GLASS FIBER PRODUCT AND METHOD OF MAKING SAME

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The invention relates to strands, yarns, cords and other textile products, and particularly to glass fiber strands, yarns, and cords and to methods and apparatus for making them.

The invention finds particular utility in the manufacture of glass strands and yarns of the continuous-type. These are made by drawing out streams of molten glass without interruption into continuous filaments which are gathered together as they are formed in a strand. The strand is made up of a compact bundle of fine filaments all extending in side by side relation and continuously throughout any normal length of strand.

It is an object of the present invention to increase the strength of glass fiber strands and yarns, especially yarns and strands of the continuous filament type, and, further, to make the strength of the strands lasting and the strands more durable.

It is another object of the invention to apply to the surfaces of each filament in the strand a coating in sufficient quantities to fully protect the surfaces. The fibers are prevented from rubbing on each other and thus scratching and eventually weakening each other.

In prior processes, the coatings were applied at a collecting or gathering eye or pad as the filaments were being gathered into a strand. Because of the speed at which the filaments traveled, the coating material did not completely and uniformly penetrate the strand but instead was largely concentrated at the outer portions of the strand and the filaments at the interior of the strand had little or no coating material thereon. This was particularly the case where more viscous coatings, such as molten waxes, were applied to the strand. If more fluid coatings or coatings that remained fluid longer were applied at the pad or gathering eye, the material might reach the interior of the strand but because of its fluidity be shaken off or thrown out by centrifugal force during the winding of the strand. Also, the more fluid coatings had to be in the form of dilute solutions or dispersions with the result that only very little coating material could be applied to the filament, often insufficient to form well coated surfaces on the filaments so that as a result the strand was weakened by the mutual abrasion of the filaments.

It is another object of the invention to coat the individual fibers with sufficient coating so that when the fibers are gathered together as they are attenuated and wound on a rotating drum the fibers will form a strand which is well bound and that can be fabricated into woven textiles without twisting.

As mentioned previously, the need to have the coating penetrate the strand resulted in prior processes in the application of dilute solutions of coating materials. But this permitted only a small amount of coating material on the strand which was not enough to bond the filaments together securely enough to allow the strand to be efficiently handled in weaving operations without first having been twisted.

It is another object of the invention to apply coatings in substantial quantity to the individual fiber surfaces without the use of aqueous solutions or dispersions and before the filaments have been exposed to the atmosphere for any appreciable length of time. This assures good wetting of the fiber surfaces by the coating material and avoids the presence of moisture on the fibers at the time the coating is applied.

It is another object of the invention to provide a process and apparatus usable in the making of glass strands by which coating materials can be applied that previously could not be used because they are not available in the forms required by prior processes.

A further object is to provide a method for treating individual glass fibers before they are combined into strand form to permit the application of a high concentration of lubricant having strong adhesion to glass, and having flow characteristics which militate against undesirable redistribution of the lubricant by centrifugal forces during the winding of the strand.

A still further object is to provide coating compositions which may be applied without diluents to glass fiber surfaces, and which exhibit the desired adhesion for glass to integrate the fibers in a fiber bundle for further processing but without making the strand stiff or rigid.

These and other objects and advantages of this invention will hereinafter appear from the disclosure of an embodiment in the following description and drawings, in which:

Figure 1 is a partially schematic elevational view of apparatus for carrying out the invention in the manufacture of continuous type glass fiber strands;

Figure 2 is a vertical sectional view of the apparatus of Figure 1 taken on the line 2—2 of that figure;

Figure 3 is a highly enlarged cross-sectional view of a glass fiber treated in accordance with this invention; and

Figure 4 is a greatly magnified cross-sectional view of a strand of glass fibers made according to the invention.

The invention comprises the application to glass filaments as they are formed of a molten coating material, the material being applied to the individual filaments before they are gathered together into a strand. The molten material may be deposited on the filaments in large quantities to provide a substantial coating on the fibers to effectively protect the fiber surfaces against abrasion and make the resulting strand or yarn considerably more durable. As the filaments are gathered together into a strand, the coatings on adjacent fiber surfaces coalesce to weld the filaments together into a well bonded highly integral bundle to thereby cause all the filaments to act together to resist stresses rather than being loaded unequally. As a result, the tensile strength of the strand is greatly increased.

The molten material applied to the individual filaments cools and solidifies or increases in viscosity almost immediately after its application to the filaments or at least prior to the time the strand reaches the winding drum and consequently is not displaced or redistributed through the body of strand wound on the drum with the result that the filaments of the finished strand are uniformly coated throughout the length and cross-section of the strand.

