United States Patent

Erickson et al.

[15] **3,680,334**

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[54] **APPARATUS HAVING CHAMBER OF OVAL CROSS-SECTION FOR HEAT TREATING LARGEDENIER TOW**

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[52] **U.S. Cl.** .....**68/5 D,** 34/37, 68/DIG. 1

[51] **Int. Cl.** **D06c 1/06**

[58] **Field of Search** .....68/5 D, 5 E, DIG. 1; 34/37; 8/149.3

[56] **References Cited**

UNITED STATES PATENTS

2,353,615	7/1944	Kauffmann et al.	8/149.3
3,137,152	6/1964	Dale et al.	68/5 D
3,240,037	3/1966	Bittle et al.	68/5 E

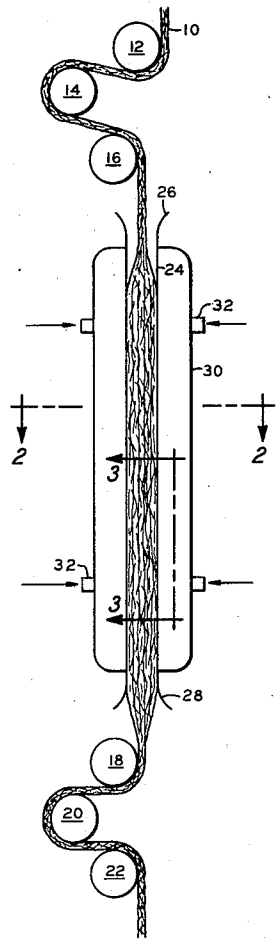
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[57] **ABSTRACT**

Fibers of propylene polymers and the like are passed rapidly through an elongated oval chamber by means of a pair of tensioning means wherein they are subjected to saturated steam to give a soil resistant resilient product.

