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D.2.3. Analyse thermique de câbles HT à isolation PR basée sur les caractéristiques thermiques non-linéaires des matériaux

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Résumé

Dans ce travail on présente des résultats de l'étude du comportement thermique non linéaire des câbles à haute tension à isolation polyéthylène réticulée qui subient des conditions variées de la mise en charge y compris stationnaires et transitoires - des surcharges, des courts-circuits. On présente des données des mesures des caractéristiques thermiques dépendantes de la température des matériaux - isolants, semi-conducteurs et employés pour des gaines; on présente aussi des calculs de la distribution de la température confirmés experimentalement basés sur la résolution analytique et numérique de l'équation de chaleur.

D.2.3. Thermal analysis of high voltage cables with XLPE insulation based on non-linear thermal characteristics of materials

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Abstract

This paper discusses a study on non-linear thermal behaviour of high voltage XLPE insulated cables subjected to different loading conditions, including stationary and time-dependent - overloads and short-circuits. The results of measurements of insulating, jacketing and semiconductoring materials thermal properties versus temperature are presented as well as experimentally verified temperature distribution calculations, based on analitical and numerical solution of heat-conduction equation.

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1. Introduction

At the present time plastic insulated power cables are widely used for power supply of large power consumers.

Reliable operation of a cable system is only possible provided its temperature does not exceed the specified value. As the direct measurements of conductor temperatures are practically impossible methods for calculating current ratings and thermal transients must be accurate and reliable enough.

IEC publications are used for thermal analysis of power cables in stationary and transient conditions. According to these recommendations a cable system may be represented as a linear system with lumped parameters. However this model cannot be associated in strict accordance with a polymer insulated cable, since it is well known that thermal and other physical properties of polymers are essentially temperature dependent.

This paper deals with measurements of thermal parameters of polymer materials used for high voltage cables and with mathematical simulation of steady-state, transient and emergency thermal fields in a cable.

2. Materials Properties

Samples of the following materials were prepared for the investigations: insulating XLPE, jacketing thermoplastic LDPE, semiconductoring carbon black filled ethylenevinylacetate copolymer. All the samples were taken from 110kV cables manufactured in Russia.

The results obtained are presented on Fig.1.

Attention is drawn to the following:

- thermal conductivity of XLPE decreases by 25% while its specific thermal capacity increases 2.3 times with the operating temperature range of 50...130°C;
- for semiconducting compound these values are 15% and 50% respectively;
- insulating XLPE and jacketing PE have similar properties which differ no more than by 3%;
- thermal conductivity of PE is by 20...30% lower than that of semiconducting compound;
- thermal properties- versus-temperature curves contain breaks with a temperature range of 90...115°C due to cristalline phase melting.

For practical application the measured temperature dependences were approximated by analytical expressions.

Thermal conductivity plots $\lambda(\Theta)$ were divided into sections and for each a straight line was chosen according to the least square method. Plots $c(\Theta)$ were approximated by