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Henderson

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[54] **NONWOVEN POLYPROPYLENE FABRIC**

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[52] **U.S. Cl.** **161/59,** 161/57, 161/62, 161/152, 161/156

[51] **Int. Cl.** **B32b 5/12**

[58] **Field of Search** 161/59, 62, 152, 156

[56] **References Cited**

UNITED STATES PATENTS

2,315,851	4/1943	Goldman	161/59
2,454,175	11/1948	Hlavaty	161/59
3,313,002	4/1967	Wyeth	425/85
3,322,607	5/1967	Jung	161/67
3,477,103	11/1969	Troth	19/163
3,546,062	12/1970	Herrman	161/169
3,563,838	2/1971	Edwards	161/57

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[57] **ABSTRACT**

A length of layered nonwoven bonded continuous filament isotactic polypropylene fabric having a high level of unlatexed tear strength at a reasonable level of neckdown and which retains a high proportion of this tear resistance even after latexing.

3 Claims, 3 Drawing Figures

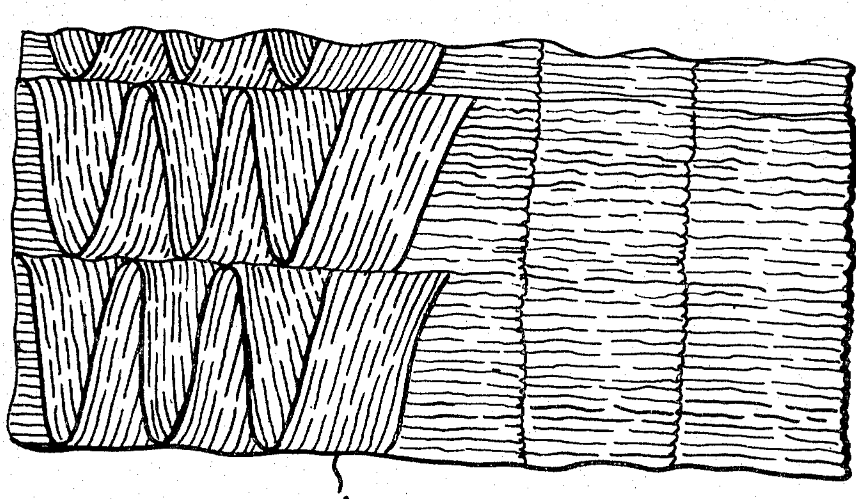

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FIG. 1

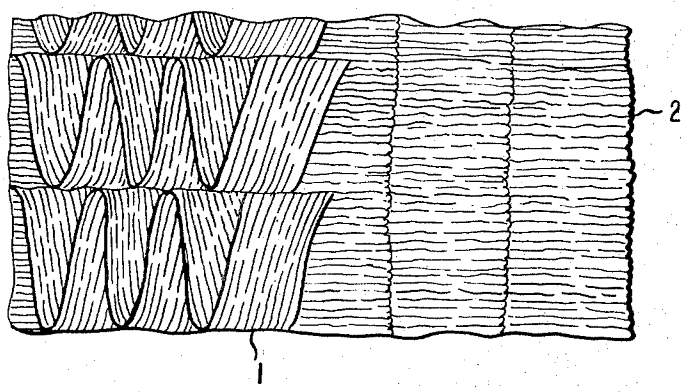


FIG. 3

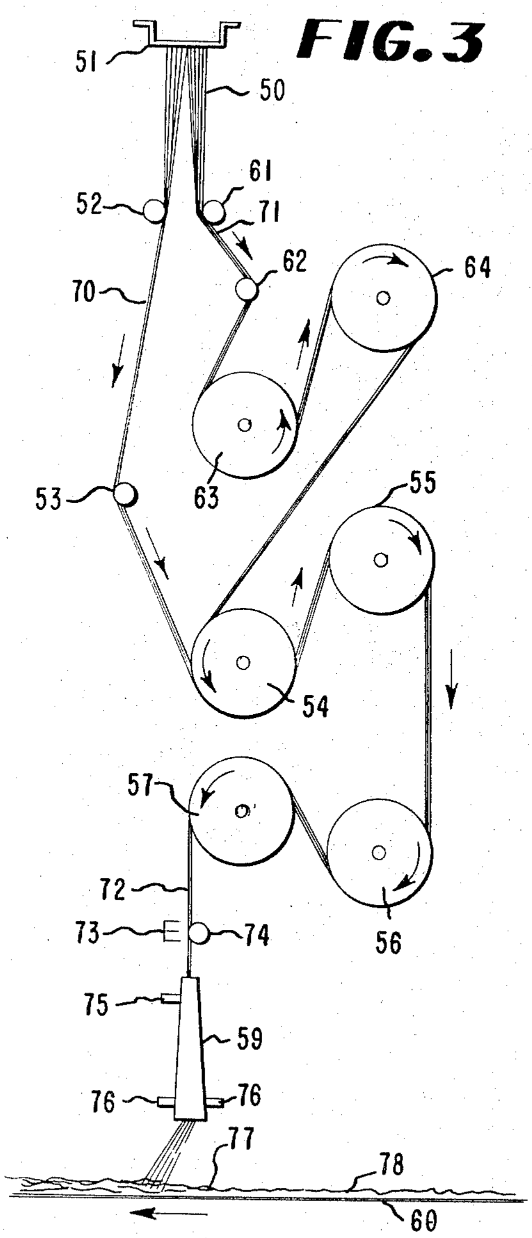
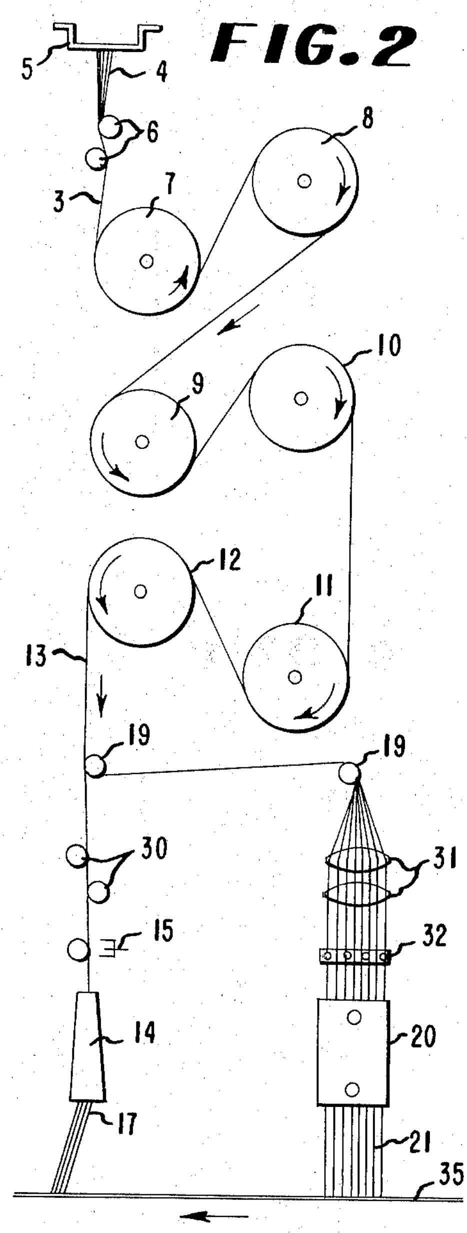