10 Claims, 4 Drawing Figures



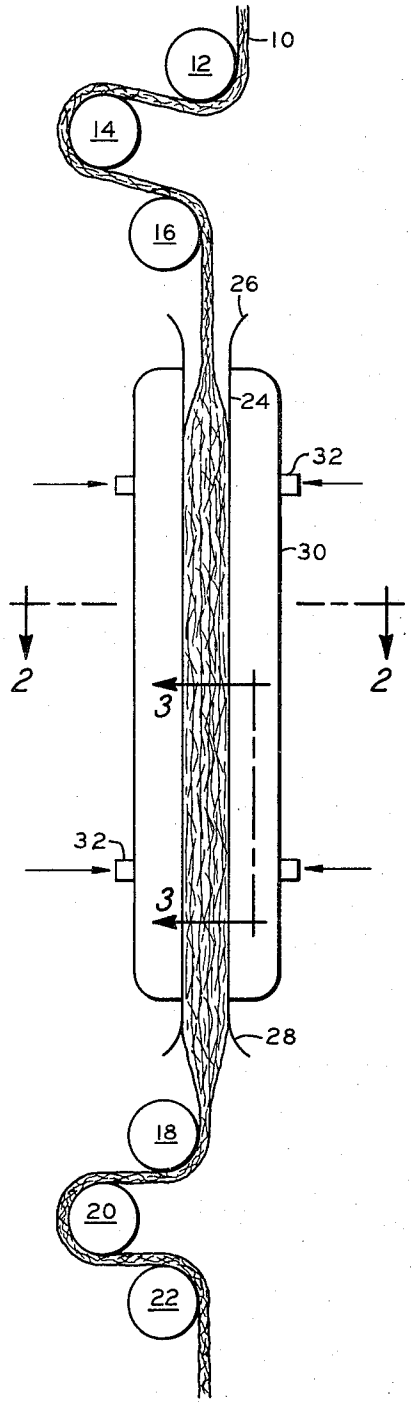


FIG. 1

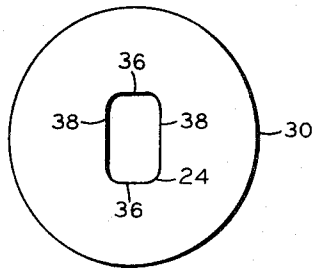


FIG. 2

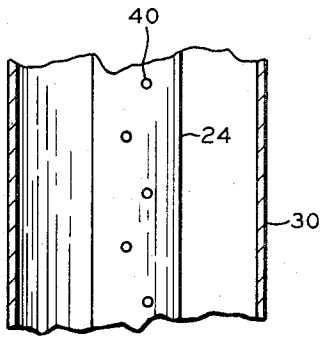


FIG. 3

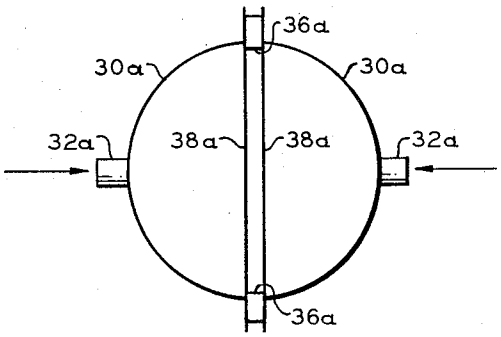


FIG. 4

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APPARATUS HAVING CHAMBER OF OVAL CROSS-SECTION FOR HEAT TREATING LARGEDENIER TOW

BACKGROUND OF THE INVENTION

It is common practice in the textile industry to utilize thermal and/or mechanical treatment of fibrous materials to improve the characteristics thereof for particular applications. For instance, Bittle et al. U.S. Pat. No. 3,240,037, discloses apparatus for annealing individual filaments or apparently small diameter yarn of acrylic or other fibrous material which becomes brittle if heated under tension at elevated temperatures. And it is also well known to anneal synthetic polymeric material in an air oven for a time period in the range of an half hour to 1 hour so as to reorder the crystal structure.

It has been found that conventional air oven annealing results in an improvement in resilience of fibers. However, with propylene polymers such treatment results in a serious deterioration in soiling characteristics.

SUMMARY OF THE INVENTION

It is an object of this invention to provide improved apparatus for producing resilient fibers of propylene polymer; it is a further object of this invention to provide apparatus to achieve reordering of crystal structure without imparting an increased tendency to soil; and it is yet a further object of this invention to provide apparatus capable of heat treating large denier tow at commercially acceptable rates.

In accordance with this invention, a pair of tensioning means is provided for transporting large denier filament tow through an elongated oval chamber which is open at each end, the ratio of the major axis to the minor axis of said chamber being within the range of 2:1 to 200:1, said chamber being further characterized by having a plurality of small holes and being encased in a jacket with connections for supply of a fluid treating medium.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings forming a part hereof wherein like reference characters denote like parts in the various views,

FIG. 1 is a side view partially in section of an apparatus in accordance with the invention;

FIG. 2 is a cross-section along lines 2—2 of FIG. 1;

FIG. 3 is a longitudinal section along lines 3—3 of FIG. 1; and

FIG. 4 is a cross-section of an apparatus in accordance with an alternative embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

It is essential to achieve heat treatment in no more than two seconds, generally within the range of 0.01 to 2, preferably 0.4 to 0.6 seconds. Thus, the apparatus of this invention can be relatively short and still provide the required treatment while moving the tow at a commercially acceptable rate. Generally, the length of the treating section will be within the range of 1 to 10, preferably 2 to 5 feet.

Considerable latitude is possible in the placement of and size of the holes in the elongated oval chamber so long as the holes are placed sufficiently close together that steam is distributed relatively uniformly through the tow passing through. It is preferred that the placement be such that no two holes are placed on opposite sides exactly across from each other. It is also preferred that the hole placement be such that the holes do not line up in rows parallel to the axis of the chamber. One convenient pattern is simply to place the holes in a spiral pattern each successive hole being rotated 90° around the circumference from the preceeding hole and moved forward axially a short distance, for instance, within the range of 0.2 to 2, preferably 0.3 to 0.7 inches. The size of the holes would also vary over a relatively wide range with the size of 10 to 200, preferably 15 to 50 mils diameter being preferred. Another preferred pattern is a randomized placement of the holes.

The aspect ratio or ratio of the major to minor axis of a cross-section of the elongated oval chamber will generally be in the range of 2:1 to 200:1, preferably 25:1 to 200:1.

The apparatus can be made of a conventional construction material as for instance steel or aluminum.

