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(54) Apparatus and method for shrinking textile substrates

(57) An apparatus and a method for shrinking continuous textile substrates are described. The apparatus comprises: a first motorized roller (4); a second motorized roller (5); an endlessly wound belt (3) for conveying and supporting the textile substrate (2); a pre-tensioning means (6) for applying a predetermined longitudinal tension to the belt and a means (7) for guiding the belt. According to the invention, the belt is substantially elastically deformable longitudinally. The pre-tensioning means comprises an idle roller (6) and the guiding means comprises a rotating drum (7) for guiding the belt (3) along a length (34) between the second motorized roller (5) and the first motorized roller (4). The textile substrate (2) is conveyed arranged between the belt (3) and the rotating drum (7).

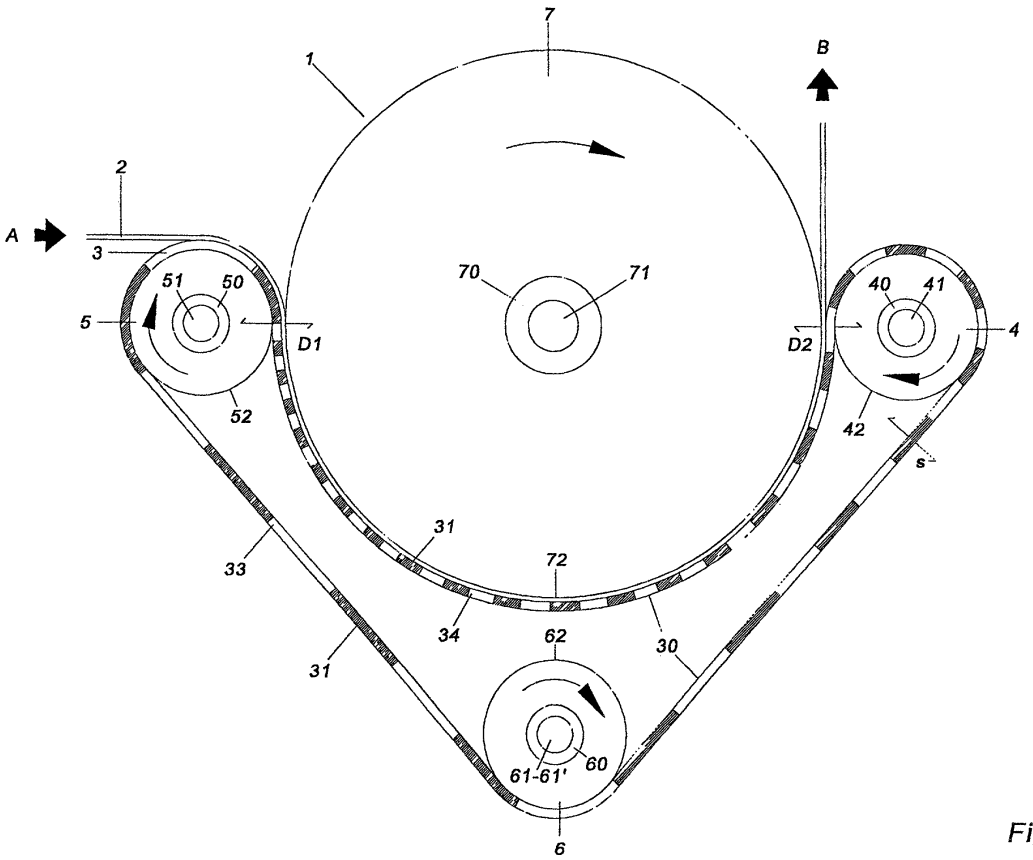

Fig. 1

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Description

[0001] The present invention relates in general to the treatments which produce shrinkage of textile substrates. In particular it relates to an apparatus and a method for shrinking continuous textile substrates such as, for example, cross-woven fabrics, knitted fabrics, non-woven fabrics and so on.

[0002] As is known, the shrinkage treatment of continuous textile substrates is performed in order to reduce substantially their tendency to shrink in an uncontrolled manner. Shrinkage of the textile substrates could occur, for example, owing to the effect of the physical and mechanical processing operations which they undergo during manufacture of the articles of clothing or following domestic maintenance of these articles of clothing.

[0003] The effect of this undesirable shrinkage phenomenon is a negative dimensional variation, i.e. a mainly longitudinal contraction. As a result, there is a reduction in the size of the clothing, compared to that envisaged during manufacture, or to that purchased by the user.

[0004] The known shrinkage treatments performed during a cycle for finishing continuous textile substrates substantially compact the threads arranged transversely with respect to the threads arranged longitudinally. In this way the transverse threads are arranged more closely together, have a greater density and a smaller freedom of movement. Consequently, the longitudinal dimension of the continuous textile substrate is reduced by a certain amount, which is variable depending on the morphological characteristics of the substrate and in particular the efficiency of the apparatus used.

[0005] A known shrinkage technique is so-called "compressive shrinkage". This technique is based essentially on the use of a belt together with which the textile substrate to be shrunk is firmly joined. The belt and the textile substrate to be shrunk are driven around rollers or cylinders with a different radius of curvature. The characteristics of the belt and/or the system are such as to cause a reduction in the length or peripheral speed of the belt along a short section immediately downstream of the joining point with the substrate. In this way, as the belt becomes shorter, it conveys along with it the textile substrate which also contracts. The technique and the characteristic features of the belt may differ depending on whether the textile substrate is essentially a cross-woven fabric or a knitted fabric.

