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(54) **PROCESS AND APPARATUS FOR MAKING ALTERNATE S/Z TWIST PLIED BRAID OR JOINED ALTERNATE S/Z TWIST PLIED YARNS**

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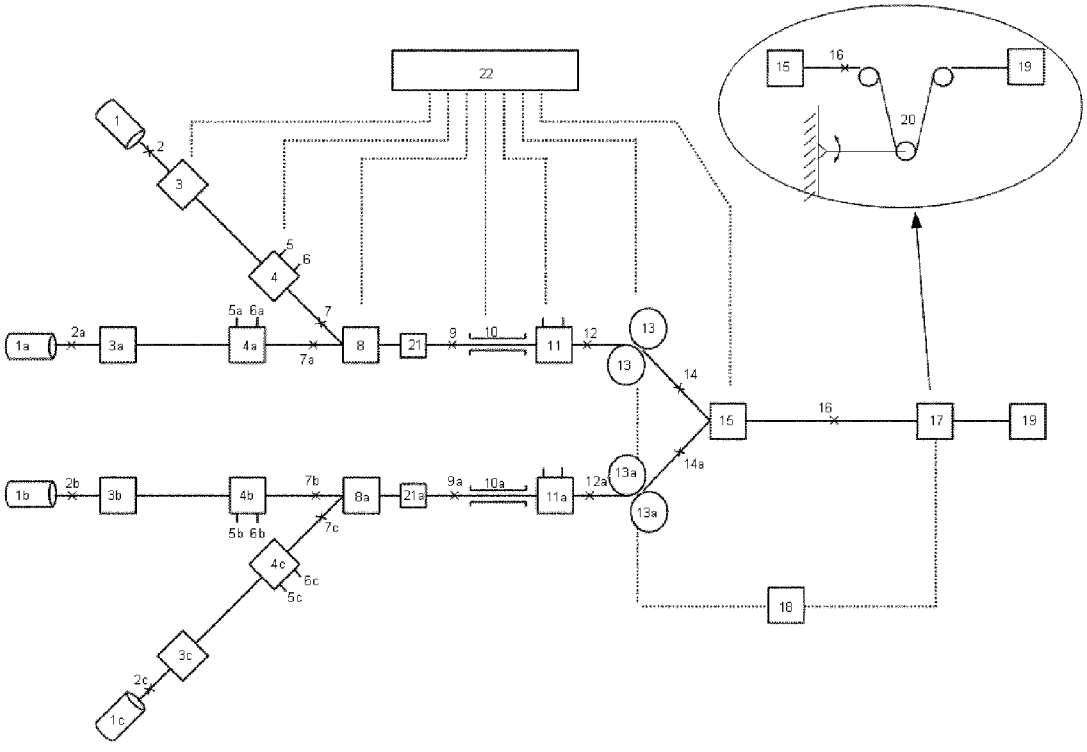
(57) **ABSTRACT**

The present invention provides an improved method and device for producing an alternate S/Z twist plied braid and joined alternate S/Z twist plied yarns. The invention further provides an alternate S/Z twist plied braid and joined alternate S/Z twist plied yarns produced according to a process of the invention.



