

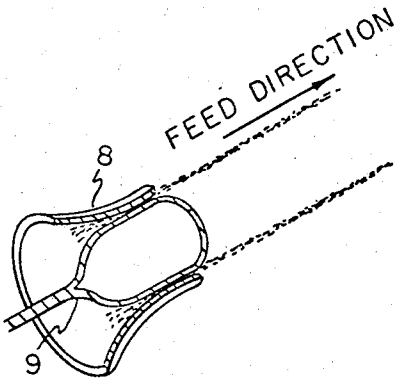
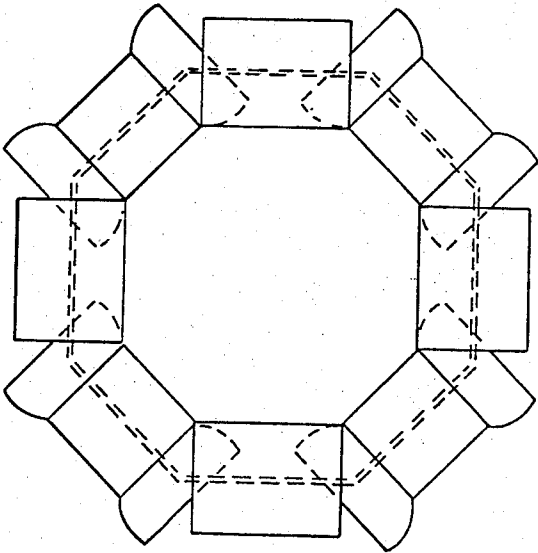
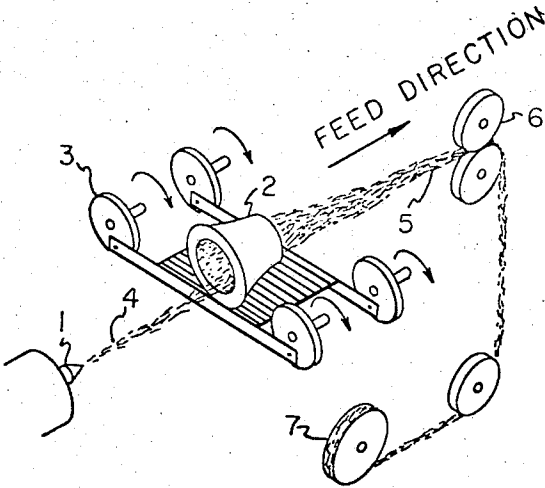
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SPRAY-SPUN CONTINUOUS TUBULAR STRUCTURE

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SPRAY-SPUN CONTINUOUS TUBULAR STRUCTURE

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Int. Cl. B32b 5/08; D04h 3/07
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5 Claims

ABSTRACT OF THE DISCLOSURE

A spray-spun nonwoven tubular structure is produced by spray spinning a fiber-forming polymer onto the inner surface of a circular forming base and withdrawing the tube continuously as it is formed.

This application is a divisional of U.S. application Ser. No. 743,863 filed July 10, 1968, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to spray-spun fibrous tubular structures and to a method of producing continuous spray-spun fibrous tubes.

Various methods have previously been advanced for producing nonwoven fibrous materials and the like directly from extruded fiber-forming materials. In general, these methods form nonwoven materials by extruding a fiber-forming polymer in liquid form through a plurality of orifices to form a like number of filaments which are either collected directly or following an intermediate drawing stage on a moving surface in the form of a mat. Examples of such methods are disclosed in U.S. Pats. 2,206,068; 2,382,290; and 2,810,426.

More recently, spray-spinning processes and apparatus have been developed which permit the formation of substantially continuous filaments at high production rates without the concurrent formation of quantities of shot and other undesirable physical forms such as very short fiber elements. The aforementioned spray-spinning processes and apparatus have been used to produce spray-spun fibrous bodies comprising randomly arranged filaments having a varying degree of crystalline orientation and a varying filament diameter along their lengths. These nonwoven spray-spun fibrous materials eliminate or substantially lessen the need for various subsequent bonding treatments by random thermal and/or adhesive bonding. The filaments are bonded to each other at crossover points and the self-bonding, in addition to some degree of filament entanglement, gives the spray-spun structure substantial coherency.

