

WIRE WINDING DEVICE

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to a wire winding device for winding a wire on a cylindrical bobbin having a flange on each end.

BACKGROUND OF THE INVENTION

[0002] A wire winding device for winding a wire on a cylindrical bobbin having a flange on each end has conventionally been used. In the wire winding device, a wire is aligned to wind per layer. As soon as one layer of the wire has been wound, a next layer of the wire is further wound thereon. Many layers of the wire are laminated by repeating thereof to be wound.

[0003] When the wire is wound, that makes the wire travel along a groove of a guide pulley to exactly determine a winding position of the wire. In a wire winding device, in many cases, a rotation axis of a bobbin is horizontal. Accordingly, the rotation axis of the bobbin will be hereinafter described as being horizontal. In the case where the rotation axis of the bobbin is vertical, the term "horizontal" should read "vertical" and the term "right and left" should read "top and bottom." When the rotation axis of the bobbin is horizontal, the bobbin is continuously moved to right and left while winding the wire. There is also a wire winding device in which a guide pulley and a

wire move from side to side with no movement of the bobbin from side to side. Since the wire is wound so that the layers of the wire may not overlap, a movement pitch of the bobbin at the time when the bobbin rotates one revolution is generally greater than the diameter of the wire.

[0004] For instance, when one layer of the wire is wound, the wire is wound from a right-end flange to a left-end flange while moving the bobbin rightward. Upon completion of winding of this layer, the movement direction of the bobbin is caused to reverse leftward to wind a next layer of the wire from the left-end flange to the right-end flange. The layer of the wire is laminated on the layer where the wire has previously been wound in a state of alignment. Further, upon completion of winding of the next layer, the movement direction of the bobbin is reversed again rightward to wind the wire from the right-end flange to the left-end flange.

[0005] An apparatus for reciprocating a bobbin or a wire is referred to as "a traverser" and a reciprocating distance of the bobbin or the wire is referred to as "a traverse width", and reversing the movement direction of the bobbin or the wire is referred to as "reversal of a traverser."

[0006] The bobbin is generally made of plastic or metal. Since there are various kinds of bobbins and various sizes of bobbins, it is needed to determine a traverse width in accordance with each bobbin.

[0007] There is a possibility that a winding amount of the wire may be excess near the flange (thickening in winding) or may be lesser near the flange (thinning in winding) when winding the wire on the bobbin while fixing the reversing position of the traverser. Such thickening and thinning in winding makes each layer of the wire to be less flat. A state in which each layer of the laminated wire is not flat is referred to as "a state in which a winding state of the wire is non-uniform."

[0008] When the winding state of the wire is in a non-uniform state, there is non-uniformity in a winding radius of the wire, which prevents the wire from being accurately fed out. In such a case, since there is an obstacle in using the wire in a later process, each layer is needed to be flat in the wire winding state.

[0009] Since wires have being wound so that each layer may be flat, a worker has been correcting a reversing position of a traverser by visually monitoring the winding state when necessary. Alternatively, the worker has been correcting the reversing position of the traverser by detecting a flange position by use of a sensor.

[0010] Japanese Unexamined Patent Application Publication No. 05-008934 A discloses that a traverser is reversed when an optical sensor detects a flange. This technology enables to wind the wire near the flange with being unaffected by variations of the flange position and errors in installation of a bobbin. Since it is not possible to

ignore time lag from detection of the flange to reversal of the traverser, there is a possibility that non-uniformity of the time lag may enlarge a winding radius near the flange (Thicken winding). Modifications are needed for thickening and thinning in winding that has occurred during the winding of the wire.

[0011] Japanese Unexamined Patent Application Publication No. 07-033326 A discloses that an optical sensor detects a flange of a winding bobbin to control such that a traverser is reversed after specified time. This technology enables to wind a wire regardless of a length of a bobbin body part. It is, however, impossible to wind the wire at a constant pitch due to variations of the winding radius in a constant speed travelling of the traverser. Further, to make the winding pitch of the wire constant, the travelling speed of the traverser needs to be changed according to the winding radius and the feeding rate of the wire. Furthermore, it is impossible to wind the wire flatly without detection of the flange of the winding bobbin by the optical sensor and calculation of time to the reversal of the traverser at the same time when the travelling speed of the traverser changes.