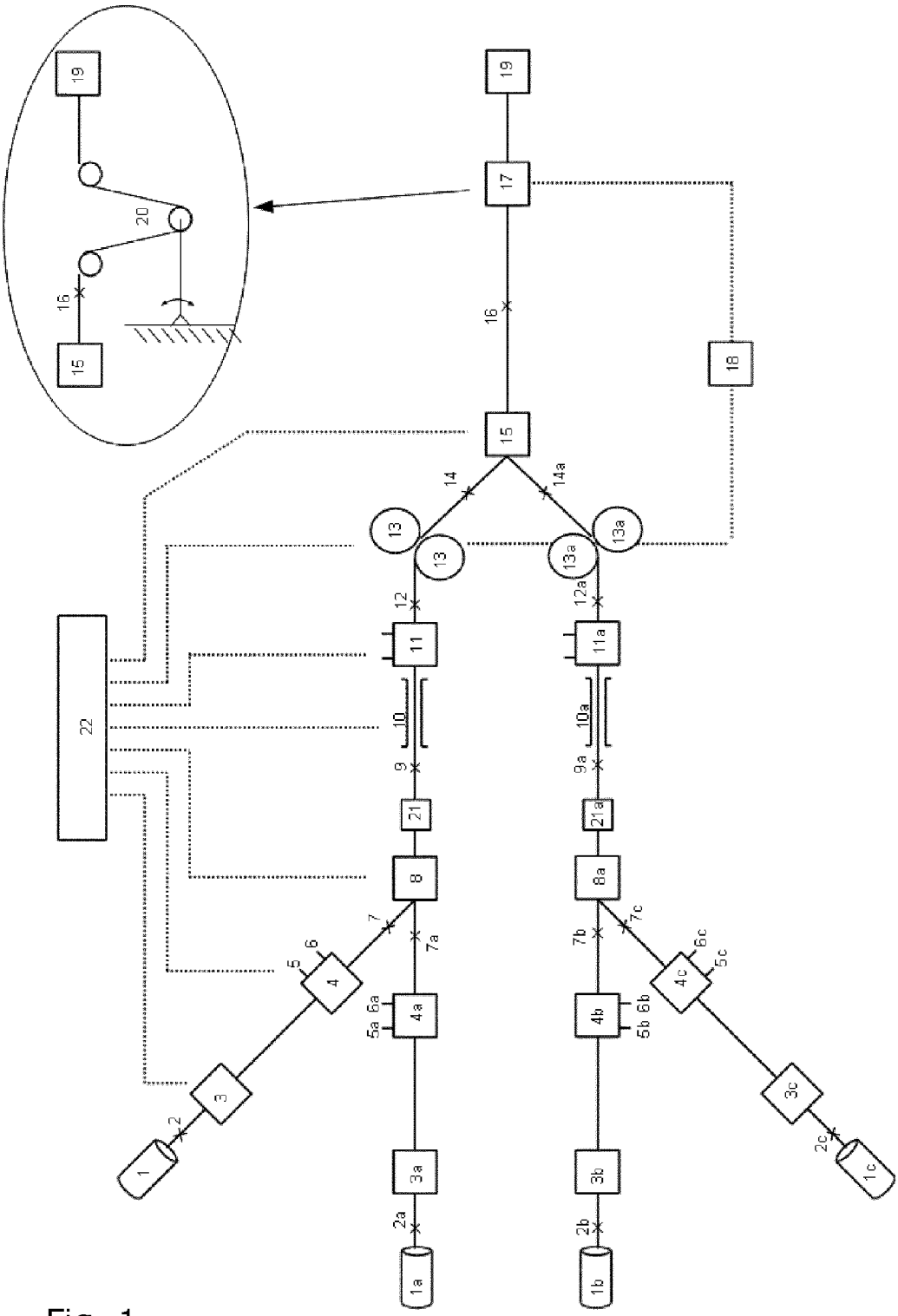

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Fig. 1

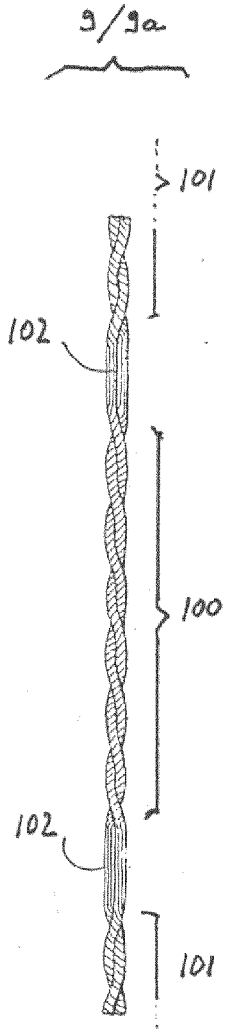

FIG. 2

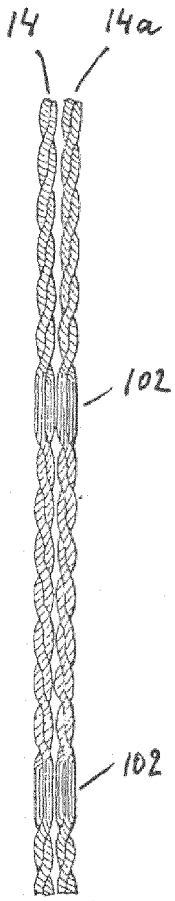

FIG. 3

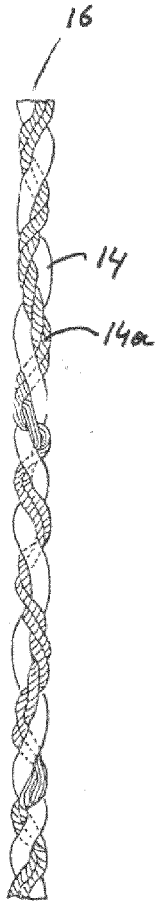

FIG. 4

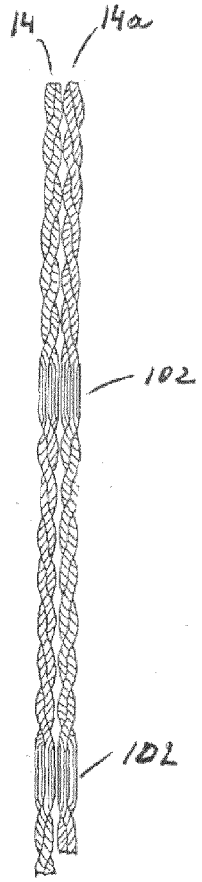

FIG. 5

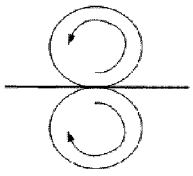

Fig. 6a

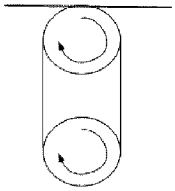

Fig. 6b

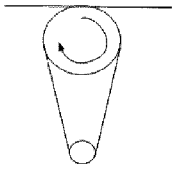

Fig. 6c

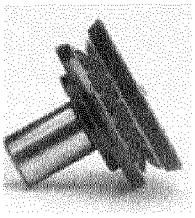

Fig. 6d

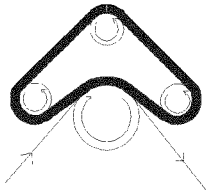

Fig. 6e

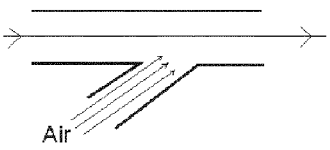

Fig. 6f

Fig. 6

PROCESS AND APPARATUS FOR MAKING ALTERNATE S/Z TWIST PLIED BRAID OR JOINED ALTERNATE S/Z TWIST PLIED YARNS

TECHNICAL FIELD

[0001] This invention relates to an improved method and apparatus for producing an alternate twist plied braid and joined alternate twist plied yarns. The invention further relates to alternate S/Z twist plied braid and joined alternate S/Z twist plied yarns obtained with the method.

BACKGROUND

[0002] The concept of producing alternate twist plied yarns using the alternate twist, self-twist phenomenon is now rather well known in the art. Documents in which the general principles of alternate twisting and self-twisting are described include the following: "Self-Twist Yarn", D. E. Henshaw, Merrow Publishing C° , Ltd., Watford, Herts, England, 1971; RE 27,717 Breen et al; U.S. Pat. No. 3,225,533 Henshaw; U.S. Pat. No. 3,306,023 Henshaw et al.; U.S. Pat. No. 3,353,344 Clendening, Jr.; U.S. Pat. No. 3,434,275 Backer et al.; U.S. Pat. No. 3,443,370 Walls; U.S. Pat. No. 3,507,108 Yoshimura et al.; U.S. Pat. No. 3,717,988 Walls; U.S. Pat. No. 3,775,955 Shahand and U.S. Pat. No. 3,940,917 Strachan.

[0003] For purposes of convenience, some general comments concerning producing plied yarn by these techniques will be described.

[0004] It is possible to form a plied yarn by alternate twisting two or more single yarn strands, attaching the strands to each other and then permitting the strands to wrap about each other using the release of forces stored by the alternate twisting to accomplishing the plying, hence the term "self-twist". The alternate twisting itself, in simplified form, involves holding spaced points of a yarn strand and twisting the strand in one direction at a point intermediate the held points, e.g., the center. This produces twists on one side of the center in one direction and on the other side of the center in the opposite direction. The center of the twisted strand constitutes a point of twist reversal and is called a "node". Clearly, forces are stored in the strand in the twisting step. When two strands similarly alternate twisted are brought together in side-by-side juxtaposition with their ends held and permitted to act against or with each other by releasing a central node, the stored forces cause the strands to ply, i.e., to wrap around each other spontaneously. The process is enhanced and the product made more stable if the nodes of the two strands are aligned and are joined or joined together before release and plying.

[0005] As will be recognized, the torque or twist force exerted by each strand is roughly proportional to the amount of twist therein and that such force decreases as the strands ply. The plying step itself therefore continues until the stored twist forces in each strand decrease to a point at which the remaining twist forces are exactly counterbalanced by the resistance to further twisting in the plied yarn. Thus, if one begins with individual strands and then alternate twists the strands and plies them, each strand will end up, in the plied yarn, with some degree of residual twist which can be thought of as some remaining stored potential energy, the force exerted thereby being too small to cause further ply twisting against opposing forces in the plied yarn. In a stable plied yarn formed in this fashion, the amount of applied singles twist always is greater than the amount of ply twist.

