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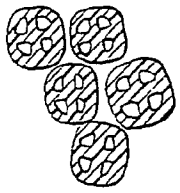
(54) **Improved hollow polyester fibers for softer fiber fillings.**

(57) Softer polyester fiber fillings for pillows, insulated garments and the like having high initial bulk are provided by nonround hollow fibers having 15 to 35% void which consists of four parallel substantially equisized and equispaced voids throughout the fiber length.



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TITLE

Improved Hollow Polyester Fibers
For Softer Fiber Fillings

DESCRIPTION

TECHNICAL FIELD

This invention relates to hollow crimped polyester fibers useful as filling material for pillows, insulated garments, sleeping bags and related articles of manufacture. It also relates to fibrous filling materials comprised of such fibers.

BACKGROUND ART

U.S. Patent 3,772,137 to Tolliver concerns filling materials comprised of round polyester fibers having a certain hollow cross-sectional configuration and crimp type which together provide a high initial filling power as well as good support bulk under load, both of which remain durable in use. In certain applications a softer filling material than is provided by these fibers is preferred. Some improvement in their softness can be realized through the use of known polysiloxane slickening agents as taught for example by Ryan in U.S. Patent 3,488,217 and by Mead in U.S. Patent 3,454,422, but even more softness combined with high bulk remains desirable.

U.S. Patent 4,146,674 to Salamon et al. concerns a filling material of crimped polyester fibers of a specific configuration to which has been applied a certain durable silicone/diepoxide slickener. Such filling is stated to remain more serviceable after washing and to have "service properties" substantially comparable with a natural down filling. However, such solid fibers do not provide the high bulk and bulk durability provided by hollow fibers as described above.

An object of the present invention is a fiber for use as a filling material which provides high bulk and high bulk durability but with improved softness more like that of natural down filling.

BRIEF DESCRIPTION OF THE DRAWING

The Figure consists of enlarged fiber sectional views taken from a photomicrograph of cross-sections of preferred polyester fibers of the invention.

DISCLOSURE OF THE INVENTION

This invention provides an improved hollow polyester fiber for use as a filling material which fiber has a continuous void throughout its length, a saw-toothed type of crimp configuration, and contains a textile slickening agent, wherein the improvement comprises said fiber having a nonround cross-section, a void content within the range of 15 to 35% resulting from four, continuous, parallel, substantially equisized voids which are substantially equispaced around a solid axial core, a denier per fiber within the range of 4 to 10, preferably 4 to 7 for pillows and insulated garments, and a crimp frequency within the range of 4 to 10 crimps per inch (1.57 to 3.94 crimps/cm.).

The fiber is comprised of a fiber-forming polyester polymer composed of at least 85% by weight of an ester of a substituted aromatic carboxylic acid including but not restricted to terephthalate units and para-substituted hydroxy benzoate units. The polyester is preferably comprised of poly(ethylene terephthalate).

The combination of fiber properties of this invention is provided by fibers of nonround cross-section having four continuous parallel voids throughout their lengths. The voids preferably have

a nonround peripheral contour, and more preferably adjacent sides of adjacent voids are substantially flat and parallel. For example, one preferred void shape has two substantially perpendicular flat sides joined at the outer ends by a third curved side (e.g., as in a segment of a circle), the apex of which is oriented toward the fiber axis. Four such voids are symmetrically positioned within a substantially quadrilateral fiber cross-section having four flattened sides connected by four rounded corners or lobes. Such a cross-section is commonly referred to as a tetralobal cross-section.

The fiber cross-sections preferably are substantially symmetrical, i.e., the voids being substantially equisized and equispaced in a substantially square tetralobal fiber subject to normal variations therein common to melt spinning. Such cross-sections plus a slickening agent on the fiber surfaces provide fibers giving surprisingly high bulk and good bulk durability along with a surprisingly improved softness, when compared at the same crimp level, with known round slickened hollow fiberfill fibers with a single void.

The term "nonround" as used herein means a deviation from circular such that the modification ratio, MR, is at least 1.05, preferably at least 1.1. Modification ratio, as known in the art, is the ratio of the radius of the circumscribing circle around the cross-section to that of the inscribed circle, both having a common center. The fiber cross-section is taken at right angles to the fiber axis and measured as known in the art.

