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Ito et al.

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[54] **PROCESS OF ENHANCING PILLING RESISTANCE OF TEXTILE MATERIALS**

[75] Inventors: **Toshio Ito; Tokuhisa Miyamatsu; Iwao Miyashita,** all of Nagoya, Japan

[73] Assignee: **Mitsubishi Rayon Company Limited,** Tokyo, Japan

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[51] **Int. Cl.** **D06c 11/00;** D06c 29/00
[58] **Field of Search** .... 26/28, 69, 1, 69 R; 51/80 R, 80 A; 101/23

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Primary Examiner—Robert R. Mackey
Attorney, Agent, or Firm—Armstrong, Nikaido & Wegner

[57] **ABSTRACT**

Pilling resistance of textile materials containing synthetic staple fibers is enhanced by pressing the textile materials laid on an abrasive surface carrying thereon numerous fine abrasive grains with sharp edges, whereby defects are formed in the staple fibers distributed on the textile fiber surface by the sharp edges.

6 Claims, 9 Drawing Figures

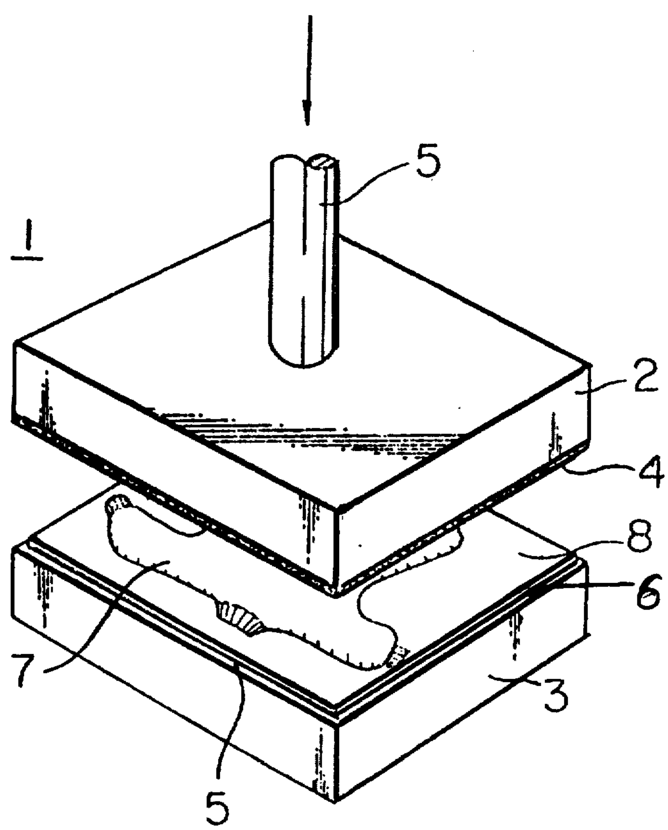


Fig. 1

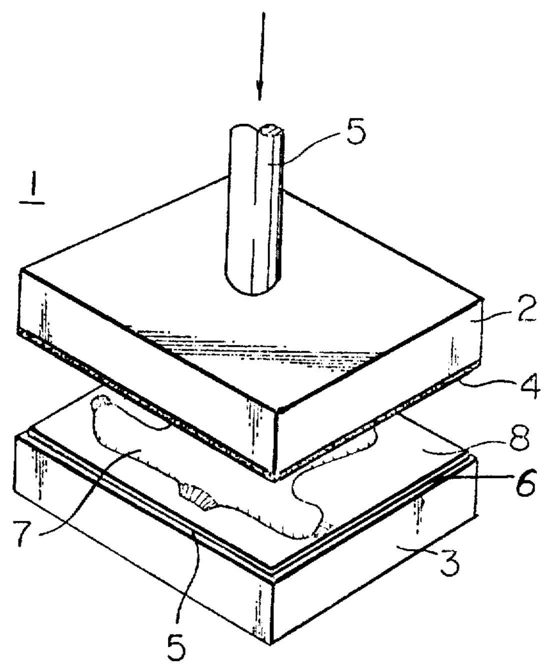


Fig. 2

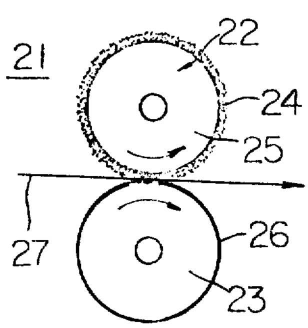


Fig. 3

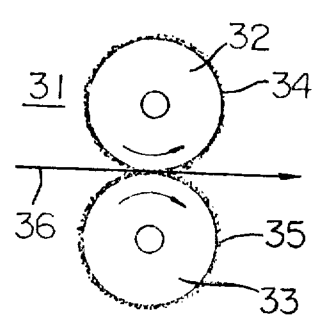


Fig. 4

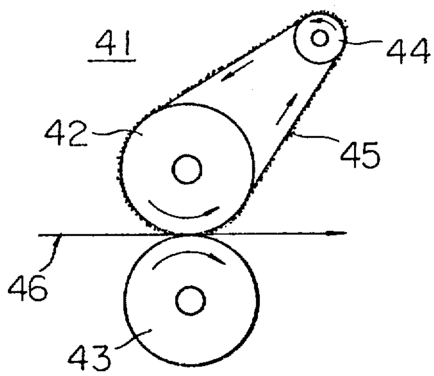


Fig. 5

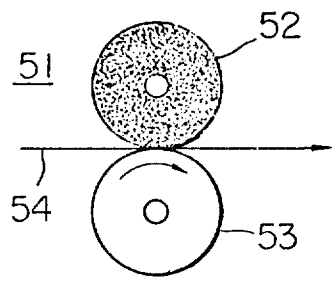


Fig. 6

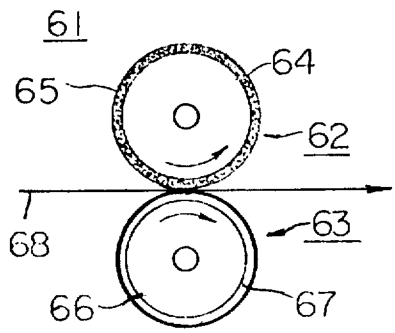


Fig. 7

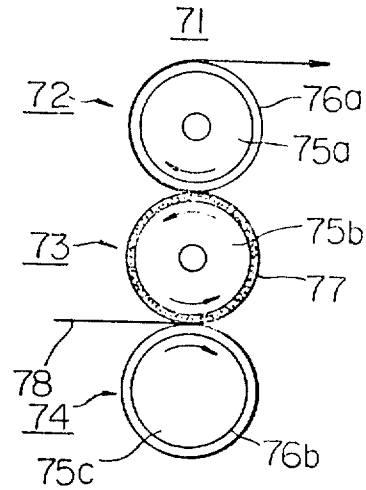


Fig. 8

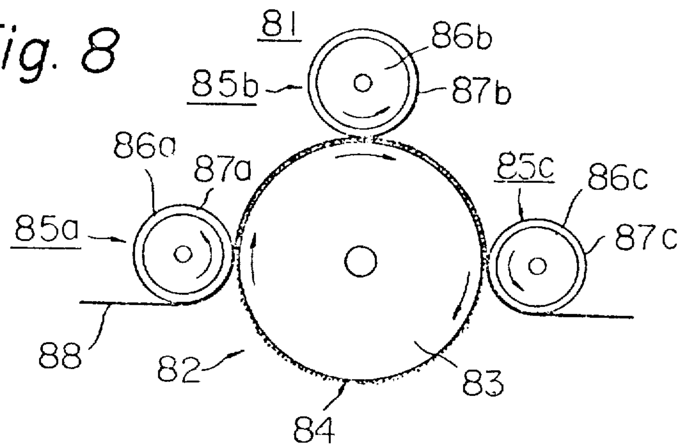
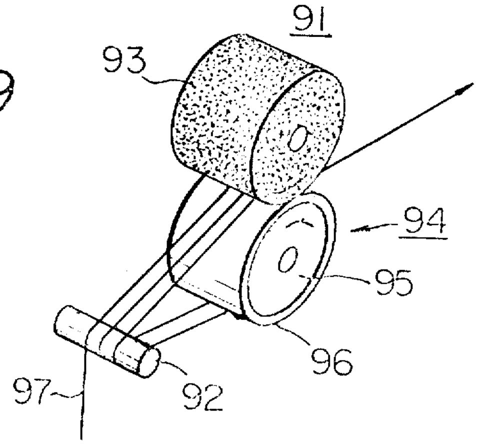


Fig. 9



PROCESS OF ENHANCING PILLING RESISTANCE OF TEXTILE MATERIALS

BACKGROUND OF THE INVENTION

The present invention relates to a process of enhancing pilling resistance of textile materials containing synthetic staple fibers; more particularly, it relates to a process of enhancing pilling resistance of spun yarns, woven fabrics and knitted fabrics containing synthetic staple fibers.

Generally, it is known that textile materials such as spun yarns, and woven knitted fabrics containing the spun yarns, have large disadvantages in that numerous pills are formed on their surfaces during wearing. This is especially true in the cases where high tenacity staple fibers, such as synthetic fibers and highly crimped fibers, are used for forming the textile material. These textile materials have a high softness due to the low frictional property of the staple fibers and it is very difficult to avoid pill-formation on the textile material surface. The pills formed on the textile material surface result in an undesirable appearance and feel to the hand.

The mechanism of the pill-formation is not completely known at the present time. However, it seems that when the textile material surface is rubbed against itself or other surfaces during wearing, fluffs, flues and dusts on the surface are entangled with each other so as to frizz a few little tufts. These little tufts draw out the fibers entangled with them from the textile material and build up into large pills.

If the staple fibers have a low tenacity or strength, they are broken by rubbing during wearing and removed from the textile material surface without pill-formation. However, the synthetic fibers usually have a high tenacity and tend to form numerous pills on the textile material surface.

