US 20070098984A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2007/0098984 A1

Peterson, II et al.

(43) Pub. Date: May 3, 2007

(54) **FIBER WITH RELEASE-MATERIAL SHEATH FOR PAPERMAKING BELTS**

(76) Inventors: **James F. Peterson II**, State College, PA (US); **Pierluigi Cappellini**, Jersey Shore, PA (US); **Kambiz Damaghi**, Great Neck, NY (US)

Correspondence Address:
MORGAN, LEWIS & BOCKIUS, LLP.
2 PALO ALTO SQUARE
3000 EL CAMINO REAL
PALO ALTO, CA 94306 (US)

(21) Appl. No.: **11/265,706**

(22) Filed: **Nov. 1, 2005**

Publication Classification

(51) **Int. Cl.**
D02G 3/00 (2006.01)

(52) **U.S. Cl.** **428/375**

(57) **ABSTRACT**

Fibers with release-material sheaths, methods and systems for making such fibers, papermaking belts incorporating such fibers, and papermaking processes using belts incorporating such fibers are described.

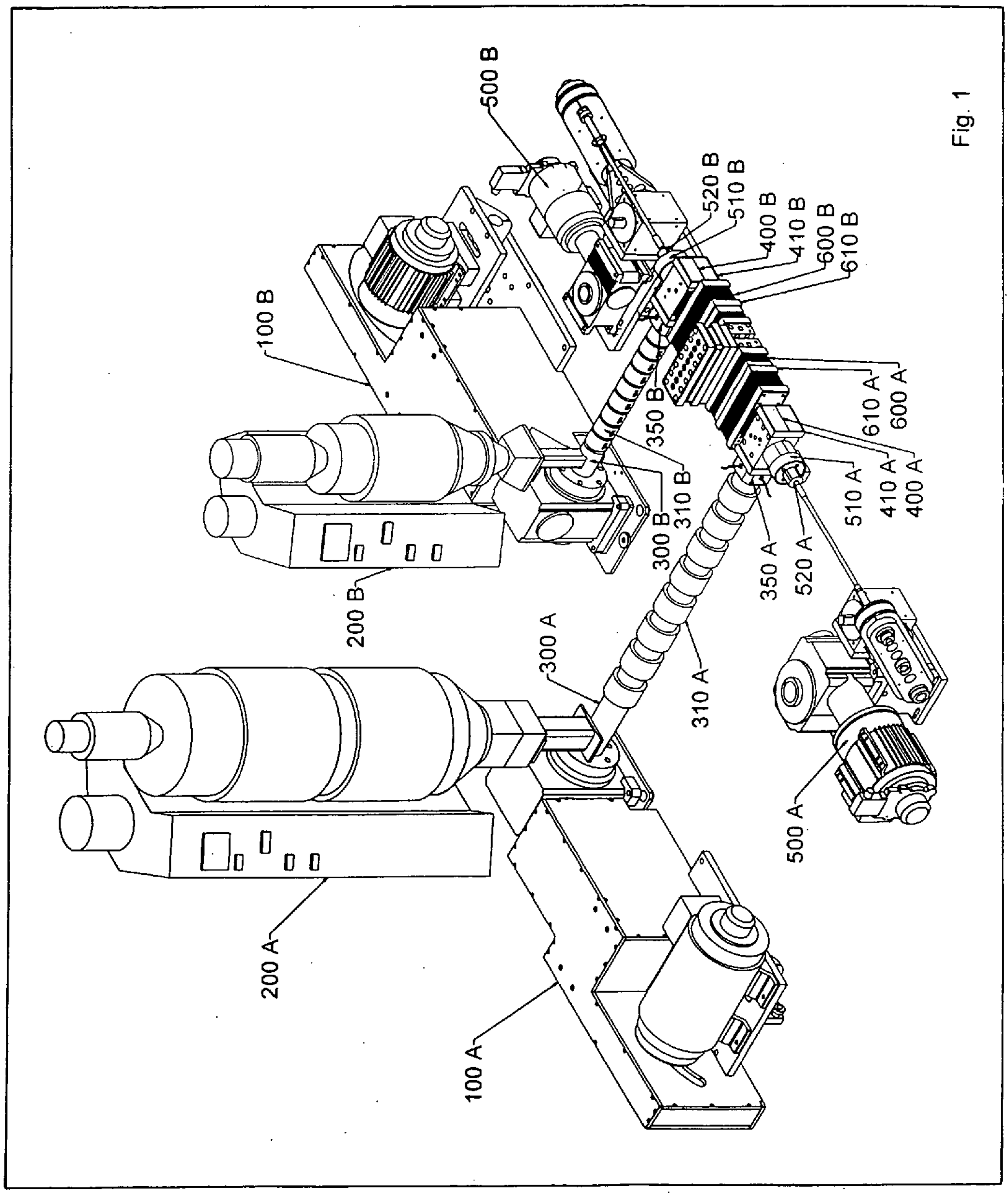

500 B
520 B
510 B
400 B
410 B
600 B
610 B
100 B
610 A
600 A
350 B
410 A
400 A
510 A
310 B
300 B
350 A
520 A
200 B
300 A
310 A
500 A
200 A
100 A