[0006] Generally speaking, this remaining stored force or energy may not be particularly disadvantageous, depending upon the type of fabric to be produced from the plied yarn. However, when the yarn is to be used to produce certain products such as pile or tufted carpet, the existence of the residual twist in the singles yarn becomes highly significant because of the appearance of the product produced therefrom.

[0007] Consider, for example, a plied yarn formed from two singles yarns in which the value of applied singles twist is equal to 1.4 times the value of ply twist (S=1.4 P). In this circumstance it has been found that the fibers in the individual strands are substantially parallel with the axis of the plied yarn. A tufted carpet made from yarn of this description exhibits two significant disadvantages, one of these being the fact that relatively minor variations in the manufacturing process, such as small variations in twist between spindles, causes large changes in the light reflectance characteristics of the carpet tufts, and the carpet can have a highly noticeable streaky appearance which is unacceptable. The second major problem is that with S=1.4 P or more , the individual yarn strands tend to retain their identity as individual strands, even though plied, and tend to split at the tuft tips into separate singles strands which are visible and which give the carpet surface an undesirable "stringy" appearance.

[0008] It is also known, as shown in aforementioned U.S. Pat. No. 3,443,370, Walls, to produce a yarn by alternate twisting a number of strands greater than two or more assembled threads or yarns, and plying steps with the previously plied yarns to form what can be termed a braid.

[0009] In forming a braid from previously plied strands, the various forces interact in each plying process in such a way that it is difficult to predict the degree of twist which will exist after all of the steps, and it is therefore a rather complicated process to arrive at an end product which has twist relationships which meet desired specifications.

[0010] However, U.S. Pat. No. 4,246,750 describes that by inserting specified degrees of twist in singles yarns, joining the nodes of the yarns, permitting them to ply together to form alternate twist plied strands, alternate twisting selected ones of the strands, joining nodes of the strands and permitting the strands to ply together into a braid, a product having predictable and consistent twist relationships can be obtained.

[0011] U.S. Pat. No. 4,246,750 further describes that joining a plurality of plied alternate twisted strands together at the nodes permits a dramatic increase in the number of strands which can be heat set in a given interval with little increase in energy input, thereby significantly increasing the production rate of such yarns and reducing the cost per unit length of the heat-setting operation.

[0012] Additionally, it describes that heat setting braided or joined alternate twisted plied strands results in a product which can be used as it is in producing, for example, tufted carpets; or which can be separated into plied strands which have predictable desired characteristics and can individually be used in carpet manufacture.

[0013] U.S. Pat. No. 4,246,750 describes a method of forming stable twisted yarn products comprising the steps of providing a plurality of singles yarns in a plurality of groups and maintaining the yarns in each group separated from each other, imparting alternate twist to at least one of the singles yarns in each group to form in the yarn a sequence of twist regions having longitudinally spaced regions of alternating S and Z twist separated by nodes of twist reversal, placing the yarns in each group in closely spaced relationship with each

other, joining the yarns in each group to each other at the locations of the nodes, permitting the yarns in each group to self-twist to form a plurality of alternate twist plied strands wherein twist torques are at substantial equilibrium, imparting additional twist to each of the alternate twist plied strands to form therein a sequence of unbalanced twist regions of alternating S and Z twist separated by the joined nodes, placing the strands in closely spaced relationship with each other with the nodes thereof longitudinally aligned, joining the plied strands to each other at the node locations, and heating the joined plied strands to a temperature sufficient to heat-set the twist characteristics thereof.

[0014] But U.S. Pat. No. 4,246,750 remains silent on how to join the plied strands to each other at the node locations, especially in a continuous process, whereby the singles yarns, the twist plied strands and the final braid are processed at a continuous process speed, i.e. without stopping them for making joints.

[0015] Such joining is very difficult in a production environment, because the yarn tensions are high after the imparting of additional twist, and because the filaments have low entanglement capabilities due to the prior joining of the nodes in the yarns. The reliable and reproducible joining of the nodes of the alternate S/Z twist plied yarn has in practice proven impossible.

[0016] U.S. Pat. No. 5,644,909 discloses a method and apparatus for making alternate twist plied yarn and product. Connections are formed nearby a node. Yarns are connected by ultrasonic bonding. These yarns have small pieces of solid, hard plastic, where the ultrasonic bonding has taken place. This is disadvantageous as it may cause discomfort, itching and scratching. In the method disclosed, the production is stopped at intervals. This is disadvantageous for the production speed and apparatus capacity. The ply reversal of the second or doubled plied end is unbounded.

[0017] Therefore, there is a need in the art for improvements. The present invention aims to provide a solution or improvement to at least one of the above mentioned problems. The objective of the invention is to provide an improved method and apparatus that enable the reliable joining of the plied strands while processing them at a continuous process speed.

SUMMARY OF THE INVENTION

[0018] In a first aspect, the invention thereto provides a process for making an alternate S/Z twist plied braid, comprising the steps of:

[0019] a) separately providing at least four strands(**2**, **2***a*, **2***b*, **2***c*), divided over at least two groups (**2**, **2***a* : **2***b*, **2***c*);

[0020] b) alternately applying S and Z twist to the strands; thereto zone of S-twist are alternated with zones of Z-twist and vice versa, with an intervening zone with approximately no twist; these reversal zones are called "nodes";

[0021] c) per group the alternately S/Z twisted strands (**7**, **7***a*, **7***b*, **7***c*), are brought together via a narrowing;

[0022] d) connecting the nodes of all strands within a group;

[0023] e) allowing the strands of a same group to self-twist thereby providing an alternate S/Z twist plied yarn (**9**, **9***a*);

[0024] f) alternately imparting additional twist to the alternate S/Z twist plied yarn (**9**, **9***a*), wherein the alternation of the direction of twist coincides with the nodes of the alternate S/Z twist plied yarns;

[0025] g) combining the alternate S/Z twist plied yarns (**12**, **12***a*) via a narrowing;

[0026] h) connecting the nodes of the alternate S/Z twist plied yarns (**14**, **14***a*);

[0027] i) allowing the alternate S/Z twist plied yarns (**14**, **14***a*), to self-twist, thereby providing an alternate S/Z twist plied braid (**16**),

[0028] j) leading away the braid (**16**) produced,

[0029] characterized in that,

[0030] tension of the alternately S/Z twist plied yarns (**9**, **9***a*) is reduced between the step f) of imparting additional alternate twist to the alternately S/Z twist plied yarns (**9**, **9***a*) and the step g) of combining these yarns (**12**, **12***a*).

[0031] In a preferred embodiment, the alternately S/Z twisted strands (**7**, **7***a*, **7***b*, **7***c*), are brought together via a narrowing, in phase: all nodes coinciding, and with zones of equal twist direction next to each other.

[0032] In a preferred embodiment, combining the alternate S/Z twist plied yarns (**12**, **12***a*) via a narrowing is in phase: all nodes coinciding, and with zones of equal twist direction next to each other.

