METHOD OF WINDING ORTHOCYCLICALLY WOUND COILS

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3 Sheets-Sheet 1

FIG. 1

FIG. 2

FIG. 3

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METHOD OF WINDING ORTHOCYCLICALLY WOUND COILS


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This invention relates to a machine for winding orthocyclic coils between flanges and on a template or coil former, preferably coils of insulated copper wire and more particularly such coils having a polygonal aperture for a core and a plurality of layers of windings.

The term “orthocyclic coil” as defined in a coil in which at least the greater part of each turn lies in one plane at right angles to the axis of the coil.

Such coils afford the advantages of a high space factor and that the turns of one layer are accommodated in the grooves of the underlining layer and hence cannot come into contact with the grooves of another layer which lies still deeper, so that greatly potential differences between two windings do not occur.

Although orthocyclic coils have been known for a long time, such coils could not be manufactured successfully in large numbers in a normal manufacturing process, because the first layer, which is decisive for the further winding process, requires special skilled knowledge on the part of the winders, and the thickness of the wire is frequently only small.

In a more specific sense the invention pertains to a machine for winding such coils having a polygonal aperture for the core and a plurality of layers of winding, in which the coil former or template on which the coil is wound performs a rotational movement, and in which at a short distance from the coil there is provided a wire guide which performs with respect to the coil former or template, a reciprocating movement parallel to the coil former or template and with a length of stroke approximately equal to the width of the coil to be wound.

The machine is provided with a driving rod which performs a reciprocating continuous movement over approximately the full length of stroke, the wire guide being coupled to this rod so that the movement of the wire guide takes place in a step-wise manner, each step corresponding to the distance between the sequential planes which are at right angles to the axis of the coil and in which each time the largest portion of a turn is located. As before, the advantage of the machine according to the invention resides in the security that the greater part of each turn lies in a plane at right angles to the axis of the coil so that the first layer which is decisive for the correct structure of the coil satisfies the requirements imposed.

In another embodiment of the invention, a coil-winding machine for winding coils having a polygonal aperture for the core is characterized in that the stepwise movement of the wire guide takes place at the moment when the wound wire has just been laid on the last edge of the template or coil former located before the beginning of the first turn of the first winding. Due to the friction which the applied portion of the turn encounters on the edge of the wire is fixed in position and does not shift when now the wire guide is moved and hence the deviation is imparted to the wire.

In a further embodiment of the invention, means are provided for giving the wire guide not only the step-wise movement, but also a transversely reciprocating second displacement, the forward part of which lies in the sense of winding. The wire is thus prevented from exerting an axial pressure upon a winding already laid on the coil former and since such axial pressures would be accumulated, a high pressure would finally result, which detracts from the accuracy of the dimensions of the coil and, in the case of insulated wire, could also damage the insulation or deform the wire.

The invention will be described with reference to the accompanying drawing, in which:

FIG. 1 shows diagrammatically a machine for winding orthocyclic coils;

FIG. 2 shows, on an enlarged scale, the connection between the wire guide and the driving rod;

FIG. 3 shows, again on an enlarged scale, part of the coupling between the wire-guide rod and the driving rod;

FIG. 4 shows the complex of levers which serves to give the wire-guide rod both a step-wise displacement and a reciprocating displacement;

FIG. 5 is a side view of the lever for releasing the clamped connection of the wire-guide rod of FIG. 4, as viewed in the direction of the arrow;

FIG. 6 is an elevation view of the lever for displacing the clamping device of FIG. 4, again as viewed in the direction of the arrow;

FIG. 7 shows, on an enlarged scale, a side view of the double tilting nut of FIG. 1;

FIG. 8 is a side view of FIG. 7, taken along the line VIII—VIII, and as viewed in the direction of the arrow;

FIG. 9 is a side view of the stop nut;

FIG. 10 shows diagrammatically a coil former with two turns of an orthocyclically wound coil, together with the wire guide;

FIG. 10a is an end view of FIG. 10;

FIG. 11 is a side view of FIG. 10 with several positions of the wire to be wound;

FIGS. 12 and 12a show diagrammatically the movement of the wire guide; and

FIG. 13 shows diagrammatically the manner in which the first turn of the second layer is laid.

