The method of precision winding of textile yarn into packages by frequently changing the wind ratio within one winding cycle.
Description

[0001] The subject of the invention is the method of precision winding of textile yarn into packages by frequently changing the wind ratio within one winding cycle, or in other words, the method of directing and winding threads on tubes so that the winding structure of odd layers in the package differs from the structure of even layers.

[0002] According to the international patent classification this invention belongs to B65H 54/02, B65H 55/04, and additionally, to B65H 81/00.

[0003] The technical problem solved by this invention is formation of such structure of layers in packages which would prevent unfavorable unwinding dynamics of the thread in odd layers during unwinding from a tube; the angle between the longitudinal axis of the package, if looked towards the back end of the package, and the position of the thread in odd layers will be approximately 90°. As a result, the frictional force is reduced during unwinding of the thread from packages so that unwinding can proceed with high speed; at the same time, the structure of the packages will be compact, and both ends will be stabilized.

[0004] Various methods of yarn winding on tubes have been known so far. Patent US 6,027,060 presents the method of yarn cross winding on cylindrical tubes with cross treads, which prevents the occurrence of ribbon winding, and which at the same time provides step precision winding by calculating for each cycle a new wind ratio which decreases in a step. Each cycle consists of a double motion of the thread guide along the tube; the wind ratio represents the ratio of the number of spindle rotations and the double motion of the thread guide. Winding based on the method according to this invention increases the uniformity of the package density and, consequently, enables faster unwinding of such a package in comparison with the package wound by the method which enables the occurrence of ribbon winding. The most typical feature of ribbon winding is that the helices of the wound yarn stack one upon another, which means even helices upon even ones, and odd helices upon odd ones. Weakness and deficiency of this known solution is above all in the fact that in one and the same cycle, the distance between helices of odd layers is the same as that of even layers, only that some are left and the others right. Due to such winding technique of odd layers, which are wound on a tube from the back end towards the front end, over which the thread will be unwound later, it is not possible to achieve the desired higher speed of unwinding despite the elimination of ribbon winding.

[0005] There are also some other known solutions according to the following patents US 4,667,889; US 4,697,753; US 4,771,961; US 5,056,724; US 5,348,238; US 5,447,777; US 6,027,060; EP 0 194 524; SL 9111546 and EP 0 578 966, however, neither of them provides as high speed of thread unwinding from the tube as is required for weft insertion in modern looms. The reason is that those solutions almost ignore the fact that odd layers in cross wound packages represent a great obstacle for achieving higher speeds of unwinding; namely, odd layers are wound from the back end of the package towards its front end, over which the thread is unwound, and with the same distance between helices as in even layers in the same cycle.

[0006] It is characteristic of described known solutions that the methods of cross winding which are based on random, precision or step precision cross winding of the yarn on cylindrically or conically shaped tubes. Within one winding cycle, the thread is guided by the thread guide from the back end towards the front end of the package, which represents the odd layer, and in the reverse direction, from the front end towards the back end of the package, which represents the even layer. In one and the same cycle, the pitch of the thread helix in the odd layer does not differ, or does not differ substantially from the pitch of the thread helix in the even layer. The fact is that with the known methods of cross winding, the helices created by the threads in odd layers always lie in the planes which are inclined towards the back end of the package so that they form, with the parallel line, the angle smaller than 90°. The parallel line is represented by the longitudinal central axis of the package looked towards the back end of the package. The helices created by the threads in even layers lie in the planes inclined towards the front end of the package so that they form, with the parallel line, the angle larger than 90°. In this case as well, the longitudinal central axis of the package, if looked towards the back end of the package, represents the parallel line.

[0007] Another common characteristic of the known parallel techniques of closed winding of threads on tubes is that the helices created by the thread lie closely together on the bobbin, and form with the longitudinal central axis of the tube the angle, which is near 90°. With this known method, the pitch of the helices is preferentially the same as the diameter of the wound thread.

[0008] Weakness and deficiency of the described known solutions of yarn winding on tubes is above all in the fact that the pitch of the thread helices is identical in even and odd layers, and the angle formed between these helices and the parallel line, i.e. the longitudinal central axis of the package in the direction towards the back end of the package, can be smaller or larger than 90°. The described structure of even and odd layers does not provide high enough speed of threads unwinding from packages. Namely, unwinding of the threads from even layers in the direction from the back to the front end of the package is carried out under the angle of a helix larger than 90°. As a result of such angle, and of the simultaneous change of the thread motion, the traction force, the so-called reaction inertial force is generated. Since this force does not substantially obstruct unwinding of threads, it can be ignored in this case. Completely different is the case in relation to the dynamics of threads unwinding from odd layers that have been wound in the
direction from the package back end to its front end. Namely, the angle between the helices and the parallel line, i.e. the longitudinal central axis of the package in the direction of the back end of the package is smaller than 90°. Due to such angle, the force which acts on the thread in the direction of unwinding acts also on the portion of the thread which is still on the package by pressing the thread against the package. Since the thread is sliding over the package surface, the reactive frictional force acting in the opposite direction of the thread unwinding direction is generated in addition to the mentioned traction force. It should be noted that at a particular speed of unwinding, this frictional force is increasing with the decreasing angle of helices, and vice-versa.

[0009] The invention solves the problem by introducing the method of precision winding of textile yarn on tubes by frequently changing the wind ratio within one and the same winding cycle, and by stabilizing the yarn packages at the same time. If the thread guide changes the direction of winding, textile yarn will be wound on a tube with or without a flange at the back end, to produce packages consisting of seven sequences and five cones. At the same time, by continuously changing the package length within the interval of the thread guide travel length, different structure of odd and even layers in the package will be obtained, with odd layers being wound as parallel as possible. The produced package will be stable, compact and step precision wound. Furthermore, the invented method enables winding of threads on tubes also in the cases in which the thread guide does not change the direction of travel, which means in the cases when a servomotor which drives the thread guide carrier or carriers does not change the direction of its rotation. In such cases, each package having the thread wound on a tube with one disc-shaped flange on the back end will consist of two sequences and two cones. It will be also possible to change the package length to be a multiple of the thread guide carrier length, while the distance between the thread guides will be the same as the length of the package. The description of the invention will be given for two feasibility examples: the first preferential feasibility example producing the yarn package consisting of five cones and being step precision wound, and the second feasibility example producing the yarn package consisting of two cones, for packages with either a cylindrical or conical tube, with or without a flange on the back end of the tube, by means of the following figures:

