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PROCESS AND APPARATUS FOR MELT-SPINNING OF POLYAMIDE

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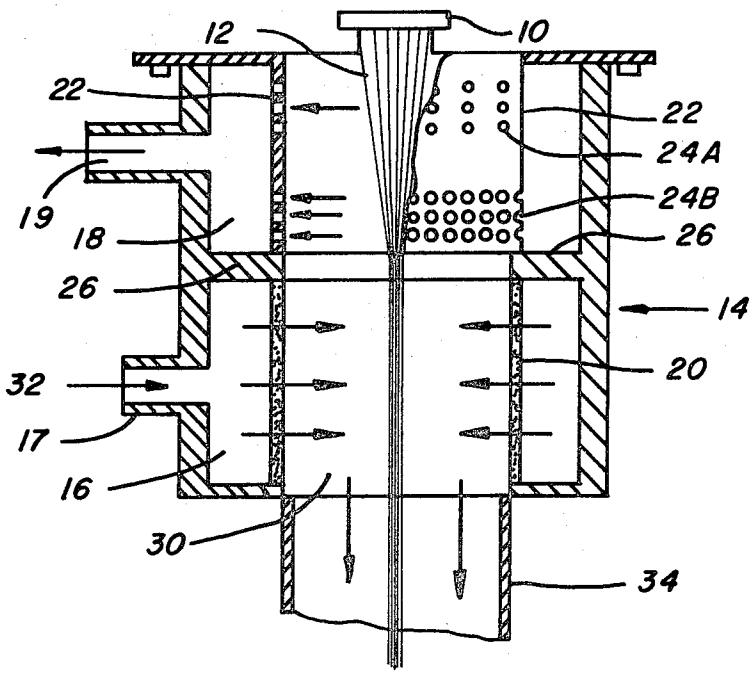


FIG. 1

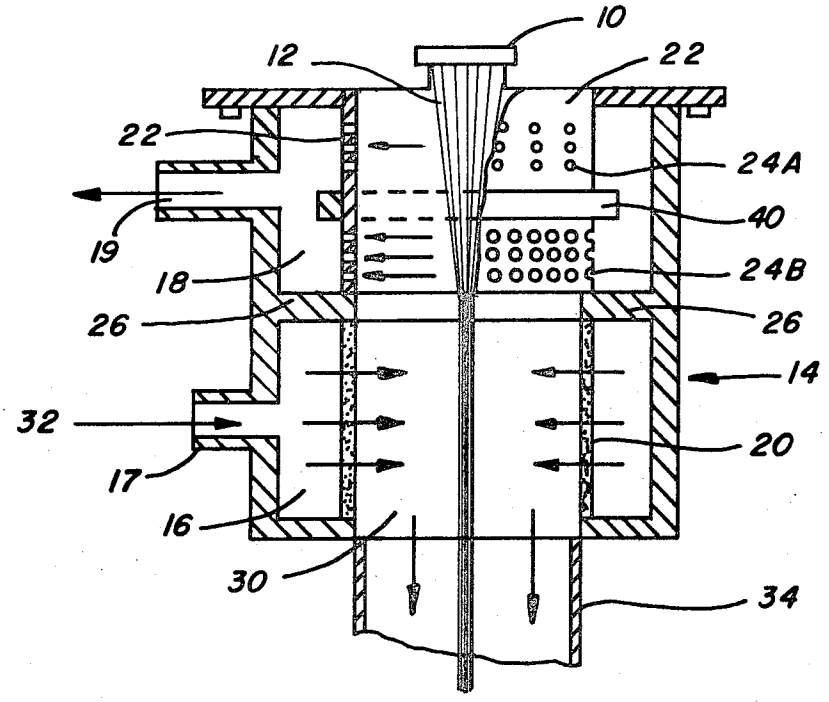


FIG. 2

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PROCESS AND APPARATUS FOR MELT-SPINNING OF POLYAMIDE

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U.S. Cl. 264—176 F 10 Claims

ABSTRACT OF THE DISCLOSURE

Low molecular material such as monomers and oligomers are removed from the vicinity of a spinneret positioned within an improved chamber for extrusion of filaments by withdrawing a smaller amount of air from near the face of the spinneret to achieve removal of low molecular substances in large quantity, provide a quiescent area in the vicinity of the spinneret surface, and maintain the atmosphere in the vicinity of the spinneret surface at an elevated temperature.

