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[54] **HOSIERY FINISHING PROCESS FOR TREATING FABRICS CONTAINING SPANDEX YARN**

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[51] **Int. Cl.** **B44d 5/00**

[58] **Field of Search**..... 117/138.8, DIG. 3, 139.5 A, 117/139.5 CQ, 161 ZA; 252/8.8

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[57] **ABSTRACT**

A finishing process for enhancing the wear life and hand of knitted fabrics containing spandex yarn comprises placing the fabric in a bath containing an aqueous emulsion of a polysiloxane polymer, exhausting the polymer onto the surface of the spandex, and adding a curable non-film forming thermosetting resin to the bath under conditions which cause a reaction between the silicone polymer and the resin.

8 Claims, No Drawings

HOSIERY FINISHING PROCESS FOR TREATING FABRICS CONTAINING SPANDEX YARN

The present invention relates generally to a method of treating a knitted fabric containing spandex and in particular to an improved finishing process for knitted hosiery including both spandex and nylon yarns.

Throughout the years substantial efforts have been made in women's hosiery products to render the same substantially run-proof. In a typical hosiery fabric, yarns of synthetic and/or natural fibers are knitted together in a circular knitting machine with the particular yarns being subjected to a wide degree of choice depending upon the desired alternate properties for the particular hosiery product. Thus, various combinations of synthetic yarns such as rayon, nylon, Orlon, Acrylon, Dacron and the like have been knitted alone or together with natural fibers, such as cotton, wool, silk and the like in various stitch configurations. With the advent of spandex, which is a long chain synthetic polymer containing approximately 85% or more of segmented polyurethane, there has been considerable interest in spandex-containing hosiery since spandex is particularly suited to impart elasticity to such knitted fabrics. One such hosiery fabric includes a matrix of interconnected spandex yarns with a body of yarn of nylon knitted in a manner to have the requisite stretch and power performance for such stretch or elastic hosiery. More recently, techniques have been developed to impart non-run characteristics to spandex yarns in the fabric at the crossover points.

Although knitted fabrics containing uncovered spandex yarn have demonstrated enhanced non-run characteristics, it has been found that fabrics containing significant quantities of uncovered spandex yarn have a somewhat objectionable rubbery hand or feel. Moreover, due to the high coefficient of friction of spandex yarns, knitted fabrics containing such yarn are subject to undesirably rapid deterioration during wear and laundering.

It is an object of the present invention to provide a finishing process for knitted fabrics containing spandex yarn.

A further object of the invention is to provide a finishing process for knitted fabrics including spandex yarns which enhances the surface lubricity of such yarns thereby reducing the rubbery feel or hand normally associated with garments formed from spandex-containing fabrics.

A still further object of the invention is to provide a finishing process which enhances the durability of knitted fabrics containing spandex yarns.

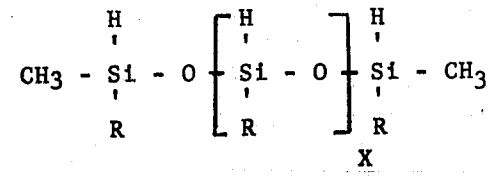
The above and other objects of the invention are accomplished by subjecting knitted fabrics containing spandex yarn to a finishing process whereby the spandex is selectively and sequentially treated with a polysiloxane polymer and a curable thermosetting resin to enhance its surface characteristics. Specifically, the spandex-containing fabric is first exposed to a bath comprising an aqueous emulsion of a polysiloxane polymer having an active hydrogen group and the bath is acidified thereby causing the polymer to exhaust onto the surface of the spandex yarn. The time and temperature of the exhaustion step are controlled so as to insure substantial uniformity of absorption on the spandex-containing fabric and to avoid premature cross-linking of the polysiloxane polymer through its

active hydrogen prior to the absorption of the polymer into the spandex yarn. Upon completion of the exhaustion step, a curable, non-film forming thermosetting resin and a curing agent or catalyst for the resin are added to the exhausted bath and the bath conditions are controlled so as to promote a relatively uniform reaction between the resin and the absorbed polysiloxane polymer on the surface of the spandex yarn. In a final step, the treated fabric is subjected to elevated temperature for a short period of time in order to cure the reaction product. The resulting treated fabrics exhibit a substantially improved hand and enhance durability to wear through repeated launderings as compared to comparable fabrics including untreated spandex yarn.

