Jan. 24, 1967 J. D. CHARLTON 3,299,469

MELT-SPINNING APPARATUS

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FIG. 1

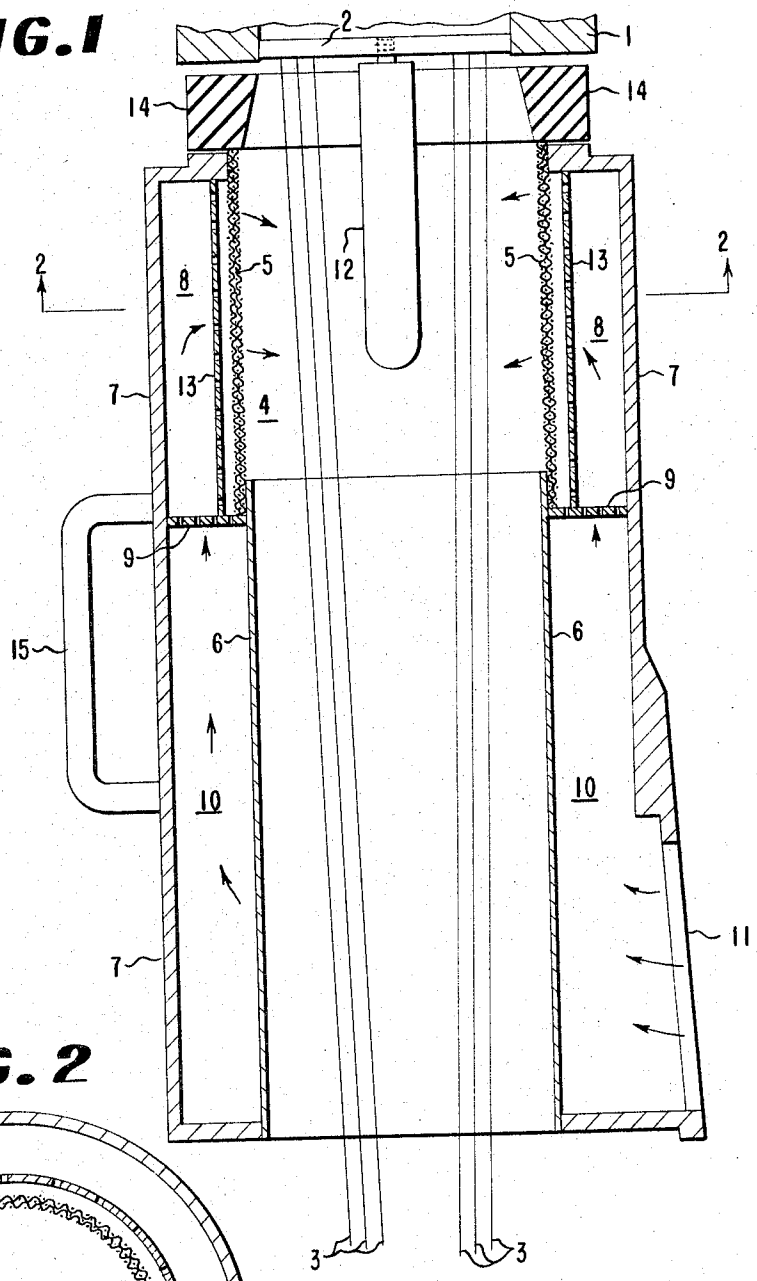
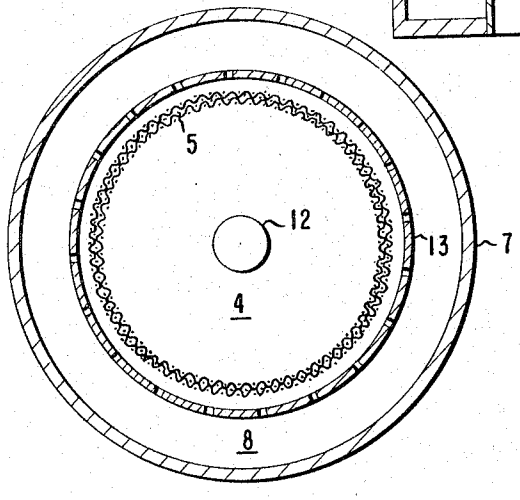


FIG. 2



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MELT-SPINNING 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 filament-quenching apparatus for use in the melt spinning of synthetic filament-forming polymers.