When applied in molten condition to the individual glass filaments as they are formed, it is possible to secure deposition of the protective coating in amounts ranging from 10% to 30% and even more by weight, quantities which were heretofore impossible to achieve in a manner that also provided uniform distribution of the coating material through the cross-section of the strand.

Attractive coating compositions, waxes such as microcrystalline waxes, amorphous waxes, such as ozokerite, montan wax, ceresin wax and other waxy compositions having a mineral origin, paraffin wax, carnauba wax, beeswax and other waxes including...
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synthetic waxes such as hydrogenated castor oil are also usable. In addition, synthetic and natural resins, rosin, and another heat softenable materials may be used. It is also possible to employ as at least one constituent of the coating composition an organo-silicon compound selected from the group consisting of hydrolyzable organo-silanes and their polydiloxanes. These are organo-silicon compounds constituted with an organo group attached to the silicon atom through carbon or in the alternative through oxygen attached to carbon in the 10 manner of an oxy group. The following is a representative formula of a polymerized organo-silicon compound.

\[
\begin{array}{c}
R \\
\begin{array}{c}
\text{Si-O-} \\
\text{Si-O-}
\end{array}
\end{array}
\]

Compatibility of the low molecular weight polymers with some waxes such as petroleum waxes is improved by the presence of aromatic R groups. Therefore when combined with such waxes the polymers having phenyl groups and the like, such as methyl phenyl polydiloxane, diphenyl polydiloxane, dimethyl phenyl polydiloxane and the like in liquid or solid form are preferred. As little as 0.5% organo-silane calculated on the weight of the entire composition is effective to increase the water resistance characteristics of the coating. Also when used with paraffin and other petroleum waxes, the silicones appear to soften the waxy substance and to give it greater strength. As much as 5% organo-silicon compound can be used advantageously and additional amounts may be used when economically feasible.

Contrary to expectations, the higher molecular weight polymers of the organo-silicon compounds do not unduly affect the viscosity of the composition and they impart better adhesion of the wax to the glass. Many suitable formulations may be prepared with a mixture of low and high molecular weight organo-silicon compounds to effect desirable combinations of characteristics in the formulated lubricant. Although not equivalent, the organo-silicon compounds may be wholly or partially replaced in the lubricating composition by a monomeric wax of more than eight carbon atoms. These include the compounds of the type described by Sloan in Patent No. 2,356,542.

Improved adhesion to glass fiber surfaces and still greater strength is secured by admixture of the waxy base with a higher molecular weight compound, including natural substances and plastics such as the bitumens, coumarononeindene, dammar, and ester gum; synthetic plastic materials of the type polyethylene, polycrlylates, polybutylene, hydrogenated rosin esters, poly-styrene, polyvinyl acetate, polyamide, styly cellulose, cellulose acetate butyrate, and thermoplastic phenolics and polyesters which are thermoset by addition of cross-linking agents, and elastomers of the type butadiene-acrylonitrile copolymer, chlorinated rubber, rubber hydrochloride, natural rubber and the like, and mixes thereof.

For instance, greatly improved results are secured by the use of polyethylene which, in combination with paraffin in proportions of 3 to 5 parts paraffin to 1 of polyethylene, imparts considerable strength and film forming characteristics to the composition and greatly increases its affinity for the glass fiber surfaces. These substances are compatible at melt temperature. Polyethylene may be used alone as a modifier for paraffin or like waxy substance, or it may be used in combination with an organo-silicon compound or cationic active substance in the liquidation and treatment of glass fibers. The use of other high molecular weight materials may be of the same order, but more often is less used depending on the method of application, the compatibility of the materials and the strength and adhesive characteristics which it is desired to develop. The lower limit of concentration is of the order of that for the organo-silicon.

Referring to the drawings, molten glass is passed through a feeder 12 of conventional kind so as to flow in a plurality of streams 14 arranged closely spaced in one or more rows. The streams are attenuated into filaments 16 by being gathered into a strand over a gathering roll 18 and then wound as a strand onto a drum 20 driven in any suitable manner. If desired, traversing mechanism may be associated with the drum to move the strand back and forth along the drum as it is wound thereon.

The gathering roll 18 is on a bracket 19 suspended by spring arms 22 from a platform 24 that carries a container 26 provided with a discharge pipe 28 arranged to feed a lubricant or other coating material for the strand onto the gathering roll 18.

