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[54] **MANUFACTURING METHOD OF INSULATED WIRE**

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[58] **Field of Search** 204/181

[56] **References Cited**

UNITED STATES PATENTS

3,540,990	11/1970	Onishi et al.	204/181
3,681,224	8/1972	Stromberg	204/181

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[57] **ABSTRACT**

This invention relates to a manufacturing method of insulated wire by electrodeposition coating. More particularly, it relates to a manufacturing method of insulated wire by electrodeposition coating which is characterized in that after the electrodeposition of a resin, the coated wire is treated with a solution or dispersion of a surface active agent or solid lubricant in a solvent.

1 Claim, No Drawings

MANUFACTURING METHOD OF INSULATED WIRE

BACKGROUND OF THE INVENTION

This invention relates to a manufacturing method of insulated wire. More particularly, it relates to imparting an excellent coiling property to insulated wire insulated by an electrodeposition coating process.

In the case of magnet wire heretofore manufactured, varnish is applied by means of dies, wiper rollers, felts, etc. and is baked. The desired properties are obtained by repeating this procedure. When manufacturing magnet wire by an electrodeposition coating process, however, varnish is applied only once and is baked, so that it is necessary to obtain a film of the desired thickness by one application. At the same time, it is necessary to obtain the desired properties by baking only once. Although the manufacture of magnet wire by an electrodeposition coating process has been studied at length and developed in many quarters in recent years, it cannot yet be said satisfactory with respect to the properties obtained as compared with those obtained by the conventional method. That is to say, since magnet wire manufactured by an electrodeposition coating process undergoes the coating process only once, its coating film is liable to have various defective portions. As a result, such wire is frequently found inferior to wire manufactured by the conventional method with respect to breakdown voltage, resistance to friction, thermal softening, etc. On the other hand, when the magnet wire is used for coils, coiling is done in most cases by an automatic coiling machine. At that time the magnet wire is subjected to a great mechanical stress, so that it is often the case that the film is impaired and the properties of the magnet wire after coiling are further lowered. Although a solution to this problem is to provide the coiling machine with such a mechanism that it will not impair the magnet wire, an alternative solution is to impart to the magnet wire itself an excellent coiling property.

BRIEF DESCRIPTION OF THE INVENTION

By imparting an excellent coiling property to magnet wire manufactured by an electrodeposition coating process and thereby eliminating mechanical impairment to the coating film by an automatic coiling machine of severe working conditions, this invention imparts to the magnet wire coated by electrodeposition a full dependability for use in electric machines and appliances in general, even if such wire is inferior to magnet wire manufactured by the conventional method with respect to general properties.

What is called, the coiling property of magnet wire is as follows. When magnet wire is coiled to make coils for the rotary part of a motor or stators, it is coiled to some desired shape by an automatic coiling machine. At that time, the magnet wire is subjected to great tension, so that friction may take place between turns of the magnet wire or between the magnet wire and the metallic core or between the magnet wire and the stator metal. As a result, the coating film of the magnet wire becomes mechanically impaired.

For this reason, magnet wire having a good coiling property is generally one having a small friction coefficient. Mechanical impairment to magnet wire is minimized by lowering this friction coefficient as far as possible. We have improved the coiling property of magnet wire by decreasing the friction coefficient of the magnet wire.

In the case of magnet wire having an electrodeposition coating, a coating film of a desired thickness must be obtained by applying the varnish once, so that it is quite conceivable, and has actually been the fact, that it is mechanically, electrically and chemically inferior to such wire manufactured by the conventional method which entails laminating thin layers one upon another.

There are two kinds of varnishes for an electrodeposition coating. One is a varnish in the state of a complete solution in a solvent, and the other is one in the state of a dispersion in a solvent. With regard to their characteristics, it may generally be said that varnishes of the solution type have a very good adhesive property. In the case of simple coatings as for magnet wire, however, a good adhesive property is not so advantageous. A cause of this good adhesive property is a very high insulation resistance of the electrodeposited film (before baking). When the film deposited becomes thick, its insulation resistance makes it impossible to have the film deposited to be more than a certain thickness. This is a serious drawback for the manufacture of magnet wire which requires a comparatively large thickness. That is to say, with varnishes of the solution type, it is difficult to obtain a coating film of a desired thickness. To the contrary, it is comparatively simple to obtain a film of a desired thickness with varnishes of the dispersion type. However, they have shortcomings that they lose luster at the time of baking and in that the coating is liable to become cracked. Together with these shortcomings, they have a fatal defect in that it is difficult to obtain a smooth surface and consequently the coiling property of the wire is low.

A point of this invention is that a surface active agent or a solid lubricant which lowers the friction resistance is caused to permeate and disperse among varnish particles before baking and an excellent coiling property is thereby imparted to the magnet wire.