In the figures, the reference numeral 1 indicates a coil spindle which is driven by an electric motor 2, which is supported at points 3 and 4. The coil spindle 1 drives a quadrangular coil former 5 with flanges 6, which is supported at the side remote from the coil spindle by means of a mandrel 7 which is displaceable in a manner not shown. In known manner, which is likewise not shown, the coil former 5 follows the movement of the coil spindle 1 upon rotation of the latter. In addition, the coil spindle 1 carries a cup-shaped disc 8 and a cam disc 9. Secured to the coil spindle 1 is a chain wheel 10 which drives through a chain 11 a wheel 12 which is secured to a shaft 13. The latter carries a gear wheel 14 which co-acts with a similar gear wheel 15. The two gear wheels 14 and 15 drive identically threaded shafts 16 and 17, each of which is provided with two diametrically opposite grooves 18 and 19. Moveable abutment nuts 20 and 21, which will be described with reference to FIG. 9, are arranged on the threaded shafts 16 and 17. The two shafts are separated by a rod 22 which has rigidly secured to it a double tilting nut 23 which will be described with reference to FIGS. 7 and 8. The rod 22 is pivotally connected to a rod 23a having a pivot 24 which is displaceable in a guide 25. For this purpose, an elongated slot 26 is provided in lever 23a. The pivot is pivotally connected to a driving rod 27 which carries a comb-like part 28 rigidly secured to driving rod 27 by means of a screw 29a. The comb-like part 28 is provided with...
a collar 29 (see FIG. 2) which has secured to it a wire-guide holder 30 by means of a screw 31.

A wire-guide rod 32, which is held in position by means of a clamping device 33 (see FIGS. 4, 5, and 6) carries at one end a coupling piece 34 which is rigidly connected to wire-guide rod 32 by means of a screw 35. The coupling piece 34 also comprises a coupling between a wire-guide 37 and a wire-guide rod 32 which has secured to it a wire-guide holder 30 by means of a screw 31. The wire-guide 37 can rotate in known manner (not shown) on spindle 36, but cannot slide axially on it. The wire-guide rod 32 can slide in the comb-like part 28. The coupling between the comb-like part 28 and the wire-guide rod 32 comprises two balls 38 and 39, springs 40 and 41 as spring 38. Secured to wire-guide rod 32 is a sleeve 40 which can slide freely in a comb 41 of the comb-like part 28. At the side of spring 39, the wire-guide rod 32 is rounded by a loose plate 42 which can move freely with respect to the rod 32.

The clamping device 33 (see FIGS. 4 and 5) which can hold the wire-guide rod 32 comprises a cylinder 43 having a cavity 44 into which the rod 32 fits in part. One end of cylinder 43 has a collar 45 and its other end has a smaller cylindrical portion 46 provided with a collar 47. The cylinder 43 is received in the machine, a spring 49 being provided between the fixed part 48 and the collar 47. The cylindrical portion 46 can slide in the part 48 of the machine against the action of spring 49. The cylinder 43 is surrounded by a sleeve 50 which is made of resilient material and arranged eccentrically about cylinder 43 so that the rod 32 is clamped between the sleeve 50 and the groove 44. At the lower side of clamping sleeve 50 there is provided an abutment bolt 51 which is secured in a fixed part 52 of the machine. At the upper side of the sleeve 50 there is provided an adjustable pressure bolt 53 arranged in one end of the lever 54. The lever 54 can pivot about a fixed point 55 and comprises, at its other end, a roller 56 which co-acts with a cam 57 of the cam disc 9. One end of a lever 58 presses against the collar 47 and its other end 59 co-acts with a cam 60 of the cup disc 8. The lever 58 can pivot about the eccentric cylinder 61 provided with a ratchet disc 62. Between the ratchet disc 62 and the lever 58 there is provided a torsion spring 63, the ends of which are connected to ratchet disc 62 and lever 58 respectively. The cylinder 61 is eccentrically connected to a fixed part 65 of the machine by means of a sleeve 61 which can rotate eccentrically about a bolt 64. A ratchet or the like 66, which can rotate about a fixed point 67, co-acts with the ratchet disc 62 and a movable abutment 68 arranged on the driving rod 27 can co-act with an arm 69 of the ratchet lever 66. The movable abutment nuts 70 and 71 are of a special design, as shown in FIG. 9, in order to obtain a rapid and also accurate adjustment of the said nuts. The nut 20 itself, which is provided with two pointed screws 70 and 70a which co-act with the grooves 18 and 19 in the threaded shaft 16 or 17, carries an abutment 71. Each nut is threaded over half its circumference, the other half being provided with a recess 72. Upon loosening the pointer screw 70a, the nut can thus be radially displaced on the threaded shaft 16 and subsequently displaced axially. There are two grooves 18 and 19 to permit the nut to be turned through 180° and subsequently fixed in position.