In melt-spinning processes for forming fibers and filaments on a commercial scale, the quenching step in which the molten polymer streams are solidified to form solid filaments is both important and critical. Various methods of quenching have been disclosed. For example, quenching with cross-flow air is described by Heckert in U.S. Patent No. 2,273,105, dated February 17, 1942, while quenching with concurrent air is described by Babcock in U.S. Patent No. 2,252,684, dated August 19, 1941. Both methods have been used in large scale yarn manufacturing plants, but neither is fully satisfactory from the standpoint of enabling the production of high-quality filaments of uniform denier at high rate of production.

The present invention provides a quenching apparatus for use in melt spinning which gives a decided improvement in the quality of the filaments spun in the sense that both denier and dyeing non-uniformities are substantially eliminated, and the uniformity of tenacity and break elongation values are greatly improved. Furthermore, the invention provides for a 20% to 50% increase in fiber productivity on existing equipment by allowing closer spacing of holes in the spinneret.

In accordance with the present invention, improved quenching of melt-spun filaments is achieved by directing quenching air radially inwardly towards the molten filaments immediately below the spinneret and providing a generally cylindrical baffle or gas damper which extends from the lower face of the spinneret downward into the radial quenching chamber to eliminate air turbulence in the center of the filament bundle.

Briefly described, the apparatus comprises a hollow cylindrical foraminous member positioned to form a quenching chamber for the filaments immediately below the spinneret, a jacket surrounding the foraminous member to form an annular plenum chamber, an exit tube positioned below the foraminous member in axial alignment therewith to form a continuous passageway for the spun filaments to pass downward from the spinneret to subsequent processing equipment, means including a gas distributing chamber surrounding the exit tube for supplying a uniform flow of cooling gas into said plenum chamber to provide a uniform radial flow of the gas into the quenching chamber through said foraminous member, and a generally cylindrical gas damper extending from the spinneret into the quenching chamber along the central axis of the foraminous member for directing the cooling gas downward in essentially streamline flow to quench the filaments by concurrent flow of gas.

The invention will be further described with reference to the accompanying drawings, in which:

FIGURE 1 is a partially diagrammatic side view, with parts in section, showing a quenching apparatus constructed in accordance with the present invention; and

FIGURE 2 is a cross-sectional view of the quenching apparatus taken along line 2—2 of the apparatus shown in FIGURE 1.

Referring now to FIGURES 1 and 2, reference numeral 1 designates a spinneret pack provided with a spinneret 2 from which a plurality of filaments 3 may

be extruded. The freshly extruded molten filaments are passed down through a hollow quenching chamber generally designated by reference numeral 4. The walls of the quenching chamber may be a cylindrical screen member 5 or other hollow cylindrical foraminous member mounted above exit tube 6 which, in the embodiment of FIGURE 1, is a cylindrical tube having a diameter about 1.5 times that of the outermost circle of spinneret orifices and a height about equal to its diameter.

The exit tube and superposed foraminous member are mounted within generally cylindrical jacket 7, which is inwardly flanged at top and bottom, to form a generally annular plenum chamber 8. Screen member 5 is surrounded by perforated cylindrical plate 13 which assists in the uniform distribution of air to the screen. Plenum chamber 8 is supplied with air or other cooling gas at a pressure slightly higher than atmospheric pressure to provide a uniform radial flow of cooling gas into the quenching chamber through the foraminous member. Gas for the plenum chamber 8 is supplied through inlet 11 in jacket 7 to a distributing chamber 10 around the exit tube, and thence through distribution plate 9 to plenum chamber 8. Inlet 11 is connected to a gas supply source which is not shown in the drawing.

Reference numeral 12 designates a bullet-shaped gas damper extending from the spinneret 2 into quenching chamber 4 along the central axis of the cylindrical foraminous member 5. It has a diameter about ⅙ that of the cylindrical foraminous member and it extends about ⅔ the distance through the quenching chamber 4.

