Title: REUSABLE YARN TUBE

Abstract: A reusable yarn tube (10) includes a hollow tube (11) having a substantially cylindrical wall (12) and an outer surface (14) adapted to carry a yarn (20) on the tube surface. The tube (10) includes a starting groove (16) in the outer surface (14) near one end of the tube (10) and an opposite, yarn-unwinding end (18). A pre-formed sleeve (30) having a smooth surface (31) is form-fitted about a portion of the outer surface (14) of the tube (10) and an end (17, 18) of the tube. In this manner, the sleeve (30) provides a smooth surface (31) for the yarn (20) to be wound onto and unwound from the tube (10). Preferably, the sleeve (30) is formed about the yarn-unwinding end (18) of the tube and across the thickness (13) of the cylindrical wall (12) without contacting the inside surface (19) of the tube (10). Such a reusable yarn tube (10) is useful for preventing yarn snags on defects in and about the ends of the tube (10).
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— with international search report
— with amended claims and statement

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REUSABLE YARN TUBE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to co-pending U.S. Provisional Patent Application No. 60/527,935, filed December 8, 2003, which is incorporated herein in its entirety.

FIELD OF THE INVENTION

The present invention relates to a yarn tube that is reusable. Embodiments of the present invention provide a reusable yarn tube useful for preventing yarn snags on defects in and about the ends of the tube.

BACKGROUND OF THE INVENTION

A yarn tube is a holder or bobbin of cylindrical shape used as a core for a “yarn package” from which the yarn can be easily unwound for use in knitting, weaving, and other processes. As such, yarn tubes are used in textile manufacturing for providing yarn to a knitting or other machine for processing the yarn. During a knitting or weaving process, yarn is unwound from a tube along the longitudinal axis of the tube such that the yarn moves across the end of the tube as it is unwound. Yarn used in textile manufacturing can be extremely fine, for example, low denier nylon yarns used in fashion hosiery production, and is thus highly susceptible to snagging on unsmooth surfaces. It is important that the end of a yarn tube be smooth so that yarn, particularly fine yarn, is not snagged or picked by imperfections in the tube end as the yarn moves across the tube end at high speed to needles in a knitting machine.

Conventional yarn tubes are often made of laminated cardboard and/or similar materials. When yarn is completely unwound from a tube, the tube is removed from a textile manufacturing machine, such as a knitting or weaving machine. During the tube removal process, and at other times, tubes may be handled without attention to protecting the surface integrity of the tube ends. At times, tubes are tossed into a container and may be dropped, causing imperfections, such as nicks or “burr” in the tube ends. If a damaged tube is then reused at high manufacturing speeds, such damage can even lead to delamination of the tube. As a result of these burrs, yarn tubes would not be suitable for re-use, because such burrs would cause yarn fed across the tube end to snag or even break. When yarn snags on a tube burr, the quality of the yarn in the knitted product may be less than desirable. Importantly, when yarn fed from a tube snags on a burr, the knitting operation often must be stopped, and a worker must repair the yarn feed into the knitting machine. Such disruption in automated,
high-speed knitting processes causes increased labor and manufacturing time, adding to the
cost of production. Moreover, when yarn being fed to a knitting machine snags on a tube end
burr, the worker may determine that the tube is unusable and discard the tube along with the
remaining yarn on the tube. Consequently, yarn tube end burrs can cause loss of significant
amounts of yarn. As a result, conventional yarn winding tubes are generally not reusable.

Yarn manufacturers and textile manufacturers use millions of yarn tubes each year.
Conventional paper tubes are relatively expensive (50 cents to $1.00 each). Thus the cost of
non-reusable yarn carriers is extremely high. Providing a means for reliably and
inexpensively overcoming burrs in tube ends in order to make yarn tubes reusable would save
much of the annual cost of yarn tubes. In view of the negative cost and manufacturing
consequences associated with yarn tube end defects, it is desirable to provide yarn tubes
having ends that resist development of burrs from use during the knitting or weaving process
and/or from handling before and after use.

Various attempts have been made to develop reusable yarn tubes, including
modifications to the starting groove and/or starting groove end of a tube. One end of a
conventional cylindrical, laminated paper tube includes a starting groove, often an annular
groove, cut, or otherwise recessed, into the outer surface near one end of the tube. The
starting groove includes a means for "leading in" and locking an initial strand of yarn.
During the initial few turns of an automatic winding operation, yarn is wound onto the
starting groove. The initial strands of yarn placed in the starting groove are commonly
referred to as the "waste bunch." After a tube has a pre-determined length of yarn wound
onto the tube surface, the completed "yarn package" is removed from the winding machine
such that the yarn can be further processed, for example, by weaving, knitting, or texturing.

One attempt to modify a yarn tube for reuse at least once involved providing a starting
groove at each end of the tube. However, paper tubes are often damaged during the
automatic placement and removal of the tubes on and off tube mounts. Consequently, using a
damaged starting groove end of a tube for unwinding yarn substantially eliminates even a
single reuse of the paper tubes.

Attempts have also been made to construct yarn tubes having reusable starting groove
ends. For example, U.S. Patent No. 4,901,941 to Powel et al. discloses an end cap and a
slidable ring releasably mounted on the end of a yarn tube to form a reusable yarn carrier or
winding tube. The opposing walls of the end cap and ring define a starting groove
therebetween. When the yarn carrier has been emptied, the end cap and ring are separated
from the tube, the residual yarn is removed, and the end cap and ring are replaced on the tube
for reuse. The Powell et al. patent is directed to winding tubes in which a yarn transfer tail (or waste bunch) is easily severed and removed from the starting groove once the yarn package has been emptied. However, this patent does not address the reusability of yarn tubes with respect to providing a smooth surface over burrs and snags in the non-starting groove end of a tube.

