Consideration regarding the behaviour of electrical insulated materials submitted to electrical fields

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Keywords: dielectric rigidity, insulation resistance, electric puncture.

Introduction

The quality of insulation resistance determined the good functioning and "life expectance" of electrical engines and equipments.

The normal life of the electrical equipment and the insulation is respectively about 15-20 years and depends very much on the environment conditions and thermal overcharge. Given these burdens (stresses), the insulation resistance is loosing much more quickly its mechanical and insulating properties.

Next to the above mentioned facts, electric insulating materials have an "aging" and fatigue tendencies, like all materials constrained to dynamic stresses.

Electric punctures and its causes

If the microstructure of the insulating material inside an electric field is analyzed, we may observe that its atoms and molecules are greatly biased.
Because of this a great number of double source moments (dipoles) inside the insulating material, this double source moments maintains the equilibrium with external electrostatic and electrodynamics forces.

In case the field forces are stronger that the critical ones, the corresponding insulation (structure of the insulating material) is destroyed.
Because of this destruction, free unbalanced charge carriers forms inside the insulation which represent the main cause for the disruption of the insulation.

This disruption causes the erosion of the material in the puncture area.
Electrical punctures of the insulation can be superficial and/or deep (as volume).
The superficial erosion of the insulation appears because of a long exposure to thermal and light phenomenons from ionization processes which is unfolding on the superficial parts of the cover. The cause of this process is, in the first place, the superficial dirt (moisture, grease, carbonic and metallic powder).

Sometimes the affected parts of the superficial cover can be made by the micro-cracks contained by the insulation. In these micro-cracks, who can appear when the insulation is manufactured, under the influence of the electric field, ionization processes can appear, this sustaining the appearance of a layer.

These processes affect the surface of the insulation and reduce its life span. Because the micro-cracks are rough edges, the layer is accentuating. In this micro-cracks are kept some foreign bodies that help this process.

The polymerization, and also the thermal exposure lead to the appearance of these cracks. The nonobservance of the technical operation concerning the inappropriate viscosity of the insulation material (insulation point) and no concordance between the previous thermic phases and the polimersation phases lead to no qualitative execution of the insulation and to a bad quality of the product in general.

When the ensemble or the component part marked for insulation is not enough degreased, a crust is formed. This crust will get cracked in time and the insulation will not correspond anymore. The same case appears when we isolate the conductor and the coil, no matter if we talk about insulating point or insulating material in shape of prepared strips (bands).

Due to the rising of polymerization temperature appears a foam formation or a leak of the insulation material or a bending. On the surface of the coil ensemble or of the impregnate reference are forming solid foaming structures, which are undesirable in every case, because they reduce the quality and life span of the product in general.

These are the potential (possible) sources of the ionization process that increase the insulation failure.

These phenomenons could be avoided if is adjusted the temperature of preparation, the viscosity of the insulation material (if we talk about the insulating point) and if the thermic process is running in vacuum furnace. The vacuum furnace makes possible the oven-drier of the coil to be more intensive; the thermic process is more qualitative and takes shorter time, because reduces the possibility of apparition of air bubbles in the interior of the insulating material. It is important to mention that at the end of the thermic process, respectively at the end of the polymerization process, it is not admitted that the reference product is exposed to sudden changes of temperature because the polymerization process takes until the temperature of the reference product it's equal to the ambient temperature.

The cool off process must be made gradually because in the opposite case can appear tensions and micro cracks in insulation, which represent a source of the ionization process.

At the preparation of the insulating material it has to be considered the level of the component material clearing (dusting).

The insulating material formed like a thermo active resin, respectively epoxidic, assess to respect strictly this criteria.

Any impurity in the insulating material consisting in foreign caps and air bubbles had an influence over the quality of the isolation. The negative air bubbles left in the insulation during the polymerization process are eliminated thanks to vacuum furnace process.

During the manufacturing process, the insulating material must be well mixed and transformed in a homogenous material. Must be taken into consideration that no water drops must enter, because they can create an intensive reaction and in the insulating material could appear foam, tending to loss off its insulating and mechanical properties.

All these lead to a fast aging, destruction and electrical insulator arc over, erosion of the insulation superficial part and the forming of a thin line of current that appears due to the influences of thermal and light ionization process.

