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G. PAMM ET AL
FIBERS AND FABRICS
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2,816,349

Fig. I



Fig. III

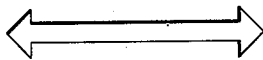


Fig. V

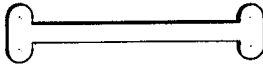


Fig. VI

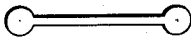


Fig. VII



Fig. VIII

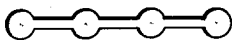


Fig. IX



Fig. XIII

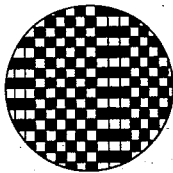


Fig. II



Fig. IV

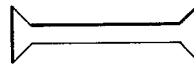


Fig. X

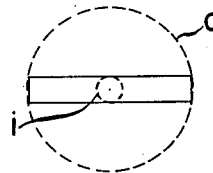


Fig. VIa



Fig. VIIa



Fig. VIIIa



Fig. IXa



Fig. XI

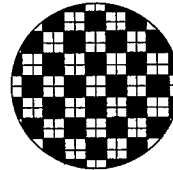


Fig. XII

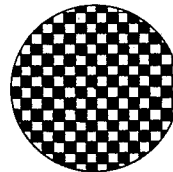
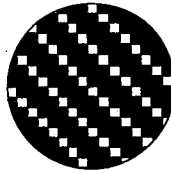


Fig. XIV



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1

2,816,349

FIBERS AND FABRICS

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4 Claims. (Cl. 28—82)

This invention relates to a fabric. More specifically it relates to a pill-resistant fabric manufactured from yarn containing a melt-spun synthetic staple.

It has long been known that when loosely woven or knitted fabric made from natural fibers (e. g., wool, cotton and the like) are subjected to wear, small fibrous balls known as "pills" form on the abraded surface. Due to the inherently weak nature of these fibers these "pills" usually do not accumulate to a highly objectionable degree, since they are abraded away. The newer synthetic fibers, however, especially those which are melt-spun, are so highly resistant to abrasion that the pills which form on the fabric surface do not wear away, but continue to accumulate.

An object of the present invention is to provide a pill resistant fabric manufactured from a yarn containing a major proportion of a melt-spun synthetic staple.

This and other objects will become apparent in the course of the following specification and claims.

In accordance with the present invention a non-pilling fabric manufactured from yarn containing a melt-spun, synthetic fiber is provided by spinning the yarn employed in fabric construction with a melt-spun synthetic staple having a denier per filament no more than about 1.6 and a filament ratio of at least about 5. Suitable filament for the production of such staple is prepared by melt-spinning a linear polymer through an essentially slot-shaped orifice, having a width no greater than about 2 mils, abruptly expanded tips and additional abrupt expansions separating every 10 to 20 mils of slot length. By "slot" is meant a substantially rectangular aperture with a length 5 or more times its width. The "expanded tips" and "additional abrupt expansions" of the slots are preferably circular, but may be rectangular, square, diamond shaped or oval, provided that the longer dimension of the non-circular embodiment is approximately perpendicular to the length of the slot. The spinneret may contain a single or multiple orifices.

The invention will be more readily understood by reference to the drawings.

Figures I to V illustrates various orifice outlines useful in spinnerets in shaping filaments for construction of fabrics of the present invention.

Figures VI to IX inclusive illustrate several dog-bone shaped orifices containing round, abrupt tip expansions. In Figures VII to IX inclusive, abrupt, round expansions are also provided along the slot body.

Figures VI(a) to IX(a) are cross-sectional elevations of filaments produced using the corresponding slot design shown in Figures VI to IX inclusive.

Figure X illustrates a general method of characterizing the degree of modification of filaments, melt-spun, employing a spinneret of the present invention as compared with conventional filaments of circular cross-section. The degree of modification may be expressed numerically as the ratio of the diameter of the circle "c" circumscribed about the filament cross-section divided by the diameter

2

of the circle "P" inscribed therein. The ratio will hereinafter be called the "filament ratio." According to this system, a truly circular filament would have a filament ratio of 1.0. A ribbon-like filament of width 6 times its thickness would have a filament ratio of 6.0.