Fig. 1

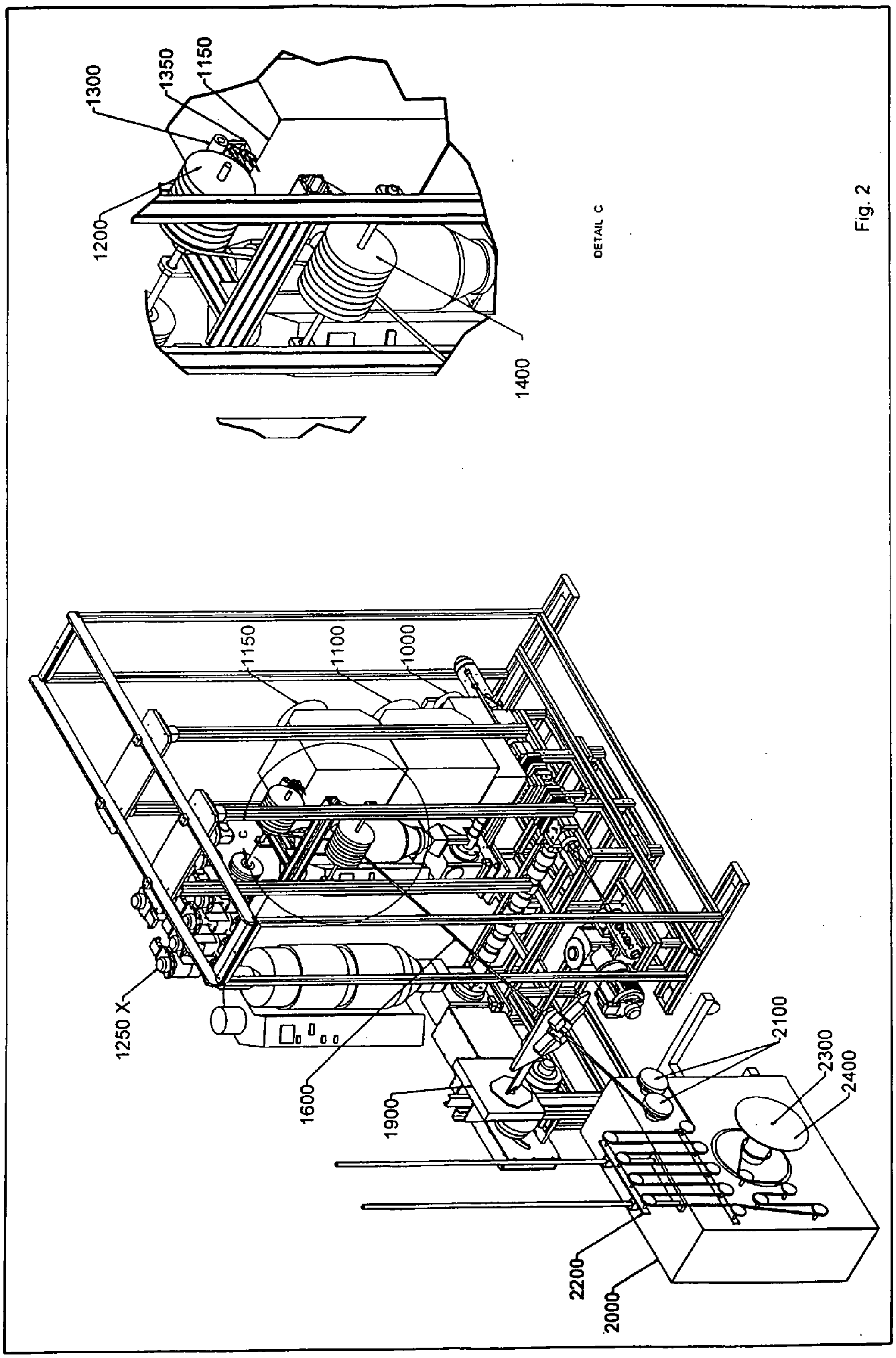

1300
1350
1150
1200
1400
DETAIL C
1250 X
1600
1900
1150
1100
1000
2100
2300
2400
2200
2000

Fig. 2

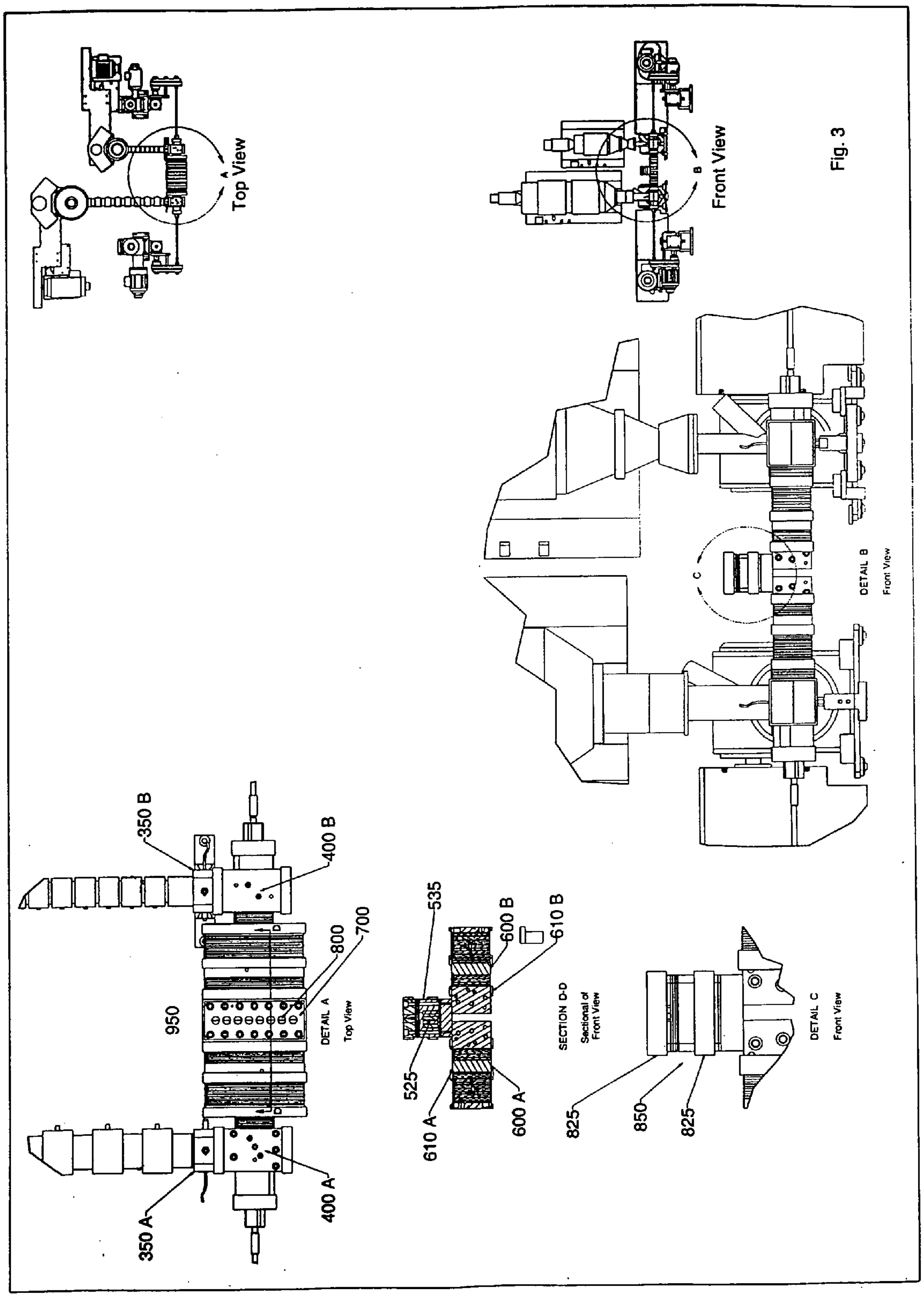

A
Top View
B
Front View
C
DETAIL B
Front View
350 B
400 B
700
800
950
DETAIL A
Top View
350 A
400 A
535
600 B
610 B
525
610 A
600 A
SECTION D-D
Sectional of Front View
DETAIL C
Front View
825
850
825

