ROLLED TISSUE PRODUCT HAVING A FLEXIBLE CORE

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ABSTRACT

A rolled tissue product having a nonwoven tissue web wrapped or wound about a flexible core is generally provided. The flexible core is constructed of a polymeric sheet of synthetic polymers. The tissue sheet has a tensile strength in the machine direction that is weaker than the strength of the flexible core. For example, the flexible core can be at least twice as strong as the tensile strength in the machine direction of the nonwoven tissue web. The flexible core can include a nonwoven web of synthetic polymeric fibers, a polymeric film of synthetic polymers, or combinations thereof. In one embodiment, the flexible core can include a hydrophilic synthetic polymer such that the flexible core disintegrates when submerged in water. In another embodiment, the flexible core can include an elastomeric polymer that provides an elastic component to the flexible core.
ROLLED TISSUE PRODUCT HAVING A
FLEXIBLE CORE

BACKGROUND OF THE INVENTION

[0001] Commercial and consumer tissue products such as shop towels, nonwoven fabrics, wipers, toilet tissue and paper towels are often packaged, distributed, and dispensed in roll format. Most products in this format include a stiff cylindrical core at the center of the roll. Typically, the tissue product is wrapped about the core. The core is usually some type of stiff cardboard tube, plastic tube, or solid spindle which is glued to the product so that the tissue product does not separate from the core.

[0002] Recently, coreless rolls of products such as, for example, toilet tissue have appeared on the market, primarily in Europe. These coreless rolls are wound throughout the entire diameter of the roll. One example of a coreless roll has the product wound tightly around a relatively small opening in the middle. This tightly wound roll product creates a false core in the small opening, which is well defined due to the tightly wound product. However, this configuration creates several problems. First, the tissue web must have a relatively high strength in the machine direction (MD) to withstand the relatively strenuous forces exerted on the product when tightly winding such a roll. This requirement for a stronger web leads to limitations in the type of tissue product that can be utilized. Specifically, the relatively high strength product can lead to sacrifices in other desired properties of the product, particularly softness and bulk. Finally, the roll bulk of the tightly wound product is extremely low, creating a hard roll. Such a low roll bulk of the product can lead to a consumer's impression that the tissue web itself is not soft.

[0003] Another example of a coreless roll is a roll that is wound more loosely, to resemble a conventional cored product roll. This type of coreless product can create a flexible false core that allows the entire product to be flattened into an oval-like (instead of round) shape for packaging and storage. However, as the product is unwound from the roll, the false core defined by the center area of the wound product weakens, which can result in lost strength and definition. Thus, as product is removed from the roll, the roll can lose dispensing performance on a conventional dispenser.

[0004] Additionally, the inside layer of the coreless roll is subjected to frictional interactions, pressures, and other forces during the use of the coreless roll on a conventional dispenser. As such, the inside layer(s) of the coreless roll can become soiled, or even damaged, discouraging their use in the normal course.

[0005] Furthermore, the false core of the coreless roll can be difficult to locate, especially after the roll has been deformed or flattened. Thus, a user may not be able to readily locate the center (i.e., the false core) when wishing to load the roll into a dispenser. The user may even damage the inner layers attempting to locate the false core.

[0006] Accordingly, a need exists for a flexible rolled product that exhibits many of the advantages of the coreless rolled products, while avoiding certain disadvantages of the coreless rolled products.

SUMMARY OF THE INVENTION

[0007] In general, the present disclosure is directed to a rolled tissue product having a nonwoven tissue web wrapped about a flexible core. The flexible core is constructed of a polymeric sheet. The polymeric sheet may be constructed, in whole or in part, of synthetic polymers. The nonwoven tissue web and the flexible core are attached to each other at an inner layer of the nonwoven tissue web by an attachment mechanism (e.g., an adhesive, heat bonded, hydrogen bonding, etc.). The tissue sheet has a tensile strength in the machine direction that is weaker than the strength of the flexible core. For example, the flexible core can be at least twice as strong as the tensile strength in the machine direction of the nonwoven tissue web.

[0008] The flexible core can include a nonwoven web of polymeric fibers, a polymeric film of synthetic polymers, natural polymers, or combinations thereof. In one embodiment, the flexible core can include a hydrophilic synthetic polymer (e.g., a water-soluble polymer or a water-dispersible polymer) such that the flexible core disintegrates when submerged in water. In another embodiment, the flexible core can include an elastomeric polymer that provides an elastic component to the flexible core.

[0009] Other features and aspects of the present invention are discussed in greater detail below.

Definitions

[0010] “Roll Bulk” can be calculated by two different methods:

\[
\text{Roll Bulk (cc/g)} = 3.142 \times \left( \frac{\text{Roll Diameter squared (cm)} - \text{outer Core Diameter squared (cm)}}{\text{Sheet length (cm) x sheet counts x Basis Weight (g/cm²)}} \right)
\]

or

\[
\text{Roll Bulk (cc/g)} = 0.785 \times \left( \frac{\text{Roll Diameter squared (cm)} - \text{outer Core Diameter squared (cm)}}{\text{Sheet length (cm) x sheet counts x Basis Weight (g/cm²)}} \right)
\]

[0011] Tissue products can be distinguished from other paper products in terms of their bulk. For various rolled products of this invention, the single sheet bulk of the sheet on the roll can be about 5 cc/g or greater, such as about 7 cc/g or greater, such as about 8 cc/g or greater, such as from about 6 cc/g to about 24 cc/g.

[0012] Single sheet bulk is calculated by taking the single sheet caliper and dividing by the conditioned basis weight of the product. The term “caliper” as used herein is the thickness of a single tissue sheet, and may either be measured as the thickness of a single tissue sheet or as the thickness of a stack of ten tissue sheets and dividing the ten tissue sheet thickness by ten, where each sheet within the stack is placed with the same side up. Caliper is expressed in microns. Caliper is measured in accordance with TAPPI test methods T402 “Standard Conditioning and Testing Atmosphere For Paper, Board, Pulp Handsheets and Related Products” and T411 om-89 “Thickness (caliper) of Paper, Paperboard, and Combined Board” optionally with Note 3 for stacked tissue sheets. The micrometer used for carrying out T411 om-89 is a Bulk Micrometer (TMI Model 49-72-00, Amityville, N.Y.) or equivalent having an anvil diameter of 4/16 inches (103.2 millimeters) and an anvil pressure of 220 grams/square inch (3.3 g kilo Pascals).

[0013] The basis weight and bone dry basis weight of the tissue sheet specimens are determined using TAPPI T410 procedure or a modified equivalent such as: Tissue samples are conditioned at 23.00 degree C. ± 1.0 degree C. and 50.0 ± 2% relative humidity for a minimum of 4 hours. After conditioning a stack of 10-12×3" samples is cut using a die press
and associated die. This represents a tissue sheet sample area of 144 in 2 or 929 cm². Examples of suitable die presses are
TMI DGID die press manufactured by Testing Machines, Inc., Islandia, N.Y., or a Swing Beam testing machine manu-
cfured by USM Corporation, Wilmington, Mass. Die size toler-
ances are,±0.008 inches in both directions. The specimen
stock is then weighed to the nearest 0.001 gram on a tared
analytical balance. The basis weight in grams per square
meter is calculated using the following equation: Basis
weight=stock wt. in grams/0.0029.

[0014] A sheet of tissue can be defined as the material
between the adjacent lines of weakness in the continuous
sheet that comprises the rolled product. The sheet length is
defined as the distance between adjacent lines of weakness
and the sheet width as defined as the edge to edge distance
of the sheet perpendicular to the sheet length. For example,
sanitary bath products preferably have single sheet lengths of
from about 3 inches to about 8 inches, such as from about 3.25
inches to about 7 inches such as from about 3.5 inches to
about 6 inches, such as from about 3.75 inches to about 5
inches. The sanitary bath products of the present invention
preferably have sheet widths of from about 3 inches to about
6 inches, such as from about 3.25 inches to about 5 inches
such as from about 3.5 inches to about 4.75 inches.

[0015] The Basis Weight of a sheet is usually expressed in
ounces of material per square yard (osy) or grams per square
meter (gsm). (Note that to convert from osy to gsm, multiply
osy by 33.91.)

