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[56]

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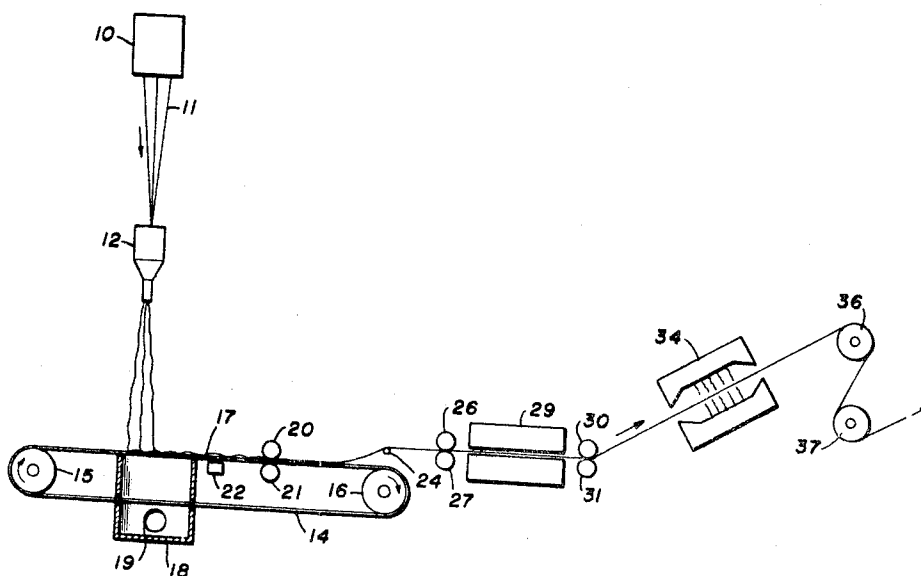
[54] **PROCESS FOR FORMING LIGHTWEIGHT NYLON**
NONWOVEN WEB
9 Claims, 1 Drawing Fig.

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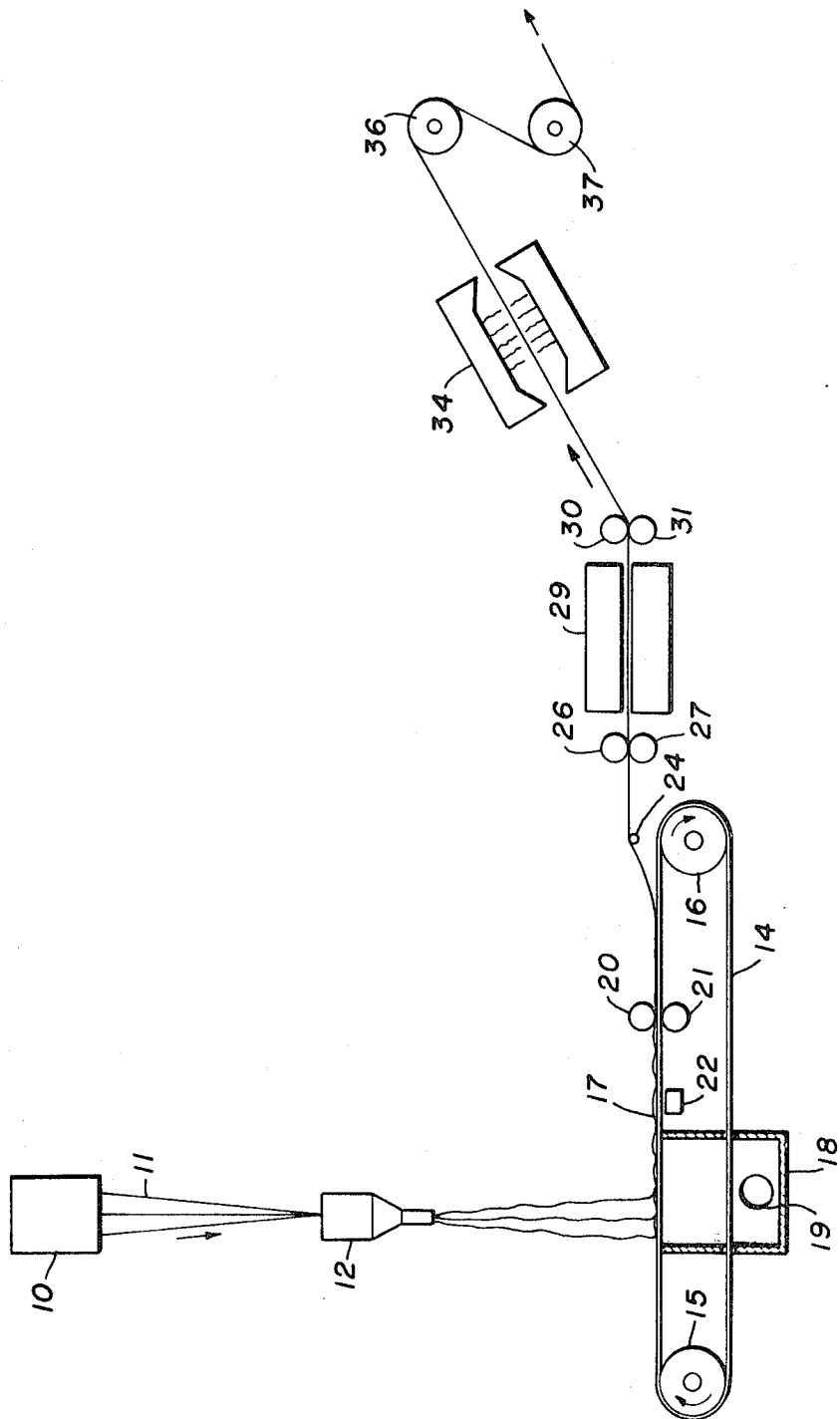
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161/150

