

1

3,331,906

PROCESS FOR PREPARING MOLDED, THREE-DIMENSION TEXTILE ARTICLES

Dustin Stetson Adams, Wilmington, Del., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware
No Drawing. Filed Sept. 25, 1964, Ser. No. 399,359
3 Claims. (Cl. 264—292)

This application is a continuation-in-part of patent application Ser. No. 313,771 filed Oct. 4, 1963, and now abandoned.

This invention relates to the preparation of three-dimensional textile articles. More particularly, it relates to a procedure for molding flat woven fabrics composed of synthetic polyester fibers.

It is an object of the present invention to provide a practical and economical procedure for molding three-dimensional articles from flat fabrics of synthetic linear polyester fibers. Other objects will become apparent in the course of the following specification and claims.

In accordance with the present invention, three-dimension textile articles having outstanding performance features are prepared by a process which comprises (1) cold drawing into the desired three-dimensional shape, at a temperature below about 100° C., a floatless, flat fabric, scoured and optionally heat-set to give a finished fabric having a tightness factor of at least 25, woven from a synthetic linear condensation polyester textile fiber having a break elongation of from about 45% to about 85% and a boil-off shrinkage of at least about 12%, (2) then heating the fabric so drawn to a temperature of from about 120° C. to about 160° C., and at least about 60° C. above the temperature of step (1), and (3) thereafter cooling the said fabric so drawn and heated to a temperature at least 30° C. below the temperature of step (2) and preferably below 100° C.

Definitions

By a "floatless fabric" is meant a fabric which contains no "floated" yarns, i.e. either warp or filling yarn that extends unbound over two or more filling or warp yarns.

By the "tightness factor" of a floatless fabric is meant:

$$\frac{\text{warp ends per inch} + \text{filling ends per inch}}{\sqrt{\text{cotton count} \times l}}$$

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

EXAMPLE 1

Polyethylene terephthalate prepared as described in U.S. 2,465,319 is melt spun and drawn according to the method of U.S. 3,091,805, using a draw bath temperature of 90° C., and a draw ratio of 2.57, a draw roll temperature of 101° C., and windup speed of 2690 y.p.m. The yarn produced is composed of 50 filaments having a total denier of 90 with a tenacity of 3.0 grams per denier, a break elongation of 50% and a boil-off shrinkage of 12%. The individual filaments have the trilobal cross-section of FIGURE 2 in U.S. 2,939,201 as a result of using a spinneret having Y-shaped orifices.

The yarn produced above is woven into a plain weave fabric having a pick count of 70/2 ply and an end count of 140. The fabric is scoured on a jig at a temperature of 82° C. and dried and seat-set on a tenter frame at a temperature of 83° C. The finished fabric has 148

2

warp ends per inch and 72 filling ends per inch, giving a tightness factor of 30. Close examination of the fabric reveals a considerable amount of "weave crimp" in both warp and filling directions.

A portion of the fabric is mounted in a mold and cold drawn into a three-dimensional shape having the general outline of a completed brassiere with size "D" cups. This shaping operation is carried out at room temperature, i.e. 28° C. The mold assembly is then heated quickly by means of an electric heater to a temperature of 140° C. and cooled immediately to a temperature of 80° C. before the shaped fabric is removed from the mold. The total molding time is 50–60 seconds.

The mold elements contacting the fabric are constructed of light-weight aluminum to facilitate rapid heating and cooling during the setting operation and subsequent release. The time required for the operation is dependent upon the heat capacity of the mold rather than the necessity for holding the fabric at any given temperature for a prescribed period of time.

The molded fabric is then converted into a brassiere by stitching around the edges, inserting elastic elements, and attaching the necessary straps and fastening elements. In a wear test involving twenty wearings with a conventional home laundering treatment (machine wash) after each wearing, the brassiere is found to exhibit remarkable dimensional stability with no detectable change in fabric dimensions or fabric character during the entire test. At the end of the wear test the brassiere cups are found to fit the mold as exactly as a freshly molded fabric sample.

In examples reported in Table I below acceptable brassiere cups are molded, following the techniques of Example 1, from polyethylene terephthalate, melt spun into continuous filament yarn which is woven into plain weave fabric, using two-ply yarn in the filling. Each fabric is scoured at 82° C. and heat seat at 94° C. prior to molding.