[0016] A “synthetic polymer” as defined herein refers to a
polymer which is not found as is in nature. The synthetic
polymers have been altered by a processing step to create a
polymer having physical or chemical properties unique to the
natural world via human intervention. Such polymers may or
may not be derived from materials from sustainable
resources. Sustainable resources are resources which can be
replenished on an on-going basis. Sustainable resources
include living plants and animals and in particular those
plants and animals grown under agricultural or domes-
ticated conditions. Most commonly, sustainable materials typically
are sourced from agricultural crops or similar plant based
materials. Cellulose fibers and cotton fibers are not synthetic
polymers however, rayon derived from cellulose fibers
would be considered a synthetic polymer for the purposes
of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] A full and enabling disclosure of the present inven-
tion, including the best mode thereof to one of ordinary skill
in the art, is set forth more particularly in the remainder of
the specification, including reference to the accompanying
figures in which:

[0018] FIG. 1 is a prospective view of an exemplary rolled
tissue product having a flexible core;

[0019] FIG. 2 is a prospective view of a stack of exemplary
rolled tissue products having a flexible core;

[0020] FIG. 3 is a side view of a stack of exemplary rolled
tissue products having a flexible core packaged in a pack-
aging material;

[0021] FIGS. 4A and 4B are different views of another
exemplary rolled tissue product with a flexible core having
tabs marking the core;

[0022] FIG. 5 shows a side view of an exemplary rolled
tissue product having a flexible core;

[0023] FIG. 6 shows an exemplary spindle attachment for
use with a coreless tissue product or a tissue product having
a flexible core;

[0024] FIGS. 7A and 7B depict an exemplary spindle for
use with a coreless tissue product or a tissue product having
a flexible core;

[0025] FIG. 8 is a schematic diagram of a tissue web form-
ing machine, illustrating the formation of a stratified tissue
web having multiple layers in accordance with the present
disclosure;

[0026] FIG. 9 is a schematic diagram of one embodiment of
a process for forming uncreped through-dried tissue webs for
use in the present disclosure;

[0027] FIG. 10 is a schematic diagram of one embodiment
of a process for forming wet creped tissue webs for use in the
present disclosure;

[0028] FIG. 11 shows a traditional spindle for use with
conventional toilet tissue products;

[0029] FIG. 12 is a side view of a traditional spindle in use
with a rolled tissue product;

[0030] FIG. 13 is a side view of a traditional spindle in use
with a deformed rolled tissue product;

[0031] FIGS. 14A and 14B are prospective views of an
expanding spindle;

[0032] FIGS. 15A and 15B are prospective views of an
expanding spindle having tapered end portions;

[0033] FIG. 16 is a side view of an expanding spindle
having the middle portion expanded to give shape defini-
tion to the flexible core rolled tissue product.

[0034] Repeat use of reference characters in the present
specification and drawings is intended to represent same or
analogous features or elements of the present disclosure.

DETAILED DESCRIPTION

[0035] Reference now will be made to the embodiments
of the invention, one or more examples of which are set forth
below. Each example is provided by way of an explanation
of the invention, not as a limitation of the invention. In fact, it
will be apparent to those skilled in the art that various modi-
fications and variations can be made in the invention without
departing from the scope or spirit of the invention. For
instance, features illustrated or described as one embodiment
can be used on another embodiment to yield still a further
embodiment. Thus, it is intended that the present invention
cover such modifications and variations as come within the
scope of the appended claims and their equivalents. It is to be
understood by one or ordinary skill in the art that the present
discussion is a description of exemplary embodiments only,
and is not intended as limiting the broader aspects of the
present invention, which broader aspects are embodied ex-
emplary constructions.

[0036] In general, the present disclosure is directed to a
rolled tissue product having a flexible core. The flexible core
can provide sufficient strength for the rolled tissue product
during storage, shipment, and use, while remaining flexible
primarily for packaging and storage purposes. As such, the
flexible core is constructed from a synthetic polymeric sheet
material that has a greater tensile strength than that of the
tissue product. Additionally, the synthetic polymeric material
of the flexible core can protect the inner layers of the rolled
tissue paper during use, which can allow these inner layers to
be used in the ordinary course without damage or waste that
sometimes occurs with coreless rolled tissue products.
FIG. 1 shows an exemplary rolled tissue product 100 having a flexible core 102. Tissue web 104 is rolled about the flexible core 102. As shown, the rolled tissue product 100 is flattened in one direction creating an oval-like shape to the rolled tissue product 100. Due to this flat oval-like shape, several rolled tissue products 100 can be stacked closely together for optimized packaging and storage purposes. For example, referring to FIG. 2, four rolled tissue products 100 are shown closely stacked together. As shown, the flexible core 102 of each of these rolled tissue products 100 does not have any significant space within the core. Thus, the stacked rolled tissue products 100 can be packaged closely together without wasting space, such as shown in FIG. 3. The package 106 is shown having packaging material 108 tightly wrapped around the stacked tissue products 100 which have been flattened into oval-like shapes.

The flexible core can be attached to the innermost layer of the tissue web by any method. In one particular embodiment, the tissue web is adhered to the flexible core through the use of an adhesive. Any suitable adhesive can be utilized for attaching the flexible core to the tissue web. Alternatively, the tissue web can be laminated to the flexible core via thermal bonding (heat and pressure). No matter the attachment of the tissue web to the flexible core, the attachment is strong enough to withstand the winding process during the manufacture of the rolled tissue product. Particularly, the force in the machine direction exerted on the attachment between the tissue web and the flexible core when the winding process begins can create significant strain on the attachment. If a water-soluble polymer film is used as the flexible core, the tissue web may be attached to the core by application of a small amount of water to the sheet at or near the point of attachment of the tissue sheet with the flexible core.

The tissue web can be wound onto the roll to create a rolled tissue product having a wide range of roll bulk. For example, the roll bulk of the products can be from about 4 cc/g to about 30 cc/g, such as from about 5 cc/g to about 25 cc/g, such as from about 6 cc/g to about 20 cc/g.

The flexible core can have tabs or flaps that extend beyond the edges of the rolled tissue product to allow for the flexible core to be readily located and separated in anticipation of use. For example, referring to FIGS. 4A and 4B, the rolled tissue product 100 is shown having flaps 110A and 110B located on either side of the flexible core 102. The user can open the core formed by the flexible core through the use of tabs 110A and 110B in order to insert a spindle through the flexible core for dispensing purposes. In an additional embodiment, the flexible core can be colored (e.g., by the inclusion of a pigment, dye, or other colorant within or onto the surface of the core) to provide a visual discernment of the flexible core for the user.

During use, the rolled tissue product 100 can be shaped back into a cylindrical shape having a circular orientation when viewed from the side. For example, referring to FIG. 5, the rolled tissue product 100 has been formed back into a circular shape when viewed from the side. Specifically, a user has formed both the tissue product 104 and the flexible core member 102 into a substantially circular shape when viewed from the side. As such, the tissue product 102 can be dispensed off the rolled tissue product 100 by the use of conventional spindles or particularly designed spindles (such as disclosed in further detail below).

The diameter of the inner roll can vary as desired. In one particular embodiment, the diameter can range from about 1.5 inches to about 1.75 inches, such as about 1.675 inches.

I. Flexible Core

According to the present invention, the flexible core is constructed from a flexible sheet of synthetic fibers. The flexible sheet can include a non-woven web of synthetic fibers, a woven web of synthetic fibers, a polymeric film, or combinations thereof. The use of the synthetic fibers allows for added strength to the flexible core, when compared to the tissue product constructed primarily of pulp fibers. For example, the flexible core can have a tensile strength that is greater than the tensile strength of the tissue web in the machine direction. In one embodiment, the tensile strength of the flexible core is at least twice that of the tissue web in the machine direction, such as at least five times stronger.

The use of a polymeric film allows standard production equipment to be used in manufacturing the roll. Polymeric films can be produced and delivered in form of an open end tube or sleeve. Such production methods are routinely used to make plastic bags and are well known in the art. These sleeves can be manufactured such that any diameter may be created. The sleeve may or may not have a seam in the longitudinal direction, the seam may or may not have overlap. In one embodiment, this sleeve can then be slid over a tissue winding mandrel in the same manner as traditional cores can be placed on these winding mandrels in the converting process. Thus, minimal impact on current production equipment is required.

