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(54) SELF-BONDING WIRE FOR WINDING INTO MAGNET COILS /

(71) We, SUMITOMO ELECTRIC INDUSTRIES LIMITED, a Japanese Company, of No. 15, Kitaham 5-chome, Higashi-ku, Osaka-shi, Osaka, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to self-bonding wire for winding into magnet coils.

Heretofore, yoke coils used in television sets have been produced by winding wire into a coil shape, subjecting the coil to rapid heating to activate a bonding layer on the wire and pressing the coil into its final shape while the bonding layer is still hot. In such a process, a self-bonding magnet-coil wire having a heat-activated layer on the top of an insulating layer is employed. Heretofore, polymers such as polyvinyl butyral and alcohol-soluble nylons have been employed as self-bonding layers for self-bonding magnet-coil wires.

In view of the requirements of broadened deflection angles, however, it has recently been desired to minimize the heat distortion of coils and the deformation of coils due to moisture absorption and to maintain adhesion even at high temperatures of about 130°C. With known self-bonding magnet-coil wires using for example, polyvinyl butyrals or alcohol-soluble nylons as a bonding layer, the polyvinyl butyrals show poor resistance to thermal deformation and the nylons inhibit a magnet-coil wire from being smoothly supplied in an automatic winding machine as they give the wires a tacky surface which tends to stick to the bobbin in the winding machine or undergo tackiness due to moisture absorption during storage.

To eliminate the above disadvantages, it has been proposed to add thermosetting resins such as polyester resins, epoxy resins, and phenol resins, or these thermosetting resins in combination with hardening agents such as blocked isocyanates, to alcohol-soluble nylons.

For example, the manufacture of a coil-forming insulating material comprising an alcohol-soluble copolyamide resin and a thermosetting synthetic resin is disclosed, e.g., in U.S. Patent 3,553,011. The conventional coating layer obtained according to said patent however, includes a portion of thermosetting resin which remains unchanged, which is alcohol-soluble, and thus it has poor toughness and resistance against chemicals and it not suited for yoke coils used in television sets, since the step of immersing in alcohols is required at the time of forming a coil.

Furthermore, such reactive varnishes either lose their fusibility if heating is conducted to avoid tackiness of the wires to bobbins, or require high fusion temperatures. As a result, it is difficult to provide products of uniform quality. Further even a self-bonding magnet-coil wire in which tackiness to bobbins is prevented under ordinary conditions as above still becomes tacky under conditions of high temperature and high humidity. Therefore, after the wire is shaped into a coil, deformation thereof by heating or moisture absorption is significant. Accordingly, the requirement of high reliability of deflecting coils has not yet been satisfied.

In order to prevent tackiness of wires to bobbins, it has also been proposed to add acrylonitrile-styrene copolymer resins or polyhydroxy-polyether resins to alcohol-soluble nylons. However, adhesion decreases as compared to the use of nylon alone, and such compositions cannot be considered an acceptable solution to the deformation problems due to heating and moisture absorption.

It is therefore an object of the present invention to provide a self-bonding wire for winding into magnet coils in which the above-mentioned disadvantages are alleviated or overcome.

In accordance with the present invention a self-bonding magnet-coil wire comprises a conductor wire coated with a baked mixture of

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nylon copolymer (A) and nylon copolymer (B), wherein the proportion of (A) and (B) is 50—95 parts of (A) to 50 to 5 parts of (B) (by weight), wherein nylon copolymer (A) is insoluble in and non-swellable by alcohols (e.g., methanol, ethanol, propanol or isopropanol) at room temperature, and contains nylon-12, and wherein nylon copolymer (B) has a lower melting point than that of nylon copolymer (A). It is found that the self-bonding magnet-coil wire of the invention does not exhibit tackiness to bobbins and permits bonding at low temperatures in a short period of time (from a few seconds to scores of seconds in the case of current heating and from about 5 minutes to about 30 minutes in the case of oven heating) and further shows excellent bond strength at high temperatures, e.g., 130°C.

In addition, the self-bonding magnet-coil wire of the present invention even when shaped into a coil, shows little deformation due to heating and moisture absorption and exhibits excellent heat distortion resistance and excellent resistance to deformation due to moisture absorption.

