95 Jicable

C. Etude radiale et angulaire du PRC dans les câbles HT par la méthode de l'onde thermique

CASTELLON J., MALRIEU S., Laboratoire d'Electrotechnique de Montpellier, France

C. Radial and angular study of XLPE in H.V. cables by the thermal step method

CASTELLON J., MALRIEU S., LEM, Montpellier, France

Résumé:

Plusieurs phénomènes électriques, mécaniques et thermiques semblent être fortement liés à la présence de charges d'espace dans les matériaux isolants.

La mesure de charge d'espace a été utilisée pour réaliser une étude radiale et angulaire du polyéthylène dans des câbles H.T. et U.H.T. en PRC par la méthode de l'onde thermique développée au Laboratoire d'électrotechnique de Montpellier (L.E.M.).

La technique de mesure est le chauffage par l'âme donnant un gradient de température, qui se propage à travers le diélectrique depuis le centre vers l'extérieur du câble.

Pendant l'extrusion du câble, le flux de polyéthylène crée des inhomogénéités autour du centre, donnant des zones différentes dans le câble. Si nous divisons le câble en plusieurs parties identiques, nous pouvons mesurer un courant sur chaque électrode externe.

Nous pouvons montrer, ainsi, des différences éventuelles dans chaque zone étudiée.

Abstract :

A lot of electrical, mechanical and thermal phenomena seem to be strongly linked to the space charge presence in insulating materials.

The space charge measurement has been made to realise a radial and angular study of polyethylene in XLPE, H.V. and U.H.V. cables by the thermal Step Method (T.S.M.) developed at the Laboratoire d'Electrotechnique de Montpellier (L.E.M.).

The measurement technique used is the heating of the sample core which gives a temperature gradient, which propagates through the dielectric from the centre to the external of the cable.

During the cable extrusion the polyethylene flow creates inhomogeneities around the centre, giving different parts into the cable. If we divide the cable in several identical parts, we can measure an external current in each electrode.

So, we can show the possible different electric states in each zone.

1./ Introduction :

A lot of electrical phenomena (dielectric rigidity, conduction, stocking of charges), mechanical phenomena (mechanical breakdown, grain boundaries), thermal phenomena (specific heat, diffusivity, conduction) seem to be linked to the space charge presence in insulating materials.

One of the causes of premature ageing of insulating polymers is, it seems, the appearance in the interior of the material of a space charge that breaks the electrical neutrality of certain regions and can turn them into high risk zones. To know the origin of this charge we have to determine its local density and the influent parameters.

The measurement and the localisation of this space charge, using a new method working on large thickness (up to 2 cm), could explain some phenomena which are still little understood.

But, now, a single study of the radial component is not sufficient enough in an study of ageing. The angular component seems the new interest in the cable manufacturing. In fact, the polyethylene extrusion doesn't respect the cylindrical symmetry of the cable, giving double refraction zones (medium residuals constraints zone and physical chemistry heterogeneity zone) [4],thanks to the residual electric field and space charge distribution measurement on each parts of the cable.

We have shown the behaviour of some insulation zones with various morphology, by the different parts observation of the cable. We have, therefore given evidence of differences between each zone, provoked by fixed constraints in the polyethylene flow during the extrusion.

In this article, we will introduce the principle of the "Thermal Step" method and a new application to cables. We will then present the thermodilatation current measurement on each zone of the cable. The determination of the distribution of the space charge in each part of the cable, can give evidence of radial anisotropy.

2./ Principle of the thermal step method:

In this study, the method used for the measurement of space charge location in insulating materials is the **thermal-step-method** developed at the Laboratoire d'Electrotechnique de Montpellier (L.E.M.), [1],[2].

The method is based on the measurement of thermal expansion current of the material after application of a thermal step on one face which is placed on a thermal diffuser.

Consider a dielectric slab with constant thickness D, placed between two plane parallel electrodes, linked by a short-circuit or a current measurement instrument. If this slab has been submitted to certain constraints (radiation, mechanical constraints, or charged at high voltage at a certain temperature), it can contain a spatial charge distribution. If we apply a thermal step ΔTo on either side of the sample, there is a thermal wave diffusion into the material. The expansion which appears, generates a displacement of charges. So, there is the apparition of a weak current of a few pico-amperes (or tens of pico-amperes) in the external circuit.

The thermal step method has been applied to flat structure samples likes plates, and has made it possible to study space charges in insulating polymers disposed between metallic electrodes or semiconducting materials.

In the case of cables, these electrodes are made of resin with a variable percentage of black carbon. Let's consider a piece of cable of a length **l**, on the internal and external faces of the insulating material of an interior radius **rri** and of an external radius **rre**, two semiconducting materials are extruded: they constitute for us the two electrodes of measurement. They are connected to each other by a device of low relative impedance.

We consider a charge **Qi** in the interior of an insulating material, inside a crown of a length **l**, of a radius **r** between **rri** and **rre**, and of a thickness **dr**. By total influence, this charge induces image charges $\mathbf{Qi_1}$ and $\mathbf{Qi_2}$ respectively on internal and external electrodes. By the propagation of a thermal step from one electrode to another, the sample is submitted to a non homogeneous dilatation which modifies the position of the Qi charge in comparison with electrodes and so, modifies the image charges values, Qi1 and Qi2. This unbalance produces a current measurable in an external circuit (figuresn°1 a, 1 b).

The experimental current measured is the global result of the contribution of all the Qi charges contained in the insulator. The constant knowledge of the current and of the temperature distribution in the sample allows us to study the spatial layout of the internal charges of the insulating material [3].