In order to improve the coiling property of magnet wire by lowering the friction coefficient of the insulating coating, a method entailing the application of a lubricating oil to the magnet wire in a thin layer after baking has heretofore been employed. However, that method has been found to be rather troublesome, as it is necessary to pay consideration to the kind and quantity of oil to be used.

The attaching of a solid lubricant to the coating film after baking is questionable with respect to the uniformity of the application, and it is not a good method if the loss of lubricant is taken into account. There is a method in which a lubricant is previously added to the varnish. This is effective with the conventional method of die drawing or of felt squeezing, but is not very effective when manufacturing electric wire by electrodeposition coating.

The reason for this is that even if a surface active agent or solid lubricant is dissolved or dispersed in a water varnish, the solvent in the varnish is affected by the action of electric osmosis when the resin in the varnish is electrodeposited on the conductor, so that it is mostly discharged from the electrodeposited resin and scarcely remains in the electrodeposited resin. It therefore is not effective, even if it can be dissolved or dispersed in the water varnish before hand. The treatment step for rendering a good coiling property which is

made midway between the electrodeposition vat and the baking furnace according to the present invention is most effective.

This invention is effective on varnishes of both the solution type and the dispersion type, and gives an excellent coiling property to magnet wire with an electrodeposited coating.

DETAILED DESCRIPTION OF THE INVENTION

Now this invention will be explained in detail.

An electrodeposited resin contains solid in a concentration of 80 – 90 percent. The resin is baked in a baking furnace. According to the present invention, a solvent treatment vat for giving a treatment to the coated wire to render an excellent coiling property is provided between the electrodeposition vat and the baking furnace. As for the solvent used, it is preferable to use a solvent which has an action which will help a surface active agent or solid lubricant penetrate into the electrodeposited resin.

A point of the present invention is that a surface active agent or solid lubricant which lowers the friction coefficient of the coating film of the magnet wire is added to such a solvent in a suitable quantity.

If the resin electrodeposited in this way is given such a treatment before baking, the coiling property of the magnet wire obtained is found to be exceedingly good. While temperatures which are not below room temperature may be satisfactory for the treating vat, it is preferable to raise its temperature to about 60° - 90° C. to obtain a better effect. It is possible thereby to have the surface active agent or solid lubricant penetrate into the coating film in a very short time and obtain, after drying, magnet wire having an excellent coiling property with a small friction coefficient. There are many surface active agents which may be used, but those which are most effective are silicon compounds.

They are, for example, those of the type such as "Paintat" of Fuji Kobunshi and "KPX" of Shinetsu Kagaku. Such surface active agents act to lower surface tension, and, in the coating film after baking, lowers the friction coefficient.

As solid lubricants, there are both inorganic and organic substances, such as graphite, molybdenum disulphide, lead oxide, polytetrafluoroethylene, etc. To ensure a better effect, it is preferable to use one which dissolves and penetrates into the electrodeposited resin together with the solvent rather than one which merely disperses in the solvent.

For example, there are the solid type as solid "FC" of tetrafluorocarbon manufactured by the 3M Company.

By dissolving a very small quantity of such a silicon or fluorocarbon product, the friction coefficient of the magnet wire can be lowered and impairment to the coating film done by the automatic coiling machine is for the most part prevented. If the additive is in a quantity of about 0.01 – 1 percent, it proves effective, but there are no limits to its quantity in so far as affecting the properties of the coating film.

When the static friction coefficient of magnet wire in general is measured, it is found to be about 0.09 – 0.12 with all of the common polyvinylformal wire, polyester wire, polyamideimide wire, polyesterimide wire, etc., while on the other hand the static friction coefficient of nylon wire and wire with nylon overcoating is about 0.04 – 0.08. The present invention is a success in lower-

TABLE

	Reference 1	Reference 2	Reference 3	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8
Manufacturing conditions:											
Water soluble or dispersion varnish.	Phenol-ester	Acrylic	Polyvinyl formal.	Phenol-ester	Phenol-ester	Acrylic	Acrylic	Acrylic	Polyvinyl formal.	Polyvinyl formal.	Polyvinyl formal.
Treating agent	N-methyl-2-pyrrolidone.	N-methyl-2-pyrrolidone	N-dimethyl-acetamide.	(N-methyl-2-pyrrolidone) plus (paintat M).	(N-methyl-2-pyrrolidone) plus (FC–98).	(N-methyl-2-pyrrolidone) plus (KPX–321).	(N-methyl-2-pyrrolidone) plus (paintat M).	(N-methyl-2-pyrrolidone) plus (FC–95).	(N-dimethyl-acetamide) plus (KPX–321).	(N-dimethyl-acetamide) plus (paintat L).	(N-dimethyl-acetamide) plus (FC–134).
Speed	40 m./min	40 m./min	40 m./min	40 m./min	40 m./min	40 m./min	40 m./min	40 m./min	40 m./min	40 m./min	40 m./min.
Voltage	120 V	45 V	35 V	120 V	123 V	46 V	45 V	45 V	36 V	35 V	35 V.
Current	450 ma	250 ma	200 ma	460 ma	460 ma	250 ma	255 ma	250 ma	210 ma	205 ma	205 ma.
Properties:											
Conductor diameter	1.0 mm	1.0 mm	1.0 mm	1.0 mm	1.0 mm	1.0 mm	1.0 mm	1.0 mm	1.0 mm	1.0 mm	1.0 mm.
Film thickness	0.021 mm	0.040 mm	0.042 mm	0.020 mm	0.020 mm	0.041 mm	0.041 mm	0.040 mm	0.042 mm	0.041 mm	0.042 mm.
Appearance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good.
Static friction coefficient	0.091	0.095	0.105	0.060	0.058	0.055	0.052	0.050	0.060	0.058	0.055.
Breakdown voltage	3,200 V	8,500 V	9,000 V	3,200 V	3,800 V	8,300 V	9,200 V	8,700 V	9,100 V	8,500 V	8,700 V.
Pinholes	1~2/m	None	None	1~2/m	1~2/m	None	None	None	None	None	None.