While not wishing to be limited to any particular theory, it is presently believed that the process of the invention produces a complex molecular structure which becomes permanently attached to the surface of the spandex yarn. Specifically, it is now believed that the molecular structure of spandex yarn permits the absorption of the relatively small polysiloxane molecule into the surface of the spandex yarn and that the more complex molecular structure which is formed as a result of cross-linking between the polysiloxane and the cured thermosetting resin through the active hydrogen on the polysiloxane molecule becomes physically locked within the surface of the spandex. Due to the physical nature of the polysiloxane and the thermosetting resins employed, the reaction product is an oily or viscous polymer rather than a solid and thereby enhances both the coefficient friction of the treated spandex surface as well as its texture or hand.

The process of the present invention does not require the use of specialized equipment and may be carried out in conventional hosiery scouring and dyeing equipment upon completion of a conventional dyeing procedure. Hosiery dyeing is normally carried out in a paddle or rotary dyeing machine in which the hosiery is bundled together in large bags, the bags are placed in a dye bath and a mechanical action tumbles or moves the bagged hosiery through the bath so as to create a circulation effect which prevents uneven dyeing. In a typical scouring and dyeing procedure, the bagged hosiery is washed with a mild detergent, rinsed and then dyed. The dyeing step is carried out by adding dispersed dyestuffs to a bath and the acidity, temperature of the bath and time are controlled so that the dyes are evenly exhausted onto the hosiery. Following the dyeing step, the bagged hosiery is normally rinsed and tumbled dried. The finishing procedure contemplated by the present invention may be carried out in the same equipment immediately following the final dye-rinse step.

As previously noted, any polysiloxane polymer having an active hydrogen may be employed in the finishing process of the invention. The following is a general formula for such polymers:



wherein R is a lower alkyl group such as a methyl or ethyl group or a simple aromatic such as benzyl or xylyl group and X is a recurring number of monomeric groups which ranges between 200 and 20,000. Typical

polysiloxane polymers falling within the above definition are lower alkyl hydrogen polysiloxanes such as methyl or ethyl hydrogen polysiloxane. In order to be useful for the purposes of the present invention, the polysiloxane must be in the form of a water emulsion. Any of the conventional emulsifiers which will maintain a stable water emulsion of polysiloxane until acidified may be employed. One such preferred emulsifier is tridecyloxypoly (ethyleneoxy)ethanol.

The curable thermosetting resin which is employed in the finishing process of the invention to form the reaction product on the surface of the spandex should preferably be a non film-forming resin, i.e. it should form a viscous polymer rather than a solid polymer upon curing. A preferred thermosetting resin for this purpose is dimethylolethylene urea. Other thermosetting resins of this type include glyoxals and carbamates.

The process of the invention also contemplates the use of a catalyst or curing agent for the resin in the bath. A preferred catalyst for this purpose is a zirconium-zinc acetate catalyst. Other suitable catalysts include zirconium acetate, zirconium formate and zinc acetate.

The amounts of silicone emulsion and thermosetting resin which are employed in the process of the invention are not critical. Ordinarily, sufficient amounts of each material will be employed so as to obtain a 2.5 to 4.0 % by weight solids concentration on the fabric preferably 3.0 to 3.5 wt.% concentration of the silicone polymer on the finished fabric and a 2.0 to 5.0 wt.% solids concentration, preferably 3.0 to 4.0 wt.% solids concentration of the thermosetting resin on the fabric. The amount of catalyst employed is not critical. Ordinarily an amount ranging from 0.2 to 0.5 wt.% of the solids concentration of the catalyst on the fabric will be employed.

Although the conditions of the reaction must be controlled to insure that the finishing materials are uniformly distributed and reacted on the spandex yarn, the temperatures, reaction times and specific degree of acidity of the baths employed in carrying out the process are not critical and may be subject to some variation while still achieving the desired result of the process. For example, with respect to acidity, the pH of the bath must be acidic, i.e. less than 7.0 in order to accomplish both the silicone polymer exhaustion step and the subsequent cross-linking reaction. The pH can be controlled by the addition of dilute acids such as acetic acid and the pH will be maintained such that the bath is sufficiently acid to permit exhaustion but not so strongly acid as to damage the fabric. The exact limits of pH can, of course, be readily determined by experimentation, and it has been found that ordinarily the pH should be maintained between 4.0 and 6.0, preferably 4.0 to 5.0 for both the exhaustion step and the cross-linking reaction.