Figures XI to XIV illustrate various weave patterns which are typical of those wherein pill propensity is reduced by construction with a yarn spun from fibers of the present invention. They illustrate a basket, a plain, a cord and a twill weave respectively.

The following examples are cited to illustrate the invention. They are not intended to limit it in any way.

Example 1

Polyhexamethylene adipamide containing 0.3% by weight of TiO_2 delusterant and having a relative viscosity of 39 (as defined in United States Patent No. 2,385,890) is spun to yarn using the apparatus of Greenwalt disclosed in United States Patent No. 2,217,743.

The grid and melt pool temperature is maintained at 288°C. and the molten polymer is blanketed with an atmosphere of nitrogen. The polymer is spun through a 36 orifice spinneret, the orifices being of conventional slotted shape, 73 mils long and 3 mils wide. This spinneret is designated hereinafter as "spinneret A."

The yarn is extruded through the orifices and is quenched by substantially room temperature air directed transversely to the filament bundle as shown by Heckert in United States Patent No. 2,273,105. The extruded yarn which is of 108 denier, is collected at the rate of about 980 yards per minute. The as-spun yarn has a relative viscosity of 52.8. The yarn can be drawn to only 1.7 times its original length without excessive filament breakage. The drawn yarn is 1.8 denier per filament and has a filament ratio of 5.7. The product has an acceptable filament ratio, but for purposes of the present invention as will be explained hereinafter, the denier per filament is too high by about 20%.

If an attempt is made to decrease the denier of the product by increasing the spinning speed by about 20% (to about 1200 yards per minute) while maintaining the same polymer throughput, the spun denier is decreased by a similar amount (to about 86). However, the lower denier as-spun yarn is now so highly oriented that it can not be drawn more than about 1.3 times its original length without excessive breakage, so that in this case the final product is still about 1.8 denier per filament.

If, on the other hand, the windup rate is maintained constant at 980 yards per minute and the polymer throughput is decreased, the molten polymer does not jet freely from the spinneret orifices, but instead wets the face of the spinneret, causing the spinning interruption known as "drips."

When spinneret A is replaced by another spinneret, designated hereinafter as "spinneret B" containing 36 conventional slotted orifices 60 mils long by 2 mils wide, filaments cannot be successfully extruded because particles in the melt continually obstruct parts of the slots, producing split filaments and defective yarn.

Spinneret B is then replaced by a third spinneret, designated hereinafter as "spinneret C," having 36 holes, each combining slots and holes substantially as shown in Figure IX. In each orifice the slot is 2 mils wide and 12 mils long between the circular expansions. Each of the five circular expansions between and joining the slots of each design is 5 mils in diameter. The total overall length of the design of each orifice is therefore 73 mils. With a windup speed of 980 yards per minute, and a spun denier of 108, the 36 filament yarn can be drawn 2.15 times its original length without excessive filament break-

age, and the drawn product has a final denier per filament somewhat less than 1.5, and a filament ratio of 5.7.

It is apparent from the foregoing example that in accordance with the teachings of the present invention a new product of high filament ratio and low denier per filament is produced, which could not be produced by the prior art.

A pill resistant fabric which may be produced from the novel filaments as described in Example 1 (i. e., having a denier of about 1.5 and a filament ratio of about 5), is of the type ordinarily used in fine sheeting or shirting. The following example illustrates its construction and utility.

Example 2

Continuous filaments of 1.5 denier per filament and a filament ratio of 5.7, produced from spinneret C as described in Example 1, are combined into a bundle or tow, mechanically crimped and then cut into staple of 1.5 inch length. This staple is processed on the conventional cotton system to a 50/1 cotton count yarn of 30 turns per inch. A basket weave fabric as illustrated in Figure XI is woven from this yarn, constructed 141 ends by 110 picks in the loom. The fabric is then finished by scouring, bleaching, heat setting and singeing, and has a final construction of 156 x 117. This fabric will be referred hereinafter as fabric "C."

