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

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 \(\Delta T\) 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 like 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 \(r_{in}\) and of an external radius \(r_{ext}\), 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 \(Q_{01}\) in the interior of an insulating material, inside a crown of a thickness \(d\), of a radius \(r\) between \(r_{in}\) and \(r_{ext}\), and of a thickness \(d\). By total influence, this charge induces image charges \(Q_{11}\) and \(Q_{22}\) 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, \(Q_{11}\) and \(Q_{22}\).

This unbalance produces a current measurable in an external circuit (figures 1 a, 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].