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RECTANGULAR SPINNING PACK

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Fig. 1

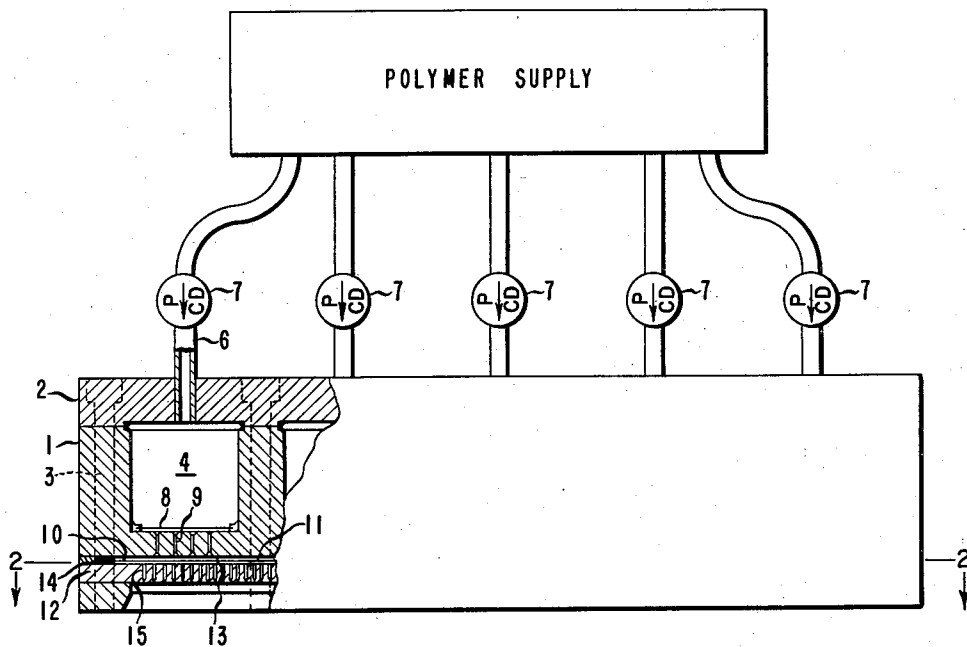
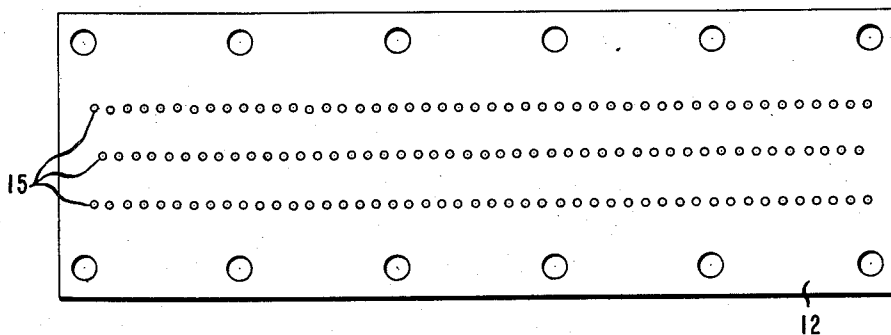


Fig. 2



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RECTANGULAR SPINNING PACK

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4 Claims. (Cl. 18—8)

This invention relates to the spinning of molten organic filament-forming compositions to produce filaments, yarns, ribbons, and the like. More particularly, it relates to an improvement in spinning of such molten compositions to obtain filaments having improved denier uniformity.

It has been customary in the melt-spinning of organic polymeric materials, such as polyhexamethylene adipamide, to pass the molten polymer through a finely divided inert filtering medium prior to extrusion through the spinneret, the spinneret being round and the filter bed conforming to the shape of spinneret. A spinneret and filter assembly of this type is described by Graves in U.S. 2,266,363. After extrusion, the filaments are quenched by passing a stream of air across the filaments after they emerge from the spinneret. This is a satisfactory mode of operation when spinning a relatively small number of filaments, but with a large number of filaments, as in the spinning of high denier industrial yarns or staple tows, it becomes impossible to maintain the required uniformity in filament diameter. Non-uniformity in filament size leads to breakage of the small denier filaments during drawing with attendant difficulties in processing due to a high incidence of filament warps on the draw rolls and a decrease in yarn quality due to the large number of broken filaments in the yarn.