In spite of possessing a strong bond strength at high temperatures, the self-bonding magnet-coil wire of the present invention permits bonding at relatively low temperatures, e.g., 150°C to 160°C. Accordingly, even if conventional polyurethanes, polyesters etc., are employed as an insulating layer, no serious decrease in the characteristic properties of the insulating layer due to heating upon bonding are encountered. In particular, in the case of using insulating materials having heat stability above Class F as an insulating layer, e.g., the heat stable polyester-imides, polyamide-imides, polyhydantoins, polyimides or multilayered structures thereof, all of which show high heat stability, superior effects are exhibited. Thus, even if pressure-forming after high speed winding, rapid heating by passage of an electric current or quenching is conducted, a self-bonding magnet-coil wire having high reliability is obtained without any deterioration in processing, layer short circuiting or a decrease in the characteristic properties of self-bonding magnet-coil wires.

The self-bonding coating of the self-bonding magnet-coil wire in accordance with the present invention has an alcohol-insoluble nylon as the main component and unlike blends having alcohol soluble nylons as the main component, does not result in a lowering of the excellent characteristic properties which nylon copolymer resins process. In addition, the self-bonding magnet-coil shows excellent solvent resistance because it is insoluble or substantially insoluble in alcohols, and further, it is less hygroscopic so that it is free from tackiness to bobbins caused by moisture absorption, any decrease in adhesion of coils obtained by molding thereof, deformation due

to expansion or swelling, etc., which are observed in self-bonding magnet-coil wires using alcohol-soluble nylons.

In the present invention, it is preferred to use, as nylon copolymer (A), which is insoluble in and non-swellable by alcohols and which contains nylon-12, nylon copolymers obtained by copolymerizing laurolactam or polylaurolactam with other polyamide-forming monomers, e.g., polyamide copolymers obtained from laurolactam and ϵ -caprolactam (nylon-12-6), polyamide copolymers obtained from laurolactam and hexamethylene diammonium adipate (nylon-12-nylon-6,6), or polyamide copolymer obtained from laurolactam and hexamethylene diammonium sebacate (nylon-12-nylon-6,10) containing laurolactam in a proportion of 60 to 90%, more preferably, 75 to 85% and most preferably 80%, by weight based on the total copolymer weight (hereafter all percentages are percents by weight, unless otherwise indicated).

Examples of nylon copolymer (B) which has a lower melting point than that of nylon copolymer (A) include nylon-6-nylon-6,6-nylon-6,10 copolymers, nylon-6-nylon-6,6-nylon-12 copolymers, nylon-6-nylon-6,10-nylon-12 copolymers and nylon-6-nylon-6,6-nylon-6,10-nylon-12 copolymers.

It is preferred to use a nylon copolymer containing nylon-12 at a proportion of 10 to 50%, obtained by copolymerizing nylon-12 with one or more monomer components selected from nylon-6, nylon-6,6 and nylon-6,10 where 10 to 50% of nylon-12 is present in the copolymer.

Examples of nylon copolymer (B) which has a lower melting point than that of nylon copolymer (A) include two-, three- or higher component copolymers, e.g., polyamide copolymers obtained from ϵ -caprolactam, hexamethylene diammonium adipate and hexamethylene diammonium sebacate (nylon-6-nylon-6,6-nylon-6,10), polyamide copolymers obtained from ϵ -caprolactam, hexamethylene diammonium adipate and polylaurolactam (nylon-6-nylon-6,6-nylon-12), polyamide copolymers obtained from ϵ -caprolactam, hexamethylene diammonium adipate and polylaurolactam, polyamide copolymers obtained from ϵ -caprolactam, hexamethylene diammonium adipate, hexamethylene diammonium sebacate and polylaurolactam (nylon-6-nylon-6,6-nylon-6,10-nylon-12). It is preferred to use a nylon copolymer containing laurolactam or polylaurolactam at a proportion of 10 to 50%, obtained by copolymerizing laurolactam or polylaurolactam with one or more other polyamide-forming monomers where 10 to 50% laurolactam or polylaurolactam is present in the copolymer. Preferred examples are nylon-6-nylon-6,6-nylon-12, and nylon-6-nylon-6,10-nylon-12. It is most preferred to use nylon-6-nylon-6,6-nylon-12 as nylon copolymer (B), when the aforementioned nylon-12-

nylon-6 is employed as nylon copolymer (A). All percentages given above are based on total copolymer weight.

5 It is commercially preferred to carry out baking under conditions of a temperature of about 250°C to about 400°C, at a linear oven velocity of about 5 m to about 20 m/min. under atmospheric pressure using an oven having an oven length of about 4 m. Usually
10 baking is conducted in air and the time of baking is a function of oven length and linear velocity.

Further, if desired, thermosetting resins such as phenol resins, melamine resins and epoxy
15 resins or blocked isocyanates, can be added to a blend containing as a main component at least 50% by weight of the mixture of (A) and (B) [a mixture of (A) and (B) as a 95/5 to 50/50 weight ratio of (A)/(B)], in
20 such an amount that bonding is not damaged, in order to improve the characteristic properties of the coils such as heat distortion resistance, resistance to deformation due to moisture absorption, etc.