TABLE I

Example No.	2	3	4
Yarn preparation:			
Draw Bath Temp., ° C.	91	90	90
Draw Ratio	2.10	2.46	2.1
Draw Roll Temp., ° C.	101	92	105
Windup Speed, y.p.m.	2,750	2,740	2,800
Yarn Properties:			
Denier/filaments	90/50	80/50	90/17
Tenacity, g.p.d.	2.5	2.9	2.3
Elongation, percent	69	62	69
Shrinkage, percent	12	26.7	12.4
Fabric Preparation:			
Picks (greige) per inch	71	70	70
Ends (greige) per inch	141	160	140
Picks (finished)/in	76	78	69
Ends (finished)/in	153	176	143
Tightness Factor	33.9	35.1	31.2
Molding:			
Molding Temp. ° C.	70	90	75
Heat Set Temp. ° C.	140	160	150
Release Temp. ° C.	80	95	80

When the yarn of Example 3 is woven to provide a tightness factor of 22.8 (i.e. 50 picks and 100 ends per inch in the greige) the fabric splits during molding. A similar result occurs when the yarn of Example 4 is woven to provide a tightness factor of 22.4 (i.e. 40 picks and 100 ends per inch in the greige).

Examples 5, 6 and 7 below illustrate conditions of preparation of unacceptable fabric which tears upon molding. In Examples 5 and 6 the elongation values are too low.

In Example 6 the tightness factor is also too low. In Example 7 only the shrinkage is outside the defined limits.

TABLE II

Example No.	*5	6	7
Yarn Preparation:			
Draw Bath Temp., ° C.	90	90	90
Draw Ratio	3.96	2.75	2.64
Draw Roll Temp., ° C.	101	99	98
Windup Speed, y.p.m.	2,600	2,750	2,700
Yarn Properties:			
Denier/filaments	90/50	90/50	90/50
Tenacity, g.p.d.	4.3	3.1	3.0
Elongation, percent	22	37	49
Shrinkage, percent	11.5	11.8	10.9
Fabric Preparation:			
Picks (greige) per inch	70	50	60
Ends (greige) per inch	140	100	120
Picks (finished)/in	73	50	60
Ends (finished)/in	147	102	128
Tightness Factor	32.3	22.4	27.7
Molding:			
Molding Temp., ° C.	70	90	85
Heat Set Temp., ° C.	145	155	160
Release Temp., ° C.	75	85	90

* Heat set before molding at 88° C.

EXAMPLE 8

This example illustrates the molding of fabrics prepared from both staple fibers and continuous filaments.

Three spun yarns having cotton counts of 40/1 (14.8 tex), 50/1 (11.8 tex) and 60/1 (9.9 tex) are prepared on cotton spinning frames from polyethylene terephthalate staple having the following properties:

1.5 denier (0.17 tex), 14 crimps per inch;
1.5 inch cut length;
Round cross-section;
3-4 g.p.d. tenacity;
78% break elongation; and
12.5% boil-off shrinkage.

These three spun yarns are used as filling yarns in the weaving of three plain weave fabrics in which the warp yarns are 70-denier (7.8 tex), 34 filament, trilobal polyethylene terephthalate continuous-filament yarns having break elongations of 55±5% and boil-off shrinkages of 15±3%.

The three fabrics are given a conventional finishing treatment consisting of a light singe, cold calendering, a beck scour, and drying in air at 121° C. Fabric properties are shown in the following table.

TABLE III

Filling Yarn	Loom Count (ends × picks)	Finished Count (ends × picks)	Tightness Factor	Fabric Weight (oz./yd. ² (gm./m. ²))
60/1 cc. (9.9 tex)	120×106	138×112	30.3	2.93 (100)
40/1 cc. (14.8 tex)	120×90	136×100	31.4	3.33 (113)
50/1 cc. (11.8 tex)	120×106	141×116	32.6	3.33 (113)

Samples of each of the above fabrics are molded into complete brassiere fronts using a molding procedure which comprises drawing the fabric into the mold at room temperature, raising the mold temperature to 140° C. for about 5 minutes to set the shaped fabric, and then cooling the mold to a temperature below 100° C. before releasing the shaped fabric from the mold. Fully satisfactory brassiere fronts are obtained in each case.