BACKGROUND OF THE INVENTION

The present invention relates to a method and an apparatus for effectively removing low molecular substances such as monomers and oligomers which are formed below a spinneret surface in the melt-spinning of polyamides.

In the melt-spinning of polyamides such as polycaproamide and polyhexamethylene adipamide, use is made of a polymer whose monomer content is previously reduced to about 2 to 3% by washing it with water or subjecting it to a vacuum treatment, but even then low molecular substances are formed in the melt-extrusion process due to pyrolysis of the polymer and the atmosphere immediately below a spinneret, into which the molten polymer is discharged, is filled with the molecular substances consisting mainly of monomers and oligomers, and the spinneret surface or the spinning apparatus is stained therewith. The attachment of the low molecular substances or the decomposition products thereof to the spinneret surface or spinning apparatus is particularly objectionable because such condition will cause troubles, such as breakage of the filaments, in the worst case. Therefore, in order to perform the melt-spinning of polyamides in a satisfactory manner, it is essential to remove the low molecular substances to the outside of the spinning system from beneath the spinneret surface as has been practiced heretofore.

The removal of the low molecular substances is effected in a region in which the filaments are at an elevated temperature and carelessness in such operation would bring about non-uniformity of the filaments, with the result that the spinnability of the polymer is rather degraded. Namely, the uniformity of the filaments is largely affected by the conditions of the atmosphere in which said filaments are maintained at an elevated temperature. Therefore, if the air flow in the vicinity of the spinneret is disturbed by the operation of removing the low molecular substances which is carried out below the spinneret surface, the uniformity of the filaments will be largely impaired.

The spinnability is also degraded by a temperature lowering of the atmosphere in the vicinity of the spinneret or of the spinneret surface proper. In view of the above, a desirable practice of removing the low molecular substances ought to be one which satisfies the following conditions: (1) the condition that the low molecular substances are removed in a large quantity, (2) the condition that the air flow in the vicinity of the spinneret surface is not disturbed, and (3) the condition that the atmosphere

in the vicinity of the spinneret surface is maintained at an elevated temperature.

For the purpose of realizing such difficult practice of removing the low molecular substances, various inventions have been made in the past (as disclosed in Japanese patent publications Nos. 5668/60 and 17764/62, and Japanese utility model publications Nos. 17211/65 and 1381/65). Unfortunately, none of these spinning apparatus are entirely satisfactory with respect to the three conditions set forth above.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, there is provided a method of melt-spinning fiber-forming polyamides derived from a polymer by removing low molecular substances in a region between the spinneret surface and a cooling air entry portion, through the removal of a smaller quantity of said substances at a portion of said region adjacent the spinneret surface and in a larger quantity at the cooling air entry portion of the same.

According to another aspect of the invention, there is provided an apparatus for melt-spinning polyamides, which is directly used for practicing the above-described method of this invention and which is characterized by a cylinder interposed between the spinneret surface and the cooling air entry portion and having a large number of apertures formed therein at a portion adjacent to the spinneret surface and at the other portion, the total area of the openings of the apertures being smaller at the former portion than at the latter portion, and suction means connected to an outlet to said cylinder from the outside, whereby low molcular substances, derived from a polymer such as polycaproamide are removed in a smaller quantity at a portion of the cylinder adjacent the spinneret surface and in a larger quantity at the other portion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional elevation of a preferred embodiment of the present invention illustrating the internal structure thereof.

FIG. 2 is a sectional elevation of the embodiment shown in FIG. 1 but modified to include a heater.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

The present invention will be described hereinafter with reference to the accompanying drawing wherein reference numeral **10** designates a spinneret having a large number of spinning holes formed therein and reference numeral **12** designates filaments spun through said spinning holes.