A comparison fabric, fabric "D," is prepared using prior art techniques and conventional slotted spinnerets (such as "A" of Example 1), from 1½ inch nylon staple filaments of 1.5 denier per filament and 3.5 filament ratio. The spun yarn size, twist, fabric construction and finishing treatment are the same as for fabric "C."

A control fabric, "E," is prepared from commercial 1½ inch, 1.5 denier per filament round cross-section nylon staple, with the same yarn count, twist, fabric construction and the like as before. Men's shirts are made from fabrics C, D and E which are given three weeks' wear testing including necessary laundering. At the end of the test period, the shirt from fabric "C" shows no evidence of pilling, while pills are beginning to form on shirt D. Shirt E containing round filaments shows highly objectionable pilling.

For fabrics of the light weight and fine weave of Example 2, it is important to utilize yarn of the lowest possible denier per filament, and therefore the usual method of decreasing pilling by increased filament denier cannot be adopted.

As an illustration of the advantages of low filament denier, it has been established that the finest yarn which can be spun with commercial operability from 1.5 denier per filament, 1½ inch nylon staple, using the cotton system, is 80/1 cc. (cotton count). The finest yarn which can be spun from 1.8 denier per filament, 1½ inch staple is 67/1 cc. Similarly constructed fabric from the 67/1 yarn (1.8 denier per filament) would necessarily be coarser and heavier than that prepared from the 80/1 yarn (1.5 denier per filament).

Alternatively, the 1.8 denier per filament yarn (produced, for example, from conventional spinneret A of Example 1) may be spun to 40/1 cc., with a twist of 27 turns, while the 1.5 denier filaments of Example 1 may be spun to 80/1 cc., and plied with 38 turns in the singles and 27 in the ply to form 80/2 cc. yarn. Since both yarns are now of the same weight, they may be woven into plain weave broadcloth of the same construction, such as one having 128 picks and 60 ends per inch. When this is done, the fabric from 1.5 denier per filament staple will be much more uniform (since it is made from a plied yarn) than that from the 1.8 denier. The latter will also show poor weaving operability, since it will display a high degree of twist liveliness.

An additional advantage of the 1.5 denier filament is that when blended with an equal weight of cotton, the finest yarn which can be spun commercially is 40/1 cc.

This yarn is the coarsest which is desirable for fine shirting fabrics; hence, in order to be acceptable for use in nylon-cotton shirting blends, the nylon filaments must be no larger than about 1.5 denier.

Figures XII to XIV illustrate other typical design patterns in which yarns containing fibers of the present invention can be conveniently employed. While woven fabrics are illustrated, the yarn is also useful in the production of knitted and felted fabrics. While it is preferred to manufacture the fabrics of the present invention from yarns containing essentially 100% of the fibers as described herein, a fiber mixture can often be employed, using as much as 75% of a natural fiber or conventional man-made staple.

The degree to which a given filament is modified from the normal circular cross-section depends on the dimensions of the spinneret orifice, and the rate at which the filament is quenched after extrusion. Rapid quenching freezes the filament into an approximation of the orifice shape before surface tension forces cause it to become cylindrical. High viscosity polymer is helpful in attaining highly modified filaments, because it maintains its extruded shape better before quenching. As a guide in this regard, polyhexamethylene adipamide of at least 40 and desirably above 50 relative viscosity (measured on the spun yarn) is preferred.

It may sometimes be desirable to cool the spinneret and filter pack to bring the polymer nearer to the solidification temperature at extrusion, or to decrease the temperature or increase the volume of the cooling air in order to hasten the quenching of the yarn. In general, neither of these changes is necessary with high viscosity polymer.

The successful production of a funicular structure of the present invention requires the combination in a spinneret orifice of a slot and at least one abrupt expansion in each tip of each slot. These abrupt expansions appear to have two functions. They provide a reservoir of polymeric material which stiffens the extruded shape, holding the shape and resisting surface tension forces until the filament solidifies. They also provide channels through which pieces of sand, foreign material and polymer gel which might otherwise obstruct the slots, are extruded. Orifices with slots two mils wide are almost always inoperable without the expansions, and even with wider slots the continuity of spinning is improved by the addition of abrupt expansions.