25 Furthermore, it is possible to improve characteristic properties as an electric wire by adding one or more additives such as plasticizers, silicones, surface active agents, pigments, dyes and organic and inorganic fillers in an appropriate amount.
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The present invention will now be illustrated in detail by the following Examples.

EXAMPLE 1.

35 Nylon copolymer (I), a nylon copolymer obtained by copolymerizing 80% lauro lactam and 20% ε-caprolactam and which has a reduced viscosity of 1.71 (η sp/C: 0.5% m-cresol solution, at 30°C.: hereafter reduced viscosity is always measured under the same conditions) as nylon copolymer (A) and nylon copolymer (II), a copolymer obtained by copolymerizing polylauro lactam, ε-caprolactam and hexamethylene diammonium adipate (1:1:1 weight ratio) as nylon copolymer (B), which
45 had an η sp/C of 1.24, were dissolved in a solvent mixture of m-cresol and naphtha (1/1 weight ratio) at a mixing proportion of (I)/(II) of 95/5 (by weight). A coating varnish of 15% concentration was thus prepared.
50 Using a copper wire having a conductor diameter of 0.5 mm. on which a polyester-imide insulating varnish having a heat stability of class H (registered Trade Mark ISOMID LV, manufactured by Schenectady Chemicals Corporation) was coated six times (4 μ per coat: total thickness 24 μ), the varnish prepared as above was then further coated twice (6 μ per coat; the layer thickness of bonding layer being 12 μ) so that the total thickness of
55 final article (after bonding) was 36 μ . Baking was then conducted at a linear velocity of 10 m./min. in a vertical baking furnace (longitudinal length of 4 m.: retention time was 24 sec.) where the furnace temperatures was

370°C. in the upper portion, 350°C in the central portion and 250°C. in the lower portion. A self-bonding magnet-coil wire was thus prepared in a continuous fashion. 65

EXAMPLES 2, 3, 4 and 5.

A self-bonding magnet-coil wire was obtained
70 as in Example 1 except that the mixing proportion of nylon copolymer (I) and nylon Copolymer (II) was changed to 90/10, 80/20, 70/30 and 50/50 (weight ratio) in Examples 2, 3, 4 and 5, respectively. 75

COMPARATIVE EXAMPLE 1.

A self-bonding magnet-coil wire was obtained by twice coating a 15% polyvinyl butyral resin (tradename ESLECK BM-1, manufactured by the Sekisui Chemical Co., Ltd.) in a naphtha-m-cresol solvent mixture as
80 in Example 1 onto a polyester-imide insulated electric wire having a conductor diameter of 0.5 mm.) same as in Example 1) and then baking in a vertical baking furnace where the
85 furnace temperature was 250°C. in the upper portion, 250°C. in the central portion and 150°C. in the lower portion.

COMPARATIVE EXAMPLE 2.

A self-bonding magnet-coil wire was prepared
90 as in Example 1 except that a 15% solution of nylon copolymer (II) alone in the m-cresol-naphtha solvent mixture was used. The thus obtained magnet wire was tacky to bobbins and could not be smoothly wound back from a
95 bobbin.

COMPARATIVE EXAMPLE 3.

A self-bonding magnet-coil wire was prepared as in Example 1 except that the mixing ratio of nylon copolymer (I) and nylon copolymer (II) was 30/70. The thus obtained magnet wire was somewhat tacky to bobbins. 100

COMPARATIVE EXAMPLE 4.

A self-bonding magnet-coil wire was prepared as in Example 1 except that a 15% solution of nylon copolymer (I) alone in the m-cresol-naphtha solvent mixture was used. The thus obtained magnet-coil wire was not tacky to bobbins but exhibited low adhesion at a bonding temperature of 160°C. 110

The bond strength of the self-bonding magnet-coil wires obtained in Examples 1 to 5 and Comparative Examples 1 to 4 was measured according to ASTM-D 2519.

The self-bonding magnet-coil wires were
115 tightly wound around a mandrel 5.0 mm. in diameter to obtain a helical coil of 70 mm. in length. The helical coils obtained were bonded under definite conditions (60°C, 10 minutes). In Table 1, a change in deformation (change in width and bend of a molded deflecting coil (kept at 60°C, 100% RH, 2 days or 7 days; see bottom of Table 1) of 0 to 0.1 mm. is referred to as "0", 0.1 to 0.5 mm. as "+", 120

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properties such as windability, windability after rapid stretching, abrasion resistance, resistance to deterioration in processing, etc., and, in addition, exhibits good thermal properties such as heat-shock resistance, resistance to deterioration due to heating, etc., which are not exhibited by conventional self-bonding magnet-coil wires.