FIG. 2



NONWOVEN POLYPROPYLENE FABRIC

BACKGROUND OF THE INVENTION

This invention provides an improved nonwoven primary carpet backing for use in preparing tufted pile carpet.

Nonwoven webs of directionally-laid polypropylene continuous filaments have been disclosed in Edwards U.S. Pat. No. 3,563,838. The nonwoven webs of Edwards are useful for preparing carpets with high resistance to tearing in the machine direction, high resistance to stretch in the machine direction and a coincident high resistance to neckdown in the cross-direction when stressed in the lengthwise direction. The specified directionality of the Edwards patent is responsible also for providing a high resistance to bias deformation. Carpet backings of the Edwards type may be prepared and bonded by a number of methods. In Herrman U.S. Pat. No. 3,546,062 a method is described for preparing sheets of randomly distributed filaments wherein the binder in the sheet is derived from segments in the filaments which are less highly drawn than other segments. These less drawn segments, being lower melting than the highly drawn segments, serve as bonding agents for the nonwoven web when the webs are heated. Herrman also discloses the use of mixtures of filaments wherein some of the filaments are highly drawn and other filaments are less drawn.

It is an established practice in the tufting industry to apply a latex of synthetic or natural rubber to the backside of tufted carpets to provide a secure anchoring for the pile yarns in the carpet backing. It has been discovered that the latex tends to promote a reduction in tear strength. The purpose of the present invention is to provide a nonwoven polypropylene carpet backing which has a high level of unlatexed tufted tongue tear strength at reasonable levels of neckdown and which retains a high proportion of its tear resistance even after latexing.

SUMMARY OF THE INVENTION

The product of the invention is a length of layered nonwoven bonded continuous filament isotactic polypropylene fabric comprising a machine direction layer constituting from 40 to 60 percent of the fabric weight and so disposed as to provide one surface of the fabric and a cross-machine direction layer which constitutes from 40 to 60 percent of the fabric weight, each of the said layers consisting essentially of binder fiber and matrix fiber, the latter having a denier/filament of at least 12 (averaged for the machine direction and cross-machine direction layers) and a tenacity of at least 2.5 gpd. (averaged for the machine direction and cross-machine direction layers), the said machine direction layer containing from 18 to 50 percent by weight of binder fiber and exhibiting an MD_L/XD_L value of at least 3.0 and said cross-machine direction layer containing from 18 to 50 percent by weight of binder fiber and exhibiting an XD_L/MD_L value of at least 3.0 wherein XD_L is a measure of the total filament length of each layer in the direction perpendicular to the fabric length direction, and MD_L is a measure of the total filament length of each layer in the fabric length direction, the filaments of the layered fabric being disposed in such a manner to provide the following directionality values for the layered fabric:

$$XD/45° \gtrsim 1.5,\ MD/45° \geq 1.5,$$

and

$$MD+XD/45° = 3.5 \text{ to } 30$$

wherein XD is a measure of the total filament length of the layered fabric in the direction perpendicular to the fabric length direction, MD is a measure of the total filament length of the layered fabric in the fabric direction and 45° is the average of the measures of the total filament length of the layered fabric in the directions at 45° to the fabric length direction, wherein XD, MD, 45°, XD_L and MD_L are measures determined by the randometer method.

In a particularly preferred form of the invention the amount of binder fiber in the machine direction layers is at least 1.2 × the amount of binder fiber in cross-machine direction layers. The binder fiber has a lower orientation than the matrix fiber as described more particularly below. The binder fiber may be separate from the matrix fiber or present as segments which alternate with matrix segments in the filaments of the fabric.

THE DRAWINGS

FIG. 1 is a schematic representation of a fabric of the *MX* type as described herein. The figure shows the sheet in the process of being deposited on a surface moving from right to left.

FIG. 2 is an apparatus arrangement as used for Examples I and II.

FIG. 3 is an apparatus arrangement as used in Example III.

