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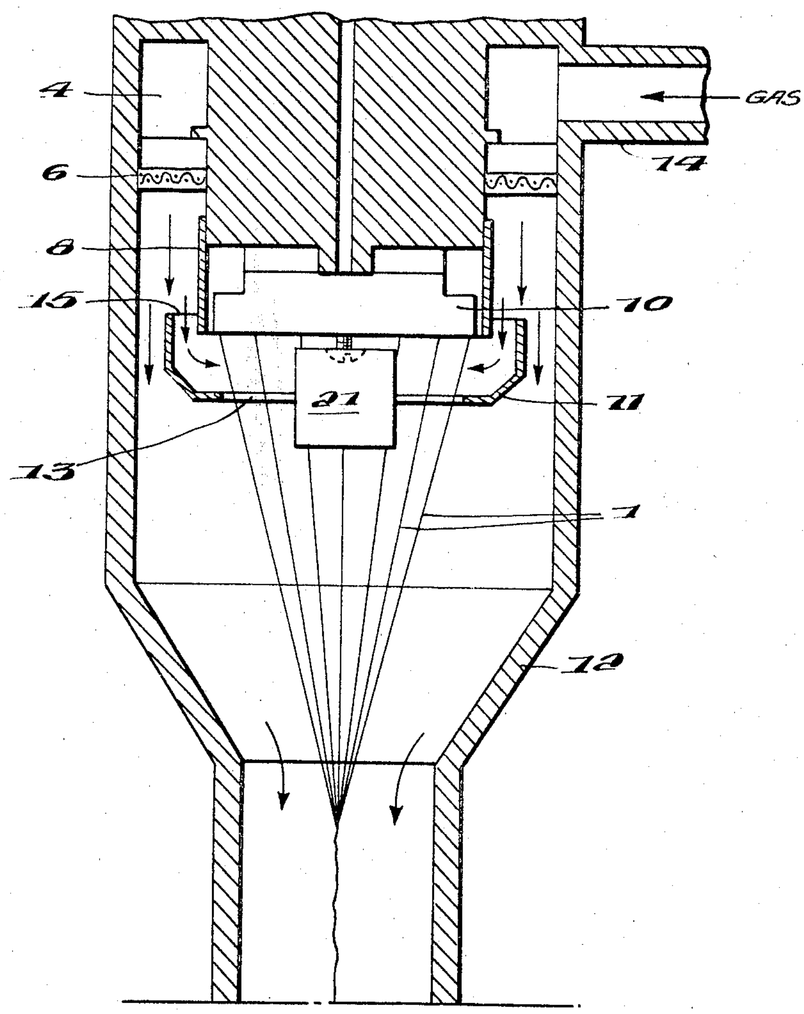

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## QUENCHING APPARATUS


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This invention relates to the preparation of fibers and filaments from synthetic organic polymers. More particularly, it relates to an improved apparatus for use in the dry-spinning of synthetic filament-forming polymers.

Spandex is useful for the manufacture of hosiery, in which the spandex is often used in a knit-in construction and in an uncovered state. If the spandex is not of uniform denier along the length of the filaments, the hosiery possesses unattractive rings and bands. The present invention provides a solution to this problem.

In U.S. Patent No. 3,111,368, issued to J. E. Romano, is described an apparatus for the dry-spinning of spandex filaments of uniform denier. The apparatus comprises a gas damper, such as a cone or cylinder, placed directly below the spinneret assembly within the circle of filaments. The gas damper helps to reduce turbulence in the vicinity of the spinneret thereby decreasing the denier variation along the length of the filaments.

Although the Romano device gives good results in dry-spinning, there is room for further improvement of denier uniformity. When the heated gas, used to evaporate solvent from the extruded streams of polymer-containing solution, is supplied at relatively high velocity and particularly when yarn of low denier is spun, it is found that the incoming stream of heated gas is carried well below the plane of the spinneret by its own momentum before it flows inward across the circle of filaments. This flow pattern of the gas, together with the downward motion of the filaments, tends to create a zone of lower pressure just below the spinneret. As a result, there is some flow of heated gas upwardly within this zone. This flow pattern produces a certain amount of turbulence, which results in decreased denier uniformity of the dry-spun filaments.

