United States Patent

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[54] **PROCESS FOR THE PRODUCTION OF ELECTRICAL INSULATION**
3 Claims, No Drawings

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ABSTRACT: A method of coating an electrical conductor with an insulating material comprising the steps of dispersing a finely ground micronitic mineral powder such as magnesium-aluminum silicate or potassium-aluminum silicate in a solution of a binder agent the concentration of which is adjusted so that each particle of the powder will be ultimately coated with only a thin skin of the binder agent, drying the dispersion so as to evaporate the solvent and establish a meallike powder in which the individual binder coated particles do not adhere to each other, and then applying the dried binder-coated particles to the electrical conductor. An after-heat treatment of the coated electrical conductor is utilized to cement the particles together and in the case of a hardenable binder, such as an epoxy resin, to harden it.

Drying of the dispersion can be effected by the spray drying technique in which all of the solvent is evaporated prior to particle impingement, or by using a rotating drum.

Application of the dried binder-coated particles can be effected by an electrophoresis bath technique, or by the suspension method, or by electrostatic spraying.

PROCESS FOR THE PRODUCTION OF ELECTRICAL INSULATION

This invention relates to a method for the manufacture of an electrical insulation on a metallic conductor through the use of a mineral powder and further, to the use of a metallic conductor with the electrical insulation manufactured in accordance with the method. The technical concept of the invention consists essentially in that an electrical insulation of high strength both electrically and mechanically is produced simply and reliably with uniform quality, and especially in the fact that with the application of the electrical insulation by means of electrophoresis, or by the suspension method, or by electrostatic spraying, no separation of the components (for instance, mineral powder and binder) can occur due to differences in migration velocity.

As is well known, asbestos, bentonite, glass, mica, caolin, corundum and quartz are among the mineral powders most frequently used for electrical insulation, and the electrophoresis method has been increasingly utilized for their application on metallic conductors in recent years, as well as also the suspension method and electrostatic spraying. As dispersion means with the electrophoresis method have been quoted, among other substances, water, alcohols, ketones and mixtures of these. Experience has shown that such powders must be used in finest form and uniform grain size in order to make possible a uniform deposit. After drying, layers produced in this manner without the addition of a binder show, in most cases, insufficient adhesion, at least for use in electrical machines. It has therefore already been proposed to improve the adhesion by subsequent impregnation with a lacquer or another binding agent; allegedly, an electrophoretically formed deposit of calcined mica powder also can be transformed into a well-adhering coating through subsequent treatment with phosphoric acid and heating. But these methods are rather tricky and cumbersome, subsequent saturation with a binder often is not successfully achieved uniformly and completely, and the choice of binder useful for this purpose is relatively limited.

In order to obtain good adhesion of electrophoretically deposited powder layers, it has already been proposed to add suitable binding agents to the electrophoresis bath, which, however, must not impair the stability of the mixture. For this purpose, silicic acid esters, emulsified fluorine compounds, aqueous solutions of silicone resins or alcoholic suspensions of silicone rubber have been mentioned as adhesion improvement agents. It is known, however, that suspended particles show different migration velocities in the electrophoresis bath, depending on size, shape, specific weight, dielectric constant, emulsibility, emulsifier and stabilizer, bath temperature and current density. This leads to an increasing shift in the mixture ratio and thereby to the shortcoming of nonuniformity of the deposited layers so that mineral powders have been preferentially precipitated up to now from binder-free suspensions and were reinforced with a binding agent only subsequently.

These shortcomings of known methods are avoided by the new method with the essential feature that the powder particles are provided, prior to their application to the conductor, with a solid coating of binding agent. According to the invention, the advantages further show particularly if a metallic conductor with insulation manufactured according to the new method is used in an electrical machine.

The technical advance is found principally in that machines, powder pretreated according to the new method can be precipitated without trouble, with highly satisfactory uniformity, for instance, from an aqueous dispersion, and can be transformed without subsequent impregnation with a binder, by simple heating, into a permanently fast-adhering coating which is uniformly dense through and through, can be produced in always uniform quality and has especially good mechanical and electrical properties. The advance has an effect particularly on electrical machines if conductors with insulation made according to the new method are used in them, because in electrical machines, the conductor insulation is

subjected to particularly high mechanical and electrical stresses, and frequently also to high thermal stresses, with which the conductor insulation manufactured according to the new method can cope without difficulty, while for the up to now common impregnation with a binding agent no suitable and, at the same time, highly temperature-stable binders are available. In detail, the new method can be implemented to advantage in the following stepwise operations:

a. The mineral powder is suspended in water and after the coarser particles have settled out, that fraction remaining in suspension is separated for further processing, the particle size of which is less than about 5 μ, and particularly less than 1 μ;

b. after removal of the water and drying or calcining, the remaining powder is ground up;

c. the powder is dispersed in a solution of the binding agent the concentration of which is adjusted so that every powder particle is coated in the following operational step with only a thin skin of binding agent;

d. the dispersion is either sprayed in a drying arrangement in such a manner that the solvent has evaporated by the time the particles impinge, or is rotated continuously until the solvent has evaporated completely, in such a manner that a meallike powder remains, the particles of which do not stick together and are coated with the solid binder;

e. the powder coated with the solid binder is applied to the metallic conductor by electrophoresis, or by the suspension method, or by electrostatic spraying.