In order to prevent the textile material from the undesirable pill-formation, various methods of enhancing the pilling resistance of the textile materials are provided, as follows.

1. The tenacity and elongation of the staple fibers to be formed into the desired textile material are reduced. The little tufts initially formed on the textile material surface are, therefore, easily removed from the surface before they build up into pills.
2. The frictional resistance of the fibers to each other is increased in order to enhance the resistance of the fiber against draw out from the textile material.
3. Staple fibers having a small number of crimps are used for forming the textile material. Such small number of crimps is effective for preventing the undesirable entanglements of the fibers with each other.

In the first method, the low tenacity fibers are produced by a special fiber-forming method or by treating the textile material with special chemicals. The former method results in difficulty in the spinning of the low tenacity staple fibers. The latter method results in disadvantages such as unevenness in dyeing characteristics and undesirable touch of the textile material.

In the second method, the high frictional resistance of the fibers results in an undesirable feel to the touch, high stiffness and limitation of use. Therefore, the second method is merely valuable for limited fabrics and uses only.

In the third method, the small number of crimps on the fibers results in difficulty in the spinning of yarns.

The object of the present invention is to provide a process of enhancing pilling resistance of textile materials containing staple fibers, without a resultant undesirable feeling to the hand and appearance.

SUMMARY OF THE INVENTION

The object of the present invention can be accomplished by the process wherein at least one surface of a textile material containing staple fibers is brought into contact with an abrasive surface, carrying thereon numerous abrasive grains having sharp edges. The textile material is pressed on the abrasive surface so as to form defects in the fibers distributed on the textile material surface with the sharp edges.

The scratched fibers on the textile material surface have a low tenacity. Therefore, when the textile material surface is rubbed, the scratched fibers are easily broken and removed from the surface without pill-formation.

In the process of the present invention, the pressing may be intermittently effected between two flat pressing faces, wherein at least one face is covered by an abrasive layer containing numerous fine abrasive grains. Also, the pressing may be continuously effected between a pair of nipping rollers, wherein at least one roller is covered by an abrasive layer containing numerous fine abrasive grains. In this case, the nipping rollers may rotate either at the same peripheral velocity as each other or at different peripheral velocities from each other. When one roller rotates at a different peripheral velocity from that of the other, it is preferable that the ratio of larger to smaller peripheral velocities is greater than 1.0 but not exceeding 1.5.

By the pressing in accordance with the process of the present invention, the textile material is enhanced in pilling resistance without undesirable changes of appearance and feeling to the hand or touch. However, its toughness is slightly lowered.

When the textile material is pressed onto the abrasive surface, carrying thereon numerous fine abrasive grains having sharp edges, the fibers located on the textile material surface are scratched by the sharp edges of the abrasive grains so as to form defects. These defects form weaknesses or incisions such as cuts, cracks, scratches or recesses, on the fiber surface. The weakness of the pressed fibers can be controlled by adjusting size and density of the abrasive grains. Also, in order to avoid a large reduction in the strength of the textile material during pressing, the material may be laid on a cushiony material such an elastic sheet; for example, a rubber sheet, polyurethane sheet or other synthetic elastic material sheet. It also may be laid on a thick fibrous sheet, for example, felt or thick cloth.

The abrasive surface usable for the present invention carries thereon numerous fine abrasive grains, having a hardness greater than the fibers with sharp edges to scratch the fibers. Such abrasive surface may be an abrasive sheet such as sand paper or sand cloth, on which numerous abrasive grains are fixed with a binder. It also may be an abrasive roller wherein an abrasive layer is formed on a metal roller, a natural or artificial grinding wheel.

The abrasive grains preferably consist of metallic material having a Shore hardness of 50 or more, for example, a carbon steel quenched by a high frequency induction process, or they may consist of an inorganic material having of a hardness of 5 or more in Moh's scale of hardness. Examples of such inorganic materials are diamond, boron carbide, silicon carbide and crystallized alumina; molten zircon, garnet, jade and rock crystal; silica, molten quartz, orthoclase and apatite; or mixtures of two or more of these materials. The abrasive grains usable for the process of the present invention preferably have a size of 16 to 250μ, and are preferably distributed in a density of 50 grains/cm^2 or more.

The pressing condition in the process of the present invention is controlled in accordance with the kind and form of the textile material and the abrasive surface.

The process of the present invention may be applied to synthetic fibers such as polyamide, polyester, polyacrylonitrile, polypropylene and polyvinyl alcohol fibers; semi-synthetic fibers such as triacetate and diacetate fibers; generated fibers such as rayon and cupra fibers; natural fibers such as wool and cotton. Also, the process of the present invention may be applied to web, tow, silver, roving yarn; non-woven fabric, spun yarn, woven fabric and knitted fabric containing the staple fiber spun yarn.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the process of the present invention will be apparent upon reading the following specification referring to the accompanying drawings in which:

FIG. 1 is a schematic view of an embodiment of a pressing apparatus usable for intermittently performing the process of the present invention,

FIGS. 2 to 8, respectively, are side views of embodiments of pressing apparatus usable for continuously performing the process of the present invention, and

FIG. 9 is a schematic view of an embodiment of a continuous pressing apparatus for a textile yarn.