[0033] In a second aspect, the invention provides a process for making joined alternate S/Z twist plied yarns, comprising the steps of:

[0034] k) separately providing at least four strands (**2**, **2***a*, **2***b*, **2***c*), divided over at least two groups (**2**, **2***a* : **2***b*, **2***c*);

[0035] l) alternately applying S and Z twist to the strands; thereto zone of S-twist are alternating with zones of Z-twist and vice versa, with an intervening zone with approximately no twist; these reversal zones are called "nodes";

[0036] m) then per group the alternately S/Z twist plied strands (**7**, **7***a*, **7***b*, **7***c*), are brought together via a narrowing, preferably in phase: all nodes coinciding, and with zones of equal twist direction next to each other;

[0037] n) connecting the nodes of all strands within a group;

[0038] o) allowing the strands of a same group to self-twist thereby providing an alternate S/Z twist plied yarn (**9**, **9***a*);

[0039] p) alternately imparting additional twist to the alternate S/Z twist plied yarn (**9**, **9***a*), wherein the alternation of the direction of twist coincides with the nodes of the alternate S/Z twist plied yarns;

[0040] q) combining the alternate S/Z twist plied yarns (**12**, **12***a*), via a narrowing;

[0041] r) connecting the nodes of the alternate S/Z twist plied yarns (**14**, **14***a*), thereby providing joined unbalanced alternate twist plied yarns comprising at least two unbalanced alternate S/Z twist plied yarns, connected with each other in the nodes,

[0042] s) leading away the yarns produced,

[0043] characterized in that, tension of the alternately S/Z twist plied yarns (**9**, **9***a*) is reduced between the step p) of imparting additional alternate twist to the alternately S/Z twist plied yarns (**9**, **9***a*) and the step q) of combining these yarns (**12**, **12***a*).

[0044] By reducing the tension at the location where the nodes of the alternate S/Z twist plied yarn are to become entangled, entanglement is facilitated and improved. Fewer

nodes are missed. A reliable and reproducible process is obtained. The movement of yarn through the process is not stopped.

[0045] In a preferred embodiment, the alternately S/Z twist plied strands (**7**, **7***a*, **7***b*, **7***c*), are brought together via a narrowing, in phase: all nodes coinciding, and with zones of equal twist direction next to each other.

[0046] In a preferred embodiment, combining the alternate S/Z twist plied yarns (**12**, **12***a*) via a narrowing is in counter phase: all nodes coinciding, and with zones of opposite twist direction next to each other. This facilitates the connection of the nodes.

[0047] In a preferred embodiment, the tension of the alternate S/Z twist plied yarns (**12**, **12***a*) is reduced in a controlled manner with a closed circuit system on the basis of the measured tension of the alternate S/Z twist plied braid respectively the joined alternate S/Z twist plied yarns (**16**).

[0048] In a preferred embodiment, the tension of the alternate S/Z twisted yarns is reduced in a controlled manner with a closed circuit system on the basis of the amount of yarn between the step of connecting the nodes of the alternate S/Z twist plied yarns (h, r), and the step of leading away the yarn produced (j, s).

[0049] In a preferred embodiment, the fibers or filaments of the alternate S/Z twisted yarns are preheated prior to imparting additional alternate twist to said yarns. Preheating further facilitates and improves the entanglement of the nodes.

[0050] In a preferred embodiment, the fibers or filaments of the alternate S/Z twist plied yarns are heated using a hot fluidum at the imparting of additional alternate twist of said yarns.

[0051] In a preferred embodiment, the fibers or filaments of the alternate S/Z twist plied yarns are heated using a hot fluidum when connecting their nodes. In a preferred embodiment, inter-fiber or -filament friction of the alternate S/Z twist plied yarns is reduced by the addition of liquid additives prior to or during imparting additional alternate twist of said yarns.

[0052] In a preferred embodiment, inter-fiber or -filament friction of the alternate S/Z twist plied yarns is reduced by the addition of liquid additives during the connection of their nodes.

[0053] In a third aspect, an apparatus is provided for making an alternate twist plied braid or joined alternate twist plied yarns formed from a plurality of at least four strands, comprising:

[0054] a source of supply for the separate feeding of individual strands (**2**, **2***a*, **2***b*, **2***c*), at least four, spread over at least two groups(**1**, **1***a*/**1***b*, **1***c*); a means for tensioning each strand (**3**, **3***a*, **3***b*, **3***c*);

[0055] a first twisting means (**4**, **4***a*, **4***b*, **4***c*) for alternatingly applying a S respectively Z twist in at least one strand of each group thereby obtaining alternate S and Z twisted strands (**7**, **7***a*, **7***b*, **7***c*);

[0056] a first fixation means (**8**, **8***a*) for combining the alternately S/Z twisted strands of each group (**7**, **7***a*, **7***b*, **7***c*) and connecting these at their nodes;

[0057] a second torsion means (**11**, **11***a*) for imparting additional alternate twist to at least one of the alternately S/Z twisted strands (**9**, **9***a*);

[0058] a second fixation means for connecting the alternately S/Z twist plied yarns (**9**, **9***a*) with each other (**15**);

[0059] a means to remove the yarn produced;

[0060] a steering means (**22**) for the coordinated control of all the above mentioned means, characterized in that the means (**13**, **13***a*) for reducing the tension in the alternate S/Z plied yarns is provided between the second torsion means (**11**, **11***a*) and the second fixation means (**15**).

[0061] In a preferred embodiment of the apparatus of the invention, a means for measuring the tension of the yarn (**17**) is provided after the second fixation means (**15**).

[0062] In a preferred embodiment of the apparatus of the invention, a means for yarn accumulation (**20**) is provided after the second fixation means (**15**).

[0063] In a preferred embodiment of the apparatus of the invention, a means for heating the alternate S/Z twist plied yarn (**9**, **9***a*) is provided before the second torsion means (**11**, **11***a*).

[0064] In a preferred embodiment of the apparatus of the invention, a means (**21**, **21***a*) is provided for the addition of liquid additives to the yarns before the second torsion means (**11**, **11***a*).

[0065] In a preferred embodiment of the apparatus of the invention, a means is provided for the addition of liquid additives to the second torsion means (**11**, **11***a*).

[0066] In a preferred embodiment of the apparatus of the invention, a means is provided for addition of liquid additives in the second fixation means (**15**).

[0067] In a final aspect, the invention provides an alternate S/Z twist plied braid and a joined alternate twist plied yarn obtained with a process according to an embodiment of the invention. These products display an improved entanglement of fibers at the nodes. Consequently the S/Z twist can be maintained. Product quality is improved. The fixation of the nodes is sturdier. The processing properties of the braid and yarn are improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0068] FIG. **1** is a schematic diagram of an apparatus according to an embodiment of the invention.

[0069] FIGS. **2-5** schematically illustrate different yarns.

[0070] FIG. **6** represents a number of yarn feed systems (FIG. **6***a-f*), suitable for use in an apparatus according to an embodiment of the invention.