The knitted fabric is held in the bath during the silicone exhaustion step for a time sufficient to exhaust substantially all of the silicone polymer in the emulsion onto the spandex yarn. The speed at which this exhaustion occurs is a function of both the acidity and temperature of the bath. Obviously, commercial practicality dictates that the exhaustion step be completed in the shortest possible time which will not adversely affect the product and which will permit substantially uniform absorption of the silicone polymer in the spandex yarn. While higher temperatures will speed up the exhaustion step, too high a temperature may result in either uneven absorption or undesirable premature cross-linking of the silicone polymer prior to its being absorbed in the spandex yarn. A temperature range of 100° to 200°F., preferably 120° to 180°F., e.g. 180°F. for a period of time sufficient to complete exhaustion, for example, 10 to 30 minutes, preferably 15 to 20 minutes, e.g. 15 minutes is acceptable. In a preferred embodiment, the temperature of the bath may be gradually elevated from the lowest to the highest temperature of the aforesaid temperature range as the exhaustion proceeds so that uniform absorption occurs in the shortest possible time and cross-linking of the silicone polymer, to the extent which it occurs, occurs subsequent to the absorption of the silicone polymer into the spandex.

Control of temperature, time and acidity of the exhausted bath after the addition of the curable thermosetting resin and catalyst is generally governed by the same considerations as the silicone polymer exhaustion step. Thus, the cross-linking reaction will be carried out at the highest temperatures, strongest acidities and for the shortest time which will permit a substantially uniform degree of reaction throughout the fabric. Ordinarily, the reaction will be permitted to continue at a temperature of 100° to 180°F. preferably 120° to 160°F., e.g. 160°F., for a time sufficient to react substantially all of the resin, e.g. 5 to 15 minutes, preferably 5 to 10 minutes. In a preferred embodiment, the temperature of the bath may be slowly increased from the lowest to the highest part of the aforesaid temperature range as the reaction proceeds in order to reduce the total required reaction time and to insure a high degree of cross-linking with the silicone polymer.

The finishing process of the invention may include appropriate rinsing steps both prior to the silicone exhaustion step and subsequent to the cross-linking reaction step. Preferably, the initial rinse will take place in an aqueous acidic solution which has been acidified with a weak acid such as acetic acid in order to assure uniform acidity throughout the bath and on the fabric so that the silicone polymer will be uniformly exhausted. The final rinse may be carried out with water or an aqueous solution of a mild detergent and is included merely for the purpose of removing unreacted materials from the surface of the fabric.

A previously noted, upon completion of the finishing process, including any rinsing steps, the knitted fabric or garments are tumbled dried in conventional tumbling equipment which normally includes an extraction step and thereafter are placed in an oven and cured. The curing step is carried out at a temperature of 220° to 250°F., preferably 220° to 230°F., e.g. 230°F. for a sufficient time to fully cure the thermosetting resin and the complex molecule formed by cross-linking the thermosetting resin with the silicone polymer, e.g. 5 to 15 minutes, preferably 5 to 7 minutes.

The invention will be further understood by reference to the following illustrative Example.

EXAMPLE 1

Large bags containing knitted hosiery formed from nylon and spandex yarns were placed in a conventional dyeing machine. The bags were scoured in a bath containing tetrasodium pyrophosphate detergent for 15 minutes at 160°F. and were then subjected to two successive 5 minute rinses with water at 120°F. Thereafter, the hosiery was dyed, using a conventional dye formu-

lation and procedure which included adding the dispersed dyestuffs to the bath and exhausting the dye onto the fabric in a slightly basic medium at elevated temperature. Upon exhaustion of the dye, the bags were rinsed with water at 160°F. for 5 minutes.

