TWO-PLANAR DEFLECTOR FOR DISPERSING AND DEPOSITING NONWOVEN FILAMENTARY STRUCTURES

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ABSTRACT OF THE DISCLOSURE

An apparatus for augmenting dispersal and for improving deposition of a plurality of continuous filaments onto a continuously moving surface whereby random distribution of the filaments is provided for the production of uniformly distributed nonwoven webs. A nonmoving two-planar deflector is positioned near the exit of an aspirator so as to provide greater openness and greater random laydown of filaments.

CROSS-REFERENCE TO RELATED APPLICATIONS

The invention herein set forth is related to the inventions described in copending applications Ser. No. 184,422 entitled "Foraminal Apparatus for Splaying and Depositing Nonwoven Filamentary Structures," filed on Sept. 28, 1971 in the name of Walter P. Lipscomb and Garland L. Turner, and Ser. No. 184,421 entitled "Apparatus for Splaying and Depositing Nonwoven Filamentary Structures," filed on Sept. 28, 1971 in the name of Walter P. Lipscomb and Eli B. Shelburne, Sr., wherein different apparatus for improving the dispersal and deposition of a plurality of continuous filaments onto a continuously moving surface are disclosed.

BACKGROUND OF THE INVENTION

This invention relates to an improved apparatus for dispersing and depositing filaments. In particular, it relates to an apparatus for augmenting the dispersal of continuous filaments onto a receiving surface so as to form a nonwoven web of randomly disposed filaments.

Nonwoven webs formed from continuous filamentary materials which have been laid on a receiving surface in a random configuration are well known in the art. In the formation of such webs, great care is frequently taken to ensure that the filaments are maintained apart from each other and that interfilamentary entanglement and the formation of filament aggregates are avoided.

Nonwoven webs comprising multi-filament are commonly formed by forwarding the filaments from a source of supply, such as a melt spinnerette, and through an aspirator and then depositing the filaments at high velocity onto a moving surface. In the production of nonwoven products having a substantial width, there must be provided either a plurality of aspirators for depositing a plurality of filamentary bundles in a random manner upon the moving surface or there must be provided a means, normally unduly complicated and cumbersome, to move the aspirator over the width of the product to be produced.

When depositing filaments from a conventional aspirator onto a collecting surface, the filaments will spread out within the confines of the aspirator boundary. However, the filament distribution in the jet stream is not always uniform and random and is often restricted to a small laydown area; for example, a web width not exceeding eight inches when a fixed aspirator jet is situated at a distance of one to three feet from the receiving surface.

Some of these deficiencies have been overcome by impinging the filaments against a single deflecting plane before the filaments are massed in web form. The intermixing which is normally attendant with the deflection promotes a filament interaction which tends to integrate but also to aggregate the product. Also, there is normally an accompanying bulkiness or uneven filament distribution, a swirl pattern or roping, a tendency toward sagging or a loss of strength, each of which is undesirable for many end uses of the web material.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide an apparatus for augmenting dispersal of filaments which are deposited onto a receiving surface so as to form a web. It is a further object of this invention to provide a simple, reliable, inexpensive, and easily constructed apparatus for more expeditiously spreading filaments and thereby for producing superior nonwoven webs having high integrity. A further object of this invention is the provision of a filament dispersing and depositing means employing no moving parts that tend to generate repeating patterns of filament laydown which are detrimental to web strength. Further objects and advantages of the present invention will become apparent by reference to the following specification and drawings.

