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D.2.4. Evaluation et optimisation des capacités de transport des liaisons de forte puissance

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D.2.4. Evaluation and optimization of transmission capacities of power link

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Résumé

Le choix d'un câble repose sur un ensemble de paramètres dimensionnants parfois complexe. Un logiciel d'aide à la conception a été développé, destiné à évaluer les limites technologiques et économiques des câbles à isolation sèche pour le transport de fortes puissances . Si la détermination des capacités de transport dans les différents modes de fonctionnement reste jusqu'ici un problème classique, l'accent a été porté sur la possibilité de mener des études comparatives (analyse de la sensibilité à un paramètre, optimisation des ouvrages, réduction des coûts, etc). La suppression des opérations répétitives, l'exploitation visuelle et l'archivage des résultats contribuent à simplifier les tâches de l'utilisateur.
L'article propose d'illustrer quelques fonctions d'un outil convivial et modulaire, s'adressant autant à un bureau d'études et ingénierie qu'à un laboratoire recherche et développement.

Abstract

Selection of a cable is based upon a certain number of sometimes complicated design parameters. An aid software has been developped to assess technological and economic limits of synthetic insulated cables for transmission of high power. If the transmission capacity determination with different modes of operation is still a classic problem, the innovation relates to the feasibility of carrying out comparative studies (analysis of the sensitivity to one factor, installation optimization, cost reduction, etc.). Suppressing repetitive operations, interpretation of visual examination and filing contribute to simplify user tasks.
The article provides some illustrating functions of a user-friendly and modular tool, applying to an engineering as much to a research and designing department.

Cable and link dimensioning

Cable dimensioning is based upon a certain number of complicated parameters relative to cable design and materials, thermal environment, structure and operating rules of the electrical network in which the power link will be installed.

High power links involve simultaneously design and economic considerations of many different units of equipment. Because every unit has many options, it is often difficult or impractical to sort out the large number of possible alternative combinations. It is the more essential to evaluate them easily as the next task of filing is arduous.

The many registered parameters are sometimes interdependant, and power link designing oversteps widely the scope of abacuses determining a conductor section in terms of the required transmission capacity... On the other hand, installation optimization often necessitates studies of sensitivity to one factor in order to reach step by step the best compromise between sometimes antagonistic solutions. This process is proving rapidly tedious and time consuming, indeed propitious to mistakes, if the user does not have an adequate user-friendly calculating tool at his disposal.

Calculation methods

In order to obtain uniform and reproductible results, all calculation methods were chosen from proved documents such as IEC publications and CIGRE working group reports (see *References* section for further details). Each of them was subjected to validation campaigns before being accepted in conformity with experimentations. Their worldwide broadcasting assure them of being acknowledged in any electrotechnical engineering field.

A large range of configurations is met : continuous load, response to a step, emergency and short-circuit ratings, buried cables and cables in free air, forced cooled cables, cables in ventilated tunnels, screen voltages. From the cable and operating mode description, the computed electrical and thermal parameters make possible the evaluation of transmission capacities of high power links. A comparison between different available materials, structures, geometries, and methods of laying, leads the designer to optimize them and to select the technological and economical solution being estimated the best. When a technological limit is reached, the reckoned data give marks to determine aims in further experimentations. For instance, a link is supposed to be directly buried in uniform soil. If it is established that thermal resistivity of soil is too high, it may be interesting to provide for a controlled filling. If the traditional materials do not meet the specified requirements, the calculation will set a maximum thermal resistivity of a new backfill material. If such a material may not be economically considered, another solution than a controlled filling must be found.

The models used in the documents mentioned in references are two-dimensional models, in which heat transfers are spreading in the radial direction. They are often quite sufficient to solve most of problems and are suitable to fast computations. The analytical solutions present very few difficulties as divergence problems. As far as possible, all calculation loops of the software described below have been built to separate parameters in terms of time or temperature. For instance, the estimation of about fifty points of a thermal image takes less than one second, with a reckoned margin of a tenth of degree on each cable component. The models comply with the same schemes and make an homogeneous unity. It is sufficient to describe once for all the cable and its environment to come and go from a study to another one.

All things considered, if first approach is unsatisfactory, special configurations should be treated with more powerful tools such finite elements softwares, at the expense of more complexity.