Mounted directly below the spinneret is a cylindrical enclosure 14 which is open at the end farthest from the spinneret. The enclosure **14** is provided with a lower annular chamber **16** having an inlet **17** for introducing cool air and an upper annular chamber **18** having an outlet **19** for removing low molecular substances. The inside wall **20** of chamber **16** is made of a porous material that will distribute equally and uniformly the air entering into the vicinity of the filaments. The inside wall **22** of upper chamber **18** is provided with a multiplicity of apertures having different diameters depending upon their location relative to the spinneret. The apertures **24***a* adjacent to the spinneret are either smaller in diameter or spaced farther apart whereby the total area of openings is substantially less than that of the apertures **24***b* located adjacent to chamber **16**. Preferably, the ratio of the areas resulting from the openings should be at least about 3:1. The chambers **16** and **18** are separated by a divider plate **26** to insure that the air introduced into chamber **16** passes through the porous wall **20** into the internal chamber **30**.

A small portion of the air is withdrawn into chamber **18** through the apertured wall **22** to entrain the low molecular weight substances in the vicinity of the spinneret before exiting at outlet **19**. A major portion of the air is withdrawn through apertures **24***b*.

In such apparatus, a molten polymer is spun into filaments **12** through a large number of spinning holes in the spinneret **10** and the filaments thus spun are cooled and solidified by cooling air **32** controlled at a constant temperature and blown thereagainst through the current equalizing means **20**. The sufficiently solidified filaments are taken up through a spinning duct **34**.

In the process of spinning, a major proportion of low molecular substances, such as monomers and oligomers, derived from the filaments are formed and the region in chamber **30** directly beneath the spinneret surface contains a large amount of the low molecular substances therein. The low molecular substances are removed from the system through outlet **19** under suction, in a smaller quantity through the apertures **24***a* and in a larger quantity through the apertures **24***b*. The low molecular substances thus removed from the system are dissolved in water and collected by conventional means, not shown.

According to the present invention, the low molecular substances are initially sucked in the vicinity of the spinneret surface. Therefore, the low molecular substances can effectively be withdrawn without establishing any adverse conditions. The rate of suction at said portion is so small that the atmosphere in the vicinity of the spinneret surface will not be disturbed and excessive lowering of the temperature of the spinneret surface and the atmosphere in the vicinity thereof can be avoided. The cylindrical wall **22** is provided with a large number of apertures **24***b* at a portion adjacent the cooling air entry chamber **16** to remove the low molecular substances therethrough from the space in the upper part of chmaber **30** and the suction of the low molecular substances at this portion will not cause a disturbance to the atmosphere in the vicinity of the spinneret surface, even if the suction is effected with a sufficient force, nor will it cause an excessive temperature lowering of the spinneret surface and the atmosphere adjacent thereto. In this case, the rate of suction of the low molecular substance-containing gas at the portion adjacent the spinneret surface and the rate of suction of the same at the portion adjacent the cooling air-chamber **16** are held in a suitable proportion, whereby the aforesaid three conditions in the removal of low molecular substances can be satisfied.

In practicing the present invention, the low molecular substance removal rate at the portion adjacent the spinneret surface must not be higher than necessary but be limited to the necessary minimum. An appropriate suction rate at this portion is variable depending upon the spinning temperature, the discharge speed, the number of of filaments, the desired temperature of the atmosphere below the spinneret surface and the location of the cooling air entry, but an optimum value can be obtained as required. In the apparatus of this invention, the proportion of the suction rates can suitably be adjusted by the diameter and the number of the apertures **24***a* and **24***b* formed in the cylindrical wall **22**.

In FIG. 2 there is shown a modified embodiment of the invention wherein a heater **40** supplied by a power source, not shown, is placed around the apertured cylinder **22** intermediate of apertures **24***a* and **24***b*. The heater may be operated at elevated temperatures to preferentially control the temperature of the atmosphere within the enclosed area **30**.

As described above, according to the present invention the low molecular substances derived from the polymer are removed in the region between the spinneret and the cooling air blowing portion, in a smaller quantity at a portion adjacent the spinneret and in a substantially larger quantity at a portion adjacent the cooling air blowing portion. Therefore, the invention has the advantages (1) that a large quantity of the low molecular substances can be removed, (2) that the air flow in the vicinity of the spinneret surface will not be disturbed and (3) that the spinneret surface and the atmosphere adjacent thereto can be maintained at a high temperature, and consequently enables the spinning operation to be performed safely, without allowing the low molecular substances to attach to the spinneret surface.