In attaining the foregoing objects, this invention features an apparatus for augmenting dispersal and for improving deposition of filaments onto a moving receiving surface in a randomly dispersed manner to form a nonwoven web. Such apparatus comprises, in combination, an aspirator to forward the filaments at a high velocity and a two-planar deflector to splay the filaments widely and randomly as such filaments pass from the aspirator to the moving receiving surface. The two-planar deflector consists of a first plane being rigidly affixed in one spatial position near or close to the aspiating means exit and a second plane being rigidly affixed in another, adjacent spatial position. The two-planar deflector is positioned near the exit of the aspirating means such that a majority of the filaments exiting from the aspirator impinge on the two-planar deflector. The first plane of its straight-line extension intersects the second plane, forming an angle greater than 90 degrees between the impinging surfaces of the two planes. The first plane makes an acute angle \( \alpha \) of between 0 and 60 degrees with a line parallel to the center line of the aspirator exit passageway, the angle being measured in the general direction of forward motion of the moving receiving surface. The second plane makes an acute angle \( \beta \) of between 20 and 85 degrees with a straight-line extension of said first plane. The sum of \( \alpha \) and \( \beta \) is always less than 90 degrees.

In a preferred embodiment of this invention, the two-planar deflector has an angle \( \alpha \) of between 25 and 50 degrees and an angle \( \beta \) of between 35 and 60 degrees, the sum of \( \alpha \) and \( \beta \) being between 45 degrees and 87 degrees. Also preferably, the two-planar deflector is affixed near the aspirator exit passageway such that there is a distance of approximately from 3 to 26 times, more preferably from 4 to 15 times, the diameter of the aspirator exit passageway between the aspirator exit and the area of initial substantial contact of the filaments on the two-planar deflector. More preferably, each plane of the two-planar deflector is substantially rectangular in shape. The first plane of such rectangular-planed deflector has a length measured in a direction proceeding from the aspirator exit passageway of approximately from 3.5 to 20 times, even more preferably from 4 to 10 times, the diameter of the aspirator exit passageway and a width approximately from 5 to 15 times, even more preferably from 7 to 13 times, the diameter of such exit passageway. Also, the second plane of such rectangular-planed deflector has a corresponding length of approximately from 1.5 to 25 times, even more preferably from 2 to 4 times, the diameter of
the aspirator exit passageway and a corresponding width of approximately at least 5 times, even more preferably 7 to 20 times, the diameter of such a passageway. Alternatively, the second plane of the two-planar deflector may be a quadrilateral having the length and width ranges similar to those described above for the rectangular-planed deflector and also having substantially equal lengths of quadrilateral second plane has widths such that the width farthest from the aspirator exit is substantially wider than the other parallel second plane width.

A feature of this invention is its quick and easy adaptability for use with many conventional aspirator jets in dispersing and depositing filamentary materials onto a moving receiving surface.

The method utilizing the apparatus for this invention comprises, in general, the utilization of the two-planar deflector in combination with an aspirator whereby filaments, preferably forwarded from a spinnerette of a spinning mechanism and thereafter from a drawing mechanism, are forwarded through a high velocity fluid jet of an aspirator. Subsequent thereto, the aspirator jet stream propels the filaments onto the two-planar deflector whereby the filaments are delivered onto the moving, preferably faromissable, surface in the form of uniform nonwoven web comprising randomly disposed, substantially uniformly distributed filaments. Deposition of the filaments may be aided by a suction chamber located underneath the moving surface.

The described apparatus can be readily used for dispersion of filaments or, alternately, strands, yarns, slivers or other similar forms of materials, or mixtures thereof. Such materials include any fiber-forming thermoplastic polymer from which filaments can be obtained. These materials include: polyamides, for example, poly(ethylene caprolactam) (hereinafter nylon 6) and poly(hexamethylenem adipamide) (hereinafter nylon 66); linear polyesters, for example, poly(ethylene terephthalate); acrylonitrile polymers and copolymers; olefinic polymers, for example, polyethylene, polypropylene, and polyvinyl chloride; and cellulose acetates. Preferred materials include nylon 6, nylon 66 and poly(ethylene terephthalate).

This invention will be more clearly understood and additional objects and advantages will become apparent upon reference to the drawings and to the description below and to the drawings which are given for illustrative purposes.

**BRIEF DESCRIPTION OF THE DRAWINGS**

In the drawings:

FIG. 1 is a schematic perspective view depicting a preferred embodiment of the apparatus employed for carrying out the invention;

FIG. 2 is a fragmentary front elevation view of an apparatus as depicted in FIG. 1, showing an aspirator in section and the two-planar deflector attached to the exit end of the aspirating means;

FIG. 3 is a fragmentary side elevation of the apparatus as depicted in FIG. 2 showing parts of the aspirator removed and turned 90 degrees clockwise from the position of FIG. 2.