DETAILED DESCRIPTION

[0071] Unless otherwise defined, all terms used in disclosing the invention, including technical and scientific terms, have the meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. By means of further guidance, term definitions are included to better appreciate the teaching of the present invention.

[0072] As used herein, the following terms have the following meanings: "A", "an", and "the" as used herein refers to both singular and plural referents unless the context clearly dictates otherwise. By way of example, "a compartment" refers to one or more than one compartment.

[0073] "About" as used herein referring to a measurable value such as a parameter, an amount, a temporal duration, and the like, is meant to encompass variations of +/−20% or less, preferably +/−10% or less, more preferably +/−5% or less, even more preferably +/−1% or less, and still more preferably +/−0.1% or less of and from the specified value, in so far such variations are appropriate to perform in the disclosed invention. However, it is to be understood that the value to which the modifier "about" refers is itself also specifically disclosed.

[0074] "Comprise," "comprising," and "comprises" and "comprised of" as used herein are synonymous with "include", "including", "includes" or "contain", "containing", "contains" and are inclusive or open-ended terms that specifies the presence of what follows e.g. component and do not exclude or preclude the presence of additional, non-recited components, features, element, members, steps, known in the art or disclosed therein.

[0075] The recitation of numerical ranges by endpoints includes all numbers and fractions subsumed within that range, as well as the recited endpoints.

[0076] The invention is an improved method and apparatus for braiding or joining alternate twist plied yarns. The invention was previously described in application BE2010/0650 filed on 3 Nov. 2010, which is herein incorporated by reference.

[0077] In particular, the invention provides a process for making an alternate twist plied braid formed from a plurality of at least four strands, comprising the steps of:

[0078] providing a plurality of strands in a plurality of at least 2 groups and maintaining the strands in each group separated from each other;

[0079] imparting alternate twist to at least one of the strands in each group to form in said strand a sequence of twist regions having longitudinally spaced regions of alternating S and Z twist separated by nodes of twist reversal;

[0080] placing the strands in each group in closely spaced relationship with each other with regions of the same direction of twist disposed beside each other;

[0081] joining the nodes of the alternate twisted strands to all the strands within each group;

[0082] permitting the strands of each group to self-twist to form an alternate twist plied yarn;

[0083] imparting additional alternate twist to at least one of said alternate twist plied yarns to form therein a sequence of regions of alternating S and Z unbalanced twist plied yarn separated by the nodes;

[0084] reducing the tension in each unbalanced alternate twist plied yarn;

[0085] placing the unbalanced twist plied yarns in closely spaced relationship with each other with their regions of like ply twist being disposed beside each other;

[0086] joining the nodes of the unbalanced alternate twist plied yarns;

[0087] permitting the unbalanced alternate twist plied yarns to self-twist to form a balanced braid.

[0088] removing of the yarn produced, i.e. the balanced alternate twist plied braid.

[0089] The invention further provides a process for making joined alternate twist plied yarns from a plurality of at least four strands, comprising the steps of:

[0090] providing a plurality of strands in a plurality of at least 2 groups and maintaining the strands in each group separated from each other;

[0091] imparting alternate twist to at least one of the strands in each group to form in said strand a sequence of twist regions having longitudinally spaced regions of alternating S and Z twist separated by nodes of twist reversal;

[0092] placing the strands in each group in closely spaced relationship with each other with regions of the same direction of twist disposed beside each other;

[0093] joining the nodes of the alternate twisted strands to all the strands within each group;

[0094] permitting the strands of each group to self-twist to form an alternate twist plied yarn;

[0095] imparting additional alternate twist to at least two of said alternate twist plied yarns to form therein a sequence of regions of alternating S and Z unbalanced twist plied yarn separated by the nodes;

[0096] reducing the tension in each unbalanced alternate twist plied yarn;

[0097] placing the unbalanced twist plied yarns in closely spaced relationship with each other with their regions of opposite ply twist being disposed beside each other;

[0098] joining the nodes of the unbalanced alternate twist plied yarns.

[0099] removing of the yarn produced, i.e. the joined unbalanced alternate twist plied yarns.

[0100] In a preferred embodiment the number of strands is four and the number of groups two, providing two groups of two strands each.

[0101] In a preferred embodiment of a process according to the invention, the tension of the alternate twist plied yarns is reduced in function of the tension of the yarn produced.

[0102] In a preferred embodiment of a process according to the invention, the tension of the alternate twist plied yarns is reduced in function of the amount of accumulated yarn produced.

[0103] In a preferred embodiment of a process according to the invention, the process further comprises the preheating of the twist plied yarns prior to the said imparting of additional alternate twist.

[0104] In a preferred embodiment of a process according to the invention, a hot fluidum is applied to the twist plied yarns for the said imparting of additional alternate twist.

[0105] In a preferred embodiment of a process according to the invention, hot fluidum is applied to the twist plied yarns for the said joining of the nodes.

[0106] In a preferred embodiment of a process according to the invention, interfilament friction is reduced by the application of fluid additives prior to or during the said imparting of additional alternate twist.

[0107] In a preferred embodiment of a process according to the invention, interfilament friction is reduced by the application of fluid additives prior to or during the said joining of the nodes.

[0108] In a preferred embodiment of a process according to the invention, the process further comprises the step of heat-setting the alternate twist plied braid.

[0109] In a preferred embodiment of a process according to the invention, the process further comprises the step of heat-setting the joined alternate twisted yarns.

[0110] The invention also provides an apparatus for making an alternate twist plied braid or joined alternate twist plied yarns formed from a plurality of at least four strands comprising:

[0111] a source of supply of the strands;

[0112] a means for tensioning the strands;

[0113] a first twisting means for twisting the strands in alternating directions;

[0114] a first means for combining the strands to form plied yarn and for joining the strands at the reversal nodes;

[0115] a second twisting means for overtwisting the alternate twist plied yarns;

[0116] a means for reducing the tension in the alternate twist plied yarns prior to joining them;

[0117] a second means for combining the alternate twist plied yarns and for joining the alternate twist plied yarns at the reversal nodes;

[0118] means for removing the yarn produced, i.e. the balanced alternate twist plied braid or the joined unbalanced alternate twist plied yarns;

[0119] means for coordinating all means mentioned.

[0120] In a preferred embodiment of an apparatus according to the invention, the apparatus comprises a means for measuring the tension of the alternate twist plied braid, or of the joined twist plied yarns.

[0121] In a preferred embodiment of an apparatus according to the invention, the apparatus comprises a means for measuring the amount of accumulated alternate twist plied braid, or the amount of joined twist plied yarns.

[0122] In a preferred embodiment of an apparatus according to the invention, the apparatus comprises a means for the preheating of the twist plied yarns prior to the said imparting of additional alternate twist.

[0123] In a preferred embodiment of an apparatus according to the invention, the apparatus comprises a means for the application of fluid additives to the yarns, positioned upstream of the second twisting means.