By enlarging these lines (channels) of current appear damages through insolation.

Craters begin to form and its depths are gradually increasing. Under the influence of these processes appear also chemical changes on the crater walls.

As a product of the insulating material erosion process appears the scorch (carbonization) of the crater walls.

If we consider the organic insulators (on carbon base) under the influence of the ionization process on these sides, the local potential of the electric field grows.

This rising of the electric field potential leads to the insulator arc over in shape of a thin carbonized line that goes through the depth of the insulation. These channels or lines of current initially have a high ohmical resistance and do not have an increasing tendency. In time, under the influence of ionization process appear sided channels, which are breaching. In this channels the process of ionization is continuous, this leading to the enhancement (intensification) of the process and its widen.

This way are formed a big number of widened thin channels or ways (lines of current) named “dendrite”. The enlargement of these dendrites goes to a final and irrevocable insulation arc over (puncture), which can be visible with the naked eye. At clorit polyvinyl, polietilen, epoxid and others, the dendrites forming and the destruction of insulation may be the cause of the inside ionization, a characteristic process for the autonomic spaces and isolated gas.

Isolated bubbles in general are formed upon a gas formed by polymerization and evaporation of insulated materials composed of more components.

Due to that or to the thermic modifications of insulation, being under pressure all the time, is another ecumbrance for the isolation, reducing the lifetime of the insulation material. The final breakdown can be also caused by the impurity of the insulating material.

In case that inside the insulation material is found a carbon or metal particle, in this parts are formed high potential of electric fields and a silent discharge appears. In time, due to the electrochemical processes, on these places more intense discharges appear causing permanent damages on the isolation.

The operating life of the insulation depends in a great measure of the size and the number of air bubbles and hidden gas inside the insulation. The size and number of these bubbles or impurities influences a lot the intensity of the ionization process, and this processes determines the operating life of the insulation.

The gas bubbles or the impurities hidden inside the insulation present a dynamic efforts source in the insulating material internal inhomogeneous zones at the temperature changing. At the power press influence may appear insulation mechanical cracks and damages and electrostatic changes .

Dielectric Characteristics And The Loss Inside The Insulation (Dielectrics)

The dielectric characteristics of the insulated material are defined by a dielectric constant representing the electrical quantity measure (electrostatic induction) that can be inserted by this material on the capacitor plates between which it is settled. This means that the dielectric has the characteristic of transforming the electric field inside (a big capacity is obtained). The dielectric constant has the maxim value at continuous current, for a certain material. This constant doesn’t depend on the dielectric thickness, the applied voltage, the frequency, the temperature, the pressure (for gases) and the humidity level.

We may conclude that the dielectric constant is relative and represents an undefined number.

At the insulated materials submitted to alternative voltages is demanded an insignificant dielectric constant and a very high total résistance. The dielectric loss that appears in this case are proportional with the dielectric constant. Considering these functioning conditions, the insulators with a high dielectric constant have a negative influence, because they behave as a parallel capacitive connexion. The variable electric field in dielectric forms a dielectric current. This current represents the dielectric loss current, causing the dielectric heating, proportional with the parasitical capacity, respectively the material dielectric constant.

The insulated material dielectric constant has an important meaning for the calculation of the board, devices and equipments insulation at high frequency. Beside, this dielectric loss appeared because of the polarization modification in the dielectric structure, under the influence of the alternative voltage variable electric field, also appear losses as consequence of the passing current through the insulator (dielectric). The losses created by the passing current are presented indifferently of the submission of the insulated material to a continuous current voltage or to a alternative current voltage. The result of these loss is the heating of the insulator. In case of insulated material (dielectric) heating, the insulation resistance decrease suddenly, leading to a sudden increase of loss power, due to the same increasing of the passing current, and the loss power is proportional with the current. at the second power.

The power losses inside the insulated material are proportional with the power factor cos (Φ), respectively with the power factor tg (δ). This characteristic appears at the alternative current, because the insulated material inside the alternative current behave as a dielectric and in this case, the current is quadratured. The current is dephased with a δ angle. This phenomenon is called dielectric hysteresis and it is different from the magnetic hysteresis because it has no remanence and no coercitive force. This effect it's very important for the calculus of the power loss in dielectric, also in the high frequency technology and in telecommunications.