DETAILED DESCRIPTION OF THE INVENTION

The product of the invention is a bonded nonwoven fibrous sheet comprising two or more layers having a differing average directionality of filaments. It may be prepared following the general techniques described in Edwards U.S. Pat. No. 3,563,838 and as shown schematically in FIG. 5 of that patent, one layer, the lower layer, is composed primarily of filaments whose major directional component is along the machine direction of the sheet while another layer, the upper layer, is composed primarily of filaments whose major directional component is across the machine direction of the fabric length. The relative lengths of fiber oriented in various directions in each layer is determined by use of the randometer technique described in said Edwards patent.

The layer of the sheet composed primarily of filaments whose major directional component is across the machine direction of the fabric length has been termed herein as the X layer while the layer whose major fiber directional component is in the machine direction of the fabric length has been termed the M layer. In FIG. 1 layer 2 is composed of fibers deposited with their major directional component in the machine direction and this layer is termed the M layer. Layer 1 is composed of filaments whose major directional component is in the cross machine direction and this layer is termed the X layer. For convenience in discussing process the layers may be indicated by a sequence of letters indicating the order of laydown with the first letter indicating the bottom layer of the sheet and so forth. Since the sheet may be observed later on from either side, only the relative placement of layers is important in characterizing the product. Using this description

XM indicates, for example, that the X layer is laid down first on a moving belt and the M layer is deposited on the X layer. An MX-laid sheet has the machine layer deposited first and the X layer second. Obviously a large number of jets may be used across the width of a collecting belt to deposit a single M layer or X layer. In addition several banks of jets may be used in succession. If successive banks of jets deposit filaments in the same general direction, then the collected material may be considered to be a single layer. An MXM-laid sheet is prepared by successively depositing a machine direction layer, a cross-machine direction layer, and another machine direction layer.

As mentioned previously, it is the practice to apply latex to the backing of carpeting material after it has been tufted. In general, sufficient latex is applied to penetrate about one half the thickness of the backing. It is important that the portion containing the latex be machine direction since this layer does not contribute appreciably to tear strength in the machine direction (which is most important to carpet manufacturers) and since the tear strength is reduced by application of latex. On the other hand the fibers laid in the cross-machine direction should be preserved so far as possible in their unlatexed condition. For this reason, the M layer should provide one surface of the fabric while the X layers should be present to the extent of at least 40 percent by weight and should be predominantly in that half of the fabric opposite the side that is latexed.

The bonded nonwoven sheet of the invention can be produced in low weights which are more economical than previous sheets and which nevertheless provide the carpet manufacturer with a carpet backing which can be tufted to produce carpets with high tufted tongue tear before or after latexing. For example, 3 oz./yd.^{2} sheets of the invention provide tufted carpets with an unlatexed tufted tongue tear of at least 55 lbs. at a neckdown of 1 percent and a latexed tufted tongue tear at about 50 percent penetration which is at least 70 percent of the unlatexed tufted tongue tear strength.

DESCRIPTION OF THE PROCESS

A process similar to the present one has been described in the aforementioned Edwards patent. Referring to FIG. 2, a ribbon of filaments 3 is obtained by extruding filaments 4 from spinneret 5, quenching the filaments and passing them over guides 6. The ribbon of parallel filaments passes successively over rolls **7, 8, 9, 10, 11** and **12.** The yarn travels at increasingly greater speed at each successive roll. A significant speed increase can occur between rolls **8** and **9** and usually between rolls **10** and **11** thereby providing an increase in molecular orientation (draw). Drawing is assisted by heating the filaments or portions thereof at rolls **8** and **10.** Since roll **8** is a smooth cylindrical roll, uniform drawing is obtained between rolls **8** and **9.** Roll **10,** however, is a fluted roll and has grooves running along its surface in the axial direction. Segments of the yarn which touch the hot surface of the roll between grooves are drawn additionally but those segments suspended over the grooved portions are not drawn additionally. The resulting filaments **13** have alternate highly oriented and less oriented segments along their length. The filaments then pass to a slot jet **14** of the type shown in FIG. 6 of the Edwards patent. The ribbon of filaments **13** passes around convex rolls **30** which widen the ribbon and then the filaments are electrostatically charged upon passing across the target bar of a corona charging device **15** such as that described in DiSabato, et al. U.S. Pat. No. 3,163,753. The ribbon of electrostatically charged continuous filaments is sucked into the orifice of slot jet **14** and issues from the slot jet exit **17**, to deposition on a belt **35** moving in the indicated direction. The width of the descending ribbon is in the cross-machine direction. A pulse of air is supplied at the jet exit alternately from one side of the moving ribbon of filaments and then from the other to deflect the ribbon and create a swath with filaments predominantly aligned in the machine direction. The output from one or more additional spinnerets is handled in a similar manner but is deposited with alignment primarily in the cross-machine direction.

Optionally the ribbon of filaments **13** may be divided, with part of the filaments proceeding as previously described and part passing over snub pins **19** over convex rolls **31** through corona charging means **32** and through slot **20** aligned at right angles to jet **14.** Filaments **21** exiting slot jet **20** are alternately pulsed to provide a swath with filaments predominantly aligned in the cross-machine direction.

In FIG. **3** filaments **50** extruding from the spinneret **51** are divided into two streams. One passes over guide rolls **52** and **53** to rolls **54, 55, 56** and **57** through a charging means comprising a multipointed electrode **73** and grounded cylindrical electrode **74** and into slot **59** for deposition on a moving belt **60.** The other group of filaments issuing from the spinneret pass around guide rolls **61** and **62** then over rolls **63** and **64** to roll **54** where they combine with the first group of filaments and continue as a single group. A swath of filaments **77** predominantly aligned in the machine direction is deposited. A similar arrangement of apparatus upstream with the slot jet at right angles to slot jet **59** is utilized to provide a layer with filaments **78** predominantly in the cross-machine direction.