The basis weight of the sheet(s) used to form the flexible core is relatively low when compared to traditional cardboard cores (which have a basis weight of about 390 grams per square meter). This low basis weight allows for less material needed (reducing cost and waste) as well as facilitating fluidity and general disposal of the product, while still enabling the core to protect the overlaying tissue web. Additionally, the relatively low basis weights of the core can increase the flexibility of the core. For example, the basis weight of the flexible core can be from about 5 grams per square meter (gsm) to about 150 gsm, such as from about 10 gsm to about 100 gsm. For example, the basis weight of the sheet(s) used to form the flexible core can have a basis weight of about 10 gsm to about 75 gsm. The basis weight of the flexible core can be calculated by measuring the weight of the flexible sheet material in grams and dividing by the surface area of the outer part of the flexible core under conditions of 23°C ± 1°C and 50%/± 5% relative humidity for a minimum of 4 hours. The surface area of the outer part of the flexible core can be determined by taking the circumference of the expanded core (i.e., π times diameter) and multiplying by the length of the roll. Alternatively, the flexible core can be cut along a traverse line and the area of the resulting flat sheet can be measured (length times width).

Preferably the flexible core is made from a single ply of polymeric material. If multiple plies of polymeric material are used the basis weight of the core is determined using the weight of all plies that comprise the core. This weight also includes any binder materials that are used to hold the flexible core together. The basis weight of the core does not include any adhesives that are applied to attach the tissue web to the core.
In one particular embodiment, the flexible core includes a nonwoven web including synthetic fibers. The nonwoven web can be made by any number of processes. As a practical matter, however, the nonwoven fabrics and the fibers that make up nonwoven fabrics usually will be prepared by a melt-extrusion process and formed into the nonwoven fabric. The term melt-extrusion process includes, among others, such well-known processes as meltblowing and spunbonding. Other methods for preparing nonwoven fabrics are, of course, known and may be employed. Such methods include air laying, wet laying, carding, and so forth. In some cases it may be either desirable or necessary to stabilize the nonwoven fabric by known means, such as thermal point bonding, through-air bonding, and hydroentangling. The non-woven web comprising synthetic fibers may also comprise a binder to provide strength and integrity to the web. Such binders are well known in the art. Preferably the binders are water soluble so as to facilitate the breakup of the flexible core in the web. These binders are included when calculating the basis weight of the flexible core.

As stated, the nonwoven web can primarily include synthetic fibers, particularly synthetic hydrophilic fibers, such as polyolefin fibers. In one particular embodiment, polypropylene fibers can be used to form the nonwoven web. The polypropylene fibers may have a denier per filament of about 1.5 to 2.5, and the nonwoven web may have a basis weight of about 17 grams per square meter (0.5 ounce per square yard). Furthermore, the nonwoven fabric may include bicomponent or other multicomponent fibers. Exemplary multicomponent nonwoven fabrics are described in U.S. Pat. No. 5,382,400 issued to Pike et al., U.S. Publication no. 2003/0118816 entitled “High Loft Low Density Nonwoven Fabrics Of Crimped Filaments And Methods Of Making Same” and U.S. Publication No. 2003/0203162 entitled “Methods For Making Nonwoven Materials On A Surface Having Surface Features And Nonwoven Materials Having Surface Features” which are hereby incorporated by reference herein in their entirety.

Sheath/core bicomponent fibers where the sheath is a polyolefin such as polyethylene or polypropylene and the core is polyester such as poly(ethylene terephthalate) or poly(butylene terephthalate) can also be used to produce carded fabrics or spunbonded fabrics. The primary role of the polyester core is to provide resiliency and thus to maintain or recover bulk under/after load.

In one embodiment, the nonwoven web can be combined with an additional sheet layer, such as another nonwoven web or webs, a film(s), or combinations thereof. When included as part of a laminate, the nonwoven web generally provides a more cloth-like feeling to the laminate. For example, a film-web laminate can be formed from the nonwoven web overlying a film layer. In one embodiment, for instance, the nonwoven web is thermally laminated to the film to form the film-web laminate. However, any suitable technique can be utilized to form the laminate. Suitable techniques for bonding a film to a nonwoven web are described in U.S. Pat. Nos. 5,843,057 to McCormack; 5,855,999 to McCormack; 6,002,664 to Kobylivker, et al.; 6,037,281 to Mathis, et al.; and WO 99/12734, which are incorporated herein in their entirety by reference thereto for all purposes.

In another embodiment, a film can be utilized within the flexible core, either alone or in combination with another layer, the film can be formed from a synthetic polymeric material that provides sufficient strength to the flexible core. For example, the film layer may be formed from a thin plastic film or other flexible liquid-impermeable material. In one embodiment, the film layer is formed from a polyethylene film having a thickness of from about 0.01 mm to about 0.05 mm.

The film may be formed from a polyolefin polymer, such as linear, low-density polyethylene (LLDPE) or polypropylene. Examples of polyethylene polymers include, without limitation, polymers produced from the following monomers: ethylene, propylene, 1-butene, 4-methyl-pentene, 1-hexene, 1-octene and higher olefins as well as copolymers and terpolymers of the foregoing. In addition, copolymers of ethylene and other olefins including butene, 4-methyl-pentene, hexene, heptene, octene, decene, etc., are also examples of preferably linear polyolefin polymers.

If desired, the film may also contain an elastomeric polymer. The use of an elastic polymer in the film can provide an elastic component to the flexible core, which can aid in the winding process of the rolled tissue product. For example, an elastic film can absorb some of the forces exerted on the tissue web and the attachment between the flexible core and the tissue web during the winding process, particularly at the beginning of the winding process. Any suitable elastomeric polymer can be included, such as elastomeric polyesters, elastomeric polyurethanes, elastomeric polyamides, elastomeric polyolefins, elastomeric copolymers, and so forth. Examples of elastomeric copolymers include block copolymers having the general formula A-B-A’ or A-B, wherein A and A’ are each a thermoplastic polymer endblock that contains a styrene moiety (e.g., poly(vinylcrolein)) and wherein B is an elastomeric polymer midblock, such as a conjugated diene or a lower alkene polymer (e.g., polystyrene-poly(ethylene-butylene)-polystyrene block copolymers). Also suitable are polymers composed of an A-B-A-B tetra-block copolymer, such as discussed in U.S. Pat. No. 5,332,613 to Taylor, et al., which is incorporated herein in its entirety by reference thereto for all purposes. An example of such a tetra-block copolymer is a styrene-poly(ethylene-propylene)- styrene-poly(ethylene-propylene) (“S-EP-S-EP”) block copolymer. Commercially available A-B-A’ and A-B-A-B copolymers include several different formulations from Kraton Polymers of Houston, Tex. under the trade designation KRATON®. KRATON® block copolymers are available in several different formulations, a number of which are identified in U.S. Pat. Nos. 4,663,220, 4,323,534, 4,834,738, 5,093,422 and 5,304,599, which are hereby incorporated in their entirety by reference thereto for all purposes. Other commercially available block copolymers include the S-EP-S or styrene-poly(ethylene-propylene)-styrene elastomeric copolymer available from Kuraray Company, Ltd. of Okayama, Japan, under the trade name SEPTON®.

Examples of elastomeric polyolefins include ultralow density elastomeric polypropylenes and polyethylene, such as those produced by “single-site” or “metalloocene” catalysis methods. Such elastomeric olefin polymers are commercially available from ExxonMobil Chemical Co. of Houston, Tex. under the trade designations ACHEIVE® (propylene-based), EXACT® (ethylene-based), and EXCEED® (ethylene-based). Elastomeric olefin polymers are also commercially available from DuPont Dow Elastomers, LLC (a joint venture between DuPont and the Dow Chemical Co.) under the trade designation ENGAGE® (ethylene-based) and AFFINITY® (ethylene-based). Examples of such polymers
are also described in U.S. Pat. Nos. 5,278,272 and 5,272,236
to Lai, et al., which are incorporated herein in their entirety by
reference thereto for all purposes. Also useful are certain
elastomeric polypropylenes, such as described in U.S. Pat.
Nos. 5,539,056 to Yang, et al. and 5,596,052 to Resconi, et al.,
which are incorporated herein in their entirety by reference
thereto for all purposes.

