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PROCESS FOR TREATING FILAMENTS

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This invention relates to the treatment of melt-spun organic filaments, yarns, ribbons and the like. More particularly, this invention relates to improvements in the method and process of quenching and finishing synthetic organic filaments. The manufacture of filaments from high polymeric filament-forming compositions by melt spinning procedures, the polymer to be shaped into filaments is normally heated to the molten or plastic state but below the decomposition temperature thereof. The molten or plastic mass is extruded at a constant rate and under pressure through small orifices in a spinneret to form molten streams of polymer. The molten polymer streams issuing from the spinneret are directed vertically downward into a quenching chamber that is normally supplied with a forced air or liquid gas which serves as the filament quenching medium. The air or gas quenching medium being applied is generally at a temperature of ambient or less. The as-spun filaments are sufficiently cooled to cause solidification of the molten polymer filaments prior to their being forwarded from the quenching chamber area by a yarn forwarding device. It can be readily appreciated that the filamentary streams after emerging from the spinneret until sufficiently cooled are particularly sensitive to deformation. Accordingly, the art has found it generally necessary to direct the cooling gas against the filamentary streams while the streams pass downwardly through a protective cell or quenching chamber and to avoid a turbulent flow of the cooling gas. Particularly advantageous results are obtained when the directional movement of the cooling air is transverse with respect to the downward direction taken by the moving streams of polymer, care being taken that the gas flow at a given point is uniform in magnitude and direction. Having traversed the protective chamber the filaments are then brought together. A finish commonly is applied to the filaments to lubricate them, reduce their electrostatic tendencies, prepare them for further processing, and the like. This step is conventionally accomplished by the utilization of finish rolls which are usually a part of the take-up equipment and normally constructed of carbon-bronze, glass or stainless steel. The rolls dip into a pan containing an aqueous solution of the finish and through slow speed rotation transmit the finish to the filaments as they pass by with rubbing contact. The filaments are subsequently collected in an orderly manner for further processing.

In this conventional spinning of molten organic filament-forming compositions, difficult is often experienced in obtaining yarns, filaments and the like structures which have a uniform denier throughout the length thereof. Such uniform structures have been found to be more uniform as to dyeing characteristics, drawability, etc. It is believed that this difficulty of obtaining filaments having uniform physical characteristics is, in part, due to an uneven and non-uniform quenching of the molten streams of polymer produced by the transverse movement of the cooling air in the quenching column.

In the above described melt spinning procedures there are a number of drawbacks. In the first place the cooling chamber normally employed is of a large size and particularly long in length, thus taking up much space and often quenching and solidifying the streams of molten polymer at a rate much reduced from that at which the composition may be extruded through the orifices of the spinneret. Additionally, it is noted that the finish is applied in a separate step and at a point where the filaments have been formed into a unified bundle instead of in a dispersed state. Thus, where the filaments are in contact with the finish applicator rolls, they are not sufficiently dispersed to afford uniform application of finish thereto. It would represent a marked advantage and saving in time, equipment, space and money if these two operations of quenching and applying finish, could be combined into one process. Also, it would be advantageous if the molten streams of polymer could be quenched at an increased rate and in a much more confined space.

Therefore, with the above in mind, it is an object of the present invention to incorporate into a single new process the steps of quenching and finishing synthetic organic filaments.

Another object of this invention is to provide a process for simultaneously quenching and finishing melt-spun filaments, yarns, ribbons, and the like.

It is a further object of the present invention to provide a method for achieving a highly uniform distribution of finish or quenching medium on the surface of the filaments by atomizing the medium at a point removed from the filaments whereby the atomized particles are uniformly impinged upon the filaments from all directions in an indirect manner.

Still another object of the invention is to provide a process for a more uniform and a more rapid quench of molten melt-spun synthetic organic filaments.

A further object of this invention is to provide a process for imparting a novel surface effect to molten synthetic organic filaments.

Still another object of the invention is to provide means and apparatus for carrying out the above.