Fig. 1 Schematic presentation of forces acting on threads during their unwinding from odd and even layers of cross winding packages

Fig. 2 Presentation of half the longitudinal section of the package wound by changing the direction and the speed of the thread guide travel by using the method according to this invention, together with symbolic presentation of the package surface within individual sectors

Fig. 3 The package produced by using the method according to this invention with the thread wound on a conical tube by changing the direction and the speed of the thread guide travel

Fig. 3A The package produced by using the method according to this invention with the thread wound on a cylindrical tube by simultaneously changing the direction and the speed of the thread guide travel

Fig. 3B Diagram of the thread guide travel speed during thread winding on tube by using the method according to this invention, which corresponds to the package with cylindrical tube presented in Fig. 3A

Fig. 3C Same diagram as in Fig. 3B, only slightly magnified and clearer

Fig. 4 The package produced by using the method according to this invention, with the thread wound on a cylindrical tube by changing the direction and the speed of the thread guide travel, with a conical flange on the back end for stabilization

Fig. 4A Same as in Fig. 3B, only for the package which corresponds to the package with a cylindrical tube having a conical flange in Fig. 4

Fig. 5 The package produced by using the method according to this invention, with the thread wound on a cylindrical tube without changing the direction of the thread guide travel, i.e. without changing the direction of rotation of the servomotor, which drives the thread guide carrier or carriers, with a disc-shaped flange to stabilize the package back end

Fig. 5A Diagram of the thread guides travel speed during threads winding on a tube by using the method according to this invention without changing the direction of travel, which corresponds to the package with cylindrical tube having a disc-shaped flange in Fig. 5

Fig. 6 Diagram presenting the comparison of the stresses exerted on a thread during thread unwinding from the packages between the known methods and the method according to this invention, by which the thread is wound on a cylindrical tube without a flange by changing the direction and the speed of the thread guide travel

Fig. 7 Photo of a package wound on a cylindrical
tube without flange by using the method according to this invention, by changing the direction and the speed of the thread guide travel.

[0010] Fig. 1 schematically presents the difference between the action of certain forces, which are generated during unwinding of threads 20 from odd layers 3 and even layers 4 of packages 1 wound by using the known methods of cross winding of packages 1, in optional points A and A’, which is the basis for the description and understanding of the problem and, at the same time, for understanding of the essence of the method according to this invention, which solves this problem. The point is that the thread 20 is unwound in the opposite direction of winding, which means that the thread 20 of odd layers 3 is unwound in direction D, i.e. from front end 18 to back end 19 of packages 1, and that the thread 20 of even layers 4 is unwound in the opposite direction C, i.e. from back end 19 to front end 18 of packages 1.

[0011] As already said, point A in Fig. 1 represents an optional point at unwinding of the thread 20 of odd layer 3 in direction D, and point A’ represents an optional point at unwinding of the thread 20 of even layer 4 in direction C with optional traction force F. Due to accelerations at high speeds of unwinding, inertial forces F and F’ are generated. In odd layers, the thread 20 is wound in such a way that in certain point A its helices close the angle α, which is smaller than 90°. In that case, in point A the traction force F acts also on a portion of thread 20 in odd layer 3, i.e. on its length from point A to point T, which still lies on package 1. During unwinding, the portion of thread 20 between points A and T presses on the surface of package 1 and slides over it; as a result, frictional force F, which acts in the direction of the helix of thread 20 in the odd layer, is generated. Force F acts until thread 20 rises in point A and detaches from the surface of package 1. The component, which in that case acts in the opposite direction of traction force F, is approximately proportional to the product of F*cosα. The problem with the frictional force appears only when thread 20 of odd layers 3 is unwound; there is no such problem with unwinding of thread 20 of even layers 4 due to the angle α’ being larger than 90° as is shown in point A’.

[0012] As a result of rotation of thread 20, the centrifugal force and the Coriolis’s force are generated between points A and B, and A’ and B during unwinding from package 1; both forces are almost equal in odd layers 3 and even layers 4, but since they have no substantial effect on the method according to this invention, they will not be specially mentioned. Point B equals the point of the position of guide 2* of thread 20 on the appropriate machine, on which packages 1, which have been previously wound by changing the winding ratio in one cycle according to this invention.

[0013] At unwinding of odd layer 3, thread 20 starts to rise from the surface of package 1 in point A. The effect of traction force F occurs lengthwise the thread 20 from point A to point T. Since in that case, angle α is considerably smaller than 90°, additional frictional force F, is generated and likewise inertial force F. At unwinding of even layer 4, thread 20 starts to rise from the surface of package 1 in point A’, and as a result, inertial force F’ is generated. Since angle α’ is larger than 90° in that case, frictional force F is not generated at unwinding of thread 20 from even layer 4 of package 1. It should be said once again that angle α or α’ presents the angle between the longitudinal central axis of package 1 if looked towards the back end 19 of package 1, and the position created by the helix of thread 20 in the odd layer 3 or even layer 4 on the surface of package 1.

[0014] It follows from the above facts that the major problem which arises in relation to cross winding of thread 20 in both, odd layers 3 and even layers 4 of packages 1, lies in the technique of winding of odd layers 3, i.e. in generation of frictional force F, at unwinding of thread 20 from odd layers. In order to solve this problem, which means to reduce the value of frictional force F, packages 1 should be wound in such a way that angle α of thread 20 in odd layers 3 will approach as much as possible the angle 90° - this is the basic and key feature of the invented method. It is important that at winding of thread 20 of even layers 4, the distance between helices of thread 20 are gradually decreasing creating in this way a cone on the surface of package 1 even if a cylindrical tube 12 is used; as a result, the value of frictional force F, is decreasing as well. It is required that package 1 remains stable during the process of unwinding, which means that thread 20 does not separate from package 1 at front end 18 and back end 19 of package 1. Such stability of package 1 is obtained by cross winding of a portion of length of package 1 at its front end 18 over which thread 20 will be unwound later, and by creating cone 9 at front end 18 of package 1. Stabilization of back end 19 of package 1 is achieved by its winding in the shape of a cone or a truncated cone. In some other feasibility example, back end 19 of package 1 can be stabilized with an additional conical flange 14 positioned on a tube 12.

