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Sirolex : A finite element computer program for the thermal analysis, design and monitoring of underground and aerial high and medium voltage insulated cable systems

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Résumé

Cet article présente un programme d'ordinateur pour l'analyse thermique des cables électrique sousterraines et aériannes à des haut et moyen potentiels. La génération du modèle d'élements finis est automatisée via la génération automatique de la maille de calcul numérique, application des conditions aux limites et l'assignation des propriétés des materiaux. Un systéme modulaire est inclus, permettant de créer des systémes à des circuits ordinaires multiples pour des tranchées et instalations a deux dimensions. Le programme permet de traiter des cas staionnaires et transitoires, permettant de tenir compte de la variation de la chaleur produite avec temperature, conductivité thermique et chaleur specifique. Il permet aussi de considerer la variation dans le temps de la temperature de l'air et du flux thermique solaire.

Abstract

A finite element program for the thermal analysis of high and medium voltage underground and aerial cable systems is described. Generation of the finite element model is automated via the automatic generation of the finite element mesh, application of boundary conditions, and assignment of material properties. Multiple circuit systems for trench and two-dimensional array installations are created by a modular system, which permits any number and any type of common circuits to be included. The program provides a wide range of steady state and transient solution options permitting temperature dependent heat generation, thermal conductivity and specific heat and time dependent heat generation, air temperature and solar heat flux.

Introduction

Over the last decade or so, the globalisation of the world economy and privatisation policies pursued by many governments, have led to pressures on the electricity supply industry to become more efficient in many areas. One such area is in the thermal design and installation of new high and medium voltage insulated cable systems. There is also a need to make more effective use of existing cable systems.

This situation has stimulated CSIRO and Olex Cables to develop a package of finite element computer programs, termed Sirolex, to address the thermal design of insulated cable systems. A number of considerations influenced the development of Sirolex. A cable system design engineer, when involved in the thermal design of a circuit, must frequently address many different design configurations. There is thus a need to quickly generate different circuit configurations while retaining accurate and detailed representations of the geometry. In addition both steady state and transient situations must be addressed. In fact cable systems are rarely, if ever, in a thermal steady state but are usually subject to load variations and a variety of diurnal and climatic changes leading to a complex transient thermal behaviour of the installed cable. Therefore some effort was invested in describing transient thermal situations.

The generation of a detailed finite element mesh can be a time consuming exercise in conventional finite element programs [1,2,3]. There is at least one commercial finite element program, FETA [4,5,6], for the thermal analysis of cable systems however, there were perceived benefits in developing a set of finite element programs with different capabilities. In Sirolex, the generation of the finite element mesh is automated by way of preconfigured and quite detailed circuit mesh modules requiring only simple dimensional data for their generation. In addition, the assignment of boundary conditions and material