[0124] In a preferred embodiment of an apparatus according to the invention, the apparatus comprises a means for the addition of fluid additives to the fluid of the second twisting means.

[0125] In a preferred embodiment of an apparatus according to the invention, the apparatus comprises a means for the addition of fluid additives to the fluid of the second joining means.

[0126] Preferably, the apparatus includes a means for measuring the tension of the alternate twist plied braid, or of the joined twist plied yarns, or a means for measuring the accumulated amount of alternate twist plied braid, or joined twist plied yarns.

[0127] Preferably also, the apparatus includes a means for heating the twist plied yarns at the upstream side of the second joining means.

[0128] Preferably also, the apparatus includes a means for the application of lubricants to the filaments of the yarns.

[0129] In a final aspect, the invention provides an alternate S/Z twist plied braid and a joined alternate twist plied yarn obtained with a process according to an embodiment of the invention. These products display an improved entanglement of fibers at the nodes. The fixation of the nodes is sturdier.

[0130] The invention is illustrated in a number of non-limiting examples. The invention will be explained further by reference to the general schematic provided in FIG. **1**. Reference will further be made to FIGS. **1-5** illustrating alternate twist plied yarns.

[0131] As shown in FIG. **1**, in an apparatus for forming yarns in accordance with the invention, individual yarns **2**, **2***a*, **2***b* and **2***c* are fed from a yarn supply, mostly from yarn packages **1**, **1***a*, **1***b* and **1***c*.

[0132] Yarns **2**, **2***a*, **2***b* and **2***c* are singles yarns which have been formed in a well-known manner and can be, for example, continuous filament or bulked continuous filament yarn, preferably of a synthetic type.

[0133] Yarns **2**, **2***a*, **2***b* and **2***c* are tensioned by means of tensioners **3**, **3***a*, **3***b* and **3***c*, and fed to twist jets **4**, **4***a*, **4***b* and **4***c*.

[0134] Twist jets suitable for use in the invention are for instance disclosed in U.S. Pat. No. 4,074,511.

[0135] The twist jets have central openings through which yarns **2**, **2***a*, **2***b* and **2***c* can pass. The twist jets themselves include pairs of inlets resp. **5** and **6**, **5***a* and **6***a*, **5***b* and **6***b*, and **5***c* and **6***c*, into which air under pressure can be selectively introduced. Inlets **5**-**5***a*-**5***b*-**5***c* and **6**-**6***a*-**6***b*-**6***c* tangentially intersect passages within twist jets **4**-**4***a*-**4***b*-**4***c* through which yarns **2**-**2***a*-**2***b*-**2***c* pass. Thus, if air under pressure is introduced through inlet **5** of each of the jets, the yarns passing through the jets will be subjected to vortexes of air in each of the central passages and will be caused to twist in one direction. If, subsequently, air under pressure is introduced into inlet **6**, the yarns will be twisted in the opposite direction.

[0136] Hence, by the application of pressured air to the air inlets **5** and **6** (respectively **5***a* and **6***q*, **5***b* and **6***b*, **5***c* and **5***c*) alternate twisted strands **7**, **7***a*, **7***b*, **7***c* are provided downstream of the jets **4**, **4***a*, **4***b* and **4***c*.

[0137] As the alternate twisted strands **7**, **7***a* leave the twist jets **4** and **4***a*, they are joined together at their nodes. Preferably the joining is in phase, meaning that regions of the same twist direction and the nodes are parallel to each other.

[0138] The alternate twisted strands **7**, **7***a* can be brought together in a node fixator **8**, wherein the nodes of the alternate twisted strands **7** and **7** a are connected. Such a node fixator **8** can be an entangle jet as known in industry.

[0139] Preferably this joining process is also applied to strands **7***b* and **7***c*. Preferably the joining of strands **7***b* and **7***c* is executed in parallel to the joining of strands **7** and **7***a*. Strands **7***b* and **7***c* are brought together as fast as possible and their nodes are joined in node fixator **8***a*.

[0140] The alternate twisted strands **7**, **7***a* can be made to self-twist or ply together, forming alternate twist plied yarn **9**. Preferably the alternate twisted strands **7***b* and **7***c*, leaving node fixator **8** a are also made to self-twist or ply together. The resulting alternate twist plied yarn is indicated in FIG. **1** by reference sign **9***a*.

[0141] FIG. **2** represents these yarns schematically: alternating zones of S-twist **100** and Z-twist **101**; with intermittent the nodes **102**.

[0142] It will be recognized that in order for the yarns to ply, it is necessary that jets **4** and **4***a* be synchronized so that twist in the same direction is imparted to yarns **2** and **2***a* at the same time. Similarly, jets **4***b* and **4***c* are synchronized to produce twist in the same direction at the same time. As will be described hereinafter, the relationship between the twist imparted by jets **4** and **4***a* and the twist imparted by jets **4***b* and **4***c* can be similarly synchronized or can be intentionally unsynchronized, depending upon the ultimate effect desired.

[0143] Yarns **9** and **9***a* are directed to further twist jet devices **11** and **11***a*. Twistjet devices **11** and **11***a* are substantially identical to devices **4**-**4***c*. Thus, twist is again imparted but this time it is imparted to the plied yarns.

[0144] At this point, it may be helpful to refer to FIG. **2** which shows in a schematic form, an alternate twisted and plied yarn such as yarn **9**. As seen therein, the section illustrated includes two nodes of twist reversal **102** which will be assumed to be joined by filament entanglement. Between the nodes **102**, it will be recognized that there is a section **100** S-plied yarn formed from two

[0145] Z-twisted singles strands the Z twist having been imparted by jets **4** and **4***a* and the S ply having been formed as the joined yarns leave node fixator **8**. Then, in jet **11**, the yarn **9** is overtwisted, the air supply to jet **11** being synchronized such that the yarn downstream is twisted in the same direction as the yarn **9**, resulting in an unbalanced alternate twist plied strand **12**. The same can be said of yarn **9***a* which is overtwisted by jet devices **11***a*, resulting in an unbalanced alternate twist plied strand **12***a*.

[0146] At the outlet of twist devices **11** and **11***a*, the unbalanced alternate twist plied strands **12** and **12***a* are brought together in a side-by-side juxtaposition, with their nodes aligned to each other, and the nodes are joined to each other in a node fixator **15**.

[0147] In twist jet devices **11** respectively **11***a* the alternate twist plied yarns **9** respectively **9***a* are alternately twisted, preferably in phase with the already formed alternate S/Z twist plied yarn. This results in unbalanced twist plied yarns **12** and **12***a*. These yarns **12** and **12***a* are also brought together as fast as possible, and their nodes connected in node fixator **15**. Imparting additional alternate twist creates a very high yarn tension, due to which the fibers or filaments in the nodes have low entanglement capabilities. In addition the fibers and filaments are very limited in their freedom of movement due to the previously made intermodal connection between the alternate twisted strands.