[0015] In the upper part of Fig. 2, the structure of odd layers 3 and even layers 4 of package 1 is presented, and in the lower part of Fig. 2, the surface of package 1 is presented symbolically. Both presentations are located inside the area of package 1, i.e. in the area of its outside five cones 5, 6, 7, 8 and 9, and sectors L1, L2, L3, L4 and L5 which together make length L of package 1. Package 1 is wound on tube 12, without added flange 14 or flange 21, by means of guide 2 of thread 20 which changes the direction and the speed of its travel during winding. Also in that case, partly cross-wound package 1 consists of an optional number of odd layers 3 and even layers 4 created by winding thread 20. Odd layers 3 are wound in direction C, which means from back end 19 towards front end 18 of package 1 or tube 12, and are therefore unwound in the opposite direction D, which means from front end 18 towards back end 19. Just the contrary applies for even layers 4 which are wound in direction D,
which means from front end 18 towards back end 19 of package 1 or tube 12, and are therefore unwound in opposite direction C, which means from back end 19 towards front end 18. The structure of package 1 is obtained by sequencing seven travel sequences of guide 2 of thread 20 through odd layers 3 and even layers 4, which is presented in the diagram in Fig. 3B and 3C. The above description refers to packages 1 that have thread 20 wound on cylindrical or conical tube 12 presented in Fig. 3 and 3A but does not refer to packages 1 that have thread 20 wound on tubes 12, with an additional conical flange 14 or additional disc-shaped flange 21 on its back end 19 as is presented in Fig. 4 and 5, and which is going to be described in detail later.

As already said, package 1 presented in Fig. 2 has five outside cones 5, 6, 7, 8 and 9, which are arranged throughout the entire length L of package 1, i.e. within the area of five sectors L1, L2, L3, L4 and L5 in the following way: the outside cone 5 lies in sector L1, cone 6 in sector L2, cone 7 in sector L3, cone 8 in sector L4, and outside cone 9 in sector L5. It is also evident from Fig. 2 that sector L4 is in fact formed of both, the helices of odd layers 3 and the helices of even layers 4 of the preceding sector L2 and the following sector L4, the result of which is interlacing of layers 3 and 4. Namely, sector L3 begins in the vertical plane 10 lying rectangular to the longitudinal axis of tube 12 and with that of package 1, and ends in the plane 11 being parallel to the plane 10. The two planes are connected with a line positioned diagonally to the longitudinal axis of tube 12; this diagonal line connects their extreme points, which are diagonally apart (dotted line in Fig. 2). In other words, point 10 represents the beginning of cross winding of a portion of the first odd layer 3, and point 11 represents the beginning of cross winding of a portion of the last odd layer 3. The dotted line, which connects points 10 and 11, simulates the shift of the beginning of cross winding of a portion of odd layers 3 towards back end 19 of package 1. Narrowing of front end 18 of package 1 over which thread 20 is unwound from odd layers 3 and even layers 4 is the result of decreasing density of helices and because of that, increasing distance between helices in the direction of winding of thread 20 in odd layers 3 on one hand, and on the other hand, the result of increasing density of helices and because of that decreasing the distance between helices in the direction of winding of thread 20 in even layers 4. Package 1 is cross wound in the area of sectors L3, L4 and L5 by changing the wind ratio at each rotation of tube 12, which means that the wind ratio changes for each helix. This only partly applies for odd layers 3, which are under the dotted line between planes 10 and 11 wound rather parallel, likewise in sector L1 or L2. This winding technique according to this invention provides full stabilization of front end 18 of packages 1. The length of the area of cross winding, i.e. of sectors L3, L4 and L5 usually does not exceed one fifth to one fourth of the entire length L of packages 1, depending on their length and on the type of yarn or thread 20. As a rule, the length L of packages 1 is longer with multifilament yarn than with spun yarn. L1, inside which outside cone 5 is located, has two basic functions. The first function is stabilization of back end 19 of package 1 to avoid separation of thread 20 from package 1 due to the used technique of winding of thread 20 in odd layers 3, and partly also in even layers 4 in their path in direction D from front end 18 to back end 19 of package 1. In addition to that, the occurrence of ribbon or stack winding with the helices of thread 20 stacking one upon another in odd layers 3 at winding of package 1 would be avoided in this way. The same applies also for even layers 4. In the first odd layer 3, inside the sectors L1 and L2, and partly also L3, thread 20 is wound almost parallelly as its helices lie in the planes which are virtually pierced by the axis of package 1 under the angle slightly smaller than 90°, whereas the wind ratio and the speed of the thread guide inside the sectors L1 and L2, and partly L3 do not change. In even layers 4 and inside the area of sectors L1 and L2, thread 20 is cross wound in such a way that the pitch of helices gradually decreases in the direction of winding. Winding of even layer 4 begins when guide 2 of thread 20 starts to travel in direction D towards back end 19 of package 1. Fig. 3B shows that guide 2 reaches the highest speed at the end of sector L4 when it already moves towards back end 19 of package 1, where its speed starts to gradually decrease. Consequently, also the pitch of the helices of thread 20 in odd layers 3 and even layers 4 gradually decreases, and at the same time, the density of their winding increases. The result is a conical shape of package 1 in sector L2 even in the case of winding thread 20 onto package 1 with a cylindrical tube. With increased inclination or cone of packages 1 inside sector L2, frictional force F, which is generated at unwinding of odd layers 3 as a result of thread 20 sliding over the surface of package 1, decreases. The cone of package 1 in sector L2 is more pronounced at winding of thread 20 on a conical tube 12 than at its winding on a cylindrical tube 12. Inside sectors L4 and L5, and partly L3, thread 20 of odd layers 3 is cross wound; the wind ratio changes in the area of sectors L4 and L5, and partly L3. Thread 20 is cross wound also in even layers 4, in which the wind ratio changes as well. In sectors L4 and L5, and partly L3 the distance between helices of thread 20 in odd layers 3 gradually increases as a result of the previously described changes of the wind ratio. The speeds of guide 2 in path L at winding of thread 20 in direction C in odd layers 3, and in direction D in even layers 4 are presented and described in Fig. 3C.