Fig. 3

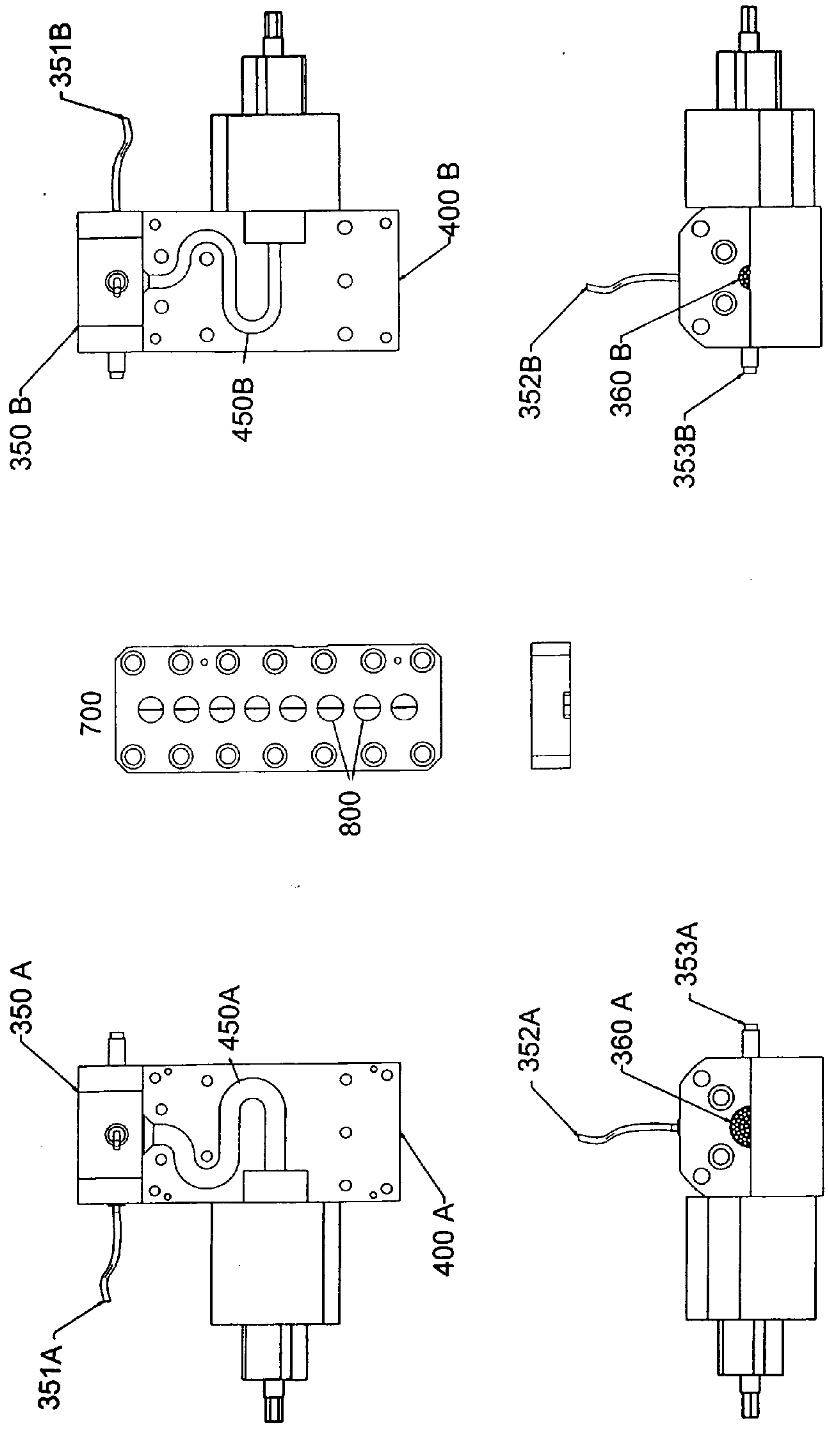

351B
350 B
450B
400 B
352B
360 B
353B
700
800
350 A
450A
351A
400 A
352A
360 A
353A

Fig. 4

FIG. 5

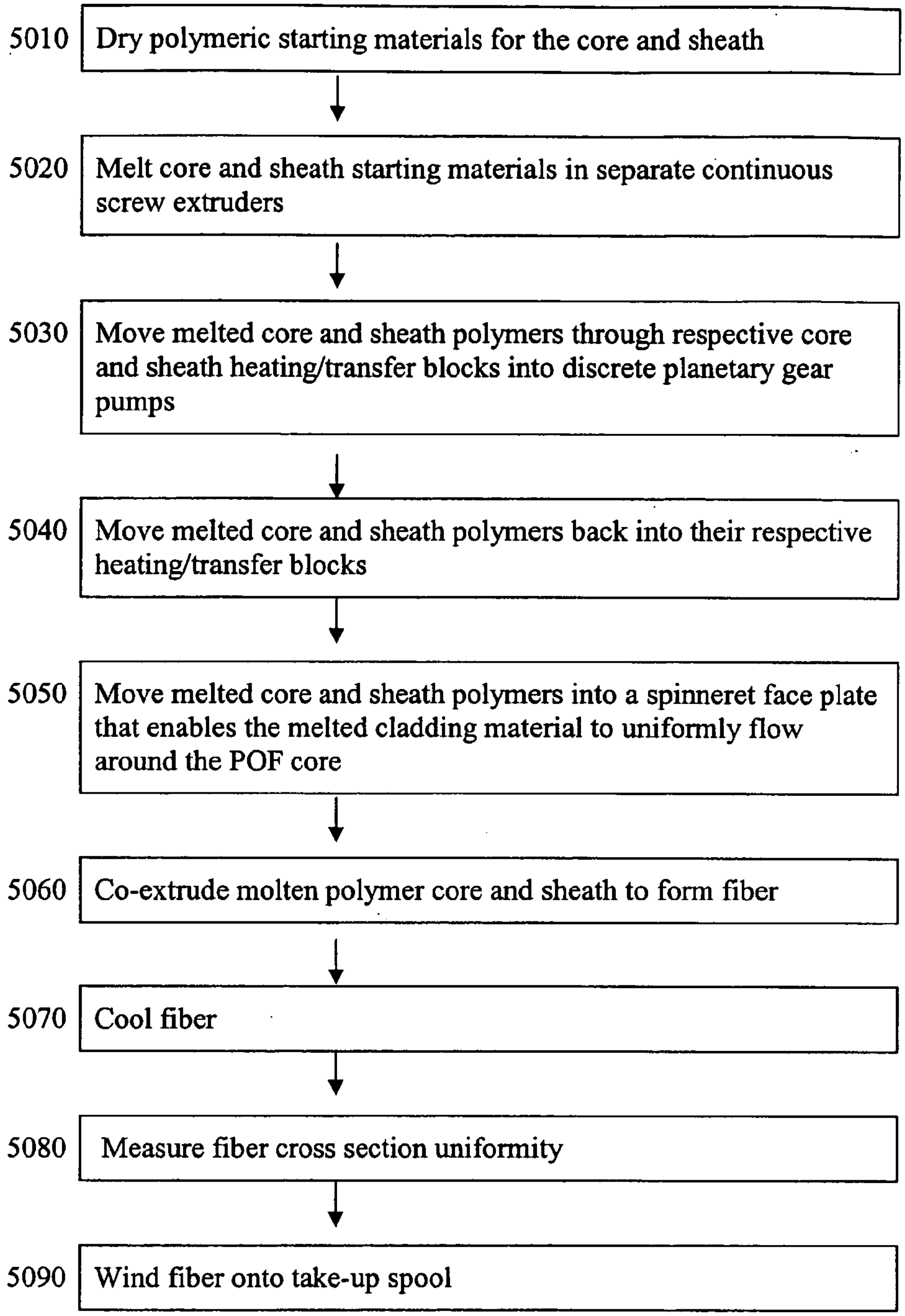
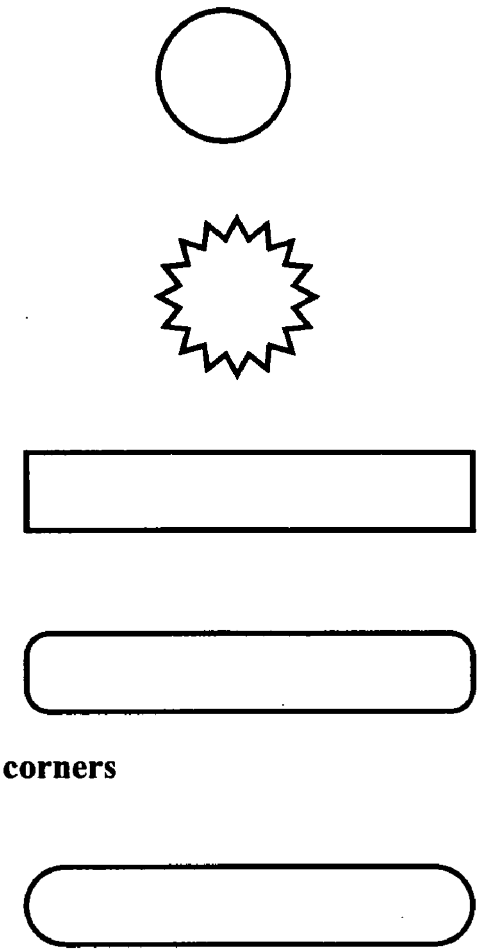

5010
Dry polymeric starting materials for the core and sheath
5020
Melt core and sheath starting materials in separate continuous screw extruders
5030
Move melted core and sheath polymers through respective core and sheath heating/transfer blocks into discrete planetary gear pumps
5040
Move melted core and sheath polymers back into their respective heating/transfer blocks
5050
Move melted core and sheath polymers into a spinneret face plate that enables the melted cladding material to uniformly flow around the POF core
5060
Co-extrude molten polymer core and sheath to form fiber
5070
Cool fiber
5080
Measure fiber cross section uniformity
5090
Wind fiber onto take-up spool

FIG. 6



(a) circular

(b) corrugated

(c) rectangle

(d) rectangle with rounded corners

(e) racetrack oval

FIBER WITH RELEASE-MATERIAL SHEATH FOR PAPERMAKING BELTS

FIELD OF INVENTION

[0001] The present invention relates to papermaking belts. More particularly, the present invention concerns fibers with release-material sheaths, methods and systems for making such fibers, papermaking belts incorporating such fibers, and papermaking processes using belts incorporating such fibers.