If desired, blends of two or more polymers may also
be utilized to form the film. For example, the film may be
formed from a blend of a high performance elastomer and a
lower performance elastomer. A high performance elastomer
is generally an elastomer having a low level of hysteresis,
such as less than about 75%, and in some embodiments, less
than about 60%. Likewise, a low performance elastomer is
generally an elastomer having a high level of hysteresis, such
as greater than about 75%. The hysteresis value may be deter-
dined by first elongating a sample to an ultimate elongation
of 50% and then allowing the sample to retract to an amount
where the amount of resistance is zero. Particularly suitable
high performance elastomers may include styrenic-based
block copolymers, such as described above and commercially
available from Kraton Polymers of Houston, Tex. under the
device designation KRATON®. Likewise, particularly suit-
able low performance elastomers include elastomeric poly-
olefins, such as metallocene-catalyzed polyolefins (e.g.,
single site metallocene-catalyzed linear low density polyeth-
ylene) commercially available from DuPont Dow Elas-
tomers, LLC under the trade designation AFFINITY®. In
some embodiments, the high performance elastomer may
constitute from about 25 wt. % to about 90 wt. % of
the polymer component of the film, and the low performance
elastomer may likewise constitute from about 10 wt. % to
about 75 wt. % of the polymer component of the film. Further
examples of such a high performance/low performance elastomer
blend are described in U.S. Pat. No. 6,794,024 to Wal-
ton, et al., which is incorporated herein in its entirety by
reference thereto for all purposes.

The film may constitute the entire flexible core, or
may be part of a multilayer film, as long as the total basis
weight remains relatively low. Multilayer films may be pre-
bared by cast or blown film coextrusion of the layers,
by extrusion coating, or by any conventional layering process.
In one embodiment, the laminate is consists only of two layers:
a nonwoven web and a film. For example, a stretched thin
polypropylene film having a thickness of about 0.015 mm
may be thermally laminated to a nonwoven web. On the other
hand, in some embodiments, other layers may be included in
the laminate, so long as the resulting laminate provides suf-
cient flexibility and strength. When present, the other layer
(s) of the laminate can include, nonwoven webs, films, foams,
etc.

In one particular embodiment, when the rolled tis-
sue product is used as toilet tissue, the flexible core can be
constructed either in whole or in part from a hydrophilic
synthetic polymer(s), such as water-soluble or water-dispers-
sible synthetic polymers. In most embodiments, a combination
of water-soluble and water-dispersible polymers can be uti-
lized. For example, the hydrophilic synthetic polymer can
allow the flexible core to disintegrate when submerged in
water for a period of time (e.g., up to about 5 or 6 hours, such
as from about 30 minutes to about an hour). Thus, in this
embodiment, the flexible core can be safely flushed along
with the used toilet tissue.

Any water soluble polymer may be used within the
films (either in whole or in part), including but not limited to,
polyvinyl alcohol, hydroxy propyl cellulose, methylhydroxy-
propyl cellulose, hydroxy ethylcellulose, and copolymers
and mixtures thereof. Examples of suitable water soluble
polymeric films include but is not limited to water soluble
packaging films and water soluble edible films, such as but
not limited to M-7031 and MC-1832 films, manufactured and
sold by Water-Sol, Inc; Merrillville, Ind. Another suitable
biodegradable polymer is available from BASF under the
name Ecovio I. Foam, which consists of BASF’s biodegrad-
polyester and renewable polylactide.

In another embodiment, the polymeric film is made
at least in part from a biodegradable thermoplastic preferably
made from sustainable resources. Flexible biodegradable
films are well studied in the field of flexible films; they
decompose naturally avoiding environmental problems once
they are thrown in composting areas as waste. Until recently
use of these films has been rather rare and limited to com-
pounds with low molecular weight and generally inferior
mechanical properties. Recent advances, however, have sig-
nificantly increased the availability of products with
improved properties such that biodegradable plastic films are
becoming used widely in products such as food wraps, trash
bags and other products. The biodegradable polymeric films
preferably meet or exceed the “ASTM D6400-99 Standard”
according to the “Specifications for Compostable Plastics”.
Such biodegradable films are now readily available. An
example of acceptable commercially available biodegradable
films are the starch based films used in trash bags sold under the
trade name BioBag® sold by Biogrupo USA.

Examples of suitable polymers includes, but is not
limited to, polylactic acid, thermoplastic starches, polyhy-
droalkanoate (PHA), and combinations thereof. Thermoplastic
starch or TPS consists typically consists of amorphous
amylose/amylopectin produced by extrusion in the presence
of a plasticizer such as glycerol to help make the films flexible
and ductile. They tend to be hygroscopic and for some applica-
tions may require blending with a hydrophobic polymer.
PLA/TPS blends and co-polymers are also known in the art
and are suitable for purposes of the present invention. Such
co-polymers may be made by reacting PLA with maleic anhy-
дрate and co-extruding with TPS in the presence of a peroxide
catalyst. Other methods for creating such blends are known in
the art.

In another embodiment, the film may be made from
a combination of a water soluble film such as PVA and a
water-soluble polymer from a natural source. For example,
pectin, a biodegradable polysaccharide can be blended with
poly(vinyl alcohol) (PVA), a synthetic polymer that is not
very biodegradable. Both materials are water soluble and thus
the blend is water soluble. As films, pectin/PVA blends are
more flexible than pectin alone and stronger than PVA alone.
A blend of the two increases the biodegradability of PVA
while maintaining its mechanical and solubility properties.
The ratio of pectin to PVA can be controlled to give the
strength and flexibility properties required for the material to
serve as the core material. Such approaches may be preferred
as a simpler alternative to increasing overall biodegradability
of the system.

II. Absorbent Product

Tissue products made according to the present dis-
closure may include single-ply tissue products or multiple-
ply tissue products. For instance, in one embodiment, the product may include two plies or three plies.

[0063] In general, any suitable tissue web may be processed as a rolled product having a flexible core in accordance with the present disclosure. For example, in one embodiment, the base sheet can be a tissue product, such as a bath tissue, a facial tissue, a paper towel, an industrial wiper, and the like. Tissue products typically have a bulk density of at least 3 cc/g. The tissue products can contain one or more plies and can be made from any suitable types of fiber.

[0064] Fibers suitable for making tissue webs comprise any natural or synthetic cellulosic fibers including, but not limited to nonwoody fibers, such as cotton, abaca, kenaf, sabaii grass, flax, esparto grass, straw, jute hemp, bagasse, milkweed floss fibers, and pineapple leaf fibers; and woody or pulp fibers such as those obtained from deciduous and coniferous trees, including softwood fibers, such as northern and southern softwood kraft fibers; hardwood fibers, such as eucalyptus, maple, birch, and aspen. Pulp fibers can be prepared in high-yield or low-yield forms and can be pulped in any known method, including kraft, sulfite, high-yield pulping methods and other known pulping methods. Fibers prepared from organosolv pulping methods can also be used, including the fibers and methods disclosed in U.S. Pat. No. 4,793,898, issued Dec. 27, 1988 to Lammert et al.; U.S. Pat. No. 4,594,130, issued Jun. 10, 1986 to Chang et al.; and U.S. Pat. No. 5,365,104. Useful fibers can also be produced by anthraquione pulping, exemplified by U.S. Pat. No. 5,595,628 issued Jan. 21, 1997, to Gordon et al.

[0065] A portion of the fibers, such as up to 50% or less by dry weight, or from about 5% to about 30% by dry weight, can be synthetic fibers such as rayon, polyolefin fibers, polyester fibers, bicomponent sheath-core fibers, multi-component binder fibers, and the like. An exemplary polyethylene fiber is Pulper®, available from Hercules, Inc. (Wilmington, Del.). Any known bleaching method can be used. Synthetic cellulose fiber types include rayon in all its varieties and other fibers derived from viscose or chemically-modified cellulose.

[0066] Chemically treated natural cellulosic fibers can be used such as mercerized pulps, chemically stiffened or crosslinked fibers, or sulfonated fibers. For good mechanical properties in using papermaking fibers, it can be desirable that the fibers be relatively undamaged and largely unrestrained or only lightly refined. While recycled fibers can be used, virgin fibers are generally useful for their mechanical properties and lack of contaminants. Mercerized fibers, reconstituted cellulosic fibers, cellulose produced by microbes, rayon, and other cellulosic material or cellulosic derivatives can be used. Suitable papermaking fibers can also include recycled fibers, virgin fibers, or mixes thereof. In certain embodiments capable of high bulk and good compressive properties, the fibers can have a Canadian Standard Freeness of at least 200, more specifically at least 300, more specifically still at least 400, and most specifically at least 500.