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0.5 to 1.0 mm. as "+ + +" and greater than 1.0 mm as "+ + + +", respectively.

The coils obtained by shaping the self-bonding magnet-coil wire of the present invention showed excellent heat distortion resistance and resistance to deformation due to moisture absorption.

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The self-bonding magnet-coil wire of the present invention exhibits excellent mechanical

TABLE 1

	Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Nylon copolymer (I)	95	90	80	70	50			30	100
Nylon copolymer (II)	5	10	20	30	50		100	70	
Polyvinyl butyral						100			
Bond Strength after fusion at 160°C for 10 mins. Measured at Room Temperature (kg.)	3.8	4.5	4.6	4.6	4.2	5.7	3.2	3.0	1.9
Measured at 130°C (g.)	570	620	570	560	320	40	70	130	-
Tackiness of wires to a Bobbin	None	None	None	None	None	None	Positive	Positive	None
Heat Distortion of Coil Aged at 130°C for 24 hrs.	0	0	0	0	+	+++	+++	++	-
Deformation of Coil due to Moisture Absorption 60°C, 100% RH 2 Days	0	0	0	0					
7 Days	0	0	+	++					

WHAT WE CLAIM IS:—

1. A self-bonding magnet-coil wire comprising a conductor wire coated with a baked mixture of nylon copolymer (A) and nylon copolymer (B), wherein the proportion of nylon copolymer (A) and nylon copolymer (B) is 50—95 parts of (A) to 50 to 5 parts of (B) (by weight), wherein nylon copolymer (A) is alcohol-insoluble and non-swellable by an alcohol at room temperature and contains nylon-12, and wherein nylon copolymer (B) has a lower melting point than that of the nylon copolymer (A).

2. A self-bonding magnet-coil wire according to Claim 1, comprising as nylon copolymer (A) a nylon copolymer containing 60—90% by weight of nylon-12.

3. A self-bonding magnet-coil wire according to Claim 1, comprising as nylon copolymer (A) a nylon copolymer containing 75—85% by weight of nylon-12.

4. A self-bonding magnet-coil wire according to any one of Claims 1 to 3, comprising as nylon copolymer (A) a nylon copolymer of nylon-12 and nylon-6.

5. A self-bonding magnet-coil wire according to Claim 1, comprising as nylon copolymer (A) a nylon copolymer containing 80% by weight of nylon-12 and 20% by weight of nylon-6.

6. A self-bonding magnet-coil wire according to any one of the preceding claims, comprising as nylon copolymer (B) a nylon copolymer containing 10—50% by weight of nylon-12.

7. A self-bonding magnet-coil wire according to any one of the preceding claims, comprising as nylon copolymer (B) a nylon-6-nylon-6,6-nylon-12 copolymer containing 10—50% by weight of nylon-12.

8. A self-bonding magnet-coil wire according to any one of Claims 1 to 6 comprising as nylon copolymer (B) a nylon-6-nylon-6,10-

nylon-12 copolymer containing 10—50% by weight of nylon-12.

9. A self-bonding magnet-coil wire according to any one of Claims 1 to 6 comprising as nylon copolymer (B) a nylon-6,6,6-nylon-12 copolymer at a weight ratio of nylon-6:nylon-6,6:nylon-12 of 1:1:1.

10. A process for forming a self-bonding magnet-coil wire comprising the steps of:—

a) coating a conductor wire with a mixture of nylon copolymer (A) and nylon copolymer (B) wherein the proportion of nylon copolymer (A) and nylon copolymer (B) is 50—95 parts of (A) to 50 to 5 parts of (B) (by weight), wherein nylon copolymer (A) is alcohol-insoluble and non-swellable by an alcohol at room temperature and contains nylon-12, and wherein nylon copolymer (B) has a lower melting point than that of the nylon copolymer (A); and

(b) baking the thus coated conductor.

11. A process as claimed in Claim 10, wherein the baking step (b) is carried out at a temperature between about 250°C and about 400°C.

12. A process as claimed in Claim 10, substantially as hereinbefore described with reference to any one of Examples 1 to 5.

13. A self-bonding magnet-coil wire produced by a method as claimed in any one of Claims 10 to 12.

14. A self-bonding magnet-coil wire as claimed in Claim 1, substantially as hereinbefore described.

15. A yoke coil for a television set comprising the self-bonding magnet-coil wire as claimed in any one of Claims 1 to 9 or Claim 13 or Claim 14.

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