United States Patent

[11] 3,600,732

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[21] Appl. No. **14,921**
[22] Filed **Feb. 27, 1970**
[45] Patented **Aug. 24, 1971**

[73] Assignee **American Cyanamid Company Stamford, Conn.**

[32] Priority **Mar. 5, 1969**
[33] **Japan**
[31] **44/17122**

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[54] **BEAM-DYEING METHOD FOR PILE FABRICS CONTAINING ACRYLIC FIBER PILE**
1 Claim, 2 Drawing Figs.

[52] **U.S. Cl.** **8/154, 68/198**

[51] **Int. Cl.** **B05c 8/02**
[50] **Field of Search** 8/154, 155, 155.1, 155.2, 177; 68/7, 8, 150, 189, 198

[56] **References Cited**

UNITED STATES PATENTS

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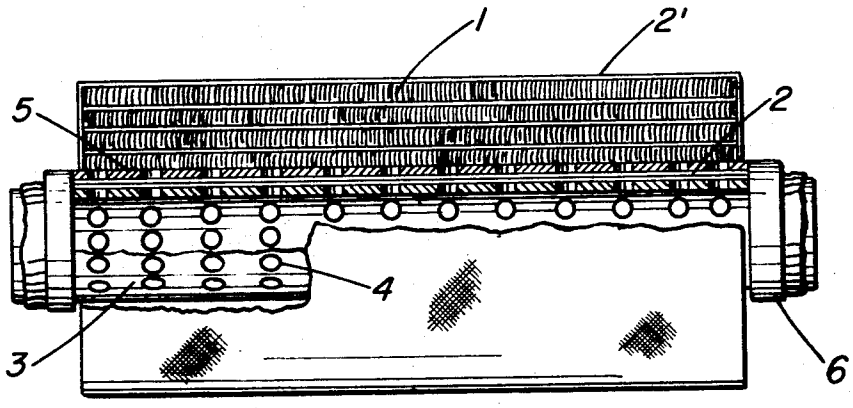
ABSTRACT: The present invention discloses a beam-dyeing process for pile fabrics having a pile of acrylic fibers involving use of a perforated plate of triangular cross section to eliminate winding irregularities and maintenance of specific winding density and volume rate of flow of dye liquor during dyeing.



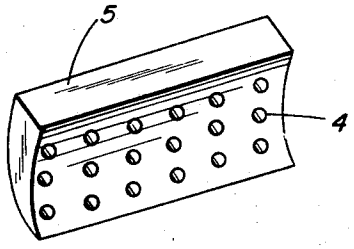


FIG. 1

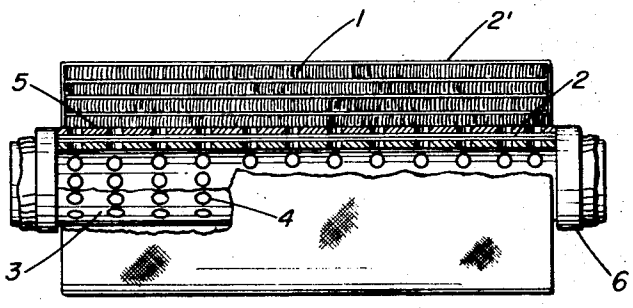


FIG. 2

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BEAM-DYEING METHOD FOR PILE FABRICS CONTAINING ACRYLIC FIBER PILE

This invention relates to an improved method for dyeing pile fabrics containing acrylic fiber pile stock employing beam-dyeing machines.

In preparing pile fabrics such as carpets, it is well known to first dye the synthetic or natural fibers used as pile stock by bulk-dyeing procedures or to hank-dye such fibers after being formed into yarn and then fabricate the pile fabric. Subsequent to the formation of pile fabrics, the practice of winch-dyeing or beam-dyeing has been widely employed involving pile of other fiber stocks.

Acrylic fibers are highly desirable for use as pile stock in such fabrics as carpets because of superior properties of bulkiness and dyeability. However, the Young's modulus of acrylic fiber stock is lower in hot water than other types of fiber stock. As a result, in employing a winch-dyeing machine for dyeing acrylic fiber stocks there will inescapeably be applied tension at temperatures above the secondary transition point of such stock and internal stresses induced by such tension will produce permanent deformation in the pile-forming stock. The result of such deformation will cause flattening of the pile from its desired erect position, formation of fluff or pills, or creation of other factors which greatly detract from the esthetic value of the pile fabric.