The brassiere fronts prepared above are subjected to a series of 5 wash-dry cycles simulating home laundering conditions. No appreciable change in shape, size, or fabric character is observed during the tests, confirming the advantages of three-dimensional articles prepared by the process of this invention.

Fiber requirements

It is essential that the fabrics to be molded in accordance with the present invention be prepared from synthetic linear condensation polyester fiber which has been

partially oriented to the extent that its break elongation is from about 45% to about 85%. A minimum value of about 45% is necessary to give the fabric sufficient extensibility to allow cold molding to the extent required in some of the larger brassiere cup sizes. The upper extensibility limit of about 85% is based upon practical limits of the yarn manufacturing process, since attempts to draw polyester fibers to elongations higher than about 85% on a commercial scale usually result in yarn containing undrawn sections or "flashes" which produce a non-uniform appearance.

It is further necessary that the fiber used exhibit a boil-off shrinkage of at least about 12%. This relatively high shrinkage facilitates the production of fabrics having the high tightness factor values needed, as described more fully below. The higher shrinkage fibers are also found to permit better conformance of the fabric to the mold during the molding operation.

Fibers having the above properties may be used in the form of continuous filament yarns, or in the form of spun yarns prepared from staple fibers. Fabrics with staple-fiber filling yarns in continuous filament warps have been found particularly advantageous for use in the process of this invention.

In comparison with these required fiber properties, it is noted that commercially-available polyester continuous filament textile yarns have heretofore possessed break elongations in the range 20 to 30% or less and boil-off shrinkages of 6 to 12%.

Suitable synthetic linear condensation polyesters are described, for example, in U.S. Patents 2,465,319, 2,658,055 and 2,676,945.

In a preferred embodiment of the invention, the polyester polymer is a synthetic linear condensation polyester of bifunctional ester-forming compounds wherein at least about 85% of the repeating glycol-dicarboxylate structural units of the polymer chain include a dicarboxylate radical derived from terephthalic acid, 2,6-naphthalene dicarboxylic acid, or 2,7-naphthalene dicarboxylic acid. Up to about 15% of the recurring structural units may contain other dicarboxylate radicals such as the adipate, sebacate, isophthalate, bibenzoate, hexahydroterephthalate, and 4,4'-sulfonyldibenzoate radicals. In a preferred polyester, 0.5% to 4% of the repeating units contain dicarboxylate radicals derived from 5-sodium sulfisophthalic acid as described in U.S. Patent 3,018,272.

The glycol portion of the glycol-dicarboxylate structural unit may be derived from any suitable dihydroxy compound. Preferred dihydroxy compounds include the aliphatic glycols of the series HO(CH₂)_nOH, where *n* is 2 to 10. Other suitable dihydroxy compounds include diethylene glycol, quinitol, cis- or trans-hexahydro-p-xylylene glycol, neopentylene glycol, 1,4-bis(hydroxyethyl)benzene, 1,4-bis(hydroxyethoxy)benzene, and 1,4-bis(β-hydroxyethyl)biphenyl.

Fabric preparation

The polyester yarn is woven, preferably in a plain weave, into a conventional floatless fabric which, after finishing, exhibits a tightness factor of 25 or higher. This compares with a normal tightness factor for 18-20 conventional textile fabrics. Tightness factors above about 35 are considered unattainable. The high tightness factor specified is essential to prevent yarn slippage and excessive "leaning out" during the molding operation. A high tightness factor also contributes to the development of an appreciable amount of "weave crimp," which in turn contributes to fabric extensibility. It is preferred that weave crimp be balanced in the warp and filling directions.

Fabric woven as above may be finished according to any of the procedures conventional in the trade. For example, the fabric may be scoured at the boil and then dried at normal drying temperatures, e.g., 90-115° C. Heat setting is unnecessary as the fabric is to be heat set later in the mold. However, if heat setting is considered desirable

5

for any reason, it may be carried out at conventional heat setting temperatures, i.e., 130 to 160° C.

Under ideal processing conditions, with relatively low amounts of fabric stretch during molding, fabric types with small floats such as broken twills, waffle weaves, and the like may be used. Fabric types which are not suited to the invention described herein include sateens, twills, basket weaves and oxfords. Fabrics in the latter group show excessive yarn slippage during the molding operation, give excessive bias stretch, or do not maintain dimensional stability in use.