Between the gathering roll 18 and the feeder 12 an applicator 32 is arranged to coat the individual filaments with a molten coating material as the filaments move from their zone of formation toward the gathering roll. As shown in Figures 1 and 2, the applicator includes a chamber 34 that acts as a reservoir for the supply 35 of molten coating material. Heating elements 36 submerge in the coating material maintain it at the desired temperature. A roll 38 is journaled at its ends in the side walls of the casing 39 and is driven to the engagement with a doctor roll 41 also journaled for rotation in the end walls of the casing and partly immersed in the supply of coating material in the reservoir. Means for rotating the roller 38, and with it, by frictional engagement, the doctor roll 41, comprises a motor 44 geared to the shaft of the roller 38 through a suitable gear reduction mechanism 46.

The roller 38 is driven at the speed that will transfer to the filaments passing over the roller the desired amount of coating material, the direction of rotation being preferable that the surface of the roller where it contacts the filaments to move in the same direction as the filaments. The rate of rotation of the roller is normally about 15 to 40 R. P. M. when the rate of attenuation of the filaments is in the order of 5,000 to 10,000 feet per minute, and this rate may be increased or decreased to increase or decrease the amount of coating material transferred to the filaments.

In addition to variation in speed of the roller, the temperature and viscosity of the coating material may be varied to change the amount of coating material transferred to the filaments. Also, the roller 38 and doctor roll 41 may be urged together under the adjustable force of springs or other conventional means so that the thickness of the film of coating material on the roller 38 can be adjusted. One or more or all of these factors may be adjusted to vary the quantity of coating material applied to the filaments. Simple trial will demonstrate which adjustments are proper in the case of any coating material to provide the normally desired 10% to 30% coating on the strand.

Beneath the gathering roll 18 a series of radiant burners 52 may be arranged to direct heat onto the strand as it travels toward the attenuating drum 20. These burners are adapted to heat the coating material on the strand to cause the material on the different fibers to coalesce into a single body of coating material. This heating operation is usually required only in the cases where the degree of cohesion that takes place when the filaments are gathered together by the gathering roll is insufficient to bond the filaments to the degree desired.

Figure 3 illustrates on a greatly enlarged scale the manner in which each filament as it passes over the roller 38 is uniformly coated over its entire surface with a film of coating material. The fact that the coating is applied to the filaments immediately after their formation and before they have had a chance to take up moisture from the atmosphere apparently aids the coating material
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in distributing itself in a highly uniform fashion about the filament and along the length of the filament. When the coated filaments are gathered together into a strand at the gathering roll 18, the coating material has normally not cooled to the point of solidification. As a result, the coatings on the different filaments flow together to form a continuous body 56 of coating material in which all of the filaments 16 are encased and by which they are all securely bonded together in the strand. As a result of this, the filaments are protected against abrasion from each other and from the external abrasion incident to being drawn over guides and other parts of the textile processing machinery. In addition, the filaments are so well bonded together that when the strand of filaments is subjected to tensile stress all of the filaments are loaded uniformly and the maximum strength of the strand is realized.

It has been found preferable to position the roller applicator so that its axis of rotation is about ten or twelve inches below the orifices in the feeder 14 in the case where the rate of attenuation of the molten glass streams to filaments is at about 5,000 to 10,000 feet per minute. However, other locations are possible and it may, for instance, be as close as three or four inches from the orifices where it is desired to apply the coating to the filaments while the filaments are hot and before they have cooled sufficiently to take up atmospheric moisture.

Suitable compositions of coating materials for application to the filaments in the manner described are as follows:

Example 1:
99% paraffin
1% diallyl diethoxysilane

Example 2:
98% paraffin
2% methylphenyl polysiloxane

Example 3:
99% ozokerite
1% octodecylamine

Example 4:
98% paraffin
1% diphenyl polysiloxane
1% of the reaction product of tetraethylene pentamine and stearic acid

It is possible to incorporate a coloring agent in the coating composition to thereby dye or color the filaments and strand. The following example is a formulation of this kind:

Example 5:
97.5% mineral wax
0.5% diallyl diethoxy silane
2.0% Sudan Red BBA soluble dye

Other formulations are:

Example 6:
76% paraffin
24% polyethylene

Example 7:
70% paraffin
10% polybutylene
20% polyethylene

Example 8:
60% polyester of rosin abietic acid, maleic anhydride and glycerol (“Amberol 800 P,” Rohm and Haas Company)
13% paraffin—m. pt. about 140° F.
15% hydrogenated castor oil
12% castor oil

Example 9:
45% polyester of rosin abietic acid, maleic anhydride and glycerol (“Amberol 800 P,” Rohm and Haas Company)
15.2% paraffin—m. pt. about 140° F.
16.6% hydrogenated castor oil
13.2% castor oil
10% ethyl cellulose—10 centipoises. (This viscosity describes the degree of polymerization. The degree of ethylation is 2.43 to 2.54 moles of ethoxy groups per glucose unit.)