BACKGROUND

[0002] Considerable efforts have been devoted to increasing the efficiency and reducing the costs of making various types of paper, including facial tissue, paper towels, bathroom tissue, and napkins. As part of this effort, there have been numerous attempts to improve the durability and/or release properties of papermaking belts (i.e., the belts and fabrics used during one or more stages of a papermaking process to carry a fibrous web that is being made into paper).

[0003] For example, U.S. Pat. Nos. 6,701,637 and 6,514,382 describe the application of release coatings (e.g., fluoropolymers and silicone release agents) to papermaking belts to reduce the tendency of the fibrous web to stick to the belt. These release coatings, however, are temporary and need to be reapplied, thereby increasing costs.

[0004] To avoid or minimize the use of temporary chemical release agents, WO 03/057977 A2, an international application published under the PCT, describes "papermaking belts and industrial textiles with enhanced surface properties." This application discusses the use of a primer to graft a resin system onto a textile fabric after the surface of the fabric has been sanded. (Belt fabric is typically sanded to increase its surface contact area.) The resin system "provides a number of benefits including the enhancement of hydrophobic properties giving superior paper web sheet release thus eliminating or at least minimizing the need to continuously apply a temporary chemical release agent to the TAD (through-air drying) fabric."

[0005] The belts described in WO 03/057977 A2, however, suffer from several deficiencies and shortcomings. The resin may not uniformly cover the fabric, thereby increasing the amount of temporary chemical release agent that needs to be applied to the fabric belt to provide acceptable release properties. Moreover, the use of a primer increases the complexity of the fabrication process.

[0006] In another example, WO 00/51801 describes a transfer fabric that "employs a sheath-core composite yarn which may be heated on one or both surfaces so that the sheath component is melted. Melting produces a support layer which is non-porous or substantially non-porous. The core of each yarn [which has a higher melting temperature than the sheath component] is unaffected by melting and thus becomes embedded in the support layer."

[0007] The belts described in WO 00/51801 also suffer from several deficiencies and shortcomings. The sheath material (e.g., polyurethane) is a tacky substance, not a non-sticking material. Thus, there is no reduction in the amount of temporary chemical release agents that must be repeatedly applied to these belts to provide adequate release properties.

[0008] In another example, WO 99/05358 describes "yarns or fibres which have been subjected to plasma treatment.""To provide a water-repellant finish (hydrophobic) the plasma may be created from a siloxane or perfluorocarbon compound." One advantage cited in WO 99/05358 for plasma treatment is that "very small amounts of the raw materials are required (e.g., 30-100 mg per m^2 fabric)."

[0009] The belts described in WO 99/05358 also suffer from several deficiencies and shortcomings. The material deposited on the yarn or fiber by the plasma is so thin (e.g., 30-100 mg per m^2 corresponds to 150-500 Angstroms for a material with a density of 2 gm/cm^3) that the material will not be durable. Indeed, most or all of the material would be removed from belts made of plasma-treated yarn if the belts were sanded.

[0010] Thus, there remains a need for improved papermaking belts with better durability and release properties.

SUMMARY

[0011] The present invention addresses the needs described above by providing fibers with release-material sheaths, methods and systems for making such fibers, papermaking belts incorporating such fibers, and papermaking processes using belts incorporating such fibers.

[0012] One aspect of the invention involves a fiber for use in a papermaking belt. The fiber includes an inner core and an outer sheath. The outer sheath has a thickness of at least 10 microns prior to sanding, if any, of the fiber, and includes a release material to facilitate the release of a paper web when the paper web is in contact with the fiber.

[0013] Another aspect of the invention involves a method for making a fiber. The method includes forming a fiber core and forming an outer sheath around the fiber core. The outer sheath has a thickness of at least 10 microns prior to sanding, if any, of the fiber, and includes a release material to facilitate the release of a paper web when the paper web is in contact with the fiber.

[0014] Another aspect of the invention involves a papermaking belt that includes a mesh of fibers. At least some of the fibers include an outer sheath integrally formed around an inner core. The outer sheath has a thickness of at least 10 microns prior to sanding, if any, of the belt, and includes a release material to facilitate the release of a fibrous web of paper when the web is in contact with the belt.

[0015] Another aspect of the invention is a method of intermeshing a plurality of fibers to form a papermaking fabric. At least some fibers in the plurality of fibers include an outer sheath integrally formed around an inner core. The outer sheath has a thickness of at least 10 microns prior to sanding, if any, of the fabric, and includes a release material to facilitate the release of a fibrous web of paper when the web is in contact with the fabric.

[0016] Another aspect of the invention is a method of using a papermaking belt to carry a fibrous web in at least one part of a papermaking process. The papermaking belt includes a mesh of fibers. At least some of the fibers include an outer sheath integrally formed around an inner core. The outer sheath has a thickness of at least 10 microns prior to sanding, if any, of the belt, and includes a release material to facilitate the release of a fibrous web of paper when the web is in contact with the belt.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] For a better understanding of the aforementioned aspects of the invention as well as additional aspects and embodiments thereof, reference should be made to the Description of Embodiments below, in conjunction with the following drawings in which like reference numerals refer to corresponding parts throughout the figures.

[0018] FIG. **1** is a schematic diagram illustrating an exemplary system for producing fibers with release-material sheaths.

[0019] FIG. **2** is a schematic diagram illustrating the system of FIG. **1** with additional components for measuring fiber uniformity, cooling fiber in a controlled manner, and winding fiber onto a spool.

[0020] FIG. **3** is a schematic diagram illustrating the spin pack assembly in more detail.

[0021] FIG. **4** is a schematic diagram illustrating multi-purpose blocks **350**A & **350**B and cutaway views of transfer/heating blocks **400**A & **400**B in more detail.

[0022] FIG. **5** is a flow chart illustrating an exemplary process for producing fibers with release-material sheaths.

[0023] FIG. **6** is a schematic diagram illustrating exemplary fiber core cross sections, including (a) circular, (b) corrugated, (c) rectangular, (d) rectangular with rounded corners, and (e) racetrack oval.

DESCRIPTION OF EMBODIMENTS

[0024] This section describes fibers with release-material sheaths, methods and systems for making such fibers, papermaking belts incorporating such fibers, and papermaking processes using belts incorporating such fibers. Reference will be made to certain embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the embodiments, it will be understood that it is not intended to limit the invention to these particular embodiments alone. On the contrary, the invention is intended to cover alternatives, modifications and equivalents that are within the spirit and scope of the invention as defined by the appended claims.

[0025] Moreover, in the following description, numerous specific details are set forth to provide a thorough understanding of the present invention. However, it will be apparent to one of ordinary skill in the art that the invention may be practiced without these particular details. In other instances, methods, procedures, and components that are well-known to those of ordinary skill in the art are not described in detail to avoid obscuring aspects of the present invention.