ABSTRACT: A method of forming a lightweight nonwoven bonded web of nylon comprises collecting nylon filaments on a moving foraminous belt at a rate to form a web which weighs less than 1 oz/yd², providing a vacuum beneath the belt, contacting the web while on the belt with an activating gas to lightly bond the filaments together at filament crossover points, and removing the web from the belt prior to the belt's entering an arc around a belt-supporting roller.



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PROCESS FOR FORMING LIGHTWEIGHT NYLON NONWOVEN WEB

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a nonwoven web and, more specifically, to a lightweight web which is comprised of continuous nylon filaments being autogenously bonded together at a substantial number of filament crossover points.

2. Description of the Prior Art

Bonded nonwoven fabrics are old in the art; however, the concept of manufacturing nonwoven webs from continuous synthetic filaments is relatively new. It was not until the 1960's that processes were developed which were capable of attenuating freshly extruded filaments and laying them down on a moving belt to form a nonwoven web (U.S. Pat. No. 3,341,394, 3,338,992 and 3,276,944). These patents deal primarily with polyester and polyolefinic filaments although the use of nylon filaments is casually mentioned. Bonding is accomplished by heat, solvents or adhesives. The reason continuous filament nylon webs are only referred to in the mentioned patents and in the prior art is that nylon is not readily bondable by these techniques. While nylon is a thermoplastic, heating nylon filaments to the melting points destroys substantially all molecular orientation thus weakening the filament to the point of uselessness. Solvent bonding of nylon filaments is impractical since the solvating rate is uncontrollable. The use of adhesive binders renders the resulting fabrics too boardy to be of any practical value.

In producing light weight webs, the use of adhesive binders to form the bonded web is further not practical because the weight of the adhesive which is generally about 40 percent of the total fabric weight replaces the equivalent weight of filaments thus leaving the web with too few filaments to provide adequate strength. The use of solvents for bonding tends to destroy the web for the bonding rate is uncontrollable. In either case, the web would be subjected to a liquid or water treatment bath which would destroy the web geometry since the web does not have the integrity to withstand the liquid.

In the manufacture of lightweight nonwoven webs, i.e., webs weighing less than 1 oz./yd.², the technique to date has been either to deposit olefinic fibrous materials on a belt with bonding being carried out by a heat process or by means of depositing submicron organic fibrils onto a collection surface as set forth in U.S. Department of Commerce, Office of Technical Services, publication number PB111437. While nonwoven fabrics can be made from nylon in accordance with the publication, the fibers are not continuous and the resulting web has little strength.

