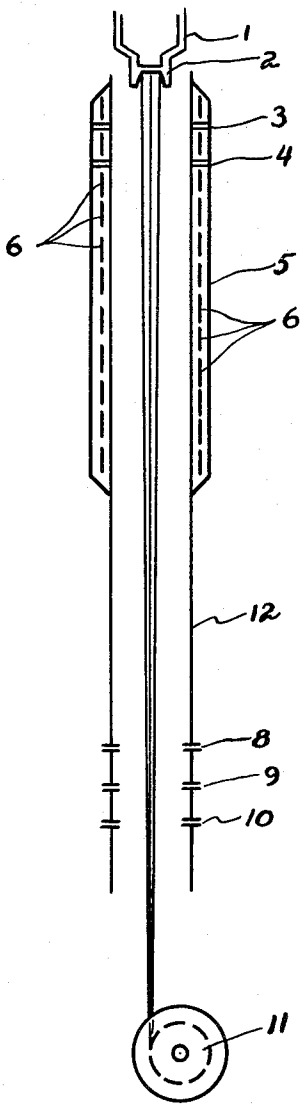
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PROCESS FOR SPINNING OF SYNTHETIC FIBERS

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PROCESS FOR SPINNING OF SYNTHETIC FIBERS

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This invention relates to a process for spinning of synthetic fibers directly from the melt with simultaneous full stretch.

The manufacture of synthetic fibers by shaping plastic or highly viscous linear high-polymers commonly is carried out by extruding the viscous material through suitable jets and reeling up the filaments thus formed onto spools at comparatively high speed. The take-up speeds commonly used are approximately 500 m./min. to 1,200 m./min., and lately machines have become available which develop speeds up to 1,600 m./min. Since the extruding speed is substantially lower than the take-up speed, the filament formed upon leaving the spinning jet is stretched to a large extent.

The special properties of filaments manufactured in this manner only are attained, however, by renewed stretching after cooling. The fibers can be stretched to 3 to 6 times their original length. The amount of stretching does not seem to be influenced to any large degree by the prior stretch (cf. D. Natus and H. Sauer, Faserforschung und Textiltechnik 7 (1956), 468–476). For instance, the maximum elongation attainable for polycaprolactam at a take-up speed of 1,000 m./min. and an original stretch of 1:100 (proportion of extruding speed to take-up speed) is 1:3.8, whereas at an original stretch of 1:500 the fiber still can be elongated cold to 2.9 times its length, although it should be assumed that even at a stretch of 1:380 a fully stretched fiber is obtained.

However, there is a connection between the maximum stretch proportions and the take-up speed. This is utilized, e.g., in the processes according to French Patent 976,505 and U.S. Patent 2,604,667, wherein upon spinning of polyamides at take-up speeds of 6,000 m./min. and of polyethylene terephthalate at take-up speeds of at least 4,750 m./min. fully stretched fibers are obtained of normal textile properties. It is obvious that for the application of such high take-up speeds involved machinery is required and that, hence, these processes hardly are applicable in practice. Especially, it has been established that fibers spun at such high speeds can be reeled up only with great difficulty, and that a change of spools without losses is practically not feasible. The quality of fibers thus produced also is not the best particularly because the fibers break more often during that process than is customary with other processes. On the other hand, it should be noted that spinning of fully stretched fibers on customary machinery would denote great technological progress. This is true especially for such high-polymers as aromatic polyesters, etc., which exhibit high second order transition and which cause difficulties upon secondary elongation.

It now has been found unexpectedly that fully stretched fibers can be produced from polyamides, polycarbonates, polyurethanes and especially polyesters, by fully stretching the fibers upon leaving the spinning jet, whereby they are spun in a spinning shaft whose upper part is heated to 10–80° C. below the melting point of the resin to be spun and whose lower part is heated to a temperature below 100° C. The most advantageous temperatures are those which lie 10–50° C. below the melting point of the resin. The length of the heating zone depends, aside from the spinning speed, particularly on the total titer of the spun fibers. In order to obtain uniform products,

the effect can be increased by blowing preheated steam or gas onto the fibers. This steam or gas may be blown in the direction of the moving fiber or against it. If desired, a cooling zone may follow the heating zone so that the length of the spinning shaft need not be larger than customary. Cooling can be accomplished, e.g., by blowing in of cold air. Under these conditions, a full stretch is obtained at take-up speeds of 1,300–2,600 m./min., preferably at 1,500–2,000 m./min. By spinning, e.g., polycaprolactam in the manner described from an 8-hole jet at a delivery of 3 g./min. in a shaft whose upper part is at 175° C. and reeling up at 1,500 m./min., a fiber having excellent textile properties is obtained. Its strength is 4 g./den. at 30–50 percent elongation. However, the present invention is not limited to filaments but can be applied with particular success to the manufacture of staple fiber. Also, special products having little stretch (for instance, tire cord) can be manufactured on the spinning machine by applying an afterstretch between the return galettes and, if necessary, applying additional heat. The return galettes should have larger than normal diameter for the purpose, in order to obtain better adhesion, and should differ in a suitable manner with regard to the circumferential speed. Additional heating can be effected by heating one of the galettes, by conducting the fibers over a heated flat iron, by infrared radiation, or by any other convenient means.

The term "galette" denotes a roller for guidance of the filament, either free-wheeling or driven, by means of which the filament, if desired, can be caused to change direction and/or to reverse its direction.