[0012] Japanese Unexamined Patent Application Publication No. 06-115810 A discloses that a difference between a winding outer diameter in the center of a bobbin and a winding outer diameter near each flange is obtained to modify the reversing position in accordance with the

difference. According to this method, it is possible to determine the reversing position of the traverser regardless of the bobbin dimensions and the bobbin outer shape.

[0013] There is no consideration for impact caused by variations in wear of traverser pulleys and rotational speed of the bobbin in this method. In a fixed abrasive grain type-saw wire, it is difficult to improve accuracy of calculation of the reversing position of the traverser due to great impact of wear of the grooves of the guide pulley. In addition, since the winding outer diameter is calculated at only one location where the sensor detects the flange, occurrence of abnormality of the winding outer diameter at the other locations is not detectable.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0014] Patent document 1: JP 05-008934 A
Patent document 2: JP 07-33326 A
Patent document 3: JP 06-115810 A

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0015] It is an object of the present invention to provide a wire winding device which is capable of automatically winding each layer in a flat manner regardless of dimensions of a bobbin to be used and impact caused by

variations in feeding speed of the wire and rotational speed of the bobbin.

MEANS FOR SOLVING THE PROBLEMS

[0016] The summary of the present invention is described as below.

In a first preferred embodiment, there is provided a wire winding device for winding a wire on a cylindrical bobbin having a flange on each end according to the present invention which includes: a rotating means for rotating the bobbin; a traverser for moving an entry position of the wire into the bobbin or the bobbin in parallel to a rotation axis of the bobbin; a plurality of distance sensors for each measuring a winding radius of the wire; a memory for storing values of the winding radius measured by each of the plurality of distance sensors; and a controlling means for calculating a reversing position where the traverser for traversing the bobbin reverses or a reversing position where the traverser for traversing the wire reverses based on the values of the winding radius stored in the memory. Each distance sensor is arranged between the entry position of the wire into the bobbin and the flange. The phrase "an entry position of the wire into the bobbin" is a position where the wire comes in contact with the bobbin or the wire that has already been wound on the bobbin when the wire is wound on the bobbin.

[0017] In a second preferred aspect of the wire winding device according to the present invention, each of the plurality of distance sensors detects the flange before the flange reaches the entry position of the wire when the flange approaches the entry position of the wire.

[0018] In a third preferred aspect of the wire winding device according to the present invention, the reversing position of the traverser is set based on the values of the winding radius at the time when each of the plurality of distance sensors detects the flange.

[0019] In a fourth preferred aspect of the wire winding device according to the present invention, the reversing position of the traverser is set based on the values of the winding radius at least three locations stored in the memory in the order of winding.

[0020] In a fifth preferred aspect of the wire winding device according to the present invention, the reversing position of the traverser is modified for each reversal of the traverser of the bobbin or the traverser of the wire.

[0021] In a sixth preferred aspect of the wire winding device according to the present invention, abrasive grains are fixed to a surface of the wire.

ADVANTAGES OF THE INVENTION

[0022] According to the present invention, it is possible to automatically keep a state in a flat manner in which each layer of the wire is wound regardless of variations in

dimensions of the bobbin to be used. In addition, there is no ununiformity because measurement of the winding radius is not affected even when the feeding speed of the wire changes according to wear of the guide pulley or changes in rotational speed of the bobbin during wiring.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

FIG. 1 is a block diagram of a major part of a wire winding device of the present invention;

FIG. 2 is an explanatory view of a traverse width control in a wire winding device of the present invention (when winding is flat);

FIG. 3 is an explanatory view of a traverse width control in a wire winding device of the present invention (when thickening in winding); and

FIG. 4 is an explanatory view of a traverse width control in a wire winding device of the present invention (when thinning in winding).