SUMMARY OF THE INVENTION

In its broadest aspects, the present invention comprehends the formation of a nonwoven web weighing less than 1 oz./yd.² and being comprised on continuous filament nylon preferably of less than 10 denier per filament with the filaments being autogenously bonded together at a substantial number of filament crossover points. The filaments comprising the web may be arranged in an orderless manner, that is, without any preferred orientation or they may be directionalized especially in the machine direction in order to build up strength therealong.

Autogenous bonding of nylon filaments can be accomplished in accordance with the method set forth in U.S. Pat. No. 3,516,900 filed June 17, 1968, by William C. Mallonee et al. By autogenous bonding, it is meant that bonds are formed between touching filaments without visible polymer migration at the bond points and in the absence of external bonding agents. As disclosed in detail in the above-identified application, gaseous hydrogen chloride or like activating gases contacts and is absorbed by the nylon filaments at least along the surfaces thereof. The hydrogen chloride molecule in the nylon causes the interchain hydrogen bonds which exist between adjacent amide groups to break and upon removal or desorption

of the hydrogen chloride from the nylon, the interchain hydrogen bonds reform, some of which reform between amide groups of different filaments (at crossover points) to form bonds therebetween.

In reference to the process for forming the lightweight nonwoven nylon webs of this invention, the general procedure is set forth in U.S. Pat. No. 3,542,615 filed June 16, 1967 by E.J. Dobo et al. However, lightweight webs must be handled more delicately than the webs of the mentioned application or the prior art. The webs of this invention should be lifted from the belt while the belt is flat or planar and prior to the belt's entering an arc around a belt-supporting roller. Such a procedure prevents the web filaments from following the belt around the roller and furthermore prevents the web filaments from being trapped between the foraminous collection belt and the roller. In order that the web has sufficient strength to maintain its integrity while being lifted from the belt, the web is prepressed while moving along the belt by means of aligned rolls or is contacted with a small amount of the activating gas while it remains on the belt so as to lightly bond selected touching filaments.

Therefore, an object of this invention is to provide a lightweight nonwoven bonded nylon web.

Another object of this invention is to provide a nonwoven web weighing less than 1 oz./yd.² which is comprised of continuous nylon filaments directionalized during laydown which are bonded together at a substantial number of filament crossover points.

A further object is to provide a process for forming a nonwoven web weighing less than 1 oz./yd.² and being comprised of continuous filament nylon.

A still further object is to provide a lightweight nonwoven web comprised of continuous nylon filaments being autogenously bonded together at a substantial number of filament crossover points.

Other objects and advantages of the present invention and their means of attainment will be apparent from the following description and accompanying drawing.

DESCRIPTION OF THE DRAWING

The figure is a schematic diagram of the apparatus used for making the lightweight nonwoven web of this invention and for carrying out the process of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to the Figure, extruder 10 is of the general type used for spinning continuous nylon filaments 11. Filaments 11 are drawn downwardly and attenuated by aspirator 12. Aspirator 12 forwards filaments 11 downwardly toward the laydown zone by means of compressed air which is fed into aspirator 12 by a supply line (not shown).

The laydown zone is comprised of an endless foraminous belt 14 which is supported and moved along a defined path by rollers 15 and 16, one of which is positively driven. While the particular path assumed by belt 14 may be varied, it is contemplated that such path will include at least one planar surface which is to receive filaments 11 forwarded to it by means of aspirator 12. The planar surface is to include the area at which filaments 11 are deposited on belt 14 and the location at which filaments 11 in the form of web 17 are lifted from belt 14. While certain undulations along that length are permissible, web 17 must be lifted from belt 14 prior to the portion of belt 14 which carries web 17 reaching roller 16 and assuming the arcuated path therearound. The laydown zone also includes vacuum source 18 which is in the shape of an open-ended box and has exhaust means 19. Vacuum source 18 is positioned directly beneath aspirator 12 and below belt 14 so as to maintain filaments 11 on belt 14 upon the deposition of the same. The length of vacuum source 18 in the direction of roller 16 should be sufficient to firmly position the filaments on belt 14. Depending upon the operating conditions, a

second vacuum source of reduced suction (not shown) may be desirable which would be located substantially adjacent vacuum source 18 in the direction of roller 16.