As is known, in a winch-dyeing machine, the operation of withdrawing the pile fabric from within a dye liquor at elevated temperature is repeated continuously during the dyeing operation. The pile fabric at the time of withdrawal is wet and is subject to the influence of the weight of dye liquor adhering to the fiber stock forming the piles as it is withdrawn from the dye liquor, thereby increasing the internal stress of the fibers. This internal stress causes flattening of the pile, i.e., pile lay, and causes formation of fluff or pills on the pile surface due to friction between the fibers.

In a beam-dyeing machine, on the other hand, the pile fabric is spirally wound on a cylindrical beam bored with a number of dye liquor jet holes and the pile fabric in fixed position is dyed in the machine. Accordingly, since there is no withdrawal of pile fabric from the dye liquor during the dyeing procedure, tensile stresses due to withdrawal do not act on the pile fabric and defects inherent in the winch-dyeing machine are substantially eliminated. However, in beam-dyeing of pile fabrics containing acrylic fibers as pile stock the effects of such dyeing on the pile are greatly different from those observed employing other types of fiber stocks and little is known both as to the nature of the effects and the causes and means for elimination thereof.

In employing pile fabrics having acrylic pile fibers in a beam-dyeing machine factors such as winding density, rate of flow of dye liquor, and the nature of the winding can have an adverse effect on the levelness of dyeing, can cause flattening of the pile, can create fluff or pills due to contact between pile fibers, and can result in undesirable hand or feel characteristics.

According to the present invention there is disclosed a beam-dyeing procedure for pile fabrics having a pile of acrylic fibers, characterized in that a perforated plate of substantially triangular cross section having substantially the same end thickness as the thickness of the pile fabric abuts against the dyeing beam having wrapping cloth therebetween and the pile fabric winding end is in contact with the perforated plate end, the pile fabric being wound around said beam while maintaining the weight per unit volume of pile-winding layers in the range of 0.15 to 0.05 grams per cubic centimeter and while maintaining the volume rate of flow of liquor per unit weight of pile fabric during dyeing in the range of 4 to 0.3 liters per second per kilogram.

When beam-dyeing is carried out in the manner indicated with pile fabrics containing acrylic pile fibers, the dyed fabric obtained is improved with respect to the deficiencies noted above and pile fabrics having superior levelness of dyeing, pile shape, and bulky feel are obtained. Such fabrics accordingly are highly desirable for the normal uses involving pile fabrics, particularly as carpet fabrics.

FIGS. 1 and 2 illustrate the perforated plate used in the process of the present invention and winding of a beam employing said perforated plate.

FIG. 1 is a perspective view of the perforated plate showing the substantially triangular cross section thereof.

FIG. 2 is a cutaway sectional view showing a condition in which a pile fabric is wound on a beam.

In FIG. 2, the dyeing beam 3 of a beam-dyeing machine is a cylindrical body made of a metal, usually stainless steel, having rust resistant and corrosion resistant properties with respect to dye liquors and is supplied with dye liquor from a supply source, not shown, which dye liquor flows through a number of dye liquor flow holes 4 arranged in suitably spaced rows bored in the lateral surface of said cylindrical body, said dye liquor thus being supplied to a pile fabric 1 spirally wound on the dyeing beam 3 with the pile surface facing out. The dye liquor is circulated through the beam-dyeing machine to an exhaust hole (not shown) to the supply source and again through the beam holes. For convenience, the direction of flow of the dye liquor has been indicated as from inside the dyeing beam 3 out through the flow holes and through the fabric winding to the exhaust hole. However, it is to be understood that the flow of dye liquor can be reversed, if desired, so as to enter the exhaust hole, then flow through the fabric winding to the flow holes to the inside of the dyeing beam and recirculated thence to the supply source. Wrapping cloth 2 is a fabriclike body interposed between the dyeing beam 3 and the first layer of the wound pile fabric in order to prevent direct contact between the pile fabric 1 and the dyeing beam 3. Usually the wrapping cloth is wound around the peripheral surface of the dyeing beam 3 while maintaining a substantially constant thickness prior to the winding of the pile fabric 1. In view of the fact that a slight amount of thermal shrinkage may result upon dyeing the pile fabric, consideration may be given to use of an elastic material such as sponge rubber as the wrapping cloth 2 so as to maintain the winding pressure of the pile fabric at substantially constant value in the dyeing process and such measure is intended within the scope of the present invention.