[0148] Imparting additional alternate twist to the strands **9**, **9***a*, results in an important increase of yarn tension downstream of the twist devices **11**, **11***a*. On top of that, due to the prior joining of the nodes in node fixators **8** and **8***a*, the filaments in the nodes have low entanglement capabilities.

[0149] The inventors have found that this problem can be advantageously addressed as follows. Between twist jet devices **11** respectively **11***a*, and the node fixator **15**, a yarn feed system **13** respectively **13***a* is provided, in order to reduce the tension in the unbalanced alternately S/Z twist plied yarns **14** respectively **14***a* can be reduced to a level appropriate for the good functioning of the node fixator **15**. Yarn feed systems **13** and **13***a* therefore reduce the tension of the unbalanced alternate twist plied yarns **12** and **12***a* prior to directing them to the node fixator **15**. Yarn feed systems **13** and **13***a* can be made according to principles well known in the art, such as nip rolls (FIG. **6***a*), capstan overfeed rolls (FIG. **6***b*), open-roll systems (FIG. **6***c*), toothed wheels (FIG. **6***d*), belt nips (FIG. **6***e*), or even by means of air (FIG. **6***f*).

[0150] After the node fixator **15**, a composite strand **16** is produced, which is conducted to the next process **19**, which can be a heat-setting process in which the twist characteristics imparted to the various components are set. The heat-set device can be any conventional heat-setting apparatus utilizing steam, infrared energy, or other forms of elevating the yarn to the necessary level to heat-set the characteristics thereof. Generally speaking, with synthetic yarns, it is necessary to elevate the temperature of the yarns to the glass transition temperature, or second order transition temperature, at which the stresses in the yarns are relieved.

[0151] The characteristics of the composite yarn will be further described in connection with FIGS. **3-5**. The characteristics of the end product are directly related to the twist directions imparted by the various twist jet devices. If the twist imparted by devices **4** and **4***a* is the same as and substantially synchronized with, the direction of twist imparted by devices **4***b* and **4***c*, the resulting plied strands **9** and **9***a* will have components of ply twist in the same directions. Also, the nodes thereof will be substantially aligned. Then, twist jet devices **11** and **11***a* can be caused to similarly produce twist in the same direction, adding twist to the plied yarns produced downstream. Node fixator **15** then joins the plied yarns together at the nodes, with increased twist there between, as illustrated in FIG. **3**. As shown therein, strands **14** and **14***a* both have S ply twist between nodes **102**, but with a higher degree of twist per inch, the plied strands being joined together at the same nodes at which the singles strands were joined.

[0152] If this yarn is then released and permitted to ply after node joining, the plied strands will again ply or "cable" around each other, forming a yarn such as that illustrated in FIG. **4**. As will be seen therein, for purposes of distinction, yarn **14***a* is drawn with the singles twist being shown, and yarn **14** is drawn as a "clear" strand. However, it will be observed that this is only to make the drawing more clear, and that yarn **14** will appear to be substantially the same as yarn **14***a* in an actual product. Thus, the ply-twisted strands will self-twist about each other in a manner similar to singles twisted strands, forming a cable.

[0153] Alternatively, if devices **4***b* and **4***c* are caused to be synchronized with twist devices **4** and **4***a*, but phased such that the opposite directions of twist are formed thereby, the nodes of the yarns as they reach yarn node fixator **15** will still be aligned but the direction of ply twist will be opposite. This can, of course, be accomplished also by lengthening the path of travel between node fixator **4***b* and node fixator **15** by the amount of one node length, or one spacing between nodes, to introduce the phase difference. Then, if the nodes are joined in node fixator **15**, the resulting product will appear as shown schematically in FIG. **5** wherein yarn **14** between nodes **102** exhibits an S ply twist with Z singles twist while the section of yarn **14***a* between those nodes exhibits a Z ply twist and S singles twist. Thus, upon node joining and release, the plied strands will not cable but will remain in the condition shown in FIG. **5**.

[0154] If the unbalanced S/Z twist plied yarns **14** and **14***a* are brought together in phase, as depicted in FIG. **3**, then these will after node fixator **15** spontaneously undergo a self-twist process, resulting in an alternate S/Z twist plied braid. **16**, as depicted in FIG. **4**, wherein for clarity one of both alternate S/Z twist plied yarns is represented as one single white strand. The reduction of the yarn tension due to the yarn feed systems **13** and **13***a* also improves this process of self-twisting.

[0155] If the unbalanced S/Z twist plied yarns **14** and **14***a* are brought together in counter phase, as depicted in FIG. **5**, then these will after node fixator **15** not undergo a self-twist process. The torsion tensions in both strands are opposite. The connection of the nodes in both yarns **14** and **14***a* provides that both yarns maintain their unbalanced twist, also over the nodes, and the yarn produced **16** in essence exists of both yarns **14** and **14***a* next to each other, but connected to each other in the nodes.

[0156] In a preferred embodiment of the invention, a system **18** controls yarn feed systems **13** and **13***a* in function of the yarn tension of the composite strand **16**, measured by a tension meter **17**, so that yarn tension variations between node fixator **15** and the subsequent process **19** can be minimized. In another preferred embodiment of the invention, tension meter **17** is replaced by a device **20**, e.g. a dancer arm, which is capable to accumulate yarn between node fixator **15** and the subsequent process **19**. In this case, the yarn feed

systems **13** and **13***a* are controlled in function of the amount of yarn accumulated, e.g. by measuring the position of the dancer arm.

[0157] In another preferred embodiment of the invention, the alternate twist plied yarns **9** and **9***a* are heated upstream of the twist jets **11** and **11***a,* by yarn heaters **10** and **10***a* known in the art such as infrared heaters, in order to make the filaments weaker and therefore further facilitate and improve the entanglement of the nodes in the node fixator **15**. By doing so, the overtwist levels at overtwisting can be increased. The overtwist levels downstream of twist jets **11** and **11***a* will also increase.

[0158] In another preferred embodiment of the invention, a hot fluidum like hot air or steam is used in the twist jets **11** and **11***a,* in order to make the filaments weaker and therefore further facilitate and improve the entanglement of the nodes in the node fixator **15**. By doing so, the overtwist levels in the overtwisting process can be increased. The overtwist levels downstream of twist jets **11** and **11***a* will also increase.

[0159] In another preferred embodiment of the invention, a hot fluidum like hot air or steam is used in the node fixator **15**, in order to make the filaments weaker and therefore further facilitate and improve the entanglement of the nodes in the node fixator **15**.

[0160] In another preferred embodiment of the invention, additives can be applied on the filaments in order to reduce friction between the filaments, and therefore further facilitate the entanglement of the nodes in the node fixator **15**. The additives are preferably certain liquid additives. These additives can be applied by applicator means **21** and **21***a* well known in the art such as kiss-rolls, wetting-jets, etc., positioned in the yarn path upstream of node fixator **15**, or can be added to the fluidum used in node fixator **15**.