[0026] FIG. **1** is a schematic diagram illustrating an exemplary system for producing fibers with release-material sheaths. The system in FIG. **1** includes both "A" components that are used to extrude the core of the fiber and "B" components that are used to continuously extrude the release-material sheath around the core of the fiber. The A and B mechanical components are nearly the same in configuration, with the main difference being the size of the motor/extruder combination. This exemplary system includes: extruder drive assemblies **100**A & **100**B, feed hopper/dryer systems **200**A & **200**B, extruder screw/barrel assemblies **300**A & **300**B, barrel heater bands **310**A & **310**B, multi-purpose blocks **350**A & **350**B, transfer/heating blocks **400**A & **400**B, band heaters **410**A & **410**B for transfer/heating blocks **400**A & **400**B, pump/drive assemblies **500**A & **500**B, pump heater bands **510**A & **510**B, planetary gear pumps **520**A & **520**B, flow distributors **600**A & **600**B, and band heaters **610**A & **610**B for flow distributors **600**A & **600**B.

[0027] FIG. **2** is a schematic diagram illustrating the system of FIG. **1** with additional components for measuring fiber uniformity, cooling fiber in a controlled manner, and winding fiber onto a spool. The additional components include: idler roll **1300**, individual product guide **1350**, segmented idler roll **1400**, quench unit stage **11100**, quench unit stage **21150**, quench unit stage **31000**, segmented drive roll **1200** (with independent controlling motors **1250**X for each segment in drive roll **1200**), laser micrometer **1900**, and winding unit **2000**. Winding unit **2000** includes electrically driven high precision draw rolls **2100**, accumulator system **2200**, and traverse mechanism **2300** for fiber spool **2400**.

[0028] In some embodiments, quench unit stage **31000** is removed and quench unit stage **11100** and quench unit stage **21150** are lowered to be closer to spinneret face plate **700**. As shown in FIG. **2**, in some embodiments, quench units **1000**, **1100**, and **1150** are stacked on top of each other in the same orientation so that the air flows in the same direction in each quench unit (e.g., right to left in FIG. **2**). In other embodiments (not shown), the quench units are stacked in a staggered configuration so that the airflows are in opposite directions in adjacent quench units. For example, the airflow in quench unit stage **11100** is right-to-left and the airflow in quench unit stage **21150** is left-to-right (with quench unit stage **31000** removed). Opposing airflows can help maintain the shape of the fiber.

[0029] In some embodiments, each filament has its own winding unit **2000**, which allows for individual adjustment in filament speed. (For clarity, only one winding unit **2000** is shown in FIG. **2**.) Multiple winding units **2000** and multiple spinneret inserts **800** allow for the formation of distinct fibers from each of the filament streams. Thus, if desired, a variety of fibers with different shapes and/or sizes can be run concurrently in the extrusion system by varying the spinneret insert(s) **800** and/or the winder **2000** settings. The winding unit accumulator system **2200** provides for continuous operation of the winder even during spool changes through the accumulation of fiber. The traverse mechanism **2300** controls the movement of spool **2400** and is electronically integrated to adjust take-up speed to uniformly wind fiber **1600** onto the spool as the diameter of the fiber accumulated on spool **2400** increases. Traverse mechanism **2300** moves fiber spool **2400** in and out during fiber **1600** uptake onto spool **2400**. Additional adjustments are provided for each of the fiber streams produced via the substitution of spinneret inserts **800**, e.g., varying the spinneret size and/or geometric shape.

[0030] It will be understood by those of ordinary skill in the art that additional flow distribution channels could be connected with additional extruders to produce multilayered fiber core and/or multilayered release-material sheaths.

[0031] FIG. **3** is a schematic diagram illustrating the spin pack assembly **950** in more detail. Spin pack assembly **950** is typically comprised of a number of sub-blocks, such as: multi-purpose blocks **350**A & **350**B, transfer/heating blocks **400**A & **400**B, filter block **535**, flow distributors **600**A & **600**B, band heaters **610**A & **610**B for flow distributors **600**A & **600**B, spinneret face plate **700**, spinneret insert(s) **800**, spin face heater bands **825**, and filtration/polymer integration sub-assembly **850**. Filter block **535** contains polymer filters **525**. Polymer filters **525** remove any polymer gels present and also remove any potential charred polymer from the extrusion system. Exemplary filter cups are available through the Mott Filter Company (84 Spring Lane, Farmington, Conn. 06032) and are capable of removing particles that typically range from 10 to 100 microns in size. Spinneret insert(s) **800** provides for rapid replacement and changeover in spinneret shape(s) and spinneret size(s). As is well-known in the art, polymer integration sub-assembly **850** combines the molten core and sheath materials just prior to co-extrusion so that integrally formed (core+sheath) fiber structures can be produced (e.g., see U.S. Pat. No. 5,533,883, the disclosure of which is hereby incorporated by reference). Co-extrusion promotes adhesion between the core and the release-material sheath so that no primer is needed.

[0032] FIG. **4** is a schematic diagram illustrating multi-purpose blocks **350**A & **350**B and cutaway views of transfer/heating blocks **400**A & **400**B in more detail. Multi-purpose blocks **350**A & **350**B include burst plugs **353**A & **353**B (pressure safety valves), temperature probes **352**A & **352**B, and pressure transducers **351**A & **351**B. The design of blocks **350**A & **350**B and **400**A & **400**B minimizes resistance to polymer flow and provides feedback on processing parameters (e.g., temperature and pressure). Blocks **400**A & **400**B can be split into two halves for easier cleaning. Transfer blocks **400**A & **400**B also include breaker plates **360**A & **360**B to improve the mixing of melted polymer. FIG. **4** illustrates system components for both the core and the sheath, with each designated by an A or B, respectively. As noted above, it will be understood by those skilled in the art that spin pack assembly **950** could be connected with additional extruders to produce multilayered cores and/or multilayered sheaths.

[0033] The methods described herein can be applied to virtually all core materials and sheath release materials.

[0034] Exemplary core materials include, without limitation, polyester; nylon; polyphenylene sulphide; poly 1,4 cyclohexane dimethylene terephthalate; polyethylene naphthalate; polyetheretherketone; or combinations thereof.

[0035] As used in the specification and claims, a "release material" is a solid fluoropolymer [e.g., polytetrafluoroethylene (PTFE); fluorinated ethylene propylene (FEP) copolymers such as a tetrafluoroethylene hexafluoropropylene copolymer; perfluoroalkoxy (PFA) polymers; ethylene and tetrafluoroethylene (EFTE) copolymers; tetrafluoroethylene hexafluoropropylene vinylidene (THV) copolymers; and polyvinylidene difluoride] that facilitates the release of a paper web from a papermaking belt.

[0036] FIG. **5** is a flow chart illustrating an exemplary process for producing fibers with release-material sheaths. As noted above, the core and sheath extruders operate in an analogous manner, although they may be different in size.

[0037] At **5010**, pellets of clean and purified core and sheath polymer resins (polymeric starting materials, typically supplied by commercial resin manufacturers) are fed into feed hopper/dryer systems **200**A & **200**B, respectively. Dryer systems **200**A & **200**B continually dry the polymer resins using compressed air and a heating system. The temperature used in dryer systems **200**A is typically between 100 to 140° C., with 135° C. being preferred. Moisture is removed from the resins by operating dryer systems **200**A at a dew point of −40° C. Dryer system **200**B is not required to operate for all materials. Both dryer systems **200**A & **200**B also have two coalescing filters in series to remove liquid water and oil droplet particles down to 0.01 micron in size. An exemplary dryer system **200** is a Novatect™ Compressed Air Dryer (Novatec, Inc. 222 E. Thomas Ave., Baltimore Md. 21225, www.novatec.com).

[0038] At **5020**, extruder drive assemblies **100**A & **100**B feed the polymers into extruder screw/barrel assemblies **300**A & **300**B, respectively, where the polymers are melted. Extruder drive assemblies **100**A & **100**B are dedicated drive systems that maintain consistent operating RPMs to provide stable pressures during the continuous extrusion processes.