[0006] The patent US 2,021,975 discloses a method and an apparatus for treating cross-woven fabrics. This known apparatus uses a belt having a surface which passes from an initial untensioned state into an extended state and again into an untensioned state following a path which is alternately more or less convex on support rollers and on a rotating drum. The textile material to be shrunk is fed onto the surface of the belt and is tightly pressed against it along the section of the path in the extended state: in this way the fabric is conveyed in such a way as to be contracted by the surface of the belt along the following length of the path where its contraction into the untensioned state occurs.

[0007] The patent US 4,156,955 describes a method and an apparatus for pre-shrinking fabrics. The apparatus comprises an entry roller, a heated rotating drum and a belt (usually consist of fibrous felt-like material) which travels so as to be wound around the surface of the entry roller and then the surface of the rotating drum. The surface of the belt which is situated on the outside with respect to the surface of the drum is subject along that very convex length (having a low radius of curvature) to an acceleration compared to the preceding straight section. On the other hand, where there is a subsequent reversal in curvature on the surface of the drum, the same surface of the belt is subject to a deceleration along that section which is not very convex. A flexible and strong sheet-like element with a smooth surface (referred to as "shoe" in the jargon of textile mechanics) is inserted between the surface of the belt which is on the outside with respect to that of the roller and the surface of the drum, extending depthwise between drum and belt. A continuous fabric is fed onto the belt wound around the roller, being inserted and arranged between its outer surface and the flexible sheet element. In this way the fabric is pressed against the belt so that they are joined together integrally and is driven by the belt so as to be wound around the surface of the drum. The fabric is in this way forced to follow the belt during the reversal in its curvature, which causes a deceleration thereof, and to undergo a consequent slowing down which produces longitudinal shrinkage.

[0008] The patents US 4,908,918 and US 4,969,243 describe a method and an apparatus for shrinking knitted fabric, in particular tubular knitted fabric. The apparatus according to both the patents comprises a belt for conveying/shrinking the textile substrate to be treated and a member ("shoe") for inserting/pressing said substrate in the shrinkage zone. The belt consists of a textile structure with a substantially non-extendable base, which supports a layer of fibrous material, usually of the needle-punched felt type, which is substantially extendable. When the bottom side rests rotationally on the surface of a drive roller, its unextendable surface does not undergo practically any longitudinal extension. On the other hand, the elastic surface of the belt is subject to an extending action along the curved section of the path, while it contracts subsequently when the path of the belt becomes substantially straight again. The degree of this elastic variation is also dependent on the total thickness of the belt and the ratio between the diameter of the belt drive roller and the thickness of the belt.

[0009] The prior documents considered indicate that the known technique of compressive shrinkage of a continuous textile substrate is based on the use of belts which are substantially deformable, be they made of rubber or fibrous material, and the deformation of which in the longitudinal direction of feeding essentially consists of a first expansion step and a second contraction step in succession. In a first case the deformation is induced by a com-

pressive pressure of the belt (which extends) followed by release of said pressure (the belt shortens, returning into the uncompressed condition); in a second case the deformation is induced by a succession of sections of the belt which are more or less convex (therefore causing extension thereof) and by means of sudden reversals in curvature (which cause shrinkage thereof).

[0010] In both cases, the textile substrate, engaged integrally with the deformable and/or extendable surface of the belt, is subject to a "compression" in the direction of feeding, namely a compaction of its structure and, ultimately, longitudinal shrinkage.

[0011] Said prior documents indicate, moreover, the need to use mechanical means able to feed, engage and press the textile substrate and the belt during the expansion and contraction steps in order to maximize the performance of the treatment.

[0012] The main problem of the known solutions is that the range of action of these expansion and contraction steps is overall relatively limited, both owing to the basic principle of the treatment and, in particular, owing to the characteristics of limited deformability of the types of belt which are used.

[0013] In fact, the desired degree of shrinkage to be imparted to the textile substrate cannot be regulated except within very small limits and depends essentially on the deformation capacity of the belt during use, in addition to the morphological and structural characteristics of the said substrate.

[0014] As a consequence, either the residual shrinkage potential of the substrates does not reach - except in exceptionally favourable circumstances - the "zero" target, or, on the other hand, the degree of "compression" imparted to it exceeds the maximum compaction limit which can be withstood by the different textile structures of the substrates.

[0015] In the first case, the textile substrate maintains a residual shrinkage potential generally of between 2% and 5%, values which are at present not satisfactory for the manufacturers of articles of clothing. In the second case, when the degree of compression is excessive, the textile substrate "rejects" the excessive compacting, resulting in undesirable surface defects, generally in the form of deformations and/or distortions (referred to as "orange peel", "elephant skin", or the like, in the technical jargon).

[0016] The object of the present invention is to provide an apparatus and a method which allow a shrinkage treatment to be performed on a textile substrate which results in extremely low values of the residual shrinkage potential following treatment of the substrate.

[0017] In particular, an object of the present invention is to provide an apparatus and method which allow a gradual and unforced shrinkage treatment to be performed, avoiding any defects in the textile substrate.

[0018] These and other objects are obtained by an apparatus according to Claim 1 and by a method according to Claim 16. Further advantage features are described in the respective dependent claims. All the claims are deemed to be an integral part of the present description.

[0019] According to a first aspect, the present invention provides an apparatus for shrinking a continuous textile substrate. The apparatus comprises: a first motorized roller, a second motorized roller, a closed loop wound belt for conveying and supporting the textile substrate and a pre-tensioning means for applying a longitudinal tension to the belt and a means for guiding the belt. According to the invention, the pre-tensioning means comprise a third roller, which is preferably idle, and the means guiding the belt comprises a rotating drum for guiding the belt along a length between the second motorized roller and the first motorized roller. The textile substrate is conveyed arranged between the belt and the rotating drum. The belt according to the present invention is substantially elastically deformable in extension.

[0020] According to the invention, the tangential speed on the outer surface of the first motorized roller is less than the tangential speed on the outer surface of the second motorized roller.