[0161] Finally, for each of the embodiments described, a control system **22** is required for the coordination of all the actuators.

[0162] The examples provided above and FIGS. **1-6** depict a situation with four strands. It should be clear that the invention also relates to larger numbers of strands and to pluralities of at least four strands. Combinations wherein more strands are alternately S/Z twisted, more than two strands per group, and more than two groups are also covered.

[0163] The process described is a continuous process: meaning that the strands provided and yarns produced move continuously through the process.

[0164] Preferably the process runs at a speed of 200-700 m/min, more preferably at least 700 m/min. No intermittent stops are made. This provides for cost-effective manufacturing.

1. A method for making an alternate S/Z twist plied braid, comprising the steps of:

a) separately providing at least four strands, divided over at least two groups;

b) alternately applying S and Z twist to the strands; thereto zone of S- twist are alternated with zones of Z-twist and vice versa, with an intervening zone with approximately no twist, wherein these reversal zones are called "nodes";

c) per group the alternately S/Z twisted strands, are brought together via a narrowing;

d) connecting the nodes of all strands within a group;

e) allowing the strands of a same group to self-twist thereby providing an alternate S/Z twist plied yarn;

f) alternately imparting additional twist to the alternate S/Z twist plied yarn, wherein the alternation of the direction of twist coincides with the nodes of the alternate S/Z twist plied yarns;

g) combining the alternate S/Z twist plied yarns via a narrowing;

h) connecting the nodes of the alternate S/Z twist plied yarns;

i) allowing the alternate S/Z twist plied yarns, to self-twist, thereby providing an alternate S/Z twist plied braid,

j) leading away the braid produced,

wherein,

tension of the alternately S/Z twist plied yarns is reduced between the step f) of imparting additional alternate twist to the alternately S/Z twist plied yarns and the step g) of combining these yarns.

2. The method according to claim **1**, wherein step c) comprises bringing together the alternately S/Z twisted strands via a narrowing, in phase: all nodes coinciding, and with zones of equal twist direction next to each other.

3. The method according to claim **1**, wherein step g) comprises combining the alternate S/Z twist plied yarns via a narrowing in phase: all nodes coinciding, and with zones of equal twist direction next to each other.

4. A method for making joined alternate S/Z twist plied yarns, comprising the steps of:

k) separately providing at least four strands, divided over at least two groups;

l) alternately applying S and Z twist to the strands, wherein zone of S-twist are alternating with zones of Z-twist and vice versa, with an intervening zone with approximately no twist, wherein these reversal zones are called "nodes";

m) then subsequently per group the alternately S/Z twist plied strands, are brought together via a narrowing;

n) connecting the nodes of all strands within a group;

o) allowing the strands of a same group to self-twist thereby providing an alternate S/Z twist plied yarn;

p) alternately imparting additional twist to the alternate S/Z twist plied yarn, wherein the alternation of the direction of twist coincides with the nodes of the alternate S/Z twist plied yarns;

q) combining the alternate S/Z twist plied yarns, via a narrowing;

r) connecting the nodes of the alternate S/Z twist plied yarns, thereby providing joined unbalanced alternate twist plied yarns comprising at least two unbalanced alternate S/Z twist plied yarns, connected with each other in the nodes,

s) leading away the yarns produced,

wherein, tension of the alternately S/Z twist plied yarns is reduced between the step p) of imparting additional alternate twist to the alternately S/Z twist plied yarns and the step q) of combining these yarns.

5. The method according to claim **4**, wherein step m) comprises bringing together the alternately S/Z twist plied strands via a narrowing, in phase: all nodes coinciding, and with zones of equal twist direction next to each other.

6. The method according to claim **4**, wherein step q) comprises combining the alternate S/Z twist plied yarns via a narrowing in counter phase: all nodes coinciding, and with zones of opposite twist direction next to each other.

7. The method according to claim **1**, wherein the tension of the alternate S/Z twist plied yarns is reduced in a controlled

manner with a closed circuit system on the basis of the measured tension of the alternate S/Z twist plied braid respectively the joined alternate S/Z twist plied yarns.

8. The method according to claim **1**, wherein the tension of the alternate S/Z twisted yarns is reduced in a controlled manner with a closed circuit system on the basis of the amount of yarn between the step of connecting the nodes of the alternate S/Z twist plied yarns (h, r), and the step of leading away the yarn produced (j, s).

9. The method according to claim **1**, wherein the fibers or filaments of the alternate S/Z twisted yarns are preheated prior to imparting additional alternate twist to said yarns.

10. The method according to claim **1**, wherein the fibers or filaments of the alternate S/Z twist plied yarns are heated using a hot fluidum at the imparting of additional alternate twist of said yarns.

11. The method according to claim **1**, wherein the fibers or filaments of the alternate S/Z twist plied yarns are heated using a hot fluidum when connecting their nodes.

12. The method according to claim **1**, wherein inter-fiber or -filament friction of the alternate S/Z twist plied yarns is reduced by the addition of liquid additives prior to or during imparting additional alternate twist of said yarns.

13. The method according to claim **1**, wherein inter-fiber or -filament friction of the alternate S/Z twist plied yarns is reduced by the addition of liquid additives during the connection of their nodes.

14. An apparatus for making an alternate twist plied braid or joined alternate twist plied yarns formed from a plurality of at least four strands, comprising:

a source of supply for the separate feeding of individual strands, at least four, spread over at least two groups;

a means for tensioning each strand;

a first twisting means for alternatingly applying a S respectively Z twist in at least one strand of each group thereby obtaining alternate S and Z twisted strands;

a first fixation means for combining the alternately S/Z twisted strands of each group and connecting these at their nodes;

a second torsion means for imparting additional alternate twist to at least one of the alternately S/Z twisted strands;

a second fixation means for connecting the alternately S/Z twist plied yarns with each other;

a means to remove the yarn produced;

a steering means for the coordinated control of all the above mentioned means, characterized in that the means for reducing the tension in the alternate S/Z plied yarns is provided between the second torsion means and the second fixation means.

15. Apparatus according to claim **14**, wherein a means for measuring the tension of the yarn is provided after the second fixation means.

16. Apparatus according to claim **14**, wherein a means for yarn accumulation is provided after the second fixation means.

17. Apparatus according to claim **14**, wherein a means for heating the alternate S/Z twist plied yarn is provided before the second torsion means.

18. Apparatus according to claim **14**, wherein a means is provided for the addition of liquid additives to the yarns before the second torsion means.

19. Apparatus according to claim **14**, wherein a means is provided for the addition of liquid additives to the second torsion means.

20. Apparatus according to claim **14**, wherein a means is provided for addition of liquid additives in the second fixation means.

21. An alternate S/Z twist plied braid obtained by the method of claim **1**.

22. A joined alternate twist plied yarn obtained by the method of claim **4**.

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