[0039] The gear ratios of the pulleys in extruder drive assemblies **100**A & **100**B can be changed to enable the drive assembly motors to run at a preferred rate of 90-100% of the rated motor speed. A stable motor speed produces a stable screw speed, which, in turn, produces a consistent extrudate pressure. The measured pressure fluctuations are less than 2% during operation at various working pressures. Thus, the precision drives in extruder drive assemblies **100**A & **100**B enable greater extruder control and feeding uniformity of the extrudates.

[0040] In some embodiments, extruder screw/barrel assemblies **300**A & **300**B may be vented to remove volatile contaminants from the melted resins. In some embodiments, the polymers in the extruder assemblies may be blanketed with nitrogen (or inert gas) or subjected to vacuum in order to further reduce resin contamination and to improve the uniformity of the melts.

[0041] At **5030**, the feed screws in extruder screw/barrel assemblies **300**A & **300**B move the melted core and sheath polymers through multipurpose blocks **350**A & **350**B and transfer/heating blocks **400**A & **400**B into planetary gear pumps **520**A & **520**B, respectively, in a continuous, uniform manner. Planetary gear pumps **520**A & **520**B are driven by dedicated drive assemblies **500**A & **500**B, respectively. Pumps **520**A & **520**B are single inlet pumps with multiple outlets. In some embodiments, the temperatures for the core and sheath polymers of the fiber are independently controlled and only come together as the fiber is being formed, thereby allowing for core and sheath polymers with different temperatures to be extruded simultaneously.

[0042] At **5040**, the melted core and sheath polymers move back into their respective transfer/heating blocks **400**A & **400**B in a continuous, uniform manner. Pumps **520**A & **520**B pressurize the molten polymers as they divide and distribute the flows into independent distribution channels in transfer blocks **400**A & **400**B. For clarity, FIG. **4** shows just one of the independent channels (i.e., channel **450**A) located within transfer/heating block **400**A. Similarly, FIG. **4** shows just one of the independent channels (i.e., channel **450**B) located within transfer/heating block **400**B.

[0043] Channels **450**A and **450**B in blocks **400**A & **400**B, respectively, permit high polymer flow rates with low restriction, thereby reducing shear heating (and concurrent temperature nonuniformities) in the polymer melts. The direction of polymer flow in spin pack assembly **950** can be changed in 90° increments. Thus, extrusion via spin pack assembly **950** can be vertically upward, vertically downward, or horizontal. Heating bands **610**A & **610**B facilitate temperature control (and thus viscosity control) of the molten polymers while passing through spin pack assembly **950**.

[0044] At **5050**, the molten sheath material flows uniformly around the molten core material in polymer integration subassembly **850**, just before the molten core and sheath enter spinneret face plate **700**. Spinneret face plate **700** is equipped with spinneret inserts **800**. Spinneret inserts **800** enable rapid changeover in spinneret hole diameter, shape and the pin length-to-diameter ratio. The spin face heaters **825** control the temperature uniformity of the core and sheath extrudates as they exit the spinneret inserts **800** to form fiber **1600**.

[0045] At **5060**, the molten polymer core and sheath are co-extruded through spinneret face plate **700**. In some embodiments, forcing the molten polymer core through circular openings in spinneret insert(s) **800** forms a fiber core with substantially circular cross-sections. In other embodiments, forcing the molten polymer core through rectangular or other similarly shaped openings in spinneret insert(s) **800** forms a fiber core with substantially flat cross-sections. FIG. **6** is a schematic diagram illustrating exemplary fiber core cross sections, including (a) circular, (b) corrugated, (c) rectangular, (d) rectangular with rounded comers, and (e) racetrack oval. The corrugation shown in FIG. **6**(*b*) applied to a circular cross section can also be applied to other shapes, such as the shapes shown in FIGS. **6**(*c*)-**6**(*e*). Co-extruding the molten polymer sheath that has flowed around the molten core material through openings in spinneret insert(s) **800** forms a sheath around the core. Spinneret insert(s) **800** may be changed to allow simultaneous production of different size and/or shaped fibers, thereby adding versatility to the production system.

[0046] In some embodiments, to increase the uniformity of the fiber cross sections, the extrusion in step **5060** is performed in a substantially vertical upward direction, against the force of gravity.

[0047] If vertically upward extrusion is used, at the start of the extrusion process, a metal rod or other inert surface makes contact with fiber **1600** exiting spinneret insert **800**, and lifts fiber **1600** up through individual product guide **1350**, then to idler roll **1300** and onto drive roll **1200**. Fiber **1600** is/are then passed over segmented idler roll **1400** and through the rest of the system in the same manner as is commonly done for horizontal or vertically downward extrusion processes. Each segment in idler roll **1400** can spin at a different speed if fiber streams with different dimensions are being extruded simultaneously. Alternatively, each segment in idler roll **1400** can spin at the same speed if fiber streams with the same dimensions are being extruded simultaneously.

[0048] At **5070**, fiber **1600** is cooled in a controlled manner. In some embodiments, fiber **1600** is cooled in a two- or three-stage cooling zone system.

[0049] In a two-stage cool with stage **3** quench unit **1000** removed, stage **1** quench unit **1100** is located adjacent to the spinneret face **700** and typically 3.5 inches away from fiber **1600** exiting spinneret insert(s) **800**. Stage **1** quench unit **1100** gradually cools fiber **1600** by blowing air over the fibers. Stage **1** quench unit **1100** is typically operated between 0 and 30° C., with 0° C. being preferred. Fans in stage **1** quench unit **1100** typically operate between 0 and 1750 RPM (corresponding to a measured air velocity of 0-493 feet per minute), with 1275 RPM (188 feet per minute) being preferred. Stage **2** quench unit **1150** typically operates at a temperature between 0 and 30° C., with 0° C. being preferred. Fans in stage **2** quench unit **1150** typically operate between 0 and 1750 RPM (corresponding to a measured air velocity of 0-573 feet per minute), with 1300 RPM (192 feet per minute) being preferred. Stage **2** quench unit **1150** is stacked in a staggered configuration with stage **1** quench unit **1100** so that the airflows in quench units **1100** and **1150** are in opposite directions. Stage **2** quench unit **1100** is positioned typically 2 inches away from the centerline of fiber **1600**. The staggered configuration allows for more uniform application of cool air to fiber **1600**, thereby producing more uniform cooling and preventing curling of the fiber. In some embodiments, the quench system is segmented into discrete chambers around each fiber filament stream to allow for individual control of air temperature and air speed around each individual fiber filament stream.

[0050] In some embodiments, stage **11100**, stage **21150** and stage **31000** quench units are stacked directly on top of one another. This embodiment is preferred for round fibers as the "curling" effect is less prevalent. This embodiment also can be segmented to allow for individual control of air temperature and airflow speed for each fiber. Tables 1-6 give exemplary process conditions for the co-extrusion of a fiber with a release-material sheath **1600**.

TABLE 1

Exemplary process conditions for 500 micron diameter polyester fiber (e.g., Dupont 5149 Polyester) with a THV sheath (e.g., Dyneon THV 220G)

Component	Temperature (° C.) for Core (A)	Temperature (° C.) for Sheath (B)
screw/barrel assembly 300 zone 1 (zone nearest dryer 200)	235	165
screw/barrel assembly 300 zone 2	265	175
screw/barrel assembly 300 zone 3	275	185
screw/barrel assembly 300 zone 4	280	200
screw/barrel assembly 300 zone 5 (zone nearest block 350)	280	240
planetary gear pump 520 inlet	283	228
planetary gear pump 520 block	271	194
planetary gear pump 520 outlet	290	251
pump heater band 510	280	240
band heater 410	281	250
band heater(s) 610	281/291/279	260/260/250
plate 700 inlet	285	267
spin face heater band 825	250	250
Component	**Core (A)**	**Sheath (B)**
Screw/barrel assembly 300 pressure set point (PSI)	1200	2000
Planetary gear pump 520 outlet pressure (PSI)	749	1495
Planetary gear pump 520 speed (RPM)	3.26	13

Fiber was produced at 8.5 meters per minute. Tensile strength was 8.60 kgf.