Tubes 12, on which thread 20 is wound in odd layers 3 and even layers 4, may be of a cylindrical or conical shape, with or without flanges 14 or 21. Fig. 3 presents a package 1 with a conically shaped tube 12, and Fig. 3A presents a package 1 with a cylindrically shaped tube 12. It is evident that with conical tube 12, cone 6 in sector L2 of package 1 is much more pronounced than with the cylindrical tube 12. It has been already explained in Fig. 2 that within each sector, from
The ordinates of absolute speeds $V_1$ axis in the coordinate system presented in the diagram, which extends from a' to e', and which will be designated path L of thread guide 2 equals length L of package 1, winding of thread 20 in odd layers 3 and even layers 4, respectively, inside which outside cones 5, 6, 7, 8 and 9 are created. Slightly magnified and clearer, this diagram is presented also in Fig. 3C. Two winding cycles, the first and the second are presented. Each cycle consists of one odd layer 3 and one even layer 4, which are wound on the tube 12 in direction C or D. Odd layers 3 are wound in direction C, and even layers 4 in direction D. Each cycle consists of seven segments. It is evident in Fig. 3C that the first cycle is going on in course a'-b'-c'-d'-e'-f'-g'-a'' and creates the following seven segments: a'-b'; b'-c'; c'-d'; d'-e'; e'-f'; f'-g' and g'-a''. The second cycle is going on in course a''-b''-c''-d''-e''-f''-g''-a''' and creates the following seven segments: a''-b''; b''-c''; c''-d''; d''-e''; e''-f''; f''-g'' and g''-a'''.

[0019] The diagram in Fig. 3B and 3C shows that at winding of thread 20 in odd layers 3 and even layers 4, path L of thread guide 2 equals length L of package 1, which extends from a' to e', and which will be designated L = a'e'. It represents the first coordinate, i.e. the abscissa axis in the coordinate system presented in the diagram. The ordinates of absolute speeds $V_1$ and $V_2$ of guide 2 represent the other coordinate in this coordinate system. In fact, it is presented how guide 2 reaches a particular different speed $V_1$ in direction C or speed $V_2$ in direction D throughout length L of package 1, i.e. a particular speed $V_1$, $V_2$ in each individual sector from L1 to incl. L5, which together represent length L of package 1. For example, in the path from a’ to b’, guide 2 reaches the speed $V_1$ = b, and in the path from c’ to d’ speed $V_2$ of guide 2 increases from c to d. Thus, at winding of thread 20 on a tube 12, into odd layers 3 and even layers 4 alternatively, guide 2 traverses a particular path L at particular speeds $V_1$ or $V_2$: in the diagram, speeds $V_1$, $V_2$ represent the first coordinate, and path L the other.

[0020] As already said, the ordinates of absolute speeds $V_1$ and $V_2$ of guide 2 are on the left side of the diagram in Fig. 3C. The ordinate $V_1$ represents the speeds of guide 2 moving from back end 19 towards front end 18 of package 1, i.e. in direction C, and the ordinate $V_2$ represents the speeds of guide 2 moving in opposite direction from front end 18 towards back end 19 of package 1.

[0021] It has been also said already that the first cycle of winding by using the method according to this invention consists of two layers: the odd layer 3, in which thread 20 is wound in direction C, and the even layer 4, in which thread 20 is wound in direction D. In the diagram in Fig. 3C, the move and the speed of guide 2 will be monitored first through seven mentioned segments of the first cycle. At winding of odd layer 3 in direction C, guide 2 of thread 20 stands still in point a’ and, then, in the path from a’ to b’ it reaches speed b. In the path from point b’ to c’, the speed of guide 2 and, consequently, of thread 20 does not change and remains constant. In the path from c’ to d’, the speed of guide 2 increases from speed c = b to speed d. In the path from d’ to e’, guide 2 begins to stop and stops definitively in point e’. At this moment, winding of odd layer 3 in direction C in the first winding cycle is completed.

[0022] The first cycle proceeds by winding thread 20 in even layer 4 in direction D. In the path from e’ to f’, guide 2 reaches speed f. In the path from f’ to g’, the speed of guide 2 decreases from speed f to speed g. In the path from g’ to a’”, guide 2 of thread 20 begins to stop and stops definitively in point a”.

[0023] The second winding cycle of package 1 according to this invention also consists of the combination of odd layer 3 being wound in direction C, and even layer 4 being wound in direction D. The description of the path traversed by guide 2 and, consequently, by thread 20, in the second cycle follows. In direction C from point a””, in which guide 2 stands still, to point b””, the speed of guide 2 increases from the starting speed of 0 to speed b” which is the same as speed b in the above described first cycle. After that, the speed of guide 2 with thread 20 in odd layer 3 does not change from point b”” to point c””, and remains constant throughout this path. In point c””, the speed of guide 2 is equal to c”, and c” is equal to b”. In the path from point c”” to point d””, the speed of guide 2 increases to d”, which is equal to speed d in the first cycle. The speed of guide 2 begins to decrease in the path between points d”” and e””, and falls from speed d” to speed 0 in point e””. Winding of the odd layer 3 in the second cycle is thus completed, and winding of the even layer 4 of the second cycle begins. In the path from point e”” to point f””, the speed of guide 2 of thread 20 increases from speed 0 in point e”” to speed f” in point f””. Then, the speed of guide 2 begins to decrease in the path from point f”” to point g”” and falls from speed f”” to speed g”. The speed of guide 2 with thread 20 continues to decrease from speed g” to 0, which happens in the path from point g”” to point a”””. Thus, in point a”””, the speed of guide 2 is equal to 0, which means that guide 2 of thread 20 has stopped completely. Winding of the even layer 4 in direction D, i.e. from front end 18 to back end 19 of package 1 in the second cycle is completed.

[0024] The first and the second cycles of winding of thread 20 on a cylindrical or conical tube 12, with or without flanges 14 and 21, in odd layers 3 and even layers 4 alternately, which are described above, are original and novel concepts introduced by the method of winding packages 1 under this invention in the case when guide 2 of thread 20 changes the direction of travel, i.e. when servomotor which drives guide 2 changes the direction of rotation.