[0021] According to one embodiment, there is a third motorized roller situated downstream, with respect to an advancing direction of the belt and the first motorized roller, and connected to the first motorized roller so that the tangential speeds on the respective outer surfaces substantially coincide. The belt is wound at least partially around the third motorized roller.

[0022] Preferably there is an idle roller for guiding the belt, situated between the third motorized roller and the idle pre-tensioning roller, the belt being wound at least partially around the idle guide roller.

[0023] According to one embodiment, there is a fourth motorized roller situated upstream, with respect to an advancing direction of the belt and the second motorized roller, and connected to the second motorized roller so that the tangential speeds on the respective outer surfaces substantially coincide, the belt being wound at least partially around the fourth motorized roller.

[0024] Preferably, a fifth motorized roller is provided. Such a fifth roller being arranged between the fourth motorized roller and the idle pre-tensioning roller and connected to the second motorized roller so that the tangential speeds on the respective outer surfaces substantially coincide, the belt being wound at least partially around the fifth motorized roller.

[0025] Typically, during use, a first length of the belt substantially lying between the first motorized roller and the third idle pre-tensioning roller and between the latter and the second motorized roller has a longitudinal extension greater than the longitudinal extension in the pre-tensioned condition.

[0026] In a preferred embodiment, the first belt length is the length between the idle guide roller, the idle pre-tensioning roller and the fifth motorized roller.

[0027] Typically, during use, a second length of the belt substantially lying between the second motorized roller and the first motorized roller has a longitudinal ex-

tension less than or equal to the longitudinal extension in the pre-tensioned condition.

[0028] Preferably, the rotating drum has a side surface for guiding at least part of the second length of the belt, the side surface of the drum being heated to a temperature higher than the ambient temperature.

[0029] Conveniently, the belt comprises a substantially extendable and elastic material, of natural origin, preferably based on rubber.

[0030] Alternatively, the belt comprises a substantially extendable and elastic material, of synthetic origin, preferably a polyurethane polymer or the like.

[0031] Alternatively, the belt comprises a substantially extendable and elastic material, of textile origin, preferably a felt supported by an extendable structure essentially consisting of elastic fibre.

[0032] Preferably, the belt is elastically deformable in extension by a percentage ranging between 5% and 100% of its length in the untensioned state and, more preferably, equal to about 50% with respect to its untensioned length when subjected to a tensile force of about 3-12 kg/cm.

[0033] Preferably, the distance between the surface of the drum and the surface of the second motorized roller is less than or equal to the thickness of the belt and the distance between the surface of the drum and the surface of the first motorized roller is greater than or equal to the thickness of the belt.

[0034] According to a second aspect, the present invention provides a method for shrinking a continuous textile substrate. The method according to the invention comprises the steps of:

- providing a closed loop wound belt, said belt being substantially elastically deformable in extension (and therefore also in contraction);
- providing a first motorized roller and a second motorized roller, closed loop winding the belt between the first and the second motorized roller and applying a pre-tensioning force to the belt;
- driving the belt by means of the first motorized means and the second motorized means so that at least a first length thereof is subjected to a pulling force greater than the pre-tensioning pulling force and a second length thereof is subjected to a pulling force less than or equal to the pre-tensioning pulling force;
- providing a treatment/guiding surface along the second belt length; and
- feeding a continuous textile substrate so that it is conveyed arranged between the treatment surface and the belt along at least one portion of its second length.

[0035] Preferably, the step of providing a belt comprises the step of providing a belt which is elastically deformable in extension by a percentage ranging between 5% and 100% of its length in the untensioned state and, preferably, equal to about 50% with respect to its untensioned length when subjected to a tensile force of about 3-12 kg/cm.

[0036] Preferably, the belt conveying step comprises the step of providing a first motorized roller; a second motorized roller; an idle roller; and a rotating drum for guiding the belt along its length between the second motorized roller and the first motorized roller, the tangential speed of the second motorized roller being greater than the tangential speed of the first motorized roller.

[0037] Preferably, the step of providing a treatment surface comprises the steps of providing an idle drum having an outer surface and heating this outer surface.

[0038] Preferably, the belt, along at least one portion of its first length, is more extended compared to its pre-tensioned condition by a percentage ranging between about 5% and 50%.

[0039] Preferably, the step of feeding the continuous textile substrate comprises the step of feeding a continuous textile substrate on the surface of the belt in the fully extended state and conveying the textile substrate on the belt in the state where fully contracted and subject to gradual untensioning. The present invention is based essentially on a shrinkage technique involving sliding. By means of the present invention all the technical and qualitative drawbacks of the known art of compressive shrinkage are overcome and the productive efficiency of the known solutions is increased.

[0040] A detailed description of the invention, provided purely by way of a non-limiting example, now follows, said description to be read with reference to the accompanying figures in which:

- Figure 1 shows, in schematic form, a first embodiment of the apparatus according to the invention; and
- Figure 2 shows, in schematic form, a second embodiment of the apparatus according to the invention.

[0041] With reference initially to Figure 1 this shows a first embodiment of the invention. The apparatus 1 for shrinking a continuous textile substrate 2 advancing in a direction A-B comprises a belt 3, a first motorized roller 4, a second motorized roller 5, an idle transmission roller 6 and a drum 7.

[0042] The belt 3 is endlessly wound and is substantially elastically deformable longitudinally. The term "belt elastically deformable longitudinally", for the purposes of the present description and the accompanying claims, is understood as meaning a belt which is elastically deformable so as to be extended and shortened such that, when subjected to a longitudinal pulling force, it is subject to an elastic deformation ranging between 5% and 100% of its length compared to its length in a substantially untensioned state (not subject to any pulling force). Preferably, the elastic deformation ranges between 5% and 50% of the length of the belt compared to its length in a substantially untensioned state when the belt is subjected to a tensile force of between about 2 kg/cm and about

15 kg/cm. More preferably, the elastic deformation is about 50% when the belt is subjected to a tensile force of between about 3 kg/cm and about 12 kg/cm.