Preferably the filaments are bonded by passage through saturated steam as described in Jung, U.S. Pat. No. 3,322,607 using a bonder of the type described in Wyeth, U.S. Pat. No. 3,313,002. A finish is applied to avoid excessive fiber breakage during tufting. The finish is preferably a polysiloxane as described in Jung U.S. Pat. No. 3,322,607. Excessive shrinkage is avoided by restraining the sheet through bonding. The degree of bonding affects the properties of the nonwoven product. As bonding temperature increases the neckdown of the tufted substrate decreases to a minimum value. At the same time increasing bonding temperature causes the tufted tongue tear values to pass through a maximum value and then to decrease again. A balance of neckdown and tufted tongue tear properties is needed for carpet backing. Desirable products have 5 to 0.1 percent neckdown, the precise values varying with the intended use.

TEST METHODS

Directionality

In the examples, measurements are given for directionality of filaments in layers of the bonded sheet. These measurements are made in a manner similar to that described in Edwards U.S. Pat. No. 3,563,838 at column 9, lines 43–54. After the bonded sheet has been separated into X and M direction layers, the measurements are made optically on each layer by use of the randometer described in Edwards and the results averaged in proportion to the weight of the layers in the bonded sheet. For example, *XD*/45° is a measure of the total filament length in the bonded sheet in the cross-machine direction divided by the average of the total filament length in the bias direction. The term *MD*/45° is a measure of the total filament length in the bonded sheet in the machine direction divided by the average of the total filament length in the bias direction. It should be understood that in these terms, 45° is not a divisor but is simply a symbol for filament length in the bias direction. Other details on the determination of the directionality factors including use of the randometer for the determination are found in the Edwards patent. In addition, the measurements of XD_L and MD_L are determined for each layer. XD_L is a measure of the total filament length of a layer in the direction perpendicular to the fabric length direction and MD_L is a measure of the total filament length of a layer in the fabric length direction.

Tufted Tongue Tear

The machine direction tufted tongue tear strength of a tufted nonwoven fabric may be measured in the following manner: A bonded nonwoven MX fabric is lubricated with about 2 percent by weight of polymethylhydrogen siloxane. A sample of the lubricated sheet is cut along its length (in the machine direction) to form a strip 8 inches wide. The strip is mounted in a tufting machine so that the needles penetrate the sheet from the M-laid side, leaving tufts on the X-laid side of the sheet. The tufting machine has needles spaced 0.188 inch apart (3/16 gauge). The fabric is tufted in the machine direction over a width of 6 inches with a 3,700-denier crimped continuous filament yarn at 7 tufts/inch to provide a loop pile carpet with 0.438 inch pile height leaving 1 inch of untufted sheet on each side of the tufted portion. The tufted substrate with 1 inch selvage on each side is cut to prepare samples 8 inches (20.3 cm.) long (machine direction). To determine the tufted tear strength, a machine direction cut is made in a prepared 8 inch × 8 inch sample starting at the center of one end and proceeding in the machine (tufting) direction for 4 inches (10.2 cm.). The sample is mounted in an Instron tensile tester using 1.5 inch (3.8 cm.) by 2 inch (5.1 cm.) serrated clamps. With a jaw separation of 3 inches (7.6 cm.), one side of the cut portion is mounted in the upper jaw and the other side of the cut portion is mounted in the lower jaw, giving a 180° change in direction for the sheet at the tear point. The width of the sample is uniformly spaced between the jaws. The full scale load is adjusted to a value greater than the tear strength expected for the sample. Using a crosshead speed of 12 inches (30.5 cm.) per minute and a chart speed of 10 inches (25.4 cm.) per minute, the tensile tester is started and the movement of the crosshead causes the sample to be torn. Stress is measured in the usual manner. An average of the three highest stresses (one hundred units = full scale deflection) during tearing is taken for each specimen. If it is not possible to obtain three peaks, the average of the peaks obtained is taken. The tongue tear strength in pounds is the average stress divided by 100 and multiplied by the full scale load.

Latexed Tongue Tear

Latexed tongue tear is a measure of the ability of the finished carpet to withstand tearing forces after latexing. A latex comprising three parts of Uniroyal 3912 latex (70.4 percent solids) and one part of Uniroyal 3911 latex (71.0 percent solids) is prepared. The 3912 product is an aqueous dispersion wherein the solid elastomeric particles are 60 weight percent styrene and 40 weight percent butadiene. The 3911 product is similar, but has 40 weight percent styrene and 60 weight percent butadiene in the solid elastomer particles. An amount of the blended latex is applied to the back of the tufted carpet equivalent to about 10 times the weight of the carpet backing in the sample. The latex is spread uniformly using rollers of different weight depending on the required level of latex penetration. Several samples are tested, the amount of latex penetration differing in each of the samples. The degree of penetration is also dependent on the latex viscosity and the weight of the roller. After drying and curing at 125°C. the degree of penetration is determined on the various samples as follows: (1) Determine the weight (W_1) of an unlatexed detufted, sample of area A, (2) In a latexed detufted sample of the same area delaminate and remove all of the fibers that are not penetrated (wetted) by latex and determine their weight W_2, (3) The percent penetration P is determined by the formula $P = W_1 = W_2/W_1 \times 100$. A more approximate method for determining percent penetration is to delaminate the sample and observe the approximate depth of unpenetrated sheet material. Latexed samples prepared with varying amounts of latex are tongue tear tested by the same procedure as the unlatexed samples. The latexed tongue tear at 50 percent penetration is obtained by interpolation of the data for samples with several levels of percent penetration P.

