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SPINNERET FOR PRODUCING HOLLOW FILAMENTS

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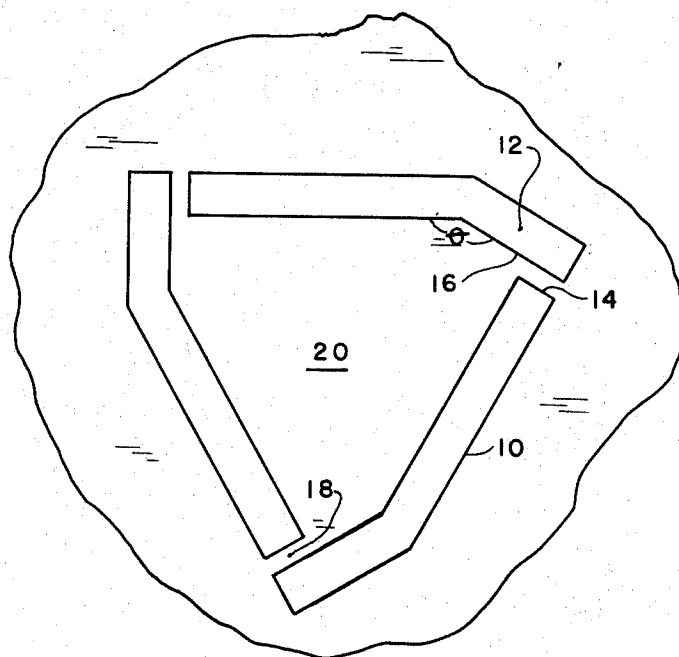


FIG. 1

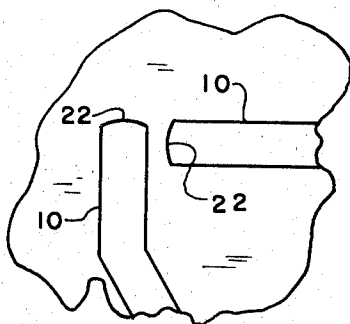


FIG. 2

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3,555,600 SPINNERET FOR PRODUCING HOLLOW FILAMENTS

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4 Claims

ABSTRACT OF THE DISCLOSURE

A spinneret for spinning hollow filaments having a maximum amount of open space in relation to the outer dimensions of said filaments. The filaments are extruded from a group of three slots having a dog-leg portion at one end facing into the opposite end of an adjacent slot. The polymer occluding area defined by the arrangement of the slots forms substantially an equilateral triangle. Filaments melt spun from this spinneret have a sharply defined inner and outer triangular cross section.

BACKGROUND OF THE INVENTION

The textile industry has long been interested in hollow filaments because of the special attributes of such fibers and the several novel effects which may be obtained with them. It is well recognized that hollow filaments have certain advantages over solid filaments having the same outer diameters. Some of the advantages which hollow filaments have over solid filaments include: improved insulation properties, increased buoyancy, reduced pilling, special optical effects, and greater covering power per unit weight. Hollow filaments also have less tendency to fibrillate under flexing conditions than corresponding solid filaments.

While hollow filaments are highly desirable by the textile industry, it has proved to be extremely difficult to manufacture these filaments in a commercially feasible manner by melt-spinning. Considerable time and effort have been spent on attempts to adapt existing methods to the production of hollow filaments on a commercial scale. Processes which have been devised for this purpose have necessitated the use of special and often expensive processing conditions and equipment.

Most of the problems involved with the spinning of hollow filaments are related to the spinneret. Unfortunately, the spinnerets that have been designed thus far are difficult to construct and are subject to frequent breakdowns which may be attributed at least in part to their complex construction.

One type of spinneret commonly used to produce hollow filaments employs orifices containing an internal obstructing member which causes the orifice to function as an annulus. The obstructive members are usually joined to the spinneret body by internal support members upstream from the extrusion face of the spinneret. This type of spinneret is difficult to make and they present a major problem keeping them in a good state of repair and cleanliness.

There are other spinnerets available that employ a multitude of unobstructed orifices grouped in a perimeter. The orifices exist in various cross-sectional shapes such as circular, rectangular, crescent shape or other curvilinear or polygonal shapes spaced in close proximity to essentially circumscribe an area of the spinneret plate. The circumscribed area blocks the flow of extrudate as the molten polymer streams emerging from the closely spaced orifices coalesce to form hollow filaments. These spinnerets require very close spacing between adjacent orifices to permit proper coalescence of the extrudate streams with the result that the thickness of the intervening metal

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between orifices is so small as to cause structural weakness and difficulties with fabrication. Thus, the weakened nature of these spinnerets is particularly significant in the melt-spinning of synthetic fibers because the extrusion pressures required will often cause distortion or actual rupture of spinnerets which are not properly designed. Another serious problem encountered with orifices spaced too closely is that polymer coalescence may occur too close to the spinneret face thus preventing the entrance of air into the hollow cavity of the filament. Therefore, the resultant vacuum within the filament causes internal coalescence of the molten polymer which minimizes or completely eliminates the central cavity.

SUMMARY OF THE INVENTION

The principal objective of the present invention is to provide a spinneret for producing hollow filaments having the maximum internal cavity obtainable within a given filament. It has been found that this particular object among others can be achieved through the use of a spinneret having at least one group of three slots, each of which has a dog leg preferentially arranged so that a substantially equilateral triangular area is circumscribed by the three slots which produce an orifice. The dog-leg portion is offset inwardly at an angle sufficient to extend transversely across the end of the adjacent slot. Preferably, the end of the dog-leg portion extends to a point parallel with the outer edge of the adjacent slot.