The slots are ordinarily as narrow as is mechanically practical to construct. Two mil slots have been satisfactory in this respect. Although such narrow slots are usually easily obstructed, the addition of abrupt expansions at their tips, renders them operable. However, it is usual to use a very fine screen (e. g., 200 mesh) above the spinneret to reduce orifice obstruction.

Although the minimum number of abrupt expansions per slot is two, more are often beneficial, particularly when spinning the ribbon filaments of the present invention. The expansions may be placed along the slot, as shown in Figures VII to IX inclusive. An excessive number of abrupt expansions must be avoided, since the orifice area is thereby substantially increased and the polymer jet velocity decreased, increasing the likelihood of drips. In general, it is preferable to have an expansion spaced every 10 to 20 mils along the slots. The diameter of the abrupt tip expansions is usually about two times the slot width, but diameters up to 5 times the slot width are useful. In general, slots up to 50 or more times as long (overall length including holes) as they are wide can be used, as long as the increased orifice area does not produce such a low polymer jet velocity at the required throughput that drips result.

The spinneret orifices described may be formed by a variety of methods well-known to the art. A satisfactory procedure is to drill a flat-bottomed counterbore of about 1/8" diameter from the back of the spinneret blank, until

5

only about 10 mils of metal thickness remains. For slots 2 x 40 mils, a punch with a tip 0.002" x 0.040" is used. The die below the spinneret is set to a width of 0.003", and a steel shim 0.002" thick is placed between the spinneret and the die to prevent tearing. The slot is then punched from the counterbore side, raising a dimple on the spinneret face. The depth of punching is adjusted so that when the dimple is sanded off, a slot 2 x 40 mils appears. Circular expansions of the desired diameter are then drilled at the slot tips. To improve orifice to orifice uniformity, the slots and abrupt expansions may be broach burnished from the face side of the spinneret.

The punch used to form the slots may have a rectangular tip with dimensions substantially the same as those of the slot which is to be formed. The blade of the punch may have parallel or arcuate sides, but it is preferred to employ a wedge shaped blade having an included angle of about 30°. The slot produced by such a punch will thus have a somewhat tapered cross-section, converging in the direction of polymer flow.

The spinneret used in the production of filaments of the present invention may be of any conventional material employed in spinneret construction for melt-spinning. The stainless steels are especially suitable.

This invention is applicable broadly to all types of fiber-forming synthetic linear polymers which are capable of being melt-spun. Illustrative of polyamides and copolyamides which can be employed in the process of this invention are those described in any of the United States Patents No. 2,071,250; 2,071,253; 2,130,523; 2,130,948; 2,190,770; 2,252,555; 2,252,557 and 2,374,137. Some of

6

the useful examples of polyesters and copolyesters are shown in United States Patents No. 2,071,250; 2,071,251; 2,465,150 and 2,465,319.

The filaments produced in accordance with the present invention may be employed as yarns and converted, e. g., by weaving into fabric patterns of any conventional design by known methods. Furthermore, these bodies may be combined with other known textiles to produce mixed yarns and fabrics.

Many equivalent modifications will be apparent to those skilled in the art from a reading of the above without a departure from the inventive concept.

What is claimed is:

1. A fabric of low pill propensity manufactured from yarn containing melt-spun synthetic staple having a denier per filament of no more than about 1.6 and a filament ratio of at least about 5.
2. A yarn containing melt-spun synthetic staple having a denier per filament of no more than about 1.6 and a filament ratio of at least about 5.
3. A fiber produced from a synthetic linear polymer, having a denier per filament of no more than about 1.6 and a filament ratio of at least about 5.
4. The structure of claim 3 wherein the polymer is polyhexamethylene adipamide.

References Cited in the file of this patent

UNITED STATES PATENTS

2,002,153 Mendel May 21, 1935