An improved apparatus and method for commingling multifilament yarn has been found. The apparatus comprises an elongated body having a straight yarn passageway with at least three orifices substantially equally spaced about the periphery of the body at substantially the same level. The orifice center lines are offset so that at least two do not intersect with the center of the effective diameter of the yarn passageway, yet all pass within an imaginary circle having a diameter about one-third the effective diameter, and the same center as the effective diameter, at the orifice level. Also, at least two of the center lines extended from the orifices should pass outside the imaginary circle at the orifice level section having the same center but only 0.02 of the effective diameter of the yarn passageway. The plane at the orifice level must be located within a length one-half the length of the yarn passageway and centered on the midpoint of the yarn passageway. These orifices communicate with a source of high pressure fluid. The high pressure fluid flows through the orifices into the yarn passageway causing a vortex of swirling fluid so that any yarn passing linearly through the passageway would have filaments commingled with one another. This improved process of entangling multifilament yarn can operate at from about 3,000 to about 8,000 feet per minute by passing continuous multifilament yarn through the above-described vortex.

13 Claims, 6 Drawing Figures
APPARATUS AND PROCESS FOR COMMINGLEING MULTIFILAMENT YARN

BACKGROUND OF THE INVENTION

This invention relates to an improved method and apparatus for commingling or entangling multifilament textile yarn by passing a continuous strand of this yarn through a yarn passageway and directing high pressure fluid from orifices onto it.

Many prior art patents show various methods and apparatus for entangling a running continuous multifilament strand of yarn. However, the prior art is directed to intersecting and tangentially-directed fluid streams or combinations of them. For example, see U.S. Pat. No. 3,443,292 to Davis and U.S. Pat. No. 3,525,133 to Psaras.

SUMMARY OF THE INVENTION

The main differences and advantages of this invention over the prior art are:

A. At least three air orifices are spaced substantially equally at substantially the same level about the periphery of the yarn passageway.

B. The orifice center lines are offset so that at least two do not intersect with the center of the effective diameter of the yarn passageway, yet all pass within an imaginary circle having a diameter about one-third the effective diameter, and the same center as the effective diameter, at the orifice level.

The resulting turbulent jet streams impinge asymmetrically in an annular area about the center line of the effective diameter of the yarn passageway and create a highly turbulent whirlpool or vortex that entangles or commingles the individual filaments in a continuous running strand of multifilament yarn. The plane at the orifice level must be located within a length one-half the length of the yarn passageway and centered on the midpoint of the yarn passageway. The method and apparatus of this invention have shown a much more efficient entangling operation using up to 75 percent less air and costing as little as one-tenth of the cost of the prior art devices, with a much quieter operation. The method and apparatus can be used at speeds from 3,000 to 8,000 feet per minute. Specifically, the improved apparatus for commingling continuous multifilament yarn of this invention comprises an elongated body having a straight yarn passageway passing through the elongated body and at least three orifices substantially equally spaced about the periphery of the elongated body at substantially the same level. These orifices communicate with the passageway so that the center line of all the orifices, if extended, would pass within an area defined by a circle in a cross section at the orifice level having the same center as the effective diameter and having a maximum diameter of about 0.3 times the effective diameter of the yarn passageway. At least two of these extended center lines must pass outside the circle in the same cross section having the same center and about 0.02 times the effective diameter of the passageway. The orifices communicate with a source of high pressure fluid. The high pressure fluid flows into the orifice into the yarn passageway causing a vortex of swirling fluids so that any yarn passing linearly through the yarn passageway would have filaments commingled with one another. By "effective diameter" is meant a diameter of the largest circle which fits within and yet is tangent to the opposite sides of the narrowest dimension across the yarn passageway. Thus, a circular yarn passageway has the same effective diameter as the actual passageway diameter. However, a polygonal passageway such as a rectangle would have an effective diameter equal to the narrowest dimension of the polygon. For example, a rectangular yarn passageway would have an effective diameter equal to the narrowest dimension of the rectangle.