The inwardly turned dog-leg portion serves two functions. Most important is the fact that substantially an equilateral triangular polymer-occluding area is formed which imparts to a filament a sharply defined triangular internal cavity that contributes to the maximum amount of open space within the filament cross section. Another important result achieved by this particular arrangement and configuration of slots resides in the fact that the walls of the hollow filaments are quite uniform. Because of the inwardly curved portion which terminates in alignment with the outer side wall of the adjacent slot there are no large areas formed at the apices or points where coalescence occurs.

The product obtained from the practice of this invention is a synthetic filament consisting of triangular-shaped sheath and an internal, longitudinally extending triangular cavity centrally disposed with respect to the filament axis and the peripheral contour of the cross section of the cavity being the same shape as the cross-sectional periphery of the sheath. The shapes of both the cavity and sheath will be essentially constant along the length of the filament. The cavity may occupy up to about 50 percent of the entire cross-sectional area of the filament depending upon the width and length of the slots.

In order to obtain a hollow filament having the maximum amount of open space internally, the ratio of the slot width to the minimum distance between the ends of the slots should be approximately 2:1 and the angle of the dog-leg of all three slots should be approximately 150°. For example, the preferred dimensions are approximately 6 mils width for the slots and 3 mils distance between the ends of the slots. Also, the ends of the slots preferably should be squared so that the plate area between the slots is a rectangle measuring approximately 3 x 6 mils. It has been found however that the ends of the slots may be slightly rounded provided the total area separating the slots is essentially the same as if the ends of the slots were squared.

Thermoplastic polymers suitable for use in the present invention include most of the fiber-forming melt-spinnable compositions. These compositions which are preferred include polyesters, such as polyethylene terephthalate and polyhexahydro p-xylylene terephthalate; polyamides such as polyhexamethylene adipamide and polycapromides;

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polyolefins, such as polyethylene and polypropylene, polyurethanes; polyesteramides; polyethers; and other synthetic polymers and mixtures thereof.

Filaments produced by the spinneret of the present invention have been found to be extremely useful for floatation materials because of their low density cross section. They may be used in the form of monofilament and multifilament yarn, tow, cords, and staple spun yarns. The filaments may be blended with other fibrous materials, and may be employed in crimped or uncrimped conditions.

Other typical textile applications include apparel products such as woven suitings, shirtings, sheeting and lingerie, tricot, circular knitted fabrics, broadcloths, satins, and the like. In view of their relatively high stiffness, strength, and low weight, the filaments of this invention are further useful in textile applications such as sewing thread, tire cord, fiber-reinforced laminates, upholstery, carpeting, drapery, curtains, ducks, parachutes, reinforced belts and hoses, marine lines, ropes and netting, and other applications. The filaments may be admixed with solid core filamentary structures of various modified cross section of the same or different denier and the same or different chemical composition to produce various special effects.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a fragmentary section of a spinneret plate illustrating the preferred arrangement and configurations of a group of slots forming an orifice in accordance with this invention.

FIG. 2 is a fragmentary section of a spinneret plate illustrating a modification of the preferred embodiment of FIG. 1 wherein the ends of the slots terminate in a radius.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In referring to FIG. 1 there is shown a triangular arrangement of three slots 10 having dog-leg or offset portions 12 which turn inwardly towards the perpendicular ends 14 of the next adjacent slot. The inside wall 16 of the dog-leg portions 12 and the end walls 14 of the perpendicular ends are parallel thus leaving a rectangular area 18 as the intervening area between the slotted orifices where coalescence occurs. The rectangular area must be large enough to prevent the triangular-shaped polymer occluding area 20 from bulging caused by extrusion pressure while being of proper dimension to insure that sufficient air enters the filament cavity prior to coalescence of the three streams. A rectangular area, as shown at 18, having a width of approximately 3 mils and length of approximately 6 mils is highly preferred. The 3 x 6 mil area provides adequate spinneret strength and permits air to

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communicate with the cavity of the extruded filament. Furthermore, there is provided a longer interface between the polymer streams to facilitate better coalescence than is provided with the use of orifice having other configurations. The angle θ should be approximately 150° for the three dog-leg portions 12.

A slight modification of the preferred embodiment of FIG. 1 is shown in FIG. 2 wherein the end of the slots 10 terminate in a radius. The radius should be substantially greater than the width of the slot however to provide a slightly arcuate end wall 22. It is essential that the total area between the slots at the point of coalescence be approximately the same as the total area 18, shown in FIG. 1.

Other modifications within the scope of the disclosed invention will be apparent to those skilled in the art without departing from the teachings herein, and accordingly, such modifications are considered to be within the scope of the appended claims.

I claim:

1. A spinneret for extruding molten synthetic linear polymer to provide triangular-shaped hollow filaments comprising a plate containing at least one group of three slots, said slots being spaced in close proximity in an end-to-end relationship to form an essentially equilateral triangular arrangement, each of said slots having a major rectangular portion and a minor substantially rectangular portion, said minor portion being offset inwardly toward the major portion of the next adjacent slot to form a substantially rectangular area therebetween, said offset portion being so spaced that coalescence occurs between the polymer streams exiting the group of slots.

2. A spinneret as described in claim 1 wherein the major portion and minor portion of the slots are the same width.

3. A spinneret as described in claim 2 wherein the substantially rectangular area between the slots is 2-6 mils by 4-8 mils.

4. A spinneret as described in claim 2 wherein the ratio of the width to the minimum distance between said slots is 2:1.

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