[0043] The first and the second roller 4, 5 are preferably motorized rollers for driving the belt 3. In turn, the belt 3 supports and conveys the textile substrate 2. The drum 7 is preferably idle and heated and acts essentially as a locating surface for guiding the belt 3. The outer surface of the drum 7 is indicated by 72 and the thickness of the belt 3 is indicated by S.

[0044] In the embodiment shown in Figure 1, the first motorized roller 4 and the second motorized roller 5 are made to rotate in a first direction (clockwise) about axial shafts 40 and 50, respectively, by motor means, known and not shown, keyed onto hubs 41 and 51 of said shafts. The rollers 4, 5 and 6 have a side surface indicated by 42, 52, and 62, respectively.

[0045] The endlessly wound belt 3 follows a closed path and defines an inner surface 30 and an outer surface 31. The belt 3 is wound, at least partially, with its inner surface 30 onto the side surface 42, 62, 52 of the rollers 4, 6, 5. The belt 6 is wound with its outer surface 31 onto the side surface 72 of the drum 7.

[0046] With the arrangement according to Figure 1, the idle roller 6 is arranged downstream of the motorized roller 4 and upstream of the motorized roller 5; the drum 7 is arranged between the motorized rollers 4 and 5 so that the side surface 72 of the cylinder is facing in the vicinity of the side surfaces of the motorized rollers 4 and 5 and at a distance D. The distance D, preferably, substantially coincides with the thickness S of the belt. In the advancing direction of the belt 3, for the purposes of the present invention, at least two lengths of the belt 3 are identified: a first "lower" length 33 substantially lying between the first motorized roller 4 and the second motorized roller 5 (passing via the idle transmission roller 6) and a second "upper" length 34 substantially lying between the second motorized roller 5 and the first motorized roller 4.

[0047] The idle roller 6 exerts on the belt, along the first length 33, a predefined vertical thrust by means of mechanical, pneumatic or hydraulic means. The belt is thus operationally pre-tensioned longitudinally over the whole of its length.

[0048] According to the present invention, the belt 3 is driven so as to be fed forwards by the first motorized roller 4 at a first predefined and adjustable tangential speed. The belt is also driven so as to be fed forwards by the second motorized roller 5 at a second tangential speed. The second tangential speed is greater than that imparted by the first roller. In this way, the first length 33 of the belt 3 is deformed so as to be extended and the second length 34 of the belt is deformed so as to be contracted. In other words, along the first length 33, the belt 3 has a longitudinal extension greater than that assumed in the pre-tensioned state. Along the second length 34 the belt has a longitudinal extension which is smaller than that assumed in the pre-tensioned state. The contracted or extended pre-tensioning and deformation states are graphically shown in Figure 1.

[0049] The drum 7 is driven so as to rotate in an anti-clockwise direction by the second length 34, the surface 31 of which is at least partially wound onto the side surface 72 of the cylinder. Preferably, the side surface 72 is heated to a predefined temperature by known steam, diathermic oil, electric resistances, etc.

[0050] Preferably, the drum 7 is made to rotate in an anti-clockwise direction about an axial shaft 70 by means of a reducer, known and not shown, keyed to a hub 71 of the shaft. The reducer is connected to the motor of the second motorized roller 5 by known transmission means. The reducer imparts to the side surface 72 of the drum 7 a tangential speed which is substantially equal to that of the side surface 52 of the second motorized roller 5.

[0051] The belt portion partially wound around the first motorized roller 4 is extended and pre-tensioned in a manner corresponding to the pre-tensioning. Along the first length 33 of the belt 3 from the first motorized roller 4 to the idle roller 6 and to the second motorized roller 5, the belt is driven so as to be pulled by the second motorized roller 5 which has a speed of rotation greater than that of the first motorized roller 4. Consequently, the belt undergoes a gradually increasing extension compared to its normally pre-tensioned length (which, as mentioned above, corresponds to the length of the belt partially wound onto the first motorized roller 4). The maximum extension of the belt 3 is achieved in the portion of the belt which is partially wound onto the second motorized roller 5.

[0052] Along the second "upper" length 34 of the belt 3 the portion 34 of the belt is driven "slack" by the first motorized roller 4 at a speed of rotation less than that of the second motorized roller 5. Consequently, along the second length, the belt is gradually slackened until it reaches its normal pre-tensioned length passing through decreasing degrees of contraction. The maximum contraction occurs immediately downstream of the second motorized roller 5 and total recovery of the pre-tensioned state is reached, as mentioned above, along the portion of the belt partially wound onto the first motorized roller 4.

[0053] During this contraction or slackening step the surface 31 of the second length 34 travels engaged with and partially wound over the surface 72 of the drum 7. However, owing to the effect of elastic recovery of the second length 34, its surface 31 "slides" partially over the surface 72 of the drum in the opposite direction to the advancing direction.

[0054] A continuous textile substrate 2 is fed in contact with the surface 31 of the belt 3 substantially where it is subject to maximum extension (around the second motorized roller 5). The textile substrate is situated tightly gripped between the surface 72 of the drum 7 and the surface 31 of the belt. Conveniently, as mentioned above, the surface 72 of the drum is heated to a certain temperature. The second length 34 of the belt and the textile substrate 2 supported by the surface 31 are pushed by

the second motorized roller 5 so as to rotate about the drum 7 and are pulled by the first motorized roller 4 so as to be extracted from the drum.