Percent Neckdown

Primary carpet backings for the manufacture of tufted carpets require resistance to width loss on stretching, coupled with high tear strength. During processing in carpet mills, tufted primary carpet backings are subjected to considerable longitudinal stress which not only may lengthen the carpet in the machine direction, but also may cause a narrowing or necking down of the tufted carpet backing in the cross-machine direction. Such dimensional changes are highly undesirable; unless corrected, they may cause changes in the carpet tufting pattern and may provide a tufted carpet of narrower width than is commercially acceptable.

The neckdown of the bonded and tufted nonwoven carpet backing may be measured in the following manner: The bonded nonwoven fabric is tufted as for the tufted tongue tear tests and is cut along tufting rows to provide a sample 5.5 inches (14.0 cm.) wide and 14 inches (35.6 cm.) long. The sample is marked across its width direction with lines parallel to the end at 4.0 inches (10.2 cm.) and 8.0 inches (20.3 cm.) from one end and 2.0 inches (5.1 cm.) from the other end. Metal staples are fastened to the sheet across the 8.0 inch (20.3 cm.) line 0.197 inch (0.5 cm.) from each edge of the sample. The distance between the staples is measured to the nearest 0.01 inch (0.0254 cm.) and recorded. The sample is mounted in an Instron tensile tester with a clamp separation of 8 inches (20.3 cm.). The sample is mounted in 1 inch (2.54 cm.) by 8 inch (20.3 cm.) Instron clamps so that the clamps are touching the 4.0 inch and 2.0 inch lines on the sample and the sample is centered in the clamps. The sample is then extended in the tester using a full scale load of 50 lbs. (22.7 kg.), a crosshead speed of 10 inches (25.4 cm.) per minute and a chart speed of 20 inches (50.8

cm.) per minute. The Instron is set to stop when the load reaches 18 lbs. (8.2 kg.). This is equivalent to 3.3 lbs. per inch of sample width. When the Instron stops, the distance between staples is measured to the nearest 0.01 inch (0.0254 cm.) while the sample is still under stress. The percent neckdown is equal to the difference of the original distance between staples and the distance between staples while under stress divided by the original distance between staples and multiplied by 100.

Fiber Tenacity

Matrix filaments are teased out of the bonded sheet, cut free, and mounted in the jaws of a tensile tester such as the Instron. The sample is stretched at a rate of 2 in./min. between jaws 1 inch apart. The breaking strength is defined as the load in grams at which the fiber breaks. Values are averaged for at least 5 fibers. The breaking strength is converted into tenacity in grams/denier by dividing the average break strength by the average matrix denier per filament (see below).

Binder Concentration and Matrix Fiber Denier

The percentage of binder fiber or binder segments of segmented fibers is an important consideration. The binder fiber has not been drawn as much as the matrix fiber and thus has a lower orientation and melting point than the matrix fiber. The concentration of binder fiber can readily be controlled in the processes described above by varying the ratio of groove to surface area in the grooved roll or by increasing the proportion of filaments that avoid part or all of the draw rolls. In any case, the binder content of the bonded fabric can be readily predetermined by its process of manufacture.

Because the binder fibers or segments of fibers have low degree of molecular orientation (low birefringence), their color under crossed polarizing lenses differs from that of matrix fibers which have a high degree of molecular orientation and consequently identification based on color is possible. The orientation difference is magnified in bonding where the high temperatures tend to destroy fine structure and reduce birefringence. This deorientation is largest when initial molecular orientation is low. In such cases the molecular chains in the binder segments are significantly deoriented giving a grayish or yellowish-white fiber when viewed under crossed polarizing lenses and matrix fibers give intense coloration under the same conditions. In sheets prepared from segment-drawn filaments, binder diameter is also larger than that of matrix so that fiber size may also be used as a binder identification feature. In sheets with less obvious differences in molecular orientation, birefringence can be measured to establish which fibers are binder and which are matrix.

To determine percent binder a thin transverse section of measured basis weight is prepared and the length and diameter of all binder fibers within a known area of this section is measured using a projection microscope and polarized light. The diameters of the matrix fibers are also measured. From these measurements the percent binder by weight may be calculated using fiber density and cylindrical geometry.

Since the percent binder is needed for each of the directionally-laid layers, the bonded sheet is delaminated into its component M and X layers. In thick sheets these layers must be further delaminated to make all fibers visible. For good visibility the lamina should each be less than about 2 oz./yd.^{2} in basis weight. Production of thin sections using a microtome may also be acceptable. The weight per square area of the component M and X layers is determined. Then the specimens are mounted on a microscope slide and immersed in an oil of about 1.5 refractive index.

An image of the specimen is thrown onto a screen by use of a Projectina or similar microscope using polarized light passing through the sample and using about 60X magnification. A tracing is made of binder segments by using a transparent overlay with Polarizing and analyzing filters set at 90° to one another. The Filters are then rotated simultaneously in 20°–25° steps until total rotation is 90°. At each step any additional binder segment within the field of view is traced. A new field of view is now chosen and the procedure repeated until a suitable total area has been scanned. A map reader can now be used to measure binder length. This length divided by magnification gives actual length of binder in the area scanned. A calibrated eyepiece can be readily used to measure diameters of the binder filaments between bonded sites where deformation is at a minimum.

