PROCESS FOR THE MANUFACTURE OF SPINNERETS FOR MELT SPINNING

James G. Sins, Pensacola, Fla., assignor to Monsanto Company, a corporation of Delaware

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This invention relates to a process for manufacturing spinnerets adapted for melt spinning highly polymeric substances. More particularly, the invention relates to a process for making new and improved spinnerets adapted for melt spinning synthetic thermoplastic polymers into filaments having a central hole extending axially thereof.

As is well known in the manufacture of man-made filaments from synthetic polymers as viscous orymer is forced, such as being pumped, through small holes in a metal spinneret, a die-like plate having a desired number of small orifices extending therethrough. In the production of synthetic melt-spin filaments molten polymer is forced through the orifices in the spinneret by pressure; and the resulting molten streams of polymer solidify and harden upon being cooled by an ambient stream of relatively cold air or other inert gas. The synthetic filaments, such as nylon-66 as conventionally produced, have the appearance of smooth solid cylindrical rods when viewed under a microscope. Among some of the disadvantages associated with melt-spin filaments compared to naturally occurring fibers such as cotton and wool are their low capacity for absorbing moisture, lower insulating power, lower covering power, and undesirable stick “hand” or feeling.

Many methods and devices are known for imparting some of the desirable properties of natural fibers to melt-spin filaments. One approach has been to provide the melt-spin filaments with a continuous central hole or opening along their lengths. However, efforts along this line generally have not been successful in producing melt-spin filaments possessing a hollow space extending continuously along their lengths. In accordance with a known device, polymerized from the production of wet-spin filaments having a central opening, a solid core is positioned concentrically within each spinneret orifice during the spinning operation, the core being suspended by a transverse piece or cross bar on the inlet side of the spinneret. In such device the polymeric substance to be spun upon entering the orifices in the spinneret surrounds the solid core, the objective being to cause the polymeric substance to assume an annular path so that a central hollow space exists in each of the ultimate filaments. However, such a device cannot be used successfully in melt spinning, since the extruded streams remain in a more or less random orientation; with low pressure within the interior, any hollow space tends to collapse upon the exodus of the streams from the spinneret orifices. The collapsed structure fuses together incompletely with the result that the filaments so-produced do not possess the desired continuous central opening.

It has been found that spinnerets with specially arranged slotted holes can be used advantageously for producing centrally hollow filaments from molten synthetic thermoplastic fiber-forming polymer. In such an arrangement for each filament produced there is provided an orificial grouping of a plurality of elongated segments or parts permitting passage therethrough of molten fiber-forming polymer. The segments are disposed with respect to each other within each orificial group in such a manner that the ends of the plurality of molten streams of polymers extruded through the segments within the orificial group-

coalesce endwise shortly after issuing from the orifices. Fabrication of such orificial grouping in a spinneret is quite expensive and is fraught with difficulties. Moreover, because of the structural weakness of the support, the central partition between opposed segments may break out during spinning, resulting in the necessity of immediate shutdown of the spinning operation; to assure coalescence of the plurality of streams, the walls of the orifices must be very accurately machined and finished. Furthermore, during spinneret cleaning operations orifice edges are easily damaged and are thereafter extremely troublesome or impossible to repair. Thus, such spinnerets are very difficult to make even at great expense and the effective service lives of the spinnerets are quite short.

It is a primary object of the invention to provide a new process for manufacturing improved spinnerets with which hollow melt-spin filaments can be made, said spinnerets overcoming the disadvantages and difficulties of the known spinnerets.

It is another object of the invention to provide the art with a novel and improved method for making spinnerets with which hollow melt-spin filaments can be made.

Other objects and advantages of the present invention will become apparent from the description of the invention which follows.