Example 10:
100% “Vuecote No. 307” (Monsanto Chemical Co., a blend of polyvinyl butyral, polymerized rosin, and waxes)

Example 11:
49% abietic acid crystals (“Tallex,” West Virginia Pulp & Paper Co.)
20% ethyl cellulose, 14 centipoises (“N 14,” Hercules Powder Company)
30% paraffin—m. pt. 130° F.
1% octyl phenol

Example 12:
33% abietic acid crystals
33% polyethylene—7000–10000 mol. wt.
34% mineral oil plasticizer (“Dutrex 20,” Shell Oil Company)

Example 13:
30% abietic acid crystals
20% cellulose acetate butyrate (“Tenite II,” Tennessee Eastman Corp.)
15% polyvinyl acetate (“Gelva 2½,” Shawinigan Products Corporation)
35% mineral oil plasticizer (“Dutrex 20,” Shell Oil Company)

Example 14:
49% glycol ester of hydrogenated rosin (“Staybelite Ester No. 10,” Hercules Powder Company)
18% ethyl cellulose, 14 centipoises (“N 14,” Hercules Powder Company)
32% paraffin, m. pt. 130° F.
1% octyl phenol

The above compositions are merely representative of the large number of combinations which may be made with the materials previously described. The compositions form compatible melts while being maintained at the preferred temperature for application to the glass fiber filaments which temperature is usually that providing a viscosity of the coating material in the order of 5 to 500 centipoises.

The application of any of these materials by the roller applicator 38 may be followed by a second coating of the strand at the gathering roll 18. In this way a heavier coating may surround the strand and this second coating may be compatible with the first-applied coating or it may be incompatible therewith so as to form a sleeve over the coated strand. For example, where a wax such as paraffin is applied to the filaments at the roller applicator, a second coating of paraffin, either molten or in an aqueous emulsion may be applied to the filaments at the roll 18 as the filaments are gathered together. Alternatively, a substance incompatible with the paraffin, for example, gelatin or animal glue, may be applied over the paraffin at the gathering roll so as to form a hard smooth sleeve encasing the paraffin-coated filaments. Also, for certain uses of the strand, an oil or other lubricant may be applied at the gathering roll that is incompatible with the coating applied to the filaments at the roller applicator to thereby keep the filaments separate and capable of relative movement in the strand. For example, a vinyl acetate-vinyl chloride-copolymer resin might be applied at the roller applicator followed by the application of a light petroleum oil or vegetable oil, such as coconaut oil, at the gathering roll. These and other changes may be made in the invention with respect to materials and amounts and to variations in the method of application without departing
from the spirit of the invention as defined in the appended claims.

We claim:

1. An article of manufacture comprising glass fibers and a sizing on the glass fiber surfaces consisting essentially of mineral wax, up to 5 percent by weight of an organo-silicon compound selected from the group consisting of silanes and polysiloxanes, and polyethylene present in the ratio of 3–5 parts by weight mineral wax to one part by weight polyethylene.

2. An article of manufacture comprising glass fibers and a sizing on the glass fiber surfaces consisting essentially of mineral wax and polyethylene present in the ratio of 3–5 parts by weight mineral wax to one part by weight polyethylene.

3. An article of manufacture comprising glass fibers and a coating on the glass fiber surfaces consisting essentially of 95 to 99.5 percent by weight mineral wax and an organo-silicon selected from the group consisting of silanes and polysiloxanes in amounts from 0.5 to 5 percent by weight of the coating composition.

4. An article of manufacture comprising glass fibers and a coating on the glass fiber surfaces consisting essentially of 95 to 99.5 percent by weight mineral wax and from 0.5 to 5 percent by weight of a polysiloxane.

5. The method of treating glass fibers in forming comprising the steps of collecting the fibers together into strands and coating the fibers prior to formation into strands with a composition the solids of which consist essentially of mineral wax and polyethylene present in the ratio of 3–5 parts by weight mineral wax to 1 part by weight polyethylene.

6. The method of treating glass fibers in forming comprising the steps of collecting the fibers together into strands and coating the fibers prior to formation into strands with a composition the solids of which consist essentially of 95 to 99.5 percent by weight mineral wax and an organo-silicon selected from the group consisting of silanes and polysiloxanes in amounts from 0.5 to 5 percent by weight of the coating composition.

7. The method of treating glass fibers in forming comprising the steps of collecting the fibers together into strands and coating the fibers prior to formation into strands with a composition the solids of which consist essentially of 95 to 99.5 percent by weight mineral wax and an organo-silicon selected from the group consisting of silanes and polysiloxanes in amounts from 0.5 to 5 percent by weight of the coating composition.

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