U.S. Patent No. 6,073,868 to Stevens et al. discloses a re-usable, cylindrical yarn carrier preferably made of a plastic material, each end of which has a channel. A resilient ring positioned within each channel forms a yarn winding engagement surface. The ring also serves as a protective edge, such that, if the tube is dropped, the ring takes the brunt of the force rather than the tube material itself. Such tubes of polymeric materials alone are undesirable, as they will not withstand conventional winding speeds because of their tendency to develop "creep" and/or to expand at such speeds; they do not provide a thickness suitable for molding or machining a satisfactory starting groove; they are prohibitively expensive to manufacture; and they do not provide a means for a reusably smooth surface over which yarn can be unwound from a tube.

In another attempt to provide a reusable yarn tube, various coatings were applied to used tubes by “hot-dipping” the tubes into the coatings. However, tube ends having a surface smooth enough to prevent snags of yarn were not produced by these attempts.

Thus, there is a need to provide yarn tubes that have ends that reliably prevent yarn snags in defects in and about the tube ends and are thus reusable. There is also a need for reusable yarn tubes having ends that resist development of burrs from use during a knitting or weaving process and/or from handling before and after use in such processes. There is also a need to provide such reusable yarn tubes that can be made easily and inexpensively.

**SUMMARY OF THE INVENTION**

The present invention provides a yarn tube, or bobbin, that is reusable. Embodiments include a reusable yarn tube useful for preventing yarn snags on defects in and about the ends of the tube.

In an embodiment of the present invention, a reusable yarn tube comprises a hollow tube having a substantially cylindrical wall, opposite ends, and an outer surface adapted to carry a yarn on the tube surface. The tube includes a starting groove in the outer surface proximate one end of the tube. A pre-formed sleeve having a smooth surface is form-fitted about a portion of the outer surface of the tube and the end of the tube opposite the starting groove end, also referred to as the yarn-unwinding end. In this manner, the sleeve provides a smooth surface for the yarn to be wound onto and unwound from the tube. In preferred
embodiments, the sleeve is fitted about the yarn-unwinding end of the tube and across the thickness of the cylindrical wall without contacting the inside surface of the tube.

In embodiments of the present invention, a pre-formed sleeve, such as a plastic sleeve, is placed onto a tube over a portion of the tube proximate to the yarn-unwinding end such that the sleeve extends a pre-determined distance beyond the tube end. The sleeve is adaptable to be form-fitted about a portion of the tube and the end of the tube. In a preferred embodiment, the sleeve is capable of being set into a desired form about the tube end by application of heat. In such an embodiment, the tube and sleeve are exposed to heat, such as in a heat tunnel, and the sleeve is heat-shrunk, or thermoset, to form fit about the tube end.

In preferred embodiments, the distance that the sleeve extends beyond the tube end prior to thermosetting is such that when the sleeve is form-fitted about the tube and tube end, the distal edge of the sleeve (the edge extending beyond the tube end) is located a distance, for example 1/16 inch, just short of the inside surface of the tube. Positioning the sleeve a distance just short of the inside surface of the tube avoids contact of the sleeve with a creel and thus avoids potential problems associated with such contact, such as interference with movement of the tube on the creel and damaging the sleeve. A sleeve that is damaged, such as by cracking when hit against a creel, can undesirably create imperfections or burrs in the tube end that can cause yarn to snag. Thus, positioning a sleeve so as to avoid contact with a creel protects the integrity of the sleeve and maintains the sleeve in a condition suitable for providing a smooth surface over which yarn can be unwound.

The distance the form-fitted sleeve extends along the outer surface of the tube from the tube end is sufficient to cover the portion of the tube over which yarn would travel as it is unwound from the tube and fed to a knitting or weaving machine. As such, the sleeve would allow yarn from the tube to travel over a smooth surface as it is fed to a knitting or weaving machine and thereby avoid snagging burrs or other imperfections in the tube near the tube end or in the tube end itself.

A sleeve of the present invention comprises a material capable of being form-fitted, such as thermoset, about a tube end. In preferred embodiments, the sleeve is slidably formed about a tube end such that after the sleeve is form-fitted onto the tube end, the sleeve can be removed from the tube by sliding it in a direction along the tube longitudinal axis away from the tube. Preferably, such a sleeve comprises polyvinyl chloride (PVC). When such a removable sleeve begins to show wear from repeated use, the sleeve can be easily slid off of the tube and replaced with another sleeve. In this manner, the same tube can be reused beyond the effective life of a single sleeve.
In embodiments of the present invention, a sleeve comprises a thickness and a composition adapted to withstand pressure from yarn wound thereon and from the stress of spinning on a tube mount. In addition, a sleeve of the present invention preferably comprises a composition adapted to avoid absorption of moisture and oils from the yarn wound thereon and from the tube itself. In a preferred embodiment, a sleeve comprises a 3 ml thick PVC plastic, which is capable of both withstanding the stress from yarn winding and spinning and avoiding absorption of moisture and oils. Such a sleeve is thus able to maintain its smooth surface integrity and avoid cracks or burrs that may cause yarn snags.

Embodiments of the present invention provide an identification means for distinguishing the yarn to be wound on the outer tube surface. The outer surfaces of yarn tubes often include one or more colors, either as a solid color, in stripes, or in another pattern. Tubes are made having different color schemes that can be used to identify a particular yarn type. In embodiments of the present invention, reusable yarn tubes include sleeves comprising a particular color that can be used to represent a particular type of yarn wound onto the tube. As a result, yarn tubes could have the same color, and colored sleeves could be to identify the yarn type, thus saving the added cost of having smaller quantities of tubes made in different colors.

In embodiments of the present invention, reusable tubes comprise paper, which can be wound in a spiral or convolute pattern. Tubes may comprise other materials suitable for yarn tubes, including steel, aluminum, metallic alloys, and fiber reinforced polymeric materials.

Embodiments of the present invention include yarn tubes having various dimensions, including various lengths, diameters, and wall thicknesses. Sleeves are pre-formed to fit the dimensions of the tubes for which they are intended.