It is an object of this invention to provide an improved process and apparatus for the melt-spinning of synthetic yarns.

Another object is to provide an improved process and apparatus for melt-spinning a large number of filaments.

A further object is to provide a process and apparatus for spinning large numbers of filaments wherein the denier uniformity of the filaments is improved.

In accordance with this invention, an organic fiber-forming molten polymer is passed at the same volume rate through each of a plurality of filters, preferably in the form of chambers containing an inert particulate filter medium, and thence, by means of a plurality of streams, from each of said chambers into a common polymer distribution zone. Preferably, the streams of polymer entering the distribution zone form a pattern which is substantially uniform over the upper surface of the distribution zone. Polymer leaving the distribution zone is continuously separated into a multitude of portions (at least 40) and each portion is continuously formed into a filament, the resulting multitude of filaments being arranged in a substantially rectangular pattern the long axis of which is at least three times the length of the short axis. The filaments are quenched by blowing air across the filaments after they emerge from the spinneret, the direction of air flow being substantially parallel to the face of the spinneret and substantially perpendicular to the long axis of the filament pattern.

The apparatus of this invention will be more readily understood by referring to the drawings. Figure 1

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is a view of a longitudinal vertical section of a spinneret assembly of this invention. Figure 2 is a top view of a typical spinneret plate showing uniformly spaced parallel rows of uniformly spaced orifices, each row being staggered relative to the adjacent rows with the rows forming a substantially rectangular pattern having a length more than three times its width.

In the apparatus shown in Figure 1, a body portion 1 is releasably joined to a lid 2 by threaded bolts 3. The body contains a plurality of filter chambers 4 which in this embodiment are filled with sand suitable for filtering molten polymeric material. Molten polymer is supplied to each of the filter chambers 4 at the same volume rate through conduits 6, each of which is supplied with polymer from a source not shown by constant delivery pumps 7, each chamber being supplied by a separate pump and conduit. As a result of the separate supply means associated with each filter chamber, polymer passes through each chamber at the same volume rate. Polymer leaves filter chambers 4 by passing through screen 8 which serves to prevent entrainment of sand and then through conduits 9 which communicate between filter chambers 4 and distribution zone 10 situated above screen 11. Conduits 9 are sufficient in number and lateral distribution to supply polymer uniformly over the lateral area of the distribution zone and over screen 11. The distribution zone is formed by the spaced apart relationship between screen 11 and the lower planar surface 13 of body 1, the height of the distribution zone being governed and maintained constant by annular gasket 14. It is preferable that the distribution zone have a height of 0.1 to 0.25 inch. Both the distribution zone 10 and screen 11 cover all of the conduits 9 and spinneret orifices 15. Screen 11 is in contact with the inner face of spinneret 12.

The exact size and shape of filter chambers 4 are not critical and may be varied depending on the spinning conditions employed. However, it is generally desirable to make the chambers as large as possible to provide the maximum filter area while maintaining chamber strength high enough to withstand the operating pressures employed. For this reason, chambers which are oval shaped in horizontal cross section are preferred. While the illustrated spinneret and filter assembly is bolted together, any suitable means for holding the various parts together may be used. The spinneret and filter assembly may be connected to the source of polymer supply as desired.

Screen 11, which contacts the spinneret inner face, is preferably a metal screen (standard) of at least 20 mesh.

The following example illustrates advantages of a specific embodiment of this invention.