This invention provides apparatus for dry-spinning of filaments having improved denier uniformity along the length of the filaments. This invention also provides apparatus which increases the rate of solvent removal from the filaments directly beneath the spinneret in a dry-spinning cell and reduces turbulence of the heated gas in this region.

The advantages of this invention are attained by providing an improvement in an apparatus for dry-spinning of filaments. The apparatus of the invention comprises a spinneret assembly having a plurality of filament-producing orifices arranged in a generally circular pattern, wall means encircling said spinneret assembly and positioned coaxially thereof to define a spinning cell, said wall means being spaced from said spinneret assembly in the region thereof to define an annular passageway for providing a cocurrent stream of heated gas to the spinning cell to evaporate solvent from extruded filaments; the improvement comprising the combination of (a) an obstruction positioned at the center of said circular pattern of orifices to restrict the cross-sectional area of the spinning cell for a substantial distance along the path of filament travel, and (b) a gas-deflecting band positioned internally and coaxially of said wall means and spaced therefrom to divide the flow of gas in said annular passageway, said band having an inwardly flared lip to direct a portion of said gas to the filaments immediately upon their extrusion from the orifices.



The invention will be further described with reference to the accompanying drawing, which is a view, partially in section, of the top portion of a dry-spinning cell containing the apparatus of this invention. A dry, heated gas is introduced into the top of spinning cell **12** through inlet **14** and gas manifold **4**. The heated gas is uniformly distributed by gas distributor **6** and is directed downwardly into the spinning cell **12** in an even flow pattern by baffle **8** which is positioned adjacent to spinneret assembly **10**, shown in full. Baffle **8**, which prevents the flow of gas between itself and spinneret assembly does not protrude below the bottom face of the spinneret. An annular passageway for heated gas is thus provided about the spinneret assembly. Gas-deflecting band **11** is positioned so as to deflect a portion of the downwardly moving stream of gas in a direction radially inward across the face of the spinneret.

A spinning solution of suitable viscosity is pumped to spinneret assembly **10** and extruded through a generally circular pattern of orifices in the face thereof to provide a plurality of filaments **1**. Centrally positioned in the spinning cell and secured to the face of the spinneret assembly **10** is gas-obstructing means **21**, shown as a cylindrical body. As taught in the aforementioned Romano patent, cylindrical body **21** need not extent completely to the face of spinneret assembly **10**.

The gas-deflecting band **11** consists of a circular element having a lip which is inwardly flared at the bottom so that its lower surface is in a plane approximately parallel to the face of the spinneret. The circular opening **13** formed at the lip is smaller than the opening **15** at the top. The band is mounted around the spinneret assembly with the smaller opening **13** below the spinneret and the larger opening **15** above the spinneret face. A portion of the heated gas which flows downwardly in the annular space around the spinneret flows into upper opening **15** and is directed across the filaments **1** which pass through the lower opening **13**. By this arrangement the filaments upon emerging from the orifices are immediately exposed to the hottest and driest gas in the cell. Upward motion of gas in the vicinity of the spinneret does not occur.

The gas-deflecting band is of generally circular shape, since it should conform to the cross-section of the spinning cell. It may be mounted in the cell in any convenient manner. The mountings should not substantially interfere with the flow of heated gas nor with the filaments extruded from the spinneret. Preferably, the gas-deflecting band is mounted by fins, not shown, in slots, not shown, in the baffle 8 around the spinneret. In general, the upper portion of the gas-deflecting band should extend above the plane of the spinneret face and the lower portion should extend a substantial distance below the spinneret face, but should not extend below the lower extremity of the gas-obstructing device **21**. The relative size of upper opening **15** determines the proportion of heated gas which is deflected radially inward under the spinneret. The proportion of gas so deflected may be chosen within rather wide limits. Generally, however, the gas-deflecting band is designed so as to divert from about 5% to about 60% of the heated gas under the spinneret.