To enhance the degree of entanglement, yarn guides can be placed about 2 inches above and below the entangling device to guide the yarn bundle through the highly turbulent whirlpool or vortex generated by the mixing of the three turbulent jet streams. To facilitate stringup, the device is slotted. Both the yarn passageway and the orifices admitting the commingling fluid may have circular or polygonal cross sections. The preferred range of the inner diameter of the annular target area is from about 0.02 to about 0.03 times the effective diameter and from about 0.23 to about 0.3 times the effective diameter for the outer diameter of the annular area. The fluid can be any fluid which can be jetted through an orifice such as nitrogen, steam or possibly even liquids. However, the preferred fluid is air. When air is used, the fluid pressure of between 30 and 90 psig is preferred. This results in a maximum air consumption of about 10 standard cubic feet per minute for each commingling device. Tension on the yarn passing through the commingling device can be any tension which gives the desired amount of commingling. The preferred range is from about 0.03 to about 0.2 gram per denier. The commingling device and method can be used on yarns of any denier but has been preferably used on 1,300 denier yarn or two ends of 1,300 denier yarn resulting in 2,600 denier yarn.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross section of the plan view of the commingling device at the orifice level.

FIG. 2 is a cross section in elevation of the commingling device.

FIG. 3 is an elevation view of the commingling device showing the string-up slot.

FIGS. 4, 5 and 6 are schematic diagrams showing the circumference of the effective yarn passageway with extended orifice center lines directed to target circles and an annular area.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

EXAMPLE 1

The device of this invention has been successfully used to commingle a single and two ends of 1,300 denier 70 filament textured carpet yarns. The operating pressure range was between 60 to 90 psig and the air consumption was approximately 10 standard cubic feet per minute at the highest pressure. The operating yarn tensions were between 0.03 to 0.20 grams per denier. Yarn entanglement as measured by a special entanglement tester can be as high as 50 or more entanglements per meter for 2,600/140 denier yarns (two ends of 1,300 denier 70 filament) at 3,000 and 5,000 feet per minute. The following correlation has been obtained from experimental data at 3,000 feet per minute;

\[
E.P.M. = 21.6 - 4.16x_1 + 6.91x_2 - 0.06x_3 - 0.01x_4^2 + 0.11x_5^2 + 0.03x_6^2 - 2.38x_7x_2 + 2.38x_8x_5 + 0.125x_9x_5
\]

where:

- \(E.P.M\) is the entanglement per meter
- \(x_1\) to \(x_9\) are variables related to the yarn properties and processing conditions
$x_1 = \text{Tension} - 125/60 \text{ gm.}$

$x_2 = \text{Air pressure} - 70/15 \text{ psig}$

$x_3 = \text{Guide spacing} - 2.0/0.75 \text{ inches}$

$x_3^{*2} = 15x_2^2 - 10.954$

** = Entanglements per Meter

 Carpets were tufted on scroll and slat machines with good performance and overall appearance, hand, apparent weight, etc. In addition commingled light and dark 1,300 denier 70 filament shag carpets were made which were equivalent to non-commingled carpets on all counts.

The dimensions of the commingling device used for this example were as follows. The circular yarn passageway length was one inch. The yarn passageway diameter was 0.180 inch. Three orifices were used at one-half inch from top. Each orifice diameter was 0.055 inch.

At least two orifice center lines, extended, were outside a circle having the same center as the yarn passageway but having a 0.004 inch diameter. All three orifice center lines extended were within an outer circle having 0.060 inch diameter.

The special entanglement test is based on the hook-drop test in U.S. Pat. No. 2,985,995, May 30, 1961. This test has been modified to the special entanglement per meter test as follows. An entanglement among the filaments in the yarn bundle is so identified when it has the cohesion to hold a 10 gram hook which is allowed to slowly move down through the yarn. The entanglement tester counts the number of times a needle with a 40 gm "trigger pull" in a horizontally moving yarn is "stopped." The instrument counts the "stop," raises the needle, moves a fresh portion of yarn under the needle, inserts the needle, and starts the yarn moving. The instrument stops the test when the needle has moved through 2 meters of yarn. Approximately 1 meter of yarn by-passes the needle between needle insertions.