Molding the fabric

The molding or shaping operation may be carried out in any convenient manner such as using plug and ring molding or by matching male and female forms. In the molding operation the fabric is cold drawn into the three-dimensional shape of the mold, utilizing the inherent extensibility of the fibers themselves as well as that of the fabric structure. Molding is conveniently carried out at room temperature, but in any case should not be carried out at a temperature higher than 100° C. Molding at the higher temperatures in this range may be convenient in a continuous operation where the mold has been heated by a previous heat-setting step.

The molded article must be heat-set to impart permanent dimensional stability. The heat-setting must be carried out while the fabric is restrained by the mold. Heating may be accomplished by hot air, steam, or other hot fluid, by radiant heating, dielectric heating, or any other conventional heating means. It is necessary only for the fabric to be raised to a temperature in the range 120–160° C. provided the setting temperature is at least 60° C. above the cold drawing temperature. Holding the fabric at this elevated temperature for any appreciable length of time is unnecessary, and in commercial operations cooling is begun immediately.

It is essential that the fabric and mold elements contacting it be cooled to a temperature at least 30° below the setting temperature, and preferably below 100° C., before the molded fabric is removed from the mold.

In the manufacture of brassieres by the above procedure, excellent results are achieved when the cup and body portions are molded as a unit from a single piece of fabric. Alternatively the cup portions may be molded separately and subsequently sewn into the bandeau. The procedure is also adaptable to the molding of several layers of fabric at the same time, e.g. when the finished brassiere is to consist of a layer of lace in combination with a layer of woven fabric.

Brassieres prepared according to the above procedure are well-shaped, strong, comfortable and wrinkle resistant, with all the "wash-and-wear" properties of polyethylene terephthalate garments. The full fabric character is retained throughout the molding operation with no significant change being observed in stitch formation other than the slight spreading-out to be expected in such a fabric stretching process. The molded garment retains its shape indefinitely in spite of exposure to considerable stress and strain during the course of normal use.

6

If a dyed article is desired, normal dyeing processes may be used. If the fabric is to be dyed before the molding operation, best results are obtained if the temperature of dyeing is no higher than about 100° C.

Although the invention has been discussed with respect to the preparation of a brassiere, it is to be understood that other shaped articles may be prepared in accordance with the principles of the invention.

Since many different embodiments of the invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited by the specific illustrations except to the extent defined in the following claims.

What is claimed is:

1. A process for preparing molded, three-dimensional textile articles which comprises the steps of (1) cold drawing into the desired three dimensional shape in a mold, at a temperature below about 100° C., a floatless, flat fabric having a tightness factor of at least 25, woven from a synthetic linear condensation polyester fiber having a break elongation of from about 45% to about 85% and a boil-off shrinkage of at least about 12%, then (2) subjecting to dry heat to heat the fabric so drawn to a temperature of from about 120° C. to about 160° C. and at least about 60° C. above the temperature of step (1) and thereafter (3) cooling the said fabric so drawn and heated to a temperature at least 30° C. below the maximum temperature of step (2) while in the said mold.

2. The process of claim 1 wherein the said textile article is a brassiere.

3. A process for preparing molded, three-dimensional textile articles which comprises the steps of (1) cold drawing into the desired three dimensional shape in a mold, at a temperature below about 100° C., a floatless, flat fabric having a tightness factor of at least 25, woven from polyethylene terephthalate having a break elongation of from about 45% to about 85% and a boil-off shrinkage of at least about 12%, then (2) subjecting to dry heat to heat the fabric so drawn to a temperature of from about 120° C. to about 160° C. and at least about 60° C. above the temperature of step (1) and thereafter (3) cooling the said fabric so drawn and heated to a temperature at least 30° C. below the maximum temperature of step (2) while in the said mold.

References Cited

UNITED STATES PATENTS

2,285,967	6/1942	Hardy	18—56
2,884,663	5/1959	Alles	18—48
3,070,870	1/1963	Alexander et al.	28—74

FOREIGN PATENTS

851,875	10/1960	Great Britain.
---------	---------	----------------

ROBERT F. WHITE, *Primary Examiner.*

G. AUVILLE, *Assistant Examiner.*