[0067] Other papermaking fibers that can be used in the present disclosure include paper broke or recycled fibers and high yield fibers. High yield pulp fibers are those papermaking fibers produced by pulping processes providing a yield of about 65% or greater, more specifically about 75% or greater, and still more specifically about 75% to about 95%. Yield is the resulting amount of processed fibers expressed as a percentage of the initial wood mass. Such pulping processes include bleached chemithermomechanical pulp (BCTMP), chemithermomechanical pulp (CTMP), pressure/pressure thermomechanical pulp (PTMP), thermomechanical pulp (TMP), thermomechanical chemical pulp (TMCP), high yield sulfite pulps, and high yield Kraft pulps, all of which leave the resulting fibers with high levels of lignin. High yield fibers are well known for their stiffness in both dry and wet states relative to typical chemically pulped fibers.

[0068] In general, any process capable of forming a paper web can also be utilized in the present disclosure. For example, a papermaking process of the present disclosure can utilize creping, wet creping, double creping, embossing, wet pressing, air pressing, through-air drying, creep through-air drying, uncropped through-air drying, hydroentangling, air laying, as well as other steps known in the art.

[0069] Also suitable for products of the present disclosure are tissue sheets that are pattern densified or imprinted, such as the tissue sheets disclosed in any of the following U.S. Pat. Nos. 4,514,345 issued on Apr. 30, 1985, to Johnson et al.; 4,528,239 issued on Jul. 9, 1985, to Trokhan; 5,098,522 issued on Mar. 24, 1992; 5,260,171 issued on Nov. 9, 1993, to Smurkosi et al.; 5,275,700 issued on Jan. 4, 1994, to Trokhan; 5,328,565 issued on Jul. 12, 1994, to Rasch et al.; 5,334,289 issued on Aug. 2, 1994, to Trokhan et al.; 5,431,786 issued on Jul. 11, 1995, to Rasch et al.; 5,496,624 issued on Mar. 5, 1996, to Stellites, Jr. et al.; 5,500,277 issued on Mar. 19, 1996, to Trokhan; 5,514,523 issued on May 7, 1996, to Trokhan et al.; 5,554,457 issued on Sep. 10, 1996, to Trokhan et al.; 5,566,724 issued on Oct. 22, 1996, to Trokhan et al.; 5,624,790 issued on Apr. 29, 1997, to Trokhan et al.; and, 5,628,876 issued on May 13, 1997, to Avers et al., the disclosures of which are incorporated herein by reference to the extent that they are non-contradictory herewith. Such imprinted tissue sheets may have a network of densified regions that have been imprinted against a drum dryer by an imprinting fabric, and regions that are relatively less densified (e.g., "domes" in the tissue sheet) corresponding to deflection conduits in the imprinting fabric, wherein the tissue sheet superposed over the deflection conduits was deflected by an air pressure differential across the deflection conduit to form a lower-density pillow-like region or dome in the tissue sheet.

[0070] The tissue web can also be formed without a substantial amount of inner fiber-to-fiber bond strength. In this regard, the fiber furnish used to form the base web can be treated with a chemical debonding agent. The debonding agent can be added to the fiber slurry during the pulping process or can be added directly to the headbox. Suitable debonding agents that may be used in the present disclosure include cationic debonding agents such as fatty dialkyln quaternary amine salts, mono fatty alkyl tertiary amine salts, primary amine salts, imidazoline quaternary salts, silicone quaternary salt and unsaturated fatty alkyl amine salts. Other suitable debonding agents are disclosed in U.S. Pat. No. 5,529,665 to Kaun which is incorporated herein by reference. In particular, Kaun discloses the use of cationic silicone compositions as debonding agents.

[0071] In one embodiment, the debonding agent used in the process of the present disclosure is an organic quaternary ammonium chloride and, particularly, a silicone-based amine salt of a quaternary ammonium chloride. For example, the debonding agent can be PROSOFT® TQ1003, marketed by the Hercules Corporation. The debonding agent can be added to the fiber slurry in an amount of from about 1 kg per metric tonne to about 10 kg per metric tonne of fibers present within the slurry.
In an alternative embodiment, the debonding agent can be an imidazoline-based agent. The imidazoline-based debonding agent can be obtained, for instance, from the Witco Corporation. The imidazoline-based debonding agent can be added in an amount of between 2.0 to about 15 kg per metric tonne.

In one embodiment, the debonding agent can be added to the fiber furnish according to a process as disclosed in PCT Application No. WO 99/34057 filed on Dec. 17, 1998 or in PCT Published Application having an International Publication No. WO 00/66835 filed on Apr. 28, 2000, which are both incorporated herein by reference. In the above publications, a process is disclosed in which a chemical additive, such as a debonding agent, is adsorbed onto cellulosic papermaking fibers at high levels. The process includes the steps of treating a fiber slurry with an excess of the chemical additive, allowing sufficient residence time for adsorption to occur, filtering the slurry to remove unadsorbed chemical additives, and redispersing the filtered pulp with fresh water prior to forming a nonwoven web.

Optional chemical additives may also be added to the aqueous papermaking furnish or to the formed embryonic web to impart additional benefits to the product and process and are not antagonistic to the intended benefits of the invention. The following materials are included as examples of additional chemicals that may be applied to the web along with the additive composition of the present invention. The chemicals are included as examples and are not intended to limit the scope of the invention. Such chemicals may be added at any point in the papermaking process.

Additional types of chemicals that may be added to the paper web include, but is not limited to, absorbency aids usually in the form of cationic, anionic, or non-ionic surfactants, humectants and plasticizers such as low molecular weight polyethylene glycols and polyhydroxy compounds such as glyc erin and propylene glycol. Materials that supply skin health benefits such as mineral oil, aloe extract, vitamin E, silicone, lotions in general and the like may also be incorporated into the finished products.

In general, the products of the present invention can be used in conjunction with any known materials and chemicals that are not antagonistic to its intended use. Examples of such materials include but are not limited to odor control agents, such as odor absorbents, activated carbon fibers and particles, baby powder, baking soda, chelating agents, zeolites, perfumes and other odor-masking agents, cyclodextrin compounds, oxidizers, and the like. Superabsorbent particles, synthetic fibers, or films may also be employed. Additional options include cationic dyes, optical brighteners, humectants, emollients, and the like.

Tissue webs that may be formed in accordance with the present disclosure may include a single homogenous layer of fibers or may include a stratified or layered construction. For instance, the tissue web may include two or three layers of fibers. Each layer may have a different fiber composition. For example, referring to FIG. 8, one embodiment of a device for forming a multi-layered stratified pulp furnish is illustrated. As shown, a three-layered headbox 10 generally includes an upper head box wall 12 and a lower head box wall 14. Headbox 10 further includes a first divider 16 and a second divider 18, which separate three fiber stock layers.

Each of the fiber layers comprise a dilute aqueous suspension of papermaking fibers. The particular fibers contained in each layer generally depends upon the product being formed and the desired results. For instance, the fiber composition of each layer may vary depending upon whether a bath tissue product, facial tissue product or paper towel is being produced. In one embodiment, for instance, middle layer 20 contains southern softwood kraft fibers either alone or in combination with other fibers such as high yield fibers. Outer layers 22 and 24, on the other hand, contain softwood fibers, such as northern softwood kraft.

In an alternative embodiment, the middle layer may contain softwood fibers for strength, while the outer layers may comprise hardwood fibers, such as eucalyptus fibers, for a perceived softness.

An endless traveling forming fabric 26, suitably supported and driven by rolls 28 and 30, receives the layered papermaking stock issuing from headbox 10. Once retained on fabric 26, the layered fiber suspension passes water through the fabric as shown by the arrows 32. Water removal is achieved by combinations of gravity, centrifugal force and vacuum suction depending on the forming configuration.

Forming multi-layered paper webs is also described and disclosed in U.S. Pat. No. 5,129,988 to Farrington, Jr., which is incorporated herein by reference.

The basis weight of tissue webs made in accordance with the present disclosure can vary depending upon the final product. For example, the process may be used to produce bath tissues, facial tissues, paper towels, industrial wipers, and the like. In general, the basis weight of the tissue products may vary from about 10 gsm to about 110 gsm, such as from about 20 gsm to about 90 gsm. For bath tissue and facial tissue, for instance, the basis weight may range from about 10 gsm to about 40 gsm. For paper towels, on the other hand, the basis weight may range from about 25 gsm to about 80 gsm.

