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(54) Title: NONWOVEN WEBS WITH ENHANCED SOFTNESS AND PROCESS FOR FORMING SUCH WEBS
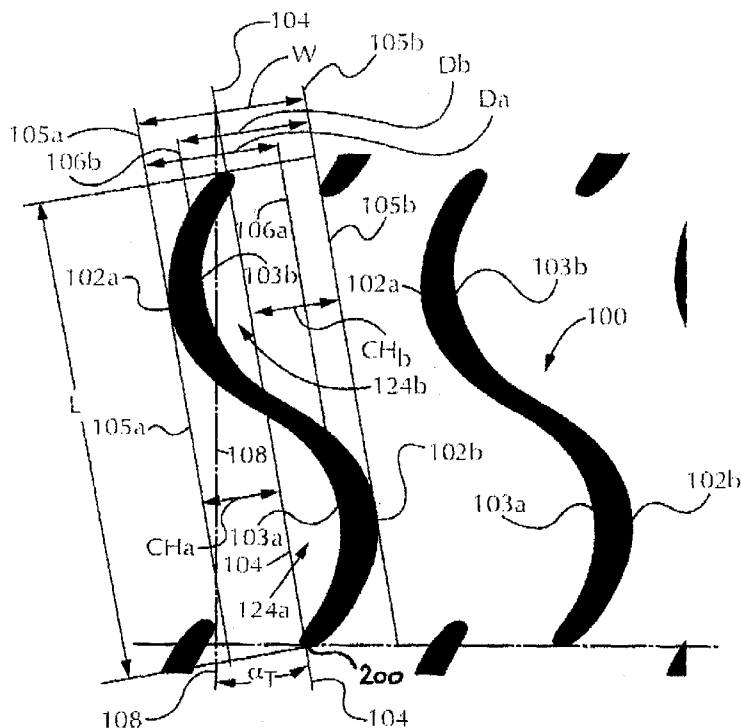
(57) **Abstract**: A nonwoven web comprising heat bondable fibres and comprising a plurality of calendering bonds having a bond shape; characterized in that said heat bondable fibres comprise propylene copolymer and softness enhanced additive and polypropylene, wherein the plurality of calendering bonds having a bond shape forms a regular pattern and wherein said bond shapes have a greatest measurable length and a greatest measurable width, wherein an aspect ratio of the greatest measurable length to the greatest measurable width is at least 2.5. A method for forming such webs is defined as well.

Fig. 4B

WO 2014/044235 A1

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

NONWOVEN WEBS WITH ENHANCED SOFTNESS
AND PROCESS FOR FORMING SUCH WEBS

FIELD OF THE INVENTION

The present invention relates to a method of producing a nonwoven web material exhibiting improved properties as well as to such a nonwoven material. Such a material may be useful for a number of applications, such as cleaning articles, like wipes or dusters, or in particular for disposable articles, such as disposable absorbent articles.

BACKGROUND OF THE INVENTION

It is well known in the industry that the final properties of nonwoven webs can be significantly influenced by used resins. Each homopolymer has its specific features and commonly used possibility to prepare various copolymers brings wide scale of new features and its combinations. Assuming combination of propylene and other olefin only there are many various copolymers described in literature and various commercial grades present on the market. It is believed that blending suitable resins together can easily bring attractive features combinations as well. Combining propylene homopolymer with propylene copolymer to reach softness is described for example in United States Patent US 6,342,565 from ExxonMobile or United States Application US2005/0215964 from Procter and Gamble. Both of them focus mainly on elastic features of final web and softness is mentioned as an extra property. Due to processing reasons both of them describes addition of process oil or slip agent that are necessary to prepare individual filaments in one spunmelt processing step.

It is well known in the industry that the final properties of thermally bonded nonwoven webs can be significantly influenced by an appropriate pattern of bonding points or bonding impressions expressed particularly by the shape and the size of the bond impression as well as the total bond area, and their arrangement in the plane such as in a certain pattern. By selecting appropriate parameters for the pattern, it is possible with the use of the same input material to, for example, produce both a strong compact web resistant against rubbing, as well as a lofty web with an increased softness. There are several methods known in the industry of how to achieve specifically softness and loft of the final material.

One of the ways is to create a web with a so-called 3D-structure, as described for example in documents US4333979 published in 1982 or JP2004113489 published in 2004. In both cases a pair of patterned rollers is used to bond the webs. The achieved thickness and structure of the resulting material are, however, not suitable for all applications.

Another known way is to limit the total bond area of material and to increase the share of so-called loose fibres. In this way it is possible to produce a soft lofty material, however at the cost of a significant loss in strength. For this reason focus goes to the shape of individual bonding points, which may increase the strength of the material.

For example document WO0004215 published in 2000 uses rectangular bonding points oriented with their longer side in the CD direction, where the importance of CD oriented lines is stressed, forming an angle of 45° with the CD direction, which do not contain any bonding points. The total bonding area represents approximately 20%.

Another strategy is demonstrated for example in document WO9411186 published in 1994, where the bonding points form the perimeter of regular hexagons arranged in a structure similar to a honeycomb. According to the description, this achieves an increased feeling of comfort when in contact with human skin.

Another document WO1999/014415, published in 1999, describes elongated lightly bent (sagging) bonding points forming an angle with the MD direction of approx. 45°, where the orientation of the points regularly changes and forms a structure remotely resembling a woven textile. According to the description, this pattern increases the softness of the resulting web.

The elongated bonding points together with convex borders of bonding points combine for example document WO2008/129138 published in 2008, where individual bonding points have the shape of oval perimeter. The orientation of longer axe regularly varies MD and CD direction. According to the description it improves the abrasion resistance without compromising softness and drapeability.

A particular application area of nonwoven webs is in the area of absorbent articles, such as disposable diapers, training pants, adult incontinence undergarments, feminine hygiene products, breast pads, care mats, bibs, wound dressing products, and the like. Manufacturers of such articles must continually strive to enhance their products in ways that serve to differentiate them from those of their competitors, while at the same time controlling costs so as to enable competitive pricing and the offering to the market of an attractive value-to-price proposition.

One way in which some manufacturers may seek to enhance such products is through enhancements to softness.

It is believed that humans' perceptions of softness of a nonwoven web material can be affected by tactile signals, auditory signals and visual signals.

Tactile softness signals may be affected by a variety of the material's features and properties that have effect on its tactile feel, including but not limited to loft, fiber thickness and density, basis weight, microscopic pliability and flexibility of individual fibers, macroscopic pliability and flexibility of the nonwoven web as formed by the fibers, surface friction characteristics, number of loose fibers or free fiber ends, and other features.

Perceptions of softness also may be affected by auditory signals, e.g., whether and to what extent the material makes audible rustling, crinkling or other noises when touched or manipulated.

It is believed that perceptions of softness of a material also may be affected by visual signals, i.e., its visual appearance. It is believed that, if a nonwoven material looks relatively soft to a person, it is much more likely that the person will perceive it as having relative tactile softness as well. Visual impressions of softness may be affected by a variety of features and

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properties, including but not limited to color, opacity, light reflectivity, refractivity or absorption, as well as to the loft, which in turn may be impacted by apparent thickness/caliper, fiber size and density, and macroscopic physical surface features.

As a result of the complexity of the mix of the above-described characteristics, to the extent softness is considered an attribute of a nonwoven web material, it may elude precise measurement or quantification. Although several methods for measuring and evaluating material features that are believed to affect softness signals have been developed, there are no standard, universally accepted units or methods of measurement for softness. It is a subjective, relative concept, difficult to characterize in an objective way. Because softness is difficult to characterize, it can also be difficult to affect in a predictable way, through changes or adjustments to specifications in materials or manufacturing processes.

Complicating efforts to define and enhance softness is the fact that differing individuals will have differing individual physiological and experiential frames of reference and perceptions concerning what material features and properties will cause them to perceive softness to a lesser or greater extent in a material, and relative other materials.

Loft in nonwovens may have importance for reasons in addition to or other than creating an impression of softness. In some applications, nonwovens may be used as components of cleaning articles, such as wipes or dusters. Improving loft of such a nonwoven can also improve its efficacy as a cleaning element. In another particular application, a nonwoven may be used to form the loops component of a hook-and-loop fastening system. Improving loft of such a nonwoven can improve its suitability for this purpose.

Various efforts have been made to provide or alter features of nonwoven web materials with the objective of enhancing loft and/or consumer perceptions of softness. These efforts have included selection and/or manipulation of fiber chemistry, basis weight, loft, fiber density, configuration and size, tinting and/or opacifying, embossing or bonding in various patterns, etc.

For example, one approach to enhancing perceived softness of a nonwoven web has involved simply increasing the basis weight of the web, otherwise manufactured through a spunlaid/spunbond process that includes formation of a batt of loose spun fibers and then consolidating by calender-bonding in a pattern. All other variables remaining constant, increasing the basis weight of such a web will have the effect of increasing the number of fibers per unit surface area, and correspondingly, increasing apparent thickness, fiber density and/or loft. This approach might be deemed effective if the only objective is increasing depth and/or loft signals affecting perceptions of softness, i.e., simply increasing the basis weight of a spunbond nonwoven is one way to increase its depth or loft. However, among the costs involved in producing nonwoven web material formed of polymer fibers is the cost of the polymer resin(s) from which the fibers are spun. Higher basis weight nonwovens require more resin to produce, and therefore, cost more per unit. Thus, attempting to enhance loft and/or perceived softness by increasing nonwoven basis weight is incompatible with the ever-present objective of controlling or reducing costs.

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Another approach has involved forming a nonwoven web of "bicomponent" polymer fibers, by spinning such fibers, laying them to form a batt and then consolidating them by calender-bonding with a pattern, selected to provide visual effects. Such bicomponent polymer fibers may be formed by spinnerets that have two adjacent sections, that express a first polymer 5 from one and a second polymer from the other, to form a fiber having a cross section of the first polymer in one portion and the second polymer in the other (hence the term "bicomponent"). The respective polymers may be selected so as to have differing melting temperatures and/or expansion-contraction rates. These differing attributes of the two polymers, when combined in a side by side or asymmetric sheath-core geometry cause the bicomponent fiber products to curl in 10 the spinning process, as they are cooled and drawn from the spinnerets. The resulting curled fibers then may be laid down in a batt and calender-bonded in a pattern. It is thought that the curl in the fibers adds loft and fluff to the web, enhancing visual and tactile softness signals.

Still another approach has involved subjecting the web to a hydroenhancing or hydroengorgement process following calender-bonding, to fluff the fibers and increase caliper 15 and loft. It is believed that the hydroenhancing/hydroengorgement process increases loft and caliper in a manner that enhances visual and tactile softness signals.

The approaches described above and others have had varying degrees of success, but have left room for improvement in enhancing loft and visual and/or tactile softness signals. Additionally, many current methods for enhancing softness signals in a nonwoven web have the 20 undesirable effect of decreasing desirable mechanical properties such as tensile strength, and may also add cost to the web manufacturing process in the form of additional materials or additional equipment and energy required for processing steps.

The challenge to improve loft and/or softness becomes more difficult as nonwoven web basis weight is reduced, because, as basis weight is reduced, fewer fibers per unit surface area are 25 available to contribute to loft and opacity of the web.

SUMMARY OF THE INVENTION

The above mentioned drawbacks are eliminated or significantly reduced by the invention defined in the independent claims, preferred embodiments are defined in the dependent claims.

30 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a simplified schematic view of a batt moving through the nip between calender rollers to form a calender-bonded nonwoven web;

Fig. 2A is a view of a pattern of bonding surface shapes of bonding protrusions that may be imparted to the surface of a calender roller, to create a corresponding pattern of consolidating 35 bond impressions having bond shapes in a nonwoven web;

Fig. 2B is a view of another pattern of bonding surface shapes of bonding protrusions that may be imparted to the surface of a calender roller, to create another corresponding pattern of consolidating bond impressions having bond shapes in a nonwoven web;

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Fig. 2C is a magnified view of the pattern of bonding surface shapes of bonding protrusions or consolidating bond impressions having bond shapes appearing in Fig. 2B;

Fig. 3A is a view of another pattern of bonding surface shapes of bonding protrusions that may be imparted to the surface of a calender roller, to create another corresponding pattern of consolidating bond impressions having bond shapes in a nonwoven web;

Fig. 3B is a magnified view of the pattern of bonding surface shapes of bonding protrusions or consolidating bond impressions having bond shapes appearing in Fig. 3A;

Fig. 3C is a magnified view of the pattern of bonding surface shapes of bonding protrusions or consolidated bond impressions having bonding impressions appearing in Fig. 4A;

Fig. 4A is a view of another pattern of bonding surface shapes of bonding protrusions that may be imparted to the surface of a calender roller, to create another corresponding pattern of consolidated bond impressions having bond shapes in a nonwoven web; and

Fig. 4B is a magnified view of the pattern of bonding surface shapes of bonding protrusions or consolidating bond impressions having bond shapes appearing in Fig. 4A.

Fig. 5 is a magnified view of the other pattern of bonding surface shapes of bonding protrusions or consolidating bond impressions that may be imparted to the surface of a calender roller, to create another corresponding pattern of consolidated bond impressions having bond shapes in a nonwoven web.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Definitions

"Absorbent article" refers to devices that absorb and contain body exudates, and, more specifically, refers to devices that are placed against or in proximity to the body of the wearer to absorb and contain the various exudates discharged from the body. Absorbent articles may include diapers, training pants, adult incontinence undergarments and pads, feminine hygiene pads, breast pads, care mats, bibs, wound dressing products, and the like. As used herein, the term "exudates" includes, but is not limited to, urine, blood, vaginal discharges, breast milk, sweat and fecal matter.

A "batt" is used herein to refer to fiber materials prior to being consolidated in a final calendering process as described herein. A "batt" comprises individual fibers, which are usually unbonded to each other, although a certain amount of pre-bonding between fibers may be performed and is also included in the meaning, such as may occur during or shortly after the lay-down of fibers in a spunlaying process, or as may be achieved be a pre-calendering. This pre-bonding, however, still permits a substantial number of the fibers to be freely moveable such that they can be repositioned. A "batt" may comprise several strata, such as may result from depositing fibers from several beams in a spunlaying process.

"Bicomponent" refers to fiber having a cross-section comprising two discrete polymer components, two discrete blends of polymer components, or one discrete polymer component and one discrete blend of polymer components. "Bicomponent fiber" is encompassed within the term

"multicomponent fiber." A Bicomponent fiber may have an overall cross section divided into two or more subsections of the differing components of any shape or arrangement, including, for example, coaxial subsections, core-and-sheath subsections, side-by-side subsections, radial subsections, etc.

5   "Bond area percentage" on a nonwoven web is a ratio of area occupied by bond impressions, to the total surface area of the web, expressed as a percentage, and measured according to the Bond Area Percentage Method set forth herein.

"Bonding roller," "calender roller" and "roller" are used interchangeably.

A "bond impression" in a nonwoven web is the surface structure created by the 10   impression of a bonding protrusion on a calender roller into a nonwoven web. A bond impression is a location of deformed, intermeshed or entangled, and melted or thermally fused, materials from fibers superimposed and compressed in a z-direction beneath the bonding protrusion, which form a bond. The individual bonds may be connected in the nonwoven structure by loose fibres between them. The shape and size of the bond impression 15   approximately corresponds to the shape and size of the bonding surface of a bonding protrusion on the calender roller.

A "column" of bonds on a nonwoven web is a group of nearest neighboring bonds of like shape and rotational orientation that are arranged along the line that extends most predominately in the machine direction.

20   "Cross direction"(CD) – with respect to the making of a nonwoven web material and the nonwoven web material, refers to the direction along the web material substantially perpendicular to the direction of forward travel of the web material through the manufacturing line in which the web material is manufactured. With respect to a batt moving through the nip of a pair of calender rollers to form a bonded nonwoven web, the cross direction is perpendicular to the direction of 25   movement through the nip, and parallel to the nip.

"Disposable" is used in its ordinary sense to mean an article that is disposed or discarded after a limited number of usage events over varying lengths of time, for example, less than about 20 events, less than about 10 events, less than about 5 events, or less than about 2 events.

"Diaper" refers to an absorbent article generally worn by infants and incontinent persons 30   about the lower torso so as to encircle the waist and legs of the wearer and that is specifically adapted to receive and contain urinary and fecal waste. As used herein, term "diaper" also includes "pant" which is defined below.

"Fiber" and "filament" are used interchangeably.

"Fiber diameter" is expressed in units of μm. The terms "grams of fiber per 9000 m" 35   (denier or den) or "grams of fiber per 10000 m" (dTex) are used to describe the fineness or coarseness of fibers, which are linked to the diameter (when assumed to be circular) by the density of the employed material(s).

"Film" – means a skin-like or membrane-like layer of material formed of one or more polymers, which does not have a form consisting predominately of a web-like structure of consolidated polymer fibers and/or other fibers.

"Length" or a form thereof, with respect to a diaper or training pant, refers to a dimension measured along a direction perpendicular to the waist edges and/or parallel to the longitudinal axis.

"Machine direction" (MD) – with respect to the making of a nonwoven web material and the nonwoven web material, refers to the direction along the web material substantially parallel to the direction of forward travel of the web material through the manufacturing line in which the web material is manufactured. With respect to a nonwoven batt moving through the nip of a pair of calender rollers to form a bonded nonwoven web, the machine direction is parallel to the direction of movement through the nip, and perpendicular to the nip.

"Monocomponent" refers to fiber formed of a single polymer component or single blend of polymer components, as distinguished from bicomponent or multicomponent fiber.

"Multicomponent" refers to fiber having a cross-section comprising more than one discrete polymer component, more than one discrete blend of polymer components, or at least one discrete polymer component and at least one discrete blend of polymer components. "Multicomponent fiber" includes, but is not limited to, "bicomponent fiber." A multicomponent fiber may have an overall cross section divided into subsections of the differing components of any shape or arrangement, including, for example, coaxial subsections, core-and-sheath subsections, side-by-side subsections, radial subsections, islands-in-the-sea, etc.

A "nonwoven" is a manufactured sheet or web of directionally or randomly oriented fibers which are first formed into a batt and then consolidated and bonded together by friction, cohesion, adhesion or one or more patterns of bonds and bond impressions created through localized compression and/or application of pressure, heat, ultrasonic, or heating energy, or a combination thereof. The term does not include fabrics which are woven, knitted, or stitch-bonded with yarns or filaments. The fibers may be of natural or man-made origin and may be staple or continuous filaments or be formed in situ. Commercially available fibers have diameters ranging from less than about 0.001 mm to more than about 0.2 mm and they come in several different forms: short fibers (known as staple, or chopped), continuous single fibers (filaments or monofilaments), untwisted bundles of continuous filaments (tow), and twisted bundles of continuous filaments (yarn). Nonwoven fabrics can be formed by many processes including but not limited to meltblowing, spunbonding, spunmelting, solvent spinning, electrospinning, carding, film fibrillation, melt-film fibrillation, airlaying, dry-laying, wetlaying with staple fibers, and combinations of these processes as known in the art. The basis weight of nonwoven fabrics is usually expressed in grams per square meter (gsm).

"Pant" or "training pant", as used herein, refer to disposable garments having a waist opening and leg openings designed for infant or adult wearers.

