

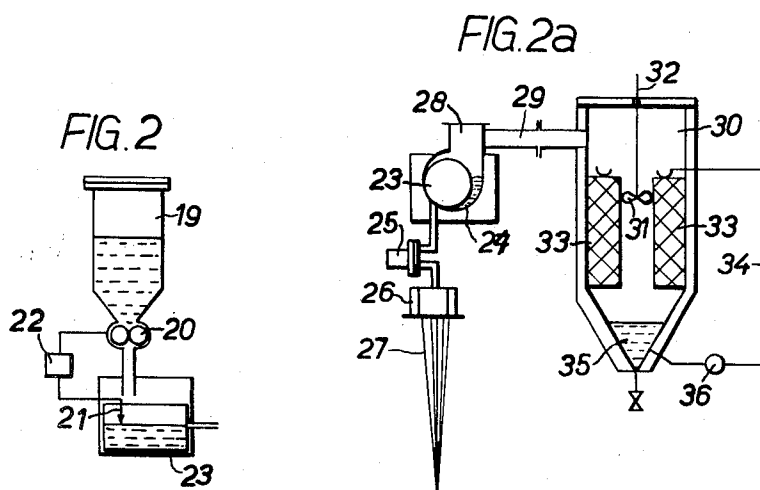
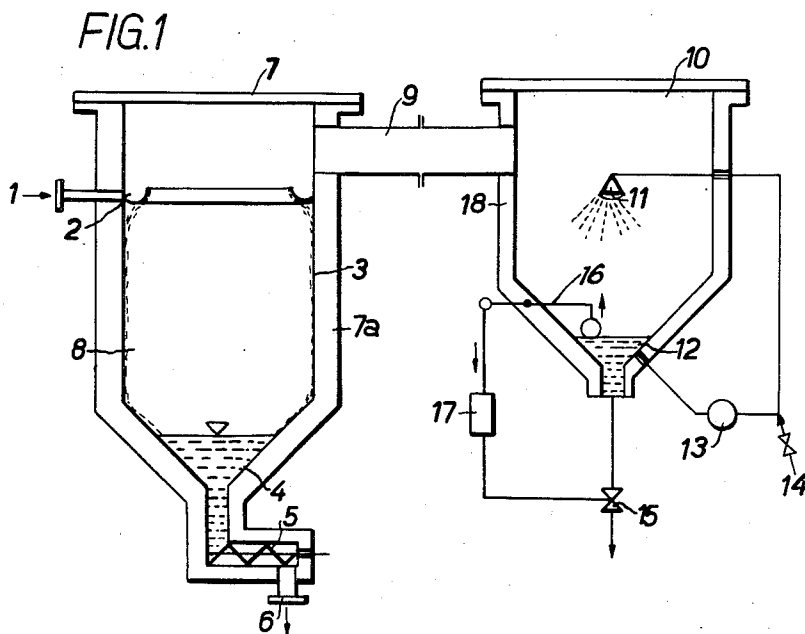
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W. RODENACKER

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POLYAMIDE MELT SPINNING PROCESS AND APPARATUS

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INVENTOR.
WOLF RODENACKER
BY
Connolly and Smith
his ATTORNEYS

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POLYAMIDE MELT SPINNING PROCESS AND APPARATUS

Wolf Rodenacker, Dormagen, Germany, assignor to Farbenfabriken Bayer Aktiengesellschaft, Leverkusen, Germany, a corporation of Germany

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This invention relates to the spinning of synthetic linear condensation polyamides, especially those of the type generally referred to as nylon 6, nylon 66 and nylon 68. Nylon 6 is commercially obtained by polymerisation of caprolactam, while nylon 66 and nylon 68 are obtained from hexamethylene diammonium adipate and hexamethylene diammonium sebacate respectively.

