METHOD FOR HEAT TREATMENT FOR PROTECTED ELECTRIC ELEMENTS HAVING A MINERAL INSULATOR IN A RUST-PROOF COVERING

Inventor: Yves Grange, Paris, France
Assignee: Les Cables de Lyon, Lyon Cedex, France

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Primary Examiner—Stallard W.
Attorney, Agent, or Firm—Sughrue, Rothwell, Mion,
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ABSTRACT

This method for heat treatment for protected electric elements comprising at least a conductive core, a coating of an insulating mineral substance and a covering made of a rust-proof substance, is applied between two successive drawing operations of a rough from which the said elements are made.

The essential part of the method consists in re-heating separately the covering and the core, the rough tempered on leaving the re-heating operations.

This method may be applied, by means of a device comprising a high frequency furnace, a thermally controlled enclosure and tempering enclosure, to any protected element having a rust-proof covering.

4 Claims, 3 Drawing Figures
METHOD FOR HEAT TREATMENT FOR PROTECTED ELECTRIC ELEMENTS HAVING A MINERAL INSULATOR IN A RUST-PROOF COVERING

FIELD OF THE INVENTION

The present invention concerns a method for heat treatment intended for a particular family of protected electric elements, protected conductors and protected cables, in which the insulation consists of a mineral substance and whose external protection is provided by means of a metallic covering, more particularly a rust-proof covering. The invention also relates to a device for applying the method in question, as well as to the products obtained by the applying of the said method.

DESCRIPTION OF THE PRIOR ART

It is known that, to manufacture elements in the family in question, a succession of drawing operations which are shaped into the finished product, starting from a blank having substantially larger dimensions than the finished product. Throughout this manufacturing method, it is nevertheless necessary to insert, between two successive drawing phases, an annealing operation.

A virtually unsolvable difficulty arises, however, in the majority of cases, because the annealing temperatures required for the coverings are greater than those imposed for the cores. Thus, there is a constant danger of obtaining blanks having, on the one hand, casings which are insufficiently annealed and, consequently, having insufficient ductility and having poor resistance to corrosion, and on the other hand, cores which are too annealed and thus made fragile on account of the presence, in the mass, of certain large crystals. In the particular case where the cable to be manufactured is required to be used for constituting thermo-electric cables, cores which are too annealed lead to the producing, of interference electromotive forces disturbing the main measuring electromotive force.

That difficulty for the annealing of the various stainless metals, is all the greater as the temperatures brought into force come, within a range going from 850° to 1300°C, whereas those corresponding to the annealing of the cores are comprised between about 400° and 1000°C.

It should, however, be stated that, in all cases, temperatures for the annealing of coverings always correspond, for the annealing of cores, to a temperature lower than the previous one, each of the two temperatures being, nevertheless, taken within the range which was previously assigned to it.

SUMMARY OF THE INVENTION

The present invention is intended to overcome the difficulty thus revealed, during the effecting of any one of the annealing operations.

According to the invention, the method constituted by each of these annealing operations taken separately must be subdivided into three distinct phases which are spaced out one after the other throughout the run of the cable being treated.

The first of the three phases concerns exclusively the annealing of the covering of the rough without taking into consideration that of the cores. Use is made, for that purpose, of a high-frequency electrical heating process which, acting by a film effect, succeeds in bringing the covering very quickly to the required annealing temperature, long before a substantial heating has occurred in the mass of the cores.

In the second phase of the method according to the invention, the cores of the rough are to be brought to their annealing temperature, taking into account more particularly the slight heat conductivity of the insulating material, while maintaining the effective temperature of the covering, which is already annealed, above a limit level, which is that of the annealing of the cores of the rough.

Thus, it appears that, as it is a case of a heat treatment to be effected continuously and, disregarding the values assigned to the various temperatures to be reached, disregarding also the frequency of the heating current which should be suited to the thickness of the covering to be annealed, the most important production parameters are, in this specific case, the respective lengths of the elements subject to the three operational phases.

It is, moreover, necessary to take into consideration, when determining the duration of the intermediate phase of the treatment according to the invention, of the reaction, during that phase, of the three components of the cable. Indeed, the covering will have to undergo a certain cooling, due to the fact that the environment temperature during that second phase, will be less than that of the preceding phase; the insulant will become heated up progressively and much more slowly and will transmit the heat flux to the copper cores, which will become heated up in their turn.