When used as an adjective in connection with a component of a material, the term "predominately" means that the component makes up greater than 50% by weight of the material. When used as an adjective in connection with a directional orientation of a physical feature or geometric attribute thereof, "predominately" means the feature or attribute has a projection onto a line extending along the direction indicated, greater in length than the projection onto a line perpendicular thereto. Within other context, the term "predominantly" refers to a condition which imparts a substantial effect on a property or feature. Thus, when a material comprises "predominantly" a component said to impart a property, this component imparts a property that the material otherwise would not exhibit. For example, if a material comprises "predominantly" heat-fusible fibers, the quantity and components of these fibers must be sufficient to allow heat fusion of the fibers.

A "bonding protrusion" or "protrusion" is a feature of a bonding roller at its radially outermost portion, surrounded by recessed areas. Relative the rotational axis of the bonding roller, a bonding protrusion has a radially outermost bonding surface with a bonding surface shape and a bonding surface shape area, which generally lies along an outer cylindrical surface with a substantially constant radius from the bonding roller rotational axis; however, protrusions having bonding surfaces of discrete and separate shapes are often small enough relative the radius of the bonding roller that the bonding surface may appear flat/planar; and the bonding surface shape area is closely approximated by a planar area of the same shape. A bonding protrusion may have sides that are perpendicular to the bonding surface, although usually the sides have an angled slope, such that the cross section of the base of a bonding protrusion is larger than its bonding surface. A plurality of bonding protrusions may be arranged on a calender roller in a pattern. The plurality of bonding protrusions has a bonding area per unit surface area of the outer cylindrical surface which can be expressed as a percentage, and is the ratio of the combined total of the bonding shape areas of the protrusions within the unit, to the total surface area of the unit.

A "row" of bonds on a nonwoven web is group of bonds of like shape and rotational orientation that are arranged along the line that extends most predominately in the cross direction.

"Tensile Strength" refers to the maximum tensile force (Peak Force) a material will sustain before tensile failure, as measured by the Tensile Strength Measurement Method set forth herein.

"Thickness" and "caliper" are used herein interchangeably.

"Volume mass"
is the ratio of basis weight and thickness and indicates the bulkiness and fluffiness of the product, which are important properties of the nonwoven web according to the invention. The lower the value, the bulkier is the web.

Volume mass [kg/m^3]= basis weight [g/m^2] / thickness [mm].

"Width" or a form thereof, with respect to a diaper or training pant, refers to a dimension measured along a direction parallel to the waist edges and/or perpendicular to the longitudinal axis.

"Z-direction," with respect to a web, means generally orthogonal or perpendicular to the plane approximated by the web along the machine and cross direction dimensions.

Nonwovens according to the present invention may be used for the topsheet, backsheet outer layer, loops component in a hook-and-loop fastening system of an absorbent article, or any other portion of a manufactured article such as cleansing wipes and other personal hygiene products, dusters and dusting cloths, household cleaning cloths and wipes, laundry bags, dryer bags and sheets comprising a layer formed of nonwoven web.

A particularly preferred application is in the area of disposable absorbent articles, wherein the enhanced properties of the nonwoven materials also enhance the *softness attributes*.

Suitable nonwoven web materials useful in the present invention include, but are not limited to spunbond, meltblown, spunmelt, solvent-spun, electrospun, carded, film fibrillated, melt-film fibrillated, air-laid, dry-laid, wet-laid staple fibers, and other and other nonwoven web materials formed in part or in whole of polymer fibers, as known in the art. A suitable nonwoven web material may also be an SMS material, comprising a spunbonded, a melt-blown and a further spunbonded stratum or layer or any other combination of spunbonded and melt-blown layers, such as a SMMS or SSMMS etc. Examples include one or more layers of fibers with diameters below 1 micron (nanofibers and nanofiber layers); examples of these rise in combinations of SMS, SMNS, SSMNS or SMNMS nonwoven webs (where "N" designates a nanofiber layer). In some examples, permanently hydrophilic non-wovens, and in particular, nonwovens with durably hydrophilic coatings may be desirable. Typically, the suitable non-woven is air permeable. Typically the suitable nonwoven is water or liquid permeable, but may also be water impermeable by reason of fiber size and density, and hydrophobicity of the fibers. Water or liquid permeability may be enhanced by treatments to render the fibers hydrophilic, as discussed below.

The nonwoven web may be formed predominately of polymeric fibers. In some examples, suitable non-woven fiber materials may include, but are not limited to polymeric materials such as polyolefins, polyesters, polyamide, or specifically polypropylene (PP), polyethylene (PE), poly-lactic acid (PLA), polyethylene terephthalate (PET) and/or blends thereof. Nonwoven fibers may be formed of, or may include as additives or modifiers, components such as aliphatic polyesters, thermoplastic polysaccharides, or other biopolymers (bio-based or renewable polymers).

The individual fibers may be monocomponent or multicomponent. The multicomponent fibers may be bicomponent, such as in a core-and-sheath or side-by-side arrangement. Often, the individual components comprise aliphatic polyolefins such as polypropylene or polyethylene, or their copolymers, aliphatic polyesters, thermoplastic polysaccharides or other biopolymers.

Further conventional nonwovens useful in such articles, fiber compositions, formations of fibers and nonwovens and related methods are described in U.S. Pat. No. 6,645,569 to Cramer et al., U.S. Pat. No. 6,863,933 to Cramer et al., U.S. Pat. No. 7,112,621 to Rohrbaugh et al.; co-

pending U.S patent application Ser. Nos. 10/338,603 and 10/338,610 by Cramer et al., and 13/005,237 by Lu et al., the disclosures of which are incorporated by reference herein.

Some polymers used for nonwoven fiber production may be inherently hydrophobic, and for certain applications they may be surface treated or coated with various agents to render them hydrophilic. A surface coating may include a surfactant coating. One such surfactant coating is available from Schill & Silacher GmbH, Böblingen, Germany, under the Tradename Silastol PHP 90.

Another way to produce nonwovens with durably hydrophilic coatings, is via applying a hydrophilic monomer and a radical polymerization initiator onto the nonwoven, and conducting a polymerization activated via UV light resulting in monomer chemically bound to the surface of the nonwoven as described in co-pending U.S. Patent Publication No. 2005/0159720.

Another way to produce hydrophilic nonwovens made predominantly from hydrophobic polymers such as polyolefins is to add hydrophilic additives into the melt prior to extrusion.

Another way to produce nonwovens with durably hydrophilic coatings is to coat the nonwoven with hydrophilic nanoparticles as described in co-pending applications U.S. Pat. No. 7,112,621 to Rohrbaugh et al. and in PCT Application Publication WO 02/064877.

Typically, nanoparticles have a largest dimension of below 750 nm. Nanoparticles with sizes ranging from 2 to 750 nm may be economically produced. An advantage of nanoparticles is that many of them can be easily dispersed in water solution to enable coating application onto the nonwoven, they typically form transparent coatings, and the coatings applied from water solutions are typically sufficiently durable to exposure to water. Nanoparticles can be organic or inorganic, synthetic or natural. Inorganic nanoparticles generally exist as oxides, silicates, and/or carbonates. Typical examples of suitable nanoparticles are layered clay minerals (e.g., LAPONITE™ from Southern Clay Products, Inc. (USA), and Boehmite alumina (e.g., Disperal P2™ from North American Sasol. Inc.). According to one example, a suitable nanoparticle coated non-woven is that disclosed in the co-pending patent application Ser. No. 10/758,066 entitled "Disposable absorbent article comprising a durable hydrophilic core wrap" by Ponomarenko and Schmidt.

In some cases, the nonwoven web surface can be pre-treated with high energy treatment (corona, plasma) prior to application of nanoparticle coatings. High energy pre-treatment typically temporarily increases the surface energy of a low surface energy surface (such as PP) and thus enables better wetting of a nonwoven by the nanoparticle dispersion in water.

Notably, hydrophilic non-wovens are also useful in other parts of an absorbent article. For example, topsheets and absorbent core layers comprising permanently hydrophilic non-wovens as described above have been found to work well.

A nonwoven also may include other types of surface coating. In one example, the surface coating may include a fiber surface modifying agent that reduces surface friction and enhances tactile lubricity. Preferred fiber surface modifying agents are described in U.S. Pat. Nos. 6,632,385 and 6,803,103; and U.S. Pat. App. Pub. No. 2006/0057921.

In some embodiments, at least a portion of the fibers may exhibit a spiral curl which has a helical shape. According to one example, the fibers may include bicomponent fibers, which are individual fibers each comprising different materials, usually a first and a second polymeric material. It is believed that the use of side-by-side bi-component fibers is beneficial for
5   imparting a spiral curl to the fibers.

A nonwoven may also be treated by a "selfing" mechanism. By "selfing" nonwovens, high densities of loops (>150 in 2) may be formed which protrude from the surface of the nonwoven substrate. Since these loops act as small flexible brushes, they create an additional layer of springy loft, which may enhance softness. Nonwovens treated by a selfing mechanism
10   are described in U.S. Pat. App. Pub. No. US 2004/0131820.

The nonwoven textile/web according to the present invention and exhibits a particular combination of softness, pleasant touch, and feel properties with good mechanical properties of the material, thus ensuring that it is easy to process it on existing equipment in converting plants. It is well known in the industry that the here described properties are among others significantly
15   affected by the type of polymer used, the batt production method, and the pattern formed during the thermal bonding of the nonwoven textile.

Polymers used for the production of nonwoven textiles have characteristic properties. For example resins including polypropylene may be particularly useful because of polypropylene's relatively low cost and the surface friction properties of the fibres formed from it (i.e. they have a
20   relatively smooth, slippery tactile feel). Resins including polyethylene may also be desirable because of polyethylene's relative softness/pliability and increased smooth/slippery surface friction properties. When compared with one another, PP currently has a lower cost and fibres formed from it have a greater tensile strength, while PE currently has a greater cost and fibres formed from it have a lower tensile strength but greater pliability and a more smooth/slippery
25   feel. Accordingly, it may be desirable to form nonwoven web/textile fibres by using a combination of PP and PE resins to find the best properties for the resulting webs/textiles.

A possible known approach towards this is for example the combination of both polymers in core/sheath type bi-component fibres. A nonwoven textile produced from such fibres retains approximately the strength of polypropylene and the touch and feel typical for polyethylene,
30   however due to poor mixability of the polypropylene with the polyethylene, particularly on fluffy material, the effect of mechanical stress certain linting can occur, which may causes subsequent problems both during further processing and is negatively perceived by the end user as a defect of the material. The degree of linting can be estimated using the Fuzz method.

Another approach is to us a propylene copolymer. A "propylene copolymer" includes at
35   least two different types of monomer units, one of which is propylene. Suitable different monomer units include, but are not limited to, ethylene and higher alpha-olefins ranging from C_4-C_{20}, such as, for example, 1-butene, 4-methyl-1-pentene, 1-hexene or 1-octene and 1-decene, or mixtures thereof, for example. Preferably, ethylene is copolymerized with propylene, so that the propylene copolymer includes propylene units (units on the polymer chain

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derived from propylene monomers) and ethylene units (units on the polymer chain derived from ethylene monomers).

Typically the units, or comonomers, derived from at least one of ethylene or a C4-10 alpha-olefin may be present in an amount of about 1 to about 35%, or about 5 to about 35%, preferably about 7 to about 32%, more preferably about 8 to about 25%, even more preferably about 8 to about 20%, and most preferably about 8 to about 18% by weight of the propylene-alpha-olefin copolymer. The comonomer content may be adjusted so that the propylene-alpha-olefin copolymer has preferably a heat of fusion of about 75 J/g or less, melting point of about 100 °C or less, and crystallinity of about 2% to about 65% of isotactic polypropylene, and preferably a melt flow rate (MFR) of about 0.5 to about 90 dg/min.

In one embodiment, the propylene-alpha-olefin copolymer comprises of ethylene-derived units. The propylene-alpha-olefin copolymer may contain about 5 to about 35%, preferably about 5 to about 20%, about 10 to about 12%, or about 15 to about 20%, of ethylene-derived units by weight of the propylene-alpha-olefin copolymer. In some embodiments, the propylene-alpha-olefin copolymer consists essentially of units derived from propylene and ethylene, i.e., the propylene-alpha-olefin copolymer does not contain any other comonomer in an amount typically present as impurities in the ethylene and/or propylene feedstreams used during polymerization or an amount that would materially affect the heat of fusion, melting point, crystallinity, or melt flow rate of the propylene-alpha-olefin copolymer, or any other comonomer intentionally added to the polymerization process.

The propylene-alpha-olefin copolymer may have a triad tacticity of three propylene units, as measured by 13C NMR, of at least about 75%, at least about 80%, at least about 82%, at least about 85%, or at least about 90%. The propylene-alpha-olefin copolymer has a heat of fusion ("Hf"), as determined by Differential Scanning calorimetry ("DSC"), of about 75 J/g or less, preferably about 70 J/g or less, about 50 J/g or less, or about 35 J/g or less. The propylene-alpha-olefin copolymer may have a lower limit Hf of about 0.5 J/g, about 1 J/g, or about 5 J/g.

The propylene-alpha-olefin copolymer may have a single peak melting transition as determined by DSC. In one embodiment, the copolymer has a primary peak transition of about 90° C. or less, with a broad end-of-melt transition of about 110° C. or greater. The peak "melting point" ("Tm") is defined as the temperature of the greatest heat absorption within the melting range of the sample. However, the copolymer may show secondary melting peaks adjacent to the principal peak, and/or at the end-of-melt transition. For the purposes of this disclosure, such secondary melting peaks are considered together as a single melting point, with the highest of these peaks being considered the Tm of the propylene-alpha-olefin copolymer. The propylene-alpha-olefin copolymer may have a Tm of about 100 °C or less, about 90 °C or less, about 80 °C or less, or about 70 °C or less. The propylene-alpha-olefin copolymer may have a density of about 0.850 to about 0.920 g/cm3, about 0.860 to about 0.900 g/cm3, preferably about 0.860 to about 0.890 g/cm3, at room temperature as measured per ASTM D-1505.

The propylene-alpha-olefin copolymer may have a melt flow rate ("MFR"), as measured per ASTM D1238, 2.16 kg at 230° C., of at least about 0.2 dg/min. In one embodiment, the propylene-alpha-olefin copolymer MFR is about 0.5 to about 5000 dg/min, about 1 to about 2500 dg/min, about 1.5 to about 1500 dg/min, about 2 to about 1000 dg/min, about 5 to about 500 dg/min, about 10 to about 250 dg/min, about 10 to about 100 dg/min, about 2 to about 40 dg/min, or about 2 to about 30 dg/min.

The propylene-alpha-olefin copolymer may have an Elongation at Break of less than about 2000%, less than about 1000%, or less than about 800%, as measured per ASTM D412.

The propylene-alpha-olefin copolymer may have a weight average molecular weight (Mw) of about 5,000 to about 5,000,000 g/mole, preferably about 10,000 to about 1,000,000 g/mole, and more preferably about 50,000 to about 400,000 g/mole; a number average molecular weight (Mn) of about 2,500 to about 2,500,00 g/mole, preferably about 10,000 to about 250,000 g/mole, and more preferably about 25,000 to about 200,000 g/mole; and/or a z-average molecular weight (Mz) of about 10,000 to about 7,000,000 g/mole, preferably about 80,000 to about 700,000 g/mole, and more preferably about 100,000 to about 500,000 g/mole.

The propylene-alpha-olefin copolymer may have a molecular weight distribution ("MWD") of about 1.5 to about 20, or about 1.5 to about 15, preferably about 1.5 to about 5, and more preferably about 1.8 to about 5, and most preferably about 1.8 to about 3 or about 4.

Examples for preferred propylene-alpha-olefin copolymers are available commercially under the trade names VISTAMAXX® (ExxonMobil Chemical Company, Houston, Tex., USA), VERSIFY® (The Dow Chemical Company, Midland, Mich., USA), certain grades of TAFMER® XM or NOTIO® (Mitsui Company, Japan), and certain grades of SOFTEL® (Basell Polyolefins of the Netherlands). The particular grade(s) of commercially available propylene-alpha-olefin copolymer suitable for use in the invention can be readily determined using methods applying the selection criteria in the above.

Propylene copolymers have a good mixability with propylene homopolymers, where depending on the mutual ratio of both constituents it is possible to prepare a material exhibiting various properties. A propylene copolymer is soft to touch and the nonwoven textile produced from it has good drapeability and is easy to bend. On the other hand polypropylene provides strength and reduces the plasticity of the material. The typical composition for the manufacturing of nonwovens useful in the hygiene industry contains at least 60% polypropylene, preferably at least 70% polypropylene and more preferably at least 75% polypropylene and at least 10%, more preferably 14% of the propylene copolymer. The described composition is generally drapable and soft but maintains the required mechanical properties. However it has a rough touch and feel and can be described as "rubbery".

The propylene copolymers can often be elastic or exhibit high elongation, so that in composition with polypropylene homopolymer person skilled in the art can expect that together with rising amount of propylene copolymer the composition will also exhibit increase in elongation and decrease in toughness, that can be unwelcome from production reasons. The

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composition according to invention should contain less than 20% propylene copolymere, preferably less than 18% of propylene copolymer.

It is found that the addition of a softness enhancer additive can be advantageous to reduce the tacky or rubbery feel of fibers that are made of a composition that includes a blend of the first
5   and second polyolefin previously described. The softness enhancer additive may be added to the composition in neat form, diluted, and/or as a masterbatch in, for example, polyolefin polymers such as polypropylene, low density polyethylene, high density polyethylene, or propylene-alpha-olefin copolymers.

A composition suitable to make fibers as described herein contains one or more softness
10   enhancer additive, which can be present in an amount of between 0,01% to 10%; preferably between 0,03% to 5%, more preferably between 0,05% to 1% and even more preferably 0,1% to 0,5% by weight of the produced fibres. Once the fiber are spun to form a nonwoven, some of the softness enhancer additive may volatilize and no longer be present in the same amount in the fibers forming the nonwoven, It is also believed that some of the softness enhancer additive may
15   migrate from the interior portion of the fiber to the outer surface of the fiber. Without intending to be bound by any theory, it is believed that this migration of the additive to the outer surface of the fiber may contribute to the perception of softness that a user experiences when she touches the nonwoven material.

In one embodiment, the softness enhancer additive is an organic amine compound, i.e.,
20   contains an amine group bound to a hydrocarbon group. In another embodiment, the softness enhancer additive is a fatty acid amine or a fatty acid amide. In some embodiments, the softness enhancer additive may have one or more paraffinic or olefinic groups bound to a nitrogen atom, forming an amine or an amide compound. The paraffinic or olefinic group may be, for example, a polar or ionic moiety as a side chain or within the amine/amide backbone. Such polar or ionic
25   moieties can include hydroxyl groups, carboxylate groups, ether groups, ester groups, sulfonate groups, sulfite groups, nitrate groups, nitrite groups, phosphate groups, and combinations thereof.

In one embodiment, the softness enhancer additive is an alkyl-ether amine having the formula $(R'OH)3-xNRx$, wherein R is selected from the group consisting of hydrogen, C1-40 alkyl radicals, C2-40 alkylethers, C1-40 alkylcarboxylic acids, and C2-40 alkylesters; R' is
30   selected from the group consisting of C1-40 alkyl radicals, C2-40 alkylethers, C1-40 carboxylic acids, and C2-40 alkylesters; and x is 0, 1, 2 or 3, preferably 0 or 1, more preferably 1. In one embodiment, R is selected from the group consisting of hydrogen and C5-40 alkyl radicals; and R' is selected from the group consisting of C5-40 alkyl radicals and C5-40 alkylethers.