[0055] The textile substrate 2, which is initially received by the belt during maximum extension, is then conveyed on the surface 31 of the length 34 of the belt during maximum contraction and gradual slackening.

[0056] However, the textile substrate 2 is not tightly constrained to the belt 3. Therefore, while the belt is contracted until it recovers practically entirely its original pretensioned state (in static or dynamic conditions) and the textile substantially follows the belt during said contraction, the textile substrate is able to slide lightly over the surface 31 and over the side surface 72 of the drum 7 in the opposite direction to the direction of contraction, namely in the opposite direction to the advancing direction.

[0057] With reference to Figure 2, a second embodiment of the present invention is described. The same reference numbers will be used to indicate the same components.

[0058] The apparatus 1 of the second embodiment is substantially similar to the apparatus 1 of the first embodiment. However, in addition to the first motorized roller 4, at least one third motorized roller 4a is provided in order to pull the belt and an idle roller 4b for guiding the belt. The third motorized roller 4a and the idle guide roller 4b are arranged in immediate succession downstream of the first motorized roller 4. A fourth motorized roller 5a and a fifth motorized roller 5b for pulling the belt 3 are arranged immediately upstream (relative to the advancing direction of the belt) of the second motorized roller 5.

[0059] The third motorized roller 4a, the fourth motorized roller 5a and the fifth motorized roller 5b are made to rotate about respective shafts 40a, 50a and 50b by transmission means, known and not shown. The transmission means are preferably keyed to respective hubs 41 a, 51 a and 51 b of the shafts 40a, 50a and 50b. The transmission means of the third motorized roller 4a are connected to the motor of the first motorized roller 4; similarly, the transmission means of the fourth and fifth motorized roller 5a, 5b are connected to the motor of the second motorized roller 5. In this way, the third motorized roller 4a will have substantially the same speed of rotation as the first motorized roller 4; the fourth and the fifth motorized roller 5a, 5b will have substantially the same speed of rotation as the second motorized roller 5.

[0060] The transmission means impart to the third and to the fourth motorized roller 4a and 5a an anti-clockwise direction of rotation and to the fifth motorized roller 5b a clockwise direction of rotation. The idle guide roller 4a also rotates freely about its shaft 40b in the clockwise direction. In this way the belt 3, along its "lower" first length 33 is wound at least partially, with its inner surface 30, onto the side surface 42, 42b, 52b, 52 of the respective rollers 4, 4b, 5b and 5; the belt 5 is wound at least partially with its opposite surface 31, onto the side surface 42a, 52a of the rollers 4a and 5a.

[0061] Consequently, the first "lower" length 33 of the belt is deformed so as to extend (i.e. is longer compared to the belt in the "static" or "dynamic" pre-tensioned states) by tensile driving by the second motorized roller 5 assisted by the third and by the fourth motorized roller 5a, 5b, with respect to the first motorized roller 4 assisted by the third motorized roller 4a. The idle roller 4b performs the function of guiding the first belt length 33 during pulling, hence extension, adapting the tangential speed of its side surface 42b to that of the surface 30 of the belt portion 33 wound around it.

[0062] Similarly, the second length 34 of the belt is deformed so as to contract by the first motorized roller 4 (assisted by the third motorized roller 4a) with respect to the second motorized roller 5 (assisted by the fourth and the fifth motorized roller 5a, 5b). Such an arrangement of motorized rollers allows the elimination, or at least minimization of any slipping between the surfaces of the rollers and those of the belt. In particular, the arrangement of the rollers is advantageous along the first belt length which is subjected to pulling and deformation in extension.

[0063] According to the invention, the belt 3 is at least partially made of substantially extendable and elastic material. According to a first preferred embodiment, this material is of natural origin, for example, rubber-based. According to a second preferred embodiment, this material is of synthetic origin, for example based on polyurethane polymer. According to a third preferred embodiment, this material is of textile origin in the form, for example, of felt supported by an extendable structure essentially consisting of an elastic fibre. Obviously, it is also possible to manufacture a belt combining two or more of the above-mentioned materials.

[0064] In any case, as mentioned above, the belt is subject to an elastic deformation in extension ranging between 5% and 100% of its length in the untensioned state and, preferably, equal to between 5% and 50% when the belt is subject to a tensile force of between about 5 kg/cm and about 25 kg/cm. More preferably, the elastic deformation in extension, with respect to its "untensioned" length is about 50% when the belt is subject to a tensile force of between about 3 kg/cm and about 12 kg/cm. In this extended condition (equal to about 50%), the contraction in the transverse direction ranges between about 10% and about 30% with respect to the substantially untensioned length.

[0065] The thickness S of the belt preferably lies in the range of between about 2.0 mm and 40.0 mm. More preferably, said thickness S lies in the range of between about 4.0 mm and 16.0 mm. According to a particularly advantageous embodiment of the invention, the belt has a thickness of about 10.0 mm. The belt is equally well made as woven fabric or non-woven fabric (for example of the felt type). Alternatively, the belt may be made as an elastic strap. The choice as to the preferred material for the belt depends primarily on the type of fabric to be treated. Preferably, rubber belts are advantageously used for cross-

woven fabrics or the like, while felt fabrics are advantageously used for knitted fabrics or the like.

[0066] The tangential or peripheral speed of the second motorized roller 5 is greater than that of the first motorized roller 4. The tangential speed of the second motorized roller 5 may also be double the tangential speed of the first motorized roller 4. Preferably, the tangential speed of the second motorized roller 5 is increased by 20% to 60% with respect to that of the first motorized roller 4. More preferably, the tangential speed of the second motorized roller 5 is about 40% greater than that of the first motorized roller 4.