In this connection, the grinding (process step b) takes care of particle size as uniform as possible; it may be omitted depending on the quality requirements of each case, especially if in the process, step (a), particles over 1 μh have already been eliminated. Powders containing water of crystallization are calcined at least 500° C. the others are dried at 105 to 150° C. Drying arrangements of the type named under (d) are basically known; one knows, for instance, spray dryers from the manufacture of mild and coffee powder, and they can readily be adapted to the task at hand. In the spray dryer, the solvent is to evaporate before the particles impinge so that the binding agent coating solidifies prior to the impact and therefore cannot be damaged or stick to adjacent particles. The spraying arrangement must, of course, work so that it does not spray the dispersion in lumps. Rotating dryers usually operate with a rotating drum; they have proven themselves well for the task at hand. In any case, one will endeavor to recover the solvent escaping in the drying process. Further information regarding the drying of the binder coating follows below in connection with the examples. Continuous operation in the implementation of the method is possible and often desirable.

With regard to the process step (c) above, it should be further explained that according to the experience to date with the new method in the manufacture of powder particles with solid binder coating, two recipes for the dispersion in binder solvent have been found especially advantageous and have proven themselves in practice. According to the one recipe, 2,000 grams of micronized talcum powder (magnesium-aluminum silicate) are dispersed in a solution of 100 grams of epoxy resin with a softening point of about 60° C. and an epoxy equivalent weight of about 410 in 5,000 grams of methylethylketone with 5 grams of a boron trifluorideethylamine complex. According to the other recipe, 2,000 grams of micronized powder of mucovite mica (potassium-aluminum silicate) is calcined and subsequently dispersed in a solution of 100 grams of epoxydized phenolic resin (Novolac) with an epoxy equivalent weight of about 180 in 5,000 grams of acetone with 3 grams of a boron trifluorideethylamine complex. Larger or smaller quantities with the same quantity ratios can, of course, also be prepared.

The eletrophoric application of layers which is finding special interest today, is further developed by the invention in a particularly advantageous manner by applying powder particles provided with a solid coating of binder to the metallic conductor. In detail, the following operational steps have been found advantageous in this connection:

a. The metallic conductor is prepared by pickling and rinsing;

b. subsequently it is placed into the confined electrophoresis bath, which is kept in motion to prevent sedimentation and which consists of a dispersion of the powder, free of agglomeration, in a dispersion medium in which the coating of binder does not dissolve, swell or coagulate, and is connected with a DC source;

c. current density and duration of treatment are selected so that the desired thickness of deposit is generated;

d. the coated conductor is lifted out, rinsed and given an after-treatment by heating so that the binder coatings of the particles are cemented together and, in the case of a hardenable binder, hardened.

In the practice of this method the following data have given good results:

a. the metallic conductor, especially of copper, is prepared by pickling in concentrated nitric acid, rinsing with water, immersion into a 1 percent tartaric solution and subsequent rinsing with fully desalted water;

b. the electrophoresis bath consists of a dispersion of, for instance, 2,000 grams of the powder with solid binder coating of its particles, in 20 liter of fully desalted water; it has a p_H value of approximately 7 and a conductivity of about 600 μS and is kept at a temperature of about 30° C.;

c. a current density of at most 0.1 ampere/cm² is maintained;

d. the after-treatment is performed by heating to about 150° C.

The invention will be illustrated by the following two examples:

EXAMPLE 1

Making a suspension of micronized talcum powder (magnesium-aluminum silicate) in water, that fraction remaining in suspension after sedimentation of the coarser particles is separated whose particle size is under 1μ. After centrifuging and evaporating the water in a rotating drum, the remaining powder is dried for several hours completely at 120° C. and immediately after ground up in a porcelain ball mill. Even in these finest particles the flaky structure can be recognized under the microscope.