In another embodiment, the softness enhancer additive is an amide-containing compound
35   having the formula: $RCONH2$, wherein R is a C5-23 alkyl or alkene. In another embodiment, the softness enhancer additive is a fatty acid amide having the formula: $(R'CO)3-xNR''x$, wherein R'' is selected from the group consisting of hydrogen, C10-60 alkyl radicals and C10-60 alkene radicals and substituted versions thereof; R' is selected from the group consisting of C10-60 alkyl radicals, C10-60 alkene radicals, and substituted versions thereof; and x is 0, 1, 2 or 3, preferably

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1 or 2, more preferably 2. As used herein, an "alkene" radical is a radical having one or more unsaturated double-bonds in the radical chain (e.g., -- CH2CH2CH2CH2CH=CHCH2CH2CH2CH.sub- .2CH2CH3), and "substituted" means substitution anywhere along the hydrocarbon chain of a hydroxyl group, carboxyl group, halide, or sulfate group.

In some embodiments, the softness enhancer additive contains an unsaturated amide. In one embodiment, the unsaturated amide-containing softness enhancer additive has the formula: RCONH2, wherein R is a C5-23 alkene. In another embodiment, the unsaturated amide-containing softness enhancer additive has the formula: (R'CO)3-xNR"x, wherein R" is selected from the group consisting of hydrogen, C10-60 alkyl radicals and C10-60 alkene radicals and substituted versions thereof; R' is selected from the group consisting of C10-60 alkene radicals and substituted versions thereof; and x is 0, 1, 2 or 3, preferably 1 or 2, more preferably 2. In some embodiments, the unsaturated amide-containing softness enhancer additive is at least one of palmitoleamide, oleamide, linoleamide, or erucamide. In other embodiments, the unsaturated amide-containing softness enhancer additive is at least one of oleamide or erucamide. In the preferred embodiment the slip additive contains erucamide.

Non-limiting examples of softness enhancer additives include bis(2-hydroxyethyl) isodecyloxypropylamine, poly(5)oxyethylene isodecyloxypropylamine, bis(2-hydroxyethyl) isotridecyloxypropylamine, poly(5)oxyethylene isotridecyloxypropylamine, bis(2-hydroxyethyl) linear alkyloxypropylamine, bis(2-hydroxyethyl) soya amine, poly(15)oxyethylene soya amine, bis(2-hydroxyethyl) octadecylamine, poly(5)oxyethylene octadecylamine, poly(8)oxyethylene octadecylamine, poly(10)oxyethylene octadecylamine, poly(15)oxyethylene octadecylamine, bis(2-hydroxyethyl) octadecyloxypropylamine, bis(2-hydroxyethyl) tallow amine, poly(5)oxyethylene tallow amine, poly(15)oxyethylene tallow amine, poly(3)oxyethylene-1,3-diaminopropane, bis(2-hydroxyethyl) cocoamine, bis(2-hydroxyethyl)isodecyloxypropylamine, poly(5)oxyethylene isodecyloxypropylamine, bis(2-hydroxyethyl) isotridecyloxypropylamine, poly(5)oxyethylene isotridecyloxypropylamine, bis(2-hydroxyethyl) linear alkyloxypropylamine, bis(2-hydroxyethyl) soya amine, poly(15)oxyethylene soya amine, bis(2-hydroxyethyl) octadecylamine, poly(5)oxyethylene octadecylamine, poly(8)oxyethylene octadecylamine, poly(10)oxyethylene octadecylamine, poly(15)oxyethylene octadecylamine, bis(2-hydroxyethyl) octadecyloxypropylamine, bis(2-hydroxyethyl) tallow amine, poly(5)oxyethylene tallow amine, poly(15)oxyethylene tallow amine, poly(3) oxyethylene-1,3-diaminopropane, bis(2-hydroxethyl) cocoamine, valeramide, caproicamide, erucamide, caprylicamide, pelargonicamide, capricamide, lauricamide, lauramide, myristicamide, myristamide, palmiticamide, palmitoleamide, palmitamide, margaric (daturic) amide, stearicamide, arachidicamide, behenicamide, behenamide, lignocericamide, linoleamide, ceroticamide, carbocericamide, montanicamide, melissicamide, lacceroicamide, ceromelissic (psyllic) amide, geddicamide, 9-octadecenamide, oleamide, stearamide, tallow bis(2-hydroxyethyl)amine, cocobis(2-hydroxyethyl)amine,

octadecylbis(2-hydroxyethyl)amine, oleylbis(2-hydroxyethyl)amine, ceroplastic amide, and combinations thereof.

Commercial examples of useful softness enhancer additives include ATMER® compounds (Ciba Specialty Chemicals), ARMID®, ARMOFILM® and ARMOSLIP® compounds and NOURYMIX concentrates (Akzo Nobel Chemicals), CROTAMID® compounds (Croda Universal Inc), CESA SLIP® compounds (Clariant). Further examples of slip additives include compounds from A.Schulman, Germany, Techmer, USA, or Ampacet, USA.

Compositions useful in the invention may include one or more different softness enhancer additives. For example, in one embodiment a composition may contain one or more unsaturated amide-containing softness enhancer additives, and in another embodiment one or more unsaturated amide-containing softness enhancer additives and one or more saturated amide-containing softness enhancer additives. In some embodiments, a composition includes a combination of low molecular weight (Mw) and thus faster migrating amides, e.g., erucamide or oleamide, and higher molecular weight (Mw) and thus slower migrating amides, e.g., behenamide or stearamide.

Person skilled in the manufacturing of nonwovens will appreciate that the processing temperature should not be above temperatures at which compounds decompose or otherwise deteriorate. Typically, the TGA Rapid weight loss temperature is considered as an upper limit for the processing. The TGA Rapid weight loss temperature for various substances can be found for example in "Plastics additives: an industrial guide" written by Ernest W.Flick.

However, it has surprisingly been found, that at least for amide type softness enhancer additives added in a spun melting process the process temperatures should be well below the TGA Rapid weight loss temperature, preferably the melt temperature before fibre production beam should be at least 20°C lower, more preferably more than 25°C lower.

Without wishing to be bound by theory it is believed that this is caused by particular effects during the fibre production process. The polymer composition including any softness enhancer additives is melted first, heated on certain level, pressed through the holes to form fibres and then very quickly cooled by huge air flow washing every single fibre surface. A skilled person would know that the sublimation level is dependent on substance temperature and partial pressure of substance vapors over the surface. When the melt composition temperature rise to a certain temperature, the softness enhancer active substance gets overheated and during fibre forming process can evaporate/sublimate from the surface of solidifying fibre. Due to cooling air flow the partial pressure is kept on low level and evaporation/sublimation can be much faster than expected from TGA values.

Following table 1 shows temperatures for several amides:

Table 1

Type	Product	Percent Total weight loss	TGA temperature when Weight loss begins °C	TGA temperature when Reapid weight loss begins °C
Primary	Oleamide	99,3%	195°C	250°C
	Erucamide	94,8%	220°C	280°C
Secondary	Oleypalmitamide	11,8%	225°C	300°C
Bisamide	Ethylenebisoleamide	11,6%	220°C	305°C

(http://www.tappi.org/Downloads/unsorted/UNTITLED---plc00927pdf.aspx)

The individual fibers may be monocomponent or multicomponent. The multicomponent fibers may be bicomponent, such as in a core-and-sheath or side-by-side arrangement. Often, the individual components comprise aliphatic polyolefins such as polypropylene or polyethylene, or their copolymers, aliphatic polyesters, thermoplastic polysaccharides or other biopolymers.

A batt of fibers may be formed from any of these resins by conventional methods, such as carding, meltblowing, spunlaying, airlaying, wet-laying etc. A preferred execution relates to spunbonding processes, in which the resin(s) are heated and forced under pressure through spinnerets. The spinnerets eject fibers of the polymer(s), which are quenched and then directed onto a moving belt; as they the fibers strike the moving belt they may be laid down in somewhat random orientations, but often with a machine-direction orientation or bias, to form a spunlaid batt. The batt then may be calender-bonded to form the nonwoven web.

Nonwovens formed of any basis weight may be usedmade with any of the compositions previously described. A nonwoven material made with the compositions previously described can be used to form one or more individual elements of an absorbent article such as for example its liquid pervious layer, its liquid impervious layer, its side panels, leg cuffs and/or waist features. Due to the perceived softness of such nonwovens, it can be advantageous to form with this nonwoven, elements of the absorbent article that may become in direct contact with the wearer's skin but the caregiver skin at the time of application. However, as noted in the background,It was previously noted that relatively higher basis weight, while having relatively greater apparent caliper and loft, also has relatively greater cost. On the other hand, relatively lower basis weight, while having relatively lower cost, adds to the difficulty of providing a backsheet that has and sustains a dramatic visual 3-dimensional appearance following compression in a package, and has suitable mechanical properties. It is believed that the combination of features described herein strikes a good balance between controlling material costs while providing a dramatic visual 3-dimensional appearance and suitable mechanical

properties. It is believed that the features of consolidating bond shapes and patterns described herein may be particularly useful in applications of nonwovens of relatively low basis weights in some applications, in that it is believed that such features provide a way to enhance loft while reducing, or at least without adding, basis weight. Accordingly, for such applications, a nonwoven having a basis weight from 6.0 to 50 gsm, more preferably from 8.0 to 35 gsm, even more preferably from 9.0 to 25 gsm, may be used. When used as a component of an absorbent article such as a topsheet, a lower basis weight nonwoven may provide strikethrough superior to that of a higher basis weight nonwoven. A lower basis weight nonwoven may be preferable to a higher basis weight one when used, for example, as a component of a zero-strain stretch laminate, because it will be more accommodating of an activation/incremental stretching process. In other applications, such as, for example, use of nonwovens to form products such as disposable clothing articles, wipes or dusters, higher basis weights up to 100 gsm, or even 150 gsm, may be desired. It is believed that the features of bonding protrusions, bonding shapes and bonding patterns described herein may have beneficial effects on loft and/or softness perception, even with nonwovens of such higher basis weights. Optimal basis weight is dictated by the differing needs in each application, and cost concerns.

Spunbonding includes the step of calender-bonding the batt of spunlaid fibers, to consolidate them and bond them together to some extent to create the web as a fabric-like structure and enhance mechanical properties e.g., tensile strength, which may be desirable so the material can sufficiently maintain structural integrity and dimensional stability in subsequent manufacturing processes, and in the final product in use. Referring to Fig. 1, calender-bonding may be accomplished by passing the batt 21a through the nip between a pair of rotating calender rollers 50, 51, thereby compressing and consolidating the fibers to form a nonwoven web 21. One or both of the rollers may be heated, so as to promote heating, plastic deformation, intermeshing and/or thermal bonding/fusion between superimposed fibers compressed at the nip. The rollers may form operable components of a bonding mechanism in which they are urged together by a controllable amount of force, so as to exert the desired compressing force/pressure at the nip. In some processes an ultrasonic energy source may be included in the bonding mechanism so as to transmit ultrasonic vibration to the fibers, again, to generate heat energy within them and enhance bonding.

One or both of the rollers may have their circumferential surfaces machined, etched, engraved or otherwise formed to have thereon a bonding pattern of bonding protrusions and recessed areas, so that bonding pressure exerted on the batt at the nip is concentrated at the bonding surfaces of the bonding protrusions, and is reduced or substantially eliminated at the recessed areas. The bonding surfaces have bonding surface shapes. As a result, an impressed pattern of bonds between fibers forming the web, having bond impressions and bond shapes corresponding to the pattern and bonding surface shapes of the bonding protrusions on the roller, is formed on the nonwoven web. One roller such as roller 51 may have a smooth, unpatterned cylindrical surface so as to constitute an anvil roller, and the other roller 50 may be formed with a

pattern as described, to constitute a bonding pattern roller; this combination of rollers will impart a pattern on the web reflecting the pattern on the bonding pattern roller. In some examples both rollers may be formed with patterns, and in particular examples, differing patterns that work in combination to impress a combination pattern on the web such as described in, for example, U.S.

5   Pat. No. 5,370,764.

A repeating pattern of bonding protrusions and recessed areas such as, for example, depicted in Fig. 2, may be formed onto a bonding roller 50 (Fig. 1). The rod-shaped bonding shapes 100 depicted in Fig. 2 depict raised surfaces of bonding protrusions on a roller, while the areas between them represent recessed areas 101. The bonding shapes 100 of the bonding

10   protrusions impress like-shaped bond impressions on the web in the calendering process.

The bonding protrusions on a roller will have a height, which may be expressed as a difference between the radius of the roller at the outermost (bonding) surfaces of the bonding protrusions, and the radius of the roller at the recessed areas 101. The height may be adjusted with the objective of minimizing the amount of material that must be removed from the roller

15   surface by machining or etching to create the desired shapes and pattern, while still providing for sufficient clearance between the roller bearing the bonding protrusions and the opposing roller, at the recessed areas 101, to accommodate passage of the batt through the nip in areas of the batt not to be bonded (i.e., at the recessed areas), without substantially compressing it – because maximum loft/caliper is the objective. For webs of the type and basis weight contemplated

20   herein, a bonding protrusion height between 0.3 mm and 1.0 mm may be desired, or more preferably, a bonding protrusion height between 0.5 mm and 0.8 mm, or even a bonding protrusion height between 0.6 mm and 0.7 mm. The bonding surfaces of the bonding protrusions may have an average area between 0.3 mm^2 and 10 mm^2. The bonding protrusions typically have sides with an angled slope when viewed in cross section through the height thereof.

25   Nonwoven webs of the type contemplated herein may be calender-bonded at line speed greater than 300 m/min., or 600 m/min., or even 800 m/min., or more, depending upon nonwoven web composition, basis weight, bonding pattern, and equipment and process variables selected. Referring again to Fig. 1, it will be appreciated that at such speeds, the batt 21a and the surfaces of rollers 50, 51 will entrain surrounding air and move it toward the nip 52, as suggested by the

30   arrows. Surface features of a bonding roller 50, as described above, will enhance this effect. It is believed that, as entrained air is carried toward the nip, the decreasing space between the rollers as the nip is approached creates a zone of relatively higher, and increasing, air pressure in front of the nip 52. A portion of the entrained air under such higher pressure will be urged into and further compressed in the nip 52, within the recessed areas of the bonding pattern on the roller,

35   and within the interstices of the fibers passing through the nip. It is believed that, as nonwoven web 21 exits the nip 52, compressed air entrained within the fibers and passing through the nip therewith encounters a zone of relatively lower pressure on the exit side, and accelerates away from the nip in all unobstructed directions as a result. Thus, it is believed that substantial air entrainment, air compression and complex air flows of relatively high velocity occur within and

about the batt 21a and web 21 as a result of movement of the batt and rotation of the calender rollers in the calender-bonding process.

It is believed that surface features of a bonding roller including the bonding protrusions affect these air flows. Particularly at the nip, the profiles of bonding protrusions present obstructions to airflow, while the recessed areas between the bonding protrusions present passageways. Thus, it is believed that for certain configurations, shapes, and positions of bonding protrusions, as will be reflected in the bond impressions created in the web, rotational orientation(s) and repeating patterns of the bonding shapes can be selected and formed to have a beneficial effect on these air flows. It is believed, further, that patterns of bonding protrusions having bonding surface shapes with certain features, reflected in the bonding surfaces and the cross sections of the protrusions along planes substantially parallel with the bonding surfaces, rotational orientations relative the plane approximated by the web surface, and spacing, may be employed to channel these air flows in a way that causes them to reposition the fibers during the calender bonding process, such as by teasing or fluffing the fibers, thus providing an enhanced calender-bonded nonwoven web having greater loft/caliper than a similar nonwoven web having other consolidated bond shapes and patterns, all other variables being the same.Figs. 3A, 3B and 3C depict one example of a bonding pattern and bonding shapes that will be reflected in bond shapes of bond impressions in a nonwoven web. Bonding shapes 100 represent the shapes of bonding surfaces of bonding protrusions that may be imparted to a bonding roller by etching, machining or other methods. Such bonding protrusions on a bonding roller will impress bond impressions into a web, of like bond shapes, arranged in a like bonding pattern. Without intending to be bound by theory, it is believed that certain aspects and features of the depicted shapes and pattern may have the beneficial effect described above.

Referring to Fig. 3B, the bonding shape 100 has a greatest measurable length L, which is measured by identifying a shape length line 104 intersecting the perimeter of the shape at points of intersection (bond shape top) 200 that are the greatest distance apart that may be identified on the perimeter, i.e., the distance between the two farthest-most points on the perimeter. The bonding shape 100 has a greatest measurable width W which is measured by identifying respective shape width lines 105a, 105b which are parallel to shape length line 104 and tangent to the shape perimeter at one or more outermost points that are most distant from shape length line 104 on either side of it, as reflected in Fig. 3B. It will be appreciated that, for some shapes (e.g., a semicircle), one of shape width lines 105a, 105b may be coincident/colinear with shape length line 104. Greatest measurable width W is the distance between shape width lines 105a, 105b. Shapes within the scope of the present invention have an aspect ratio of greatest measurable length L to greatest measurable width W of at least 2.5, more preferably at least 2.7, and even more preferably at least 2.8. The bond shapes and sizes impressed on the nonwoven web will reflect and correspond with the bonding shapes 100 and sizes thereof on the roller.

In order to gain the benefit of energy from a substantial mass of air flowing through the nip, it is also believed desirable that a pattern of bonding protrusions not be excessively obstructive of air flow through the nip, nor that it remove too much energy from the air flow by overly slowing, or halting, and absorbing the energy from, forward (machine-direction) momentum of air flows. Referring to Fig. 3C, a nip line 107a along the cross direction is identified along a pattern where the bonding shapes occupy the greatest proportion of distance along a cross direction line that can be identified in a pattern. Thus, nip line 107a located as shown represents a cross-direction line along which bonding protrusions presented the greatest amount of obstruction that can be identified in a particular pattern, to air flow through the nip, during the bonding process. A repeating series of shapes can be identified; in this example, the repeating series consists of the four shapes 100a, 100b, 100c and 100d. Widths w1, w2, w3, and w4 of the identified shapes 100a, 100b, 100c, 100d in the repeating series reflect restriction of air flow along the nip line 107a. Width wp is the width of the entire repeating series, including the distances between the bonding shapes. The proportion of maximum restriction along the nip length for the pattern is reflected by the ratio (w1+ w2+ w3+ w4 . . . + wn)/ wp, referred to herein as the nip airflow restriction ratio (where "w" is the cross-direction width along the nip line 107a of a bonding shape perimeter, and "n" is the number of bonding shapes along nip line 107a that make up a repeating series). In order that a bonding pattern allows for effective air flow through the nip in order to take advantage of energy of moving air, it may be desirable that the nip airflow restriction ratio be 0.40 or less, more preferably 0.30 or less, and even more preferably 0.25 or less. The bond shapes, rotational orientations and density/numerosity per unit surface area of bond impressions on the nonwoven web will reflect and correspond with the bonding shapes, rotational orientations and density/numerosity per unit surface area of bonding protrusions on the roller, and thus, also reflect the airflow restriction ratio.

