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3,052,947

PRODUCTION OF EMBOSSED PILE FABRICS

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The present invention relates to a method for producing a pile fabric in which the pile has depressed areas determined by a pattern, thereby giving the pile fabric an embossed appearance. More particularly, the invention is concerned with a method for embossing carpeting and other pile fabrics composed of acrylonitrile-containing fibers.

Heretofore, numerous methods have been employed by the art to produce embossed pile fabrics having indented designs of various types. For example, pile fabrics having designs in the pile formed by fibers of different height have been produced by hand-sculpturing techniques using electric shears. Unfortunately, such a method is slow, subject to inaccuracy and the cost of production, when compared with more mechanical embossing operations, is relatively high. Another method for producing embossed pile fabrics has been to spin heat-shrinkable fibers with other textile fibers, thereafter weaving the pattern desired into a pile fabric using the blended fibers in the pattern area and subsequently applying heat to the pile fabric so as to shrink the fibers in the pattern area. Such a method, however, requires the anticipation of the design to be embossed at the time the pile fabric is produced, thereby limiting the utility of the pile fabric insofar as the choice of pattern subsequently to be embossed is concerned. Moreover, since a considerable period of time generally passes between the formation of the pile fabric and subsequent marketing, the design of the embossed pattern may no longer meet acceptance at the consumer level. Still another method for producing embossed pile fabrics has been to incorporate a plastic mass in the fabric backing, into which, under conditions of heat, fibers in certain areas of the pile fabric are depressed and sealed. Disadvantageously, concomitant with the use of a plastic mass in the backing of the pile fabric is the use of complicated manufacturing procedures required to produce the pile fabric, both during its initial formation and during the subsequent embossing operation. Moreover, the embossed patterns so produced may be unstable upon prolonged wear.

The disadvantages of the prior art, as hereinabove described, can now be overcome to a substantial extent through the practice of the present invention, which, in its broadest aspect, contemplates the production of embossed pile fabrics composed of acrylonitrile-containing fibers by depressing the fibers of the pile fabric in certain areas as determined by a desired pattern, while the fibers in the areas undergoing depression are at a temperature above the second order transition temperature of the fibers and below the temperature at which substantial shrinkage of the fibers occurs. Thereafter, the depressed fibers are cooled to a temperature below their second order transition temperature. Thus, by following the teachings of the present invention, unpatterned pile fabrics can be produced, stored and subsequently embossed in a pattern which finds commercial acceptance at the time of the embossing operation in a convenient and economical manner. In addition, the embossed pile fabrics so produced have been found to withstand prolonged wear, normal laundering, and other common usage, without adverse effect upon their design.

The term "second order transition temperature," as employed herein and in the appended claims, is intended to

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define the temperature at which the amorphous portion of the fiber melts. This term is discussed more fully in the Textile Research Journal, vol. 25, No. 11, pages 891-901 (November 1955).

Unlike certain of the prior art methods for the production of embossed pile fabrics in which heat-shrinkable fibers are employed, the present invention depends upon the heat-shaping rather than the heat-shrinkage of the pile fibers to produce an embossed pattern. Hence, the necessity for weaving both shrinkable and non-shrinkable fibers into a pile fabric in anticipation of the desired pattern to be embossed is now obviated. It is, in fact, of critical importance to this invention that the fibers of which the pile fabric is composed be substantially non-shrinkable at the temperature encountered during the embossing operation. In this connection, the fibers of the pile fabric can be either substantially unoriented, as determined, for instance, by X-ray analysis, and therefore evidence little tendency to shrink when heated in accordance with this invention, or they can be oriented fibers which have been dimensionally stabilized against shrinkage at temperatures up to at least those to be utilized during the embossing operation.

The dimensional stabilization of the oriented fibers, which may or may not in itself involve the limited shrinkage of the fibers, can be effected either prior or subsequent to the formation of the pile fabric, but is, however, necessarily accomplished prior to the embossing operation. The dimensional stabilization of the fibers can be achieved, for example, by heating the fibers at or above that temperature subsequently to be employed during the embossing operation and by either holding the heated fibers under tension so as to prevent shrinkage or by allowing the heated fibers to relax to a predetermined extent so that a limited amount of shrinkage will occur. If the dimensional stabilization of the fibers is to be effected after the formation of the pile fabrics, the fibers generally cannot be held under a degree of tension sufficient to prevent shrinkage. It is to be noted here, however, that under such conditions, all of the fibers of the pile fabric will shrink relatively uniformly, and that the subsequent embossing of the pile fabric can still be performed as contemplated by this invention. Similar considerations hold true when the fibers are dimensionally stabilized, accompanied by the limited shrinkage of the fibers, prior to the formation of the pile fabric. Thus, it can be seen that, under all circumstances in accordance with this invention, the fibers of the pile fabric are substantially non-shrinkable during the embossing operation under the conditions employed, that is to say, the fibers of the pile fabric are heated in connection with the embossing operation to a temperature below that at which substantial shrinkage of the fibers will occur.