It is known, for instance from the United States Patent 2,571,975, that in the melt spinning of these polyamides a yarn having optimum uniformity of physical properties can be obtained by controlling the polymerisation-depolymerisation equilibrium by conducting the spinning under a positive and predetermined water vapor pressure. In this known process an atmosphere of saturated steam is brought into contact with the polymer flake. The melt is obtained by melting the flake.

The process has the advantage that the uniformity of the melt is improved, this uniformity being important for the spinning operation and for the textile properties of the filaments which are manufactured. On the other hand, it has the disadvantage that the degree of polymerisation obtained is too low to yield the optimum strength values of the yarn, in spite of its improved uniformity.

It is therefore an object of this invention to provide a process which avoids these disadvantages and which results in yarn of optimum tenacity and uniform properties.

A further object is the provision of means for controlling the equilibrium between polymerisation and depolymerisation in such a manner that the resultant degree of polymerisation is as high as possible.

Other objects will appear hereinafter.

The objects are accomplished by the invention which consists in conducting the spinning of the melted polyamide in contact with steam, while a constant atmosphere of water vapor, unsaturated at the temperature of the melt, is maintained in the melting chamber.

The invention will be more clearly understood by reference to the attached figures which show in Figure 1 a diagrammatic side elevational view of a melt spinning apparatus and in Figures 2 and 2a a diagrammatic view of a different type of a melt spinning apparatus. In Figure 1 the melt is introduced through a pipe 1 into an annular channel 2. The melt runs down on the wall of a vessel 3 and collects in a sump 4. It is fed by a discharge worm 5 through an outlet opening 6 to the spinning nozzle. A vessel 7 contains a steam chamber 8 which is connected by a pipe 9 of very large diameter to an additional chamber 10. The additional chamber 10 contains a spray nozzle 11 by means of which there is sprayed water which is withdrawn and circulated by a pump 13 from the sump having the level 12. In order to prevent contamination of the water, for example due to precipitated lactam, fresh water is added to the circulation system through an outlet 15, which is controlled by a float member 16 and a regulator 17. The vessel 10 includes a jacket 18 by means of which the

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water and the vessel are kept at a constant temperature. The vessel 7 is kept at the melting temperature by a heating jacket 7a. The two internal chambers 8 and 10 which are connected to one another are therefore only different as regards their temperature. The partial steam pressure of the steam in the chamber 8, the other constituent in which is nitrogen, is thus defined by the temperature difference between the chamber 8 and the additional chamber 10.

In Figure 2 the shreds come from a shred container 19 by way of a controlled feed device 20, which is moved by a lever control device 21 and regulator 22. The melt is thoroughly stirred by a roller 23 which is moved between two wedge-shaped spaces 24 (Fig. 2a). Due to the pressure in the space 24, the melt is supplied by a pump 25 to a nozzle device 26 and spun to form filaments 27. A space 28 above the level of the melt is connected by a large-diameter pipe 29 to a vessel 30. The vessel 30 contains a central tube 31 in which is disposed an axial fan 32 serving to circulate a gas, for example nitrogen, in the vessel 30. A space 33 in the vessel is filled with Raschig rings, which are sprayed with liquid from above through a pipe 34. The sprayed liquid accumulates in a sump 35, from which it is extracted by way of a pump 36 and used again for sprinkling purposes. The washing liquid can be replenished.

In the process of the invention the partial pressure of the steam in the melting chamber is kept constant throughout the melting and processing operations. As can be seen from the drawings, this is effected by attaching to a conventional melting chamber by way of a large-diameter opening an air-conditioning chamber in which the circulated protective gas, which is generally pure nitrogen, is saturated with steam at a substantially lower temperature than the temperature of the melt chamber, but at the same pressure as that obtaining in the melt chamber. Care must be taken that all parts of the melt chamber have a temperature which is above the dew point of the saturated protective gas, so that no condensation of the steam occurs.