The pressing apparatus as shown in FIG. 1 is useful for pressing piece goods of textile material such as sweaters, skirts and dresses in accordance with the process of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a pressing apparatus 1 is composed of a pair of flat pressing plates 2 and 3. The upper pressing plate 2 has a lower flat abrasive layer 4 and is connected to a driving means (not shown in the drawing) through a shaft 5. The lower pressing plate 3 has a flat upper surface 6 for supporting thereon a piece good 7 of the textile material. If it is necessary, the upper surface 6 of the lower pressing plate 3 may be covered by a cushiony sheet 8, such as a rubber sheet or felt sheet.

The abrasive layer 4 contains numerous abrasive grains. The upper pressing plate 2 is pushed down by the driving means and presses the piece good 7 on the lower pressing plate 3 which is non-movable. By this pressing action the upper side of the piece good 7 is brought into contact with the abrasive surface 4 and its pilling resistance is enhanced. Next, the opposite side of the piece good 7 is put on the upper surface 6 of the lower pressing plate 3 so that the unscratched surface of the piece good 7 comes into contact with the abrasive surface 4 when pressed by the upper pressing plate 2.

In the apparatus of FIG. 1, the upper surface 6 of the lower pressing plate 3 may be covered by an abrasive layer instead of the cushiony sheet 8. In such case, both the upper and lower sides of the piece goods 7 are simultaneously pressed by the abrasive surfaces.

The apparatus as shown in FIGS. 2 to 9 are useful for continuously pressing textile material such as tow, silver, web, roving, fabric and yarn.

Referring to FIG. 2 the continuous pressing apparatus 21 is composed of two rotatable rollers 22 and 23. The upper roller 22 has a core roller 25 surrounded by an abrasive paper 24 which contains numerous abrasive grains. The lower roller 23 has a smooth surface 26. A continuous textile material 27, such as fabric or yarn, is supplied into the pressing apparatus 21 and continuously nipped between the upper and lower rollers 22 and 23. One side surface of the textile material which has contacted the abrasive paper 24 is enhanced in pilling resistance.

Referring to FIG. 3, the pressing apparatus 31 is composed of upper and lower rollers 32 and 33. Each roller respectively has abrasive paper 34, 35 surrounding it. When a textile material 36 is continuously pressed by the pressing apparatus 31, both the upper and lower side surfaces of the textile material 36 are simultaneously brought into contact with the abrasive papers 34, 35 and thereby enhanced in pilling resistance.

The apparatus 41 as shown in FIG. 4 is provided with a upper roller 42, lower roller 43, a tension roller 44 and an abrasive cloth 45. When the upper or lower roller 42 or 43 is driven the abrasive cloth 45 endlessly circulates around the upper roller 42 and tension roller 44 while pressing the textile material 46. The tension roller 44 is movable so as to keep the abrasive cloth 45 at a predetermined tension. That is, in the pressing apparatus of FIG. 4, the abrasive cloth 45 is separable from the upper roller 42.

In the pressing apparatus 51 of FIG. 5, an upper roller 52 is made from a grinding wheel and a lower roller 53 has a smooth surface. A textile material 54 is pressed between the upper and lower rollers 52 and 53.

Referring to FIG. 6, a pressing apparatus 61 is provided with an upper roller 62 and a lower roller 63. The upper roller 62 has a core roller 64 and a surrounding abrasive layer 65, which consists of numerous abrasive grains and a binder for fixing the abrasive grains. The lower roller 63 has a core roller 66 and a cushiony layer 67. The cushiony layer 67 consists of an elastic or compressible material and surrounds the core roller 66. When a textile material 68 is pressed between the abrasive layer 65 and the cushiony layer 67, a portion of the pressure is absorbed by the cushiony layer 67. This prevents scratches in the textile material which are too large.

The pressing of the present invention may be applied to the textile material only once under a suitable pressure. However, the pressing may be applied to the textile material twice or more under a relatively low pressure. Such repeated pressing is valuable for enhancing the pilling resistance of the textile material with a small decrease of the tenacity and elongation.

The apparatus as shown in FIGS. 7 through 9 are useful for continuously and repeatedly pressing the textile material.

Referring to FIG. 7, the pressing apparatus 71 is provided with an upper roller 72, a middle roller 73 and a lower roller 74. The upper roller 72 is composed of a core roller 75*a* and a cushiony layer 76*a*; the middle roller 73 is composed of a core roller 75*b* and an abrasive layer 77; the lower roller 74 is composed of a core roller **75**c and a cushiony roller **76**b. A textile material is first pressed between the lower roller **74** and the middle roller **73**, after which it is pressed a second time between the middle roller **73** and the upper roller **72**. In this case, one side surface of the textile material is pressed twice by the abrasive surface.