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring to the drawings and particularly to FIG. 1, a bundle of freshly formed filaments 12 enter inlet aperture 57 of an aspirator such as aspirating jet 14. The filaments are formed from the spinnerette of a melt spinning apparatus (not shown). Subsequent to spinning, the filaments may also be attenuated and oriented on a drawing apparatus (also not shown). Filament bundles having a broad width range, i.e. 30 to 2400 total denier, may be used in the apparatus of this invention. Within the aspirating jet 14, the filaments are acted upon by a high velocity fluid medium such as air, which is supplied through inlet conduit 13. Aspirating jet 14 comprises an air nozzle 9, a collar 10 and a diffuser 11. The filament bundle 12 is forwarded via the high-velocity aspirating medium from the jet exit 17 of such an apparatus. Alternatively, a majority of filament bundles 12 are deflected from such a two-planar deflector 22 onto receiving surface 20. Air stream deflection and its attendant turbulence spreads and opens the filament bundle 12 deflecting from two-planar-deflector 22 in a wide and random manner, as shown in FIG. 1. The two-planar deflector 22 is clamped substantially rigidly near the exit end of jet 14 via any suitable means, such as extension 16 and clamp 15 at the exit end of aspirating jet 14. On receiving surface 20, preferably a faromissable continuously moving conveyor, with a suction chamber 21 provided beneath that portion of conveyor 20 on which the filaments are being laid down, the filaments are deposited in a random manner to form web 23.

In FIG. 2, the aspirating jet comprises: a hollow air nozzle 9 which is externally threaded at each end and which has an air inlet conduit 13 attached to its upper end; a hollow collar 10 which is internally threaded at both ends so as to connect air nozzle 9 with diffuser 11 and which has an inlet aperture 57 for receiving filament bundle 12; and diffuser 11 which is preferably faromissable at its upper end and through which the filaments and high velocity air are propelled onto two-planar deflector 22 and thereafter onto a receiving surface. The annular internal aperture 57 is arranged to direct the filaments entering therein downwardly, i.e. in direction of air flow. The internal diameters of collar 10 and of diffuser 11 are arranged so as to minimize twisting, knotting and entanglement of the filaments passing therein. By way of example only, the diameter of nozzle passageway 51 is most preferably from 20 percent to 33 percent of the nozzle passageway length. Also, cross-sectional area of nozzle passageway 51 is preferably from 25 percent to 35 percent of the cross-sectional area of diffuser passageway 54. Further, the diameter of diffuser passageway 54 is preferably from 2 percent to 10 percent of the length thereof. Still further, the maximum diameter of diffuser entrance chamber 53, which is conical in shape, is most preferably approximately two times the diameter of the diffuser passageway 54. The cross-sectional area of diffuser passageway 54 is designed such that the cross-sectional area of filament bundle 12 passageway therein ranges from 0.1 percent to 5 percent, preferably from 0.2 percent to 1.5 percent, of the diffuser passageway cross-sectional area. The respective lengths and diameters of air nozzle entrance chamber 50 and of collar chamber 52 are not critical. However, such lengths and diameters should be used as are practical, i.e. compatible with the overall operation of the present process.

The first plane 18 and the second plane 19 of the two-planar deflector 22 are each of a width W which is sufficient to deflect at least a majority of the filaments emanating from the aspirator exit passageway 17. It is not essential that any width of plane 18 equal any width of plane 19. The widths W of each plane may be varied to suit the particular situation. Each situation is dependent on such variables as air velocity at the jet exit, jet-deflector distances, type and properties of polymer from which the filaments are made, and desired filament laydown pattern. Preferably, a width of the first plane 18 ranges from approximately 5 to 15 times, and more preferably from 7 to 13 times, the diameter of the aspirator exit passageway 17 and a width of the second plane 19 ranges at least 5 times, more preferably from 7 to 20 times, the diameter of exit passageway 17. These enumerated ranges for plane 18 width and plane 19 width are not limiting and are given in order to provide suitable widths for deflecting at least a majority of the filaments exiting from jet 14. In an alternative preferred embodiment, the second plane width which is farthest from the jet exit 17 may be substantially wider than the other width of second
plane 19, so as to increase the capacity of the two-planar deflector in deflecting a greater number of filaments when this is desired.