Another aspect of the present invention includes methods of making a reusable yarn tube. An embodiment of such a method includes first providing a hollow tube having a substantially cylindrical wall, an outer surface adapted to carry a yarn thereon, a starting groove in the outer surface proximate one end of the tube, and an opposite, yarn-unwinding end. A pre-formed sleeve having a smooth surface is fitted about a portion of the outer surface of the yarn-unwinding end. The sleeve is formed about the yarn-unwinding end of the tube so that the sleeve provides a smooth surface for the yarn to be wound onto and unwound from the tube.

In an embodiment of such a method, fitting the sleeve about the yarn-unwinding end of the tube includes extending the sleeve a distance beyond the yarn-unwinding end such that
when the sleeve is formed about the yarn-unwinding end, the sleeve extends across the thickness of the cylindrical wall of the tube without contacting the inside surface of the tube.

In preferred embodiments, methods of the present invention include placing the yarn-unwinding end of the tube having the sleeve fitted thereabout onto a sleeve-forming mold. The mold has a substantially cylindrical outer surface having an outside diameter sized to fittingly receive the tube. The mold further includes a ring projecting outwardly from its outer surface for supporting the tube when the tube is placed onto the mold.

In embodiments, the ring has a thickness projecting outwardly from the outer surface of the mold such that the distal edge of the sleeve (extending beyond the tube end) will not contact the ring when the sleeve is formed about the tube and tube end. Accordingly, the outwardly projecting thickness of the mold ring is less than the distance from the inside surface of the tube that the distal edge of the sleeve is located when the sleeve is formed about the tube and tube end. As such, the sleeve will not contact the ring during the form-fitting process, and avoid having its movement interfered by the ring or becoming attached to the ring.

In addition, embodiments include a mold, the bottom of which is spaced a distance from the surface below the mold, for example, a mold support base. The distance the bottom of the mold is spaced above the surface below is sufficient for the portion of the sleeve extending beyond the end of the tube to clear the surface below the mold. This clearance distance allows the portion of the sleeve extending beyond the end of the tube to move freely (and not contact the surface below) during the form-fitting process. As such, the sleeve avoids interference by, or attachment to, the surface below.

In embodiments of methods of the present invention, fitting the sleeve about an end of the tube includes expanding the sleeve with a cup device and placing the cup device and expanded sleeve onto the yarn-unwinding end of the tube.

In preferred embodiments of the present invention, the sleeve is thermosettable, such that the sleeve can be formed about an end of the tube by application of a pre-determined level of heat for a prescribed amount of time sufficient to form the sleeve about the tube end. For example, a sleeve can be formed about a paper yarn tube end by heating a sleeve-forming mold supporting the yarn tube and pre-formed, polyvinyl chloride (PVC) sleeve fitted about the tube end in a heat tunnel. The mold-tube-sleeve assembly is subjected to a temperature and for a period of time sufficient to form the sleeve about the outer surface of the tube and the tube end such that the sleeve is slidably removable from the tube. During the process of
preparing yarn tubes for placement into, for example, a heat tunnel, the tubes can be inspected for burrs or other defects.

Methods of making a reusable yarn tube of the present invention provide embodiments that include automated processes. For example, computer-based logic, mechanisms, and devices can be applied to such processes in order to automatically make a reusable yarn tube of the present invention.

Features of a reusable yarn tube of the present invention may be accomplished singularly, or in combination, in one or more of the embodiments of the present invention. As will be appreciated by those of ordinary skill in the art, the present invention has wide utility in a number of applications as illustrated by the variety of features and advantages discussed below.

A reusable yarn tube of the present invention provides numerous advantages over prior yarn tubes. For example, the present invention advantageously provides yarn tubes that are reusable, thereby decreasing the cost of purchasing one-time-use yarn tubes.

Another advantage is that the present invention provides a reusable yarn tube that decreases down time during knitting operations due to yarn snags on tube end burrs.

Another advantage is that the present invention provides a reusable yarn tube that prevents waste of yarn due to disposal of a tube with unused yarn after a yarn snag occurs on tube end burrs during a knitting operation.

Another advantage is that the present invention provides a reusable yarn tube that can be easily made, for example, by using a conventional heat tunnel.

Another advantage is that the present invention provides a reusable yarn tube that can be inexpensively made, for example, by utilizing conventional heat tunnels to form a sleeve about a tube end. Plastic sleeves of the present invention can be produced commercially for a cost in the range of 1-1.5 cents per sleeve.

Another advantage is that the present invention provides a reusable yarn tube including a sleeve that is removably slidable about a tube end such that after the sleeve has been utilized for its useful life, it can be removed and another sleeve applied. As such, tubes of the present invention can be utilized repeatedly, beyond the useful life of a single sleeve.

Another advantage is that the present invention provides a reusable yarn tube including a sleeve having a thickness and a composition adapted to withstand pressure from yarn wound thereon and from the stress of spinning on a tube mount. In addition, such sleeves have a composition adapted to avoid absorption of moisture and oils from the yarn
wound thereon and from the tube itself. Consequently, the effective useful life of yarn tubes can be further extended.

Another advantage is that the present invention provides sleeves having a particular color that can be used to represent a particular type of yarn wound onto a tube. As a result, a textile manufacturer could purchase all yarn tubes having the same color and save the cost of having multiple smaller portions of tubes made in different colors.

As will be realized by those of skill in the art, many different embodiments of a reusable yarn tube according to the present invention are possible. Additional uses, objects, advantages, and novel features of the invention are set forth in the detailed description that follows and will become more apparent to those skilled in the art upon examination of the following or by practice of the invention.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a side view of a reusable yarn tube having a sleeve formed about an end of the tube in an embodiment of the present invention.

FIG. 2 is a view of a smooth, plastic sleeve useful in an embodiment of the present invention, as shown in Fig. 1.

FIG. 3 is a view of a reusable yarn tube showing a sleeve formed about an end of the tube and yarn wound onto the tube in an embodiment of the present invention.

FIG. 4 is a perspective view of the end of a yarn tube having a sleeve fitted about a portion of the outer surface of the tube and extending a distance beyond the tube end in an embodiment of the present invention.

