DEVICE AND PROCESS FOR THE MANUFACTURE OF HOLLOW SYNTHETIC FIBERS

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ABSTRACT OF THE DISCLOSURE

A spinneret for the manufacture of hollow synthetic fibers which has at least one bore group with at least two opposing openings which are star-shaped. Different star configurations are feasible, such as X and Y shapes whose respective slits must be at given angles and locations relative to each other and to opposing bore openings, respectively.

The invention relates to a novel process for the melt spinning of synthetic fibers to produce hollow profiles therein and to a device facilitating this manufacture, more particularly to a spinneret or spinning plate.

Profilated spun fibers have attained increased technological and economical significance in the recent past. They are used increasingly for such end products as upholstery and rugs. These profilled spun synthetic fibers have high stability and bending strength and impart to the finished product high gloss and bulk. However, the heat retarding properties of synthetic spun materials is inferior to those made from natural fibers. A profilled fiber which not only is hollow but in addition has closed ends is most advantageous with respect to heat retanability. The incorporation of a hollow space in a synthetic fiber, moreover, imparts increased stability and bending strength thereto.

The design of the profile, including hollow profiles, depends upon the design of the spinneret. These usually are made of stainless steel or of hardened special steels, and a number of designs are known. These designs and the ones according to the invention now will be discussed with reference to the accompanying drawings, all of which are schematics of spinneret profiles.

In these drawings, FIGS. 1–8 are spinneret profiles according to prior art, FIGS. 9–10 are profiles according to the invention. Known plates may contain suitable spinning openings provided with a pin as a core, and the molten mass is forced through the openings under air pressure or by the pressure of another gas. Spinnerets of this kind generally consist of several plates, usually three plates, and are quite intricate. When a plurality of openings is present, great precision is required in the manufacture and installation.

Other plates are known which dispense with the center pin and instead contain especially disposed capillaries which, for certain uses, may be of a particular shape. Fibers produced with these devices melt together, forming a hollow yarn. For instance, spinnerets are employed which have single bores of round cross section or a plurality of single straight or bent slits of small width. As shown in FIG. 1, these bores are disposed in a circle relative to each other. FIG. 2 illustrates the version wherein slits are provided each of which is straight; and FIG. 3 shows embodiments which use bent slits.

It has been established, however, that the adhesion of the single fibrils to each other produced with these devices is unsatisfactory because of the fineness of the fibrils and their inherent mobility. Cross sections frequently form which lack the closed hollow spaces and, in part, are open.

More advantageous are those spinnerets wherein the single slits or bores are interconnected, as shown in FIGS. 4 and 5, respectively. The melt flows through all these slits or bores and provides the fiber to be formed with an inner structure within its profile.

Other known spinning plates are made of equal halves provided with fitting shoulders, as shown in FIG. 6, or of uneven parts which lap, shown in FIG. 7. Bores with numerous single slits, as in FIG. 8, have only been used experimentally.

It now has been found that spinnerets are of great value for the production of hollow, closed-end synthetic fibers which have star-shaped profiles in a given configuration. When several bores in a spinning plate are disposed in a group so that the individual melt streams leaving the spinneret come to adhere to each other to form a fiber at a distance of substantially 10–40 cm. below the plate, a distance at which these streams still are sufficiently liquid, a very constant cross section is obtained without the use of a gas. The hollow space in the fiber thus formed and the wall thickness remain uniform thereby.

Well-profiled fibers or filaments are obtained by the combination of not more than 3 star profiles per bore group. More than three single bores per group produce less pronounced profiles and are applicable only in very special instances.

The spinneret according to the invention thus is characterized by 2–3 spinning openings with star-like profile per bore group.

A mirror-image disposition of 2 star profiles is shown in FIGS. 9 and 10 and is of great advantage. A plurality of bore groups may be distributed at will over the plate. The wall thickness of the hollow space, i.e., the cross section of the fiber produced can be varied in dependence on the operational conditions, such as the viscosity of the melt, its temperature, cooling and draw-off conditions.

The size of the hollow space to be formed is readily controlled during the manufacture of the fiber. The time of adhesion during cooling of the melt which had passed the nozzle in the spinneret can be regulated exactly so that the hollow space is of any desired size and is kept constant. Preferred is a cross section which amounts to approximately 10–30% of the total area. Fibers thus spun not only retain their form but also the area proportions named during stretching and stretch twisting. Moreover, they are suited for such further processing wherein profiles of very slender cross sections generally meet with difficulties.