Fiber cross-sections of this invention can be prepared as described for example in U.S. Patent 3,745,061.

Fibers having such multivoid cross-sections as called for in this invention can be prepared using known post-coalescent spinning techniques. Techniques for forming spinneret capillaries for spinning such filaments are described for example by Hawkins in U.S. Patent 3,834,251, particularly in reference to Figures 1 and 12 thereof. To facilitate coalescence of the polymer in forming all four voids a spinneret configuration of the type shown in said Figure 12 is preferred but with squared rather than pointed inner ends on the radial slots. The use of enlarged tips on adjacent slot ends for better coalescence is known for example also from Hodge in U.S. Patent 3,924,988. Of course, as known in the art, the exact spinneret configuration and dimensions selected for making a particular fiber size and contour depends among other things upon the nature of the polymer, and the spinning and quenching conditions employed, which can be readily determined by one skilled in the art.

The fibers of the invention can be spun, drawn, crimped and heat relaxed by methods known in the art.

Crimping of the fibers is performed preferably by means of a stuffer-box crimper at an elevated temperature. The yarn temperature should be about 35° to 130°C which may be obtained for example by running the crimper with hot (e.g. 90°C) finish or steam. The crimped filaments can be dried and relaxed in an oven at 130°-200°C to yield a crimp character within the desired range.

Whereas the overall behavior of the fibers of this invention is not fully understood, it is believed that the fiber cross-section and the presence of the slickening agent are primarily

fundamental to providing the combination of initial bulk, bulk durability and softness of the invention.

As used herein crimps per inch is the number of crimps imparted to each inch of uncrimped fiber wherein a "crimp" is one cycle of deformation of the fiber, similar to one cycle of a sine wave. The crimps have peaks in a saw-toothed type of configuration common to stuffer-box crimping. In determining crimps (i.e., cycles) per inch, the total number of crimps in a fiber is found and the fiber length measured when the fiber is extended just enough to straighten out the crimps. The crimps per inch of extended fiber is then calculated. The value as reported in the following Example is an average of at least ten such measurements.

The denier of the fibers is also important to this invention. Fibers having a denier per filament above about 10, provide significantly reduced softness and below about 4 give less filling power. The fibers most preferably have a denier per filament within the range of 5.0 to 6.0 for the most desirable combinations of softness and bulk properties. Fiber lengths (extended) within the range of 0.7 to 3.0, most preferably 2.0 to 3.0 inches (1.90 to 7.62 and 5.08 to 7.62 cm, respectively) are preferred for the best performance in pillows.

The fibers of this invention may be converted into filling materials of the invention in conventional ways known in the art for producing low density structures, i.e., webs and battings thereof; for example as by forming a web by garnetting and cross-lapping the web onto a moving apron to form a batt.

To obtain the desired more down-like softness, the fibers of this invention are treated with an effective amount (e.g., 0.1 to 1.0% of silicon by weight of fiber) of a textile silicone-based slickening agent to provide a durable, soft, slick handle thereto. Suitable silicone compositions are described by Ryan in U.S. Patent 3,488,217, but for the present use in fillings it is unnecessary to include any polyepoxide resin as described therein. Curing can be provided by other means, as with a catalyst. Although not essential, a suitable catalyst can be used to facilitate curing of the silicone resin. Useful catalysts include amine salts of a volatile weak acid, e.g. acetic, formic or carbonic acid. Suitable amines include diethanol amine, triethanol amine and 2,4,6-tris(dimethylaminomethyl)phenol.

In general, the silicones preferred for this invention are polysiloxanes made from mono-, di-, and trichlorosilanes which bear substituents of the groups consisting of an alkyl of 1 to 8 carbon atoms, an aryl group of 6 to 8 carbon atoms, or mixtures of such silanes. Preferably, at least one of the substituents is methyl or ethyl. In all cases, the silane monomers employed should consist predominantly of dichlorosilanes; monochlorosilanes are desirable in minor quantities to act as chain stoppers; trichlorosilanes have a cross-linking effect and can be present only in a minor proportion. The molecular weight of the polymers preferably is no less than 500 and no greater than about 100,000; and more preferably from 1,000 to 50,000.

Suitable silicones are commercially available under various tradenames such as "Syl-mer,"

"Syl-soft," "LE-48," "L-31" (methylhydrogen silicone) and "Decetex" 104.