It is also believed that arranging the bonding protrusions in a pattern such that a relatively straight, unobstructed passageway between them exists along recessed areas 101 at the nip, at least partially along the machine direction, may have beneficial effects. Referring to Figs. 3A and 4A, it can be seen that each example has a cross-nip airflow line 109 that can be identified, that intersects no bonding shape, and intersects a cross direction axis 107 at an angle such that it has a machine direction vector component. Cross-nip airflow line 109 intersects cross direction axis 107 to form a smaller angle, identified herein as cross-nip airflow angle βA. It is believed that cross-nip airflow angle βA is preferably greater than 45 degrees, more preferably between 50 degrees and 90 degrees, and even more preferably between 60 degrees and 90 degrees. It is believed desirable that cross-nip airflow line 109 should extend indefinitely without intersecting a bonding shape 100, but at a minimum, past at least 8 rows 110 of bonding shapes 100 without intersecting a bond shape. Again, geometric features of the bond shapes and pattern on the nonwoven web will reflect and correspond with those of the shape, size, rotational orientation, density and arrangement of the bond shapes 100.

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In one embodiment, referring to the Fig. 2A each column of like bond shapes is perpendicularly to the line offset with respect to both directly neighboring columns by a distance of between 30% and 70% of the greatest measurable length of the like bond shape. Not to be bound by theory, it is believed that when the air flowing through passageway between columns of

5 the bonding protrusions on the nip in MD direction became too strong, it can cause unpleasant decrees of fabric thickness. Described line offset can help to divided airflow into small turbulent streams. Without intending to be bound by theory, it is believed that it may have the beneficial effect described above.

In other embodiment the bond shapes tops 200 in adjacent lines forms isosceles triangle

10 symmetric to MD axe, what should cause similar positive effect on thickness as described above.

In other embodiment, referring to Fig. 3B, a bonding shape 100 may have a shape perimeter with a convex portion 102, lying on one side of the shape length line 104. Fig. 3B shows also that the convex portion may have a varying radius or radii. The varying radius/radii of the convex portion 102 may render the shape perimeter similar to the profile of the camber of

15 an airfoil in cross section. Viewed another way, the cross-sectional profile of an airfoil has a convex portion and is asymmetric about any line or axis that traverses the profile, which can be identified. The convex portion 102 may have a camber height CH measured as the distance between shape length line 104 and the shape width line 105b that is tangent to the convex portion 102. It is believed that, for maximum beneficial impact on airflow, it may be desirable that the

20 ratio between camber height CH and greatest measurable length L be 0.30 or less, more preferably 0.25 or less, but greater than zero. It is believed that a bonding protrusion having a cross section along a plane parallel the bonding surface, fitting this description, repeated and arranged in a pattern, has beneficial effects on acceleration and deceleration of air through nonwoven fibers at and about the nip. Again, the bond shapes and sizes impressed on the

25 nonwoven web will reflect and correspond with the bonding shapes and sizes on the roller.

The shape perimeter may have a convex portion with or without a varying radius on both sides of shape length line 104, such that it has the overall contour of an airfoil with symmetrical camber, in cross section. In another alternative, the shape perimeter may have a convex portion on one side of shape length line 104 and a straight portion on or on the other side of shape length

30 line 104, such that it has the overall contour of an airfoil/aircraft wing with asymmetrical camber, in cross section. In another alternative, the shape perimeter may have a convex portion on one side of shape length line 104 and a concave portion 103, disposed substantially opposite the concave portion, as reflected in Fig. 3B, such that it has the overall contour of an airfoil/aircraft wing with asymmetrical camber and relatively high-loft, low-speed features, in cross section.

35 The extent of the concavity of concave portion 103 may be quantified by measuring the depth thereof, relative the greatest measurable length. The concavity depth D may be measured by identifying a shape concavity line 106 that is parallel with the shape length line 104 and tangent to the deepest point along the concave portion 103. The concavity depth D is the distance between the shape width line 105a facing the concavity and the shape concavity line 106. The

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extent of the concavity of concave portion 103 may be expressed as a ratio of concavity depth D to shape length L (hereinafter, "concavity depth ratio"). Although shapes that do not have a concave portion 103 are contemplated, it may be desirable that a bonding shape has a concave portion having a concavity depth ratio between 0.00 and 0.30, more preferably between 0.00 and 5   0.25, and even more preferably between 0.00 and 0.20. Again, the bond shapes and sizes impressed on the nonwoven web will reflect and correspond with the bonding shapes and sizes on the roller.

Whilst the explanation above refers to bonding protrusions and resulting consolidated bond shapes in the web, which have bonding shape/bond shape perimeters following "convex" 10 and/or "concave" (impliedly, smooth) curves, it may be appreciated that the effect may be substantially realized by approximating such smooth curves with chains of straight line segments. Accordingly, each of the terms "convex" and "concave" herein includes a portion of a shape perimeter formed of a chain of 5 or more straight line segments lying on one side of a shape length line and connected end-to-end, that is each a chord of a smooth convex or concave curve lying on one side of a shape length line, or portion of a curve lying on one side of the shape 15 length line that does not include an inflection point.

Without intending to be bound by theory, it is believed that calender roller bonding protrusions having bonding shapes with one or more features as described above have aerodynamic effects on air flow in and about the nip, that cause acceleration and deceleration of 20 air in and about the interstices of the nonwoven fibers in a way that repositions the fibers, and may effect teasing or fluffing, adding loft and caliper.

Additionally, the rotational orientations of the protrusions affect the orientations of the bonding protrusions at the nip, and it is believed that this has an impact. Bonding shapes 100 and the bonding protrusions supporting them may be arranged along an individual shape tilt angle 25 relative the machine and cross directions. Without intending to be bound by theory, it is believed that the shape tilt angle should not exceed a certain amount for the bonding protrusion to have maximum beneficial effect on air flow. Referring again to Fig. 3B, the shape tilt angle α_T may be expressed as the smaller angle formed by the intersection of an axis along the machine direction 108 and the shape length line 104. It is believed, that the shape and the shape tilt angle 30 have cooperating effects on the air flow. In the case of an asymmetric bonding shape, such as the described airfoil-like shape, it is believed that this asymmetric bonding shape is sufficient for effecting the desired changes in air flow. However, a rotational orientation with a tilt angle of more than zero may enhance the effect. With respect to a bonding shape that is not asymmetric, it is believed that the shape tilt angle α_T provides the desired effects on air flow, such that it then 35 should not be less than 1 degree and should not exceed 40 degrees, more preferably, 30 degrees, and still more preferably, 20 degrees. It is believed that a shape tilt angle within this range effectively provides air flow through the nip, while at the same time, imparts cross-direction vector components to air flows through the nip. Conversely, a shape tilt angle greater than 40

degrees may create too much of an obstruction to air flow through the nip to have a beneficial effect, and even greater shape tilt angles combined with sufficient density of bonding protrusions may have the effect of creating enough obstruction at the nip to substantially divert airflow from the nip, *i.e.*, toward the sides of the bonding rollers, rather than through the nip. The bond shapes
5   and rotational orientations impressed on the nonwoven web will reflect and correspond with the bonding shapes and rotational orientations on the roller.   It is believed that air flows having cross-direction vector components flowing across or through the batt/web as it passes through and exits the nip may urge fibers in the cross-direction, helping add loft, caliper and/or cross direction tensile strength. It will be appreciated that the fibers of many nonwoven batts are laid
10   down in the nonwoven web manufacturing process with a general machine direction orientation or bias, which tends to result in the finished web having relatively greater machine direction tensile strength, and relatively less cross direction tensile strength. Thus, any process that tends to impart some added cross-direction orientation to the fibers prior to bonding may be useful for increasing cross direction tensile strength, bringing about better balance between machine
15   direction tensile strength and cross-direction tensile strength, and adding loft such as by repositioning of the fibers in the z-direction. It is believed that, for best results, it may be even more desirable that shape tilt angle α_T is between 5 degrees and 15 degrees, more preferably between 8 degrees and 12 degrees, and even more preferably between 9 degrees and 11 degrees, for the most beneficial effects on airflow at the line speeds contemplated herein. The rotational
20   orientation of the bonding pattern impressed on the nonwoven web will reflect and correspond with the rotational orientation of the bonding pattern on the roller.

         Referring to Figs. 4A and 4B, an alternative bonding pattern is depicted. The repeated bonding shape 100 and profile of the associated bonding protrusion is a composite of a pair generally convex/concave sub-shapes joined or superimposed at their respective tips, in reversed
25   orientation, to form an open "S" shape which is rotationally symmetric about this juncture of the component sub-shapes, respectively its middle inflection point. It will be appreciated, however, that the depicted repeated "S" shape may have several of the features of the bonding shape depicted in Figs. 3A and 3B, described above, which are believed to be beneficial. The depicted bonding shape 100 in Figs. 4A and 4B has a greatest measurable length L and greatest
30   measurable width W, measured with respect to shape length line 104 and shape width lines 105a, 105b, identified in the manner described above. As set forth above, bonding shapes 100 within the scope of the present invention have an aspect ratio of greatest measurable length L to greatest measurable width W of at least 2.5, more preferably at least 2.7, and even more preferably at least 2.8.

35   The depicted bonding shape in Figs. 4A and 4B also has convex portions 102a, 102b along its perimeter. One or both of the convex portions 102a, 102b may have varying radii, and have camber heights CH_A and CH_B. It is believed that, for maximum beneficial impact on

airflow, it may be desirable that the ratio between camber height CH and the greatest measurable length L also be 0.30 or less, more preferably 0.25 or less, but greater than zero.

The depicted bonding shape also has concave portions 103a and 103b along its perimeter. Concavity depth Da is the distance between shape width line 105a facing concavity 103a, and

5   shape concavity line 106a. Concavity depth Db is the distance between shape width line 105b facing concavity 103b, and shape concavity line 106b. Although bonding shapes that do not have a concave portion 103a, 103b along their perimeters are contemplated, it may be desirable that a bonding shape perimeter has one or more concave portions such as concave portions 103a, 103b having a concavity depth ratio:

10   Concavity depth / $(L*nc) \le 0.30$, more preferably 0.25, and even more preferably 0.20, where nc is the number of fully enclosed shapes that are defined by portions of the bonding shape perimeter and the shape length line, which evidence concavities. For example, for the "S" shape shown in Fig. 4B, nc $= 2$ because there are 2 such fully enclosed shapes 124a and 124b.

The shapes 100 in Figs. 4A and 4B also may have a shape tilt angle α_r determined as set

15   forth above, and within the ranges set forth. The geometric features of the bond shapes and pattern on the nonwoven web will reflect and correspond with those of the shape, size, rotational orientation, density and arrangement of the bond shapes 100.

Another aspect of the bonding shapes and patterns depicted in, e.g., Figs. 3A-5 is that they may have any combination of the above-described aspect ratios, maximum nip airflow restriction

20   ratio (0.40 or less), shape asymmetry, shape tilt angles, and other features, and may also reflect use of adjacent pairs of bonding protrusions that define air passageways through the nip that alternately narrow and widen, or converge and diverge, in the manner of a venturi. Without intending to be bound by theory, it is believed that such venturi passageways have the effect of causing localized zones of acceleration and deceleration, and increases and decreases in pressure,

25   as well as turbulence, of air as it passes through the nip. It is believed that these effects serve to tease and/or fluff the fibers of the batt and web about the nip.

For purposes of downstream handling and manufacturing processes, it may be desirable to ensure that no line along the machine direction exists along the nonwoven web surface that is indefinitely long without intersecting a bond impression. This condition (indefinitely long

30   machine direction strip of web without bonds) may result in relatively long lengths of unbonded fibers that may be prone to moving away from a cutting knife in downstream machine direction web slitting operations, resulting in a poorly defined or sloppy slit edge. Additionally, such long, unbonded fibers may also separate from a manufactured edge or slit edge of the web (fraying), which may cause other difficulties in downstream operations. To avoid this condition, it may be

35   desirable to impart a pattern angle γ_p to the bonding pattern. Referring to Fig. 4A, pattern angle γ_p may be expressed as the smaller angle formed by the intersection of a line connecting like points on repeating, similarly oriented shapes in columns 112, and a machine direction axis. To avoid the above-mentioned problems, it may be desirable that pattern angle γ_p be greater than 0

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degrees. A pattern angle greater than 0 degrees will ensure that an indefinitely long machine direction strip of web without bonds will not exist. To avoid creating complications with respect to the air flow benefits of the pattern, however, it may be desirable to limit pattern angle γ_P to 4 degrees or less, more preferably 3 degrees or less, and even more preferably 2.5 degrees or less.

5   Again, features of the bond pattern on the nonwoven web including pattern angle will reflect and correspond with those of the pattern and pattern angle γ_P on the roller.

The features described above apply to the shapes of bonding surfaces of bonding protrusions in a pattern on a bonding roller, and it will be understood that these features are impressed by the roller into the nonwoven batt to form bond impressions having bond shapes and

10   bonds thereat, to form the calender-bonded nonwoven web. As impressed into a nonwoven web, the bonding shapes are reflected as bond shapes, and are identifiable, and measurable in the web, in laminates that include such nonwoven web as a composite layer, and in composite products made from such nonwoven web and/or such laminates.

An additional aspect that it believed important is bonding area of a roller, reflected in

15   bond area on the web. Imagining a pattern of bonding surfaces having shapes reflected in Figs. 3A and 4A impressed on a surface of a nonwoven web, bonding area and bond area is the area occupied by the bonding shapes on the roller and bond shapes impressed on the surface of the web. In the field of nonwoven web manufacturing, bonding area is often expressed as a percentage, calculated as:

20   Bonding area = [(bonding area within a surface area unit) / (total surface area of the surface area unit)] * 100%.

The bonding area reflects the combination of bonding protrusion density (number of bonding protrusions per unit surface area) and average surface area of the bonding shapes 100 in the unit surface area. Thus, increasing the number of bonding protrusions and/or increasing the

25   surface area of the individual bond shapes 100 increases the bonding area, and *vice versa*. It is believed that bonding area has an impact on the entrainment of air as well as the proportion of entrained air carried toward the nip, which will pass through the nip. If bonding area is relatively greater, this means that more and/or larger bonding protrusions are present at the nip point at any time to obstruct air flow through the nip; conversely, if bonding area is relatively less, this means

30   that fewer and/or smaller bonding protrusions are present at the nip point at any time to obstruct air flow through the nip. Bond area has another effect as well. Increasing bond area increases the number and proportion of the fibers in the nonwoven web that are bonded together, and *vice versa*. Within a certain range of bond area, tensile strength of the nonwoven web in the machine and/or cross directions may be increased by increasing the bond area. However, bending

35   stiffness of the nonwoven web may be correspondingly increased, and loft decreased – compromising the soft feel and/or appearance of the nonwoven. In order to best realize the benefits of air flow, air compression and channeling believed to be occurring through use of the bond shapes described herein, enhancing loft, while still imparting satisfactory tensile properties

to the web, it is believed that bonding area should be in the range of 4.0% and 18%, more preferably between 6 % and 16%, and even more preferably between about 8 % and 14%. At the line speeds contemplated herein, and relative to the bonding area, the average surface area per bonding shape affects bonding area and bonding protrusion density. It is believed desirable that the average bonding shape 100 surface area be in the range of 0.3 mm^2 to 10 mm^2. Correspondingly, it is believed desirable that the density of the bonding protrusions, and correspondingly, the impressed bond shapes, be between 0.4 bonding protrusions/cm^2 for bonding shape/bond shape area of 10 mm^2 at 4% bonding area, and 60 bonding protrusions/cm^2 for bonding shape/bond shape area of 0.3 mm^2 at 18 % bonding area. Similar calculations of bonding protrusion density and average bond shape surface area to arrive at the bond areas in the ranges set forth above, will be appreciated. The surface area and density of bond shapes impressed on the nonwoven web will reflect and correspond with those of the bonding shapes, and thus, the bond area on the web will reflect and correspond with the bonding area on the roller as well. It is also believed that the speed of travel of the batt toward the bonding nip (batt line speed) is important. It will be appreciated that, if the batt line speed is too slow, air mass entrained by the batt as it approaches the nip will not have sufficient linear momentum to maintain a large enough zone of sufficiently elevated air pressure at the entry side effective to ensure that substantial air mass is urged through the nip, rather than being merely urged around the nip and the rollers along alternate pathways. Accordingly, it is believed that line speed at which the batt is conveyed toward the nip should be equal to or greater than 300 meters/minute, more preferably, equal to or greater than 600 meters/minute, and even more preferably, equal to or greater than 800 meters/minute.

It is believed that use of a calender roller having bonding patterns and bonding shapes as described herein take advantage of air flows resulting from entrainment of air along a moving nonwoven batt and calender rollers, and air compression, that occur during calender-bonding, in a way that causes the resulting nonwoven web to have enhanced loft and a soft feel. It is believed also that the bonding shapes need not be all of like kind or rotational orientation, but rather, that suitable combinations of differing shapes including bonding shapes having features as described herein, and optionally, in combination with other shapes, may be used and included. Employment of the described features may reduce or eliminate a need for other loft enhancement processes, such as hydroengorgement or hydroentanglement – which may save costs of additional equipment and operation.

It is also believed that there are several additional characteristics that may impact how a nonwoven material is perceived by a user. One such characteristic is the perceived softness of the nonwoven material by an end user. "Perceived softness" is at least in part related to the user's perception or feel of the material when she passes her finger across the surface of the nonwoven. But it is also believed that other properties or characteristics from the nonwoven material can impact the user's perception of a material. The caliper of the material (or thickness

under pressure), the material ability to drape, as well as, the material coefficient of friction are physical characteristics that a person uses to assess the softness of a material. Without intending to be bound by any theory, it is believed that a good way to discriminate among various material is to calculate the Softness Factor of a particular material with the following formula.

5

$$\text{Softness Factor} = \frac{\text{Handle} - \text{O} - \text{Meter(in MD of material)} * \text{COF (Static in MD of material)}}{\text{caliper}^2}$$

The Softness Factor is expressed in kN/m, the Handle-o-Meter (or drape) is expressed mN, the COF (Coefficient of Friction) is unit-less, and the caliper is expressed in mm.

10

Several samples of spunbond nonwoven materials are made and tested for different properties. The results of these tests are summarized in Table 2 below.