During the third and last phase of the method according to the invention, the reaction of the three components of the blank will be as follows: the tempering of the covering, which will be suddenly and directly put into contact with the cooling liquid and will undergo a sudden drop in temperature, until it reaches that of the structural stabilization sought; the cores will become cooled down more slowly, because of the slight heat conductivity of the insulating material.

The device for bringing the method according to the invention into effect is characterized by the existence of three items which are independent but situated one after another along the path of the cable to be treated, the latter being driven along by a suitable device.

The first of these items is constituted by a high-frequency furnace comprising essentially a muffle made of a refractory substance, quartz, for example, that muffle being surrounded by an inductor conveying the high-frequency supply current of the furnace.

Inside the muffle, a reducing atmosphere or, even, a neutral atmosphere, is provided by a flow of an appropriate gas.

As has already been specified, particular attention will be given to the determining of the length of the muffle, as the conditions required for the annealing of the covering include the keeping of the latter for a certain time at the required temperature or at a slightly higher temperature. As for the frequency of the current, it will be chosen as a function of the thickness of penetration sought, so that only the covering receives the heat energy applied.

As for the temperature reached by the cores when they come out of the furnace, there is no need to be particularly concerned on this matter; the run speed defined by the condition previously set forth is indeed such that, taking into account the heat conductivity of
the insulant, the temperature reached by the cores will always be very substantially below the annealing temperature of the said covering.

The annealing of the cores of the blank will be effected inside the second item of the device according to the invention, an element which is constituted by a thermally controlled enclosure and in which is to be effected the transmission, to these cores, of the heat energy stored, during the passing of the rough in the high frequency furnace by the covering, as, nevertheless, the heat energy which the cores must receive is strictly limited to the required value with a view to the annealing of the said cores. The duration of the stay of the blank inside the thermally controlled enclosure should be defined as a function of that condition, here again taking into account the coefficient of heat transmission of the insulant.

In the majority of cases, the heat energy stored previously by the covering is over-abundant, this involving the dissipation, during the following phase, of the corresponding excess.

If, in certain particular cases, the contrary situation occurred, namely, if there were an insufficiency of heat energy at the input of the controlled enclosure, it would always be possible to supply to the blank a make-up quantity of heat energy, by any known means, more particularly by electric heating with resistors or by gas heating; the thermally controlled enclosure could then be a furnace.

The said enclosure or, possibly, the furnace which would substitute it, is crossed longitudinally, right through, by a muffle which may be made of steel and which must follow that of the high-frequency furnace, to which it will be assembled by a suitable connecting means.

The atmosphere inside the said enclosure will also be a reducing or neutral atmosphere. Preferably, a unique gaseous flow will be provided, in the downstream direction, in the assembly constituted by the said two muffles; in the case of a reducing gas and if it is required to avoid the setting up of a closed circuit flow, it would be sufficient to burn the said gas at its output, at the upstream end of the quartz muffle of the high-frequency furnace.

The reaction of the various components of the blank inside the thermally controlled enclosure will be essentially as follows: the temperature of the covering will undergo a certain drop, between the input and the output of the enclosure; the cores which had already undergone a beginning of heating up inside the high-frequency furnace, will have their temperature raised progressively as a function of their inherent heat conductivity as well as of the coefficient of heat transmission of the insulant.

Indeed only the temperature reached by the cores will fix the length of the enclosure, it being compulsory for the said temperature to be that of the annealing sought, taking into account the period during which the said cores must be kept at that same temperature or at a slightly higher temperature; this condition alone will determine, finally, the length of the enclosure. In general, the temperature in question will remain very clearly lower than that which the covering of the blank would have reached at the same instant, that is, at the output of the enclosure.

The third item of the device, namely, a tempering enclosure, in which the blank will be put into direct contact with the cooling fluid, which may be water, will be arranged following the maintaining furnace; a forced flow of the said fluid in the enclosure will be set up, so as to be absolutely certain that the blank will effectively be tempered at the required temperature as soon as it enters inside the said enclosure. The reaction, during the tempering of the three components of the rough is substantially the same, even if it is only because of its inherent thermal inertia and the slight heat conductivity of the insulant; the core of the rough will cool down less rapidly than the covering.