The superiority of the present invention will more practically be illustrated by way of example.

EXAMPLE

Using the apparatus of the present invention as shown in FIG. 1 of the accompanying drawing, a molten polycaproamide was spun at 260° C. through a spinneret having 136 spinning holes. For control, the same polyamide was spun using a conventional apparatus (corresponding to the apparatus of the drawing from which the cylinder **22** is removed). The outer wall of chamber **18** adjacent the spinneret surface was heated by a band heater in both instances.

The total amount of the low molecular substance-containing gas withdrawn was 0.30 $m.^3$/min. and, in case of the present invention, the gas was removed through the apertures **24***a* and **24***b* in the proportion of 1:5. Cooling air was supplied at the rate of 4.0 $m.^3$/min.

The temperature of the aetmosphere at a point 20 mm. below the spinneret surface was 255° C. in case of the conventional method and 270° C. in case of the present method. After taking up at the rate of 800 m./min., the spun filaments were subjected to a drawing by a conventional method. The following results were obtained.

	Present method	Conventional method
Frequency of filament breakage during spinning (time/1,000 km.)	0.08	0.5
Unevenness of undrawn yarn (Uster) (percent)	4.3	8.5
Frequency of filament breakage during drawing (time/1,000 km.)	1.1	3.5
Strength of drawn yarn (g./d.)	9.6	9.4
Elongation of drawn yarn (percent)	17.0	16.0

Although in the embodiment described and illustrated herein, the apertures **24***b* are formed in the cylinder wall **22** immediately above the cooling air chamber **18**, it is to be understood that the positions of said apertures are not restricted to those shown but may suitably be selected above the cooling air chamber such that a large quantity of the low molecular substances can be removed with the least possible influence on the temperature of the spinneret surface and the atmosphere in the vicinity thereof.

I claim:

1. A method for melt spinning polyamide filaments through an enclosure open at one end comprised of an upper annular chamber and a lower annular chamber wherein the improvement comprises:

(a) extruding a fiber-forming polyamide through an orificed spinneret positioned at the top of said enclosure to form a plurality of filaments,

(b) passing the filaments vertically downward through the enclosure,

(c) introducing air into the enclosure through the lower annular chamber for quenching the filaments, and

(d) removing low molecular weight substances from the vicinity of the spinneret by withdrawing a small quantity of air containing said substances from a first zone adjacent the spinneret and a substantially larger quantity at a second zone farther removed from said spinneret, said second zone being positioned immediately adjacent said first zone and within said upper annular chamber.

2. A method as described in claim **1** wherein the air containing said substances is removed through the upper annular chamber at a rate of about 0.30 cubic meter per minute.

3. A method as described in claim 2 wherein the air containing the low molecular weight substances is removed from said zones in a ratio of at least 3:1.

4. A method as described in claim 3 wherein heat is imparted between said removal zones.

5. A method as described in claim 1 wherein the fiber-forming polyamide is polycaproamide.

6. Apparatus for melt-spinning fiber-forming polyamides which comprises:

(a) an enclosure surrounding a spinneret comprised of an outer wall and a pair of cylindrical inserts positioned within said wall to form separate annular chambers, said inserts being essentially in vertical alignment to provide a cylindrical passageway for a group of filaments,

(b) an inlet for introducing a volume of air into the lower chamber, and

(c) an outlet for withdrawing a portion of the air first through the cylindrical insert of the lower chamber into said filament passageway and then through the cylindrical insert of the upper chamber in disproportionate amounts with respect to the upper and lower portions of said upper insert whereby low molecular weight substances are removed without disturbing spinning conditions.

7. The apparatus as described in claim 6 wherein the upper cylindrical insert is provided with a multiplicity of apertures of which the total open area adjacent the spinneret is substantially less than the total open area in the lower portion of said insert.

8. The apparatus as described in claim 7 wherein the ratio of the areas is at least 3:1.

9. The apparatus as described in claim 8 wherein said lower cylindrical insert is a porous material which equally distributes air passing through said material.

10. The apparatus as described in claim 9 wherein a heating element is positioned around the upper insert intermediate the apertured areas.

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