A second wrapping cloth 2' surrounds the outer peripheral surface of the pile fabric 1 spirally wound on the dyeing beam 3, and a clamping pressure is exerted on the wrapping cloth 2' by circular rings 6 fitted on the ends of the dyeing beam. The clamping pressure can be set at a predetermined value without changing the winding density of the pile fabric on the dyeing beam.

Pile fabrics, as can be readily appreciated, can have an appreciable thickness compared to other fabric types. This thickness presents a particular difficulty with respect to winding such fabric around a dyeing beam. This difficulty arises from crossing over the winding end of the fabric of the various layers of pile fabric wound around the beam. Because of the initial crossover the pile near the winding end of the fabric is flattened considerably and interferes with passage of dye liquor therethrough. Since the initial crossover tends to produce an uneven hump in the winding, subsequent crossovers are affected by this hump with the appearance of flattened pile therein and nonlevel dyeing due to the interference with flow of dye liquor therethrough. While this difficulty is not present in beam winding employing fabrics of nonpile type and of no appreciable thickness and is of no particular consequence when pile fabrics of other pile fiber types are employed, it is extremely important that the uneven hump be eliminated in the winding of pile fabrics containing acrylic pile fibers to avoid permanent flattening of the pile and to achieve level dyeing by use of the beam-dyeing machine.

In the improved beam-dyeing method of the present invention, there is provided the perforated plate shown in FIG. 1 and shown positioned in the beam winding in FIG. 2. As shown in FIG. 1, the perforated plate has a cross-sectional

shape that is substantially triangular, with sides diverging slightly from straight lines in order to conform to the curvature of the beam, thus forming a concave side for positioning against the beam and a convex side for positioning the winding so as to eliminate the uneven hump. The end, or base, of the triangular section is of a thickness which substantially corresponds to the thickness of the pile fabric. The length of the perforated plate corresponds to the width of the pile fabric. The sides of the triangular section of the perforated plate are of a length sufficient to prevent formation of the hump and may vary considerably depending upon the thickness of the pile fabric. Since the perforated plate is to eliminate the uneven hump formed when a pile fabric containing acrylic pile fibers is wound on a beam, it is apparent that any length of sides of the triangular cross section of the perforated plate capable of achieving this result is suitable and may be employed. The perforated plate is bored with a suitable number of holes corresponding in positioning to the pattern of the boring of the beam so that when the plate is positioned on the beam, holes in the plate will be in register with holes in the beam. The perforated plate may be made from a variety of suitable materials but it is desirable to employ materials superior in resistance to contamination by dye liquid as in the case of the dye beam, and such materials as teak coated with Teflon or other coating resin and plastic materials which are heat and chemical resistant, such as melamine plastics may be employed. If desired, a fabric, not shown, may be interposed between the perforated plate **5** and the pile fabric **1**.

As described above, the wrapping cloth **2** is wrapped around the dyeing beam **3**, the perforated plate **5**, with or without wrapping cloth interposed, is arranged to have the end or base of its triangular cross section contact the winding end of the pile fabric while its holes are in register with holes in the beam. The pile fabric is then wound about the beam while maintaining a predetermined winding density. Thereafter, the wrapping cloth **2'** is positioned in such a manner as to surround the pile fabric while maintaining the winding density employed. The sides of the wrapping cloth **2'** which extend beyond the width of the pile fabric are drawn to the lateral surface of the dyeing beam and passed between the circular rings **6** and the dyeing beam. The clamping pressure exerted by the clamping rings **6** on the wrapping cloth **2'** is then adjusted to maintain the winding density of the pile fabric **1** at substantially constant value.

In accordance with the present invention wherein the pile fabric contains acrylic pile fibers it is necessary that the winding density expressed as weight of pile fabric per unit volume be in the range of 0.15 to 0.05 grams per cubic centimeter. If the winding density is below that range specified, color differences between inner and outer layers of pile fabric after dyeing will be so great as to detract from the commercial value of the pile fabric from the viewpoint of level dyeing, although difficulties as to flattening of the pile and damage to the external appearance of the piles will not be encountered because of the low clamping pressure on the pile fabric. If the winding density exceeds 0.15 grams per cubic centimeter, the acrylic fibers, whose Young's modulus in hot water is inherently low, would readily lose stiffness with the result that the piles, which were upright in the weaving and finishing steps, will become flattened and contact each other so as to produce fluff or pills. Also, the bulky nature of the pile fabric will be lost and the hand and feel will be spoiled.