Referring to FIG. **8**, the pressing apparatus **81** has a large roller **82** which is composed of a core roller **83** and a surrounding abrasive cloth **84** and three small rollers **85**a, **85**b, **85**c. Each of the three small rollers is composed of a core roller **86**a, **86**b, **86**c and a cushiony layer **87**a, **87**b, **87**c surrounding the core roller. When the large roller **83** rotates, a textile material **88** is successively pressed three times between the abrasive cloth **84** of the large roller **82** and the small rollers **85**a, **85**b, **85**c.

The pressing apparatus as illustrated in FIG. **9** is useful for successively pressing a textile yarn twice or more. Referring to FIG. **9**, the pressing apparatus **91** is provided with a guide roller **92**, an upper roller **93** and a lower roller **94**. The guide roller **92** is located in front of the upper and lower rollers **93** and **94** and in parallel with them. The upper roller **93** consists of a grinding wheel and thus has an abrasive surface on its periphery. The lower roller **94** is provided with a core roller **95** surrounded by a cushiony layer **96**. A textile yarn **97** is supplied to the upper and lower rollers **93** and **94** through the guide roller **92** and wound around the guide roller **92** and the lower roller **94** once or more times (twice in FIG. **9**). When the upper or lower roller **93** or **94** rotates, the textile yarn is pressed twice or more (three times in FIG. **9**) between the upper and lower rollers **93** and **94**.

In the process of the present invention, the pressure to be applied to the textile material is adjusted in consideration of the kind, form and thickness of textile material, kind, size and density of the abrasive grains on the abrasive surface; diameter of the pressing roller, and utilization of the cushiony roller. When the textile material is pressed with an abrasive surface without cushion, the pressure is adjusted into a relatively low value in order to prevent breakage of the textile material.

In the case where the textile material is pressed between two flat pressing surfaces, it is preferable that the pressure is adjusted into a value of $180\sqrt{W}$ or more in g/cm^2, wherein W represents the weight in g/m^2 of the textile material. In this flat pressing if the cushion is utilized for absorbing a portion of the pressure, the pressure to be applied to the textile material will be increased with the increase of pressure absorption by the cushion.

In the case where the textile material is continuously pressed by nipping it with nipping rollers while rotating them, it is preferable that the pressure to be applied to the textile material is adjusted to a value of $60\sqrt{W}$ in g/cm^2 or more, wherein W represents the weight in g/m^2 of the textile material. In this continuous pressing, if one of the nipping rollers is covered by a cushion layer on its periphery, the nipping pressure will be increased with the increase of pressure absorption by the cushion.

In the case where a textile yarn is continuously pressed using a nipping roller, the pressure to be applied to the textile yarn is preferably adjusted to a value of $1,100\sqrt{D}$ in g/meter 2 count or more, where D represents the sum of the meter count of the textile yarns applied to the nipping roller at the same time. In this nipping, if one of the nipping rollers is surrounded by a cushion layer, the pressure to be applied to the textile yarn will be increased with the increase of the pressure absorption of the cushion.

The process of the present invention is usually effected at a room temperature. However, it is preferable that the textile material containing thermoplastic synthetic fibers is pressed at a relatively high temperature at which the hardness of the synthetic fibers is lowered. Such pressing at a temperature higher than the room temperature results in a decrease of pressure necessary under which the textile material is enhanced in pilling resistance.

Generally, in the continuous nipping process of the present invention, a pair of nipping rollers is rotated at the same peripheral velocity. However, they may rotate at a different peripheral velocity from each other. In this case, it is preferable that the ratio of higher to lower peripheral velocities of the two rollers is greater than 1 but not exceeding 1.5. If the ratio is greater than 1.5, it results in undesirable frizzing or breakage of the textile material.

The following examples illustrate the present invention but are not intended to limit the scope of the invention thereto.

In the examples, pilling resistance, bursting strength and flat abrasion resistance of the textile material were respectively determined by the methods described below.

The pilling resistance was determined using an ICI type tester as follows.

ICI TYPE TESTER

The ICI type test consists of a rotating box lined with cork and of special rubber tubes to be put in it.

The rotating box is a regular hexahedron of an inner side 23 cm, and the lining cork has the following conditions:

Thickness	Approx. 3 mm
Density	0.21 ± 0.03 g/cm^3
Tensile strength	7 kg/cm^2 or more
Hardness	62 ± 2 deg. (by Asker Type F)
Grain size	10 to 60 mesh

However, the usable limit of cork surface lining in principle is 1,500 hours rotation, and is replaced each time it is broken or worn.

Each special rubber tube is a cylinder having both ends rounded, and has the following parameters:

Thickness	Approx. 3 mm
Length	Approx. 150 mm
Outer diameter	Approx. 31 mm
R of both end corners	Approx. 4 mm
Weight	50 ± 2 g
Hardness	42 ± 5 deg. (by Asker Type C)

When first used, 4 per set are put in the box and the box was rotated empty for 10 hours before putting it to use.