ing the friction coefficient of 0.09 – 0.10 to about one half, 0.05 – 0.06, by having a silicon compound or fluoride resin in the coating film of the magnet wire by the method of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Explanation will now be given with reference to examples.

Example for Comparison 1.

The electrodeposition vat was filled with a polyester water-soluble phenol varnish modified with maleic acid, and a treating vat of a length of 30 cm was provided between the baking furnace and the electrodeposition vat.

N-methyl-2-pyrolidone was used as the principal solvent of the treating liquid. The temperature of the treating liquid was 40° C. The manufacturing conditions and properties are given in the table.

Example for Comparison 2.

The electrodeposition vat was filled with Lecton RK-6338 of Du-Pont, whose principal component is acrylonitrile. The principal solvent for the treating liquid was N-methyl-2-pyrolidone. The temperature of the treating liquid was 70° C. The manufacturing conditions and properties are given in the table.

Example for Comparison 3.

The electrodeposition vat was filled with a varnish of the dispersion type, the principal component of which was polyvinylformal.

N-dimethylacetamide was used as the principal solvent for the treating liquid, and the temperature of the treating liquid was 70° C. The manufacturing conditions and properties are given in the table.

Example of embodiment 1.

In employing the method of Example for comparison 1, Paintat M, a silicon surface active agent of Fuji Kobunshi, was added to the treating liquid in a quantity of 0.5 percent. The coating film of the magnet wire had a smaller friction coefficient, and its coiling property was found improved.

The manufacturing conditions and properties are shown in the table.

Example of Embodiment 2.

Fluorocarbon FC-98, a solid lubricant of 3M Company, was added in a quantity of 0.3 percent to the treating liquid of the method of Example for Comparison 1. The friction coefficient became smaller and the coiling property was improved. The manufacturing conditions and properties are shown in the table.

Example of Embodiment 3.

KPX-321, a surface active agent made by Shinetsu Kagaku, was added in a quantity of 0.5 percent to the treating liquid of the method of Example for Comparison 2. Magnet wire having a good coiling property was manufactured.

The manufacturing conditions and properties are shown in the table.

Example of Embodiment 4.

Paintat M, a surface active agent made by Fuji Kobunshi, was added in a quantity of 0.5 percent to the treating liquid of the method of Example for Comparison 2. Magnet wire having a good coiling property was manufactured.

The manufacturing conditions and properties are shown in the table.

Example of Embodiment 5.

Fluorocarbon FC-95, a solid lubricant made by 3M Company, was added in a quantity of 0.3 percent to the treating liquid of the method of Example for Comparison 2.

Magnet wire having a good coiling property was manufactured.

The manufacturing conditions and properties are shown in the table.

Example of Embodiment 6.

KPX-321, a surface active agent made by Shinetsu Kagaku, was added in a quantity of 0.5 percent to the treating liquid of the method of Example for Comparison 3. Magnet wire having a good coiling property was manufactured.

The manufacturing conditions and properties are shown in the table.

Example of Embodiment 7.

Paintat L, a surface active agent made by Fuji Kobunshi, was added in a quantity of 0.5 percent to the treating liquid of the method of Example for Comparison 3. Magnet wire having a good coiling property was obtained.

The manufacturing conditions and properties are shown in the table.

Example of Embodiment 8.

Fluorocarbon FC-134, a solid lubricant made by 3M. Company was added in a quantity of 0.3 percent to the treating liquid of the method of Example for Comparison 3. Magnet wire having a good coiling property was manufactured.

The manufacturing conditions and properties are shown in the table.

We claim:

1. The method of manufacturing insulated wire comprising the steps of electrodepositing a resin coating on an electric conductor, at least partially dissolving the electrodeposited resin with a solution or dispersion of a solid lubricant in an organic solvent thereby introducing said solid lubricant into said electrodeposited resin to lower the friction coefficient thereof, and thereafter baking the treated resin.

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