The double tilting nut 23, as shown in FIGS. 7 and 8, comprises two parts 23a and 23b which are rigidly connected together and clamped in position on the shaft 22 by means of clamping pieces 73a and 73b so that they cannot slip on the shaft but cannot slide on it. The parts are threaded at the area indicated by 74a and 74b. Each part also has a ridge 75a and 75b, respectively, which forms part of the segment of a circle, the centre of which lies on the centre of the threaded shaft 17 or 16. If in FIG. 7 the set of nuts 23 moves to the right, then at a given moment the abutment 71 co-acts with the segment of a circle 75a and hence the set of nuts 23 thus being tilted so that the screw threads 74a starts to co-act with the threaded shaft 16 and the sense of movement of the shaft 22 varies.

In order to clarify the operation of the assembly, the FIGS. 10, 10a and 11 will first be considered. FIGS. 10 and 10a show a quadrangular coil former 76 which has a flange 77 and on which an orthocyclic coil is to be wound. The wire 79 which is of copper insulated by a lacquer layer and finally provided with a thin layer of thermoplastic material (a so-called adhesive layer) is shown with exaggerated thickness for the sake of clarity. This wire actually has a much smaller diameter. The beginning of 79 being twice as long as the end of the flange 77, the first turn being laid in a plane at right angles to the axis of the coil former 76. As soon as the wire 79 has been laid on the coil former through a little more than three quarters of a turn, the wire must be given a deviation equal to the distance between two planes in which each time the greater part of one turn is located so that the subsequent turn comes at the right place. Since the wire does not encounter friction on the flat portions of a quadrangular coil former, the deviation must be imparted only when the wire has been laid in a fixed part 44 of the machine (see 80) before the beginning of the turn. As soon as the wire is thus fixed in position on the edge 80, the wire-guide 37 is given a displacement with respect to the initial position 81, which displacement is equal to the diameter of the wire 79 lies at some distance from the coil former and, after the displacement thereof, the wire occupies a position as indicated by a dash-and-dot line (at an angle with the plane of the first turn). This is the correct position of the wire guide for laying the second turn, but then during laying the last quarter of the first turn the wire exerts an axial pressure upon that portion of the first turn which lies on the first edge 83, as may clearly be seen from the figure. The wire is deformed as a result of this pressure and accordingly as more turns are laid, the length of the winding at the edge 83 of the coil former is smaller than the winding at the other edges, due to this deformation, which is not permissible in practice. As a result of this difference, it may occur, for example, that on this edge the distance between the last turn of the first layer and the flange, which distance in the case of an orthocyclic coil must be equal to half the diameter of the wire, is larger and may sometimes be more than the diameter of the wire, so that the first turn of the second layer lies on the relevant edge. This axial pressure may be avoided by giving the wire a transient second displacement whereby the wire-guide 37 assumes the dotted position 82. The wire itself then assumes the position likewise shown in dotted line of FIG. 10, in which the wire is laid along the first turn 79 without axial pressure occurring. This second displacement must also be given only when the wire is held in position on the edge 80. The second displacement must be maintained until the wire is fixed in position on the subsequent edge 83. Then the wire-guide 37 must be moved from the dotted position 82 to the proper position 37. The foregoing is clarified further in FIG. 11 in which it has been assumed for the sake of clarity that the wire-guide turns along the coil. As soon as the wire has been laid on the edge 80 after passing through angle P (FIG. 11), the wire-guide is given a displacement through an angle α which corresponds to a displacement from position 81 to position 37 in FIG. 10. Then the wire is securely held on the edge 80 and is wound about the coil 76. As soon as the wire has been laid in the direction 80 after passing through angle P (FIG. 11), the wire-guide is given a displacement through an angle β whereby the wire-guide in FIG. 10 is moved from position 37 to position 82. This second displacement is obviated as soon as the wire fixedly lies on the edge 83 after passing through the angle α. It will be evident that the second displacement could involve difficulty at the end of the first layer of turns, since there is a risk of
the wire then running up the second flange. In view thereof, the second displacement is not given to the wire for the last few turns, which is not objectionable since the axial pressure of the last few turns is not dangerous. It will also be evident that the second displacement is not required for the second and further layers of turns, since the wire then comes to lie in the "dead zone" underlying layer and if these turns have been laid properly, no more axial pressures occur between the wires of the second layer. The displacements of the wire guide which cause the displacement of the wire are shown again in FIG. 12 in which the length of the coil is plotted on the a-axis and the turns of the subsequent layers. The second displacement is switched off by means of the moveable abutment 68 which is arranged on driving rod 27 and which at a given moment engages the arm 69 of a latch 66 or the like. The latch 66 is thus turned away and now, due to the stressed torsion spring 63, the eccentric 61 performs half a revolution about the bolt 64 so that the end of lever 58 no longer engages the collar 47 and hence the lever 58 is inoperative. By means of a simple lever (not shown), the eccentric 61 is moved into the initial position before the winding of a new coil is started whereby the torsion spring 63 is stressed again and the latch 66 again meshes with cam disc 62.