TEST METHOD

Two pieces each of test piece, 10×12 cm, are sampled from the specimen, in warp direction and weft direction in the case of woven fabric, and in wale and course direction in the case of knit fabric, and shall be wound around the special rubber tube in the natural state so as not to apply tension in the short side direction. The excess specimen is cut off to prevent the test pieces from being piled on together, and the test pieces are sewn with cotton yarn, and both ends are taped so as not to cover the edge of the rubber tube with the film form adhesive tape approx. 1.8 cm wide. A unit of 4 of these test pieces wound around the rubber tubes is put into the rotating box of the tester, and the tester is operated at the rotational speed of 60 r.p.m. for 10 hours in case of the woven fabric and 5 hours in the case of the knit fabric. The test result is represented by the average value of four test pieces.

The pilling resistance of the specimen is classified in five classes. Class 1 represents the poorest resistance and class 5 represents the highest resistance.

The bursting strength of the textile material, that is, woven and knitted fabrics, is determined in accordance with the method defined in JIS L-1076 (Method A) using an ICI type tester.

The flat abrasion resistance of the textile material is determined in accordance with the procedure defined in ASTM D1175-64T, Infrated Diaphragm Method, using an abrasive paper No. 0.

EXAMPLE 1

A knitted fabric for a sweater having a weight of 110 g/m^2 was prepared from a folded yarn of 42 metric count. This consisted of a blend of 50 percent by weight of cotton and 50 percent by weight of polyethylene terephthalate fiber of a denier of 1.5 and a length of 48 mm. An abrasive paper, carrying thereon abrasive grains consisting of silicon carbide, and having an average size of 24μ, was superimposed on the above-prepared knitted fabric so as to bring an abrasive surface of the abrasive paper into contact with a surface of the knitted fabric. This was then pressed between a pair of flat pressing plates, as shown in FIG. 1, under a pressure of 10 kg/cm^2. The pressed knitted fabric had a pilling resistance of class 4 at the end of testing for 10 hours in the ICI type method. Compared with this, the control knitted fabric had a pilling resistance of class 2.5.

EXAMPLE 2

Plain knitted fabrics with a weight of 180 g/m^3 were prepared from a high bulky folded yarn of 36 metric count using a knitting machine of 12 gauge. The yarn consisted of acrylic fibers having a denier of 3 and a length of 51 mm.

The knitted fabrics were dyed and finished with a softening agent by a conventional process. Each knitted fabric was then superimposed on abrasive paper, carrying abrasive grains consisting of alumina and having an average grain size of 48μ and a density of about 1,000 grains/cm^2, so as to bring a surface of the knitted fabric into contact with an abrasive surface of the abrasive paper. The knitted fabrics on the abrasive surfaces were pressed 1 to 5 times by nipping them between a metal roller, of a diameter of 350 mm, and a felt-covered roller of a diameter of 600 mm. Each roller rotated at the same peripheral velocity of 18 m/min and a pressure of 32 kg/cm^2.

The knitted fabrics thus pressed were subjected to testing of pilling resistance, bursting strength and flat abrasion resistance. The results are shown in Table 1.

Table 1

Item Number of pressing times	Pilling resistance (class)	Bursting strength (kg/cm^2)	Flat abrasion resistance (times)
Control	1 – 2	8.2	330
1	3 – 4	7.5	299
2	4	7.2	280
3	4 – 5	7.1	272
4	5	6.9	260
5	5	6.6	240

As Table 1 clearly illustrates, although the knitted fabric not pressed together with the abrasive paper had a very poor resistance to pilling, the pressed knitted fabrics had a high resistance to pilling. The larger the number of pressings, the higher the resistance of the knitted fabric to pilling, and the lower the bursting strength and flat abrasion resistance. The knitted fabrics pressed five times had a bursting strength of 6.6 kg/cm^2 and a flat abrasion resistance of 240 times, which are sufficient for practical use.

EXAMPLES 3 to 5

The following three fabrics were provided.

The fabric of Example 3 was a plain woven fabric having a weight of 80 g/m^2, and consisting of a blend of 30 percent by weight of cotton and 70 percent by weight of polyethylene terephthalate fibers.

The fabric of Example 4 was a plain stitch knitted fabric having a weight of 280 g/m^2, and consisting of a blend of 20 percent by weight of polycapramide fibers and 80 percent by weight of wool.

The fabric of Example 5 was a double jersey having a weight of 190 g/m^2, and consisting of a blend of 60 percent by weight of acrylic fibers and 40 percent by weight of wool.

Each fabric was pressed between two metal rollers. One metal roller had a diameter of 300 mm, and was coated with a hard polyurethane resin with a rubber hardness of 90 and a thickness of 5 mm. The other metal roller had a diameter of 150 mm, and was coated with an abrasive layer containing 10 parts by weight of silicon carbide grains, having sizes of 48 to 125μ, and 3 parts by weight of epoxy resin with a thickness of 30 mm. These two rollers rotated at the same peripheral velocity of 15 m/min, at nipping pressures as shown in Table 2.

The pressed fabrics were steam-treated by passing them through a steamer under an ambient pressure. The fabrics were then subjected to testing of pilling resistance for 10 hours.