Any conventional tow handling means can be utilized for transporting the tow through the treating chamber under tension. A preferred means which is readily adapted to commercial use is simply a set of three rollers at each end over which the yarn passes. Means can be provided to vary the relative speed of the first and second rolling zones so that the tension on the fibers may be sufficient to prevent any shrinkage or may be only sufficient to prevent undue shrinkage. Generally, the tension will be such that the final length of a section of the fiber after treating is 70–100 percent, preferably 90–100 percent of the original length. This invention allows effective treatment of large denier tow at line speeds of 100 to 250, preferably 125 to 150, meters per minute.

In operation, saturated steam, as opposed to superheated steam is introduced into the annulus between the elongated oval treating chamber and the jacket (or into separate enclosures around the flat sides of the treating chamber). The steam at this point is under a pressure of about 55–90, preferably 70–80 psig. The time as well as steam temperature and pressure must must be correlated so that no substantial melting of the tow results. Generally the tow will be heated to a temperature of 10° to 35° C. below the melting point of the polymer constituting the tow. For example with polypropylene homopolymer the preferred temperature to which the tow will be heated is within the range of 135° to 160° C. The fibers treated utilizing the apparatus of this invention have improved resilience due to reordering of the crystal structure. This change can be measured by small-angle X-ray diffraction. Polypropylene fibers as normally spun and drawn are characterized by imperfect crystals of length in the fiber axis direction of less than 100A, typically in the range of 85–100A. The fibers treated in the apparatus of the instant invention exhibit crystal size of 125–200A, preferably 140–160A with a corresponding improvement in resiliency. The same apparent crystal structure can be obtained by heating in an air oven for

30–60 minutes but the resulting polymer has an increased tendency to soil whereas the fibers treated with the apparatus of this invention does not.

This apparatus is of particular utility in the treatment of fibers made from propylene polymers including homopolymers and copolymers having a small amount of a monomer other than propylene and also in the treatment of fibers made of blends wherein a propylene polymer is a major constituent. Of course, in all cases conventional additives such as stabilizers, pigments, and the like can be present.

While the description hereinabove has referred to fibers or filaments, as a practical matter treatment will usually be carried out on a tow comprising a large number of individual fibers or filaments. The oval cross-sectional shape allows large denier tow to be treated rapidly and uniformly so as to achieve the improvement in resilience without harm to the soiling characteristics; further the treatment is more uniform since the flattened tow is penetrated and contacted by the steam. Generally the tow will have a denier of greater than 100,000, preferably 250,000 to 750,000 denier. On initial contact with the steam the tow expands to essentially fill the oval treating chamber. This makes possible efficient use of the steam without the need for seals at each end of the elongated oval chamber which further facilitates treatment at commercially feasible rates.

Referring now to the FIGURES, particularly FIG. **1**, is shown an apparatus for conditioning tow in accordance with the invention. A continuous length of tow **10** is fed through a first tensioning means comprising rollers **12**, **14** and **16**, which in combination with a second tensioning means made up of rollers **18**, **20** and **22**, serve as a tensioning means to maintain tension on the tow as it passes through a treating zone. Specifically, the tow passes through oval chamber **24** which has a flared forward end **26**. Chamber **24** has a second open end **28**. Surrounding oval chamber **24** is jacket **30** which is sealed around each end thereof to oval chamber **24**. Jacket **30** contains steam introduction means **32**. The steam exhausts both at end **26** and with the tow at the second end **28**. As can be seen from FIG. **2**, tube **24** has an oval cross-section with opposed generally flat walls **36** at each end of a major axis thereof and generally flat walls **38** at opposite ends of a minor axis thereof.

Referring now to FIG. **3**, it is shown a longitudinal section of jacket **30** showing holes **40** and oval chamber **24**.

As can be seen from FIG. **1**, steam enters through inlets **32** and into the annular space between jacket **30** and oval chamber **24** and thence through holes **40** into contact with tow **10**. This contact of steam with tow **10** causes the tow to fluff out as can be seen from FIG. **1** to substantially fill the space within the tube **24**.

Many conventional parts such as drive motors, temperature controllers, speed controllers, and the like have been omitted from the drawings for the sake of simplicity but their inclusion is understood by those skilled in the art and is within the scope of the invention.

FIG. **4** shows a preferred embodiment wherein the elongated oval treating chamber is made by welding flat plates having holes therein to a split pipe and affixing the two halves together with spacers. The inner surfaces of the spacers form flat side walls **36***a* of the oval treating chamber with the portion of the flat plates between the spacers forming flat side walls **38***a*. The two halves of the pipe form jackets **30***a* with steam introduction means **32***a*.