The diameter of the matrix filaments can be measured in the same way. The measurements are, of course, corrected by the magnification factor. The percent binder Q by weight in a given layer of sheet is calculated from Formula I:

$$Q = \pi D_b^2 L\phi / 4AB \times 100 \qquad \text{I}$$

where

L = Actual length of binder in area scanned in cm. Length measured on overlay/magnification factor

A = Area scanned in cm.^{2} Overlay area/(Magnification)^2

D_b = Diameter of binder in cm.

ϕ = Density of fibers in g/cm.^{3} (For polypropylene assume 0.9 g/cm.^{3})

B = Basis weight of dissected layer in g/cm.^{2}

AB = Weight of area scanned in grams

When the X or M layer is so thick as to require delaminating each layer into several sublayers, the percent binder is determined for each sublayer, and the results for the sublayers are then averaged to obtain values for X or M layers.

The denier per filament d_m of matrix filaments is calculated from Formula II:

$$d_m = \pi D_m^2 1 \phi / 4 \qquad \text{II}$$

where

D_m = Diameter of matrix filaments in cm.

1 = Standard length in cm. for denier determination (9×10^5 cm.)

Formula II may be simplified to Formula III by inserting the proper value for π and assuming density of 0.9 g/cm.^{3} for polypropylene:

$$d_m = 6.36 \times 10^5 D_m^2 . \qquad \text{III}$$

EXAMPLE I

Several nonwoven webs consisting of continuous filaments of isotactic polypropylene were prepared from a polymer having a melt flow rate of 3.2 using an arrangement similar to that shown in FIG. 5 of Edwards U.S. Pat. No. 3,563,838 except that a row of three jets were used for cross-machine direction deflection on the upstream end of the belt and a row of three jets were used for machine direction deflection on the downstream end of the belt. The distance between jets and their elevation above the collecting surface were such that the output from adjacent jets did not overlap significantly but just barely met on the collecting surface. The polypropylene filaments were extruded from six spinnerets at a temperature of 250°C., the spinnerets each having 300 orifices of size 0.015 inch diameter at a throughput of 0.705 g/min/hole. The bundle of filaments from each spinneret was formed into a ribbon of parallel filaments and each ribbon was segmentally drawn by passage successively over six rolls (each 24 inches circumference) arranged as in FIG. 2, running at progressively higher speeds from roll 7 to roll **12.** The rolls **8** and **10** were steam heated to 130° and 140° respectively, while the other rolls were unheated. The surface of roll **10** was grooved in the axial direction so that filaments were unheated over short lengths of the circumference. The remaining portions of the circumference provided heat to draw those portions of the filament which passed over the heated surface. The ribbon of segmentally drawn continuous filaments **13** thus formed was given a negative electrostatic charge by passage across the target bar of the corona charging device. Each ribbon of the charged continuous filaments passed then to a single slot jet of the type described in FIG. **6** of Edwards. The mainstream gap designated **4** in Edwards was 0.115 inch in width and 9.5 inches in the other dimension. The oscillating plenum air gap designated **6** in the jet described in Edwards was about 0.008 to 0.010 inch measured from one parallel side to the other. This permitted a high air velocity of the secondary air stream without an increase in air flow and hence a high degree of deflection without disrupting filament separation and uniformity of the web at laydown. The air velocity was between 10 and 1.2 times the primary air velocity in the jet. The nonwoven web deposited by the six jets was collected on a suction receiver.

Four 30 inch wide webs (A, B, C, and D) were produced using the above process, further details, such as roll slot dimensions, speeds, etc. being shown in Table **1.** The collecting belt speed was adjusted to collect sheet having a basis weight of 3 oz./yd.^{2}. The samples of the sheet were subjected to bonding in saturated steam at several different temperatures to determine conditions for obtaining the optimum balance of properties. After bonding, each of the samples were lubricated and then tufted in preparation for determining the tufted tongue tear strength and percent neckdown. In each case the bonded samples were analyzed by selecting specimens from different channels across the web. Data from several specimens across and along the sheet were averaged to obtain basis weight, percent neckdown, and tufted tongue tear. In addition, fiber directionality in the sheet was determined on each of the two (i.e., X and M) layers. Data for the various sheets have been summarized in Table 2. Latexed tongue tear was also determined at about **50%** penetration. Matrix fiber denier, fiber break strength and percent binder for the X and M layers were measured on one of the bonded sheets for each set of operating conditions. It is assumed that under equivalent operating conditions, each of the bonded samples contained the same amount of binder. In Table 2 the data for Sheets A, B, and D characterize sheets of the invention while Sheet C represents a sheet outside the invention. It should be noted that Sheet C had poor directionality in the M layer. Each sheet had 50 percent by weight in X layer and 50 percent in M layer.

EXAMPLE II

Three nonwoven webs consisting of continuous filaments of isotactic polypropylene were prepared from a polymer having a melt flow rate of 2.5 using the same 6-jet arrangement as in Example I but using only 3 spinnerets to supply the 6 jets. Polypropylene filaments were extruded at a temperature of 270°C. through three spinnerets, each having 800 orifices of size 0.020 inch diameter at a throughput of 0.56 g/min/hole. The filaments were drawn over successive rolls as described in Example I but only roll **10**, the fluted roll, was heated. The temperature of roll **10** is shown in Table **3** and the roll speeds are indicated. The ribbon of filaments from each spinneret was split evenly between an M- and an X-deflecting jet after passing roll **12.** Three jets were used for cross-machine laydown on the upstream end of a moving belt and three jets were used for machine direction laydown nearer the downstream end of the moving belt. Before entering the corresponding jets each of the ribbons of continuous filaments was charged as in Example I. The nonwoven webs were collected on a moving belt, the belt speed being adjusted to give a basis weight of about 3.0 oz-/yd^2. The nonwoven webs were bonded in steam as in Example I. Three 33-inch wide webs of 3.0 oz/yd^2 average basis weight were produced using the above process and operating under the conditions shown in Table 3. Fiber properties and average sheet characteristics are given in Table 4. Web **1** is within the scope of this invention. Webs **2** and **3** are not.