Although the two-planar deflector 22 works especially compatibly with the preferred aspiring jet 14 as described, and as described in a patent application Ser. No. 184,542 entitled "Process and Apparatus for Production of a Nonwoven Web," filed on Sept. 28, 1971 in the name of Walter P. Lipscomb and Garland L. Turner, it has been designed to work compatibly with many conventional aspirators. In general, such conventional aspirators are especially suitable for use with the apparatus and invention if these aspirators forward the filaments at high velocity, generate sufficient pull therein to maintain the filaments under minimum tension, open and separate the filament bundle during the exiting of the filaments from the aspirators, and prevent filaments from undergoing any substantial twisting, knotting, or entanglement therein.

Referring now to FIG. 3, the critical angular and dimensional relationship of the components of the two-planar deflector to the aspirator jet exit is shown. The first plane 18 is affixed rigidly to the exit of aspiring jet 14 by clamp 15 via a suitable extension 16, which is comparatively operatively with plane 18. Plane 18 and plane 19 of the two-planar deflector, extension 16 and clamp 15 are designed to remain substantially rigid during normal operation of the apparatus. Planes 18 and 19 are positioned near the exit of the aspirator 14 such that a majority of said filaments impinge on the two-planar deflector after exiting from the aspirator. Plane 18 or its projection intersects plane 19, forming an angle greater than 90 degrees between the impinging surface of plane 18 and the impinging surface of plane 19 in order to maintain control over the extent of filament deflection from the two-planar deflector. Plane 18 and plane 19 are configured of a suitable material which is substantially rigid and does not degrade the filaments which contact it; e.g. shim brass or stainless steel. The angles which the two planes make with a line parallel to the center line of the aspirator are critical to the operability of this invention. For convenience, this is defined as the acute angle as the length of plane 18 makes with a line which is parallel to the center line of the exit passageway 17 of aspiring jet 14, and β is defined as the acute angle which a straight-line extension of first plane 18 makes with the second plane 19. We have found that a jet deflection angle of 16, which is suitably high degree of filament dispersal and separation. An exact determination of α and β is dependent on such variables as the type of polymer from which the filaments are made, the physical properties of the filaments which contact the two-planar deflector, the speed of filaments at the point of contact with the two-planar deflector, the desired properties of the resultant nonwoven web of filaments, and the desired filament laydown pattern. In order to obtain a suitable degree of filament spreading, α should range between 0 degree and 60 degrees, preferably between 25 degrees and 30 degrees. Similarly, β should range between 20 degrees and 85 degrees, preferably between 20 degrees and 60 degrees. The sum of α and β is less than 90 degrees and ranges preferably between 20 degrees and 89 degrees, more preferably between 45 degrees and 87 degrees. Use of the preferred values for α and β under the conditions of this invention, in comparison to a similar apparatus without the two-planar deflector, assures a surprisingly greater spreading of the filaments prior to deposition on the receiving surface and a surprisingly greater random distribution of uniformly distributed filaments within a wider web formed on the receiving surface. Experience has shown that a distance of approximately 3.5 to 26 times the diameter of aspiring passageway exit 17 between the exit end of jet 14 and the area of initial substantial contact on the surface of two-planar deflector 22 has yielded satisfactory results. With values of such aspirator-deflector contact distance less than 3.5 times the jet exit diameter, filament deposition profiles are characterized by a detrimentally high degree of filament compacting and agglomeration. On the other hand, with values greater than 26 times the exit diameter, such profiles are characterized by decreasing deposition area and result in reduced air velocities at such greater distances.