The gas-obstructing means **21**, which is centrally mounted under the face of the spinneret, may have a variety of shapes, including cylindrical and conical shapes and combinations thereof. For example, the device may be bullet-shaped to provide an annular passage having a constant cross-sectional area adjacent to the spinneret and a cross-sectional area which continuously increases downwardly. A combination of a bullet-shaped gas-obstructing means together with the gas-deflecting band as described above has been found to be particularly desirable in the dry-spinning of spandex filaments. As taught in the Romano patent, the ratio of length of the gas-obstructing device to its diameter should lie between 1:1 and 4:1, whereas its diameter should be less than half that of the spinning cell.

This invention is particularly useful in obtaining improved denier uniformity in the cocurrent dry-spinning of filaments derived from segmented polyurethanes, widely known in the art as spandex filaments. This invention is also useful in improving the uniformity of other dry-spun filaments, for example, homopolymers of acrylonitrile and copolymers thereof containing at least 85% of acrylonitrile units, and nylon polymers, especially the wholly aromatic polyamides.

Although it is possible to obtain improved uniformity in dry-spun spandex without use of the present invention, such as by adjusting the spinning conditions, such adjustment frequently results in a sacrifice of physical properties, quality, or yield of the product. The combination of the gas-deflecting band and gas-obstructing device comprising the present invention permits obtaining good uniformity under spinning conditions which also give good properties, quality, and yield. Use of this invention is particularly advantageous when higher gas velocities are employed in cocurrent dry-spinning.

This invention is further illustrated, but is not intended to be limited, by the following examples in which parts and percentages are by weight, unless otherwise indicated.

*Example I*

Polytetramethylene ether glycol of molecular weight about 2,000 and p,p'-methylenediphenyl diisocyanate are intimately mixed in the ratio of 2 mols of diisocyanate per mol of polyether glycol and are reacted to yield an isocyanate-terminated polyether. The isocyanate-terminated polyether (132 parts) is mixed with 164 parts of N,N-dimethylacetamide to form a mixture containing 45% solids. Then a mixture of 76.5 parts of dimethylacetamide, 6.8 parts of m-xylylenediamine, and 0.5 part diethylamine is added with mixing. The polymer solution so obtained contains approximately 36.5% solids and has a viscosity of about 2400 poises at 40° C. The polymer has an inherent viscosity of 1.20, measured at 25° C. in hexamethylphosphoramide at a concentration of 0.5 gram per 100 ml. of solution. To the polymer solution are added a slurry of titanium dioxide in dimethylacetamide, a solution of poly-(N,N-diethyl-beta-aminoethyl methacrylate) in dimethylacetamide and a solution of 4,4'-butylidenebis-(2-t-butyl-m-cresol) in dimethylacetamide such that the final mixture contains 5%, 5%, and 1%, respectively, of each additive, based on the elastomeric solids.

The foregoing mixture is heated to a temperature of 60° C. and extruded through a spinneret containing 80 holes into a spinning column 6 meters in length. Kemp gas, essentially a mixture of about 87% nitrogen and 13% carbon dioxide, heated to 300° C. is introduced at the top of the spinning column and is drawn off at a point about 1.5 meters above the exit point of the filaments.