The acrylonitrile-containing fibers used in forming the pile fabrics with which this invention is concerned are well known to the art and are the fibers designated as acrylic and modacrylic fibers in accordance with the Federal Trade Commission Rules and Regulations under the Textile Fiber Products Identification Act, enacted September 2, 1958. Such fibers can be defined more particularly as the fibers spun in accordance with conventional fiber-spinning operations from homopolymers of acrylonitrile and/or copolymers thereof with one or more other ethylenically unsaturated monomers polymerizable therewith, such copolymers containing the acrylonitrile component in a concentration of at least about 35 percent by weight based upon the weight of the copolymer. As employed herein and in the appended claims, the term "polymer" is intended to include both homopolymers and copolymers; the term "copolymer" is intended to include the polymers produced by the interaction of

two or more different monomers or by the grafting of two or more different polymers.

As illustrative of the ethylenically unsaturated compounds which can be polymerized with acrylonitrile to produce fiber-forming polymers from which the acrylonitrile-containing fibers herein described can be obtained, there can be mentioned the following: vinyl chloride, vinylidene chloride, vinyl pyridine, vinyl pyrrolidone, styrene, methyl acrylate, methyl methacrylate, methacrylamide, methallyl alcohol, allyl cyanide, methallyl cyanide, vinyl acetate and the like. Of these, pile fabrics composed of the acrylonitrile-containing fibers produced from copolymers of acrylonitrile and either vinyl chloride, vinylidene chloride or both are preferred.

In addition, the fibers found most useful in forming the pile fabrics of this invention are those having a second order transition temperature of from about 70° C. to about 100° C. and a stiffness modulus of up to about 15 grams per denier and more preferably less than about 10 grams per denier. It is to be noted, however, that the acrylonitrile-containing fibers contemplated by this invention are not necessarily limited thereto.

As employed herein and in the appended claims the term "stiffness modulus" is intended to define the textile modulus of the fibers as determined in accordance with the ASTM Standards on Textile Materials, 1957, page 9, measured at a temperature of 100° C. and at a fiber extension of 1.0 percent at a rate of 0.2 inch per minute.

The acrylonitrile-containing polymers and the fibers produced therefrom can be obtained in well known manner, such for example, as by the processes disclosed in U.S. Patents 2,420,565, 2,603,620 and 2,868,756, which disclose suitable acrylonitrile-containing polymers and fibers for use in the present invention, or by any other convenient means known to the art. Moreover, while such patents disclose the ultimate production of oriented fiber, it is to be noted that the pile fabrics produced from substantially unoriented fibers can also be employed in accordance with this invention. The pile fabrics can be formed from the acrylonitrile-containing fibers by the conventional processes well known to the ordinary person skilled in the art, such for example, as by weaving, tufting or knitting operations, and the like.

If the pile fabric is formed from substantially unoriented fibers or from fibers which were previously dimensionally stabilized, further treatment of the pile fabric prior to the embossing operation is unnecessary. However, with those pile fabrics prepared from oriented fibers, an initial heat treatment of the pile fabric at or above that temperature subsequently to be employed during the embossing operation is necessarily conducted, during which time the fibers are generally allowed to shrink freely. Naturally, any heat treatment carried out in connection with the dimensional stabilization of the fibers is preferably conducted at a temperature below that at which discoloration or fusion of the fibers occurs.

The embossing operation can be performed by contacting the face of the pile fabric at a temperature as herein described with an embossing device, such as an embossed roller or other conventional apparatus for embossing pile fabrics, and by applying a pressure therewith on the pile fabric sufficient to depress the pile of the fabric. The pressure required to emboss the pile fabric and therefore to be exerted with the embossing device is relatively low and depends for the most part on the depth of design that is desired. Such pressures can readily be determined by one skilled in the art in light of this disclosure.