While the steam jacket **30** is shown round in FIGS. **1–3** and is shown formed from round pipe in FIG. **4**, it can be any convenient shape such as square and the like

EXAMPLE

Melt spun yellow pigmented polyproplene fibers from a creel containing a pluality of yarn packages were plied together through ring guides to form a tow band of about 500,000 denier. The polypropylene had a melting point of about 170° C. The tow, maintained under tension, was passed through two sets of rolls allowing no more than about 10 percent relaxation. The apparatus of this invention was placed between these rolls. The tow was then passed to a stuffer-crimper and cut into staple. The treating apparatus of this invention was 6 feet long overall and had an oval treating chamber with a 32 to 1 aspect ratio and an effective treating length of 58 inches. The oval treating chamber was 4 inches wide by ⅛ inch deep with 660 1/32-inch diameter holes on a ⅜ by 2 inch grid on the flat sides (the spacing on the two plates was offset slightly so holes did not occur directly across from each other). The shell was made from a split 4-inch diameter pipe with ⅛-inch polytetrafluoroethylene gaskets so as to form separate steam enclosures around each flat side as shown in FIG. **4**. Each steam enclosure had two 1-inch steam inlets. Saturated steam was used as the treating fluid at a temperature of 157° C. and a pressure of 75 psig Residence time for treating tow in the apparatus was 0.5 seconds. Both treated and untreated samples were made. Samples were cut into staple 1½ inches long. One gram samples were taken from the prepared staple and hand carded. The samples were placed in a 1-inch diameter die and compressed at 10,000 psi for 1 minute. Measurements of returned plug height were taken after 30 seconds and 24 hours. Crystal lengths of both samples were measured by small angle X-ray diffraction. The treated samples had a longer crystal length and exhibited a higher degree of resilience by plug height measurement as shown in Table 1 and was a satisfactory product for carpet yarn.

TABLE 1

Sample	Denier Per Fiber (Nominal)	Crystal Length	Plug Height (24 hrs.)
Control 1 (untreated)	18	105 A	0.244 inches
Run 1 (treated)	18	155.8 A	0.636 inches

Large denier tow was annealed in an air oven under optimum conditions to improve resiliency. The resulting product was not satisfactory for carpet yarn.

While this invention has been described in detail for the purpose of illustration, it is not to be construed as limited thereby but it is intended to cover all changes and modifications within the spirit and scope thereof.

We claim:

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1. Filament tow treating apparatus comprising in combination:

an elongated oval chamber having a tow receiving opening at a first end thereof and an exit opening at a second end thereof, said chamber having a ratio of the major axis to minor axis of from 2:1 to 200:1, said chamber having a plurality of holes therein;

a jacket around at least the flat sides opposite said minor axis of said oval chamber, said jacket being sealed at each end thereof to said oval chamber to form at least one steam enclosure;

steam inlet means on said enclosure;

and means for transporting tow through said oval chamber under tension.

2. Apparatus according to claim 1 wherein said means for transporting said tow through said oval chamber comprises a first set of three rolls at the forward end of said oval chamber and a second set of three rolls at the exit end thereof.

3. Apparatus according to claim 1 wherein said holes are spaced on said oval chamber in a spiral configuration with the axial distance between successive holes being within the range of 0.2 to 2 inches.

4. Apparatus according to claim 1 wherein said holes are placed in a random pattern.

5. Apparatus according to claim 1 wherein said holes have a diameter within the range of 10 to 200 mils.

6. Apparatus according to claim 1 wherein said treating chamber has an axial length within the range of 1 to 10 feet.

7. Apparatus according to claim 1 wherein said means for transporting said tow through said chamber comprises a first set of three rolls that the forward end of said chamber and a second set of three rolls at the exit end thereof;

wherein said holes are arranged in a generally spiral configuration on said chamber and are spaced axially apart a distance of 0.5 to 0.7 inches and have a diameter within the range of 15–50 mils;

and wherein said chamber has a length in the range of 2 to 5 feet.

8. Apparatus according to claim 1 wherein said ratio is within the range of 25:1 to 200:1.

9. Apparatus according to claim 8 wherein said holes have a diameter within the range of 10–200 mils.

10. Apparatus according to claim 9 wherein said means for transporting said tow through said oval chamber comprises a first set of three rolls at the forward end of said oval chamber and a second set of three rolls at the exit end thereof.

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