[0051]

TABLE 2

Exemplary process conditions for 350 micron diameter polyester fiber (e.g., Dupont 5149 Polyester) with a THV sheath (e.g., Dyneon THV 220G)

Component	Temperature (° C.) for Core (A)	Temperature (° C.) for Sheath (B)
screw/barrel assembly 300 zone 1 (zone nearest dryer 200)	235	165
screw/barrel assembly 300 zone 2	265	175
screw/barrel assembly 300 zone 3	275	185
screw/barrel assembly 300 zone 4	280	200
screw/barrel assembly 300 zone 5 (zone nearest block 350)	280	240
planetary gear pump 520 inlet	282	230
planetary gear pump 520 block	271	191
planetary gear pump 520 outlet	290	252
pump heater band 510	280	240
band heater 410	281	260
band heater(s) 610	285/291/279	267/260/250
plate 700 inlet	285	267
spin face heater band 825	250	250
Component	**Core (A)**	**Sheath (B)**
Screw/barrel assembly 300 pressure set point (PSI)	1200	2000
Planetary gear pump 520 outlet pressure (PSI)	827	1187
Planetary gear pump 520 speed (RPM)	3.56	10

Fiber was produced at 14.6 meters per minute. Tensile strength was 6.00 kgf.

[0052]

TABLE 3

Exemplary process conditions for 500 micron diameter polyester fiber (e.g., Dupont 5149 Polyester) with a THV sheath (e.g., Dyneon THV 815G)

Component	Temperature (° C.) for Core (A)	Temperature (° C.) for Sheath (B)
screw/barrel assembly 300 zone 1 (zone nearest dryer 200)	235	275
screw/barrel assembly 300 zone 2	265	285
screw/barrel assembly 300 zone 3	280	285
screw/barrel assembly 300 zone 4	285	285
screw/barrel assembly 300 zone 5 (zone nearest block 350)	285	285
planetary gear pump 520 inlet	288	284
planetary gear pump 520 block	276	283
planetary gear pump 520 outlet	294	299
pump heater band 510	282	292
band heater 410	285	280
band heater(s) 610	285/285/282	290/290/280
plate 700 inlet	290	290
spin face heater band 825	296	296
Component	**Core (A)**	**Sheath (B)**
Screw/barrel assembly 300 pressure set point (PSI)	1200	2250
Planetary gear pump 520 outlet pressure (PSI)	367	1467
Planetary gear pump 520 speed (RPM)	3.40	13

Fiber was produced at 8.4 meters per minute. Tensile strength was 9.44 kgf.

[0053]

TABLE 4

Exemplary process conditions for 350 micron diameter polyester fiber (e.g., Dupont 5149 Polyester) with a THV sheath (e.g., Dyneon THV 815G)

Component	Temperature (° C.) for Core (A)	Temperature (° C.) for Sheath (B)
screw/barrel assembly 300 zone 1 (zone nearest dryer 200)	235	275
screw/barrel assembly 300 zone 2	265	285
screw/barrel assembly 300 zone 3	280	285
screw/barrel assembly 300 zone 4	285	285
screw/barrel assembly 300 zone 5 (zone nearest block 350)	285	285
planetary gear pump 520 inlet	287	284
planetary gear pump 520 block	275	282
planetary gear pump 520 outlet	292	299
pump heater band 510	282	290
band heater 410	285	280
band heater(s) 610	285/285/282	285/290/290
plate 700 inlet	282	283
spin face heater band 825	297	297
Component	**Core (A)**	**Sheath (B)**
Screw/barrel assembly 300 pressure set point (PSI)	1200	1750
Planetary gear pump 520 outlet pressure (PSI)	469	1638
Planetary gear pump 520 speed (RPM)	3.39	13

Fiber was produced at 14.2 meters per minute. Tensile strength was 5.84 kgf.

[0054]

TABLE 5

Exemplary process conditions for 500 micron diameter polyester fiber (e.g., Dupont 5147 Polyester) with a THV sheath (e.g., Dyneon THV 220G)

Component	Temperature (° C.) for Core (A)	Temperature (° C.) for Sheath (B)
screw/barrel assembly 300 zone 1 (zone nearest dryer 200)	235	165
screw/barrel assembly 300 zone 2	265	175
screw/barrel assembly 300 zone 3	275	185
screw/barrel assembly 300 zone 4	295	200
screw/barrel assembly 300 zone 5 (zone nearest block 350)	290	240
planetary gear pump 520 inlet	267	225
planetary gear pump 520 block	279	192
planetary gear pump 520 outlet	299	255
pump heater band 510	285	233
band heater 410	290	240
band heater(s) 610	286/286/280	260/260/250
plate 700 inlet	285	261
spin face heater band 825	252	252
Component	**Core (A)**	**Sheath (B)**
Screw/barrel assembly 300 pressure set point (PSI)	400	1400
Planetary gear pump 520 outlet pressure (PSI)	171	1229
Planetary gear pump 520 speed (RPM)	7.5	17

Fiber was produced at 7.3 meters per minute. Tensile strength was 9.83 kgf.

[0055]

TABLE 6

Exemplary process conditions for 350 micron diameter polyester fiber (e.g., Dupont 5149 Polyester) with a FEP sheath (e.g., Dupont FEP 100)

Component	Temperature (° C.) for Core (A)	Temperature (° C.) for Sheath (B)
screw/barrel assembly 300 zone 1 (zone nearest dryer 200)	255	310
screw/barrel assembly 300 zone 2	285	380
screw/barrel assembly 300 zone 3	287	385
screw/barrel assembly 300 zone 4	285	380
screw/barrel assembly 300 zone 5 (zone nearest block 350)	285	380
planetary gear pump 520 inlet	275	388
planetary gear pump 520 block	277	372
planetary gear pump 520 outlet	294	400
pump heater band 510	282	368
band heater 410	285	376
band heater(s) 610	285/285/282	364/364/322
plate 700 inlet	293	322
spin face heater band 825	359	359
Component	**Core (A)**	**Sheath (B)**
Screw/barrel assembly 300 pressure set point (PSI)	1000	2750
Planetary gear pump 520 outlet pressure (PSI)	340	2822
Planetary gear pump 520 speed (RPM)	1.4	15

Fiber was produced at 8.3 meters per minute. Tensile strength was 8.60 kgf.

[0056] At **5080**, the uniformity of the fiber cross section is measured. In some embodiments, the measurement is done using laser micrometer **1900**. An exemplary laser micrometer **1900** is a Beta LaserMike diameter gauge (Beta LaserMike, 8001 Technology Blvd., Dayton, Ohio 45424, www.betalasermike.com). In some embodiments, to increase the uniformity of the fiber cross section, laser micrometer **1900** can be part of an on-line automatic feedback control system. An automatic feedback system integrated with laser micrometer **1900** can send information used to control a servo-motor system for each fiber filament, thereby controlling size and operation independently for each fiber filament.

[0057] As shown in FIG. **2**, at **5090**, fiber **1600** is fed to S wrap system **2100** in winding unit **2000** and wound onto fiber spool **2400**.

[0058] In addition to the steps described above, after extrusion, fiber **1600** can be drawn (i.e., stretched) by a variety of different methods, including without limitation: (1) spin drawing; (2) spin drawing plus solid-state drawing; and (3) continuous incremental drawing.

[0059] In spin drawing, fiber **1600** are drawn immediately after co-extrusion and wound onto a spool. This drawing method typically provides excellent sheath uniformity with no phase separation between the sheath and the core. This drawing method typically produces fiber with low molecular orientation and moderate strength.