The tissue web bulk may also vary from about 3 cc/g to 20 cc/g, such as from about 5 cc/g to 15 cc/g. The sheet “bulk” is calculated as the quotient of the caliper of a dry tissue sheet, expressed in microns, divided by the dry basis weight, expressed in grams per square meter. The resulting sheet bulk is expressed in cubic centimeters per gram. More specifically, the caliper is measured as the total thickness of a stack of ten representative sheets and dividing the total thickness of the stack by ten, where each sheet within the stack is placed with the same side up. Caliper is measured in accordance with TAPPI test method T411 om-89 “Thickness (caliper) of Paper, Paperboard, and Combined Board” with Note 3 for stacked sheets. The micrometer used for carrying out T411 om-89 is an Enveco 200-A Tissue Caliper Tester available from Enveco, Inc., Newberg, Oreg. The micrometer has a load of 2.00 kilo-Pascals (132 grams per square inch), a pressure foot area of 2500 square millimeters, a pressure foot diameter of 56.42 millimeters, a dwell time of 3 seconds and a lowering rate of 0.8 millimeters per second.

In multiple ply products, the basis weight of each tissue web present in the product can also vary. In general, the total basis weight of a multiple ply product will generally be the same as indicated above, such as from about 20 gsm to about 110 gsm. Thus, the basis weight of each ply can be from about 10 gsm to about 60 gsm, such as from about 20 gsm to about 40 gsm.

Once the aqueous suspension of fibers is formed into a tissue web, the tissue web may be processed using various techniques and methods. For example, referring to FIG. 9, shown is a method for making throughdried tissue
sheets. (For simplicity, the various tensioning rolls schematically used to define the several fabric runs are shown, but not numbered. It will be appreciated that variations from the apparatus and method illustrated in FIG. 9 can be made without departing from the general process.) Shown is a twin wire former having a papermaking headbox 34, such as a layered headbox, which injects or deposits a stream 36 of an aqueous suspension of papermaking fibers onto the forming fabric 38 positioned on a forming roll 39. The forming fabric serves to support and carry the newly-formed wet web downstream in the process as the web is partially dewatered to a consistency of about 10 dry weight percent. Additional dewatering of the wet web can be carried out, such as by vacuum suction, while the wet web is supported by the forming fabric.

[0086] The wet web is then transferred from the forming fabric to a transfer fabric 40. In one embodiment, the transfer fabric can be traveling at a slower speed than the forming fabric in order to impart increased stretch into the web. This is commonly referred to as a "rush" transfer. Preferably the transfer fabric can have a void volume that is equal to or less than that of the forming fabric. The relative speed difference between the two fabrics can be from 0-60 percent, more specifically from about 15-45 percent. Transfer is preferably carried out with the assistance of a vacuum shoe 42 such that the forming fabric and the transfer fabric simultaneously converge and diverge at the leading edge of the vacuum slot.

[0087] The web is then transferred from the transfer fabric to the throughdrying fabric 44 with the aid of a vacuum transfer roll 46 or a vacuum transfer shoe, optionally again using a fixed gap transfer as previously described. The throughdrying fabric can be traveling at about the same speed or a different speed relative to the transfer fabric. If desired, the throughdrying fabric can be run at a slower speed to further enhance stretch. Transfer can be carried out with vacuum assistance to ensure deformation of the sheet to conform to the throughdrying fabric, thus yielding desired bulk and appearance if desired. Suitable throughdrying fabrics are described in U.S. Pat. No. 5,429,686 issued to Kai F. Chiu et al. and U.S. Pat. No. 5,672,248 to Wendt et al. which are incorporated by reference.

[0088] In one embodiment, the throughdrying fabric contains high and low impression knuckles. For example, the throughdrying fabric can have about from 5 to about 300 impression knuckles per square inch which are raised at least about 0.005 inches above the plane of the fabric. During drying, the web can be macroscopically arranged to conform to the surface of the throughdrying fabric and form a three-dimensional surface. Flat surfaces, however, can also be used in the present disclosure.

[0089] The side of the web contacting the throughdrying fabric is typically referred to as the "fabric side" of the paper web. The fabric side of the paper web, as described above, may have a shape that conforms to the surface of the throughdrying fabric after the fabric is dried in the throughdrying dryer. The opposite side of the paper web, on the other hand, is typically referred to as the "air side". The air side of the web is typically smoother than the fabric side during normal throughdrying processes.

[0090] The level of vacuum used for the web transfers can be from about 3 to about 15 inches of mercury (75 to about 380 millimeters of mercury), preferably about 5 inches (125 millimeters) of mercury. The vacuum shoe (negative pressure) can be supplemented or replaced by the use of positive pressure from the opposite side of the web to blow the web onto the next fabric in addition to or as a replacement for sucking it onto the next fabric with vacuum. Also, a vacuum roll or rolls can be used to replace the vacuum shoe(s).

[0091] While supported by the throughdrying fabric, the web is finally dried to a consistency of about 94 percent or greater by the throughdrying dryer and thereafter transferred to a carrier fabric 50. The dried basesheet 52 is transported to the reel 54 using carrier fabric 50 and an optional carrier fabric 56. An optional pressurized turning roll 58 can be used to facilitate transfer of the web from carrier fabric 50 to fabric 56. Suitable carrier fabrics for this purpose are Albany International 84M or 94M and Astex 959 or 937, all of which are relatively smooth fabrics having a fine pattern. Although not shown, reel calendering or subsequent off-line calendering can be used to improve the smoothness and softness of the basesheet.

[0092] In one embodiment, the reel 54 shown in FIG. 9 can run at a speed slower than the fabric 56 in a rush transfer process for building crepe into the paper web 52. For instance, the relative speed difference between the reel and the fabric can be from about 5% to about 25% and, particularly from about 12% to about 14%. Rush transfer at the reel can occur either alone or in conjunction with a rush transfer process upstream, such as between the forming fabric and the transfer fabric.

[0093] In one embodiment, the paper web 52 is a textured web which has been dried in a three-dimensional state such that the hydrogen bonds joining fibers were substantially formed while the web was not in a flat, planar state. For instance, the web can be formed while the web is on a highly textured throughdrying fabric or other three-dimensional substrate. Processes for producing uncreped throughdried fabrics are, for instance, disclosed in U.S. Pat. No. 5,672,248 to Wendt, et al.; U.S. Pat. No. 5,656,132 to Farrington, et al.; U.S. Pat. No. 6,120,642 to Lindsay and Burzin; U.S. Pat. No. 6,096,169 to Hermans, et al.; U.S. Pat. No. 6,197,154 to Chen, et al.; and U.S. Pat. No. 6,143,135 to Hada, et al., all of which are herein incorporated by reference in their entirety.

[0094] In FIG. 9, a process is shown for producing uncreped through-air dried tissue webs. For example, referring to FIG. 10, one embodiment of a process for forming wet creped tissue webs is shown. In this embodiment, a headbox 60 emits an aqueous suspension of fibers onto a forming fabric 62 which is supported and drawn by a plurality of guide rolls 64. A vacuum box 66 is disposed beneath forming fabric 62 and is adapted to remove water from the fiber furnish to assist in forming a web. From forming fabric 62, a formed web 68 is transferred to a second fabric 70, which may be either a wire or a felt. Fabric 70 is supported for movement around a continuous path by a plurality of guide rolls 72. Also included is a pick up roll 74 designed to facilitate transfer of web 68 from fabric 62 to fabric 70.

[0095] From fabric 70, web 68, in this embodiment, is transferred to the surface of a rotatable heated dryer drum 76, such as a Yankee dryer.

[0096] In this embodiment, as web 68 is carried through a portion of the rotational path of the dryer surface, heat is imparted to the web causing most of the moisture contained within the web to be evaporated. Web 68 is then removed from dryer drum 76 by a creping blade 78. Creping web 78 as it is formed further reduces internal bonding within the web and increases softness.

[0097] Creping the tissue web as shown in FIG. 10 increases the softness of the web by breaking apart fiber-to-
fiber bonds contained within the tissue web. Applying the additive composition to the outside of the paper web, on the other hand, not only assists in creping the web but also adds dry strength, wet strength, stretchability and tear resistance to the web.

[0098] According to the process of the current disclosure, numerous and different tissue products can be formed. For instance, the tissue products may be single-ply wiper products. The products can be, for instance, facial tissues, bath tissues, paper towels, napkins, industrial wipers, and the like. As stated above, the basis weight can range anywhere from about 10 gsm to about 110 gsm.

[0099] In one embodiment, tissue webs made according to the present disclosure can be incorporated into multiple-ply products. For instance, in one embodiment, a tissue web made according to the present disclosure can be attached to one or more other tissue webs for forming a wiping product having desired characteristics. The other webs laminated to the tissue web of the present disclosure can be, for instance, a wet-creped web, a calendered web, an embossed web, a through-air dried web, a creped through-air dried web, an uncropped through-air dried web, an airlaid web, and the like.