FIG. 5 is a perspective view of the end of a yarn tube having a sleeve formed thereabout in an embodiment of the present invention.

FIG. 6 is a perspective view of a sleeve-forming mold useful in an embodiment of the present invention.

FIG. 7 is a view of a reusable yarn tube having a sleeve formed about an end of the tube and supported on a sleeve-forming mold in an embodiment of the present invention.

FIG. 8 is diagrammatic chart illustrating the steps in an embodiment of a method of the present invention.

**DETAILED DESCRIPTION**

The present invention provides a yarn tube that is reusable. Embodiments include a reusable yarn tube useful for preventing yarn snags on defects in and about the ends of the tube. Figs. 1-8 illustrate such embodiments.
In an embodiment of the present invention, as shown in Figs. 1-5, a reusable yarn tube 10 comprises a hollow tube 11 having a substantially cylindrical wall 12, and an outer surface 14 adapted to carry a yarn 20 on the tube outer surface 14. The tube 10 includes a starting groove 16 in the outer surface 14 proximate one end of the tube 10. The starting groove 16 provides a means for yarn 20 to connect to the tube 10 so that the yarn 20 can be wound onto the tube 10. The end of the tube 10 near the starting groove 16 is a starting groove end 17, and the opposite end of the tube 10 is a yarn-unwinding end 18. A pre-formed sleeve 30 having a smooth surface 31 is fitted about a portion 15 of the outer surface 14 of the tube 10 and an end 17, 18 of the tube 10. In this manner, the sleeve 30 provides a smooth surface 31 for the yarn 20 to be wound onto and unwound from the tube 10. In preferred embodiments, the sleeve 30 is fitted about the yarn-unwinding end 18 opposite the starting groove end 17, and across the thickness (t₁) 13 of the tube 10 cylindrical wall 12 without contacting the inside surface 19 of the tube 10.

Generally, the term “tube end” refers to the surface along the thickness (t₁) 13 of a tube wall 12 between the inside surface 19 and the outer (outside) surface 14 of the tube 10. Where reference is made herein to the outer surface 14 of a tube 10 near a tube end together with the surface along the thickness (t₁) 13 of the tube wall 12 as being the portion of the tube about 10 which a sleeve 30 is fitted, “tube end” refers to both structures 13, 14.

In embodiments of the present invention, a pre-formed sleeve 30, such as a plastic sleeve, is placed onto a tube 10 over a portion 15 of the tube 10 proximate to the yarn-unwinding end 18 such that the sleeve 30 extends a pre-determined distance (d₁) 32 beyond the tube end 18. The sleeve 30 is adaptable to be form-fitted about a portion 15 of the tube 10 and the end 18 of the tube 10. In a preferred embodiment, the sleeve 30 is capable of being set into a desired form about the tube end 18 by application of heat (as discussed below). In such an embodiment, the tube 10 and sleeve 30 are exposed to heat, such as in a heat tunnel (not shown), and the sleeve 30 is heat-shrunk, or thermostet, to form fit about the tube end 18.

In preferred embodiments (as shown in Figs. 2, 4, and 5), the distance (d₁) 32 that the sleeve 30 extends beyond the tube end 18 prior to thermostetting is such that when the plastic sleeve 30 is thermostet to form fit about the tube 10 and tube end 18, the distal edge 33 of the sleeve (the edge extending beyond the tube end 18) is located a distance (d₂) 34 (Fig. 5) just short of the inside surface 19 of the tube 10. For example, for a tube 10 having a wall thickness (t₁) 13 of 3/8 inch, the sleeve 30 is positioned to extend 5/16 inch beyond the tube end 18 so that when the sleeve 30 is heated to form fit the tube 10 and tube end 18, the distal
edge 33 of the sleeve 30 is located 1/16 inch from the inside surface 19 of the tube 10. Positioning the sleeve 30 a distance (d₂) 34 just short of the inside surface 19 of the tube 10 avoids contact of the sleeve 30 with a creel (not shown), or other spool rack, as the tube 10 is placed onto the creel and while the tube 10 spins on the creel as yarn 20 is wound onto the tube 10 and subsequently unwound from the tube 10. Preventing contact of the sleeve 30 with a creel avoids potential problems associated with such contact, such as interference with movement of the tube 10 on the creel and damaging the sleeve 30. A sleeve 30 that is damaged, such as by cracking when hit against a creel, can develop more extensive cracks as yarn 20 is wound onto and unwound from the tube 10. Such cracks in a sleeve 30 can undesirably create imperfections or burrs in the tube end 18 that can cause yarn to snag. Thus, positioning a sleeve 30 so as to avoid contact with a creel protects the integrity of the sleeve 30 and maintains the sleeve 30 in a condition suitable for providing a smooth surface 31 over which yarn 20 can be unwound.

The distance (d₂) 35 the heat-shrunk, form-fitted sleeve 30 extends along the outer surface 14 of the tube 10 from the tube end 18 is sufficient to cover the portion of the tube over which yarn 20 would travel as it is unwound from the tube 10 and fed to a knitting or weaving machine. For example, for a tube 10 having a length 21 of about nine inches, a sleeve 30 would extend approximately one and one half to two inches from the tube end 18 in the direction of the longitudinal axis 22 and along the outer surface 14 of the tube 10. Accordingly, the sleeve 30 would allow yarn 20 from the tube 10 to travel over a smooth surface 31 as it is fed to a knitting or weaving machine and thereby avoid snagging burrs or other imperfections in the tube 10 near the tube end 18 or in the tube end 18 itself.

A sleeve 30 of the present invention comprises a material capable of being form-fitted, such as thermoset, about a tube end 17, 18. In preferred embodiments, the sleeve 30 is formed to be slidably removable about a tube end 17, 18 such that after the sleeve 30 is thermoset onto the tube end 17,18, the sleeve 30 can be removed from the tube 10 by sliding it in a direction along the tube longitudinal axis 22 away from the tube 10. Preferably, such a sleeve 30 comprises polyvinyl chloride (PVC).