Inasmuch as the essential advantage of the present invention consists in the elimination of a special procedural step for stretching of fibers, foils and ribbons, i.e., a continuous process is feasible, it is advisable to combine the process with a continuous manufacture of fusible high-polymers. For instance, polyamides, made in a VK tube, or polyesters, stored after polycondensation, can be spun by the process according to the present invention, and a fully continuous manufacture of fibers, etc., can be carried out in that manner.

The "VK tube" for a simplified continuous process for the manufacture of polyamides (V and K are the starting letters for the German words for "simplified" and "continuous," respectively), has been described in U.S. Patent 2,241,321, issued May 6, 1951.

The invention now will be further illustrated by the following examples. However, it should be understood that these are given merely by way of explanation, not of limitation, and that numerous changes may be made in the details without departing from the scope and spirit of the present invention as hereinafter claimed.

Example 1

Polycaprolactam is extruded from a VK tube by means of spinning pumps through a jet with 12 holes at an extrusion speed of 5 g./min. into a spinning shaft of 3.5 m. length whose upper third has a temperature of 175° C. The fibers formed, after passing the part of the shaft which is at room temperature, are moistened, prepared and reeled up at a speed of 1,450 m./min. The filaments thus obtained and having a single titer of 2.6 g./den. are fully stretched and have a strength of 5.2 g./den, at an elongation of approximately 35 percent.

Example 2

Polycaprolactam, poor on monomer and of low molecular weight, is melted on a spinning rost and is spun by means of pumps through a jet having 40 apertures at a speed of 25 g./min. into a spinning shaft of 4 m. length. In the upper quarter of the shaft, the fibers are heated by infrared lamps to approximately 180° C.

while being cooled by blowing cold air onto them approximately 1 m. before the end of the shaft. This cold air contains atomized water. After preparing the fibers in a known manner, they are conducted over two galettes of a spinning machine. The first of these galettes has a circumferential speed of 1,600 m./min., and the second a speed of 1,800 m./min. Between the two galettes, a device is positioned which heats the fibers to 120° C., e.g., a flat iron, infrared lights, etc. The tire cord thus formed is reeled up over a notched drum at a speed of 1,820 m./min. onto spools. The cord has only approximately 12 percent elongation at a total titer of 124 denier.

Example 3

Polyethylene terephthalate is conducted by means of a worm and a spinning pump from an evacuated storage container through a jet having 40 apertures at a speed of 25 g./min. into a spinning shaft of 2 m. length and heated at 220° C. A downward circulation is provided by blowing preheated nitrogen into the shaft from the top. At a distance of approximately 15 cm. from the heated shaft, another shaft of 2 m. length is connected thereto by a wire screen. For the deflection of heat, cold water is sprayed into the second shaft. The fibers thus obtained, after passing the preparation device, are reeled up at a take-up speed of 1,600 m./min. They are fully stretched and can be made into staple fibers in a customary manner. These staple fibers have a single titer of 3.5 g./den, and normal textile properties.

Example 4

Polycaprolactam, manufactured continuously by the so-called rapid polymerization process and having a melt viscosity of 4,000 poises, is extruded by means of a worm through a jet having 40 holes at a speed of 30 g./min. into a spinning shaft whose upper third is heated at 185° C. The fibers formed are reeled up at a speed of 1,800 m./min. and have, at a tear strength of 75 km., an elongation of 11 percent or less.

Example 5

Polyurethane bristles which need no particular elongation are produced by spinning in accord with the Examples 1–4. The upper part of the spinning shaft is to be heated at 160° C.

The accompanying drawing is a schematic showing a preferred embodiment of the device according to the invention. From the spinning head **1**, fibers are spun through spinning jet **2** and reeled off on spool **11**. Between jet **2** and spool **11**, the fibers traverse a spinning shaft **12**. The upper portion of shaft **12** is provided with a heating jacket **5** which can be heated electrically by means of resistance wires **6**. Hot gases are blown into the upper part of shaft **12** through slits **3** and **4**. Below the heatable portion of shaft **12** is the coolable portion into which cold gases, which may contain water, are blown through slits **8**, **9** and **10**.

I claim as my invention:

1. A process for the manufacture of fully stretched fibers by the melt spinning method of synthetic polymers selected from the group consisting of polyamides, polycarbonates, polyurethanes and polyesters by extrusion through a spinning jet and conducting the fibers thus formed through a spinning shaft, which comprises spinning said fibers in said shaft in the presence of air and in the absence of solvents at a temperature ranging from 10 to 80° C. below the melting point of said polymers in the upper part of said shaft and at a temperature below 100° C. in the lower part of said shaft, and reeling up said fibers on spools at a speed of 1,600 to 2,600 meters per minute.

2. The process according to claim 1, wherein said fibers, after leaving said spinning shaft and before reeling up, are subjected to an afterstretch.

3. The process according to claim 2, wherein said afterstretch is carried out at temperatures above 100° C.

4. The process according to claim 1, wherein the fibers, held at 10–80° below the melting point in the upper part of the spinning shaft, are cooled in the lower part of said shaft by blowing in a gas.

5. A process for the manufacture of fully stretched fibers by the melt spinning method of synthetic polymers selected from the group consisting of polyamides, polycarbonates, polyurethanes and polyesters, by extrusion through a spinning jet and conducting the fibers thus formed through a spinning shaft, which comprises spinning said fibers in said shaft in the presence of air and in the absence of solvents at a temperature ranging from 10 to 80° C. below the melting point of said polymers in the upper part of said shaft and at a temperature below 100° C. in the lower part of said shaft, said temperature below 100° C. being attained by blowing a moisture-containing gas into said lower part, and imparting a full afterstretch to the fibers by reeling them up on spools at a speed of 1,600 to 2,600 meters per minute.

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