III. Spindles and Spindle Attachments

[0100] When utilized as toilet tissue, the flexible core tissue product can be mounted on traditional spindles for dispensing. However, due to the flexibility of the core over traditional toilet tissue products (especially those having hard, cardboard cores) the flexible core tissue products may not rotate about the traditional spindle smoothly. Thus, the flexible core tissue product can be provided with a specially designed spindle or spindle attachment for dispensing purposes. For example, the flexible core tissue product can be included in a kit along with a specially designed spindle or spindle attachment.

[0101] A suitable spindle attachment can be included to mount over a traditional spindle. A traditional spindle 200 is shown in FIG. 11. The traditional spindle has a first tube 202 and a second tube 204 that are configured in a telescoping arrangement. Specifically, the second tube 204 has a slightly wider inner diameter so that the first tube 202 can slide within the inner diameter of the second tube 204. Internally, a spring (not shown) is provided within the center of the first and second tubes 202, 204 so that the tubes are biased away from each other. Thus, the length L1 of the traditional spindle can vary, but is generally designed to fit within a pair of spindle holders (not shown). The pegs 206, 208 are positioned along the ends of each tube 202, 204, respectively, to secure the traditional spindle in the spindle holder.

[0102] However, this traditional spindle 200 presents several problems when used with a flexible core tissue roll of the present invention. For example, since the flexible core may not be perfectly circular (such as shown in FIG. 5), the roll may not spin well on the spindle. Referring to FIG. 12, a traditional rolled tissue product 300 is shown having a stiff cardboard core 302. The traditional rolled tissue product 300 rests on the spindle 304 such that the axis of rotation is on the spindle, not the center of the roll. Additionally, when rotating, the axis of rotation of the roll varies as the roll bounces and moves about the spindle 304. When the traditional rolled tissue product 300 is flattened, the deformed core 302 does not rotate smoothly about the spindle 304, such as shown in FIG. 13.

[0103] This problem is especially present when there is a significant difference in the outer diameter dO and the inner diameter defined by the inner surface of the flexible core of the rolled tissue product. This difference is present in most circumstances because the traditional spindle typically has an outer diameter dO from about 0.75 inches to about 1 inch while the inner diameter defined by the inner surface of the flexible core of the rolled tissue product is typically from about 1.5 inches to about 2 inches, such as from about 1.5 inches to about 1.75 inches.

[0104] Additionally, the traditional spindle can create problems when mounting the flexible core tissue roll. For instance, the 90° angles formed by the cylindrical shape of both the first and second tubes 202, 204 and the pins 206, 208 can be difficult to insert into the flexible core of the rolled tissue product. In some instances, these sharp edges can tear or otherwise damage the flexible core member during insertion.

[0105] In order to overcome these problems associated with using the traditional spindles with the flexible core rolled tissue products of the present disclosure, the present inventors have created specially designed spindle attachments and spindles.

[0106] First, referring to FIG. 6, a spindle attachment 210 is shown. In this embodiment, the spindle attachment 210 is designed for use with a traditional spindle (such as shown in FIG. 11). As shown, the spindle attachment 210 has an inner opening 212 extending the entire length L1, of the spindle attachment 210. This inner opening is designed to accommodate insertion of a standard bath or towel spindle as well as allow the spindle to fit the so called J-hook bath tissue dispensers. J-hook dispensers typically are designed as a rod perpendicularly extending from a wall. The end of the rod furthest from the wall when perpendicularly extended is turned upwards or flared slightly. In normal use, the core is slid over the rod and the rod rotates about the rod. The upward or flared end prevents the roll from sliding off the rod during use. The inner opening 212 has an inner diameter dI that is larger than the spindle to which it is desired to be attached. In one embodiment, the inner diameter dI of the inner opening 212 ranges from about 0.75 inches to about 1.25 inches. However, the inner diameter dI does not have to closely match the outer diameter dO of the traditional spindle 200 in order to function properly.

[0107] In use, a flexible core rolled tissue product can be mounted onto the spindle attachment 210. Each of the ends of the spindle attachment 210 includes a tapered section 214 that gradually increases the width of the spindle attachment 210 from the inner diameter dI to the outer diameter dO of the middle section 216. In one particular embodiment, the tapered sections 214 have an angle of less than about 45°, such as from about 20° to about 40°. These tapered end sections 214 help a user insert the spindle attachment 210 into the flexible core of a rolled tissue product. By gradually increasing in diameter, the spindle attachment 210 can be more easily inserted into the flexible core, when compared to a traditional spindle. Additionally, the gradual increase in diameter of the tapered sections 214 can help prevent the spindle attachment 210 from damaging the flexible core of the rolled tissue product.

[0108] The middle section 216 has an outer diameter dO that is configured to closely match the inner diameter defined by the flexible core of the rolled tissue product (e.g., is less from about 0.001 inch to about 0.1 inch less than the diameter of the flexible core). For example, depending on the inner diameter of the flexible core rolled tissue product, the outer diameter dO can range from about 1.25 inches to about 2
inches, such as from about 1.5 inches to about 1.75 inches. In one particular embodiment, the outer diameter \( d_o \) can be from about 1.45 inches to about 1.6 inches. Thus, once mounted onto the spindle attachment 210, the flexible core rolled tissue product will be shaped to be substantially round by the middle section 216. As such, the flexible core rolled tissue product will rotate smoothly and properly on a traditional spindle.

Additionally, an outer coating can be applied to the outer surface of the spindle attachment 210 in order to reduce the coefficient of friction between the spindle attachment and the flexible core.

Alternatively, or additionally, the outer surface can be grooved to reduce the contact area of the spindle attachment surface and the flexible core. Thus, less frictional forces are asserted between the two when the rolled tissue product is mounted on the spindle attachment.

After mounting the flexible core rolled tissue product onto the spindle attachment 210, the spindle attachment 210 can then be mounted onto a traditional spindle (such as the traditional spindle 200 shown in FIG. 11). The overall length \( l_{sp} \) of the spindle attachment 210 is less than that of the traditional spindle 200, such that the spindle attachment 210 can be mounted onto a traditional spindle while still allowing the traditional spindle to be mounted onto the mounting brackets.

In one embodiment, at least one spindle attachment 210 and at least one flexible core rolled tissue product can be included within a kit. By packaging the spindle attachment 210 together with the flexible core rolled tissue product, the outer diameter \( d_o \) of middle section 216 on the spindle attachment 210 can be uniquely matched to the inner diameter defined by the inner surface of the flexible core on the rolled tissue product. For example, the outer diameter \( d_o \) of the spindle attachment 210 can from about 0.1% to about 5% smaller (in diameter) than the inner diameter defined by the inner surface of the flexible core in the kit.

Although the spindle attachment 210 is shown for use with a traditional spindle, a spindle replacement can be designed having a similar overall design. For example, the spindle replacement can have substantially the same outer appearance (e.g., tapered ends and a larger middle portion), but can be provided with outer pegs for use in traditional mounting brackets (instead of having openings in each end). In this embodiment, the spindle replacement can be separated into two pieces and telescopically arranged with a spring internally positioned, as described with respect to FIG. 11.

In another embodiment, the flexible core rolled tissue product can be provided in a kit with a spindle replacement that is designed to overcome the problems associated with the traditional spindle 200. For example, referring to FIGS. 7A and 7B, an armed spindle 220 is shown. The armed spindle 220 can be used in place of a traditional spindle. The armed spindle 220 is shown having four arms \( 222a-222d \) that are connected on each end by pegs \( 224a, 224b \). Each arm \( 222a-222d \) is tapered on the end portions of the arm. Thus, each arm \( 222a-222d \) gradually increases in distance away from the axis X defined through the center of each peg \( 224a, 224b \). Due to this tapered increase in diameter (i.e., distance away from the axis X defined through the center of each peg \( 224a, 224b \)), the armed spindle 220 can be more easily slid into a flexible core of a rolled tissue product, when compared to a traditional spindle.

Additionally, the arms \( 222a-222d \) of the armed spindle 220 can be configured such that they can be interchanged between a substantially flat orientation and a rotating position having each arm spaced apart in a substantially equal distance. For example, referring to FIG. 7A, the arms \( 222a-222d \) can be oriented in a cross-like shape, such that each arm is substantially equally spaced apart from each other. This cross-like shape can help give the flexible core of the rolled tissue product definition during use. Thus, the rolled tissue product can spin more smoothly once mounted on the armed spindle 220 and the spindle is oriented in a cross-like shape.