While the embossing operation can be carried out at any temperature between the second order transition temperature of the acrylonitrile-containing fibers and that temperature at which substantial shrinkage of the fibers occurs, particularly good results have been obtained in this connection at temperatures of from about 110° C.

and more preferably from about 120° C. up to about 160° C. By conducting the embossing operation at a temperature of at least about 110° C., for example, the stability of the embossed pattern upon the prolonged usage or mild laundering of the pile fabric is assured. On the other hand, temperatures above about 160° C., while operable, may, in some instances, cause discoloration of the acrylonitrile-containing fibers, thus limiting the utilization of the embossed pile fabric to those applications in which discoloration is not objectionable.

The embossing operation can be performed by heating the pile fabric to the prescribed temperature prior to contact with an unheated embossing device; by contacting an unheated pile fabric with an embossing device which has been heated to the prescribed temperature; or in any other convenient manner. When a heated embossing device is employed, the embossing device is necessarily maintained in contact with the pile fabric for a period of time sufficient to bring the fibers of the pile fabric to within the prescribed temperature range. This is accomplished generally in a matter of minutes. Good results have been obtained, for instance, by contacting the pile fabric with the heated embossing device for a period of from about 8 to about 10 minutes. Alternatively, when a heated pile fabric is employed, the contact time can be reduced to several seconds if desired. Thus, the period of contact can be varied broadly, but should not be so long as to cause discoloration of the fibers. Moreover, care must be taken so that any fibers in areas outside of the desired pattern areas heated to above their second order transition temperature are not depressed by the embossing device.

Upon completion of the embossing operation, the embossing device is removed and the pile fabric cooled to a temperature below the second order transition temperature of the acrylonitrile-containing fibers. The cooling of the pile fabric in this manner should be accomplished before the pile fabric is subject to any distortional forces so as to prevent a loss of contrast in the imparted design. Thereafter, the pile fabric can be subjected to normal usage.

The invention can be illustrated further in connection with the following specific examples of its practice, but is not intended to be limited thereto.

EXAMPLE I

A pile fabric suitable for use as carpeting and made by tufting substantially unoriented fibers spun from a copolymer containing about 40 percent by weight of acrylonitrile and 60 percent by weight of vinyl chloride polymerized therein was placed on a commercially available flat bed steam press and heated to a temperature of about 115° C. by means of steam at a pressure of 60 pounds per square inch gauge at the press. A metal screen having diamond-shaped openings was impressed upon the heated pile fabric depressing certain of the fibers of the pile fabric in areas corresponding to the metal portions of the screen and held in place for a period of about 8 minutes. Heating was then discontinued, the screen removed and the pile fabric cooled to room temperature by drawing air through the fabric by means of a vacuum. The embossed pile fabric thus formed was found to possess stable, sharply defined, diamond-shaped designs.

EXAMPLE II

A pile fabric prepared from substantially unoriented fiber spun from a copolymer containing about 40 percent by weight of acrylonitrile and 60 percent by weight of vinyl chloride was heated at a temperature of 121° C. for a period of about 10 minutes. A metal screen similar to that described in Example I was then impressed upon the heated fabric thereby depressing certain of the pile fibers in areas corresponding to the metal portion of the screen and held in place for a period of about 2 minutes.

Heating was then discontinued, the screen removed and the pile fabric cooled to room temperature. The embossed pile fabric thus formed was found to possess sharply defined diamond-shaped designs. The embossed pile fabric was then placed on the floor of a building and subjected to normal wear as a carpeting material for a period of 7 months, after which the embossed pile fabric was cleaned with a commercially available carpet cleaner (Glamorene). Upon use and treatment in this manner, the embossed pile fabric was observed to retain the sharply defined diamond-shaped designs originally imparted thereto as hereinabove described.

EXAMPLE III

A pile fabric of the type described in Example II was embossed by heating the fabric at a temperature of 250° F. for a period of about 8 minutes and then impressing upon the heated fabric a narrow steel ring having a diameter of about 3 inches, thus depressing the pile fibers in areas contacting the ring. The ring was held in place for a period of about 3 seconds. The ring was then removed and the pile fabric cooled to room temperature. The embossed pile fabric thereby formed was found to possess a sharply defined ring-shaped design.