Example

Polyhexamethylene adipamide is melted and brought to a temperature of 280–295° C. in a conventional manner. The molten polymer is then pumped to a filter assembly of the type described above. The assembly has four filter chambers filled with sand in the conventional manner. Polymer is pumped through each filter chamber at the same constant volume rate by a four-stream metering pump into the common polymer distribution zone below the filter block by means of a plurality of conduits leading from the bottom of each filter chamber to the bottom of the filter block. The polymer distribution zone is 0.12 inch in height. The polymer is then extruded through a spinneret covered by a screen and having 140 holes (each with a diameter of 0.009 inch) to form yarn having a final denier of 840. The spinneret holes are arranged in four rows and the holes are

0.23 inch apart (center to center) in the rows and the rows are 0.37 inch apart (centerline to centerline).

The filaments are quenched by cooling with air passed in a straight-line flow across the filament bundle as described in U.S. 2,273,105 to Heckert. The flow of air is substantially parallel to the face of the spinneret and perpendicular to the long axis of the spinneret hole pattern.

Filament diameters are measured by taking samples of undrawn yarn periodically, embedding the filaments in wax, cutting cross sections and measuring the diameter of the cross sections by microscopic examination in the conventional manner. The yarn is subsequently drawn with a draw ratio of 5:1, twisted about 0.2 turn per inch and wound into packages in the conventional manner.

For control purposes 840 denier, 140 filament yarn is spun using a conventional round spinneret and filter assembly with the spinneret holes arranged in a pattern of concentric circles.

The standard deviation, i.e., the root mean square of the deviations from the mean, of the filament diameters is 1.89 for filaments prepared using the process and apparatus of the present invention, while with the round spinneret and filter assembly the standard deviation is 3.92.

In a second spinning test with the process and apparatus of the present invention, the standard deviation of the filament diameters is found to be 1.44.

On inspection of the yarn packages, 4.3% of those produced by the process and apparatus of this invention are rejected and sold as second-grade yarn due to a high incidence of broken filaments, while 7.3% of the packages produced with the round spinneret assembly are rejected.

As shown by the foregoing example, the process and apparatus of this invention provide the necessary cooperating elements required to greatly improve the denier uniformity of filaments where a considerable number of filaments are extruded through a single spinneret. The elongated filament pattern in combination with the proper air flow provide uniform cooling of the filaments. However, in addition to uniform quenching of the filaments, it is necessary that the rate of flow of polymer through the spinneret holes be as uniform as possible for all the spinneret holes. To accomplish this, a number of factors must be critically controlled. It is essential that a plurality of filter chambers be used, the exact number depending on the length of the assembly. This is necessary because it is impossible to maintain a uniform flow of polymer through a single large chamber due to difficulties in preparing the filter bed uniformly and localized differences in flow which occur during operation of the filter. Two chambers will provide adequate filament uniformity in some cases, although in other cases a larger number are preferred. The optimum number of chambers will depend on the number of spinneret orifices and other prevailing conditions. In addition to contributing to a uniform flow of the polymer, the use of several separate chambers contributes to the strength of the assembly. This is important since in the spinning of relatively high viscosity polymer at high speeds pressures in the range of 5,000 to 10,000 p.s.i. are frequently encountered.

Polymer must be supplied to each filter chamber at a constant rate of flow at all times. If this is not done, slight differences in the character of the filter bed, either initially or after the filter bed has been operating for some period, may result in differences in rate of flow among the several filter beds thus causing pressure inequalities at the spinneret. A constant flow of polymer is preferably accomplished by the use of individual metering pumps for each chamber or by the use of one or more multiple stream metering pumps. Finally, the height of the polymer distribution zone between the spinneret and filter block must be sufficient to permit equalization of any slight variations in pressure which may occur in spite of the above-mentioned precautions, and on the other

hand must not be so great as to permit formation of gels due to the hot polymer being held up for too long a period in the cavity. While the optimum height will depend on the rate at which the polymer is passed through the distribution cavity, at commercial spinning speeds it is highly preferable that the cavity height be in the range of 0.10 to 0.25 inch.