Needless to say, the fluid-tight connections must, more particularly, be made at points where the blank will enter the tempering enclosure and come out therefrom.

The device according to the invention will, of course, be completed by the drive system of the blank, that drive being effected, preferably, simultaneously, according to the invention, at the input and at the output of the device. The drive system could, more particularly, be constituted, at each of these points, by a double caterpillar drive belt made of an elastic substance, india rubber, for example, the said double caterpillar belt driving the blank along two generating lines diametrically opposite to that belt.

The finished product, that is, the conductor or the cable obtained subsequent to the successive drawing operations and intermediate heat treatments, has the following essential characteristics: the internal structure of the covering is essentially austenitic and free from slippage lines which are liable to cause as many beginnings of breakage; whereas the structure of the cores is that of as many crystalline systems having fine meshes, that structure being free, more particularly from any accumulation of any size, constituted by crystals having rounded edges.

Among the characteristics of the cables according to the invention, in the first instance, it is necessary to mention their faculty of being folded without breaking at a curve radius of practically zero. To appreciate this advantage thus constituted, it is sufficient to state for reference that the curving radius usually imposed for cables of this type never falls below a limit figure, representing substantially one and a half times the inherent diameter of the cable.

Another test to which this type of cable is also frequently subjected consists in suspending a determined weight at a point of the cable, at the end of a wire having a sufficient length, to be able to form several turns round the cable; the latter is then made to pivot on its axis, between two points, relatively close together and situated symmetrically in relation to the point of suspension of the wire; the pivoting movement will continue until the wire is completely wound. The cable is then made to pivot in the opposite direction, to unwind the wire completely. The operation is repeated as many times as is necessary, to make a beginning of breakage appear. Subjected to this test, a cable obtained according to the method described by the invention easily withstands, in relation to a currently manufactured cable, twice the number of wire winding and unwinding operations before the beginning of breakage appears.

Other particularities and advantages of the invention will become apparent from the following description and on referring to the accompanying drawings, that description and those drawings concerning a particular embodiment of a device constituting the applying of
the invention and given only by way of an illustration having no limiting character.

DESCRIPTION OF DRAWINGS

FIG. 1 shows a view, partially in section, of the device of the present invention;

FIG. 2 is a diagram of the variations in the temperature respectively in the covering and in the cores of the article being treated; and

FIG. 3 is a longitudinal sectional view, magnified, of the detail A in FIG. 1.

DESCRIPTION OF THE INVENTION

In FIG. 1, the rough 1 being treated crosses right through the device, in the direction of the arrow F, the driving of that blank being provided by means of the two systems 5 and 6, each of these systems being constituted by a double caterpillar drive belt.

The first element of the device, shown at 2, comprises a high-frequency furnace, in which the longitudinal muffle 7, made of a refractory substance, preferably quartz, is surrounded by the inductor 8, which is connected to the electric power source, not shown.

The cable blank 1 then enters inside the muffle 11 of the thermally controlled enclosure. A neutral atmosphere or, preferably, a reducing atmosphere prevails inside that muffle 11. The feed tube for the corresponding gas, which entering inside the muffle, propagates also inside the quartz muffle 7 of the high-frequency furnace, connecting to the aforesaid muffle 11 by a fluid-tight connection, is seen at 12. The gases leave through the upstream end 9 of the muffle 7, where they may be burnt, as shown at 10.

A forced flow cooling fluid runs through the tempering enclosure 4, whose function is to bring the cable blank 1 leaving the preceding enclosure 3 as suddenly as possible to the required temperature, the said fluid entering simultaneously into the tempering enclosure 4, preferably, through the two ends 13 and 14 of the latter to leave it through the only output 15, situated essentially in the middle of the said enclosure 4.

An injector fixed to each of the ends of the enclosure 4 has the function of making the fluid enter into the said enclosure at a certain speed, the two jets being directed towards the middle of the latter in directions opposite to each other, thus causing a depression at the level of the input connections and output connections of the rough. This device aims at avoiding or, in any case, reducing very substantially the leaks of fluid which might occur at these points.

The detail of the injector is shown in FIG. 3, which will be described further on.

The thermal diagram in FIG. 2 groups together the curves 16 and 17 diagrammatically showing the variations in the temperatures reached, at different points of the circuit, respectively, by the covering and by the cores of the cable blank. That illustration has been given with reference to the corresponding points of the treating circuit, such as they are shown in FIG. 1.

