dans les années 50 pour déterminer la charge admissible des câbles. Cette méthode s'applique à des installations de câbles relativement simples. Cependant, dans plusieurs installations complexes, cette méthode n'est pas recommandée. La méthode des éléments finis est tout à fait indiquée pour les calculs complexes de charge admissible des câbles. Cette méthode permet d'analyser n'importe quelle installation de câbles, dans un environnement quelconque sous n'importe quelle conditions de charge. Ce papier traite de notre expérience à l'IREQ dans ce domaine.

Abstract

The great majority of utilities and cable manufacturers have been using the IEC-287 standard based on the analytical Neher-McGrath method developed 50 years ago for cable ampacity calculation. This method is suited for the analysis of simple cable configurations. However, in many complex cable installations, it cannot be used. The Finite Element Method (**FEM**) is better suited for ampacity calculation in complex cable installations. This method can handle any complex cable configuration located in any environment and subjected to any load condition. This paper reports on IREQ's 20 years experience in this field and describes some of the real life installations where this method has been used with great success.

Introduction

In the past, scientists and engineers avoided using computer programs based on the numerical methods. The main reason is that these methods, namely the finite element one, are tedious to implement due to the required mesh generation and to the time consuming solution of large matrices. Nowadays, the numerical methods are playing a major role in solving complex engineering problems in wide area of applications thanks to the improved speed and memory of computers.

In the field of cable ampacity, the trend to switch from analytical to numerical methods is slow. The electrical utilities, conservatives by nature, have adopted the Neher-McGrath analytical method [1] for over 50 years. This method employs a lot of simplifications and has its limitations. It cannot be used for the analysis of complex configurations (duct banks crossing each other, cables crossing steam pipes, cables on trays, cables near buildings, cable splices, forced cooling, etc.). For such cases, the present practice calls for a specific derating factor that can be estimated with little precision based on experience or measurements on mockups. This leads generally to conservative cable loading. Moreover, it is unlikely that one can easily find the right derating factor for any particular installation.

The FEM, on the other hand, is more powerful and more precise. It can handle any complex cable configuration, located in any environment and subjected to any load condition. In this paper, we will report on our experience with this method at IREQ over the last 20 years and outline its capabilities in solving some of the real life complex installations that cannot be done otherwise with sufficient precision. The theory behind the FEM can be found elsewhere [2,3,4] and will not be detailed in this paper.

Examples of complex installations

A high voltage installation may span over hundreds of kilometers. Although, most of the length consists of a simple configuration that can be rated satisfactorily, according to IEC-287, often, few sections with complex geometry and environment may be found along the cable route. Usually, these sections constitute the bottle neck for the global rating. Followings are some of the real life cable installations for which the FEM would be the appropriate calculation tool. For each example, the finite element mesh is shown. It consists of