In operation, when a sleeve 30 begins to show wear from repeated use, the sleeve 30 can be easily slid off of the tube 10 and replaced with another sleeve 30. In this manner, the same tube 10 can be reused an even greater number of times, for example, until the tube 10 begins to show interruptions in structural integrity other than burrs in the tube end 17, 18 (such as warping of the tube 10). Thus, tubes 10 of the present invention can be utilized repeatedly, beyond the useful life of a single sleeve 30.
In embodiments of the present invention, a sleeve comprises a thickness (t₂) 37 (as shown in Fig. 2) and a composition adapted to withstand pressure from yarn 20 wound thereon and from the stress of spinning on a tube mount. To be reliable on modern winding and yarn processing machinery, yarn tube 10 constructions are required which will resist the stress loads, particularly tensile, or "hoop," stress, imposed at winding speeds in excess of 18,000-20,000 revolutions per minute (RPM). Further, it is desirable that yarn tubes 10 maintain the same effective outer diameter and inner diameter during repeated use, so as to be compatible with drive rolls and mounting spindles of yarn winding and processing machinery. In a preferred embodiment of the present invention, a sleeve 30 comprises a 3 ml thick PVC plastic, which is capable of withstanding the stress from yarn winding and spinning on a tube mount. The 3 ml PVC plastic sleeve 30 is able to maintain its surface integrity during yarn winding and unwinding operations so as to avoid cracks or burrs that may cause yarn snags.

Preferably, a sleeve 30 of the present invention comprises a composition adapted to avoid absorption of moisture and oils from the yarn 20 wound thereon and from the tube 10 itself. In a preferred embodiment, such a sleeve 30 comprise a 3 ml thick PVC plastic.

A thickness (t₂) 37 and a composition of a sleeve 30 adequate to withstand yarn winding pressure and to avoid absorption of moisture and oils from the yarn 20 and the tube 10 provide characteristics, in addition to a smooth (non-burred) surface 31, to a yarn tube 10 that allow the tube 10 to be reusable. Such characteristics enhance the ability to reuse a tube 10 of the present invention in repeated fashion. Yarn tubes 10 of the present invention can be reused five or more times with the same sleeve 30 without experiencing a reduction in ability to maintain a smooth tube end 17, 18 over which yarn 20 can travel.

Embodiments of the present invention provide an identification means for distinguishing the yarn 20 to be wound on the outer tube surface 14. The outer surfaces 14 of yarn tubes 10 often include one or more colors, either as a solid color, in stripes, or in another pattern. Tubes 10 are made having different colors. As such, the color scheme of a tube 10 can be used to identify a particular type of yarn 20. In embodiments of the present invention, reusable yarn tubes 10 include sleeves 30 comprising a particular color 38 that can be used to represent a particular type of yarn 20 wound onto the tube 10. As a result, a textile manufacturer could purchase all yarn tubes 10 having no color or the same color, and use colored sleeves 30 to identify the yarn 20 type wound onto a particular tube 10. In this manner, the textile manufacturer could save the added cost of having multiple smaller portions of the needed number of tubes 10 made in different colors.
In embodiments of the present invention, reusable tubes 10 comprise paper 23. Such a paper tube 10 can be spirally or convolutely wound. Tubes 10 may comprise other materials suitable for yarn tubes 10. Such materials include steel, aluminum, metallic alloys, and fiber-reinforced polymeric materials, such as epoxides, polyesters, and vinylesters. Such polymeric materials may be reinforced by fibers of glass, carbon, ceramics, aramids, or hybrids thereof. Tubes 10 made from such materials other than paper 23 generally have a wall thickness 13 less that hollow paper tubes 10.

Embodiments of the present invention include yarn tubes 10 having various dimensions, including various lengths 21, diameters, and wall thicknesses 13. Sleeves 30 are pre-formed to fit the dimensions of the tubes 10 for which they are intended.

Another aspect of the present invention includes methods of making a reusable yarn tube 10. Referring to Figs. 6-8, an embodiment of such a method 50 includes first providing a hollow tube 10 having a substantially cylindrical wall 12, an outer surface 14 adapted to carry a yarn 20 thereon, a starting groove 16 in the outer surface 14 proximate one end 17 of the tube 10, and an opposite, yarn-unwinding end 18. A pre-formed sleeve 30 having a smooth surface 31 is fitted about a portion 15 of the outer surface 14 of the yarn-unwinding end 18. The sleeve 30 is formed about the yarn-unwinding end 18 of the tube 10 so that the sleeve 30 provides a smooth surface 31 for the yarn 20 to be wound onto and unwound from the tube 10.

In an embodiment of such a method, fitting the sleeve 30 about the yarn-unwinding end 18 of the tube 10 includes extending 55 the sleeve a distance (d1) 32 beyond the yarn-unwinding end 18 such that when the sleeve 30 is formed 58 about the yarn-unwinding end 18, the sleeve 30 extends across the thickness (t1) 13 of the cylindrical wall 12 of the tube 10 without contacting the inside surface 19 of the tube 10.

In preferred embodiments, methods of the present invention include placing 56 the yarn-unwinding end 18 of the tube 10 having the sleeve 30 fitted thereabout onto a sleeve-forming mold 40. Such a mold 40, as seen best in Fig. 6, can be made of any material suitable for forming a sleeve 30 about a yarn tube 10, for example, in a heat tunnel. Preferably, such a mold 40 is made from stainless steel. The mold 40 has a substantially cylindrical outer surface 41 having an outside diameter 42 sized to fittingly receive the tube 10. The mold 40 further includes a ring 43 projecting outwardly from its outer surface 41 for supporting the tube 10 when the tube 10 is placed onto the mold 40.