[0025] It follows from the description of the first and the second cycles of the method that with the combination of various speeds of travel of guide 2 of thread 20 in the path lengthwise package 1, five outside cones 5, 6, 7, 8 and 9 are created. As already said, packages 1 consist
of a large, optional number of previously described double layers. A double layer means one completed cycle of winding of thread 20, consisting of one odd layer 3 wound in direction C and one even layer 4 wound in direction D on tube 12 respectively package 1. Outside cones from 5 to 9 inclusive are created in individual segments or stages inside individual sectors L1, L2, L3, L4 and L5 in the path L lengthwise tube 12 of packages 1. Their creation at winding of thread 20, in odd layers 3 or even layers 4 on tubes 12 without flanges 14, 21 will be described with reference to Fig. 3B and 3C.

[0026] Formation of outside cone 5 is the result of the difference between the path of guide 2 in the first and the second cycles, and in all other pairs of cycles that follow. The reason lies in the length of path L traversed by guide 2 of thread 20 between point a’ in the first cycle and point a” in the second cycle in which guide 2 and consequently thread 20 stops completely.

[0027] Formation of outside cone 6 is the result of gradual decrease in speed of guide 2 of thread 20 in the path from point f’ to point g’. With the decrease in speed of guide 2 from speed f to speed g in this segment, the distances between helices of thread 20 wound in even layer 4 also gradually decreases, the result of which is the increased winding density of thread 20 on package 1 in this segment.

[0028] Formation of outside cone 7 is the result of the changing position of point c’ after each winding cycle; speed c, which is the same as speed b, begins to change after each cycle so that in the second cycle it changes already in point c”, which is closer to back end 19 of package 1 than point c’. The same applies for the following cycles. Formation of outside cone 8 is the result of the increase in speed c in point c’ to speed d in point d’ of guide 2 of thread 20. Outside cone 8 is also the result of the winding technique of even layers 4 in this part of package 1. When guide 2 of thread 20 reaches speed f in point f’, its speed begins to decrease, and it moves slower. Consequently, the distance between helices of thread 20 decrease, and the winding density of package 1 increases.

[0029] Formation of outside cone 9 is the result of the difference between the path traversed by guide 2 of in the first and the second cycles, and in all the pairs of cycles that follow. The reason lies in the difference in the length of the path traversed by guide 2 of thread 20 between point e’ in the first cycle and point e” in the second cycle; in e”, guide 2 and consequently thread 20 stop completely.

[0030] Prior to winding, it is necessary to experimentally determine optimal values of the parameters of winding of packages 1 for each textile yarn or thread 20, and to set the machine accordingly, i.e. to enter the parameters into the program of winding. There are at least fourteen parameters, including the parameter based on yarn or thread 20 thickness. After each completed winding cycle, the rotational speed of tube 12 on appropriate machines decreases. In this way, constant winding speed is provided. The quantity of the wound yarn or thread 20 is measured by the number of completed cycles, which means by the number of double layers of wound yarn, each of them consisting of one odd layer 3 and one even layer 4.

[0031] After winding of multifilament yarn or thread 20, particularly of glass multifilament yarn or thread 20, into packages 1 by using the method according to this invention, outside cone 5 in sector L1 and outside cone 9 in sector L3 are slightly gentler and longer than after winding of spun yarn or thread 20, with final diameter of packages 1 being the same. It should be also noted that at winding of thread 20 in odd layers 3, the distance between helices in sector L2 does not change. Thus, in this part, winding is almost parallel. When sector L3 is reached, the distance between helices of thread 20 gradually increases, and is the biggest at front end 18 of package 1. However, in comparison with the entire length L of package 1, the length of this portion of package 1 is relatively short. At unwinding of odd layer 3, the length of the balloon increases between point A and point B respectively guide 2 of thread 20. At the same time, the distance between helices of thread 20 decreases. The conditions of unwinding of odd layer 3 in sector L3 do not considerably worsen because of that. Furthermore, the lengths of helices also increase at unwinding of thread 20 from even layer 4 between points a’ and e’ from Fig. 3C, and at the same time, the length of the balloon decreases, which nullifies or neutralizes the effect of the increased the helix pitch length in sector L3. As already mentioned, unwinding of even layers 4 is not problematic. The narrowed portion of package 1, wound by using the method according to this invention, enables the positioning of guide 2 of thread 20 closer to tube 12 at front end 18, the result of which is decrease in the length of the mentioned balloon 20 of thread 20 in both, odd layer 3 and even layer 4. The narrowed portion of package 1 also enables successful unwinding of relatively long packages 1, or threads 20 wound into these packages, without the balloon hitting against front end 18 of package 1.

[0032] Fig. 4 presents package 1 with odd layers 3 and even layers 4 of thread 20 wound on a cylindrical tube 12, with an additional conical flange 14 on its back end 19. The only difference between winding of yarn or thread 20 on a tube with flanges 14 and previously described winding on cylindrical and conical tubes 12 without flanges 14 is in the formation of an inside cone 13, which has replaced an outside cone 5 of the previously described feasibility example in Fig. 3 and 3A. That is why only a part of the process of formation of this inside cone 13 by using the method according to this invention is going to be described, the description of the identical, already described process will not be repeated.

[0033] On the surface of package 1 presented in Fig. 4 having thread 20 wound on a cylindrical tube 12 with an additional conical flange 14, four outside cones 6, 7, 8 and 9 are created, while in the package, cone 13 is formed close to or on the inclined plane of the conical
As is presented in the diagram in Fig. 4A, at winding of thread 20 on a cylindrical tube 12 with a flange 14, inside cone 13 is formed in the path of guide 2 of threat 20 from point a’ to point a” in the first cycle, and in the path of guide 2 from point a” to point a*** in the second cycle. The speed of guide 2 increases between point a’ and point b’ from 0 to b. The process, which is up to point g identical to the process already described in relation to Fig. 3, 3A, 3B and 3C, follows. After that, the speed of guide 2 in the first cycle abruptly falls in the path from point g’ to point a” from speed g to speed 0.