This invention also comprehends a fibrous filling material consisting essentially of intermingled fibers of the invention as defined just above.

Still another embodiment of the invention is an improved polyester fiber for use as a filling material and having a continuous void throughout its length, a saw-toothed type of crimp configuration, and containing a textile slickening agent comprised of a polysiloxane resin and a void content within the range of 15 to 30% (preferably 17 to 25%), wherein the improvement comprises said void content resulting from four, continuous, parallel, substantially equisized voids which are substantially equispaced around a solid axial core, a denier per fiber within the range of 4 to 7 and said fiber in bulk providing a Total Bulk Range Measurement (TBRM) as defined herein under a load of 0.2 lbs./square inch (0.014 kilograms/square centimeter) within the range of 0.45 to 0.60 and at least 5.7 at 0.001 psi. When tested from freshly prepared unbaled continuous tow said fibers provide a slightly lower TBRM bulk under the same load within the range of about 0.40 to 0.55. Such fibers can be used as a filling material for pillows to provide a softness as defined herein within the range of 5.7 to 6.5.

The high initial bulk and softness realized from the fibers of this invention remain durable in use as reflected in good retention of properties through cyclic compression and release as shown for example by the stomp test described herein.

The bulk properties of batts made from fibers and filling materials of this invention are

conveniently determined by compressing batts thereon on an Instron tester and determining the height under a specific load. The test referred to herein as the Total Bulk Range Measurement (TBRM) is performed on a sample of fibers taken from baled stock. The test is carried out by cutting 6-inch (15.25-cm.) squares from a 6-inch (15.25 cm.) wide carded web thereof and forming a stack in a criss-cross manner until their total weight is 20 grams. The web is obtained from a worsted card machine set to give a weight of 100 grains/yd. (7.09 gms./meter). The entire area is then compressed under a load of 50 lbs. (22.7 kilograms). The stack height is recorded (after one conditioning cycle briefly under a load of 2 lbs., 907 gms) for heights and loads of 0.001 (H_i) and 0.2 (H_g) lbs./square inch 0.00007 and 0.014 kilograms per square cm. gauge. H_i is the initial height and is a measure of filling power; H_g is the height under load and is a measure of support bulk or conversely softness.

In the Example that follows, pillows are prepared from the filling, and subjected to tests for determination of their bulk properties. The pillows are prepared by producing a batt of a cross-lapped web. The batt is cut to suitable length for providing the desired weight (20 oz., 567 gms.) and rolled and placed into a cotton ticking measuring 20 X 26 inches (50.8 X 66.0 cm.) when flat. The values for measurements of the filling structures reported in the example are averaged values.

Pillows fabricated from a filling material having the most effective bulk or filling power will have the greatest center height. The center height of the pillow under no load, H_0, is determined by mashing in the opposite corners of the pillows

several times and placing the pillow on the load-sensitive table of an Instron tester and measuring its height at 0 load. The Instron tester is equipped with a metal disc presser foot that is 4 inches (10.2 cm.) in diameter. The presser foot is then caused to apply a load of 10 lbs. (4.54 kilograms) to the center section of the pillow and the height of the pillow at this point is recorded as the load height, H_L. Before the actual H_0 and H_L measurements, the pillow is subjected to 1 cycle of 20 pounds (9.08 kilograms) compression and load release for conditioning. A load of 10 pounds (4.5 kilograms) is used for the H_L measurement because it approximates a load applied to a pillow under normal conditions of actual use. Pillows having the higher H_L values are more resistive to deformation and thus provide the greater support bulk; but for down-like softness a lower H_L is preferred.

Bulk durability is determined by submitting the filling structure to repeated cycles of compression and load release. Such repeated cycles, or workings, of the pillows are carried out by placing a pillow on a turntable associated with 2 pairs of 4 X 12 inch (10.2 X 30.5 cm.) air powered worker feet which are mounted above the turntable in such a fashion that during one revolution essentially the entire contents are subjected to compression and release. Compression is accomplished by powering the worker feet with 80 pounds per square inch (5.62 kilograms/square cm.) gauge air pressure such that they exert a static load of approximately 125 lbs. (56.6 kilograms) when in contact with the turntable. The turntable rotates at a speed of one revolution per 110 seconds and each of the worker feet compresses and releases the filling material 17 times

per minute. After being repeatedly compressed for a specified period of time, the pillow is refluffed by mashing in the opposite corners several times. As before, the pillow is subjected to a conditioning cycle and the H_0 and H_L values are determined. The difference between these values is a measure of softness.