In embodiments, the ring 43 has a thickness (t3) 44 projecting outwardly from the outer surface 41 of the mold 40 such that the distal edge 33 of the sleeve 30 extending...
beyond the tube end 18) will not contact the ring 43 when the sleeve 30 is formed about the
tube 10 and tube end 18. Accordingly, the outwardly projecting thickness \( t_s \) 44 of the mold
ring 43 should be no greater than the distance \( d_2 \) 34 from the inside surface 19 of the tube
10 that the distal edge 33 of the sleeve 30 is located when the sleeve 30 is formed about the
tube 10 and tube end 18. For example, for a tube 10 on which the distal edge 33 of the sleeve
30, when formed about the tube end 18, is located 1/16 inch from the inside surface 19 of the
tube 10, the ring thickness 44 should be less than 1/16 inch. As such, the sleeve 30 will not
contact the ring 43 during the form-fitting process. In this manner, the sleeve 30 avoids
having its movement interfered by the ring 43 or becoming attached to the ring 43.

In addition, embodiments include a mold 40, the bottom 45 of which is spaced a
distance \( d_4 \) 46 from a surface below the mold 40, for example, a mold support base 47 or
the top surface of a mold conveyor tray (not shown). The distance \( d_4 \) 46 the bottom 45 of
the mold 40 is spaced above the surface below is sufficient for the portion of the sleeve 30
extending beyond the end 18 of the tube 10 to clear the surface below the mold. This
clearance distance \( d_4 \) 46 allows the portion of the sleeve 30 extending beyond the end 18 of
the tube 10 to move freely (and not contact the surface below) during the form-fitting
process. For example, in embodiments of the present invention, a pre-formed sleeve 30
having a smooth surface 31 is fitted about a portion 15 of the outer surface 14 of the yarn-
unwinding end 18 of a tube 10. The sleeve 30 is positioned 55 to extend, for example, 5/16
inch beyond the tube end 18. The bottom 45 of the mold 40 is spaced greater than 5/16 inch
above the top surface of the mold support base 47 below. The tube 10 is placed 56 onto the
sleeve-forming mold 40 and supported on the outwardly projecting ring 43 of the mold.
When the sleeve 30 is form-fitted 58 about the tube end 18, the distal edge 33 of the sleeve 30
moves freely of the top surface of the mold support base 47 below and forms about the tube
end 18 while avoiding any interference by, or attachment to, the surface below.

In embodiments of methods of the present invention, fitting 54 the sleeve 30 about an
end 17, 18 of the tube 10 includes expanding 53 the sleeve 30 with a cup device (not shown)
and placing the cup device and expanded sleeve 30 onto the yarn-unwinding end 18 of the
tube 10.

In embodiments of the present invention, the sleeve 30 is thermosetable, such that the
sleeve 30 can be formed 58 about an end 17, 18 of the tube 10 by application 57 of a pre-
determined level of heat for a prescribed amount of time sufficient to form 58 the sleeve 30
about the tube end 17, 18. For example, a sleeve 30 can be formed 58 about a paper yarn
tube end 18 by placing a sleeve-forming mold 40 supporting the yarn tube 10 and pre-formed,
polyvinyl chloride (PVC) sleeve 30 fitted about the tube end 18 in a heat tunnel (not shown). In one heat tunnel, the mold-tube-sleeve assembly is subjected to a temperature of about 500 degrees Fahrenheit and moved through the tunnel at a relatively slow speed, for example, six feet per minute. In this manner, the PVC sleeve 30 is form-fitted 58 by heat about the end 18 of the tube 10. Conventional heat tunnels are useful for such a process. In embodiments of automated methods, molds 40 and tubes 10 can be exposed to heat for shorter periods of time, for example, by moving through a heat tunnel at, for example, ten to fifteen feet per minute. In embodiments utilizing different types of heat tunnels, molds 40 and tubes 10 may be exposed to temperatures lower than 500 degrees Fahrenheit to achieve an optimal thermosetting of the sleeve 30 about the tube 10, so as to create greater efficiency in large scale production.

Molds 40 and tubes 10 can be placed onto a tray (not shown), for example, 12 molds 40 on a single tray. In a heat tunnel having an opening that is 16-22 inches wide, a tray carrying 12 molds 40 and tubes 10 can be accommodated. Alternatively, molds 40 and tubes 10 can be placed on a conveyor means in other configurations, for example single file, for moving through a heat tunnel. During the process of preparing yarn tubes 10 for placement into a heat tunnel, the tubes 10 can be inspected 52 for burrs or other defects. At this point, a quality control check can be made to determine whether to reuse a particular tube 10.

In one embodiment of such a method, a pre-formed PVC sleeve 30 having a thickness \( t_z \) 37 of about 3 ml fitted 54 about a paper tube end 18 is subjected 57 to a temperature of about 500 degrees Fahrenheit for approximately ten seconds. The sleeve 30 forms 58 about the outer surface 14 of the tube 10 and the tube end 18 such that the sleeve 30 is slidably removable from the tube 10.

In embodiments of methods of the present invention, the sleeve 30 has a color 38 to identify a particular yarn 20 wound onto the tube 10.

Methods of making a reusable yarn tube 10 of the present invention provide embodiments that include automated processes. That is, any or all of the steps in such methods can be automated. For example, with reference to Fig. 8, each of the following steps can be automated: (1) providing 51 a cylindrical, hollow yarn tube 10; (2) inspecting 52 the tube 10 for burrs or other defects; (3) expanding 53 a pre-formed sleeve 30 with a cup device and placing the cup device and expanded sleeve 30 onto the tube 10; (4) fitting 54 the sleeve 30 about a portion 15 of the tube outer surface 14; (5) extending 55 the sleeve 30 a distance \( \text{d}_1 \) 32 beyond the end 18 of the tube 10; (6) placing 56 the end 18 of the tube 10 having the sleeve 30 fitted thereabout onto a sleeve-forming mold 40; (7) applying 57 heat to the tube-
sleeve-mold assembly at a pre-determined temperature and time; and/or (8) forming 58 the sleeve 30 about the yarn-unwinding end 18 of the tube 10. Computer-based logic, mechanisms, and devices can be applied to such processes in order to automatically make a reusable yarn tube 10 of the present invention.