EXAMPLE IV

Various pile fabrics, each prepared from a different commercially available acrylonitrile-containing fiber, were backwashed with a rubber latex and dried at a temperature of 130° C. The pile fabrics were then embossed by depressing the fibers of the pile fabrics using a metal screen similar to that described in Example I, heated to a temperature of 121° C. In each run, the heated screen was held in place for a period of about 8 minutes. The screen was then removed and the pile fabric cooled to about room temperature. The durability of the embossed designs thus produced was then evaluated by washing the pile fabrics in an automatic washing machine using the normal wash cycle with one cup of soap flakes (Ivory) at the warm setting, rinsing the fabrics and allowing them to air dry. The initial sharpness of the embossed designs and the degree of retention of the designs after laundering were evaluated visually. In Run No. 1, the acrylonitrile-containing fibers employed were oriented fibers containing about 89 percent by weight of acrylonitrile, 6 percent by weight of vinyl pyridine and 5 percent by weight of vinyl acetate polymerized therein; in Run No. 2, the acrylonitrile-containing fibers employed were oriented fibers spun from a polymer containing about 70 percent by weight of acrylonitrile, 20 percent by weight of vinyl chloride and 10 percent by weight of vinylidene chloride polymerized therein; in Run No. 3, the acrylonitrile-containing fibers employed were oriented fibers containing about 56 percent by weight of acrylonitrile, 36 percent by weight of vinylidene chloride and 8 percent by weight of vinyl pyridine polymerized therein; in Run No. 4, the acrylonitrile-containing fibers were substantially unoriented fibers spun from a copolymer containing about 40 percent by weight of acrylonitrile and 60 percent by weight of vinyl chloride polymerized therein. For comparison, one run, Run No. 5, was conducted using a pile fabric prepared from commercially available oriented polyamide fibers. The results obtained are tabulated below in Table A.

Table A

Run No.	Initial Sharpness of Design	Durability of Design
1	Good	Good.
2	do.	Do.
3	do.	Do.
4	do.	Do.
5	Poor.	None.

From the above table it can be seen that the pile fabric produced from non-acrylonitrile-containing fibers in Run No. 5 did not permit a satisfactory embossing operation and did not evidence the retention of design after conventional laundering. In each instance, however, sharp and durable designs were formed using pile fabrics produced from acrylonitrile-containing fibers in accordance with the method of this invention.

What is claimed is:

1. A method for embossing a pile fabric composed of fibers selected from the group consisting of acrylic and modacrylic fibers, which comprises depressing the fibers of said pile fabric in areas determined by a pattern while the fibers in the areas undergoing depression are at a temperature above the second order transition temperature of the fibers and below the temperature at which substantial shrinkage of the fibers occurs, and subsequently cooling the depressed fibers to a temperature below their second order transition temperature.
2. A method for embossing a pile fabric composed of fibers selected from the group consisting of the substantially unoriented acrylic and modacrylic fibers having a second order transition temperature of from about 70° C. to about 100° C., and a stiffness modulus of up to about 15 grams per denier which comprises depressing the fibers of said pile fabric in areas determined by a pattern while the fibers in the areas undergoing depression are at a temperature of from about 110° C. to about 160° C., and subsequently cooling the depressed fibers to a temperature below their second order transition temperature.
3. The method according to claim 2 wherein the fibers of the pile fabric have a stiffness modulus of less than about 10 grams per denier.
4. The method according to claim 2 wherein the fibers of the pile fabric are produced from copolymers containing about 40 percent by weight of acrylonitrile and about 60 percent by weight of vinyl chloride polymerized therein.
5. A method for embossing a pile fabric composed of dimensionally stabilized fibers selected from the group consisting of the oriented acrylic and modacrylic fibers having a second order transition temperature of from about 70° C. to about 100° C., and a stiffness modulus of up to about 15 grams per denier, which comprises depressing the fibers of said pile fabric in areas determined by a pattern while the fibers in the areas undergoing depression are at a temperature of from about 110° C. to about 160° C., such temperature being below the temperature at which substantial shrinkage of the fibers occurs, and subsequently cooling the depressed fibers to a temperature below their second order transition temperature.
6. The method according to claim 5 wherein the fibers of the pile fabric have a stiffness modulus of less than about 10 grams per denier.
7. The method according to claim 5 wherein the fibers of the pile fabric are produced from copolymers containing about 40 percent by weight of acrylonitrile and about 60 percent by weight of vinyl chloride polymerized therein.

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