[0067] The drum 7 for guiding the belt is preferably heated to a temperature ranging between about 50°C and about 200°C and, more preferably, to a temperature ranging between about 110°C and 140°C.

[0068] A distance D1 is provided between the side surface 72 of the drum 7 and the side surface 52 of the second motorized roller 5. Preferably, the distance D1 is less than the thickness S of the belt by an amount ranging between about 0% and about 50%. In this way, the belt and the textile substrate are firmly engaged with each other.

[0069] A distance D2 is provided between the side surface 72 of the drum 7 and the side surface 42 of the first motorized roller 4. Preferably, the distance D2 is greater than the thickness S2 of the belt by an amount ranging between 0% and 100%.

[0070] The continuous textile substrate may be a cross-woven fabric, or a knitted fabric or a non-woven fabric. The knitted fabric equally well has an open form or a tubular form.

[0071] The apparatus and the method for shrinking continuous textile substrates by means of "sliding" according to the present invention allow the textile substrate to exploit practically the whole of its shrinkage potential. In this way, the goal of "zero" residual shrinkage is achieved.

[0072] Advantageously, with use of the apparatus and the method according to the present invention the maximum shrinkage limit which is imposed by a specific textile structure of the substrate and beyond which said textile structure would be ultra-compacted is not exceeded. In other words, superficial deformations and/or distortions of the textile substrate are not generated.

[0073] Expressed in different terms, owing to the extensibility and elasticity characteristics of the belt and the possibility of deformation with extension and contraction by a predetermined and adjustable amount, the degree of compaction of the textile substrate may be varied and adjusted in proportion to its potential shrinkage limit.

[0074] However, owing to the possibility of sliding present in the apparatus and in the method according to the invention, it is possible in any case for the textile substrate to automatically regulate its degree of longitudinal contraction and therefore shrinkage, without encountering negative side effects.

[0075] A further advantage consists in the fact that the maximum contraction/shrinkage of the textile substrate is so rapid that it may be performed at speeds of advancing movement of the substrate which are considerably greater than those of the known "compressive" technique. In this way the productive capacity of the treatment is increased considerably.

Claims

1. Apparatus (1) for shrinking a continuous textile substrate (2), said apparatus (1) comprising: a first motorized roller (4); a second motorized roller (5); an endlessly wound belt (3) for conveying and supporting the textile substrate (2); a pre-tensioning means (6) for applying a predetermined longitudinal tension to the belt and a means (7) for guiding the belt, **characterized in that** said belt is substantially elastically deformable longitudinally, said pre-tensioning means comprise an idle roller (6) and said guiding means comprises a rotating drum (7) for guiding the belt (3) along a length (34) between the second motorized roller (5) and the first motorized roller (4), the textile substrate (2) being conveyed arranged between the belt (3) and the rotating drum (7).

2. Apparatus (1) according to Claim 1, wherein said first motorized roller (4) has an outer surface (42) and said second motorized roller (5) has an outer surface (52), **characterized in that** the tangential speed on the outer surface (42) of the first motorized roller (4) is less than the tangential speed on the outer surface (52) of the second motorized roller (5).

3. Apparatus (1) according to any one of the preceding claims, **characterized in that** it also comprises a third motorized roller (4a) arranged downstream, with respect to an advancing direction of the belt (3) and said first motorized roller (4), and connected to said first motorized roller so that the tangential speeds on the respective outer surfaces (42, 42a) substantially coincide, the belt (3) being wound at least partially around said third motorized roller (4a).

4. Apparatus (1) according to Claim 3, **characterized in that** it also comprises an idle roller (4b) for guiding said belt, the idle roller (4b) being arranged between said third motorized roller (4a) and said idle pre-tensioning roller (6), the belt (3) being wound at least partially around said idle guiding roller (4b).

5. Apparatus (1) according to any one of the preceding claims, **characterized in that** it also comprises a fourth motorized roller (5a) being arranged upstream, with respect to an advancing direction of the belt (3) and said second motorized roller (5), and connected to said second motorized roller (5) so that the tangential speeds on the respective outer sur-

faces (52, 52a) substantially coincide, the belt (3) being wound at least partially around said fourth motorized roller (5a).

6. Apparatus (1) according to Claim 5, **characterized in that** it also comprises a fifth motorized roller (5b) arranged between said fourth motorized roller (5a) and said idle pre-tensioning roller (6) and connected to said second motorized roller (5) so that the tangential speeds on the respective outer surfaces (52a, 52b) substantially coincide, the belt (3) being wound at least partially around said fifth motorized roller (5b).

7. Apparatus (1) according to any one of the preceding claims, **characterized in that**, during use, a first length (33) of the belt (3) substantially lying between said first motorized roller (4) and said idle pre-tensioning roller (6) and between the latter and said second motorized roller (5) has a longitudinal extension greater than the longitudinal extension in the pre-tensioned condition.

8. Apparatus (1) according to Claim 7, **characterized in that** said first belt length (33) is the length between said idle guide roller (4b), said idle pre-tensioning roller (6) and said fifth motorized roller (5b).

9. Apparatus (1) according to any one of the preceding claims, **characterized in that**, during use, a second length (34) of the belt (3) substantially lying between the second motorized roller (5) and the first motorized roller (4) has a longitudinal extension less than or equal to the longitudinal extension in the pre-tensioned condition.

10. Apparatus (1) according to any one of the preceding claims, **characterized in that** said rotating drum (7) has a side surface (72) for guiding at least part of said second length (34) of the belt (3), said side surface (72) of the drum being heated to a temperature higher than the ambient temperature.

11. Apparatus (1) according to any one of the preceding claims, **characterized in that** said belt (3) comprises a substantially extendable and elastic material, of natural origin, preferably based on rubber.