[0060] In spin drawing plus solid-state drawing, fiber **1600** is drawn immediately after co-extrusion and wound onto a spool. Fiber **1600** is then unwound from the spool in a secondary process and drawn in the solid state with a large draw ratio. This drawing method typically produces highly oriented fiber with high strength and excellent sheath uniformity. However, phase separation between the core and sheath during the solid-state drawing step may produce defects in fiber **1600**.

[0061] In continuous incremental drawing, co-extruded fiber **1600** is continuously drawn by increasing the linear speed of each roll that fiber **1600** passes over. For example, the linear speed of a second roll will be greater than the linear speed of a first roll, thereby drawing the fiber between the second roll and the first roll. This incremental drawing process can be repeated between additional rolls and under different drawing temperatures. This drawing procedure results in a large draw ratio and high molecular orientation without a separate solid-state drawing step. This drawing method typically produces high strength fiber with excellent physical and environmental stability, excellent cross section uniformity, and no phase separation between the sheath and core of fiber **1600**.

[0062] Fiber **1600** with a wide range of dimensions can be manufactured. Table 7 presents exemplary dimensional data for 350 micron and 500 micron diameter fibers. In some cases, the standard deviation in fiber cross-section diameter is less than 2 percent of the average fiber cross-section diameter. In some cases, the standard deviation in fiber cross-section diameter is less than 0.5 percent of the average fiber cross-section diameter. The uniformity of the fiber core cross section is essentially the same as the uniformity of the entire (core+sheath) cross section because the sheath thickness is much less than the core thickness. The sheath thickness was typically 10 microns, although greater thicknesses can be used (e.g., to ensure that some release material remains if belts made from the fibers are sanded).

TABLE 7

Exemplary dimensional data

Nominal fiber dimensions (microns)	Actual Size (microns)	Roundness (microns)
350	Fiber 1 Avg: 349.3	Fiber 1 Avg: 3.9
(core w/ sheath)	StdDev: 3.2	StdDev: 1.1
Core: Polyester	Fiber 2 Avg: 351.4	Fiber 2 Avg: 2.3
(e.g., Dupont 5149 Polyester)	StdDev: 4.5	StdDev: 1.2
Sheath: THV	Fiber 3 Avg: 351.1	Fiber 3 Avg: 3.2
(e.g., Dyneon THV 815G)	StdDev: 3.8	StdDev: 1.1
	Fiber 4 Avg. 352.1	Fiber 4 Avg. 4.6
	StdDev: 3.6	StdDev: 1.3
	N = 5731 Samples	N = 5731 Samples
500	Fiber 1 Avg: 499.1	Fiber 1 Avg: 4.2
(core w/ sheath)	StdDev: 1.8	StdDev: 0.9
Core: Polyester	Fiber 2 Avg: 500.3	Fiber 2 Avg: 3.3
(e.g., Dupont 5149 Polyester)	StdDev: 1.8	StdDev: 1.3
Sheath: THV	Fiber 3 Avg: 499.4	Fiber 3 Avg: 3.3
(e.g., Dyneon THV 815G)	StdDev: 2.4	StdDev: 1.6
	Fiber 4 Avg. 500.1	Fiber 4 Avg. 3.4
	StdDev: 2.3	StdDev: 1.6
	N = 2355 Samples	N = 5731 Samples
350	Fiber 1 Avg: 358.5	Fiber 1 Avg: 11.8
(core w/ sheath)	StdDev: 26.5	StdDev: 6.0
Core: Polyester	N = 93 Samples	N = 93 Samples
(e.g., Dupont 5149 Polyester)		
Sheath: FEP		
(e.g., Dupont FEP 100)		

[0063] A plurality of fibers can be intermeshed to form a papermaking fabric (belt). The intermeshing can be done in a wide variety of ways that are well known in the art, including by weaving, knitting, or coiling. Examples of these methods are described in U.S. Pat. Nos. 6,352,772; 6,174,825; 5,776,313; and 4,239,065, the disclosures of which are hereby incorporated by reference. In some embodiments, the paper making belt made from the fibers also includes a temporary release material applied to the mesh of fibers.

[0064] The papermaking belt can be used to carry a fibrous web in at least one part of a papermaking process. The papermaking can be done in a wide variety of ways that are well known in the art. Examples of papermaking methods are described in U.S. Pat. Nos. 6,514,382; 6,248,212; 6,139,686; 3,994,771; and 3,825,381, the disclosures of which are hereby incorporated by reference.

[0065] The foregoing description, for purpose of explanation, has been described with reference to specific embodiments. However, the illustrative discussions above are not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed is:

1. A fiber for use in a papermaking belt, comprising:

an inner core and an outer sheath that are integrally formed, wherein the outer sheath:

has a thickness of at least 10 microns prior to sanding, if any, of the fiber, and

includes a release material with a melting temperature greater than the melting temperature of the inner core to facilitate the release of a paper web when the paper web is in contact with the fiber.

2. A fiber for use in a papermaking belt, comprising:

an inner core and an outer sheath, wherein the outer sheath:

has a thickness of at least 10 microns prior to sanding, if any, of the fiber, and

includes a release material to facilitate the release of a paper web when the paper web is in contact with the fiber.

3. The fiber of claim 2, wherein the core and the outer sheath are integrally formed.

4. The fiber of claim 3, wherein the core and the outer sheath are formed by co-extrusion.

5. The fiber of claim 2, wherein the thickness of the outer sheath is sufficient to allow sanding of the fiber without reaching the inner core.

6. The fiber of claim 2, wherein the release material has a melting temperature greater than the melting temperature of the inner core.

7. The fiber of claim 2, wherein the standard deviation in fiber cross-section diameter is less than 2 percent of the average fiber cross-section diameter.

8. The fiber of claim 2, wherein the standard deviation in fiber cross-section diameter is less than 0.5 percent of the average fiber cross-section diameter.

9. A method of making a fiber, comprising

forming a fiber core, and

forming an outer sheath around the fiber core, wherein the outer sheath:

has a thickness of at least 10 microns prior to sanding, if any, of the fiber, and

includes a release material to facilitate the release of a paper web when the paper web is in contact with the fiber.

10. The method of claim 9, wherein the core and the sheath are integrally formed.

11. The method of claim 9, wherein the core and the sheath are formed by coextrusion.

12. The method of claim 9, wherein there is no primer between the core and the sheath.

13. A paper making belt, comprising:

a mesh of fibers, wherein at least some of the fibers include an outer sheath integrally formed around

an inner core,

wherein the outer sheath:

has a thickness of at least 10 microns prior to sanding, if any, of the belt, and

includes a release material to facilitate the release of a fibrous web of paper when the web is in contact with the belt.

14. The paper making belt of claim 13, further including a temporary release material applied to the mesh of fibers.

15. A method, comprising:

intermeshing a plurality of fibers to form a papermaking belt,

wherein at least some fibers in the plurality of fibers include an outer sheath integrally formed around an inner core,

wherein the outer sheath:

has a thickness of at least 10 microns prior to sanding, if any, of the belt, and

includes a release material to facilitate the release of a fibrous web of paper when the web is in contact with the belt.

16. The method of claim 15, wherein the intermeshing is done by weaving, knitting, or coiling.

17. A method, comprising:

using a papermaking belt to carry a fibrous web in at least one part of a papermaking process,

wherein the belt comprises a mesh of fibers,

wherein at least some of the fibers include an outer sheath integrally formed around an inner core,

wherein the outer sheath:

has a thickness of at least 10 microns prior to sanding, if any, of the belt, and

includes a release material to facilitate the release of a fibrous web of paper when the web is in contact with the belt.

* * * * *