These and other objects and advantages will become readily apparent and appreciated as the invention becomes better understood by reference to the accompanying drawings in which:

FIGURE 1 is an elevational view, partly in section, of an embodiment of the apparatus used in carrying out one aspect of this invention;

FIGURE 2 is a sectional view of the apparatus shown in FIGURE 1 taken along line 2—2 of FIGURE 1, showing details of the fluid atomizing means, and

FIGURE 3 is a fragmentary view showing a modified form of the apparatus of FIGURE 1 which is employed for carrying out another aspect of the present invention.

In general, the objects of the present invention are accomplished by continually passing molten streams of polymer through a colloidal suspension, mist, or fog of atomized coolant medium such as water, a non-aqueous solution of chemicals, or like substances. The coolant used may be either water or finish that is to be applied to the filaments. Also, the coolant may be an aqueous finishing solution containing not more than 95 percent water. Means are provided for confining the colloidal suspension to the desired area of quenching and finish application and yet allowing the continuous passage of the filaments from the spinneret to the take-up equipment. Means are also provided for the continuous generation of the colloidal suspension, collection, and re-use of those colloidal particles which collect on the chamber walls or through collision with one another that grow in size and fall out of suspension.

In FIGURE 1 of the drawing, reference numeral 10 designates a spinneret assembly which incorporates an orificted spinneret 11 through which a molten or plastic
filament forming polymer is extruded or shaped into a plurality of filaments 12. The molten polymer is pumped or propelled to the spinneret under pressure through a conduit 13 from a suitable source, not shown, where the polymer is melted in a molten or plastic condition. The face of the spinneret preferably is horizontally disposed so that the normal extrusion axis extends vertically downward, although it is well contemplated that it may take any downwardly directed orientation. Upon extrusion, the molten polymer assumes the form of a stream or plurality of streams of polymer. Where the process and apparatus of this invention are used to quench and/or finish the molten streams of polymer, the streams 12 first pass through ambient air for a distance of approximately 8 to 24 inches, as shown in FIGURE 1, before entering substantially enclosed hollow chamber 14 through opening 15. 

Where the apparatus and process are used to impart a novel surface effect, the molten streams of polymer 12 are received immediately after extrusion by substantially enclosed chamber 14 through opening 15, as shown in FIGURE 3, without being subjected to a pre-quench to quench the polymer as and in a molten state at the time the colloidal particles filling the chamber 14 contact the surface thereof. Enclosed hollow chamber 14 is constructed of any suitable material, i.e., plastic, glass, metal or the like that is chemically inert to the finishing and/or quenching medium. In the particular embodiment shown in FIGURE 1, the elongated chamber 14 is of a cylindrical shape and made of clear plastic. Once the molten streams of polymer have entered hollow chamber 14 through opening 15, they pass through a colloidal suspension 16 which is generated at atomizer 17, shown in greater detail in FIG. 2 and which will be discussed more fully hereinafter. The colloidal suspension 16 may be better defined or understood by describing it as a dense fog or mist which completely fills hollow chamber 14. This colloidal suspension 16 is the quenching and finishing medium or may be the quenching medium alone or the finishing medium alone if these operations are not conducted simultaneously. Additionally, quenching medium 16 is the medium which will, when desired, impart a novel surface effect to the molten streams of polymer. Once the filaments have passed through colloidal suspension 16 contained in hollow chamber 14, they leave the chamber through opening 18 and are brought together into a single bundle of filaments 19 and forwarded by yarn forwarding rolls 20 to be taken up or to be further processed. Enclosed hollow chamber 14 is further supported in its vertical position in the filament path by base 21 and legs 22.

As has been stated, colloidal suspension 16 is generated at atomizer 17 which is connected to and supplied by flow line 23 with the quenching and/or finishing medium. Flow line 23 is provided with a micron filter 24 to prevent clogging of atomizer orifices 31. This filter is so sized that the solids in the finish are not removed thereby. Positive displacement pump 25 is driven by a motor and a variable speed drive (not shown). When the particles of colloidal suspension condense and form droplets, they fall to the bottom of hollow chamber 14 where they are held and collected by means of standpipe 26 which is integrally connected to hollow chamber 14, to serve as a reservoir of fluid for the system. This reservoir of fluid is connected to the intake side of pump 25 by flow line 27 and is by the pump circulated to atomizer 17. A branch line 28 with relief valve 29 is shown between lines 23 and 27. Relief valve 29 is necessitated to prevent excessive pressure build-up in the system.