In order that web 17 has the integrity to withstand the tension required to lift it from belt 14 at a second location which can be said to be included along the planar surface, web 17 and that portion of belt 14 supporting the web may be passed through a pair of press rolls 20 and 21 which compact web 17 and increase filament cohesion. Alternatively, web 17 may be lightly bonded by means of an activating gas applicator 22 which directs an activating gas such as hydrogen chloride into web 17. Sufficient bonding will occur at filament crossover points allow the web to be lifted from belt 14. While only one of these web takeoff aiding methods is generally required, it is possible that more than one may be desired. Such an occasion may arise when the relative humidity is extremely low thus making it difficult for any static electric charge on the filaments to be dissipated.

Web 17 is lifted from belt 14 at a second location by means of a guide bar 24, is passed over guide bar 24 and is passed through nip rolls 26 and 27 which forwards web 17 to gas cage 29. While in gas cage 29, the nylon filaments comprising web 17 absorbs the hydrogen chloride gas or come like activating gas. Web 17 is then removed from gas cage 29 by means of guide rolls 30 and 31 and is passed through a heater 34 where desorption is effected and as a result permanent bonding occurs. After desorption, web 17 is drawn over guide rolls 36 and 37 whereupon it proceeds to an appropriate take up mechanism (not shown). If required additional gas desorption can be achieved by a subsequent water wash.

EXAMPLE I

Nylon 6 flake was extruded through a 14 hole spinnerette, at a rate of 2.6 g./min. Two reciprocating aspirators were used which were supplied compressed air having an input pressure of 64 p.s.i.g. The aspirators attenuated the filaments to a finished denier of from 2.0 to 2.5 and were positioned about 16 inches above the foraminous belt. The belt speed was 8.6 ft./min. and the weight of the web deposited on the belt was 0.09 oz./yd.² The unbonded web was pressed by a pair of prepress rolls while remaining on the belt. Ambient conditions during web laydown were 76° F. and a relative humidity of 40 percent.

The web was lifted from the belt by means of being pulled over a lift bar and was passed through a gas chamber filled with gaseous hydrogen chloride. After being exposed to the gaseous hydrogen chloride for approximately 6 seconds, the web was passed through a heated area which was comprised of two opposed Fostoria heat lamps where the hydrogen chloride having been absorbed by the nylon filaments was desorbed. The web was exposed for 25 seconds to a temperature in excess of 200° F. The heat treatment reduced the hydrogen chloride content in the web to a residual level of about 0.2 percent by weight.

The web properties are as follows:

Thickness (mils)	2.0
Density (g./cm. ³)	0.06
Bending length (ins.)	0.4
Tenacity (lbs./in./oz./yd. ²)	5.0
Elongation (%)	45
Tongue tear (lbs.)	0.12

EXAMPLE II

The procedure as set forth in example I was followed with the exception that nylon 6,6 flake was extruded. Web properties were as follows:

Thickness (mils)	4.2
Density (g./cm. ³)	0.06
Bending length (ins.)	0.5

Tenacity (lbs./in./oz./yd. ²)	4.3
Elongation (%) 48	
Tongue tear (lbs.)	0.19
Weight (oz./yd. ²)	0.18

EXAMPLE III

The procedure as set forth in example I was followed with the exception that nylon 6,6 flake was extruded. Web properties were as follows:

Thickness (mils.)	4.4
Density (g./cm. ³)	0.08
Bending length (ins.)	1.0
Tenacity (lbs./in./oz./yd. ²)	5.8
Elongation (%)	58
Tongue tear (lbs.)	0.43
Weight (oz./yd. ²)	0.26

EXAMPLE IV

The procedure as set forth in example I was followed and the resulting web properties were:

Thickness (mils)	3.4
Density (g./cm. ³)	0.12
Bending length (ins.)	0.9
Tenacity (lbs./in./oz./yd. ²)	6.6
Elongation (%)	38
Tongue tear (lbs.)	0.46
Weight (oz./yd. ²)	0.30

EXAMPLE V

The procedure as set forth in example I was followed and the resulting web properties were:

Thickness (mils.)	5.0
Density (g./cm. ³)	0.11
Bending length (ins.)	1.0
Tenacity (lbs./in./oz./yd. ²)	9.5
Elongation (%)	49
Tongue tear (lbs.)	0.80
Weight (oz./yd. ²)	0.41