On the other hand, the arms \( 222a-222d \) of the armed spindle 220 can be laid substantially flat to facilitate the insertion of the armed spindle 220 into the flexible core of the rolled tissue product, such as shown in FIG. 7B. In this orientation, the armed spindle 220 can more closely resemble the substantially linear shape of the flexible core of the rolled tissue product after it is removed from its packaging. As such, the arms \( 222a-222d \) of the armed spindle 220 can be more easily inserted into the flexible core. After being inserted into the flexible core, the arms \( 222a-222d \) of the armed spindle 220 can be rotated to the cross-like orientation shown in FIG. 7A and described above.

Rotation between the substantially flat orientation and the cross-like orientation can be accomplished according to any method. For example, in the shown embodiments, oppositely positioned arms move in concert with each other but independent of their neighboring arms. Referring to FIGS. 7A and 7B, arms \( 222a \) and \( 222c \) move in concert with each other, but independently from arms \( 222b \) and \( 222d \). The opposite is also true: arms \( 222b \) and \( 222d \) move in concert with each other, but independently from arms \( 222a \) and \( 222c \).

Although the embodiment shown in FIGS. 7A and 7B includes 4 arms \( 222a-222d \) on the armed spindle 220, any number of arms can be included within the scope of the present disclosure. For example, the armed spindle 220 can have from 4 arms to 8 arms. In one particular embodiment, the armed spindle 220 can have 6 arms. Likewise, the armed spindle can have as few as 3 arms. Thus, any reasonable number of arms (at least 3) can be used. Additionally, the armed spindle can be provided with an outer surface (not shown) that conceals the inner arms positioned within the construction of the spindle.

Alternatively, the spindle replacement can increase its width upon compression of the ends toward the middle. For example, referring to FIGS. 14A and 14B, an expanding spindle replacement 310 is generally shown. Upon compression of the end portions 312a, 312b towards each other, the middle portion 314 expands. By expanding the middle portion 314, the flexible core (and thus the entire flexible core rolled tissue product) can be given shape definition. For example, the middle portion 314 can be designed to expand to within 5% of the inner diameter of the flexible core. This compression can allow the replacement spindle to be inserted into the flexible core when expanded to have a smaller diameter \( d_{cor} \), but at the length of the spindle holder \( l_{sp} \), have a diameter \( d_{cor} \) that gives shape definition to the flexible core. In this embodiment, the expanding spindle can rotate with the rolled tissue product, instead of being stationary on the holder during use.

In one embodiment, the expanding spindle can have two tapered end portions 320a, 320b that are engaged to the expanding middle pieces 322a, 322b. When compressed towards each other (to the length of the spindle holder—typically 5 and ½ inches), each tapered end portion moves between the middle pieces 322a, 322b separating them far-
Ther apart. Thus, the expanded middle portions 320a, 320b
give shape definition to the flexible core 322. Although the
expanding spindle is shown using tapered end portions in this
embodiment, any method of expanding the middle portion
can be utilized. For example, the middle portion can be
expanded using an air pocket or bladder, a spring loaded
system, etc.

[0121] These other modifications and variations to the
present invention may be practiced by those of ordinary skill
in the art, without departing from the spirit and scope of the
present invention, which is more particularly set forth in the
appended claims. In addition, it should be understood that
aspects of the various embodiments may be interchanged
both in whole or in part. Furthermore, those of ordinary skill
in the art will appreciate that the foregoing description is by
way of example only, and is not intended to limit the invention
so further described in such appended claims.

What is claimed:

1. A rolled tissue product comprising:
a flexible core comprising a polymeric sheet of synthetic
polymers, wherein the flexible core has a strength; and
a nonwoven tissue web comprising pulp fibers wound
about the flexible core to form the rolled tissue product,
wherein the nonwoven tissue web and the flexible core
are attached to each other at an inner layer of the non-
woven tissue web by an attachment mechanism, and
wherein the tissue sheet defines a machine direction, the
tissue sheet having a tensile strength in the machine
direction that is weaker than the strength of the flexible
core.

2. A rolled tissue product as in claim 1, wherein the flexible
core comprises a nonwoven web of synthetic polymeric
fibers.

3. A rolled tissue product as in claim 1, wherein the flexible
core comprises a polymeric film of synthetic polymers.

4. A rolled tissue product as in claim 1, wherein the flexible
core comprises a hydrophilic synthetic polymer such that the
flexible core disintegrates when submerged in water.

5. A rolled tissue product as in claim 4, wherein the hydro-
philic synthetic polymer comprises a water-soluble polymer.

6. A rolled tissue product as in claim 5, wherein the water-
soluble synthetic polymer comprises polyvinyl alcohol,
hydroxy propyl cellulose, methylhydroxypropyl cellulose,
hydroxy ethyloehullulose, and copolymers and mixtures
thereof.

7. A rolled tissue product as in claim 1, wherein the flexible
core comprises an elastomeric polymer that provides an elas-
tic component to the flexible core.

8. A rolled tissue product as in claim 1, wherein the syn-
thetic polymer comprises a biodegradable polymer.

9. A rolled tissue product comprising:
a flexible core consisting essentially of a polymeric sheet of
synthetic polymers, wherein the flexible core has a
strength; and
a nonwoven tissue web comprising pulp fibers wrapped
about the flexible core to form the rolled tissue product,
wherein the nonwoven tissue web and the flexible core
are attached to each other at an inner layer of the non-
woven tissue web by an attachment mechanism, and
wherein the tissue sheet defines a machine direction, the
tissue sheet having a tensile strength in the machine
direction that is weaker than the strength of the flexible
core.

10. A rolled tissue product as in claim 9, wherein the flexible
core consists essentially of a nonwoven web of syn-
thetic polymeric fibers.

11. A rolled tissue product as in claim 9, wherein the flexible
core consists essentially of an elastomeric polymeric
film of elastic synthetic polymers.

12. A rolled tissue product as in claim 9, wherein the flexible
core comprises a hydrophilic synthetic polymer such that the
flexible core disintegrates when submerged in water.

13. A rolled tissue product as in claim 12, wherein the
hydrophilic synthetic polymer comprises a water-soluble
polymer.

14. A rolled tissue product as in claim 13, wherein the
water-soluble synthetic polymer comprises polyvinyl alco-
hol, hydroxy propyl cellulose, methylhydroxypropyl cellulose,
hydroxy ethylcellulose, and copolymers and mixtures
thereof.

15. A rolled tissue product as in claim 9, wherein the flexible
core comprises an elastomeric polymer that provides an elas-
tic component to the flexible core.

16. A rolled tissue product as in claim 9, wherein the
synthetic polymer comprises a biodegradable polymer.

17. A rolled tissue product comprising:
a flexible core comprising an elastomeric polymeric sheet
of elastic synthetic polymers, wherein the flexible core
has a strength; and
a nonwoven tissue web comprising pulp fibers wrapped
about the flexible core to form the rolled tissue product,
wherein the nonwoven tissue web and the flexible core
are attached to each other at an inner layer of the non-
woven tissue web by an attachment mechanism, and
wherein the tissue sheet defines a machine direction, the
tissue sheet having a tensile strength in the machine
direction that is weaker than the strength of the flexible
core.

18. A rolled tissue product as in claim 17, wherein flexible
core is at least twice as strong as the tensile strength in the
machine direction of the nonwoven tissue web.

19. A rolled tissue product comprising:
a flexible core comprising a polymeric sheet of a hydro-
philic synthetic polymer such that the flexible core dis-
integrates when submerged in water, wherein the flex-
ible core has a strength; and
a nonwoven tissue web comprising pulp fibers wrapped
about the flexible core to form the rolled tissue product,
wherein the nonwoven tissue web and the flexible core
are attached to each other at an inner layer of the non-
woven tissue web by an attachment mechanism, and
wherein the tissue sheet defines a machine direction, the
tissue sheet having a tensile strength in the machine
direction that is weaker than the strength of the flexible
core.

20. A rolled tissue product as in claim 19, wherein the
hydrophilic synthetic polymer comprises a water-soluble
polymer.

21. A rolled tissue product as in claim 19, wherein the
polymeric sheet comprises a combination of a hydrophilic
synthetic polymer and such as PVA and a water-soluble
polymer from a natural source.

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