EXAMPLE

This example shows the surprising improvement in softness which is obtained with fibers of this invention having a multivoid nonround cross-section as compared to similar fibers of round cross-section with a single central continuous void.

A tow of hollow filaments is prepared by spinning poly(ethylene terephthalate) from a spinneret containing 265 orifices having a symmetrical configuration of the type as shown in Figure 12 of U.S. Patent 3,834,251 except that the inner ends of the radial slots are squared rather than pointed as shown therein. This orifice configuration is comprised of 4 arcuate slots arranged to form a circle with each being intersected at its midpoint by a radial slot extending towards the center but ending before intersecting any of the other radial slots. The inner edge of the arcuate slots is enlarged at each end to facilitate coalescence in the general manner taught by Hodge in U.S. Patent 3,924,988. The polymer has a relative viscosity (LRV) of 20.3 measured at 25°C using a 4.75% by weight solution of polymer in hexafluoroisopropanol containing 100 ppm of sulfuric acid. The filaments are spun at a temperature of 284-288°C using a windup speed of 1482 yds./min. (1355 mpm) with a throughput in each capillary of 0.232 lbs./hr (0.105 kg/hr.). Groups of filaments

are combined to provide a total rope denier of 838,000. The rope of filaments is drawn in a conventional manner using a draw ratio of 2.71 in a hot-wet spray draw zone maintained at 98°C. The drawn filaments are crimped in a conventional stuffer box crimper of a cantilever type (3.5 inch, 8.89 cm., size) and the crimped tow is relaxed in an oven at 170°C. A slickening finish containing a polysiloxane as described below is applied to the filaments at the crimper to give a percent silicon on fiber of about 0.3 by weight of fiber. A conventional antistatic/lubricating overlay finish of about 0.05% by weight is applied to the slickened fibers to facilitate subsequent processing. The fibers are cut in a conventional manner to a length of 2.5 inches (6.35 cm.). The fibers are found to have an average total void content of about 20% and a denier per fiber of about 5.3. The fibers have a cross-section containing four continuous voids which are parallel, substantially equal size and substantially equispaced around a solid axial core. The peripheral contour of the fiber cross-section is of a substantially quadrilateral (tetralobal) shape with four flattened sides and four rounded corners giving a cross-section modification ratio of about 1.14.

The Figure herein is taken from cross-sections of fibers at a magnification of 770X of Item B below which cross-sections are representative of Items A-D.

A series of four test items (A-D) is prepared by adjusting the gate pressure of the crimper to provide four different levels of crimp.

Control fibers representative of the prior art are prepared as described in U.S. Patent 3,772,137 which have a single central continuous void

of about 14.5% throughout the fiber length and a round fiber cross-section from poly(ethylene terephthalate) having an LRV of 20.4, and which are drawn and crimped in a manner similar to that above to provide two control items having different levels of crimp and bulk.

The slickener composition as applied in each case consists of a water based emulsion containing two polysiloxane resins. One of the resins is prepared from methylhydrogen diclorosilane and trimethylchloro silane to give a trimethyl siloxy end-blocked methylhydrogen polysiloxane. The other resin is prepared from dimethyldichlorosilane to provide an hydroxy-ended dimethylpolysiloxane with a viscosity of about 8,000 centistokes. The two resins are combined in a ratio of 20 parts of the former and 80 parts of the latter. A water emulsion is prepared by adding a solution of the resins to water containing an emulsifier consisting of a linear secondary alcohol containing from 11 to 15 carbon atoms condensed with about 12 units of ethylene oxide. The emulsion also contains an amine salt catalyst for the resin.

Comparative data for the test and control items are summarized in the following Tables. Table I summarizes crimp and TBRM data for the items. And Table II summarizes the performance of the items in pillows before and after a 2 hour stomp test for durability.