Although the present invention has been described with reference to particular embodiments, it should be recognized that these embodiments are merely illustrative of the principles of the present invention. Those of ordinary skill in the art will appreciate that a reusable yarn tube of the present invention may be constructed and implemented in other ways and embodiments. Accordingly, the description herein should not be read as limiting the present invention, as other embodiments also fall within the scope of the present invention.
What is claimed is:

1. A reusable yarn tube, comprising:
   a hollow tube having a substantially cylindrical wall, an outer surface adapted to carry a yarn thereon, a starting groove in the outer surface proximate one end of the tube, and an opposite, yarn-unwinding end; and
   a pre-formed sleeve having a smooth surface adapted to fit about a portion of the outer surface of the tube and the yarn-unwinding end of the tube;
   wherein the sleeve provides a smooth surface for the yarn to be wound onto and unwound from the tube.

2. The reusable yarn tube of claim 1, the hollow tube further comprising an inside surface and the cylindrical wall further comprising a thickness, wherein the sleeve is fitted about the yarn-unwinding end of the tube and across the thickness of the cylindrical wall without contacting the inside surface of the tube.

3. The reusable yarn tube of claim 1, wherein the sleeve is thermosetable.

4. The reusable yarn tube of claim 1, wherein the sleeve comprises a thickness and a composition adapted to withstand pressure from yarn wound thereon.

5. The reusable yarn tube of claim 1, wherein the sleeve comprises a composition adapted to avoid absorption of moisture and oils from the yarn and the tube.

6. The reusable yarn tube of claim 1, wherein the sleeve comprises polyvinyl chloride.

7. The reusable yarn tube of claim 1, wherein the tube has a color to identify a particular yarn wound thereon.

8. The reusable yarn tube of claim 1, wherein the sleeve has a color to identify a particular yarn wound onto the tube.

9. The reusable yarn tube of claim 1, wherein the tube comprises paper.

10. The reusable yarn tube of claim 1, wherein the sleeve is slidably removable from the tube.

11. A reusable yarn tube, comprising:
    a hollow, paper tube having a substantially cylindrical wall, an outer surface adapted to carry a yarn thereon, a starting groove in the outer surface proximate one end of the tube, and an opposite, yarn-unwinding end of the tube having a smooth surface; and
    a pre-formed, thermosetable sleeve having a smooth surface adapted to fit about a portion of the outer surface of the tube and the yarn-unwinding end of the tube;
    wherein the sleeve provides a smooth surface for the yarn to be wound onto and unwound from the tube;
wherein the sleeve has a color to identify a particular yarn wound onto the tube;
wherein the sleeve further comprises a thickness and a composition adapted to
withstand pressure from yarn wound thereon and adapted to avoid absorption of moisture and
oils from the yarn and the tube; and

wherein the sleeve is slidably removable from the tube.

12. The reusable yarn tube of claim 11, the hollow tube further comprising an inside
surface and the cylindrical wall further comprising a thickness, wherein the sleeve is fitted
about the yarn-unwinding end of the tube and across the thickness of the cylindrical wall
without contacting the inside surface of the tube.

13. A method of making a reusable yarn tube, comprising:

providing a hollow tube having a substantially cylindrical wall, an outer surface
adapted to carry a yarn thereon, a starting groove in the outer surface proximate one end of
the tube, and an opposite, yarn-unwinding end;
fitting a pre-formed sleeve having a smooth surface about a portion of the outer
surface of the yarn-unwinding end; and

forming the sleeve about the yarn-unwinding end of the tube so that the sleeve
provides a smooth surface for the yarn to be wound onto and unwound from the tube.

14. The method of claim 13, the hollow tube further comprising an inside surface and the
cylindrical wall further comprising a thickness, wherein fitting the sleeve about the yarn-
unwinding end of the tube further comprises extending the sleeve a distance beyond the yarn-
unwinding end such that when the sleeve is formed about the yarn-unwinding end, the sleeve
extends across the thickness of the cylindrical wall without contacting the inside surface of
the tube.

15. The method of claim 14, further comprising placing the yarn-unwinding end of the
tube having the sleeve fitted thereabout onto a sleeve-forming mold comprising a
substantially cylindrical outer surface having an outside diameter sized to fittingly receive the
tube and a ring projecting outwardly from the outer surface of the mold for supporting the
tube.

16. The method of claim 15, wherein the outwardly projecting ring has a thickness such
that the sleeve will not contact the ring when the sleeve is formed about the yarn-unwinding
end of the tube.

17. The method of claim 15, wherein the mold is spaced a distance from a surface below
the mold sufficient to allow the sleeve extending beyond the yarn-unwinding end of the tube.
to move freely above the surface below the mold during forming the sleeve about the yarn-unwinding end.

18. The method of claim 13, wherein fitting the sleeve about the yarn-unwinding end of the tube further comprises expanding the sleeve with a cup device and placing the cup device and expanded sleeve onto the yarn-unwinding end of the tube.

19. The method of claim 13, wherein the sleeve is thermosetable.

20. The method of claim 13, wherein the sleeve comprises polyvinyl chloride.

21. The method of claim 13, wherein the sleeve has a color to identify a particular yarn wound onto the tube.

22. The method of claim 13, wherein the sleeve is slidably removable from the tube.

23. The method of claim 18, wherein the method is automated.

24. A method of making a reusable yarn tube, comprising:

providing a hollow tube having a substantially cylindrical wall, an inside surface, an outer surface adapted to carry a yarn thereon, a starting groove in the outer surface proximate one end of the tube, and an opposite, yarn-unwinding end, the wall having a thickness;

inspecting the tube for defects;

fitting a pre-formed sleeve having a smooth surface about a portion of the outer surface of the yarn-unwinding end;

extending the sleeve a distance beyond the yarn-unwinding end of the tube;

placing the yarn-unwinding end of the tube having the sleeve fitted thereabout onto a sleeve-forming mold; and

forming the sleeve about the yarn-unwinding end of the tube,

wherein when the sleeve is formed about the yarn-unwinding end of the tube, the sleeve extends across the thickness of the cylindrical wall without contacting the inside surface of the tube, and

wherein the sleeve provides a smooth surface for the yarn to be wound onto and unwound from the tube.