At the level of the spinneret, the spinning cell has an inner diameter of 37.5 cm. The spinneret assembly is 20 cm. in diameter and contains orifices 0.18 mm. in diameter, the orifices being arranged in two circles. The circles have diameters of 15.6 cm. and 14.0 cm., respectively. In passing the face of the spinneret, the Kemp gas used at a rate of 27 kg. (60 lbs.) per hour has a velocity of about 19.5 cm. per second. Directly below the center of the spinneret and within the circles of orifices is attached a gas-obstruction device, generally in the shape of a bullet, which is 10 cm. in diameter, 12 cm. in length, and is made of stainless steel. Mounted within the annular space between the spinneret and the cell wall is a gas-deflecting band having upper and lower circular openings. The diameter of the upper circular opening is 27 cm., and the diameter of the lower circular opening



is 19 cm. The lower circular opening is located 1.9 cm. below the spinneret face. This device deflects about 30% of the Kemp gas radially inward across the spinneret face.

Below the cell, the filament bundle passes through a jet twister which backs twist up the bundle into the cell to a point about 2 meters above the exit. The well coalesced multifilament of about 70 denier leaving the jet is treated with a silicone-containing finish and is then wound up in the usual manner.

The denier variability of the product is measured according to the method described hereinafter and is found to have a value of 1.81%. This figure is the average value of eight separate measurements on the product. Under identical spinning conditions, but without the gas-deflecting band surrounding the filament bundle, the denier variability is 3.83%.

*Example II*

Dry-spinning of the spandex solution described in Example I is repeated under the same conditions except that the Kemp gas is heated to 355° C. and is used at a rate of 23.5 kg. (52 lbs.) per hour at a velocity of 18.5 cm. per second. The denier variability of the yarn is 1.23%. Without the gas-deflecting band, the denier variability is 1.81%.

*Example III*

Dry-spinning of the spandex solution described in Example I is repeated under the same conditions except that the spinning solution is heated to 90° C., and the Kemp gas is heated to 390° C. and is used at a rate of 15.8 kg. (35 lbs.) per hour at a velocity of 13 cm. per second. With the gas-deflecting band in place, the denier variability has a value of 1.15%. Without the gas-deflecting band, the denier variability is 1.29%.

*Example IV*

Dry-spinning of the spandex solution described in Example I is repeated under the same conditions except that the Kemp gas is heated to 345° C. and is used at a rate of 23.5 kg. (52 lbs.) per hour at a velocity of 18.2 cm. per second. In this example a gas-deflecting band having an upper circular opening 24 cm. in diameter and a lower circular opening 19 cm. in diameter is used. The lower circular opening is located 1.3 cm. below the spinneret. This device deflects about 15% of the gas radially inward across the spinneret face. The denier variability of the yarn is 1.67%. Without the gas deflecting band, the denier variability is 2.48%.

The denier variability in the above examples is determined by means of the well known Uster Evenness Tester, which measures variations in dielectric strength as a yarn is passed between the plates of a capacitor. The integrator in the instrument provides a continuous reading of the deviation in dielectric strength as a percent of the total average. The yarn is passed through the dielectric gauge at a speed of 12 cm. per second under a stretch of 1.25× and with sufficient false twist to consolidate the yarn. The integrator reading at the end of a five-minute period, having been set to zero at the beginning of the period, is reported as the denier variability of the yarn.

What is claimed is:

1. In an apparatus for the dry spinning of filaments comprising a spinneret assembly having a plurality of filament-producing orifices arranged in a generally circular pattern, wall means encircling said spinneret assembly and positioned coaxially thereof to define a spinning cell, said wall means being spaced from said spinneret assembly in the region thereof to define an annular passageway for providing a cocurrent stream of heated gas to the spinning cell to evaporate solvent from extruded filaments; the improvement comprising the combination of (a) an obstruction positioned at the center of said circular pattern of orifices to restrict the cross-sectional area of the spinning cell for a substantial distance along

the path of filament travel, and (b) a gas-deflecting band positioned internally and coaxially of said wall means and spaced therefrom to divide the flow of gas in said annular passageway, said band having an inwardly flared lip to direct a portion of said gas to the filaments immediately upon their extrusion from the orifices.

2. Apparatus according to claim 1 wherein said obstruction is a cylindrical body.

3. Apparatus according to claim 1 wherein the lip of



said band terminates between the extremities of said obstruction.

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