FIG. 1 shows a cross-sectional view of the orifice level of a commingling device of this invention. Inner body 1 has a yarn passageway 2 passing longitudinally through it. Inner body 1 also has off-set orifices 3 spaced substantially equally about the diameter of yarn passageway 2. These orifices are off-set so that the center line of each orifice, if extended, would not pass through the center line of the yarn passageway 2. Orifices 3 communicate with manifold 4 which in turn communicates with large orifice 7 in register with tube fitting 6 which is secured to outer body 5. Outer body 5 also contains string-up slot defined by the surfaces labeled 8 and 9. The string-up slot has a flared opening.

FIG. 2 is an elevation view cross section at A—A on FIG. 1 of the commingling device of this invention. Like numbers indicate the same apparatus as in FIG. 1. In addition, Yarn Y is shown passing through guide 11 above yarn passageway 2. Guide 11 and another guide identical below the commingling device keep the yarn Y centered through yarn passageway 2 to effect more efficient commingling.

FIG. 3 is an elevation view of the commingling device of this invention. Here again, like numbers indicate the same parts of the apparatus as in FIG. 1.

FIGS. 4, 5 and 6 are schematic diagrams showing the circumference of the effective yarn passageway and extended orifice center lines passing tangent to or within target circles or an annulus.

FIG. 4 shows the circumference of the yarn passageway 24 having fluid orifice extended center lines 19, 20 and 21 which pass through a target annulus defined by an outer circumference 22 and an inner circumference 23. The preferred range of the inner diameter of the annular target area is from about 0.02 to about 0.03 times the effective diameter. The preferred range for the outer diameter of the annular target area is from about 0.23 to about 0.3 times the effective diameter. In the preferred embodiment of this invention, all of the fluid orifice center lines extended, such as, 19, 20, and 21, must cross within the outer circumference of the annulus. However, only at least two must pass outside the inner circumference 23.

For example, in FIG. 5, showing circumference of effective yarn passageway 24 and target circle 15, the extended fluid orifice center lines 17 and 18 are tangent to the target circle 15 but extended fluid orifice center line 16 passes through the center of the circles. This is still an embodiment of this invention.

In the preferred embodiment of the invention shown in FIG. 6, all fluid orifice extended center lines 12, 13 and 14 are tangent to a target circle 15 having an effective diameter about 0.1 times the effective diameter of the yarn passageway. Here again, the effective yarn passageway is shown by a circumference of effective yarn passageway 24.

CRITICALITY OF THE ECCENTRICITY OF THE ORIFICE CENTER LINES

The criticality of the orifice center lines extended impinging on the annular target area as set forth in FIGS. 4, 5 and 6, is shown in Table I. The procedure of Example 1 was followed using 2,600 denier steam jet textured yarn operating at 3,000 feet per minute. Three orifices were used to impinge air on the yarn in the jet. In all cases, the yarn tension was held constant at 125 grams. Air pressure was 80 pounds per square inch gauge in all cases. All three orifices were circular in cross section and had a diameter of 0.055 inch. The yarn passageway diameter is shown in Table I. All other dimensions are given in Example 1. Tension in all cases was 125 grams.

<table>
<thead>
<tr>
<th>TABLE I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarn Passageway Diameter (in inches)</td>
</tr>
<tr>
<td>Run No.</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>E</td>
</tr>
<tr>
<td>F</td>
</tr>
</tbody>
</table>