Atomizer 17 is more clearly depicted in FIG. 2. As shown, the atomizer or mixing head is connected to and attached to one side of the hollow chamber 14 and is connected through the wall of hollow chamber 14 to fluid line 23. Atomizer 17 does not extend into the middle of the substantially enclosed hollow chamber 10, thus avoiding contact or interference with the moving strands and is so constructed that the colloidal particles generated are not directed directly upon the strands but only make contact therewith through the motion imparted thereto by the velocity at which the colloidal particles depart atomizer surfaces 33. This facilitates a substantial improvement over the conventional method of using rolls in the curing pan to apply finish and prior quenching mediums which are directed against the filaments since the present method causes the dispersed medium to impinge on all of the filaments uniformly. The atomizer is constructed of stainless steel or other like material. Numeral 30 represents internal borings in mist head 17 which allow passage of the fluid from supply line 33 to orifices 31. Fluid is forced through said orifices under pressure forming fluid streams or jets 32 which impinge against slanting sides 33, thus becoming atomized and creating colloidal suspension 16. When the fluid passes through orifices 31 it has its pressure head changed to a velocity head such that the fluid streams impinge against the slanting sides 33 with sufficient force to atomize the fluid at surface 33. From experimentation, it has been found that the optimum orifice size to be used in the apparatus and process of this invention is from 0.002 inch in diameter to 0.008 inch in diameter. Additionally, it has been found that in order to create the dense fog that is necessary to carry out the process of this invention by atomizing the fluid at slanting surfaces 33 of misting head 17, the fluid should be under a pressure of at least 100 p.s.i.g. The optimum pressure range for operation of this system would be approximately 400 to 600 p.s.i.g. The size of the particles in colloidal suspension 16 are contingent upon the as-spun deniers being processed. The latter normally falling in the range of from 4 to 63 denier per filament for commercially produced yarns. Thus, where the process and apparatus are being utilized to apply finish and/or the quenching medium the particle size of colloidal suspension 16 should be in the range of from 50 to 500 microns and when being utilized to impart a novel surface effect colloidal suspension 16 should be in the range of from 1 to 80 microns to prevent obtaining thorough quenching of the strands which might result in producing variable denier yarns of the nylon type.

Variations in colloidal particle size are dependent upon the viscosity of the fluid medium employed, the surface tension of the fluid medium, the orifice size, the fluid pressure and the velocity imparted to the fluid as it emerges from the orifice. Fluid temperature is not a critical variable in the process of this invention although the temperature of the fluid can control the rapidity of the quench, the degree to which the novel surface effect is imparted, and the temperature at which the finish is applied.

In operation, the process of this invention may be used to:

1. Quench molten streams of polymer issuing from the spinneret,

2. Apply a finish to the filaments prior to the point where they are brought together into a single bundle,

3. Simultaneously quench and finish filaments while they are yet in a dispersed state, and

4. Impart a novel surface effect to filaments.

In (1), (2) and (3) of the above described processes, the molten streams of polymer 12 should first be passed through air for a short distance before entering hollow chamber 14 containing colloidal suspension 16 through opening 15 as illustrated in FIGURE 1. While in process (4) where a novel surface effect is imparted to the filaments, the molten streams of polymer 12 should be introduced immediately from spinneret 11 into hollow chamber 14 as shown in FIGURE 3. When following this latter procedure, the filaments will be in a molten and semi-plastic state when they come into contact with the colloidal suspension contained in the hollow chamber. Thus, the droplets of fluid or finely divided solid particles contained within the treating medium will cause depressions or nodules to form on the molten filaments when they
come in contact therewith. In the processes of (1), (2) and (3) of the above the molten streams of polymer will become partially solidified in air before coming in contact with the colloidal suspension contained in chamber 14. Therefore, the particles of fluid in the heavy mist will complete the quenching in a uniform and complete manner in a shortened period of time and the finish will be applied uniformly, evenly and completely.