Table 2

Example No.	Nipping pressure (kg/cm^2)	Pilling resistance (class)
3	2.5	4.5
	Control	3.5
4	6.5	3.5
	Control	1
5	5.0	4.0
	Control	2

From Table 2, it is obvious that the fabrics treated by the method of the present invention had higher pilling resistances than the control fabrics.

EXAMPLES 6 to 8

The following three fabrics were provided. The fabric of Example 6 was a plain stitch knitted fabric prepared from a blend yarn. This blend consisted of 40 percent by weight of polyethylene terephthalate fibers, of a denier of 3 and a length of 51 mm, and 60 percent by weight of rayon staple, of a denier of 2.5 and a length of 51 mm.

The fabric of Example 7 was a tubular knitted fabric with a Milano rib structure prepared from a blend yarn. This blend consisted of 35 percent by weight of polycapramide fibers, of a denier of 3 and a length of 64 mm, and 65 percent by weight of wool.

The fabric of Example 8 was a plain woven fabric prepared from a spun yarn of 100 percent acrylic fibers of a denier of 1.2 and a length of 51 mm.

Each fabric was pressed once between two rollers under a nipping pressure of 120 kg/cm². One roller was an abrasive roller, wherein a metal roller having a diameter of 320 mm is covered with an abrasive paper carrying thereon abrasive grains, consisting of silicon carbide and having an average size of 57μ. The other roller was a cushion roller comprising a metal roller having a diameter of 500 mm covered with a compressed felt of a thickness of 3 mm.

The abrasive roller was rotated at a peripheral velocity of 5 m/min constant. The cushion roller was varied in peripheral velocity to 2, 3.5, 5, 7.5 and 10 m/min. The pressed fabrics were subjected to the testing of pilling resistance in the ICI type method for 10 hours. The results are shown in Table 3.

From Table 3, it is understood that in the cases where the ratio of larger to smaller peripheral velocities of the two rollers was greater than 1.0 but not exceeding 1.5, the pressed fabrics had a pilling resistance higher than that in the case where both rollers rotated at the same peripheral velocity. However, in the former cases, the pressed fabrics had a bursting strength lower than that in the latter case.

Considering now the cases where the ratio of larger to smaller peripheral velocities of the two rollers was larger than 1.5. That is, in Table 3, the cases where the cushion roller was in peripheral velocities of 2 and 10 m/min. The fabrics of Examples 6 and 7 were broken during the pressing and the bursting strength of the pressed fabric of Example 8 was too low to use in practice.

EXAMPLE 9

A folded yarn of 32 metric count, having a potential high bulkiness, was prepared from 60 parts by weight of regular acrylic fibers and 40 parts by weight of high shrinkage acrylic fibers of a denier of 2 and a length of 51 mm. The yarn was pressed between two rollers, having a peripheral velocity of 420 m/min under a pressure of 1.0 kg/cm² 1, 2, 3, 4 and 5 times. One roller was a stainless steel drive roller of a diameter of 120 mm and a width of 50 mm. The other roller was an abrasive follow roller of a diameter of 100 mm and a width of 20 mm.

The abrasive follow roller was made of a medium density high hardness grinding wheel containing abrasive grains, consisting of alumina crystals, and having an average size of 60μ.

The pressed yarns were converted to high bulky yarns by steaming. The bulky yarns were dyed and finished with a softening agent by a conventional process and, thereafter, knitted into plain stitch knitted fabric using a knitting machine of 12 gauge. Bursting strength, flat abrasion resistance and pilling resistance of the resultant knitted fabrics are shown in Table 4 in comparison with the pressing times.

Table 3

Example No.	Item	Control	Pressed fabric at peripheral velocity of cushion roller in m/min 2.0	3.5	5.0	7.5	10.0
6	Pilling resistance (class)	2	—	4	3	4	—
	Bursting strength (kg/cm²)	6.5	—	3.2	5.8	4.2	—
7	Pilling resistance (class)	2.5	—	4	3.5	4	—
	Bursting strength (kg/cm²)	7.1	—	5.0	6.5	4.8	—
8	Pilling resistance (class)	1.5	4.5	3.5	3	4	4.5
	Bursting strength (kg/cm²)	8.2	2.8	6.2	7.4	5.4	3.6

Table 4

	Pressing		Yarn		Knitted fabric		
Experiment No.	Nipping pressure (kg/cm²)	Number of pressing times	Tensile strength (g)	Elongation at break (%)	Bursting strength (kg/cm²)	Flat abrasion resistance (time)	Pilling resistance (class)
1	1.0	1	690	29.8	5.79	310	3.5
2	1.0	2	650	26.0	5.68	304	4.5
3	1.0	3	625	24.0	5.52	305	5.0
4	1.0	4	570	22.7	5.45	300	5.0
5	1.0	5	550	21.3	5.30	295	5.0
6	0.25	5	690	28.2	5.72	290	1.5
7	0.5	5	630	24.5	5.65	282	4.0
8	0.75	5	590	22.7	5.50	292	5.0
9	1.5	5	420	18.0	4.90	293	5.0
Control	—	—	880	34.5	6.20	325	1.5

Note: The testing of pilling resistance was carried out for 5 hours in the ICI type method.