TABLE I

Fiber Crimp Character

Item	Gate Pressure, psi. (Kgm/cm^2)	Crimps per in. (per cm)	TBRM 0.001* in. (cm)	TBRM 0.2* in. (cm)
A	20 (1.41)	5.1 (2.0)	6.6 (16.8)	0.51 (1.30)
B	32 (2.25)	6.1 (2.4)	6.7 (17.0)	0.58 (1.47)
C	43 (3.02)	7.2 (2.8)	6.4 (16.3)	0.64 (1.63)
D	55 (3.87)	7.6 (3.0)	6.1 (15.5)	0.70 (1.78)
Control I	55 (3.87)	6.0 (2.4)	6.3 (16.0)	0.54 (1.37)
Control II	65 (4.57)	7.8 (3.1)	5.7 (14.5)	0.62 (1.57)

* In psi. In gm/cm^2, 0.001 psi corresponds to 0.070 and 0.2 psi to 14.1.

TABLE II

PILLOW PROPERTIES

Initial

Item	H_0, in. (cm)	H_{10}, in. (cm)	Softness, ΔH, in. (cm.)
A	8.45 (21.5)	1.99 (5.05)	6.46 (16.4)
B	8.63 (21.9)	2.84 (7.21)	5.79 (14.7)
C	8.63 (21.9)	3.12 (7.92)	5.51 (14.0)
D	8.51 (21.6)	3.36 (8.53)	5.15 (13.1)
Control I	8.48 (21.5)	3.27 (8.31)	5.21 (13.2)
Control II	8.73 (22.2)	3.70 (9.40)	5.03 (12.8)

2 Hour Stomp

Item	H_0, in. (cm)	H_{10}, in. (cm)	Softness, ΔH, in. (cm.)
A	7.43 (18.9)	1.42 (3.61)	6.01 (15.3)
B	7.52 (19.1)	1.74 (4.42)	5.78 (14.7)
C	7.64 (19.4)	2.04 (5.18)	5.61 (14.2)
D	7.43 (18.9)	2.05 (5.21)	5.39 (13.7)
Control I	7.63 (19.4)	2.11 (5.36)	5.51 (14.0)
Control II	7.61 (19.3)	2.39 (6.07)	5.22 (13.3)

From Table II it is readily apparent that all of the items have substantially the same filling power as shown by the pillow heights under zero load (H_0); however items of the invention show a significantly higher softness at a comparable crimp level. This improved softness is most significant for Items A and B at the lower crimp level. The improved softness of A and B is readily apparent in subjective evaluations of the pillows when given to a randomly selected panel of people who are asked to feel the pillows and determine for themselves which one is the softest. The high softness for Items A and B is particularly surprising in that the TBRM heights for these items are comparable to that of Control I but yet they have a readily detectable difference in subjective softness. The softness coupled with high bulk remains durable in use as shown by the properties in Table II after subjection to a 2 hour stomp test.

CLAIMS

1. An improved hollow polyester fiber for use as a filling material which fiber has a continuous void throughout its length, a saw-toothed type of crimp configuration, and contains a textile slickening agent, wherein the improvement comprises said fiber having a nonround cross-section, a void content within the range of 15 to 35% resulting from four, continuous, parallel, substantially equisized voids substantially equispaced around a solid axial core, a denier per fiber within the range of 4 to 10 and a crimp frequency within the range of 4 to 10 crimps per inch.

2. A fiber of claim 1 wherein the polyester is comprised of poly(ethylene terephthalate), the voids have substantially nonround cross-sectional peripheral contours and the fiber cross-section has a quadrilateral peripheral contour defined by four flattened sides and four rounded corners with a modification ratio of at least 1.1.

3. A fiber of Claim 1 or claim 2 wherein the percent void is within the range of 17 to 25%, the denier per fiber is within the range of 5.0 to 6.0, the crimp frequency is within the range of 5 to 7, the fiber length is within the range of 2.0 to 3.0 inches and the fiber contains from 0.1 to 1.0% by weight of silicon as a silicone slickening agent.

4. A fiber of claim 1, 2, or 3 wherein adjacent sides of adjacent voids are substantially flat and parallel.

5. A fiber of any one of claims 1 to 4 wherein the fiber provides a TBRM under 0.2 psi within the range of 0.45 to 0.60 and at least 5.7 at 0.001 psi.

6. A fibrous filling material consisting essentially of intermingled fibers of claim 1, 2, 3, 4 or 5.