This invention is applicable to any filamentary material, examples of which might be rope, twine, wire, cable, glass fibers, fiber-forming polymers, and any other like materials to which it is desired to impart finish mediums in a highly uniform and rapid fashion. A preferred species of the fiber-forming polymers are the crystallizable polymers. Examples of suitable synthetic polymers are polyamides, polyesters, polyhydrocarbons such as polypropylene, polyurethane, polyureas, vinyl polymers such as polyvinyl chloride, polyvinylidine chloride, and copolymers thereof, acrylic polymers such as polyacrylonitrile when sufficiently plasticized to render it fusible, copolymers of acrylonitrile, halogenated hydrocarbons such as polychlorotrifluoroethylene, polycetals, polyanhydrides, polyoxymethylene, polyformals, polyethers, polythioethers, polysulfides, polythiosters, polysulfones, polythioureas, polythioamides, polysulphonamides, polyimides, and polytriazoles. Copolymers of all sorts are usable.

Obviously numerous modifications and variations of the present invention are possible in the light of the above teachings. It is to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described herein.

What is claimed is:

1. A method for treating uniformly a bundle of melt-spun organic thermoplastic filaments in a substantially enclosed chamber comprising extruding a thermoplastic polymer in a molten condition through a spinneret into streams which are solidified to form filaments, advancing the filaments through the chamber and causing the stream of liquid to pass through orifice openings having diameters within the range of 0.002 to 0.008 inch and under a pressure of at least 100 p.s.i.g. which causes the liquid to atomize against flat surfaces positioned against the inner wall of the chamber out of the path of the filaments and impinge upon said filaments indirectly thereby obviating pressure being directed onto the filaments, and continuously removing the treated filaments from the chamber.

2. The method of claim 1 in which the filaments are nylon.

3. The method of claim 1 in which the filaments are polyester.

4. In the production of synthetic filaments by melt spinning processes wherein a thermoplastic polymer in a molten state is extruded into separate streams in a path extending generally downwardly through a substantially enclosed chamber at a constant extrusion rate while being cooled and solidified into continuous filaments in said chamber, the improvement which comprises imparting a novel surface effect to the filaments while simultaneously quenching and applying a finish solution in a uniform manner within said chamber, said improvement being accomplished by directing a liquid at a pressure of at least 100 p.s.i.g. from a pair of nozzles against oppositely disposed members having divergent flat surfaces positioned within said chamber along a wall thereof adjacent to the path of the filaments but spaced therefrom which causes the liquid to atomize into particles of less than 80 microns in diameter to facilitate impingement of the particles upon the surface of the filaments indirectly from said nozzles to improve uniformity of the application of said particles.

5. The method of claim 4 in which the liquid is at ambient temperature.

References Cited

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Date</th>
<th>Inventor</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,891,909</td>
<td>12/1932</td>
<td>Bills</td>
<td>239—544</td>
</tr>
<tr>
<td>2,568,429</td>
<td>9/1951</td>
<td>Burman</td>
<td>239—544X</td>
</tr>
<tr>
<td>2,605,144</td>
<td>7/1952</td>
<td>Northrup</td>
<td>239—544</td>
</tr>
<tr>
<td>2,755,135</td>
<td>7/1956</td>
<td>Guschin</td>
<td>239—544X</td>
</tr>
<tr>
<td>2,953,427</td>
<td>9/1960</td>
<td>Egger</td>
<td>264—167</td>
</tr>
<tr>
<td>3,115,437</td>
<td>12/1965</td>
<td>Adams</td>
<td></td>
</tr>
<tr>
<td>3,234,596</td>
<td>2/1966</td>
<td>Sims</td>
<td>18—8</td>
</tr>
</tbody>
</table>

FOREIGN PATENTS

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Date</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,296,993</td>
<td>5/1962</td>
<td>France</td>
</tr>
<tr>
<td>963,384</td>
<td>7/1964</td>
<td>Great Britain</td>
</tr>
</tbody>
</table>

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