Nonwoven fibrous materials made by spray-spinning and by other similar methods should preferably have sufficient structural coherency and stability to retain their identity when handled manually or mechanically. The fibers or filaments themselves must not be made so resistant to stretching as to become brittle or susceptible to breaking when subjected to various operations to improve their properties for a particular end use. Nonwovens having insufficient tensile strength generally do not retain their dimensions on handling due to their own weight. However, the spray-spinning operation may be controlled to obtain the desired amount of tensile strength by self-bonding of the tacky fibers to each other. A bonding agent may also be utilized to increase or achieve the desired bonded strength to maintain structural coherency.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a novel method for producing continuous spray-spun fibrous tubing.

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Another object of this invention is to provide a novel fibrous spray-spun tubular structure having acceptable drapability and tensile strength per unit area per weight and which does away with the necessity of sewing or bonding a nonwoven sheet to produce tubular structures.

These and other objects will become apparent to those skilled in the art from a description of the invention.

In accordance with the present invention, these and other objects of the invention are realized by spray-spinning substantially continuous filament material in a tubular form. The filamentary material has a varying amount of orientation and is randomly bonded to itself at crossover points between filament sections during spray-spinning so as to form varying lengths subject to drawing.

The continuous spray-spun tubing is produced by spray-spinning a fiber-forming polymer onto a stationary or moving circular collection device, whose diameter is preferably changeable, positioned in front of one or more spray nozzles. The fibers are deposited around the inner surface of the circular collection device, forming a continuous tube, which is continuously withdrawn through the outlet end of the circular collection device, which outlet end is preferably smaller in diameter than the inlet end. The continuous spray-spun fibrous tube formed, which can be tapered, may be used as it is but it is preferably subjected to a drawing operation to further improve tensile strength, stretch and drapability. The tubes may also be slit to form flat sheets useful in making flat sheet nonwovens. The spray-spun tubes are especially useful in garments where tubular structures are normally made by sewing or otherwise bonding sheets, such as for sleeves or pants legs.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

This invention can be used in connection with the production of nonwoven spray-spun fibrous tubular structures from any of the polymers which are melt or solution spinnable. Of the various high molecular weight fiber-forming crystalline polymers that can be extruded through an orifice, the polyolefins, polyesters and polyamides are preferred. Cellulose acetate and polyacetal resins are examples of other polymers within the scope of this invention and are used with correspondingly good results. Suitable blends and copolymers of the above are also within the scope of this invention.

The spray-spinning operation may be carried out by various processes, but it is preferably effected by the use of the general techniques and apparatus disclosed in copending patent applications of Wagner et al., Ser. No. 581,075, filed on Sept. 21, 1966 now abandoned, and Ser. No. 740,913, filed on June 28, 1968, now U.S. Pat. 3,543,332, which applications are commonly assigned to the assignee of the present application. The disclosure of these patent applications are incorporated herein by reference.

Basically, the spray spinning is effected by extruding liquid fiber-forming material, which may be either molten or plasticized and dissolved in a solvent therefor, through an orifice as a filamentary material. Attenuation of the incompletely hardened filament is effected by a plurality of high velocity gas streams issuing from gas passages spaced about the extrusion orifice and having axes that converge toward but do not intersect the extrusion orifice axis. The gas flow projects the filament away from the nozzle in an expanding conical pattern.

The filamentary material projected from the spinning zone has desirable characteristics which have been found to be particularly beneficial in the construction of nonwovens. Although the fiber is similar to conventionally spun fibers in the sense that it is in the form of a substantially continuous filament structure, it exhibits random lengthwise variations in diameter and degree of orientation

which result from random variations in the attenuating action of the gas streams acting on the freshly spun filaments.

These variations in filament properties are usually substantial. For example, the cross-sectional area of the largest filament portion may be more than about 10 times that of the smallest filament portion, with the mean being about 3 times the cross-sectional area of the smallest filament portion. Thus, in a typical medium denier structure, the as-spun mean denier per filament is from about 12 to 18 with an average of about 15. After stretching, the denier per filament is reduced to from about 1.5 to 15, with the average being about 4. In heavier filament structures, the denier per filament usually varies over a wider range, whereas in the lower denier ranges, e.g., 0.5 to 15, the variance is normally over a narrower range. In a nonwoven structure embodying this filamentary material, the smaller diameter segments represent a larger portion of surface area per unit volume, while the larger diameter segments are relatively stiff and resist crushing of the nonwoven.