A second displacement in laying the second layer of turns cannot be obtained with the structure shown and described. However, the clamping device may be connected to the fixed part 48 in a simple manner so that a movement which is subject to spring tension is possible to each side, in which event two levers 58 are required which are applied to each side of the clamping device.

The laying of the second layer of turns, when the wire guide 37 thus each time must move in a stepwise manner to the left, is effected in a similar manner as described for the movement to the right. In this case, sleeve 40 and plate 42 keep in position to the right of the comb 41 until the wire-guide rod is released and the sleeve and the plate again assume the positions shown. The force then acting upon the rod 32 is equal to the difference between the spring forces of the springs 38 and 39.

The laying of the first turn of the second layer, indicated by 84 in FIG. 13, will now be described. It is usually desirable for each layer to comprise the same number of turns. When the first turn of the first layer engages the flange, then the turns 34 and 39 on the wire-guide rod 32, the wire-guide keeps in position. The spring 38 is thus compressed and sleeve 40 slides in the comb 41 due to its being rigidly connected to the wire-guide rod 32. As soon as the coil spindle 1 has performed one revolution, the cam 57 (FIG. 5) of cam disc 9 engages the roller 56 so that the lever 54 turns about the fixed point 55 and the pressure bolt 53 deforms the resilient sleeve 50, the lower side of which engages the fixed abutment 51. Consequently, the wire-guide rod 32 is released and by the action of the compressed spring 38, moves on one step (to the right in the drawing) so that the wire-guide 37 assumes the next position. The variation in the position of the wire guide 37 thus takes place in a step-wise manner. Since the spring 39 is twice as strong as the spring 38, the rest position of the rod 32 with respect to the comb-like part 28 is fully determined. After the wire-guide rod 32 has been discharged, the lever 54 returns to its initial position since the cam 57 releases the roller 56 and the wire-guide rod 32 is again clamped in position. After the coil spindle 1 has rotated further a small angle (angle $r$ of FIG. 11), the cam 60 of cam disc 8 abuts against the end 59 of lever 58. This lever thus turns about the eccentric 61, its other end being urged against the collar 47 of clamping device 33. The clamping device 33, which can slide in the fixed part 48, is then moved to the right against the pressure of spring 49 and thus drives the wire-guide rod 32, whereby the sleeve 40 and the plate 42 (FIG. 3) are taken along and spring 39 also is compressed, since the movement of the wire-guide rod is greater than the continuous movement of the comb-like part 28 which continues to move under the influence of rod 17 nut 23 etc. Thus, the second displacement of the wire guide is obtained. As soon as the cam 60 releases the lever arm 59, the arm 58 moves to the left and, due to the spring 49 and 39, the clamping device 33, the sleeve 40 and the plate 42 re-assume their initial positions.

The second displacement of the wire guide is not required for laying the last turns of the first layer and all turns of the second layer. The second displacement is switched off by means of the moveable abutment 68 which is arranged on driving rod 27 and which at a given moment engages the arm 69 of a latch 66 or the like. The latch 66 is thus turned away and now, due to the stressed torsion spring 63, the eccentric 61 performs half a revolution about the bolt 64 so that the end of lever 58 no longer engages the collar 47 and hence the lever 58 is inoperative. By means of a simple lever (not shown), the eccentric 61 is moved into the initial position before the winding of a new coil is started whereby the torsion spring 63 is stressed again and the latch 66 again meshes with cam disc 62.
3. Apparatus for winding orthocyclically wound coils on a polygonal coil former, comprising means for rotating said coil former, a guide-wire means for directing wire onto said coil former, a driving rod, drive means for imparting continuous linear movement to said driving rod in a first direction and alternatively in the opposite direction, means connecting said driving rod and said guide-wire, said last named means being continuously moved by said driving rod, and means operatively connected with said last named means for periodically imparting step-wise movement to said wire-guide relative to said last named means, said step-wise movement being substantially equal to the distance between sequential planes which are at right angles to the axis of the coil and in each of which a greater part of each turn is located.

4. Apparatus for winding orthocyclically wound coils on a polygonal coil former comprising means for rotating said coil former, a guide-wire means for supplying wire to said coil former, and means for periodically moving said wire-guide in a step-wise movement relative to said coil former, said means for moving said wire-guide comprising means for supporting said wire-guide, a continuously linearly moving driving rod, means including a biased spring coupling said driving rod and said wire-guide rod, a clamping device for locking the wire-guide rod against movement, the clamping device means for releasing the wire-guide rod after locking and means for releasing the wire-guide rod for a short time during each revolution of said coil former whereby the wire-guide rod assumes a new position under the action of the spring proportional to movement of the driving rod.