Table 2

Sample	Material Composition	Polypropylene copolymer content (weight %)	Softener enhancer additive active substance content (weight %)	Pattern	Basis weight
A	PP+PP Co+SEA	16	0.2%	P1	24.9
B	100% PP	NA	0.0%	P2	25.2
C	PP+PP Co+SEA	16	0.2%	P2	24.5
D	PP/PE 50/50	NA	0.0%	P3	26.8
E	PP+PP Co+SEA	16	0.2%	P3	26.9
F	100% PP	NA	0.0%	P3	25.4
G	PP+PP Co+SEA	16	0.2%	P3	24.8
H	PP+PP Co	16	0.0%	P2	24.23

Table 2 (continued)

Sample	caliper (mm)	Fuzz (mg/cm^2) - embossed side of nonwoven	Handle-O-Meter MD (mN)	COF-stat.smooth MD	Softness Factor
A	0.297	0.14	59.06	0.31262	209
B	0.386	0.13	127.63	0.4611	395
C	0.34	0.15	50.91	0.3049	134
D	0.387	0.3	52.97	0.2988	106
E	0.37	0.17	45.42	0.359	119
F	0.447	0.22	137.24	0.6192	425
G	0.365	0.09	45.22	0.3403	116
H	0.335	0.12	66.6	0.4914	292

For the sake of clarity, PP+PP Co+SEA refers to a nonwoven material with fibers made from a composition that includes a polypropylene homopolymer, a polypropylene copolymer and a softness enhancer additive. PP/PE 50/50 refers to a nonwoven material with bi-component fibers with a core made of polypropylene and a sheath made of polyethylene. PP+PP Co refers to a nonwoven material with fibers made from a composition that includes a polypropylene homopolymer, a polypropylene copolymer and no softness enhancer additive. 100% PP refers to a nonwoven material with fibers made from polypropylene without any copolymer or softness enhancer additive. P1 corresponds to to a calendering pattern with bonds having an oval shape similar to the shape shown in Fig. 2C and an aspect ratio of 1.74. P2 corresponds to a calendering pattern with bonds having a linear segment shape similar to the shape shown in Fig. 2A and an aspect ratio of 9.98. P3 corresponds to a calendering pattern with bonds having an S shape similar to the shape shown in Fig. 4A and an aspect ratio of 18.5.

Without intending to be bound by any theory, it is believed that nonwoven materials having a Softness Factor of less than 180 kN, less than 170 kN, or less than 160 kN, or even less than 150 kN provide the best softness perception not only to the touch but also from a visual and thickness point of view. It can also be advantageous to have a material resulting in less than 0.3g, less than 0.25g, or even less than 0.2g of Fuzz. Materials resulting in higher Fuzz are perceived as poor in quality by a user. In addition, materials resulting in higher Fuzz may also represent a choking hazard if used to make products that are worn by babies.

The Handle-O-Meter in the MD of the material is used to determine the Softness Factor. It can be advantageous for a nonwoven material to have a drape or Handle-O-Meter in the MD of less than 100 mN, or less than 80 mN or even less than 70 mN. The Handle-O-Meter in the MD may also be greater than 10 mN, or greater than 15 mN, or even greater than 20 mN.

The Static COF in the MD of the surface, or side of the material that is adapted to be touched by a consumer or a user is (it can be both smooth or embossed side) used to determine the Softness Factor. It may be advantageous for the nonwoven material to have a Static COF in the MD of less than 0,55, or less than 0,5, or even less than 0,45. The Static COF in the MD may also be greater than 0,2, or greater than 0,25, or even greater than 0,3.

It may be advantageous for the nonwoven material to have a Caliper of at least 0,1 mm, or at least 0,15 mm, or even at least 0,2 mm. The Caliper may also be less than 2 mm, or less than 1 mm, or even less than 0,6 mm.

Examples

In following examples for the manufacture of nonwoven webs, if it is not defined differently, the batt was produced from 3 following spunbond beams on REICOFIL 4 technology, using following bonding patterns:.

Pattern P3 "**S-shape v2**" (Fig. 5)
- Bonding area percentage = 13 %
- Bonding protrusions / cm^2 = 2,4
- Angle α_T = 10°
- Angle β_A = 63°
- Angle γ_P = 1°
- L = 9,2 mm
- W = 3,0 mm
- D_A = 2,3 mm
- D_B = 2,3 mm
- CH_A = 1,3 mm
- CH_B = 1,6 mm
- Distance between beginning of repeating shapes in columns (DRC) = 8,8 mm
- Distance between beginning of repeating shapes in rows (DRR) = 4,65 mm
- Bonding protrusion height = 0,75 mm

Pattern P2 "**Bulky**" (Fig. 2A).
- Bonding area percentage = 14,0%
- Bonding protrusions / cm^2 = 9
- Angle α_T = 0°
- Angle β_{A1} = 90°
- Angle β_{A2} = 55°
- Angle γ_P = 0°

- L = 3,4 mm
- W = 0,4 mm
- D = 0 mm
- CH = 0,2 mm
- Distance between beginning of repeating shapes in columns = 5,6 mm
- Distance between beginning of repeating shapes in rows = 2,0 mm
- Bonding protrusion height = 0,7 mm

Comparative pattern P1 "**Standard**" – Pattern U2888 of Ungricht GmbH, Germany(oval shape, Fig. 2B)

- Bonding area percentage = 18,1%
- Bonding protrusions / cm^2 = 49,9
- Angle α_Γ = 60°
- Angle β_A – does not exist
- Angle γ_P = 0°
- L = 0,9 mm
- W = 0,5 mm
- D – does not exist
- CH = 0,3 mm
- Distance between beginning of repeating shapes in columns = 1,5 mm
- Distance between beginning of repeating shapes in rows = 2,6 mm
- Bonding protrusion height = 0,6 mm

The key parameter and test results for the examples are summarized in Table 2 herein above.

Example 1 – sample A

The 25 gsm spunmelt type nonwoven batt produced online in a continuous process from composition that includes a polypropylene homopolymer (Tatren HT2511 from Slovnaft Petrochemicals), 16% propylene copolymere (Vistamaxx 6202 from Exxon) and a 2% softener enhancer additive containing 10% erucamide (CESA PPA0050079 from Clariant). The maximum meltage temperature measured after extrusion system is 252°C. Melt spun monocomponent filaments with a fibre diameter of 15-25 μm are produced and subsequently collected on a moving belt. After a patterned calender is used consisting of a pair of heated rollers, where one roller has raised comparative pattern P1(Fig 2B). The temperature of the calender rollers (smooth roller / patterned roller) is 160°C/ 164°C and the pressure is 75 N/mm.

Example 2 – sample B

A 25 gsm spunmelt type nonwoven batt produced online in a continuous process from polypropylene (Tatren HT2511 from Slovnaft Petrochemicals), where monocomponent

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polypropylene filaments with a fibre diameter of 15-25 μm are produced and subsequently collected on a moving belt. To increase strength a patterned calender is used consisting of a pair of heated rollers, where one roller has raised pattern P2 (Fig. 2A). The temperature of the calender rollers (smooth roller / patterned roller) is 165°C/168°C and the pressure is 75 N/mm.

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Example 3 – sample C

The 25 gsm spunmelt type nonwoven batt produced online in a continuous process from composition that includes a polypropylene homopolymer (Tatren HT2511 from Slovnaft Petrochemicals), 16% propylene copolymere (Vistamaxx 6202 from Exxon) and a 2% softener

10   enhancer additive containing 10% erucamide (CESA PPA0050079 from Clariant). The maximum meltage temperature measured after extrusion system is 252°C. Melt spun monocomponent filaments with a fibre diameter of 15-25 μm are produced and subsequently collected on a moving belt. After a patterned calender is used consisting of a pair of heated rollers, where one roller has raised comparative pattern P2 (Fig 2A). The temperature of the calender rollers

15   (smooth roller / patterned roller) is 160°C/ 164°C and the pressure is 75 N/mm.

Example 4 – sample D

A 25 gsm spunmelt type nonwoven batt, produced using a continuous online process from polypropylene (Tatren HT2511 from Slovnaft Petrochemicals) and polyethylene (Liten LS87

20   from Unipetrol), where first the bicomponent core/sheath type filaments are produced, where the core representing 50% is from polypropylene and the sheath is from polyethylene. The individual filaments with a fibre diameter of 15-25 μm are collected on a moving belt.

To increase strength a patterned calender is used, that consist of a pair of heated rollers, where one roller has raised pattern P3 (Fig. 5). The temperature of the calender rollers (smooth roller /

25   patterned roller) is 154°C/154°C and the pressure is 75 N/mm.

Example 5 – sample E

The 25 gsm spunmelt type nonwoven batt produced on a pilot line from two production beams, one Reicofil 4 and the second Reicofil 3 technology. The batt was produced online in a

30   continuous process from composition that includes a polypropylene homopolymer (Tatren HT2511 from Slovnaft Petrochemicals), 16% propylene copolymere (Vistamaxx 6202 from Exxon) and a 2% softener enhancer additive containing 10% erucamide (CESA PPA0050079 from Clariant). The maximum meltage temperature measured after extrusion system is 252°C. Melt spun monocomponent filaments with a fibre diameter of 15-25 μm are produced and

35   subsequently collected on a moving belt. After a patterned calender is used consisting of a pair of heated rollers, where one roller has raised comparative pattern P3 (Fig 5). The temperature of the calender rollers (smooth roller / patterned roller) is 160°C/ 164°C and the pressure is 75 N/mm.

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Example 6 – sample F

A 25 gsm spunmelt type nonwoven batt produced online in a continuous process from
polypropylene (Tatren HT2511 from Slovnaft Petrochemicals), where monocomponent
polypropylene filaments with a fibre diameter of 15-25 μm are produced and subsequently
5   collected on a moving belt. To increase strength a patterned calender is used consisting of a pair
of heated rollers, where one roller has raised pattern P3 (Fig. 5). The temperature of the calender
rollers (smooth roller / patterned roller) is 165°C/168°C and the pressure is 75 N/mm.

Example 7 – sample G

10   The 25 gsm spunmelt type nonwoven batt produced online in a continuous process from
composition that includes a polypropylene homopolymer (Tatren HT2511 from Slovnaft
Petrochemicals), 16% propylene copolymere (Vistamaxx 6202 from Exxon) and a 2% softener
enhancer additive containing 10% erucamide (CESA PPA0050079 from Clariant). The maximum
meltage temperature measured after extrusion system is 252°C. Melt spun monocomponent
15   filaments with a fibre diameter of 15-25 μm are produced and subsequently collected on a
moving belt. After a patterned calender is used consisting of a pair of heated rollers, where one
roller has raised comparative pattern P3 (Fig 5). The temperature of the calender rollers (smooth
roller / patterned roller) is 160°C/ 164°C and the pressure is 75 N/mm.

20   Example 8 –sample H

The 25 gsm spunmelt type nonwoven batt produced online in a continuous process from
composition that includes a polypropylene homopolymer (Tatren HT2511 from Slovnaft
Petrochemicals) and 16% propylene copolymere (Vistamaxx 6202 from Exxon). Melt spun
monocomponent filaments with a fibre diameter of 15-25 μm are produced and subsequently
25   collected on a moving belt. After a patterned calender is used consisting of a pair of heated
rollers, where one roller has raised comparative pattern P2 (Fig 2A). The temperature of the
calender rollers (smooth roller / patterned roller) is 160°C/ 164°C and the pressure is 75 N/mm.

Test methods

30   The **"basis weight"** of a nonwoven web is measured according to the European standard
test EN ISO 9073-1:1989 (conforms to WSP 130.1). There are 10 nonwoven web layers used for
measurement, sample size 10x10 cm^2.

The **"MD/CD ratio"** is the ratio of material's tensile strength at peak in the MD and CD
direction. Both were measured according to the EDANA standard method WSP 110.4-2005,
35   where sample width is 50 mm, jaw distance is 100 mm, speed 100 mm/min and preload 0,1N.

MD/CD ratio [-] = tensile strength at peak in MD[N/5cm] / tensile strength at peak in CD[N/5cm]

The **"volume mass"** is the ratio of basis weight and thickness and indicates the bulkiness
and fluffiness of the product, which are important qualities of the nonwoven web according to the
invention. The lower the value, the bulkier is the web.

Volume mass [kg/m^3] = basis weight [g/m^2] / thickness [mm].

The "**hydrophilic properties**" of a nonwoven web may be measured using the "**Strike Through Time**" test. The test used herein is the EDANA standard test WSP 70.3-2005 The lower the value, the more hydrophilic is the web.

The "**Handle-O-Meter**" is determined using the test method described in INDA IST 90.3-01. The Handle-O-Meter can be measured in the Machine Direction (MD) or Cross-machine Direction (CD) material. The Handle-O-Meter in the MD of the material is used to determine the Softness Factor.

The "**Static COF**" can be measured using ASTM Method D 1894-01 with the following particulars. The test is performed on a constant rate of extension tensile tester with computer interface (a suitable instrument is the MTS Alliance using Testworks 4 Software, as available from MTS Systems Corp., Eden Prarie, MN) fitted with a coefficient of friction fixture and sled as described in D 1894-01 (a suitable fixture is the Coefficient of Friction Fixture and Sled available from Instron Corp., Canton, MA). The apparatus is configured as depicted in Figure 1c of ASTM 1894-01 using a stainless steel plane with a grind surface of 320 granulation as the target surface. A load cell is selected such that the measured forces are within 10% to 90% of the range of the cell. The tensile tester is programmed for a crosshead speed of 127 mm/min, and a total travel of 130 mm. Data is collected at a rate of 100 Hz. The specimen is cut down to a reduced size of 63.5 mm x 63.5 mm (again, with cut edges parallel and perpendicular, respectively, with the longitudinal axis of the diaper) and mounted onto the foam rubber side of the sled using double sided adhesive tape (tape should be wide enough to cover 100% of the sled's surface). The specimen is oriented on the sled such that the wearer-facing surface, or outward- facing surface (as on the diaper, according to whether the specimen was taken from topsheet or backsheet) will face the target surface, and the longitudinal orientation of the specimen, relative the longitudinal axis of the diaper, is parallel to the pull direction of the sled. The mass of the sled with mounted sample is recorded to 0.1 gram.

The target surface of the stainless steel plane is cleaned with isopropanol before each test. In order to acquire CoF between nonwovens, a obtain a second specimen, duplicate to the one mounted to the sled, which is large enough to cover the target surface. Place the second specimen on the target surface, oriented so that the same surface of the two specimens will face each other during the test with the machine direction parallel to the pull direction of the sled. Align the specimen on the target surface so that it is equidistant between the edges. Align the end of the specimen with the protruding end of the platform, and fix it using tape or clamps along the entire protruding end only, leaving the other end of the specimen unsecured to prevent buckling of the material during testing.

The static and kinetic coefficients of friction (COF) for the specimen are calculated as follows:

Static COF = AS / B

AS = maximum peak force in grams force (gf) for the initial peak

B = mass of sled in grams

Kinetic COF = AK / B

AK = average peak force in grams force (gf) between 20 mm and 128 mm

B = mass of sled in grams

The Static COF can be measured in the Machine Direction (MD) or Cross-machine Direction (CD) material. The Static COF in the MD of the material is used to determine the Softness Factor.

The "Caliper" or the "thickness" of the nonwoven material is measured according to the European standard test EN ISO 9073-2:1995 (conforms to WSP 120.6) with following modification:

1.the material shall be measured on a sample taken from production without being exposed to higher strength forces or spending more than a day under pressure (for. example on a product roll), otherwise before measurement the material has to lie freely on a surface for at least 24 hours.

2. the overall weight of upper arm of the machine including added weight is 130 g.

The "Fuzz" test is performed to gravimetrically measure the amount of loose fibers collected from a nonwoven material after abrasion with sandpaper. The nonwoven can be oriented to test in either the CD and/or MD direction. The test is performed using a Model SR 550 Sutherland Rub Tester (available from Chemsultants, Fairfield OH) with the 906 g abradent weight block supplied with the instrument. A 50.8 mm wide cloth, 320 grit aluminum oxide sandpaper (available as Part No. 4687A51 from McMaster-Carr Supply Co., Elmhurst, IL) is used as the abrading surface. Fibers are collected using a 50.8 mm wide polyethylene protective tape (available as 3M Part No. 3187C). The nonwoven is mounted to the Rub tester's base plate (steel, 205 mm long x 51 mm wide x 3 mm thick) using a 50.8 mm wide double-sided tape (available as 3M Part No. 9589). All tape materials and samples are conditioned at 23 °C ± 2 C° and 50 % ± 2 % relative humidity for two hours prior to testing. All analyses are also performed in a lab maintained at 23 °C ± 2 C° and 50 % ± 2 % relative humidity.

Cut a 160 mm by 50.8 mm piece of the sandpaper. Mount the sandpaper onto the abradent weight block using its side clips. A new piece of sandpaper is used for every specimen. Cut a piece of the fiber collecting tape approximately 165 mm long by 50.8 wide. On both 50.8 wide ends, fold approximately 6 mm of the tape over onto itself (i.e., adhesive side to adhesive side) to provide a flap at each end to hold the tape without touching the adhesive. Two fiber collecting tapes are prepared for each specimen.

Place the sample to be tested flat on a lab bench with the outward facing surface, relative to the article, facing downward. Identify the CD direction of the nonwoven. Cut a piece of the sample mounting tape approximately 130 mm long by 50.8 mm wide. Place the exposed adhesive side of the tape onto the surface of the nonwoven with its longest side parallel to the CD of the nowoven. Using a paper cutter, cut a strip, 110 mm ± 1 mm in the CD direction and 40 mm ± 1 in

the MD from the tape nonwoven sandwich. Remove the release paper from the specimen and adhere the specimen to the steel base plate centering the sample in the length and width dimensions. Gently place a 2.2 Kg weight block (flat-bottom, rectangular surface 50 mm wide by 150 mm long) covering the specimen for 20 sec ± 1 sec. Remove the weight.

5   Mount the base plate on the Sutherland Rub tester. Attach the abradent weight block onto the reciprocating arm. Start the Rub tester and allow to run for 20 cycles at a rate of 42 cycles per minute. Using an analytical balance measure the mass of each fiber collecting tape to the nearest 0.0001 g. Record separately as the sandpaper-tape tare weight (STW) and the nonwoven-tape tare weight (NTW).

10   After 20 cycles, carefully lift off the abradent weight block and place it on the lab bench with the sandpaper side facing upward. Take the preweighed sandpaper-fiber collecting tape and lightly touch the tape's adhesive surface to the loose fibers on the surface of the sandpaper. Care is taken to remove all loose fibers from the entire abrading surface of the sandpaper. Measure the mass of the fiber collecting tape/loose fibers to the nearest 0.0001 g. Record as the sandpaper-
15 tape combined weight (SCW).

Carefully remove the base plate with the abraded specimen and place it on the lab bench with the nonwoven facing upward. Take the preweighed nonwoven-fiber collecting tape and cover the surface of the nonwoven with the adhesive side of the tape facing the nonwoven. Gently place a 2.2 Kg weight block (flat-bottom rectangular surface 50 mm wide by 150 mm
20 long) covering the specimen for 20 sec ± 1 sec. Remove the weight.

Care is taken to remove all loose fibers from the entire surface of the nonwoven. Replace the release paper and measure the mass of the nonwoven-fiber collecting tape/loose fibers to the nearest 0.0001 g. Record as the nonwoven-tape combined weight (NCW).

Fuzz level (mg/cm2) = 1000 x [(SCW - STW) + (NCW – NTW)] / 44

25   Repeat testing on a total of three substantially identical samples Average the results and report the CD Fuzz Level to the nearest 0.001 mg/cm2.

In like fashion, repeat fuzz testing for three substantially identical samples in which the specimen is oriented parallel to the MD for analysis. Average the three MD results and report the MD Fuzz Level to the nearest 0.001 mg/cm2.