With this, the first winding cycle in relation to this feasibility example is completed, and the second cycle starts with abrupt increase in speed of guide 2 from 0 to b” in its path from point a” to point b”. Then, up to point g”, an identical process as described for the previous feasibility example in relation to Fig. 3, 3A, 3B and 3C, follows. In the path from point g” to point a***, the speed of guide 2 abruptly falls from speed g” to 0 in point a***, and guide 2 moves towards flange 14 for a distance equal to the path from point a” to point a***. It should be noted that the travel speed of thread 20 along the tube is identical to the travel speed of guide 2 as they move together.

[0034] A winding machine for winding threads 20 on cylindrical or conical tubes 12, with or without an added cone flange 14, in relation to which guides 2 of threat 20 change the direction of travel consists, as a rule, of several basic components and elements. Tubes 12 are placed on corresponding spindles; they are driven by the main motor that can be programmed. A digital/analogue converter provides communication between the control unit and the main motor. Prior to winding of packages 1 by using the method according to this invention, the frequency, i.e. the number of rotations of the spindle with tube 12 on it in a time unit is to be programmed. In this way, the starting number of rotations of tube 12 and consequently of package 1 is preset. In addition to that, any projected changes, including reductions, of the frequency after each completed winding cycle, i.e. after winding of each double layer - odd layer 3 and even layer 4 together, are to be programmed as well. The values of all these parameters are entered into the application program of the winding machine control mechanism. This control mechanism equipped with application program provides extremely flexible control of the motion of guide 2 with thread 20, and efficient operation of a servomotor driving guide 2. The application program of the winding machine is adapted for winding packages 1 on tubes 12, with or without additional flanges 14.

[0035] Fig. 5 presents package 1 having thread 20 wound on cylindrical tube 12 with disc-shaped flange 21 at its back end 19. The servomotor of the winding machine, on which package 1 is wound, which drives the carrier or carriers of guides 2 and 2’ of threat 20 does not change the direction of rotation during operation. Guides 2 and 2’ travel lengthwise package 1 in both directions - C and D. Guide 2’ travels in direction D winding thread 20 on tube 12 towards back end 19 of package 1, whereas guide 2 travels in the opposite direction C, winding thread 20 on tube 12 towards front end 18 of package 1. The distance between the oppositely moving guides 2 and 2’ equals the length of package 1, and is a multiple of the length of the carrier of guides 2 and 2’.

[0036] Fig. 5A presents the diagram of the speed of guides 2 and 2’ of threat 20 at winding package 1 on the basis of the process described in relation to Fig. 5. Guide 2 moving towards front end 18 of package 1 grasps thread 20 in point b’, and proceeds with the unchanged speed b to point c’. In point c’, guide 2 with thread 20 has speed c, which is the same as speed b. From point c’ to point d’, which is at the same time front end 18 of package 1, guide 2 of threat 20 travels with accelerated speed, and reaches the highest speed in point d’. Equal is the speed of guide 2’, which travels in the opposite direction towards back end 19 of package 1. Guides 2 and 2’ of threat 20 can be mounted on one or two carriers, which are driven by one servomotor, and, as already said, they travel in the opposite directions - guides 2 in direction C, and guides 2’ in direction D. When guide 2 of threat 20, which travels in direction C, reaches front end 18 of package 1, i.e. point d’, it delivers thread 20 to guide 2’, which has reached point f’ (f’ = d’) and has speed f (f = d), and which travels in opposite direction D. During moving towards back end 19 of package 1, the speed of this guide 2’, which travels in direction D, decreases, and reaches speed g (g = b) at back end 19 of package 1; there, it delivers thread 20 to the next guide 2 which travels towards front end 18 of package 1. With this, the first winding cycle is completed. All the cycles that follow are identical to the described first cycle, and are repeated until package 1 is completely wound.

[0037] In the case of direct drive when the servomotor changes the direction of rotation, only one guide 2 of thread 20 per tube 12 is sufficient to carry out the method of winding of odd layer 3 and even layer 4 according to this invention. In the case of direct drive of tube 12 when servomotor does not change the direction of rotation, at least two guides 2 and 2’, or more are required for each tube 12. More than two guides 2 and 2’ of threat 20 are necessary when it is required to change the length of package 1 during the winding process. In that case at least three or more guides 2 and 2’ are required. The number of guides 2 and 2’ is thus a multiple of the length of the carrier of guides 2 or 2’, and the distance between guides 2 and 2’ should be the same as the length L of package 1.

[0038] Therefore, in the case of direct drive of tube 12, at least one pair of guides 2 and 2’ belongs to each tube 12 - one guide moving in direction C and winding thread 20 to tube 12 towards its front end 18, the other guide moving in direction D and winding thread 20 on tube 12 towards its back end 19. In their path in directions C and D, the described pair of guides 2 and 2’ exchanges one and the same thread 20 at the beginning and at the end of tube 12 during winding it in directions C and D so many times and so long that package 1 is wound completely.
The method according to this invention enables unwinding of yarn or threat 20 from various packages 1, some of them being wound by using the known methods, and the others by using the method according to this invention.

Curve 15 simulates the speed of unwinding of thread 20 from cross-wound package 1, which has been wound onto conically shaped tube 12 on a winder with circumferential drive by using a known method. The diagram in Fig. 6 reveals that at unwinding of thread 20 from this package 1 with the speed of up to 1.2 km/min., force F with value 9 to 10 cN is generated in thread 20.

Curve 16 simulates the speed of unwinding of thread 20 from package 1, which has been wound by using a known method, and which has a flat end, the so-called Top-Flat Package wound on the winding machine by Murata. This curve 16 shows that at unwinding of this package 1, with the speed of 1.2 km/min., force F with value 3 to 4 cN is generated, which is approximately three times less than in the case of curve 15.