25. The method of claim 24, wherein fitting a sleeve about a portion of the outer surface of the yarn-unwinding end comprises expanding the sleeve with a cup device and placing the cup device and expanded sleeve onto the tube.

26. The method of claim 24, wherein forming the sleeve about the yarn-unwinding end of the tube comprises applying heat to the sleeve at a pre-determined temperature and time.

27. The method of claim 26, wherein the method is automated.
AMENDED CLAIMS

[Received by the International Bureau on 16 May 2005 (16.05.05) ;
original claims 1-27 replaced by amended claims 1-18]

1. A reusable yarn tube, comprising:
   a hollow tube having a substantially cylindrical wall, an outer surface adapted to carry
   a yarn thereon, a starting groove in the outer surface proximate one end of the tube, and an
   opposite, yarn-unwinding end; and characterized by
   a pre-formed sleeve having a smooth surface adapted to fit about a portion of the
   outer surface of the tube and the yarn-unwinding end of the tube;
   wherein the sleeve provides a smooth surface for the yarn to be wound onto and
   unwound from the tube.

2. The reusable yarn tube of claim 1, the hollow tube further comprising an inside
   surface and the cylindrical wall further comprising a thickness, wherein the sleeve is fitted
   about the yarn-unwinding end of the tube and across the thickness of the cylindrical wall
   without contacting the inside surface of the tube.

3. The reusable yarn tube of any of claims 1 or 2, wherein the sleeve is thermosettable.

4. The reusable yarn tube of any of claims 1 to 3, wherein the sleeve comprises a
   thickness and a composition adapted to withstand pressure from yarn wound thereon.

5. The reusable yarn tube of any of claims 1 to 4, wherein the sleeve comprises a
   composition adapted to avoid absorption of moisture and oils from the yarn and the tube.

6. The reusable yarn tube of any of claims 1 to 5, wherein the sleeve comprises
   polyvinyl chloride.

7. The reusable yarn tube of any of claims 1 to 6, wherein the tube has a color to identify
   a particular yarn wound thereon.

8. The reusable yarn tube of any of claims 1 to 7, wherein the sleeve has a color to
   identify a particular yarn wound onto the tube.

9. The reusable yarn tube of any of claims 1 to 8, wherein the tube comprises paper.
10. The reusable yarn tube of any of claims 1 to 9, wherein the sleeve is slidably removable from the tube.

11. A method of making a reusable yarn tube according to claims 1 to 10, comprising:
providing a hollow tube having a substantially cylindrical wall, an outer surface adapted to carry a yarn thereon, a starting groove in the outer surface proximate one end of the tube, and an opposite, yarn-unwinding end; and characterized by
fitting a pre-formed sleeve having a smooth surface about a portion of the outer surface of the yarn-unwinding end;
forming the sleeve about the yarn-unwinding end of the tube so that the sleeve provides a smooth surface for the yarn to be wound onto and unwound from the tube. The method of claim 11, the hollow tube further comprising an inside surface and the cylindrical wall further comprising a thickness, wherein fitting the sleeve about the yarn-unwinding end of the tube further comprises extending the sleeve a distance beyond the yarn-unwinding end such that when the sleeve is formed about the yarn-unwinding end, the sleeve extends across the thickness of the cylindrical wall without contacting the inside surface of the tube.

13. The method of any of claims claim 11 or 12, further comprising placing the yarn-unwinding end of the tube having the sleeve fitted thereabout onto a sleeve-forming mold comprising a substantially cylindrical outer surface having an outside diameter sized to fittingly receive the tube and a ring projecting outwardly from the outer surface of the mold for supporting the tube.

14. The method of any of claims 11 to 13, wherein the outwardly projecting ring has a thickness such that the sleeve will not contact the ring when the sleeve is formed about the yarn-unwinding end of the tube.

15. The method of any of claims 11 to 14, wherein the mold is spaced a distance from a surface below the mold sufficient to allow the sleeve extending beyond the yarn-unwinding end of the tube to move freely above the surface below the mold during forming the sleeve about the yarn-unwinding end.
16. The method of any of claims 11 to 15, wherein fitting the sleeve about the yarn-unwinding end of the tube further comprises expanding the sleeve with a cup device and placing the cup device and expanded sleeve onto the yarn-unwinding end of the tube.

17. The method of any of claims 11 to 16, wherein the method is automated.

18. The method of any of claims 11 to 16, wherein forming the sleeve about the yarn-unwinding end of the tube comprises applying heat to the sleeve at a pre-determined temperature and time.
STATEMENT UNDER ARTICLE 19(1)

This Statement accompanies Amendments under PCT Article 19, in response to the Written Opinion of the International Searching Authority and the International Search Report mailed on 16 March 2005 (16.03.2005), in connection with the above-identified application. In response thereto, Applicant has submitted the attached Amendments to claims with replacement sheets for pages 16 – 18. Claims 1 to 27 have been replaced by amended claims 1 to 18.

The Amendments do not go beyond the disclosure in the international application as filed. Applicant respectfully requests that the enclosed replacement pages including Amendments of the claims and this Statement Under Article 19(1) in the above-identified application be published with the international application.
51 Providing a cylindrical, hollow yarn tube
52 Inspecting yarn tube for burrs and other defects
53 Expanding a pre-formed sleeve with a cup device and placing cup device and expanded sleeve onto end of tube
54 Fitting sleeve about a portion of tube outer surface
55 Extending sleeve distance beyond end of tube
56 Placing end of tube having sleeve fitted thereabout onto sleeve-forming mold
57 Applying heat to tube-sleeve-mold assembly at a pre-determined temperature and time
58 Forming the sleeve about the yarn-unwinding end of the tube

Fig. 8
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B65H75/10 B65H75/50

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B65H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of box C. Patent family members are listed in annex.

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Date of the actual completion of the international search 8 March 2005
Date of mailing of the international search report 16/03/2005

Name and mailing address of the ISA
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