According to the invention, each individual star opening may have a bore hole; the holes of correlated star-spin nozzles may overlap; or a single bore hole may be present per nozzle pair.

Contrary to all expectations, a very slight strength of the plate at leg a (FIG. 9) suffices. This leg separates the actual profiles. Even at high pressures on the melting side of the spinneret these legs are not forced out so that the conventional bore channel length and its proportion to the channel opening can be used, i.e., proportions of 1:2 to 2:1.

The plate may contain any desired number of nozzle openings. It is recommended to keep the distances between the individual bore groups sufficiently large and to adapt the total number of bore holes to the cooling conditions so that undesirable adhesion of several single hollow fibers is avoided. The star-shaped bores can be disposed on the plate either in parallel or in concentric circles.

A particularly advantageous embodiment of a spinning plate is obtained by disposing 2 spin openings of 3- or 4-cornered star profile in mirror image relative to each other, i.e., in Y- or X-form, as shown in FIGS. 9 and 10.

The following considerations are valid for the Y-form: The lengths A, B and C of the slits may be
alike or different, however, they should be at least twice the width of the slit. Angles $\alpha$, $\beta$ and $\gamma$ may be alike or different, but the most advantageous relation is attained with one of the following:

$$a = \beta = \gamma \text{ or } a > \beta = \gamma$$

The most advantageous formations of the X-form are as follows:

$$a = \beta \text{ and } A = B = C = D$$

The distance $a$ of the two star profiles is at least equal to the slit width $b$.

Spinnernet of the kind described are eminently suited for the melt spinning of synthetic hollow fibers made from high-polymers, such as polyamides, polyesters or poly-alkylenes.

The spinneret according to the invention enables the manufacture of a large number of hollow profile fibers per hour, having a hollow space of 15% of the cross section, and constant cross section. This cannot be accomplished with spinners such as shown in FIGS. 3 and 5, wherein several correlated slits are used, because of the instability of the individual spin components. Moreover, the manufacturing costs of a spinneret having, e.g., a YY-bore are approximately 30% of those of the simplest spinning plate shown in FIGS. 7 and 8, and this is significant for the manufacture of synthetic fibers considering the number of nozzles in a plate which amounts to 100–300.

The invention now will be further explained with reference to the drawings and by specific examples. However, it should be understood that these are given merely by way of illustration, and not of limitation, and that modifications and changes may be made without departing from the spirit and the scope of the invention as herein-after claimed.

**Example 1a**

A spinneret having two Y-profile bores according to FIG. 9 was used which had the following dimensions:

- Length of slits $A$ and $B$: 1.0 mm
- Length of slit $C$: 0.5 mm
- Width of slits $b$: 0.2 mm
- Distance $Y-Y$ ($a$): 0.2 mm
- Angles of $\alpha$, $\beta$ and $\gamma$: 120 degrees

Polycapro lactam shavings having a relative solution viscosity of 1.60 at 0.5% solution in cresol were spun to hollow profile fibers at a melt temperature of 252° C. through a spinneret as described in Example 1a. The hollow space in the fibers was 20% of the cross section. The staple fiber thus produced, after stretching to 1:3.9, had a strength of 4.1 g/den. and an elongation at break of 31.0%.

We claim as our invention:

1. A spinneret for the manufacture of hollow profile synthetic fibers comprising a plate containing at least one bore group having at least two spinning openings of star-shaped profile.

2. The spinneret as defined in claim 1, wherein said bore group has two spinning openings in the form of stars disposed in mirror image relative to each other.

3. The spinneret as defined in claim 2, wherein said stars are Y-shaped.

4. The spinneret as defined in claim 3, wherein the lengths of the slits of said Y-shape are equal and at least twice the length of their widths, and the distance between said stars in mirror image is at least as large as the width of said slits.

5. The spinneret as defined in claim 4, wherein the angles at which said slits meet are equal.

6. The spinneret as defined in claim 4, wherein the angles $\alpha$, $\beta$ and $\gamma$ at which the slits meet are $\alpha > \beta = \gamma$.

7. The spinneret as defined in claim 2, wherein said stars are X-shaped, the slits defining each said star being of equal length, the angles at which said slits meet are right angles, and the distance between said stars is at least as large as the width of said slits.

8. A spinneret for the manufacture of hollow profile synthetic fibers which comprises a plate provided with at least one bore group having at least two spinning openings of star-shaped profile, the stars being disposed in mirror image relative to each other; the slits defining said stars being of equal length, and the distance between said stars being at least as large as the width of said slits.

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