30   The "Molecular weight (Mn, Mw, and Mz)" and "MWD" is determined as follows and as described in Verstate et al., 21 MACROMOLECULES 3360 (1988). Conditions described herein govern over published test conditions. Molecular weight and MWD are measured using a Waters 150 gel permeation chromatograph equipped with a Chromatix KMX-6 on-line light scattering photometer. The system is used at 135[deg.] C. with 1,2,4-trichlorobenze as the mobile
35 phase. Showdex (Showa-Denko America, Inc.) polystyrene gel columns 802, 803, 804, and 805 are used. This technique is discussed in Verstate et al., 21 MACROMOLECULES 3360 (1988). No corrections for column spreading are employed; however, data on generally acceptable standards, e.g., National Bureau of Standards Polyethylene 1484, and anionically produced hydrogenated polyisoprenes (an alternating ethylenepropylene copolymer) demonstrate that such

corrections on Mw/Mn or Mz/Mw are less than 0.05 units. Mw/Mn was calculated from an elution time-molecular relationship whereas Mz/Mw was evaluated using the light scattering photometer. The numerical analysis can be performed using the commercially available computer software GPC2, MOLWT2 available from LDC/Milton Roy-Rivera Beach, Fla.

5   The "DSC" is determined as follows. About 0.5 grams of polymer is weighed and pressed to a thickness of about 15 to 20 mils (about 381-508 microns) at about 140-150[deg.] C., using a "DSC mold" and MYLAR(TM) film as a backing sheet. The pressed polymer sample is allowed to cool to ambient temperatures by hanging in air (the MYLAR(TM) film backing sheet is not removed). The pressed polymer sample is then annealed at room temperature (about 23-25[deg.]
10   C.) for about 8 days. At the end of this period, a 15-20 mg disc is removed from the pressed polymer sample using a punch die and is placed in a 10 microliter aluminum sample pan. The disc sample is then placed in a DSC (Perkin Elmer Pyris 1 Thermal Analysis System) and is cooled to about -100[deg.] C. The sample is heated at about 10[deg.] C./min to attain a final temperature of about 165[deg.] C. The thermal output, recorded as the area under the melting
15   peak of the disc sample, is a measure of the heat of fusion and can be expressed in Joules per gram (J/g) of polymer and is automatically calculated by the Perkin Elmer system. Under theses conditions, the melting profile shows two (2) maxims, the maxima at the highest temperature is taken as the melting point within the range of melting of the disc sample relative to a baseline measurement for the increasing heat capacity of the polymer as a function of temperature.

20   The "Triad tacticity" is determined as follows. The tacticity index, expressed herein as "m/r", is determined by 13C nuclear magnetic resonance ("NMR"). The tacticity index m/r is calculated as defined by H. N. Cheng in 17 MACROMOLECULES 1950 (1984), incorporated herein by reference. The designation "m" or "r" describes the stereochemistry of pairs of contiguous propylene groups, with "m" referring to meso and "r" referring to racemic. An m/r
25   ratio of 1.0 generally describes a syndiotactic polymer, and an m/r ratio of 2.0 generally describes an atactic material. An isotactic material theoretically may have a m/r ratio approaching infinity, and many by-product atactic polymer have sufficient isotactic content to result in an m/r ratio of greater than 50.

In the "Bond Shape Measurement Method" area, distance and angle measurements are
30   performed on images generated using a flat bed scanner capable of scanning at a resolution of at least 4800 dpi in reflectance mode (a suitable scanner is the Epson Perfection V750 Pro, Epson, USA). Measurements are performed using ImageJ software (Version 1.43u, National Institutes of Health, USA) and calibrated against a ruler certified by NIST.

Samples of the subject nonwoven web that are 80 mm by 80 mm are used. Precondition
35   the samples at about 23 °C ± 2 C° and about 50% ± 2% relative humidity for 2 hours prior to testing. Identify the machine direction of the nonwoven web and draw a fine line on each sample along the machine direction to enable scanned images to be aligned.

Place the sample to be measured on the flat bed scanner, with the surface bearing the bond impressions or bond shapes facing downward, with the ruler directly adjacent. Placement is such

that the dimension corresponding to the machine direction of the nonwoven is parallel to the ruler. A black backing is placed over the specimen and the lid to the scanner is closed. Acquire an image composed of the nonwoven and ruler at 4800 dpi in reflectance mode in 8 bit grayscale and save the file. Open the image file in ImageJ and perform a linear calibration using the
5   imaged ruler.

Unless otherwise stated, dimensional and area measurements are made in triplicate, of three similar bond shapes on each sample for 6 similar samples. The 18 values are averaged and reported.

Not intending to be bound by the specific examples, Figs. 3A through 4B are referenced
10   to illustrate the following dimension measurements. These measurement methods are equally applicable to other bond shapes and repeating bond patterns.

Greatest Measurable Length (L). The bond shape has a perimeter and a greatest measurable length. Identify a shape length line (e.g. line 104) which intersects the two farthest-most points along the perimeter. Draw a shape length line through these points. With the
15   measuring tool, measure the length along the line segment between these points to the nearest 0.001 mm. For example, the greatest measurable lengths in Figs. 3B and 4B are indicated at L, respectively measured along shape length lines 104.

Greatest Measurable Width (W). Relative the greatest measurable length, the bond shape has a greatest measurable width measured along a direction perpendicular to the shape length
20   line. Draw two lines, parallel to the shape length line, and tangent to the bond shape perimeter at one or more outermost points that are most distant from the shape length line. These are the shape width lines. With the measuring tool, measure the greatest measurable width between the shape width lines along a line segment perpendicular to the shape length line to the nearest 0.001 mm. For example, the greatest measurable widths in Figs. 3B and 4B are indicated at W,
25   respectively measured between lines 105a and 105b perpendicular to shape length lines 104.

Camber Height (CH). If the bond shape has a perimeter with a convex portion, the convex portion lies a maximum distance from the shape length line, referred to herein as the camber height. Draw a line that is tangent to the convex portion, and parallel to the shape length line. With the measuring tool, measure the distance between width between this tangent line and
30   the shape length line along a direction perpendicular to the shape length line, to the nearest 0.001 mm. For example, the camber heights of the convex portions in Figs. 3B and 4B are CH, and CH_a and CH_b, respectively.

Concavity Depth (D). If the bond shape has a perimeter with a concave portion, the concave portion has a maximum distance from the facing shape width line. Draw a line that is
35   tangent to the deepest point along the concave portion of the profile, and parallel to the shape length line. This is the shape concavity line. With the measuring tool, measure the distance between shape concavity line and the shape length line along a direction perpendicular to the shape length line to the nearest 0.001 mm. For example, the concavity depths of the concave portions in Figs. 3B and 4B are D, and D_a and D_b, respectively.

Shape Tilt Angle (α_T). The bond shape is rotationally oriented relative to the machine direction by shape tilt angle α_T. Draw a line in the cross direction, intersecting the shape length line. Draw a line in the machine direction perpendicular to the cross direction line, intersecting both the cross direction line and the shape length line. Using the angle measuring tool, measure the smaller angle between the machine direction line and the shape length line to the nearest 0.1 degree. For example, the angle between lines 108 and 104 in Figure 3B is the shape tilt angle α_T.

Pattern Tilt Angle (γ_P). The bond shapes may form a pattern that is tilted from the machine direction by the angle γ_P. Identify a repeating series of bond shapes in a column. Draw a column line that is tangent on one side at the same position on two similar shapes having similar rotational orientations in the column. Draw a line in the machine direction that intersects this column line at an angle, if such a line exists. With the angle measuring tool, measure the smaller angle between the column line and the machine direction line to the nearest 0.1 degree.

Airflow Restriction Ratio. The bond shapes form a pattern that identifies a maximum airflow restriction by the corresponding bonding roller at the nip. Identify a repeating series of bond shapes lying in a row. Draw a line in the cross direction which intersects these bond shapes at the position relative the machine direction where the shapes occupy the greatest proportion of the distance along the cross direction line. It will be appreciated that it may be necessary to take measurements along several cross direction lines to empirically and/or iteratively identify the one along which the bond shapes occupy the greatest proportion of the distance. With the measuring tool, measure the length from the start of the repeating series to the corresponding location at the end of the repeating series (including distances between bonding shapes) to the nearest 0.001 mm. This is the repeat length in the cross direction. With the measuring tool, measure each of the lengths of the line segments on the cross direction line that lie over the bond shapes, to the nearest 0.001 mm. Add the lengths of all of these line segments within the repeat length, and divide the total by the repeat length. Report to the nearest 0.001. This is the airflow restriction ratio. For example, in Figure 3C, the repeat length w_p is measured along the cross direction line 107a. The line segments lying over the bond shapes are w_1 through w_4. The airflow restriction ration is the sum of lengths w_1 through w_4 divided by the repeat length w_p.

Cross-nip Airflow Angle (β_A). The bond pattern may provide an airflow path that has a machine direction vector component. Draw a line in the cross direction. Identify a line that can be drawn that extends past at least eight rows of bond shapes without intersecting a bond shape, if such a line exists. This is the cross-nip airflow line. Extend this line to intersect the cross direction line. Using the angle measurement tool, measure the smaller angle between the cross direction line and the airflow line and report to the nearest 0.1 degree. For example line 109 in Figure 3A and 109 in figure 4A are cross-nip airflow lines which intersects the cross direction line 107 to form the cross-nip airflow angle β_A

Bond Area Percentage. Identify a single repeat pattern of bond shapes and areas between them and enlarge the image such that the repeat pattern fills the field of view. In ImageJ, draw a rectangle that circumscribes the repeat pattern. Calculate area of the rectangle and record to the

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nearest 0.001 mm^2. Next, with the area tool, trace the individual bond shapes or portions thereof that are entirely within the repeat pattern/rectangle and calculate and add the areas of all bond shapes or portions thereof that are within the repeat pattern/rectangle. Record to the nearest 0.001 mm^2. Calculate as follows:

5   Bond Area % = (Sum of areas of bond shapes within repeat pattern) / (total area of repeat pattern) x 100%

Repeat for a total of three non-adjacent regions randomly selected across the sample. Record as Percent Bond Area to the nearest 0.01%. Calculate the average and standard deviation of all 18 of the bond area percentage measurements and report to the nearest 0.01 %.

10   Average Individual Bond Area. Enlarge the image of a region of the sample such that edges of a bond shape can be identified. With the area tool, manually trace the perimeter of a bond. Calculate and record the area to the nearest 0.001 mm^2. Repeat for a total of five non-adjacent bonds randomly selected across the total sample. Measurements are made on each sample. A total of six samples are measured. Calculate the average and standard deviation of all

15   30 bond area measurements and report to the nearest 0.001 mm^2.

CLAIMS

1. A nonwoven web (21) comprising heat bondable fibres and comprising a plurality of calendering bonds (100) having a bond shape;

   a. characterized in that said heat bondable fibres comprise propylene copolymer and softness enhanced additive and polypropylene,

   b. wherein the plurality of calendering bonds (100) having a bond shape forms a regular pattern and wherein said bond shapes have a greatest measurable length (L) and a greatest measurable width (W), wherein an aspect ratio of the greatest measurable length (L) to the greatest measurable width (W) is at least 2.5.

2. A nonwoven web (21) according to claim 1, wherein said heat bondable fibres comprise

   a. between 10% a and 20% of propylene copolymer, preferably between 14 and 18% of propylene copolymer; and /or

   b. between 0,01% to 10% of softener enhanced additive, preferably between 0,03% to 5%, more preferably between 0,05% to 1% and even more preferably 0,1% to 0,5% by weight of the produced fibres; and /or

   c. at least 60%, preferably at least 70% , even more preferably at least 80% of prolypropylene homopolymer.

3. A nonwoven web (21) according to claim 1 or 2, wherein said bond shapes are arranged in a pattern so that there are lines (109) which do not intersect any individual bond shape, but intersect the axis in the CD direction (107) perpendicular to MD, said lines (109) forming with the cross-machine direction CD (107), extending perpendicularly to the machine direction, an angle (βA) which is greater than 45°, preferably between 50° and 90°, even more preferably between 60° and 90°.

4. A nonwoven web (21) according to any of claim 1, wherein the number of individual bond shapes per cm2 is lower than 11.

5. A nonwoven web (21) according to any claims 1 to 4, wherein the ratio of the bond shapes on said surface relative to the total area of the surface is between 4 % and 18%, more preferably between 6 % and 16% and even more preferably between 8 % and 14%.

6. A nonwoven web (21) according to any of claims 3 to 5, wherein said calendering bonds (100) have a bond shape

   a. with the bond shape perimeter comprising a convex portion and

   b. wherein the bond shape is asymmetric or is oriented such that a straight line (104) intersecting the bond shape perimeter along the greatest measurable length (L)

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exists and forms an angle (αT) of between 1 degree and 40 degrees with the MD of the nonwoven web (21).

7. A nonwoven web (21) according to any of claim 3-5, wherein said calendering bonds (100) having a bond shape are arranged in a pattern of columns (112) and rows (110), said pattern exhibiting at least one of following conditions:

   a. each column (112) of like bond shapes is perpendicularly to the line offset with respect to both directly neighboring columns (112) by a distance of between 30% and 70% of the greatest measurable length (L) of the like bond shape;

   b. the points of the bond shapes tops (200) which form the machine directional end of bond shapes in directly neighboring columns (112) form isosceles triangle symmetric to the MD axis.

8. A nonwoven web (21) according to any of claims 1 to 7, wherein said propylene copolymer satisfies at least one of following conditions:

   a. heat of fusion of of about 75 J/g or less, preferably about 70 J/g or less, about 50 J/g or less, or about 35 J/g or less as measured according to described DSC method;

   b. a lower limit Hf of about 0.5 J/g, about 1 J/g, or about 5 J/g as measured according to described DSC method;

   c. melting point of about 100 °C or less, about 90 °C or less, about 80 °C or less, or about 70 °C or less as measured according to described DSC method;

   d. crystallinity of about 2% to about 65% of isotactic polypropylene;

   e. a melt flow rate (MFR) of about 0.5 to about 5000 dg/min, about 1 to about 2500 dg/min, about 1.5 to about 1500 dg/min, about 2 to about 1000 dg/min, about 5 to about 500 dg/min, about 10 to about 250 dg/min, about 10 to about 100 dg/min, about 2 to about 40 dg/min, or about 2 to about 30 dg/min as measured per ASTM D1238, 2.16 kg at 230° C;

   f. a density of about 0.850 to about 0.920 g/cm3, about 0.860 to about 0.900 g/cm3, preferably about 0.860 to about 0.890 g/cm3, at room temperature as measured per ASTM D-1505;

   g. an Elongation at Break of less than about 2000%, less than about 1000%, or less than about 800%, as measured per ASTM D412;

   h. a molecular weight distribution ("MWD") of about 1.5 to about 20, or about 1.5 to about 15, preferably about 1.5 to about 5, and more preferably about 1.8 to about 5, and most preferably about 1.8 to about 3 or about 4.

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9. A nonwoven web (21) according to any of claims 1 to 8, wherein said propylene copolymer comprises about 5 to about 35%, preferably about 5 to about 20%, more preferably about 10 to about 20% of ethylene-derived units by weight of the propylene-alpha-olefin copolymer.

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10. A nonwoven web (21) according to any of claims 1 to 9, wherein said propylene copolymer has a triad tacticity of three propylene units, as measured by 13C NMR according to description of at least about 75%, at least about 80%, at least about 82%, at least about 85%, or at least about 90%

10

11. A nonwoven web (21) according to any of claims 1 to 10, wherein the softness enhancer additive comprises chemical compounds having a nitrogen bond to organic chain, preferably being organic amine or amide.

15   12. A nonwoven web (21) according to claim 11, wherein said softness enhancer additive comprises one or more compounds selected from the group consisting of bis(2-hydroxyethyl) isodecyloxypropylamine, poly(5)oxyethylene isodecyloxypropylamine, bis(2-hydroxyethyl) isotridecyloxypropylamine, poly(5)oxyethylene isotridecyloxypropylamine, bis(2-hydroxyethyl) linear alkyloxypropylamine, bis(2-hydroxyethyl) soya amine,
20   poly(15)oxyethylene soya amine, bis(2-hydroxyethyl) octadecylamine, poly(5)oxyethylene octadecylamine, poly(8)oxyethylene octadecylamine, poly(10)oxyethylene octadecylamine, poly(15)oxyethylene octadecylamine, bis(2-hydroxyethyl) octadecyloxypropylamine, bis(2-hydroxyethyl) tallow amine, poly(5)oxyethylene tallow amine, poly(15)oxyethylene tallow amine, poly(3)oxyethylene-1,3-diaminopropane, bis(2-hydroxyethyl) cocoamine, bis(2-
25   hydroxyethyl)isodecyloxypropylamine, poly(5)oxyethylene isodecyloxypropylamine, bis(2-hydroxyethyl) isotridecyloxypropylamine, poly(5)oxyethylene isotridecyloxypropylamine, bis(2-hydroxyethyl) linear alkyloxypropylamine, bis(2-hydroxyethyl) soya amine, poly(15)oxyethylene soya amine, bis(2-hydroxyethyl) octadecylamine, poly(5)oxyethylene octadecylamine, poly(8)oxyethylene octadecylamine, poly(10)oxyethylene octadecylamine,
30   poly(15)oxyethylene octadecylamine, bis(2-hydroxyethyl) octadecyloxypropylamine, bis(2-hydroxyethyl) tallow amine, poly(5)oxyethylene tallow amine, poly(15)oxyethylene tallow amine, poly(3) oxyethylene-1,3-diaminopropane, bis(2-hydroxethyl) cocoamine, valeramide, caproicamide, erucamide, caprylicamide, pelargonicamide, capricamide, lauricamide, lauramide, myristicamide, myristamide, palmiticamide, palmitoleamide, palmitamide,
35   margaric (daturic) amide, stearicamide, arachidicamide, behenicamide, behenamide, lignocericamide, linoleamide, ceroticamide, carbocericamide, montanicamide, melissicamide,

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lacceroicamide, ceromelissic (psyllic) amide, geddicamide, 9-octadecenamide, oleamide, stearamide, tallow bis(2-hydroxyethyl)amine. cocobis(2-hydroxyethyl)amine, octadecylbis(2-hydroxyethyl)amine, oleylbis(2-hydroxyethyl)amine, ceroplastic amide, and combinations thereof.

5

13. A nonwoven (21) web according claim 11, wherein the softness enhancer additive comprises erucamide.

14. A nonwoven web (21) according to to any of claims 1 to 13, wherein said nonwoven material
10   exhibiting a softness factor of less than 180 kN/m, preferably less than 170 kN/m, more preferably less than 160 kN/m and even more preferably less than 150 kN/m.

15. A nonwoven web (21) according to any of claims 1 to 14, wherein said nonwoven material has fuzz lower than 0,3, preferably lower than 0,25, even more preferably lower than 0,2.