In accordance with the present invention, it is now possible with the spinnerets hereindicated to produce filaments by the melt-spinning process, said filaments having a continuous central opening therein. Into a spinneret plate of the type conventionally employed for the melt-spinning operation a hole or a plurality of spaced holes are formed in the first step by suitable means such as by drilling, grinding or punching with a suitable apparatus. A conventional spinneret plate is usually composed of stainless steel of sufficient thickness to withstand the normal extrusion pressure and mechanical forces involved during melt spinning. It will be understood that these forces will vary depending on the polymeric material to be melt spun. Next, pieces of metal of the same or different type from the metal of which the plate is made are shaped in a suitable manner so that only three or more portions of the outer periphery thereof will engage the inside periphery of the hole upon inserting such a piece in one of said holes, thereby leaving a plurality of open spaces extending axially through the spinneret plate and clustered around the inserted metal members or pieces to form an orificial grouping. Preferably, the inserted pieces are of such length that the bottom thereof is positioned in the same plane as the bottom of the spinneret plate. The vertical surfaces of the inserted metal pieces and the inner vertical surfaces of the spinnerets except where they engage each other define a plurality of elongated openings through which molten polymer may be pumped in a suitable manner. The molten polymer is extruded through the openings spaced around the metal pieces disposed centrally of the orificial groupings, the streams of each group are guided so that they coalesce endwise to form a consolidated periphery leaving a hollow central hole in the resulting filaments. Preferably the plurality of openings defined by the vertical surfaces of the metal pieces and spinneret plate assume the form of a discontinuous arcuate segmented configuration but may assume any arbitrary configuration of unconnected openings provided that the extruded polymer streams in an orificial grouping will coalesce to form a filament having a central hole. For example, the openings in the orificial grouping may have the form of a discontinuous polygon.

The novel features which are believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention itself both as to its
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In FIGURE 3 a spinneret made in accordance with the present invention is shown in cross section taken centrally of a hole opening drawing in which three part of the outside periphery of insert 7 are spaced from the inside periphery of portion 6, a plurality of passageways 11 forming one orificial grouping are provided through which molten polymer moves in operation. It will be appreciated that the number of orificial groupings on the plate will be determined by the size of the plate and the number of hollow filaments desired in one bundle. As the extruded streams in each group move downwardly from the bottom of the spinneret, they are caused to be consolidated into unitary hollow filaments.

The insert 12 as shown in FIGURE 4 has a triangular cross section approximating that of an equi-angular triangle having slightly angular apexes. These apexes of insert 12 are rounded to correspond with the inside curvature of the hole in the spinneret in which it is to be inserted. Insert 12 is shaped by conventional machining procedures or molded by conventional methods. For convenience, an elongated rod or bar of suitable size and material can be shaped, such as by wire-drawing or by using a shaper, into the three-sided shape and the resulting rod or bar cut into pieces of appropriate lengths adapted to insert 7 in FIGURE 1. The three streams issuing from each orificial group are brought together just below the bottom of the spinneret to produce an integral filamentary structure having a central, longitudinally extending hole.

The insert 14 as shown in FIGURE 6 has a main body section 15 of circular cross section with four circumferentially disposed, equi-spaced extending legs 16 terminating with convexly rounded extremities. The radius of curvature of the arcuate extremities is substantially identical to the radius of the orifice in the spinneret into which it is placed. As above in connection with the method of producing insert 12, insert 14 can be shaped or molded by known procedures to form an elongated rod or the like, the shaped rod being cut into desired lengths.

In FIGURE 7 insert 14 is mated securely in a hole in spinneret plate 3 as to provide for the emission of four streams of polymer from segmented annuli 17, 18, 19 and 20. The annuli 17, 18, 19 and 20 are circularly spaced from each other and rim forming one orificial grouping are provided through which molten polymer moves during melt spinning. To produce a hollow filament the four streams issuing from each orificial group are brought together just below the bottom of the spinneret to fuse into an integral filamentary structure having a central longitudinally extending hole.

The insert 21 as shown in FIGURE 8 has a main body section 22 of square cross section with four extending legs 23 adapted to fit snugly in a square hole and to withstand extrusion pressures. As above in connection with the method of producing insert 12, insert 21 can be shaped or molded by known procedures to form an elongated rod or the like, the shaped rod being cut into pieces of desired lengths.

In FIGURE 9 insert 21 is mated securely in a hole in spinneret plate 3 so as to provide for the emission of four streams from polygonally arranged slots 24, 25, 26 and 27.