The value of the loss angle is very much influenced by the dielectric temperature. In most dielectrics, the loss factor grow with the growth of the temperature.

Exceptions are the mineral and organic oils, but only in the first part of the characteristic, where the factor is dropping, followed by a growing of the temperature. The loss factor tg (δ) do not depend on the shape and the capacity, but is dependent on the frequency more or less.

For the 50Hz frequency, the dielectrical losses are small. For the high frequencies the dielectrical losses reach high values, this becoming important. In this case, a meaningful worming-up appears at the dielectric which will damage the insulation.

Dielectric Rigidity

The dielectric rigidity is the second characteristic of the insulation. This represents the dielectric propriety of avoiding the breaking down to a certain field value in which it is inserted. In these circumstances, the structure of the insulation is under the influence of the extended electric field and suffers a certain elastic deformation.

When the influence of the electric field stops, the insulated material comes back to its initial status. If the critical value of the electric field is passed, is opened the dielectric breakdown. The dielectric rigidity of the insulated material decrease its thickness, and because of that it is always mentioned the thickness of the insulation for which is determined. The dielectric rigidity for a smaller thickness of the insulation presents a constant because the transfer of the heating is better. Decreasing the dielectric rigidity with the increasing of the insulated material thickness can be explained by making the assumptions that at a big thickness, the insulation can't eliminate the heat produced by that conduction current and proportional dielectric loss.

Inside the insulated material, due to this cause, it is produced an increasing quantity of heat which can determinate the deterioration of the insulated material.

Decreasing the dielectric rigidity with the increase of insulated material thickness, can be explained by the fact that, in the higher volume of the insulation, we also encounter a large number of ionization processes sources, as follows: gas capture, respectively air in different forms like bubbles, foreign corps (impurity inside the insulated material, humidity holding and also a large number of impure crystalline structures inside the insulated material).

In case of the insulated material breakdown at a short time voltage, we can assume that happens a so-called "cold" breakdown of the insulation. A breakdown of this kind can appear when we apply a voltage for a short time, and appear in the most cases, on the weak portion of the insulated material.

The influence of short time potential, in this case, did not produced the heating of the insulation material to the critical value, in order for the insulation to be punctured electrically.

It has been discovered the existence of two temperature areas (zones) in which the insulating material behave differently. Rupturing voltage depending on a material temperature U=f(C) is presented in fig.1

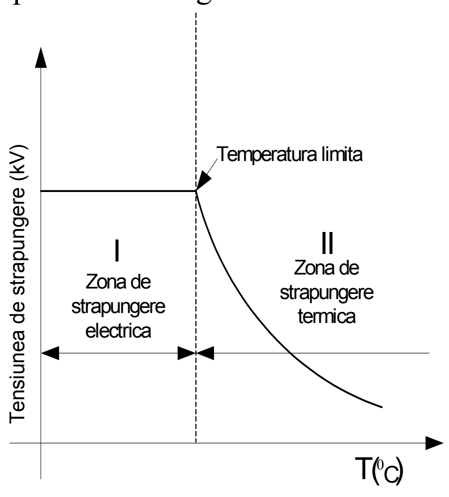

Fig. 1

Area II is the thermic puncture area mentioned above. In this area, the rupturing voltage depends greatly on the temperature and duration of the electric effort (force) of the insulation, for a given insulation thickness.

In this area it's possible to appear the puncture of the insulating material with a short time potential. This is why the name electro-thermic puncture is introduced .

Of a great importance is the electric puncture area, in the area I on the figure, separated from area II by a precise temperature which characterizes each insulating material. In this area it's observed that the breaking potential is nearly uninfluenced by the temperature that indicates that in this area is present only the electric puncture.

This electric puncture of the insulating material it's explained by presuming the existence of a followed crystalline net in the insulating material. It's presumed that the structure of the insulating material it's not ideally formed (for the solid materials).

The link between crystals in some places is week and between crystals there are cracks. Under the influence of exterior forces, in this places inside the structure, strong electric fields forms, this accelerating strongly the electrons and unbalanced ions.

This particles receive sufficient kinetic energy for the breaking of the crystalline mass of the material and thus forms a great number of free carriers (cumulative process) and the insulation is electrically punctured.

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