EXAMPLE VI

The procedure as set forth in example I was followed and the resulting web properties were:

Thickness (mils)	6
Density (g./cm. ³)	0.17
Bending length (ins.)	1.2
Tenacity (lbs./in./oz./yd. ²)	11.2
Elongation (%)	47
Tongue tear (lbs.)	2.00
Weight (oz./yd. ²)	0.75

By certain process modifications the filaments comprising the webs of this invention can be directionalized so that the webs have greater strength, for example, in the machine direction than in the transverse direction. A web having differential strengths find utility where tension is applied in only one direction such as impregnated tapes and the like. Since substantially no forces are applied in the transverse direction, a savings in web weight or a stronger web per unit weight can be obtained by arranging most of the filaments in the preferred direction so that they become the load-bearing members.

While any one of several methods may be used to compare the strengths in the given directions, the preferred method is a correlation between the zero span tenacities of the two directions. In zero span tenacity, the measured rupture load is

dependent upon the component filament strength and fila-
ment orientation only since opposed clamps which receive the
fabric are positioned adjacent each other and are pulled in op-
posite directions to rupture the web. It has been found that the
ratio of the zero span tenacity in the high strength direction to
the zero span tenacity in low strength direction (DH/DL)
generally should be at least 1.50 for there to be useful realiza-
tion of the unidirectional strength characteristics of the web.

EXAMPLE VII

The general procedure as set forth in example I was fol-
lowed with the exception that nylon 6.6 was used and aspira-
tor 12 was sloped at an angle of 30° from the vertical in the
machine direction. Spinnerette 10 and aspirator 12 were posi-
tioned to direct filaments 11 onto belt 14 in the area above
vacuum source 18. By sloping aspirator 12, filaments 11 were
laid on belt 14 with the preferred orientation being in the
machine direction. The resulting web properties were:

Weight (oz./yd. ²)	0.22	
Thickness (mils)	5	
Density (g./cm. ³)	0.06	
	Machine	Transverse
	Direction	Direction
Tenacity (lbs./in./oz./yd. ²)	4.7	3.1
Tongue Tear (lbs.)	0.6	0.7
Zero Span Tenacity (lbs./in./oz./yd. ²)	12.6	7.6
=DH/DL=1.65		

We claim:

1. A process for producing a lightweight nonwoven web of
continuous nylon filaments comprising the steps of:
- a. forwarding a plurality of said nylon filaments toward a
laydown zone, said laydown zone including a foraminous
belt moving along an endless path, said belt being planar

- for a given length along said path;
- b. collecting said filaments on said belt at a first location
along said planar length to form a web having a weight
being less than 1 oz./yd.²;
- c. including a vacuum beneath said planar length to main-
tain said filaments on said belt during and subsequent to
collection;
- d. contacting said web while on said belt with an activating
gas to lightly bond said filaments together at selected fila-
ment crossover points whereby web integrity is increased;
and
- e. removing said web from said belt at a second location
along said planar length.
2. The process of claim 1 wherein said filaments are au-
togenously bonded together at a substantial number of fila-
ment crossover points.
3. The process of claim 2 wherein said autogenously bond-
ing said filaments include the steps of subjecting said web to
an activating gas, said gas being at least partially absorbed by
said filaments and desorbing said gas from said filaments to
permanently bond said filaments together at a substantial
number of said crossover points.
4. The process of claim 3 wherein said desorbing is substan-
tially completed by subjecting said web to heat.
5. The process of claim 4 wherein said web is calendered
while on said belt prior to said web removal by means of press
rolls spaced in alignment on either side of said belt.
6. The process of claim 5 wherein said filaments of said web
are lightly bonded together at selected filament crossover
points prior to said web removal from said belt.
7. The process of claim 4 wherein said filaments are less
than 10 dpf.
8. The process of claim 4 wherein said filaments are
preferentially arranged in a first selected direction within said
fabric to increase the fabric tenacity in said first selected
direction relative a second selected direction.
9. The process of claim 8 wherein the ratio of said first
selected direction tenacity to said second selected direction
tenacity is greater than 1.50.

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