Jacket 7 is also fitted with mounting means, not shown, for removably attaching the quenching apparatus to the melt-spinning machine. Handle 15 assists in moving the assembly into position. Insulating ring 14 assists in the proper spacing of the quenching assembly from the spinneret and reduces heat transfer from the spinneret pack to jacket 7.

Radial introduction of the quenching gas uniformly from all directions, to be redirected downward in essentially streamline flow by the gas damper 12, followed by concurrent flow of the gas with the filaments causes uniform and rapid solidification of the filaments within the quenching apparatus. In the optimum form of the apparatus, the height of the hollow cylindrical foraminous member is of about the same order as its diameter, which diameter is determined by the diameter of the filament bundle. The inner diameter of this cylindrical foraminous member must be slightly greater than the diameter of the filament bundle as it is extruded from the spinneret; e.g., at least ½-inch larger than the outermost circle of spinneret orifices, and it may be twice as large. The height of the exit tube of the quenching apparatus is advantageously about 1 to 2 times its diameter, and the diameter should be the same as, or slightly smaller than, the diameter of the hollow cylindrical foraminous member. In general, the height of the hollow cylindrical foraminous member is usually in the range of about 0.25 to about 4 times its diameter, and the height of the exit tube is usually in the range of about 0.25 to about 4 times the diameter of the tube. Of course, the foraminous member and the exit tube are positioned in axial alignment with the path of the filaments between the spinneret and the filament forwarding means. In the case of molten polyethylene terephthalate filaments extruded at a temperature of about 285° C., the optimum rate of air flow is usually in the range of 1 to 10 cubic feet per minute per square inch of cross section of the exit tube, measured at the upper end of the exit tube, or of the cross section of the filament bundle.

The gas damper 12 is of generally cylindrical shape, with the surface approximately parallel to the surrounding filaments. If the filaments converge rapidly, the gas damper

may be tapered slightly to parallel the paths of the filaments, i.e., may have an elongated frusto-conical shape. The lower end is preferably rounded to provide streamline flow around this end. The gas damper should have a diameter about 10% to 50% of the diameter of the hollow cylindrical foraminous member, and extend about 40% to 100% of the total distance of filament travel through the quenching chamber formed by the foraminous member. Preferably it extends at least 4 inches into the chamber. The diameter of the gas damper is, of course, less than that of the innermost circle of spinneret holes to prevent contact between the damper surface and unsolidified filaments. In practice a clearance of 0.37 inch (9.5 mm.) is usually sufficient for this purpose. Hence, there should be at least ¾-inch difference between the diameters of the gas damper and the innermost circle of spinneret holes.

In quenching extruded molten filaments with a radially introduced concurrent flow of cooling gas, the yarn product obtained is quite uniform in properties so long as the spinning filaments are maintained in a smooth, stable pattern. On the other hand, yarn uniformity is severely affected by interruption of the spinning pattern, i.e., movement of the filaments relative to each other. Such fluttering of the filaments, whether caused by air turbulence below the point at which the filaments are completely solidified or turbulence in the quenching chamber, results in interfilament fusion near the spinneret as well as differential tension on the filaments in the bundle at the solidification point. The present invention provides a very stable spinning pattern which eliminates non-uniformities and interfilament fusion.

The invention will be further illustrated by the following examples, which, however, are not intended to be limitative.