12. Apparatus (1) according to any one of the preceding claims, **characterized in that** said belt (3) comprises a substantially extendable and elastic material, of synthetic origin, preferably a polyurethane polymer or the like.

13. Apparatus (1) according to any one of the preceding claims, **characterized in that** said belt (3) comprises a substantially extendable and elastic material, of textile origin, preferably a felt supported by an extendable structure essentially consisting of elastic fibre.

14. Apparatus (1) according to any one of the preceding claims, **characterized in that** said belt (3) is elastically deformable in extension by a percentage ranging between 5% and 100% of its length in the untensioned state and, more preferably, equal to about 50% with respect to its untensioned length when subjected to a tensile force of about 3-12 kg/cm.

15. Apparatus (1) according to any one of the preceding claims, **characterized in that** a distance (D1) between the surface (72) of the drum (7) and the surface (52) of the second motorized roller (5) is less than or equal to the thickness (S) of the belt (3) and a distance (D2) between the surface (72) of the drum (7) and the surface (42) of the first motorized roller (4) is greater than or equal to the thickness (S) of the belt (3).

16. Method for shrinking a continuous textile substrate (2), the method comprising the steps of:

- providing an endlessly wound belt (3), said belt (3) being substantially elastically deformable longitudinally in extension;
- providing a first motorized roller (4) and a second motorized roller (5), endlessly winding the belt (3) between the first and the second motorized roller (4, 5) and applying a pre-tensioning pulling force to the belt;
- driving the belt by means of the first motorized means (4) and the second motorized means (5) so that at least a first length (33) thereof is subjected to a pulling force greater than the pre-tensioning pulling force and a second length (34) thereof is subjected to a pulling force less than or equal to the pre-tensioning pulling force;
- providing a treatment surface (72) along the second belt length (34); and
- feeding the continuous textile substrate (2) so that it is conveyed arranged between the treatment surface (72) and the belt (3) along at least a portion of its second length (34).

17. Method according to Claim 16, **characterized in that** the step of providing a belt (3) comprises the step of providing a belt which is elastically deformable in extension by a percentage ranging between 5% and 100% of its length in the untensioned state and, preferably, equal to about 50% with respect to its untensioned length when subjected to a tensile force of about 3-12 kg/cm.

18. Method according to Claim 16 or 17, **characterized in that** the belt conveying step comprises the step of providing a first motorized roller (4); a second mo-

torized roller (5); an idle pre-tensioning roller (6); and a rotating drum (7) for guiding the belt (3) along its length (34) between the first motorized roller (4) and the second motorized roller (5), the tangential speed of said second motorized roller (5) being greater than the tangential speed of said first motorized roller (4).

19. Method according to Claim 18, **characterized in that** the step of applying a pre-tensioning pulling force to the belt comprises the step of exerting on the belt a predetermined vertical thrust by means of the side surface (62) of said idle roller (6).

20. Method according to any one of Claims 16-19, **characterized in that** the step of providing a treatment surface (72) comprises the steps of providing an idle drum (7) having an outer surface (72) and heating said outer surface.

21. Method according to Claim 18, **characterized in that** the belt, along at least one portion of its first length (33), is more extended compared to its pre-tensioned condition by a percentage ranging between about 5% and 50%.

22. Method according to any one of Claims 16 to 21, **characterized in that** the step of feeding the continuous textile substrate comprises the step of feeding a continuous textile substrate (2) on the surface of the belt in the fully extended state and conveying the textile substrate on the belt in the state where fully contracted and subject to gradual untensioning.

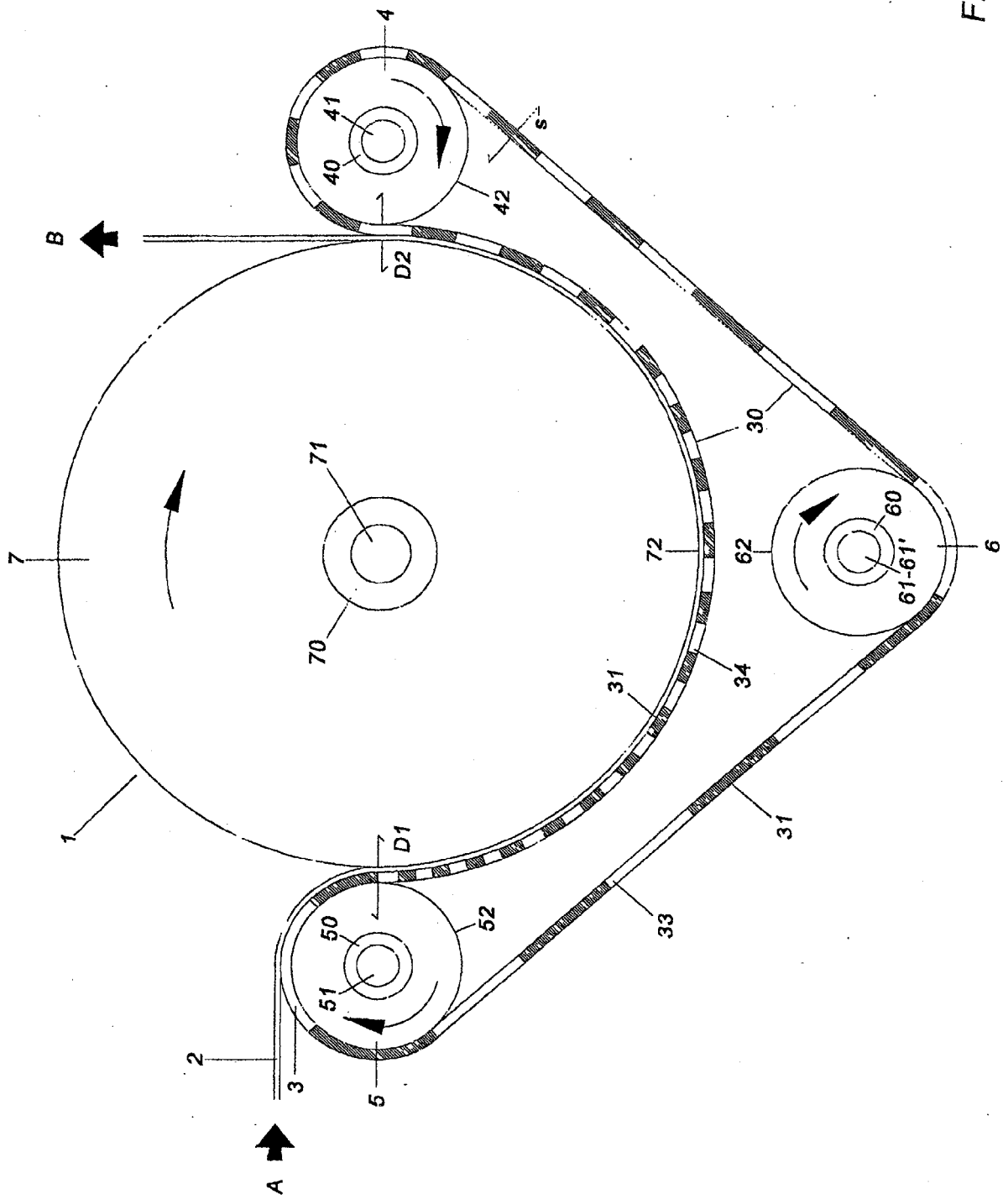
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Fig.1