It should be understood that minor amounts, i.e., up to 20 percent of additional layers may be present in the sheet. For example the sheet could consist of MXM layering providing that one outside layer M layer is at least 40 percent by weight of the total sheet and provided that one X layer is at least 40 percent by weight.

EXAMPLE III

A nonwoven web consisting of continuous filaments of isotactic polypropylene was prepared from a polymer having a melt flow rate of 3.2 using one jet for cross-machine direction deflection on the upstream end of the belt and one jet for machine direction deflection on the downstream end of the belt. The polypropylene filaments were extruded from two spinnerets at a temperature of 250°C., the spinnerets each having 500 orifices of size 0.015 inch diameter at a throughput of 0.68 g/min/hole. The bundle of filaments from each spinneret was divided into two ribbons of parallel filaments in the ratio of 31/69 binder/matrix. The filaments were forwarded and drawn over six rolls as shown in FIG. **3.** The apparatus provided uniform drawing rather than segmented drawing since no fluted roll was employed. To achieve a difference in orientation between binder filaments and matrix filaments, 31 percent of the filaments from each spinneret were strung over guides so as to bypass the first two forwarding rolls while the remaining 69 percent passed over all six rolls.

Referring to FIG. 3, filaments 50 were extruded from spinneret 51. The filaments were separated into two ribbons 70 and 71 by means of guides 52 and 61. The ribbon 71 representing 69 percent of the filaments passed over guide 62 and then passed over the six rolls 63, 64, 54, 55, 56 and 57. This ribbon of filaments 71 was drawn on the six rolls to produce filaments with a high degree of molecular orientation. This orientation was effected in two stages, first between rolls 64 and 54 and second between rolls 55 and 56. The drawing conditions are described in greater detail in Table 5. Rolls 64 and 55 are smooth rolls, each heated to 135°C.

The filaments 70 from spinneret 51 representing 31 percent of the total filaments were passed over guides 52 and 53 thereby avoiding rolls 63 and 64. These filaments passed over rolls 54, 55, 56, and 57 and had a lower degree of molecular orientation than the filaments from ribbon 71.

The combined ribbon 72 of high molecularly oriented and less molecularly oriented filaments passed through an electrostatic charging device consisting of a multipointed electrode 73 and a grounded cylindrical electrode 74. The charged filaments then pass through jet 59 which was provided with a main air supply 75 and secondary air supplies 76. The main air supply carried the ribbon of filaments toward the collecting surface 60. The secondary air supplies 76 provided for oscillating steam 77 of filaments.

The filaments from the second spinneret were handled in a similar manner, however, these filaments passed through a jet which caused them to oscillate in the cross direction. These filaments 78 were deposited on the same belt upstream. The resulting sheet had the XM configuration with 50 percent by weight in the X layer and 50 percent by weight in the M layer. Properties of the sheet are shown in Table 6.

The data in Tables 2, 4 and 6 for Examples I, II and III show that tufted tongue tear values of 55 to 79 lbs. at 1 percent neckdown can be obtained on XM-laid sheets on a 3 oz/yd² basis by proper control of directionality, use of high percent binder in each layer, use of high denier in the matrix filaments and use of tenacity of at least 2.8 in the matrix filaments. The data also show that the latexed sheets of the invention retain a high percentage of their tufted tongue tear values through latexing.

TABLE 1

PROCESS CONDITIONS FOR EXAMPLE I

Web Designation	A		B		C		D	
Web Layer	M	X	M	X	M	X	M	X
Roll Speeds, ypm.								
No. 7	173	136	173	136	173	136	136	136
8 (120°C., smooth)	180	147	180	147	180	147	147	147
9	240	188	240	188	240	188	188	188
10 (140°C., fluted)	258	204	258	204	258	204	204	204
11	380	380	380	380	380	380	380	380
12	380	380	380	380	380	380	380	380
Fluted Roll 10 Dimensions:								
Total circumference of grooved sections, inches	7.5	5.5	7.5	5.5	7.5	5.5	7.5	5.5
Total circumference of ungrooved sections, inches	16.5	18.5	16.5	18.5	16.5	18.5	16.5	18.5
Jets[1]								
Primary Air Pressure, psig.	55	55	55	55	55	55	55	55
Secondary Air Pressure, psig. at value	70	100	90	100	35	60	70	100
Secondary Air Pressure, psig. plenum	14	20	18	20	7	12	14	20
Oscillating frequency, cps.	5.2	5.0	7.1	7.0	3.0	6.0	5.2	5.0

[1]See FIG. 6 of Edwards. Gap at 4 is .115 × 9.5 inch. Secondary air gap at 6 is .010 × 9.5 inches.