Curve 17 shows the speed of unwinding V of threads 20 from packages 1, which have been previously wound on a tube without a flange 14 or 21 by using the method according to this invention. It is evident that the method according to this invention enables unwinding of yarn or threat 20, which is 4 km long or even longer, from packages 1 in one minute, and with lower stress/force F, which is in fact the result of the decrease in frictional force F. The experiments have revealed that at max. speed of unwinding V = 4,000 m/min., the stress exerted on thread 20 was only 40 cN. It is also very important that at unwinding of packages 1, which have been wound by using the method according to this invention, to which curve 17 refers, breakage of thread 20 did not occur in any case. In this experiment, length L of package 1 was 20 cm, and its diameter 13 cm. This means that the diameter of package 1 wound by using the method according to this invention was almost twice smaller than the diameter of packages 1 wound by using the known methods, to which curves 15 and 16 refer. At the same time, the length of package 1 that had been wound by using the method according to this invention was 5 cm longer than the length of packages 1 wound by using the known methods.

Experiments have also proved that the method of winding packages 1 under this patent enables at least three or even four times faster unwinding of yarn or threat 20 from packages 1 than the known methods of winding packages 1, by, at the same time, providing equal or even higher compactness of the winding structure of odd layers 3 and even layers 4. It is also very important that at the speed of unwinding V = 1.2 km/min. by using the method according to this method, the stress lower than 1 cN is generated. With the known solutions, this stress is even few times higher (from 3 to 10 cN) at the same speed V = 1.2 km/min. In other words, this means that packages 1 wound by using the method according to this invention, can be unwound on average three to four times faster than packages 1 wound by using the known methods. It has been proved as well that despite such high speed V of unwinding, provided that quality yarn or threat 20 is used, 5% of breaking strength of thread 20 is not exceeded at the speed of unwinding 3 to 3.5 km/min.

The most important original feature and advantage of the method according to this invention is that it provides such technique of winding odd layers 3 and even layers 4 into packages 1 which does not change, i.e. which remains the same either at winding package 1 with five cones 5, 6, 7, 8, 9 (Fig. 2 and Fig. 3) on a conical or cylindrical tube 12, with or without flange 14 or 21, or at winding package 1 with only two cones 6 and 8 (Fig. 5) on tube 12, with flange 21. The diagram in Fig. 6 compares stresses F (cN), which are generated at unwinding of thread 20 from various packages 1, with the speed of V in Fig. 3 and 3A. In this experiment, length L of package 1 was 20 cm, and its diameter 13 cm. This means that the diameter of package 1 wound by using the known method was almost twice smaller than the diameter of package 1 wound by using the method according to this invention, can be unwound on average three to four times faster than packages 1 wound by using the known methods. It has been proved as well that despite such high speed V of unwinding, provided that quality yarn or threat 20 is used, 5% of breaking strength of thread 20 is not exceeded at the speed of unwinding 3 to 3.5 km/min.

The method of precision winding of textile yarn into packages by frequently changing the wind ratio in one and the same winding cycle, using either cylindrically or conically shaped tube, with or without added flanges on the back end of the package, in which the thread guide is driven by a servomotor of such a construction that it changes the direction of its rotation, and which is based on the travel of the thread guide through several cycles of winding of odd and even layers during which a package with five outside cones, or four outside cones and one inside cone, with a conical flange on the back end of the package is formed inside the corresponding segments and sectors along the entire length of the package, characterized by the fact that in the first cycle, guide (2) with thread (20) traverses the path (L) twice, i.e., for the first time, at winding of odd layer (3) in direction (C), an, for the second time, at winding of even layer (4) in direction (D), whereby guide (2) moves in dependence of its speed (V, V) and of the path (L) through virtual points (a-b-c-d-e-f-g-a") which mutually and in the given sequence preferentially create seven speed segments of winding (a-b), (b-c), (c-d), (d-e), (e-f), (f-g) and (g-a") through which guide (2) with thread (20) travels, and the speed of travel changes; in the second cycle, guide (2) with thread (20) also traverses path (L) twice; i.e. at winding of odd layer (3) in direction (C), and at winding of even layer (4) in direction (D), whereby guide (2) moves in dependence of its speed (V, V) and of path (L) through virtual points (a"-b"-c"-d"-e"-f") which
2. The method of precision winding of textile yarn into packages by frequently changing the wind ratio in one and the same winding cycle, using either cylindrically or conically shaped tubes with added flange on the back end of the package, in which the thread guide is driven by a servomotor, which does not change the direction of its rotation, and which is based on the travel of the thread guide through several cycles of winding of odd and even layers during which a package with two outside cones along the package is formed inside the corresponding segments and sectors, characterized by the fact that guide (2) moves with speed (b), takes-up thread (20) in virtual point (b*) at back end (19) of package (1), and brings it with speed (b2) to virtual point (c*), and then with accelerated speed to virtual point (d*) at front end (18) of package (1) in which it delivers thread (20) with speed (d) to the next guide (2') in point (f'); with point (f') being the same or corresponding to point (d*'), and with speed (f) being the same as speed (d) proceeds with decreasing speed (V1, V2) to the next virtual point (g') which corresponds to point (b'), in which guide (2') has speed (g) which is the same as speed (b), and delivers thread (20) to the next guide (2), which moves with speed (b) towards front end (18) of package (1); this process is repeated in a cyclical sequence until the completion of winding of thread (20) into package (1) which is not step wound.

3. The method of precision winding of textile yarn into packages by frequently changing the wind ratio in one and the same winding cycle, using either cylindrically or conically shaped tube without added flange, which is based on the travel of the thread guide through several double cycles of winding of odd and even layers being driven by such a construction of servomotor which changes the direction of its rotation, and during which a package with five outside cones along the package is formed inside the corresponding segments and sectors, characterized by the fact that in the first cycle, guide (2) with thread (20) traverses path (L) in direction (C) at winding of odd layer (3), and again path (L) in opposite direction (D) at winding of even layer (4); whereby guide (2) travels in dependence of its speed (V1, V2) and path (L) through virtual points (a*→b*→c*→d*→e*→f*→g*→a*), which mutually and in a given sequence preferentially create seven speed segments of winding (a*→b*), (b*→c*), (c*→d*), (d*→e*), (e*→f*), (f*→g*) and (g*→a*) through which guide (2) travels with changing speed; in the second cycle, guide (2) with thread (20) traverses path (L) in direction (C) at winding of odd layer (3), and again path (L) in opposite direction (D) at winding of even layer (4); whereby guide (2) travels in dependence of its speed (V1, V2) and path (L) through virtual points (a*→b*→c*→d*→e*→f*→g*→a*), which mutually and in a given sequence preferentially create seven speed segments of winding (a*→b*), (b*→c*), (c*→d*), (d*→e*), (e*→f*), (f*→g*) and (g*→a*) through which guide (2) travels with changing speed; the produced package (1) of thread (20) is step wound.