Thus, the curve 16, denoting the temperature of the covering, starting from the ambient temperature, has, when the cable blank enters into the high-frequency furnace, at the point 18, an ascending portion which is very steep up to the point 19. The rise of that temperature continues up to 20 at the output of the high-frequency furnace, then the cable blank enters into the enclosure 3. The temperature of the covering then lowers until it leaves the enclosure at 21, in the diagram; for its part, the curve 17 corresponding to the temperature of the cores shows a much slighter increase of the temperature inside the high-frequency furnace, up to the point 24, that increase continuing at a lower rate, in the enclosure 3, up to the point 25.

The entering of the rough into the enclosure 4 causes a sudden drop, down to the point 22, in the temperature of the covering, that of the cores following with a certain delay, down to 23, at the output of the enclosure.

The variations in temperature of the insulant have not been shown. It must, however, be stated that the successive drawing operations cause, on account of the increase in compactness of the insulant, an increase in its heat conductivity.

FIG. 3 shows one of the injectors 27, intended for inserting, in the tempering enclosure 4, the cooling fluid.

That injector, in the form of a nozzle, comprises a substantially truncated cone shaped converging space 28 through which the fluid, water, for example, is made to penetrate, that penetration taking place at a certain speed, from the input tubing 13.

In this way, the occurring of leaks of fluid in the tubular space remaining free between the central bore of the injector, extended by a tube such as 29 and the cable blank 1, is avoided, as explained before. Nevertheless, if such leaks should occur, they could be collected in a suitable receptacle such as 30, fitted with a drain cock such as 31.

On the downstream side, the injector 27 is connected to the wall 26 of the tempering enclosure 4.

It should be noted that the leaks likely to occur at the point where the cable blank leaves the enclosure are not specially detrimental.

The following text sets forth a few approximate figures of the temperatures read on a particular example of embodiment.

Thus, for a covering made of 18/8 stainless steel, whose melting point is relatively low, a rated annealing temperature comprised in a range going from 900° to 1000°C is taken, the said temperature admitting, for its part, only a tolerance of about 50°C.

If a maximum temperature of 600°C is then fixed for the annealing of the cores of the rough, with a tolerance in the same order as previously, the temperature of the cable blanks may be allowed to rise up to about 300°C at the output of the high-frequency furnace (reference 24) and the annealing temperature of 600°C will be found at the output of the enclosure 3 (reference 25).

Inasmuch as concerns the lengths, for a cable blank having an outside diameter of 22 mm, the figures 0.30, 2.50 and 2.00 m may be quoted respectively for the high-frequency furnace 2, the thermally controlled enclosure 3 and the tempering enclosure 4.

The above lengths may respectively be brought to 0.20, 1.00 and 0.50 m for a cable blank having an outside diameter of 4 mm.

Run speeds of the rough, ranging between 0.15 and 2.00 m/min., for diameters ranging between 22 and 4 mm, correspond to these lengths.

Contingently, it is possible to indicate, for the current frequencies, the figures 350 Kc/s and 2 Mc/s respectively for the already quoted diameters of 22 and 4 mm. As for the voltages, they may be in the order of 5000 V with, possibly, peaks of 7000 V.
It should also be stated, moreover, that blanks having an outside diameter of less than 4 mm may, during treatment, more particularly during finishing runs, have a tendency to creep; it is then preferable to set the device according to the invention as a whole in a vertical position.

I claim:

1. Heat treatment method for protected elements having at least one conductive core, a coating of an insulating mineral substance and an outside covering made of a rust-proof substance, the said elements undergoing several drawing operations, a suitable heat treatment being effected between two successive drawing operations, the said method comprising the steps of:
   a. annealing the covering,
   b. annealing of the cores, and
   c. tempering of the said covering and said cores.

2. Heat treatment method according to claim 1, characterized in that the step of annealing the covering is carried out by passing the element through a high frequency furnace.

3. Heat treatment method according to claim 1, characterized in that the step of annealing the cores of the element is effected by passing said element through a thermally controlled enclosure.

4. Heat treatment method according to claim 1, characterized in that the step of tempering the covering and cores is carried out by spraying said element with a coolant.

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