TABLE 2

SHEET AND FIBER CHARACTERISTICS FOR EXAMPLE I

Web Designation	A			B			C			D		
Web Layer	M	X	Total Sheet	M	X	Total Sheet	M	X	Total Sheet	M	X	Total Sheet
Matrix Fiber Denier, dpf	22	21		21	21		23	21		21	21	
Matrix Breaking Strength, g	66	72		64	71		66	72		81	74	
Matrix Fiber Tenacity, gpd	3.0	3.4		3.1	3.3		2.9	3.4		3.9	3.5	
Binder concentration, % by weight	28	21		28	21		28	21		26	21	
Randometer directionality												
MD_L/XD_L	6.1			10			2.6			6.0		
XD_L/MD_L		7.4			6.6			5.6			6.5	
$MD/45$			2.4			2.6			1.3			2.1
$XD/45$			2.6			2.1			2.0			2.4
$MD + XD/45$			5.0			4.7			3.3			4.5
Basis Weight, oz/yd²			3.0			3.0			3.0			3.0
Tufted tongue tear at 1% neckdown, lbs.			55			60			45			63
Tufted tongue tear of sample before latexing			62			61						
after latexing to 50% penetration			48			58						

TABLE 3

PROCESS CONDITIONS FOR EXAMPLE II

Web Designation	1		2		3	
Roll Speeds[1], ypm.						
No. 7	110		124		260	
8	118		129		276	
9	146		137		292	
10	168		158		335	
11	350		350		650	
12	350		350		650	
Fluted Roll 10:						
Circumference, inches	26		26		26	
Temperature, °C.	140		130		130	
Total circumference of grooved sections	8.25		3.0		3.0	
Total circumference of ungrooved sections	17.75		23.0		23.0	
Layer Designation:	M	X	M	X	M	X
Jet						
Pressure, primary, psig.	55	50	55	50	55	50
secondary, psig.	0.3–1.8	3.5–4.9	2.3	4.0	2.3	4.0
Oscillating frequency, cycles/second	5	5	7	6	9	9

Note 1: Rolls 7, 8, 9, 11, 12 have 24 inch circumference. Roll 10 circumference is indicated.

TABLE 4

SHEET AND FIBER CHARACTERISTICS FOR EXAMPLE II

Web Designation	1			2			3		
Layer Designation	M	X	Total Sheet	M	X	Total Sheet	M	X	Total Sheet
Matrix fiber denier, dpf.	17	15		19	21		14	14	
Matrix breaking strength, g.	71	69		60	61		40	36	
Matrix tenacity, gpd.	4.2	4.6		3.2	2.9		2.9	2.6	
Binder concentration, % by weight	37	29		17	16		20	15	
Randometer directionality									
MD_L/XD_L	4.4			5.2			5.2		
XD_L/MD_L		10.4			4.6			4.2	
$MD/45°$			2.2			2.0			1.9
$XD/45°$			2.9			1.9			1.7
$MD + XD/45°$			5.1			3.9			3.6
Basis weight, oz/yd²	1.5	1.5	3.0			3.0			3.0
Tufted tongue tear* at 1% neckdown, lbs.			58			46			41

* Samples 6 inches wide by 8 inches long, tufted across entire width.

TABLE 5

PROCESS CONDITIONS FOR EXAMPLE III

Web Layer	M	X
Roll Speeds, ypm.		
No. 63	141	141
64 (135°C.)	153	153
54	270	270
55 (135°C.)	292	292
56	467	467
57	467	467
Jets		
Primary Pressure, psig.	55	55
Secondary Air Pressure, psig. at valve	80	90
Oscillating frequency, cps.	7.1	8.0
Plenum gap, inches	.010	.010

TABLE 6

SHEET AND FIBER CHARACTERISTICS FOR EXAMPLE III

Web Layer	M	X
Matrix fiber denier, dpf*	17	18
Matrix breaking strength, g	64	74
Matrix fiber tenacity, gpd*	3.8	4.1
Binder concentration, % by weight and length	31	31
Randometer Directionality		
MD_L/XD_L	10.2	
XD_L/MD_L		15.9
$MD/45°$	3.83	
$XD/45°$	3.57	
$MD + XD/45°$	7.4	
Basis Weight	3.2	
Tufted tongue tear at 1% neckdown	84	
Tufted tongue tear of sample		
before latexing**	73	
after latexing at 50% penetration	69	

*Determined on filament sample taken from jet.
**This carpet sample prepared by tufting with 2600-denier crimped continuous filament nylon yarn.

What is claimed is:

1. A length of layered nonwoven bonded continuous filament isotactic polypropylene fabric comprising a machine direction layer constituting from 40 to 60 percent of the fabric weight and so disposed as to provide one surface of the fabric and a cross-machine direction layer which constitutes from 40 to 60 percent of the fabric weight, each of the said layers consisting essentially of binder fiber and matrix fiber, the latter having an average denier per filament of at least 12 and a tenacity of at least 2.5 g./den., the said machine direction layer containing from 18 to 50 percent by weight of binder fiber and exhibiting an MD_L/XD_L value of at least 3.0 and said cross-machine direction layer containing from 18 to 50 percent by weight of binder fiber and exhibiting an XD_L/MD_L value of at least 3.0 wherein XD_L is a measure of the total filament length of each layer in the direction perpendicular to the fabric length direction, and MD_L is a measure of the total filament length of each layer in the fabric length direction, the filaments of the layered fabric being disposed in such a manner to provide the following directionality values for the layered fabric:

$$XD/45° \gtrsim 1.5,\ MD/45° \gtrsim 1.5,$$

and

$$MD + XD/45° = 3.5 \text{ to } 30$$

wherein XD is a measure of the total filament length of the layered fabric in the direction perpendicular to the fabric length direction, MD is a measure of the total filament length of the layered fabric in the fabric length direction and 45° is the average of the measures of the total filament length of the layered fabric in the directions at 45° to the fabric length direction, and wherein XD, MD and 45° are measures determined by the randometer method.

2. The product of claim 1 wherein the amount of binder fiber in the machine direction layer is at least 1.2X the amount of binder fiber in the cross-machine direction layer.

3. The fabric of claim 1 having a machine direction layer at one surface and a cross-machine direction layer at the other surface of the fabric.

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