Upon completion of the above-described dyeing procedure, the bags of hosiery were left in the dyeing machine and were rinsed with water at a temperature of 120°F. The pH of the water was adjusted to 5.0 by the addition of acetic acid. Subsequently, the bath was dropped and a fresh bath of water adjusted to a pH of 4.5 was circulated for approximately 5 minutes. Thereafter, 3 wt.% of a silicone water emulsion containing 3 wt.% silicone polymer solids based upon the weight of the hosiery was added to the bath and the pH was adjusted to 4.0 by the addition of suitable quantities of acetic acid. The emulsion comprised methylhydrogen polysiloxane emulsified with tridecyloxypoly(ethyleneoxy) ethanol having a 30 wt.% solids content. After addition of the silicone emulsion, the temperature of the bath was raised to 140° and the bath was circulated for approximately 15 minutes. Thereafter the temperature was slowly raised to 180°F. until the silicone was exhausted. Exhaustion occurred in 10 minutes and was determined by a change of the bath from a cloudy or milky appearance to a clear solution.

The temperature of the exhausted bath was dropped to 120°F., its pH adjusted to 4.5, and thereafter 0.3 wt.% based on the weight of the hosiery of a zirconium-zinc acetate catalyst and 3 wt.% of dimethylol ethylene urea were added to the bath. The bath was circulated for approximately 5 minutes after which time the temperature of the bath was raised to 160°F. and held for an additional 5 minutes. The bath was then dropped and the bags of hosiery were rinsed with water containing a small amount of soap at a temperature of 110°F. for a period of 5 minutes.

The bags of hosiery were subjected to a conventional drying process consisting of extracting for 2 minutes followed by tumble drying at 200°F. for 30 minutes. Finally, the bags of hosiery were placed in a Despatch oven and cured at a temperature of 230°F. for 5 minutes.

The finished hosiery produced in accordance with the above process was subjected to multiple launderings and exhibited significantly more durability than similar hosiery which had not been subjected to the finishing process. Examination of the hosiery revealed that it had an improved hand and did not possess the "rubber" feel normally associated with the spandex-containing hosiery.

A latitude of modification, change and substitution is intended in the foregoing disclosure and in certain instances, some features of the invention will be used without a corresponding use of other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the spirit and scope of the present invention.

What is claimed is:

1. A finishing process for treating fabrics containing spandex yarn comprising placing the fabric in a bath containing a water emulsion of a lower alkyl polysiloxane polymer, said polymer having an active hydrogen group, acidifying the bath, exhausting said polymer onto said fabric at a temperature of 100° to 200°F. for a period of 10 to 30 minutes to permit substantially uniform absorption of said polymer by the spandex in said fabric, adding dimethylolethylene urea and a curing agent for said urea to said bath, said urea being curable to form a viscous thermosetting resin, reacting said urea with said absorbed polysiloxane polymer at a temperature and for a time sufficient to permit a substantially uniform reaction throughout the fabric and thereafter subjecting said fabric to elevated temperature for a time sufficient to cure the reaction product.

2. The process of claim **1** wherein the pH of said bath is maintained in the range of 4.0 to 6.0.

3. The process of claim **1** wherein said reaction is carried out at a temperature of 100° to 180°F. for a period of 5 to 15 minutes.

4. The process of claim **1** wherein said reaction product is cured by exposure of the fabric to a temperature of 220° to 250°F. for a period of 5 to 15 minutes.

5. The process of claim **1** further including the step of rinsing said fabric with an acidic solution prior to said polysiloxane exhaustion step.

6. The process of claim **1** wherein said fabric is rinsed and dried prior to said curing step.

7. The process of claim **1** wherein said fabric is dyed prior to said polysiloxane exhaustion step.

8. A finishing process for treating fabrics containing spandex yarn comprising placing the fabric in a bath containing a water emulsion of a lower alkyl polysiloxane polymer, said polymer having an active hydrogen group, acidifying the bath, exhausting said polymer onto said fabric at a temperature of 100° to 200°F. for a period of 10 to 30 minutes to permit substantially uniform absorption of said polymer by the spandex in said fabric, adding a curable dimethylolethylene urea and a curing agent for said urea to said bath, said urea being curable to form a viscous thermosetting resin, reacting said urea with said absorbed polysiloxane polymer at a temperature of 100° to 180°F. for a period of 5 to 15 minutes to permit a substantially uniform reaction throughout the fabric and thereafter subjecting said fabric to a temperature of 220° to 250°F. for a period of 5 to 15 minutes to cure the reaction product.

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