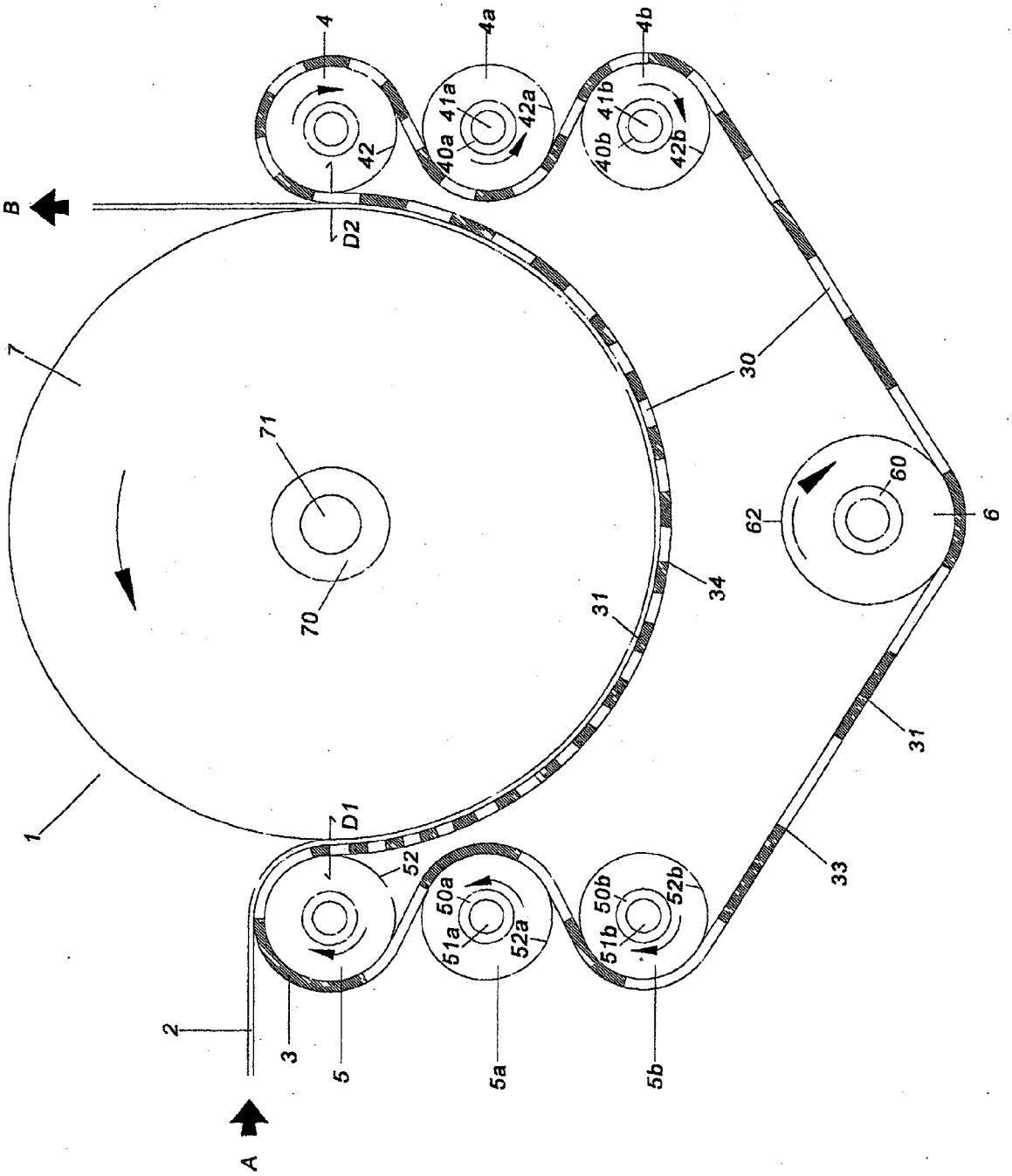
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Fig.2

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EUROPEAN SEARCH REPORT

Application Number
EP 04 42 5854

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D06C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	31 August 2005	Goodall, C

CATEGORY OF CITED DOCUMENTS

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