In addition the requirement for winding density of pile fabrics containing acrylic pile fibers, as described above, in beam dyeing it is also necessary that the volume rate of flow of dye liquor per unit weight of pile fabric be controlled within specific limits. In the process of the present invention the volume rate of flow of dye liquor must be maintained in the range of from 4 to 0.3 liters per second per kilogram of fabric, preferably in the range of from 2 to 0.3 liters per second per kilogram of fabric. If the volume rate of flow of dye liquor is in excess of the range specified, local flattening of the piles will occur in the innermost and outermost layers of pile fabric on the dyeing beam. If the volume rate of flow of dye liquor is below the range specified, nonuniform dyeing and formation of air spaces will occur in the pile fabric.

By an acrylic fiber, as that term is employed in the present specification, is meant a fiber consisting of a major portion of acrylonitrile, particularly one consisting of at least 70 percent acrylonitrile and the balance of one or more monomers copolymerizable with acrylonitrile, as is well known in the fibers field. The acrylic fibers useful in the invention include composite fibers obtained by cospinning two or more acrylonitrile polymers varying in thermal shrinkage, as are well known. The pile fabrics contain pile of at least 50 percent by weight thereof of acrylic fibers and may be mix-spun pile fibers having additionally a content of natural or other synthetic fibers within the limits specified.

It is within the scope of the present invention to employ various additives in the dye liquor as is well known such as a softener, for example.

The invention is illustrated by the example which follows in which the percentages are by weight.

EXAMPLE 1

As a base fabric in preparing a pile fabric containing acrylic pile fibers was employed a 3 millimeter-thick hemp base having a twill weave with a warp content of 15 yarns per 25 millimeters and a weft content of 31 yarns per 25 millimeters. As the pile yarn was employed a two-ply 4'S (British Cotton Count) (first twist = 130 turns per 25 millimeters, right-hand twist; second twist = 180 twists per 25 millimeters, left-hand twist) prepared by mix-spinning 40 percent of fiber A, 20 percent of fiber B, and 40 percent of fiber C, identified as follows:

fiber A = two component fiber having as polymer components;

1. A copolymer of acrylonitrile, methyl acrylate, and methallylsulfonic acid in the proportions 90/10/0.5 respectively, and

2. A copolymer of acrylonitrile and vinyl acetate in the proportion 89/11, respectively. This fiber is of 10 denier and has staple lengths varying between 89 millimeters and 127 millimeters.

fiber B = monocomponent fiber having as polymer component that designated as 1 in fiber A. This fiber is of 10 denier and has staple lengths of 114 millimeters.

fiber C = monocomponent fiber having as polymer component that designated as 1 in fiber A. This fiber is of 15 denier and has staple lengths varying between 89 millimeters and 127 millimeters.

The yarn was incorporated into the base fabric so as to form 8 stitches per 25 millimeters, with the height of the cut piles adjusted to about 10 millimeters.

A dye liquor having the following composition was prepared for use in dyeing the above-described pile fabric using a beam-dyeing machine:

Cationic Dyestuff	Sumiacryle Brilliant Red 2B (trademark Sumitomo Kagaku Kogyo Co., Ltd.)	2.80percent
	Sumiacryle Blue 3R (trademark Sumitomo Kagaku Kogyo mCo., Ltd.)	0.07 percent
	Sumiacryle Red G (trademark Sumitomo Kagaku Kogyo Co., Ltd.)	1.80 percent
Acetic Acid		1 gram/1 liter
Sodium Acetate		0.50 percent
Sodium Sulfate		10.00 percent

(The percentages are by weight based on the weight of fabric to be dyed.)

The above-described pile fabric in separate experiments was wound on beams with the winding end abutting a perforated plate having as end or base of its triangular cross section one of a thickness of 12 millimeters in several weights per unit volume of pile fabric. Dyeings were also run at various volume rates of flow of dye liquor per unit weight of pile fabric. The dyeings were carried out as described below.