The length L1 of first plane 18 and the length L2 of second plane 19 are designed to be of a total dimension which is sufficient to deflect at least a majority of the filaments exiting from the aspirator passageway 54. For similar reasons as described above for planes width, the lengths of each plane may be varied, in varying the passageway situation. To accomplish a suitable degree of deflection when the two-planar deflector has quadrilateral planes, L1 as measured in a direction proceeding from the aspirator exit ranges preferably approximately from 1.5 to 20 times, even more preferably from 4 to 10 times, the diameter of the aspirator exit passageway 54. Also L2 ranges preferably approximately from 1.5 to 25 times, more preferably from 2 to 4 times, the diameter of passageway 54. With values of L1 less than 3.5 times and L2 less than 1.5 times the diameter of passageway 54, no significant improvement was found when compared against apparatus using the jet without the two-planar deflector. With values of L1 greater than 20 times and L2 greater than 25 times the diameter of passageway 54, the filament deposition profile was characterized by a relatively highly nonuniform distribution of filaments due to excessive randomness as a result of loss of control of filament laydown pattern.

The two-planar deflector is most preferably placed near the aspirator exit in a manner such that the widths of each plane are substantially perpendicular to the direction of forward motion of the moving receiving surface. Such placement ensures that the filaments are positioned against the surface of the receiving apparatus. Alternatively, the two-planar deflector may be placed such that the widths are at an angle which deviates from a direction perpendicular to the direction of motion of the receiving surface. However, such non-perpendicular placement is made at a sacrifice of uniform distribution of filaments across the laydown area during deposition; in some cases, depending on the intended usage of the nonwoven web product, this may be desirable.

We recognize that the planes of the two-planar deflector of this invention are not limited to quadrilateral forms. Planes of a greater number of sides than four may be used. However, as the number of sides is increased, expenses in production of the plane may increase without any substantial improvement in the degree of spreading occurring.

In operation, the aspirating medium, which may be a pressurized fluid such as air, is introduced from a supply source, not shown, into chamber 50, at a pressure preferably ranging from 30 to 100 p.s.i.g. Such media enters and flows through nozzle passageway 51 and exits therefrom at a high velocity stream. The pressurized state of the aspirating medium is constant upon several conditions and thus may be varied to meet the specified circumstances. Some factors which influence operating pressures are the aspirating jet design, aspirating media, pressure consumed, type and nature of filament-forming polymer, degree of orientation on a wet basis which filament has been subjected, and the resulting properties of the nonwoven product. The high velocity fluid stream exiting nozzle passageway 51 engages filaments 12 entering the aperture 57 with sufficient energy to propel the filaments through collar chamber 52 into the diffuser 11, which is characterized by an initially diverging chamber 53. Subsequently, the propelled filaments preferentially dispersed from diffuser passageway exit 17 in a wide and random manner via deflection from the two-planar deflector 22. Then the filaments are deposited on a receiving surface which normally takes the form of a conveyor belt moving at a predetermined con-
stant speed and at a predetermined distance from the exposed width of the second plane 19 of the two-planar deflector 22. The receiving surface should be placed below the two-planar deflector of this invention at a distance such that effectiveness and efficiency of random dispersal of filaments thereon in a uniform manner is achieved.

The following example is provided as further illustrative of the present invention. The enumeration of details therein, however, should not be considered as restrictive of the scope of this invention.

In an example, nylon 6 is melt spun into a 32-filament bundle 12 of 150 denier. The filament bundle 12 is subsequently introduced into aspirating jet 14 via aperture S7. In collar chamber S2, the filaments are subjected to air as the aspirating medium at a pressure of 30 p.s.i.g. The filaments 12 are forwarded to and through diffuser passageway 54 by the aspirating jet stream. Thereafter, the filaments 12 exit from jet 14 onto a two-planar deflector 22. The two-planar deflector 22 has a ½-inch long, ¾-inch wide first plane 18, and ¾-inch wide second plane 19, an angle α of 40 degrees and an angle β of 45 degrees. The filaments exhibit an initial point of substantial contact on two-planar deflector 22 at a distance from jet exit passageway 54 of approximately ¾ inch. Upon deflection from two-planar deflector 22, filaments 12 open up considerably and are deposited on continuously moving, foraminous, horizontal conveyor 20 which is moving at a speed of 8 feet per minute and is at a distance of 9 inches from the closest portion of the two-planar deflector 22. The nonwoven web produced is characterized by having a random filament distribution throughout. The appearance of the web is uniform and is essentially free of filament aggregates.