In order to obtain the maximum benefits from the rectangular spinneret hole patterns the holes are preferably arranged in such manner that the filament bundle is only a few filaments deep, i.e., the spinneret holes are arranged in a few relatively long rows so that they are contacted uniformly by quenching air moving in a direction perpendicular to the filaments and perpendicular to the long axis of the filament bundle. In a preferred arrangement, the long axis of the hole pattern is at least 5 times the length of the short axis. Also, it is desirable that the spinneret holes be staggered relative to the air flow so that each filament will be contacted by its own line of air flow; that is to say, no filaments are closely positioned in a line with other filaments in the direction of the air flow. The spinneret holes should be spaced far enough from adjacent holes to obtain uniform cooling of the filaments, and to prevent filaments sticking together. While the exact distance required will vary depending on other conditions, it is preferable to space holes at least 0.15 inch apart (measured center to center).

Adjustment of the volume of air flowing across the filaments will depend on the number of filaments, the spinning speed, the air temperature, and other variables. Adjustments in accordance with prevailing conditions may readily be made by one skilled in the art. In accordance with this invention, it is essential that the air be blown across the filaments in a direction substantially perpendicular to the long axis of the filament pattern.

In addition to the advantages mentioned previously, the process and apparatus of the present invention lend themselves readily to the spinning of more than one yarn from one spinneret assembly with the resultant economy in space and equipment. Separation of the filament bundle after quenching is easily accomplished. If desired the spinneret may be provided with two sets of orifices each having the desired rectangular pattern but spaced slightly apart to facilitate separation of the filaments. If the latter arrangement is used, it is usually preferable to provide separate polymer distribution zones by suitable arrangement of the gasket. While appreciable improvements may be realized in accordance with the invention when using spinnerets having at least 40 orifices, the maximum benefits are realized when it becomes necessary to use spinnerets with at least 100 orifices.

While the invention has been described in connection with this use in the manufacture of filaments from polyhexamethylene adipamide, it is obviously applicable to melt extrusion of any organic filament-forming composition. Exemplary filament-forming compositions include synthetic linear polyamides and other synthetic linear polymers such as polyesters, polyethers, polyacetals, and mixed polyester-polyamides, such as may be prepared by condensation reactions as described in U.S. Patent 2,071,250. Other types of synthetic polymers such as ethylene polymers, vinyl polymers, and polystyrene may also be spun with advantage in accordance with the present invention.

The claimed invention:

1. In a spinneret pack assembly the improvement comprising a spinneret plate having at least 40 orifices arranged in a substantially rectangular pattern having a length at least three times its width, the orifices being staggered in the direction of the width, a metal screen of at least 20 mesh in contact with the inner spinneret face and covering all the spinneret orifices, a filtration apparatus having a lower planar surface parallel to said screen and spaced thereabove between about 0.1 and about 0.25 inch to provide a single distribution zone above said

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screen, said filtration apparatus containing at least two separate and independent filter chambers, each individually connected to a source of polymer and each communicating by a plurality of conduits with the distribution area above said screen, and means to supply polymer at substantially the same volume rate to each of the filter chambers.

2. The apparatus of claim 1 in which the spinneret orifices are arranged in less than ten uniformly spaced parallel rows of uniformly spaced orifices, each row being staggered relative to the adjacent rows, with the rows forming a substantially rectangular pattern having a length at least five times its width.

3. A process for spinning a molten organic fiber-forming polymeric material into a large number of filaments from a single spinneret which comprises continuously separating the polymer into portions, simultaneously and separately filtering each of the portions at substantially the same volume rate, further separating each of the filtered portions into a plurality of smaller portions and transmitting these smaller portions in the form of streams to a common distribution zone, separating the polymer as it leaves the distribution zone into at least 40 separate parallel polymer streams which form a substantially rec-

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tangular pattern in cross section having a length at least three times its width, shaping each of these streams into a filament, to produce a filament bundle having a substantially rectangular transverse cross section, and quenching the freshly formed filaments by passing through a mass of air moving perpendicular to the filaments and perpendicular to the longer axis of the filament bundle cross section.

4. The process of claim 3 in which the polymeric material is poly(hexamethylene adipamide).

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