Preferably, the as-spun average denier per filament is in the range from about 1 to 30, and most preferably from 3 to 10. The preferred stretched denier per filament averages about 0.25 to 3.

As the freshly spun filament is projected away from the spinning nozzle in an expanding conical pattern by the gas streams, a circular collection surface, e.g., the inner surface of a tube, is preferably rotated and moved continuously in the path of the projected filamentary material to collect the filamentary material without destroying the random distribution of the filamentary sections. The movement of the collector surface or of the spinning orifice serves to bring new sections of the surface into the path of the filamentary material continuously so that the collected fiber forms a tube that is continuously removed from the collection zone and the fiber is uniformly deposited. The extrusion rate and the speed of the collection surface are preferably related to each other to assure that the collected tubes will have the desired weight per unit length and uniformity for the intended use of the nonwoven.

A better understanding of the invention may be had from a discussion of the drawings wherein:

FIG. 1 is a schematic drawing of the process of producing the spray-spun tubular structures of this invention.

FIG. 2 is a set of rolls arranged in a circular manner for use as a circular collection device.

FIG. 3 represents a funnel-shaped forming base for use as a circular collection device, consisting of an outer member 7 and an inner member 8.

Referring to FIG. 1, a continuous spray-spun fibrous tubing 5 is produced by directing fibers spun from a fiber-generating spinnert 1 onto the inner face of a circular forming base 2 and withdrawing the tube continuously as it is formed. The forming base can be a set of specially designed rolls, as shown in FIG. 2, arranged in a circular manner forming a doughnut-like construction, or a set of conveyor belts arranged in a doughnut fashion, riding over rolls similar to those shown in FIG. 2, or simply a funnel-shaped forming base as shown in FIG. 3 in which case the fibers are directed between outer member 7 and inner member 8 of the collection device. A method of imparting circular motion 3 to the forming base 2 is necessary unless there has been circular motion imparted to the spinning orifice itself. If a single fiber-generating source is used, the base travels circularly in a plane perpendicular to the direction of the advancing fiber 4. If several nozzles are used, the forming base rotates or oscillates in partial circular motion around the central axis of the doughnut hole.

The collection of the nonwoven spray-spun fibrous material in tubular form can be controlled so as to provide a structure of almost any weight, preferably within the range of from about 0.1 to about 50 ounces per square

yard. The particular weight of the spray-spun material produced depends upon the end use for which it is intended. For instance, when the material is to be used as a carpet backing material, the stretched product desirably has a weight of from about 4 to about 5 ounces per square yard. The spray-spun fibrous material may be originally collected in the weight range of from about 10 to 20 ounces per square yard and, on subsequent drawing, the area increase generally reduces the total weight per unit area, e.g., a reduction of from between 1 to 15 ounces per square yard. Weights of from about 0.5 to 30 ounces per square yard are prepared in this manner.

In controlling the weight of the nonwoven, the degree of self-bonding can also be controlled by varying the distance from the extrusion means to the collection surface so as to collect the fiber at a temperature whereby the residual heat and/or solvent retains the fiber sufficiently tacky to produce self-bonding. Of course, it will be recognized that by placing the collecting zone in a closer proximity to the extrusion orifice, an increase in bonding area occurs whereas when the collection surface is further removed, the amount of self-bonding can be reduced. In certain applications, such as for high-loft materials as contrasted with paper-like products, variations in bonding are often desired. Supplemental bonding means may also be used such as by applying a suitable bonding material to the collector along with the filamentary material or by the subsequent application of a binder.