The nonwoven web or other useful construction processed from a coherent filament bundle which is prepared in accordance with this invention may serve a variety of useful purposes, particularly in the manufacture of nonwoven fabrics, such as carpet backing, wall covering, insulation, coating substrates, interfacing, filters, and the like.

Various modifications and other advantages will be apparent to one skilled in the art, and it is not intended that this invention be limited to details presented by way of illustration except as required by express limitations in the appended claims.

What is claimed is:

1. In an apparatus for depositing filaments onto a moving receiving surface in a randomly dispersed manner to form a nonwoven web of randomly disposed filaments substantially uniformly distributed throughout said web, said apparatus comprising an aspirating means for forwarding said filaments at high velocity to said moving receiving surface, the improvement comprising a two-planar deflector spaying means for augmenting spreading of, while advancing said filaments from said aspirating means to said moving receiving surface, said two-planar deflector consisting of a first plane rigidly affixed in one spatial position and a second plane being rigidly affixed in another spatial position, said two-plane deflector being positioned near the exist of said aspirating means such that a majority of said filaments exiting from said aspirating means impinge on said two-planar deflector and such that said first plane or its straight-line extension intersects said second plane in a manner so as to form an angle greater than 90 degrees between the impinging surfaces of said planes, said first plane producing an acute angle α of approximately between 0 degree and 60 degrees with a line parallel to the center-line of the exit passageway of said aspirating means, α being measured in the general direction of forward motion of said moving receiving surface, and said second plane producing an acute angle β of approximately between 20 degrees and 85 degrees with the extension of said first plane in said direction, the sum of said angle α and said angle β being less than 90 degrees.

2. The apparatus of claim 1 wherein α is between 25 degrees and 50 degrees, β is between 35 degrees and 60 degrees, and the sum of α and β is between 45 degrees and 87 degrees.

3. The apparatus of claim 2 wherein said two-planar deflector is affixed in a manner such that there is a distance ranging approximately from 3 to 26 times the diameter of said aspirating means exit passageway between said aspirator exit means and the area of initial substantial contact of said filaments on said two-planar deflector.

4. The apparatus of claim 3 wherein said distance ranges from 4 to 15 times said aspirating means exit passageway diameter.

5. The apparatus of claim 2 wherein said two-planar deflector has substantially rectangular planes, said first plane having a length in a direction proceeding from said aspirating means exit ranging from 3.5 to 20 times said aspirating means exit passageway diameter and a width ranging from 5 to 15 times said exit passageway diameter, and said second plane having a length in a direction proceeding from said aspirating means exit ranging from 1.5 to 25 times said exit passageway diameter and a width of at least 5 times said passageway diameter.

6. The apparatus of claim 5 wherein said first plane length ranges from 4 to 10 times said aspirating means exit passageway diameter, said first plane width ranges from 7 to 13 times said exit passageway diameter, said second plane length ranges from 2 to 4 times said exit passageway diameter, and said second plane width ranges from 7 to 20 times said exit passageway diameter.

7. The apparatus of claim 5 wherein α is 40 degrees and β is 45 degrees.

References Cited

UNITED STATES PATENTS

3,692,618 9/1972 Dorschner et al. 156—118
3,655,862 4/1972 Dorschner et al. 156—290
3,423,266 1/1969 Davies et al. 156—167
2,736,676 1/1956 Frickert, Jr. 156—441

DANIEL J. FRITSCH, Primary Examiner

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156—167, 181, 433, 497; 425—83