15

16. A method for producing a nonwoven web (21) comprising the steps of

    a. providing a mixture comprising propylene homopolymer, propylene copolymer and softness enhancer additive;

    b.   melting said mixture;

20 c.   feeding the mixture in an extrusion system to a spun melt system and forming heat bondable essentially endless fibres;

    d. forming a batt (21a) of said fibres on a moving belt;

    e. providing a first (50) and a second (51) roller having a first and a second surface, respectively, at least one of said rollers being heated, and said first (50) and
25   second (51) roller forming a nip (52),

        whereby at least the first of the surfaces comprises spaced apart bonding protrusions (100) surrounded by recessed areas (101);

        and whereby the bonding protrusions (100) have a greatest measurable length (L) and a greatest measurable width (W), wherein an aspect ratio of the
30   greatest measurable length (L) to the greatest measurable width (L) is at least 2.5.

        and wherein further

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    A. either

        i.   the perimeter of the shape of said bonding protrusions (100) comprises a convex portion (103) and

        ii.   the shape of said bonding protrusions (100) is asymmetric

        iii.   or said bonding protrusions (100) are oriented such that a straight line (104) intersecting said perimeter of the shape of said bonding protrusions (100) along the greatest measurable length (L) exists and forms an angle αT of between 1 degree and 40 degrees with the MD of the nonwoven (21),

    B. or

        i.   the bonding protrusions (100) are arranged in a pattern of columns (112) and rows (110), said pattern exhibiting at least one of following conditions:

                I.   each column (112) of bonding protrusions with like shape is offset with respect to both directly neighboring columns (112) by a distance of between 30 and 70% of the greatest measurable length (L) of the like bonding protrusion (100) measured perpendicularly to the line connecting the bonding protrusions in a column (112);

                II.   the points of the bonding protrusions tops (200), which form the machine directional end of bonding protrusions (100), of three directly neighboring columns (112) form isosceles triangle symmetric to the MD axis,

  f. feeding said batt (21a) into said nip (52), thereby compressing said batt (21a) in said nip (52) between said first (50) and said second (51) roller, such that the positioning of said fibres of said batt (21a) is affected by said bonding protrusions (100) directly or indirectly by affecting the airflow in said nip (52);

  g. bonding said batt (21a) in said nip (52) by contacting said batt (21a) with said bonding protrusions (100) of the first surface and the second surface thereby forming consolidating bonds;

  h. removing the web (21) from the nip (52).

17. A method for producing a nonwoven web (21) according to the claim 16, wherein the mixture comprising propylene homopolymer, propylene copolymer and softness enhancer additive comprise

    a.   between 10% a and 20% of propylene copolymer, preferably between 14 and 18% of propylene copolymer; and / or

    b.   between 0,01% to 10% of softener enhanced additive, preferably between 0,03% to 5%, more preferably between 0,05% to 1% and even more preferably 0,1% to 0,5% by weight of the produced fibres; and / or

    c.   at least 60%, preferable at least 70% , even more preferably at least 80% of prolypropylene homopolymer.

18. A method according to any of claim 16 or 17, wherein the temperature of said molten mixture does not exceed a maximum temperature which is at least 20°C below the TGA Rapid weight loss temperature of the softness enhancer additive, preferably at least 25°C below.

19. A method according to any of claims 16 to 18, wherein the softness enhancer additive comprises chemical compounds having a nitrogen bond to organic chain, preferably being organic amine or amide.

20. A method according to any of claims 16 to 19, wherein said softness enhancer additive comprises one or more compounds selected from the group consisting of bis(2-hydroxyethyl) isodecyloxypropylamine, poly(5)oxyethylene isodecyloxypropylamine, bis(2-hydroxyethyl) isotridecyloxypropylamine, poly(5)oxyethylene isotridecyloxypropylamine, bis(2-hydroxyethyl) linear alkyloxypropylamine, bis(2-hydroxyethyl) soya amine, poly(15)oxyethylene soya amine, bis(2-hydroxyethyl) octadecylamine, poly(5)oxyethylene octadecylamine, poly(8)oxyethylene octadecylamine, poly(10)oxyethylene octadecylamine, poly(15)oxyethylene octadecylamine, bis(2-hydroxyethyl) octadecyloxypropylamine, bis(2-hydroxyethyl) tallow amine, poly(5)oxyethylene tallow amine, poly(15)oxyethylene tallow amine, poly(3)oxyethylene-1,3-diaminopropane, bis(2-hydroxyethyl) cocoamine, bis(2-hydroxyethyl)isodecyloxypropylamine, poly(5)oxyethylene isodecyloxypropylamine, bis(2-hydroxyethyl) isotridecyloxypropylamine, poly(5)oxyethylene isotridecyloxypropylamine, bis(2-hydroxyethyl) linear alkyloxypropylamine, bis(2-hydroxyethyl) soya amine, poly(15)oxyethylene soya amine, bis(2-hydroxyethyl) octadecylamine, poly(5)oxyethylene

octadecylamine, poly(8)oxyethylene octadecylamine, poly(10)oxyethylene octadecylamine, poly(15)oxyethylene octadecylamine, bis(2-hydroxyethyl) octadecyloxypropylamine, bis(2-hydroxyethyl) tallow amine, poly(5)oxyethylene tallow amine, poly(15)oxyethylene tallow amine, poly(3) oxyethylene-1,3-diaminopropane, bis(2-hydroxethyl) cocoamine, valeramide, caproicamide, erucamide, caprylicamide, pelargonicamide, capricamide, lauricamide, lauramide, myristicamide, myristamide, palmiticamide, palmitoleamide, palmitamide, margaric (daturic) amide, stearicamide, arachidicamide, behenicamide, behenamide, lignocericamide, linoleamide, ceroticamide, carbocericamide, montanicamide, melissicamide, lacceroicamide, ceromelissic (psyllic) amide, geddicamide, 9-octadecenamide, oleamide, stearamide, tallow bis(2-hydroxyethyl)amine. cocobis(2-hydroxyethyl)amine, octadecylbis(2-hydroxyethyl)amine, oleylbis(2-hydroxyethyl)amine, ceroplastic amide, and combinations thereof.

21. A method according to any claims 16 to 19, wherein the enhance softness additive comprises erucamide.

22. A method according to claim 16, wherein the propylene copolymer exhibiting at least one of following conditions

    a.   heat of fusion of of about 75 J/g or less, preferably about 70 J/g or less, about 50 J/g or less, or about 35 J/g or less as measured according to described DSC method;

    b.   a lower limit Hf of about 0.5 J/g, about 1 J/g, or about 5 J/g as measured according to described DSC method;

    c.   melting point of about 100 °C or less, about 90 °C or less, about 80 °C or less, or about 70 °C or less as measured according to described DSC method;

    d.   crystallinity of about 2% to about 65% of isotactic polypropylene;

    e.   a melt flow rate (MFR) of about 0.5 to about 5000 dg/min, about 1 to about 2500 dg/min, about 1.5 to about 1500 dg/min, about 2 to about 1000 dg/min, about 5 to about 500 dg/min, about 10 to about 250 dg/min, about 10 to about 100 dg/min, about 2 to about 40 dg/min, or about 2 to about 30 dg/min as measured per ASTM D1238, 2.16 kg at 230° C;

    f.   a density of about 0.850 to about 0.920 g/cm3, about 0.860 to about 0.900 g/cm3, preferably about 0.860 to about 0.890 g/cm3, at room temperature as measured per ASTM D-1505;

g.   an Elongation at Break of less than about 2000%, less than about 1000%, or less than about 800%, as measured per ASTM D412;

h.   a molecular weight distribution ("MWD") of about 1.5 to about 20, or about 1.5 to about 15, preferably about 1.5 to about 5, and more preferably about 1.8 to about 5, and most preferably about 1.8 to about 3 or about 4.

23. A method according to any claims 16 or 22, wherein propylene copolymer comprises of about 5 to about 35%, preferably about 5 to about 20%, more preferably about 10 to about 20% of ethylene-derived units by weight of the propylene-alpha-olefin copolymer.

24. A method according to any claims 16 or 22 or 23, wherein propylene copolymer have a triad tacticity of three propylene units, as measured by 13C NMR according to description of at least about 75%, at least about 80%, at least about 82%, at least about 85%, or at least about 90%
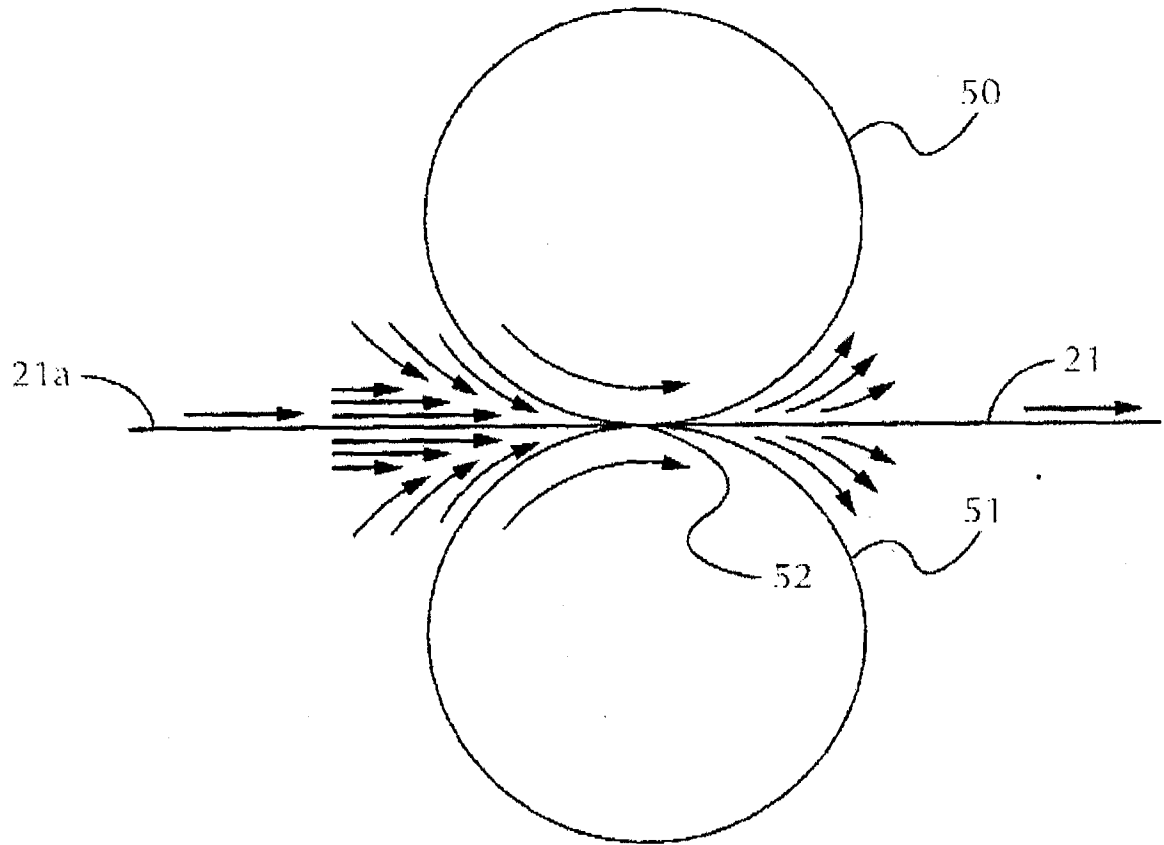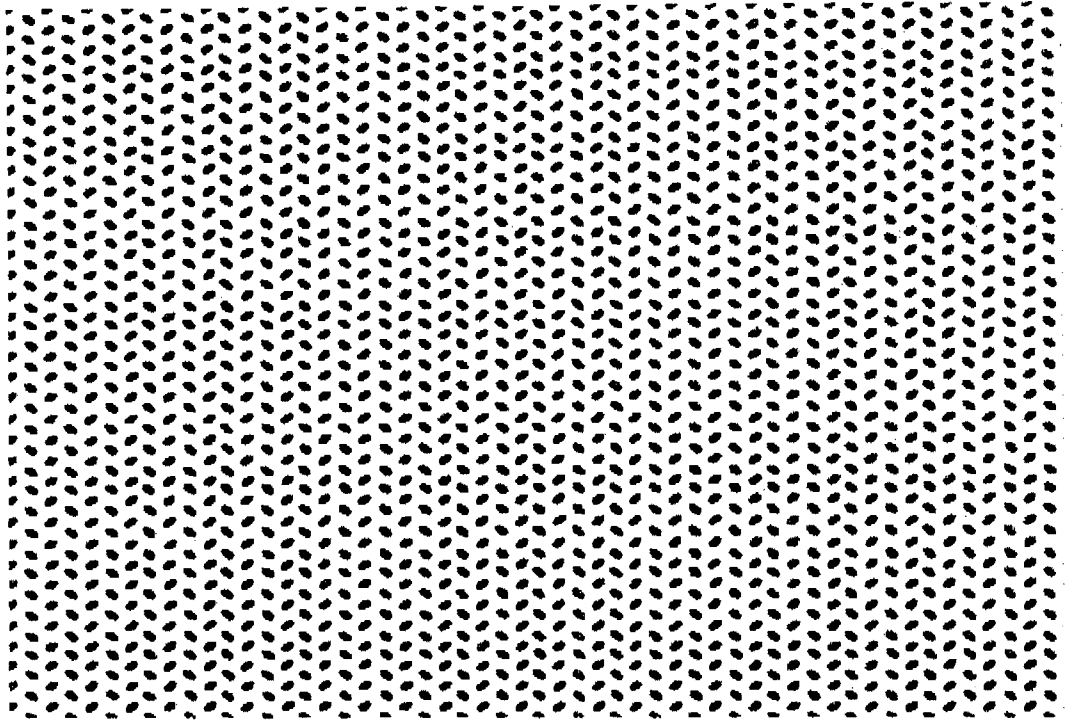
Fig. 1
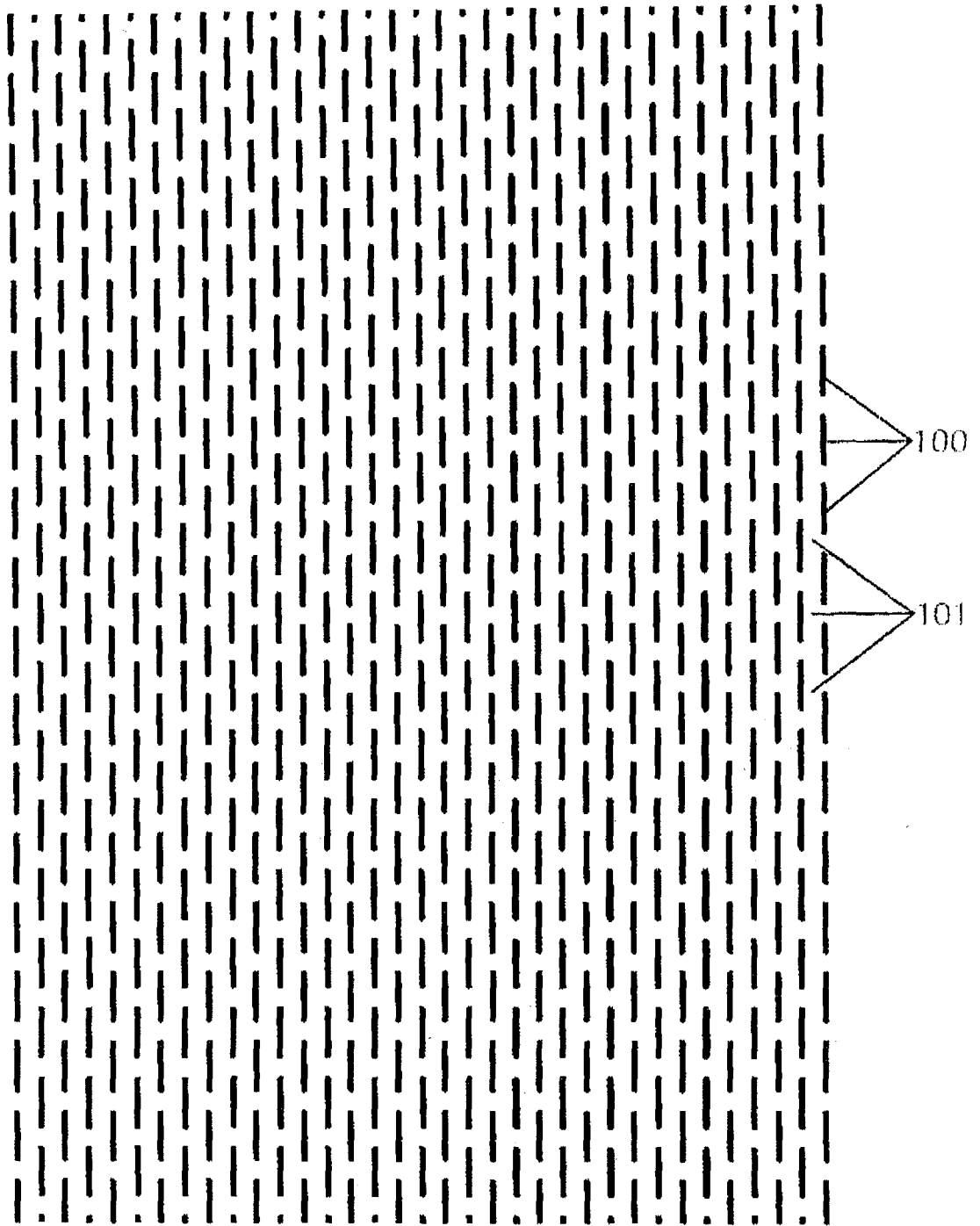
Fig. 2A
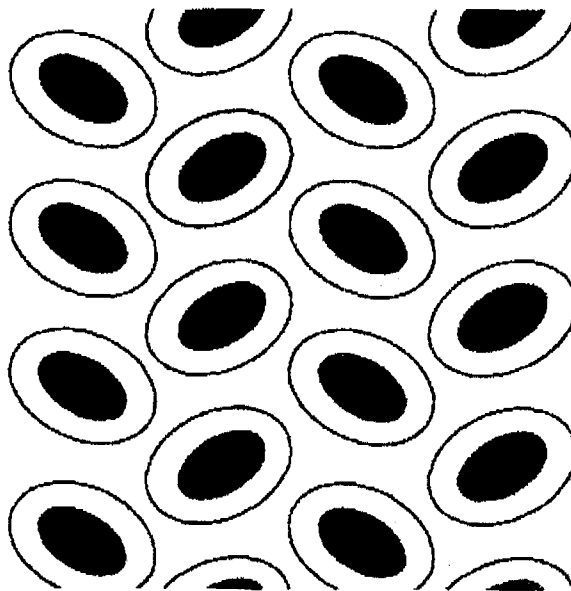
Fig. 2B