The air-conditioning chamber consists in principle of an additional chamber in which the condition of saturation of the protective gas with steam is maintained by spraying water or injecting steam at an adjustable temperature. This additional chamber has a definite volume, temperature, pressure and steam content, and makes it possible to maintain the melt chamber conditions which differ only in temperature, and thereby to produce any desired water content and thus a constant degree of polymerisation of the melt. By this means, it is possible within certain limits to be independent of the water content of the shreds which are melted. If the water content is too high, the water in the air-conditioning chamber is condensed and if it is too low, more steam is supplied from the air-conditioning chamber.

The following examples are given to further illustrate the invention:

Example 1

Shreds of the polyamide of caprolactam, with a water content of 0.1%, are introduced into the spinning device described with reference to Figures 2 and 2a. The pipe 29 is initially closed, so that the additional chamber 30 is not connected to the melting chamber 28. A temperature of 270° C. at normal pressure is maintained in the melting chamber. With an optimum stretching ratio of 1:3.9, the filaments which are obtained have an elongation of 23% and a strength of 5.3 grams/denier.

The air-conditioning chamber is then set to give a temperature of 30° C. and a superatmospheric pressure of 7 pounds per square inch gauge, the operation in the melting chamber being continued at a temperature of 270°

C. A constant steam partial pressure is then obtained in the melting chamber. The filaments then have an optimum stretching ratio of 1:4.1, and the elongation is 21% and the strength of 6.85 grams/denier. The textile properties of the filaments obtained are thus substantially improved by the provision of the constant steam partial pressure.

Example 2

Using the same apparatus as in Example 1, monofilaments of 20 denier are spun at a spinning temperature of 270° C. and at normal pressure with a withdrawal speed of 630 metres per minute. If the temperature in the vessel 30 is raised from 40 to 80° C., the crystallisation velocity is increased from 3 to 18 after adjustment to give a constant steam partial pressure in the melting chamber. Raising the crystallisation velocity means an improvement in the solidification conditions of the filament in the spinning funnel. It is possible in this way to manufacture filaments having an elongation of 20% and a strength of about 7 grams/denier.

I claim:

1. In a process of spinning a synthetic linear polyamide wherein the polymer flake is melted in a melt chamber and the melt is exposed to water vapor for a time sufficient to establish equilibrium between the melt and the water vapor before the melt is spun, the improved method of controlling the equilibrium between polymerization and depolymerization which comprises maintaining the partial pressure of the steam in the melt chamber constant throughout the melting and spinning operations by maintaining said melt chamber in open communication with an air-conditioning chamber, circulating through the latter chamber an inert gas which is saturated with steam at a lower temperature than the temperature of the melt chamber, but at the same pres-

sure as that in the melt chamber, so that the atmosphere of the melt chamber differs only in temperature from that of said air-conditioning chamber whereby the ratio of the partial pressures of the water vapor and the said inert gas are maintained constant at the temperature of the melt, and producing from said spinning process polyamide filaments having improved physical properties.

2. Process of claim 1 wherein said inert gas is nitrogen.

3. Process of claim 1 wherein said melt chamber is maintained at a temperature above the dew point of the saturated inert gas, so that no condensation of steam occurs within said chamber.

4. Process of claim 2 wherein the nitrogen is saturated with steam within said air-conditioning chamber by continually contacting the nitrogen with moisture at the desired predetermined temperature.

5. Process of claim 1 wherein said polyamide is polycaprolactam.

6. In a system comprising a spinneret for the extrusion of molten polyamide and a melt chamber which supplies molten polyamide to said spinneret, in combination, an air-conditioning chamber positioned adjacent said melt chamber, a conduit connecting said chambers, means for saturating nitrogen with water vapor within said air-conditioning chamber, the latter being maintained at a temperature lower than that in said melt chamber, and means for circulating said saturated nitrogen through said conduit into said melt chamber so as to maintain the ratio of the partial pressures of water vapor and nitrogen constant at the temperature of the melt.

References Cited in the file of this patent

UNITED STATES PATENTS

2,571,975 Waltz ----- Oct. 16, 1951