The actual dimensions of the openings comprising an orificial group depend upon the characteristics of the polymer, the filament size or denier, the spinning speed, and other factors in the particular melt-spinning process. In the production of filaments for textile and industrial yarns the circumference of the open hole in the spinneret plate (without insert) is preferably within the range of 0.040 inch to 0.80 inch. To insure proper coalescence.
of the individual polymer streams, relative proportions between dimensions must be maintained within certain limits. The total area of the segments or annuli in an orificial grouping shall be between 30 percent and 60 percent of the area defined by the open hole. The ratio of the maximum length of each segment to its maximum width should not be less than 3; for example, in FIGURE 9 rectangular slots 24, 25, 26 and 27 ought to have a length to width ratio not less than 3; similarly, in FIGURE 5, the ratio of the length of the chord to the height of the segment on the chord must not be less than 3. Furthermore, the minimum distance separating the orificial segments must not exceed the maximum width and is preferably not greater than one-half the maximum width.

The spinneret of the present invention can be used to produce filaments from any suitable substance that can be melt spun. Specific polymere materials capable of being melt spun include: nylon-66, nylon-6, nylon-4, nylon-610, nylon-11, and their filament-forming co-polymer wherein, e.g., nylon-6-66, 6/610/66, etc.; polyesters derived from terephthalic acid and ethylene glycol and from terephthalic acid and bis-1,4-(hydroxymethyl)-cyclohexane; polyethylene and polypropylene, and other substances.

It is apparent from the foregoing description that this invention represents a material advance in the art of manufacturing spinnerets for producing hollow filaments. Heretofore the processes have been slow and costly and the spinnerets had a limited service life. Existing spinnerets for producing solid filaments can be converted with rather nominal expense to spinnerets from which hollow filaments can be produced. For example, an insert of the type above-described can be placed in reamed orifices formed in a spinneret normally used in melt spinning. The savings in time, capital investment in equipment, maintenance costs and melt-spinning efficiency compared with known spinnerets and methods of producing same for use in the formation of hollow filaments show the present invention to be distinctly advantageous.

It is apparent that many widely different embodiments of this invention can be made without departing from the spirit and scope thereof; and, therefore, it is not intended to be limited except as indicated in the appended claims.

This application is a divisional application of pending application Serial No. 58,288, filed September 26, 1960, now abandoned.

What is claimed is:
1. A process for the manufacture of a spinneret adapted for melt spinning thermoplastic polymers into filaments having a continuous axially extending hole comprising forming an extrusion hole extending through a plate, shaping an insert member so that said member is engageable with the inside periphery of said extrusion hole along at least three portions of its periphery only to provide a plurality of laterally elongated open spaces extending through the said plate, the total lateral cross-sectional area of the open spaces in each orificial grouping being between 30 percent and 60 percent of the lateral cross-sectional area of the corresponding extrusion orifice, the length:width ratio of the annuli not being less than 3, and the distance separating the adjacent ends of the annuli not exceeding the width of the annuli, and force-fitting said insert member so-shaped into the portion of the extrusion orifice of smaller diameter in tightly assembled relation therewith so that the bottom of said insert member is flush with the bottom of the plate.

2. A process for the manufacture of a spinneret adapted for melt spinning thermoplastic polymers into filaments having a continuous axially extending hole comprising forming a plurality of extrusion holes extending through a plate, shaping an insert member for each extrusion hole so that said member is engageable with the inside periphery of its respective extrusion hole along at least three portions of its periphery only to provide a plurality of laterally elongated open spaces extending through the said plate, the total lateral cross-sectional area of the open spaces in each orificial grouping being between 30 percent and 60 percent of the lateral cross-sectional area of the corresponding extrusion orifice, the length:width ratio of the annuli not being less than 3, and the distance separating the adjacent ends of the annuli not exceeding the width of the annuli, and force-fitting said insert member so-shaped into the portion of the extrusion orifice of smaller diameter in tightly assembled relation therewith so that the bottom of said insert member is flush with the bottom of the plate.

References Cited by the Examiner

UNITED STATES PATENTS
1,597,928 8/26 Simons 76—107
2,820,374 1/58 De Wolf 76—107
1,952,071 9/60 Burt 29—525 XR
7,962,810 12/60 Gillmor 29—525 XR
3,102,439 9/63 Martin et al. 76—107

FOREIGN PATENTS
22,568 1913 Great Britain
843,179 8/60 Great Britain

WHITMORE A. WILTZ, Primary Examiner.