The spray-spun tubing of this invention may be subjected to subsequent treatment such as drawing. The drawing and orientation of the spray-spun tubular material produced can be effected by drawing over a heated element such that the tube is enlarged and elongated or biaxially drawn. The drawing may be effected at temperatures which result in heating the sheet material from room temperature (20 degrees centigrade) to just below the melting temperature of the polymer. The drawing is effected in the presence of heat such as by drawing the fibrous tubular material over a heated expanding element. By controlling the expansion of the heated element, a tapered structure may be uniformly drawn so as to maintain uniform strength. Various drawing means can be used as well as various known heating means to produce correspondingly good results. Heating means such as radiant heating, gaseous heating, liquid heating, induction heating and the like are used.

The present invention will be more fully described by reference to the following examples which illustrate certain preferred embodiments of this invention. Unless otherwise indicated, all temperatures are in degrees centigrade and all parts and percentages are by weight.

EXAMPLE I

Polypropylene (Profax Polypropylene Type 6423) was extruded through a nozzle in accordance with the aforementioned Wagner et al. apparatus and process, and collected on the inner surface of a circular rotating funnel (as shown in FIG. 3) to form a spray-spun, fibrous, nonwoven tubular material. The inner member of the circular collection device had a diameter of 4 inches with the outer member having a diameter of 14 inches. The fibrous tube, when cut into a 12-inch finished length, weighed about 4 ounces per square yard. The polypropylene was spun at a temperature of 355 degrees centigrade using a 0.028-inch diameter nozzle of the geometric configuration described in the aforementioned Wagner et al. application. A sample of this spray-spun tube had an average denier per filament of about 4, varying from about 1.5 to 15 denier per filament.

EXAMPLE II

Polypropylene (Profax Polypropylene Type 6423) was extruded through a nozzle in accordance with the aforementioned Wagner et al. apparatus and process, and collected on the inner surface of a circular arrangement of

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rolls (as shown in FIG. 2) to form a spray-spun fibrous nonwoven tubular material. The inner surface of the circular collection device had a diameter of 8 inches with the outer surface having a diameter of 12 inches. The fibrous tube, when cut into a 12-inch finished length, weighed about 4 ounces per square yard. The polypropylene was spun at a temperature of 355 degrees centigrade using a 0.028-inch diameter nozzle of the geometric configuration described in the aforementioned Wagner et al. application. A sample of this spray-spun tube had an average denier per filament of about 4, varying from about 1.5 to 15 denier per filament.

Spray-spun materials produced using various other polymeric fiber-forming materials such as polyamides, polyesters, cellulose acetate, acrylics, conjugates thereof and the like thermoplastic polymers are used with correspondingly good results.

The fibrous structures of this invention may serve a variety of useful purposes. With suitable coating and/or laminations, they may serve in industrial applications instead of conventional woven materials, films and papers. By the use of a circular collection device whose diameter may be varied, tapered tubular structures such as are used in tapered pants legs or shirt sleeves are easily produced. The nonwoven structures of this invention can also serve in the preparation of felts, leather-like materials and suede-like materials. It may also be used as an interlining or interfacing material used in imparting shape and/or stiffness to garments. In addition, the tubular nonwoven fabric may be used in the fabrication of pants legs, sleeves for sweaters, coats and work uniforms, or the like.

While various embodiments of the present invention have been described, the methods and elements described herein are not intended to limit the scope of this invention since changes therein are possible. It is intended that each element recited in any of the following claims is to be understood as referring to all equivalent elements for

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accomplishing the same results in substantially the same or equivalent manner. It is intended to cover the invention broadly in whatever form its principles may be utilized, being limited only by the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A nonwoven fibrous tubular structure comprising substantially continuous, randomly arranged, filamentary material consisting essentially of thermoplastic, fiber-forming crystalline polymeric material, said filamentary material having a varying degree of crystalline orientation, random lengthwise variations in diameter and filament segments extending in all directions and crossing each other at randomly located points to bond filament segments together at filament crossover points to form varying effective filament lengths.

2. The tubular material of claim 1 having a varying diameter.

3. The tubular material of claim 1 additionally containing a binder.

4. The tubular material of claim 1 wherein said filamentary material comprises a polyolefin.

5. The filamentary material of claim 4 wherein said polyolefin is polypropylene.

References Cited

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WILLIAM J. VAN BALEN, Primary Examiner

U.S. Cl. X.R.

156—167, 181, 229; 161—402; 264—12, 210