4. The method according to Claim 1, characterized by the fact that thread (20) is step wound on tube (12) as a result of changing rotation of the servomotor and because of that the speed of moving guide (2) during winding of package (1), and by providing continuous changing of the length of tube (12) and package (1) throughout the entire length of travel of guide (2) of thread (20) by changing the number of impulses for the parameter of tube (12) and package (1) length in the application program loaded into the control unit memory.

5. The method according to Claim 2, characterized by the fact that thread (20) is not step wound on tube (12) as a result of non-changing rotation of the servomotor and because of that, not-changing moving direction of guides (2, 2') during winding of package (1), and by providing non-continuous changing of the length of tube (12) and package (1) by changing the number of guides (2, 2') of threads (20) on their carriers.

6. The method according to Claim 1, characterized by the fact that the travel of guide (2) of thread (20) which, at winding of first odd layer (3) in the first cycle, starts with accelerated speed in direction C from point of standstill (a1) towards point (b1), in which it reaches programmed speed (b), and proceeds steadily and with the unchanged wind ratio to point (c1), producing almost parallel winding of thread (20) in odd layer (3) by considering the pre-programmed distance between helices, with speed (b) being the same as speed (c) in point (c), and with guide (2) reaching point (b) before package (1) makes one revolution.

7. The method according to Claims 1, 2 and 3, characterized by the fact that guide (2) reaches the programmed speed (d) in path (L) from point (c) to point (d'), with speed (d) being the highest during winding of odd layer (3), and with yarn or thread (20) being in this segment cross wound on tubes (12) in such a way that the distance between the helices of thread (20) increases from point (c) to point (d').

8. The method according to Claims 1 or 4, characterized by the fact that one guide (2) of thread (20)
belongs to each tube (12).

9. The method according to one of Claims 2 or 5, characterized by the fact that at least two guides (2) and (2') belong to each tube (12).

10. The method according to Claim 2, characterized by the fact that the number of guides (2, 2') is a multiple of the length of their carriers and the distance between guides (2, 2') is equal to length (L) of package (1).

11. The method according to Claims 1, 2 and 3, characterized by the fact that the two, asymmetric, methods of winding of odd layer (3) and even layer (4) in one cycle of winding of thread (20) on tubes (12) are identical from point (b') to point (d') in odd layer (3), and from point (f') to point (g') in even layer (4), either at winding of packages (1) with five cones (5, 6, 7, 8, 9) or (6, 7, 8, 9, 13) on cylindrical or conical tubes (12), with or without conical flange (14) or disc-shaped flange (21), or at winding of packages (1) with only two cones (6, 8), with disc-shaped flange (21) at back end (19) of tube (12), and producing at the same time the structure of odd layers (3) which is different from the structure of even layers (4).

12. The method according to Claim 7, characterized by the fact that angle (α) between the helices of thread (20) in odd layers (3) is very close to right angle 90° except at front end (18) of package (1) between virtual points (c') and (d') where thread (20) is cross-wound.

13. The method under claim 1, characterized by winding of thread (20) on tube (12) in sectors (L3, L4, L5) by changing the wind ratio at each revolution of tube (12), which means with each helix of thread (20).

14. The method according to Claims 1, 2 and 3, characterized by the fact that in each cycle of winding of thread (20) onto tube (12), at least one odd layer (3) in direction C and one even layer (4) in direction D are wound.

15. The method according to Claim 1, characterized by the fact that both, the helices of threads (20) of odd layer (3) and those of even layer (4) from two adjacent sectors (L2) and (L4) are inside the sector (L3).

16. The method according to Claim 15, characterized by the fact that the sector (L3) begins in a vertical plane (10) positioned perpendicular to the axis of tube (12), and ends in plane (11) which is also perpendicular to the axis of tube (12), and which is connected with plane (10) by a diagonal line simulating the shift of the starting point of winding of the cross-wound portion of odd layers (3) towards back end (19) of package (1).

17. The method according to Claim 1, characterized by the fact that it is possible to use a conical flange (14) or disc-shaped flange (21) positioned on tubes (12) instead of an outside cone (5) to stabilize back end (19) of package (1).
Fig. 1

Fig. 2
Fig. 6
## DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document with indication, where appropriate, of relevant passages</th>
<th>Relevant to claim</th>
<th>CLASSIFICATION OF THE APPLICATION (IPC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>DE 43 10 905 A1 (SCHLAFLORST &amp; CO W [DE]) 6 October 1994 (1994-10-06) * column 10, line 64 - column 11, line 8; figures 5,7,9 *</td>
<td>1-3</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>CH 425 572 A (METTLER SOEHNE MASCHF [CH]) 30 November 1966 (1966-11-30) * the whole document *</td>
<td>1-3</td>
<td>TECHNICAL FIELDS B65H SEARCHED (IPC)</td>
</tr>
</tbody>
</table>

The present search report has been drawn up for all claims.

### CATEGORY OF CITED DOCUMENTS
- **T**: theory or principle underlying the invention
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Examiner: Lemmen, René
This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>JP 2002104730 A</td>
<td>10-04-2002</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>WO 2004035445 A</td>
<td>29-04-2004</td>
<td>CN 1703366 A</td>
<td>30-11-2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2005082758 A1</td>
<td>09-09-2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2007523814 T</td>
<td>23-08-2007</td>
</tr>
<tr>
<td>DE 4310905 A1</td>
<td>06-10-1994</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>CH 425572 A</td>
<td>30-11-1966</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 19817111 A1</td>
<td>05-11-1998</td>
</tr>
</tbody>
</table>

For more details about this annex: see Official Journal of the European Patent Office, No. 12/82
REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6027060 A [0004] [0005]
- US 4667889 A [0005]
- US 4697753 A [0005]
- US 4771961 A [0005]
- US 5056724 A [0005]
- US 5348238 A [0005]
- US 5447277 A [0005]
- EP 0194524 A [0005]
- EP 9111546 A [0005]
- EP 0578966 A [0005]