From Table 4, it is seen that the pilling resistance of the knitted fabrics tended to be enhanced as the number of pressing times increased. The resultant knitted fabrics had substantially the same feel to the hand and appearance as those of the control fabric which was non-pressed.

Further, the same pressing was repeated five times to the same yarns under nipping pressures of 0.25, 0.5, 0.75 and 1.5 kg/cm^2. The resultant yarns, and knitted fabrics from the yarns, had the properties as shown in Table 4.

From Table 4, it is obvious that, for the yarn used in the present invention, it is necessary to press it under a pressure of 0.50 kg/cm^2 or higher with the nipping rollers used in the present example.

EXAMPLE 10

A folded yarn of 20 metric count was prepared from 40 percent by weight of polycapramide fibers of 2 denier and 60 percent by weight of wool and dyed by the conventional process. The yarn was pressed under a condition detailed below.

1. Nipping rollers

A metallic upper roller of a diameter of 50 mm and a width of 50 mm was covered with a polyurethane resin sheet having a rubber hardness of 90 and a thickness of 1.5 mm. A metallic lower roller having a diameter of 30 mm and a width of 20 mm was covered with an abrasive layer. This layer was composed of abrasive grains consisting of finely divided carbon steel, hardened by a high frequency induction quenching method; having a Shore hardness of 60 and sizes of 34 to 80μ, and a binder combining the abrasive grains in a thickness of 3 mm.

2. Nipping pressure: 1.2 kg/cm^2
3. Peripheral velocity of rollers: 250 m/min
4. Number of times of pressing: 1

The pressed yarn had a small decrease of tensile strength of 9 percent, and a small decrease of elongation at break of 10 percent, with respect to those of the original yarn. The yarn was formed into a plain stitch knitted fabric which had the same feel to the hand and appearance as that of the original yarn. The knitted fabric had a pilling resistance of class 4 in the testing for 5 hours in the ICI type method, and a bursting strength similar to that of the knitted fabric from the original yarn.

EXAMPLE 11

A web of a weight of 100 g/m^2 was prepared from regular acrylic fibers having a denier of 3 and a length of 51 mm. The web was pressed once by nipping it between a smooth metal roller and an abrasive roller under a nipping pressure of 15 kg/cm^2 and at a peripheral velocity of both the rollers of 10 m/min. The abrasive roller carried abrasive grains of an average size of 85μ consisting of silicon carbide.

60 parts by weight of the pressed acrylic fiber web was blended with 40 parts by weight of non-pressed acrylic fibers. This non-pressed acrylic fiber had a shrinkage higher by 25 percent than that of the regular acrylic fibers in boiling water under atmospheric pressure. The blend was formed into a folded yarn of 36 metric count having a high bulkiness potential by a conventional spinning process. The yarn was heated in steam to convert it to a high bulky yarn. The yarn had the pilling resistance, tensile strength and the elongation at break as shown in Table 5.

For comparison, a yarn was prepared in the same procedure as that stated above using the non-pressed regular acrylic fiber web. The comparison yarn had the properties as shown in Table 5.

Table 5

Yarn	Pilling resistance (class)	Tensile strength (g)	Elongation at break (%)
The Present Example	4 – 5	600	25
Comparison Example	1 – 2	850	27.2

Note:
The testing of pilling resistance was carried out for 5 hours in the ICI type method.

We claim:

1. A process of enhancing the pilling resistance of textile fabrics, which comprises bringing at least one surface of a textile fabric containing synthetic staple fibers into contact with an abrasive surface formed on the periphery of a rotating abrasive roller, said abrasive surface carrying thereon numerous abrasive grains having sharp edges, rotating a pressing roller in cooperation with said abrasive roller, wherein the peripheral velocity of the faster of the abrasive roller or pressure roller is 1.0 to 1.5 times the peripheral velocity of the slower of the abrasive roller or pressure roller; and simultaneously pressing said textile fabric on said abrasive surface with said pressing roller rotating in cooperation with said abrasive roller at a pressure such that said abrasive roller forms incisions on the surface of the fibers distributed on the textile surface to enhance the pilling resistance without substantially changing the appearance and feel of said textile fabric and while retaining acceptable fabric bursting strength.

2. A process as claimed in claim 1, wherein the pressing is applied onto said textile fabric under a nipping pressure of at least 60 $\sqrt{W}$ in g/cm^2 wherein W represents a weight in g/m^2 of the textile fabric.

3. A process as claimed in claim 1, wherein the abrasive grains have an average size of 16 to 150μ.

4. A process as claimed in claim 1, wherein said pressing roller has a cushiony peripheral surface.

5. A process as claimed in claim 4, wherein the cushiony surface is formed with an elastic material.

6. A process as claimed in claim 1 further including rotating at least a second pressing roller in cooperation with said abrasive roller and pressing said textile fabric on said abrasive surface with said second pressing roller thereby forming additional incisions on the surface of the fibers distributed on the textile surface to further enhance the pilling resistance.

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