By "radial eccentricity" is meant the radius of a circle concentric with the yarn passageway and tangent to the nearest point on the center line extended out of the orifice. Note that the first two and the last Runs A, B and F did not succeed in producing a very high level of entanglements per meter. The reason for this is the criticality of the annular target area outlined above. In order to figure the ratio to see if the radial eccentricity or the center line extended is within the annular area, the ratio of $2E/D$ where $E$ equals the radial eccentricity and $D$ equals the yarn passageway diameter must be between the critical limits 0.02 and 0.3 as in the paragraphs given above. For example, in Run A, the radial
eccentricity of orifice 3 would be 0.068/0.190 = 0.358 which indicates that the center line extended of orifice 3 would be outside the circle having a diameter 0.3 times the effective diameter. Thus, this commingling apparatus and method would be outside the limits of this invention. Similarly in Run B, orifice 2 has a radial eccentricity too large. The ratio of 0.074/0.180 = 0.39 which indicates that the center line extended of orifice 2 would be even further outside the circle having 0.3 times the effective diameter. On the other end of the scale, Run F shows that more than two center lines extended cannot be within a circle having a diameter 0.02 times the effective diameter. Orifice 3 in Run F passes exactly through the center of the yarn passageway. Considering orifice 1 also in Run F, to figure the critical ratio would be 0.002/0.180 = 0.011 which is within a circle having a diameter 0.02 times the effective diameter. Thus, this embodiment in Run F is outside the scope of this invention because two of the orifice center lines extended pass too close to the center of the yarn passageway. A check of the other dimensions shown in Table I will further illustrate the criticality of this annular target area of this invention.

I claim:

1. An improved apparatus for commingling multifilament yarn comprising an elongated body having a straight yarn passageway passing through said elongated body, at least three orifices substantially equally spaced about the periphery of said body at substantially the same level, the plane at said orifice level must be located within a length one-half the length of the yarn passageway centered on the midpoint of length of the yarn passageway, said orifices communicating with said passageway so that the center line of all of said orifices, if extended, would pass within an area defined by a circle in a cross section at the orifice level having the same center as the circle of the effective diameter and having a diameter of about 0.3 times the effective diameter of the yarn passageway and at least 2 of said extended center lines would pass outside a circle in the same cross section having the same center but about 0.02 times the effective diameter of the yarn passageway said orifices communicating with a source of high pressure fluid so that any yarn passing linearly through said passageway would have continuous filaments commingled with one another.

2. The apparatus of claim 1 wherein said orifices are cylindrical and said extended center lines of said orifices pass within an area defined by the circle having the same center but a diameter of about 0.23 times the effective diameter of the yarn passageway and at least two of the said extended center lines would pass outside a circle in the same cross section having the same center but a diameter of about 0.03 times the effective diameter of the yarn passageway.

3. The apparatus of claim 1 wherein said fluid is air.

4. The apparatus of claim 1 wherein guides located above and below said apparatus are used to locate said yarn in said passageway.

5. The apparatus of claim 4 wherein said guides are located about 2 inches above and about 2 inches below said apparatus.

6. The improved process of entangling multifilament yarn comprising passing said yarn through a yarn passageway at speeds from about 3,000 to about 8,000 feet per minute while creating a highly turbulent whirlpool of entangling fluid in said yarn passageway by directing jets of fluid under pressure from at least three orifices located at substantially the same level in said yarn passageway, the plane at said orifice level must be located within a length one-half the length of the yarn passageway and centered on the midpoint of the length of the yarn passageway said fluid jets being directed so that at least two said jets do not impinge directly on the center of the effective diameter of said passageway, but so that all impinge directly on an area within a circle in a cross section at the orifice level having the same center as a circle of the effective diameter but having a diameter of about 0.3 times the effective diameter of said yarn passageway whereby said yarn passing through said yarn passageway has its individual filaments entangled with one another.

7. The method of claim 6 wherein said fluid is air.

8. The method of claim 6 wherein yarn guides are used to guide said yarn through said yarn passageway.

9. The method of claim 8 wherein said guides are located about 2 inches above and about 2 inches below said yarn passageway entrance.

10. The method of claim 6 wherein said fluid jets impinge on the annular area having the same center as the effective diameter with an inner diameter of about 0.03 times the effective diameter of the yarn passageway and an outer diameter about 0.23 times the effective diameter of the yarn passageway.

11. The method of claim 10 wherein all of said jets of fluid impinge the outer circle of the annulus but only at least two impinge outside of the inner circle of the annular area.

12. The method of claim 7 wherein said fluid pressure is 30 to 90 psig.

13. The method of claim 6 wherein the yarn has a textured denier of about 1,300 to about 2,600 and the tension on said yarn is from about 0.03 to about 0.2 gram per denier.

* * * *