Fig. 2C
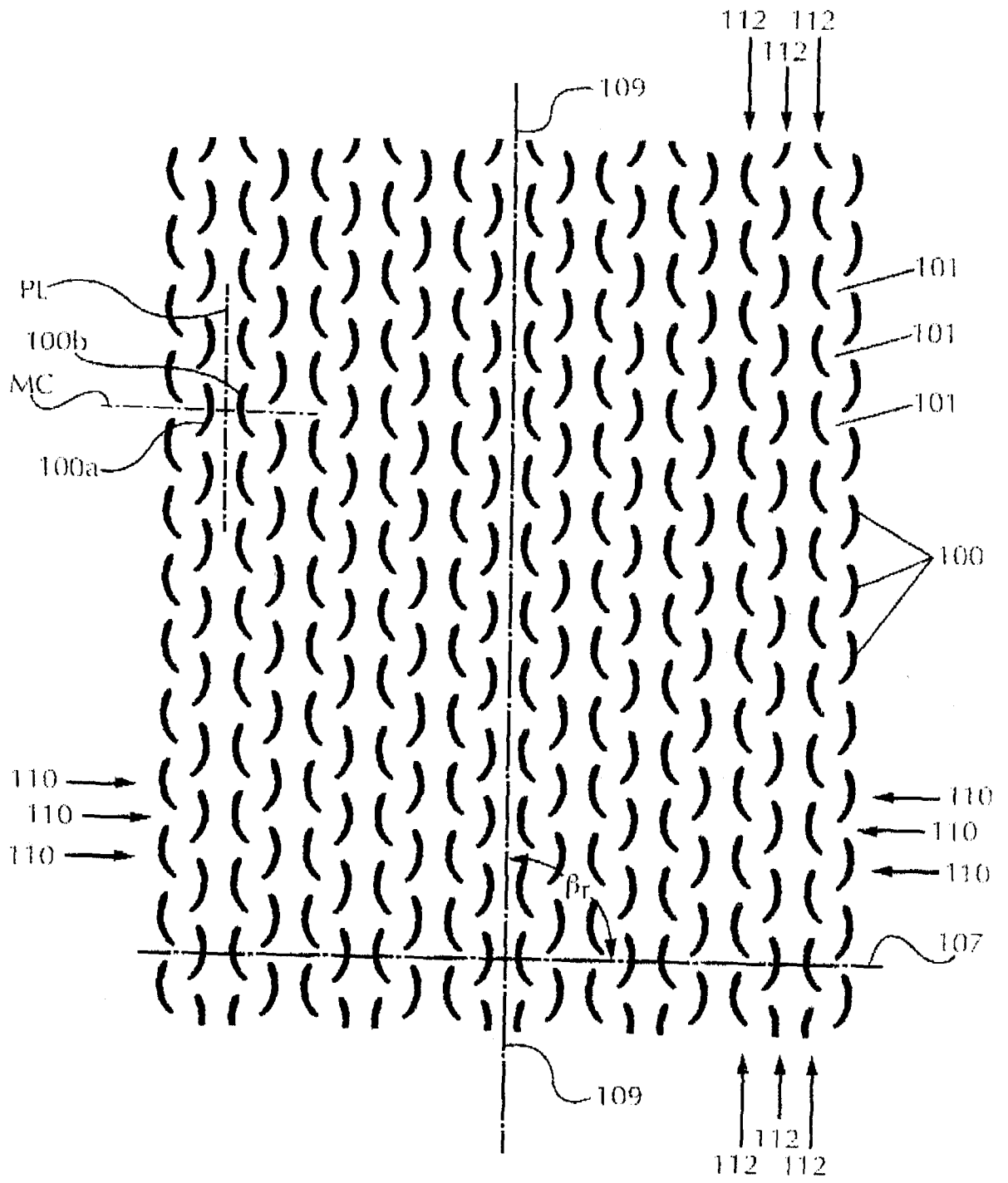
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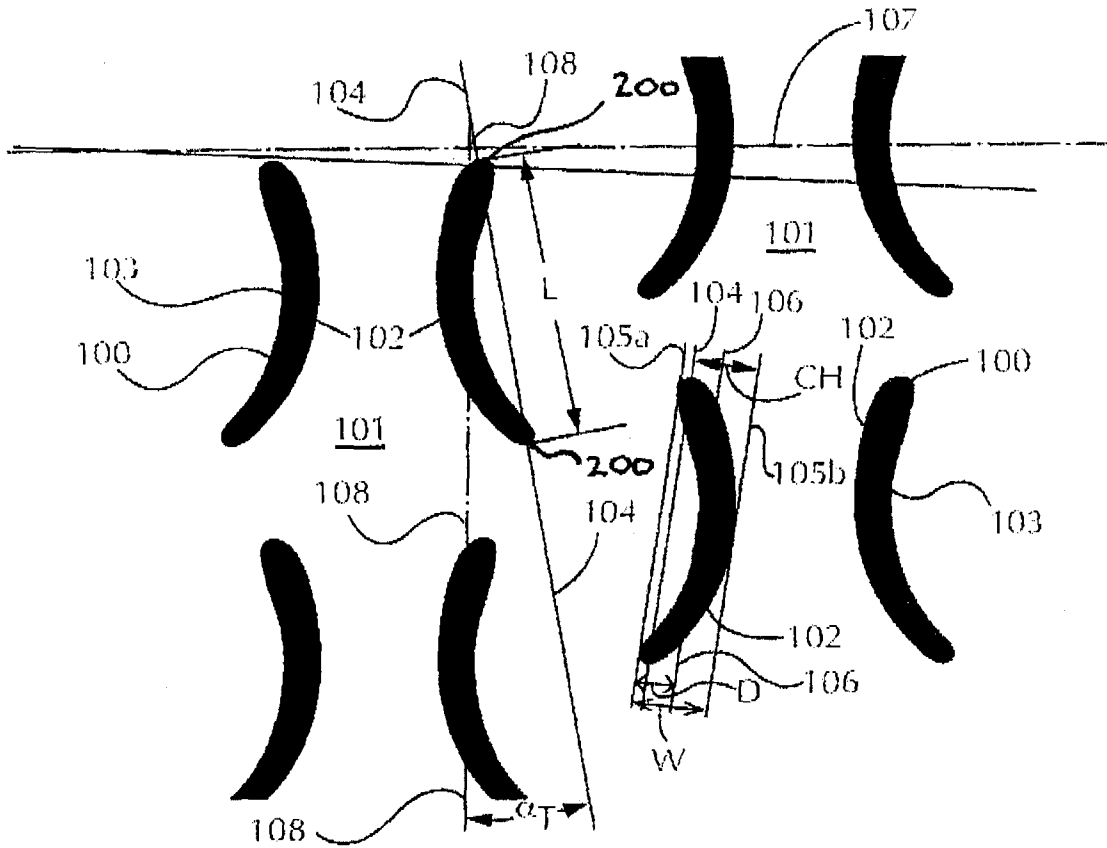
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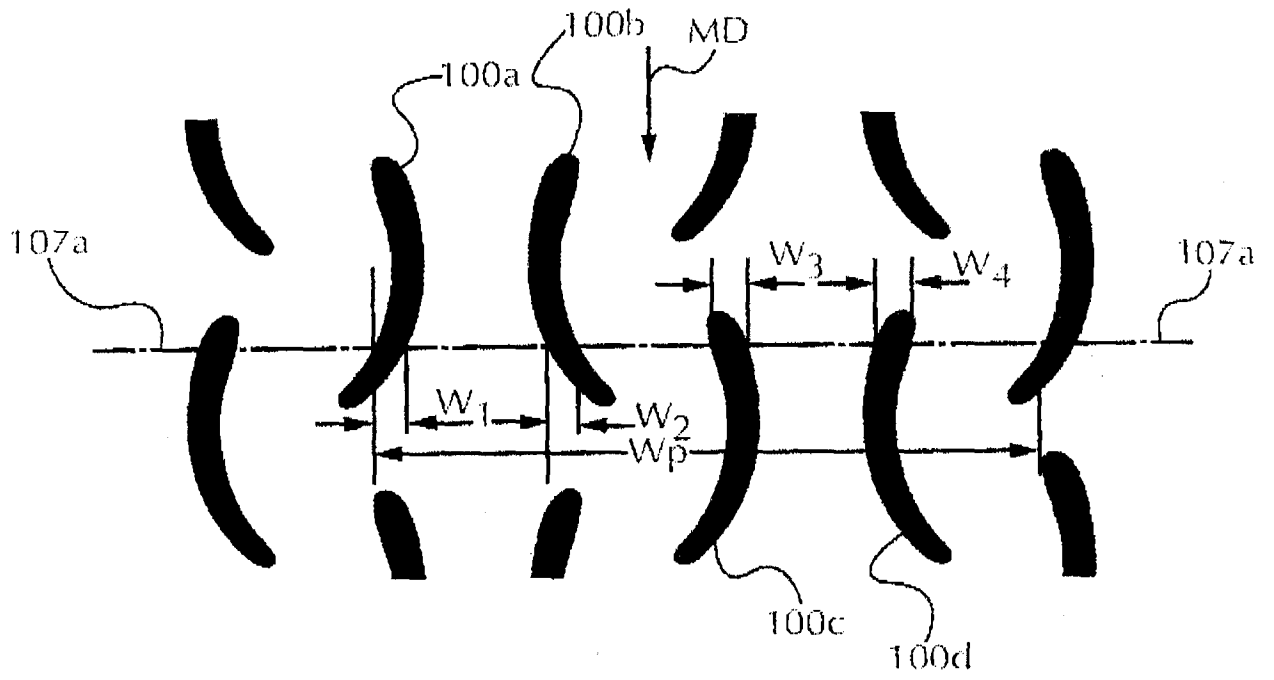
Fig. 3C
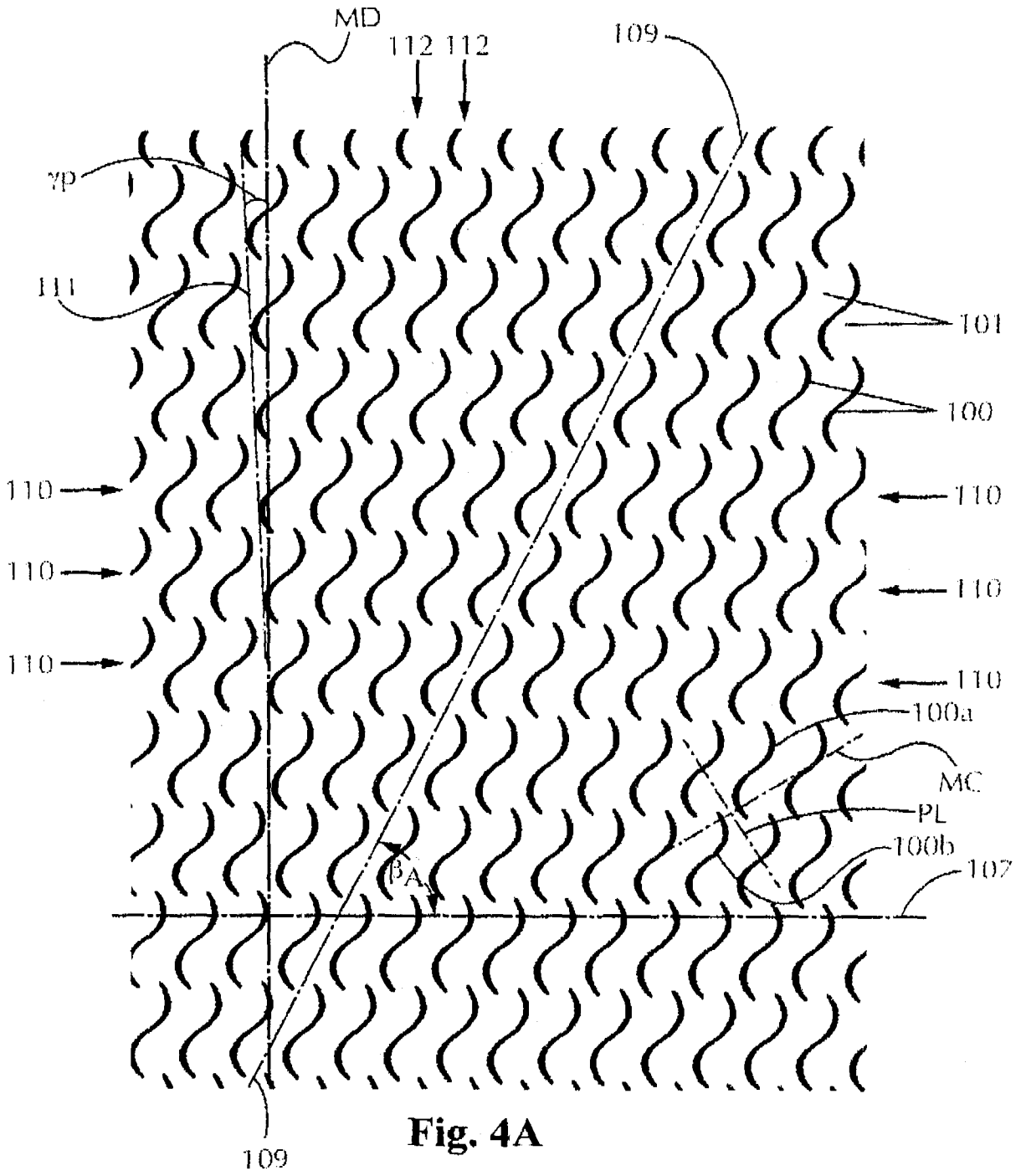
Fig. 4A
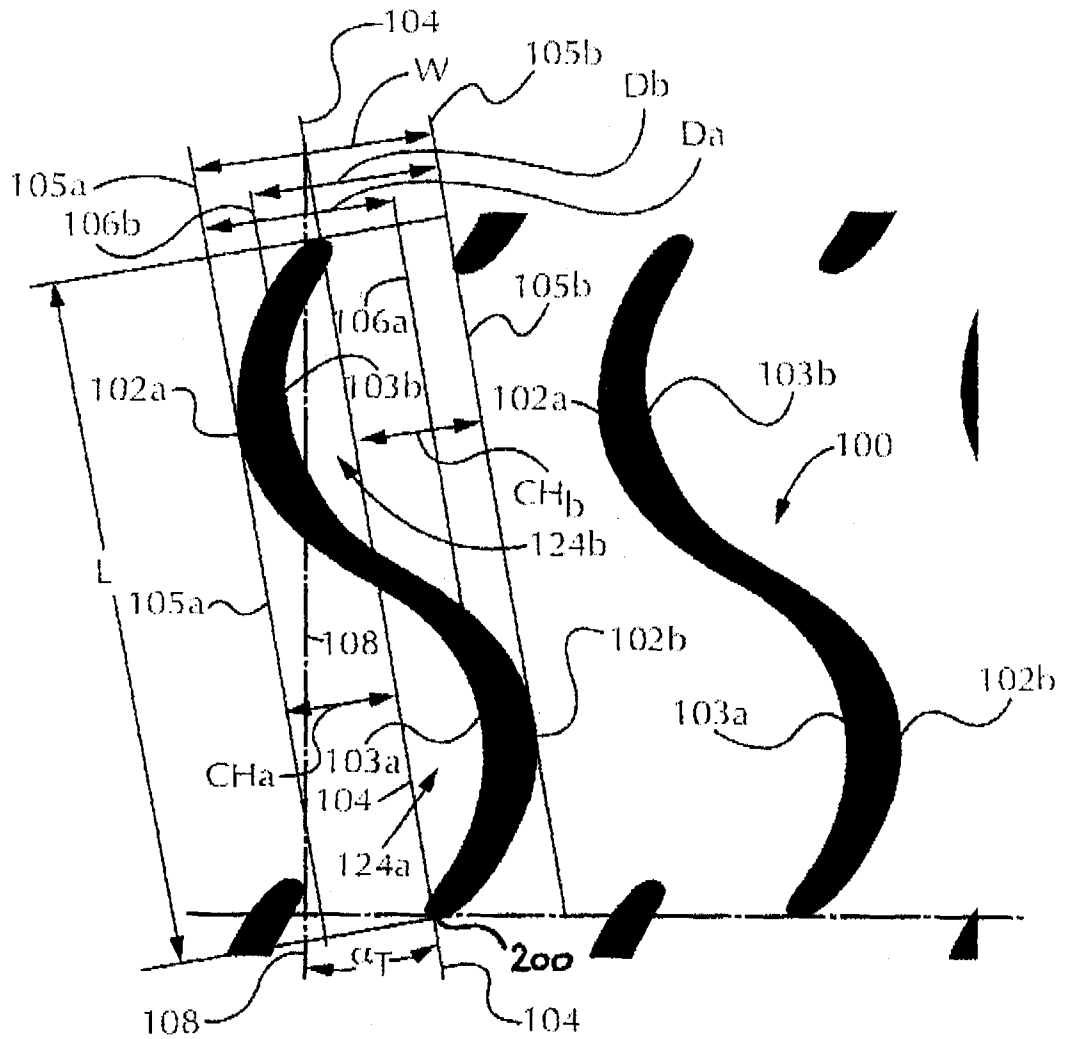
Fig. 4B
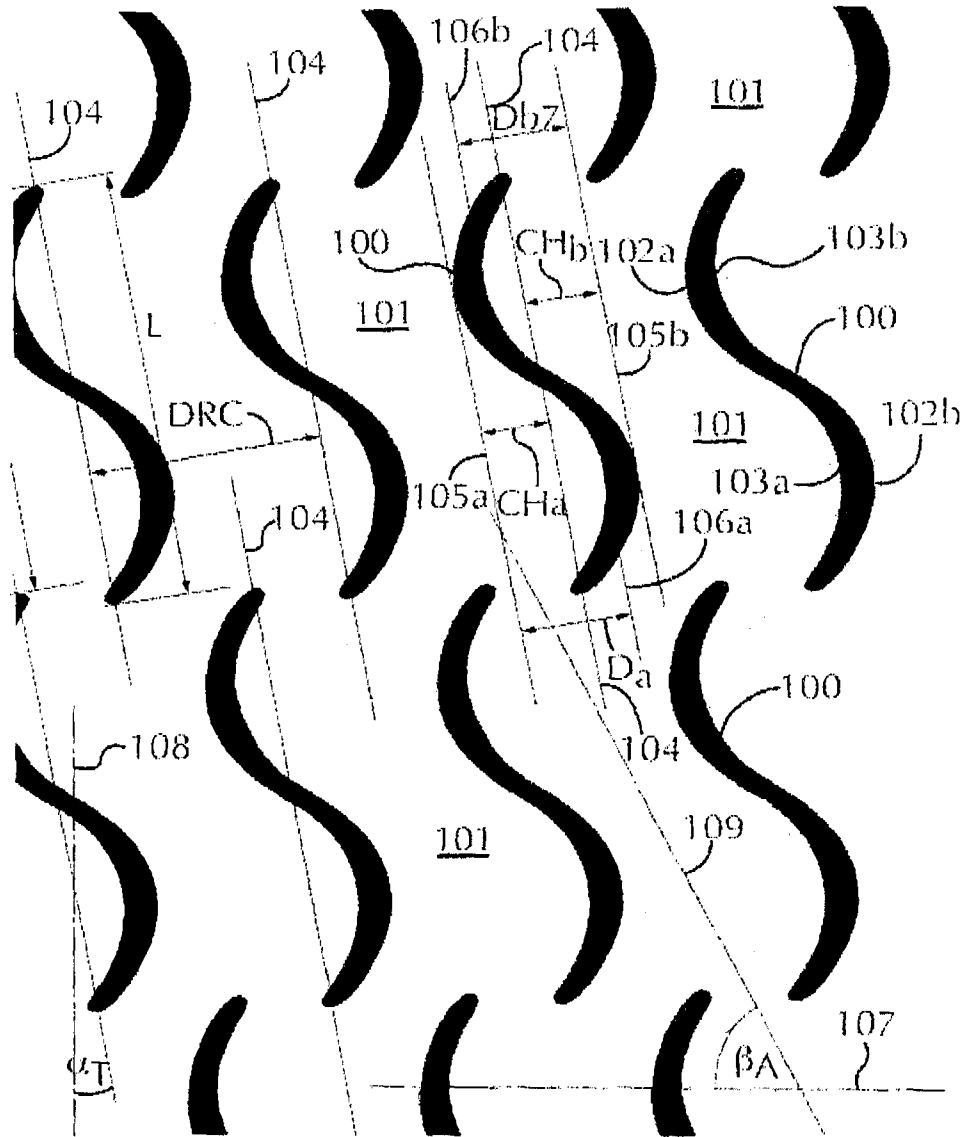
Fig. 5

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. D04H3/007   D04H3/147   D04H3/16   D01D1/10   D01F6/06
D01F8/06
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

D04H   D01D   D01F   B29C

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 November 2013	27/11/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Barathe, Rainier

C(Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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