5. Apparatus for winding orthocyclically wound coils on a polygonal coil former comprising means for rotating said coil former, a guide-wire means for directing wire onto said coil former, and means periodically reciprocally moving said wire-guide in a step-wise movement relative to said coil former, said means including a wire-guide rod supporting said wire-guide, a continuously linearly moving driving rod, biased spring means coupling said driving rod and said wire-guide rod, a clamping device for locking the wire-guide rod against movement, means connected with said clamping device for imparting movement to said clamping device for releasing the clamping device after locking the wire-guide rod for a short time during each revolution of said coil former whereby the wire-guide rod assumes a new position under the action of the spring means for preventing axial pressure between turns of wire in said layers.

6. Apparatus for winding orthocyclically wound coils on a polygonal coil former comprising means for rotating said coil former, a guide-wire means for supplying wire to said coil former, and means periodically reciprocally moving said wire-guide in a step-wise movement relative to said coil former, said means including a wire-guide rod supporting said wire-guide, a clamping device for locking the wire-guide rod against movement, means connected with said clamping device for imparting movement to said clamping device for releasing the clamping device after unlocking the wire-guide rod for a short time during each revolution of said coil former whereby the wire-guide rod assumes a new position under the action of the spring means for preventing axial pressure between turns of wire in said layers.

7. Apparatus for winding orthocyclically wound coils on a polygonal coil former comprising means for rotating said coil former, a guide-wire means for supplying wire to said coil former, and means periodically reciprocally moving said wire-guide in a step-wise movement relative
to said coil former, said means including a wire-guide rod supporting said wire guide, a driving rod, means for moving said driving rod, means including spring means coupling said driving rod and said wire-guide rod, a clamping device for locking the wire-guide rod against movement, said clamping device comprising a circular cylinder, a circular resilient sleeve surrounding said cylinder and engaging the cylinder on one side thereof, said cylinder having a recess into which a portion of said wire-guide rod fits and is clamped between the sleeve and the cylinder, and means for deforming the sleeve for a period during each turn whereby the wire-guide rod can slide between the sleeve and the cylinder and moves under the action of the spring means a distance proportional to movement of the driving rod, and means coupled with said clamping device for imparting a transient displacement to said wire-guide rod whereby said wire-guide is moved to prevent axial pressure between turns of wire in said coil.

8. Apparatus for winding orthocyclically wound coils on a polygonal coil former comprising means for rotating said coil former, a wire-guide means for supplying wire to said coil former, and means periodically reciprocally moving said wire-guide in a step-wise movement relative to said coil former, said means including a wire-guide rod supporting said wire-guide, a driving rod, means for moving said driving rod, a biased spring means coupling said driving rod and said wire-guide rod, a clamping device for locking the wire-guide rod against movement, said clamping device comprising a circular cylinder, a circular resilient sleeve surrounding said cylinder and engaging the cylinder on one side thereof, said cylinder having a recess into which a portion of said wire-guide rod fits and is held against movement between the sleeve and the cylinder, means for deforming the sleeve for a period during each turn whereby the wire-guide rod is free to slide between the sleeve and the cylinder and moves under the action of the spring means proportional to movement of the driving rod, said means for deforming said sleeve including a fixed pin member engaging one side of said sleeve, a moveable pin member engaging the opposite side of said sleeve, a lever rotatable about a shaft, said lever being connected at one end to said moveable pin member, a cam engaging the other end of said lever for periodically rotating said lever and means for imparting a transient movement to said wire-guide comprising an eccentrically rotatable lever having one end engaging said clamping device and a cam engaging the other end of said lever, a ratchet means engaging said eccentric lever for engaging and disengaging said eccentric lever and said clamping device whereby axial pressure on the starting turns of the wire of said coil is prevented.

9. Apparatus for winding orthocyclically wound coils as claimed in claim 8, in which an adjustable abutment is provided which is connected with the driving rod for disengaging said ratchet means.

10. Apparatus for winding orthocyclically wound coils as claimed in claim 1 in which the means for imparting continuous movement to the driving rod includes a double-tilting nut co-acting alternately with two threaded shafts rotating in opposite directions, and means interconnecting said nut and said driving rod.

11. Apparatus according to claim 10 wherein said means interconnecting said nut and said driving rod including a lever having a displaceable pivot.

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