Then follows the coating of the talcum powder particles with a selected binder; the solution of which is to be adjusted as to its concentration so that each of its powder particles is coated only with a thin skin. In the present example, 100 grams of epoxy resin with a softening point near 60° C. and an epoxy equivalent weight of 410 are dissolved in 5,000 grams of methylethylketone. To this solution are added 5 grams of a boron trifluoride ethylamine complex and well mixed by stirring. In this synthetic resin solution, 2,000 grams of the dried and ground talcum powder is to be dispersed. This suspension is filled into a special, horizontally located rotating drum. This has a circular opening on both sidewalls where the solvent can escape. The porcelain drum, which is placed on rotating rollers, is located in a vacuum chamber which is equipped with a recovery system for the solvent. After the drum is placed in slow rotation, the vacuum pump is started. The vacuum is to be adjusted so that the solvent does not foam or boil too much. After 2 to 4 hours, the talcum powder coated with binder is dry and flows down the inside wall of the rotating drum in meallike form. The product thus prepared is now ready for the preparation of the electrophoresis bath, or for processing in the suspension method, or for electrostatic spraying. For electrophoretic coating, the bath is prepared as follows:

In a rectangular tank of 18/8 steel, equipped with a heater and a powerful agitation arrangement, 20 liters of fully desalted water are maintained at 30 ± 1° C. Into this bath are fed 2,000 grams of the powder described above so that a uniform dispersion without agglomeration results. The contents of the bath must be kept in motion so intensively that no sedimentation of the suspended material is possible. The p_H value of the immersion bath thus prepared should be about 7.0 and the conductivity near 600 μS.

The electrophoretic coating of metallic conductors is carried out as follows:

For instance, copper plates are first pickled in concentrated nitric acid, rinsed with water, briefly dipped in a 1 percent tartaric solution and subsequently washed in fully desalted water. After this preparatory treatment, a plate is connected to the direct current supply and hung into the grounded electrophoresis bath. The voltage is raised to 100 v., with a current density of 0.06 A./cm.² resulting. Depending on the duration of the current application and the magnitude of the voltage, the thickness of the deposited layer can be influenced.

After termination of the electrophoretic deposition, the direct current is switched off and the copper plate is lifted out of the bath. By spraying off with fully desalted water the plate is cleansed. An oven treatment of 150° C. for 4 hours causes hardening of the binder in the layer of talcum powder.

EXAMPLE 2

Micronized powder of muscovite mica (potassium-aluminum silicate) is preliminarily treated in the manner described in example 1, to obtain those particle sizes which are under 3 μ. By repeated grinding in a porcelain ball mill and subsequent calcining at a temperature above 500° C. the final quality of the powder with the desired fineness of less than 1 μ is obtained.

2,000 grams of this mica powder are subsequently dispersed in a solution of binder agent which is composed as follows:

100 grams of epoxydized phenolic resin (Novolac) with epoxy equivalent weight of about 180;

3 grams boron fluoride-ethylamine complex;

500 grams acetone.

The mica dispersion thus prepared is fed to a spray dryer from the top. In its drying tower this dispersion is atomized into the finest droplets on a disc rotating at high speed (for instance, 5,000 r.p.m.). Warm air with a temperature of 80° C. flows through from bottom to top. The solvent evaporates very fast, escapes with the air, and is subsequently recovered in a cooler. The dry mica particles, coated with solid binder, drop downward as a fine meal and are useable in this form for electrostatic spraying, the suspension method, or the electrophoresis bath. The preparation of the latter has been described in example 1. The binder of this variant is hardened for 24 hours at 150° C.

We claim:

1. The method of producing electrical insulation on an electrical conductor which comprises the steps of dispersing a finely ground mineral powder in a solution of a binder agent the concentration of which is adjusted to ultimately establish a thin skin of the binder agent on each individual particle of the powder, drying the dispersion to effect evaporation of the solvent and thereby produce a fine meallike powder the individual particles of which are each thinly coated with solid binder and nonadherent to each other, and applying said binder coated powder particles to the electrical conductor by electrophoresis.

2. The method as claimed in claim 1 and which includes the further steps of preparing the metallic conductor by pickling and rinsing, placing said prepared metallic conductor into a grounded electrophoresis bath which is kept in motion to prevent sedimentation and which consists of a conglomerate-free suspension of the binder coated mineral particles with a dispersion medium in which the binder coating does not dissolve, swell or coagulate, passing an electrical current through the bath and electrical conductor to cause the binder coated mineral particles to be deposited on the electrical conductor to the desired thickness, removing the coated electrical conductor from the bath and rinsing, and then subjecting the coated electrical conductor to a heating treatment to cement the binder coated particles together, and in the case of a hardenable binder to harden the same.

3. The method as defined in claim 2 wherein said pickling step for said electrical conductor is carried out in concentrated nitric acid and which includes the steps of rinsing out the nitric acid with water, immersing the rinsed electrical conductor in a 1 percent tartaric solution, and finally rinsing with fully desalted water, wherein said electrophoresis bath consists of a dispersion of 2,000 grams of the binder coated

mineral particles in 20 liters of fully desalted water, has a p_H value of about 7.0 and a conductivity of about 600 μS and is maintained at at temperature of about 30° C., wherein a current density of at most 0.1 ampere/cm.^{2} is maintained in the bath, and wherein the after heating treatment is carried out at a temperature of about 150° C.

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