EXAMPLE I

Polyethylene terephthalate having an intrinsic viscosity of 0.59 is extruded at 275° C. from a conventional melt-spinning apparatus through a spinneret containing 600 holes, each 0.015 inch (0.38 mm.) in diameter, arranged in 8 equally spaced concentric circles, the diameter of the outermost circle being about 3.90 inches (9.9 cm.). The filaments are passed through a quenching apparatus of the type illustrated in FIGURE 1, passed over a finish roll which applies a lubricating, antistatic finish to the filaments, passed over a set of forwarding rolls and then packaged using a conventional wind-up apparatus operating at 1600 yds./min. (1460 meters/min.). The foraminous member comprises a cylindrical assembly of 5 layers of 100-mesh screen, 6 inches (15.2 cm.) high and 6 inches (15.42 cm.) in inside diameter, positioned inside a hollow cylindrical perforated plate containing 3.05% free area. The exit tube is 13 inches (33 cm.) in height and has a diameter of about 6 inches (15.2 cm.). The distribution plate between upper and lower plenum chambers has 30% free area. A gas damper of bullet shape, 1 inch (2.54 cm.) in diameter and 6 inches (15.2 cm.) long, extends down into the quenching chamber formed by the cylindrical foraminous member for a distance of 4 inches (10.2 cm.). Cooling air is supplied to the plenum chamber at a rate of 90 to 100 cubic feet per minute (2.54 to 2.83 cu. meters/min.). It is observed that the pattern of filaments during spinning is very stable, despite the occurrence of strong air drafts in the room as observed by releasing smoke in the vicinity of the apparatus. The yarn has a denier per filament as spun of 3.70. After drawing at 2.88×, the yarn has a denier per filament of 1.50, a tenacity of 4.1 g.p.d., and an elongation of 34.0%. The yarn is found to be substantially free of segments or undrawn filaments.

EXAMPLE II

In another experiment, the apparatus of Example I is modified by removing the bullet-shaped gas damper. Using the same spinneret, polyethylene terephthalate having an intrinsic viscosity of 0.59 is spun and wound up as 3.70 d.p.f. yarn at 1600 yds./min. as in Example I. The yarn product is found to be unacceptable because of the high incidence of interfilament fusing. When the yarn is drawn, an unacceptable level of segments of undrawn filament resulting from the sections of fused filaments is observed.

In order to obtain an acceptable yarn product under these conditions, it is found necessary to employ a spinneret having only 450 holes vs. the 600 holes of Example I.

The present invention offers many advantages among which may be mentioned the production of filaments of an exceptionally uniform denier at good rates of speed. The uniformity of denier is of such a high degree that subsequent dyeing is level and the dyed yarn is free of streaks or flecks due to varying shades of color. The tenacity and break elongation of the filaments produced according to the present invention, as well as the denier, are likewise uniform. Furthermore, considerably more filaments may be spun into the same quenching space. These results appear to be attributable to the combination of radial quenching with a central baffle as herein described.

It will be apparent that many widely different embodiments of this invention may be made without departing from the spirit and scope thereof, and therefore it is not intended to be limited except as indicated in the appended claims.

I claim:

1. In apparatus for melt spinning synthetic filament-forming polymers through a spinneret, filament-quenching apparatus which comprises a hollow cylindrical foraminous member positioned to form a quenching chamber for the filaments immediately below the spinneret, a jacket surrounding the foraminous member to form an annnular plenum chamber, an exit tube positioned below the foraminous member in axial alignment therewith to form a continuous passageway for the spun filaments to pass downward from the spinneret to subsequent processing equipment, means including a gas distributing chamber surrounding the exit tube for supplying a uniform flow of cooling gas into said plenum chamber to provide a uniform radial flow of the gas into the quenching chamber through said foraminous member, and a generally cylindrical gas damper extending from the spinneret into the quenching chamber along the central axis of the foraminous member for directing the cooling gas downward in essentially streamline flow to quench the filaments by concurrent flow of gas.

2. Apparatus as defined in claim 1 wherein said generally cylindrical gas damper has a diameter about 10% to 50% of the diameter of said cylindrical foraminous member, extends 40% to 100% of the distance of filament travel through the quenching chamber formed by the foraminous member, and there is at least ¾-inch difference between the diameters of the gas damper and the innermost circle of spinneret holes.

3. Apparatus as defined in claim 2 wherein said gas damper has a diameter of about 1 inch and extends at least 4 inches into said quenching chamber.

4. Apparatus as defined in claim 1 wherein said cylindrical foraminous member has an inner diameter which is from slightly greater to twice the diameter of the outermost circle of spinneret orifices, the height of the foraminous member is from 0.25 to 4 times the diameter, and the height of said exit tube is about 1 to 2 times the diameter.

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