The pile fabrics wound on the dyeing beams were immersed in the dye liquor at 60° C. which was then heated for 30 minutes to reach a temperature of 90° C., this temperature being maintained for 10 minutes. Heating was then carried out for 10 minutes to reach a temperature of 98° C. and this temperature was maintained for 60 minutes. The temperature was then lowered to 60° C. over a period of 40 minutes, thus completing the dyeing.

The dyed pile fabrics were measured for bulkiness by measuring the thickness of the fabric in millimeters including base fabric and pile using a standard thickness-measuring instrument at several values of applied loads of fabric samples taken from several positions of the beam winding. The results of these measurements are shown in Table I along with the variations in winding density and flow rate of dye liquor studied in the various experiments.

TABLE I.—BULKINESS IN MILLIMETER MEASURED AT VARIOUS LOADS

Carpet sample from—	Measuring load	Winding density, grams/cm.[3] 0.08 Flow rate, liters/second/kilogram 0.5	2.0	4.0	0.13 Flow rate, liters/second/kilogram 0.5	1.0	2.0	4.0	0.20[1] Flow rate, liters/second/kilogram 1.0	4.0
Innermost layer	None	10.75	10.53	10.41	8.90	8.80	8.70	8.59	6.20	6.10
Central layer	do	12.01	11.80	11.67	10.90	10.37	9.80	9.58	6.95	6.88
Outermost layer	do	13.00	13.05	12.41	12.41	11.68	11.00	11.17	7.20	7.13
Innermost layer	1.6 grams/cm.[2]	10.04	9.84	9.73	8.51	7.98	7.65	7.32	5.32	5.21
Central layer	do	10.97	10.70	10.59	10.43	9.91	8.80	8.66	6.21	6.19
Outermost layer	do	11.25	11.21	10.94	10.75	10.64	10.40	10.25	6.24	6.21
Innermost layer	8 grams/cm.[2]	9.92	9.73	9.63	8.20	7.95	7.61	7.29	5.25	5.15
Central layer	do	10.83	10.61	10.54	10.35	9.63	9.21	8.88	6.19	6.16
Outermost layer	do	11.15	10.90	10.85	10.73	10.60	10.40	10.21	6.20	6.17

[1] Comparative.

TABLE II

Appearance and Color Values of Beam Dyed Acrylic Pile Fabrics

Winding density[1]	Flow rate[2]	Carpet taken from— Innermost layer External appearance	−Log T	Central layer External appearance	−Log T	Outermost layer External appearance	−Log T
0.04	[3] 4.0	Poor	.550	Poor	.327	Poor	.272
0.08	0.5	Good	.331	Good	.310	Good	.290
0.08	2.0	do	.329	do	.311	do	.293
0.08	4.0	Fair to good	.330	do	.312	do	.295
0.13	0.5	Good	.329	do	.317	do	.290
0.13	1.0	do	.321	do	.318	do	.305
0.13	2.0	do	.340	do	.329	do	.310
0.13	4.0	Fair to good	.354	do	.335	do	.315
0.20	[3] 1.0	Bad	.369	Bad	.319	Bad	.295
0.20	[3] 4.0	Bad	.370	Bad	.320	Bad	.315

[1] Grams per cm.[3]
[2] Liters/second per kilogram.
[3] Comparative.

A second set of similar samples of the dyed pile fabrics were separately immersed in γ-butyrolactone at 60° C. to dissolve the acrylic fiber and the solutions were then allowed to cool to room temperature. The solution containing dissolved dyed fibers was measured for absorbancy by use of a colorimeter. In table II are shown the various color comparisons expressed as -log T as well as the external appearance of the dyed fabrics based on a visual-sensual evaluation taking into account the pile configuration, bulky feel and hand of the fabrics.

We claim:

1. A beam-dyeing procedure end, pile fabrics having a pile of acrylic fibers characterized in that a perforated plate of substantially triangular cross section having substantially the same end thickness as the thickness of the pile fabric abuts against the dyeing beam having wrapping cloth therebetween and the pile fabric winding end is in contact with the perforated plate end the pile fabric being wound around said beam while maintaining the weight per unit volume of pile-winding layers in the range of 0.15 to 0.05 grams per cubic centimeter and while maintaining the volume rate of flow of liquor per unit weight of pile fabric during dyeing in the range of 4 to 0.3 liters per second per kilogram.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,600,732 Dated August 24, 1971

Inventor(s) Genichi Hayashi; et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, Claim 1, line 11, "end," should read -- for --.

Signed and sealed this 18th day of January 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
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