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] The present invention relates to a wire winding device for winding a wire on a cylindrical bobbin having a flange on each end. More specifically, the present invention is characterized in control of a reversing position of a traverser. Examples of the wire include a metal wire, a wire rope (metallic twisted wire), an

electric wire, optical fiber, a metallic pipe, a resin wire, a resin pipe, a thread, and a rope. The wire is, however, not limited to these.

[0025] In the case where a wire is a saw wire to be used for a wire saw having a diameter of about 100 μm with abrasive grains fixed on a surface of the wire, there is no slippage of the wire because adjacent abrasive grains of the wire are hooked, which disables the wire from being wound in a flat manner without precise reversal of a traverser. In the saw wire, since the abrasive grains are fixed to the surface of the saw wire, a guide pulley is rapidly worn. This makes groove-shaped variations of the guide pulley greater. Accordingly, it is difficult to obtain a wire speed and a winding distance from the number of rotations of the guide pulley to accurately calculate a winding radius based on the above. The present invention is particularly suitable for a wire such as a saw wire which is difficult to be wound.

[0026] FIG. 1 shows one example of a wire winding device of the present invention. A wire winding device 10 includes: a rotating means 12 for rotating a bobbin 11 around a rotation axis 13 thereof and a traverser 14 for moving the bobbin 11 in a direction parallel to the rotation axis 13 thereof. The bobbin 11 is attachably and detachably installed on the wire winding device 10. With reference to the dimensions of the bobbin 11, for example, a winding part of a wire 17 has a diameter of 100 mm, a flange 21 has

a diameter of 150 mm, and the winding part has a length of 200 mm. The dimensions of the bobbin 11, are however, not limited to these. Broken lines in FIG. 1 indicates a signal line. The wire 17 is fed out at constant tension from a wire feeding device not shown.

[0027] A typical example of the rotating means 12 of the bobbin 11 includes an electric motor. It is preferable that the electric motor for rotating the bobbin 11 is equipped with an encoder 24 for detecting a rotation angle and the rotation rate of the electric motor is precisely controlled.

[0028] Typical examples of the traverser 14 of the bobbin 11 include the bobbin 11 and a reciprocating means 15 for supporting the rotating means 12 of the bobbin 11 at a bobbin support 30 and reciprocating the bobbin support 30 in parallel to a rotation axis 13 of the bobbin 11. The reciprocating means 15 includes: the bobbin support 30 for rotatably supporting the bobbin 11; a pulse motor 16 fixed to a base body 31 for supporting the bobbin support 30; a plurality of ball screws 25 connected to the pulse motor 16; and nuts (not shown) screwed with the plurality of ball screws 25 and fixed to the bobbin support 30. The ball screws 25 are rotated by the pulse motor 16 to reciprocate the bobbin support 30. This enables the bobbin 11 to reciprocate. A servomotor may be used instead of the pulse motor 16. A linear pulse motor or a linear servomotor may be used instead of a combination of the pulse motor 16 and

the ball screws 25. The traverser 14 of the bobbin 11 is, however, not always limited to these reciprocating means.

[0029] When the wire 17 is wound on the bobbin 11, the wire 17 is guided to a groove of a guide pulley 18 to travel so as to accurately set an entry position of the wire 17.

While the bobbin 11 moves in parallel from side to side in the wire winding device 10 in FIG. 1, the guide pulley 18 and the wire 17 may move in parallel from side to side instead of the bobbin 11.

[0030] The wire winding device 10 of the present invention includes a plurality of distance sensors 20. The plurality of distance sensors 20 are used to each measure a distance l from zero point to a layer 19 of a surface of the wound wire 17 taking the periphery of the flange 21 of the bobbin 11 as a standard (base zero point). "A winding radius r " herein is obtained by a value in which the distance l to the layer 19 of the surface of the wound wire 17 has been deducted from an outer diameter L of the flange 21 of the bobbin 11.

[0031] Each of the plurality of distance sensors 20 is preferably arranged in the right and left with the wire 17 sandwiched. A distance sensor 20 (L) on the left side toward the drawing is used to control reversal of the traverser when the flange 21 on the left side approaches the entry position of the wire 17. A distance sensor 20 (R) on the right side is used to control the reversal of the traverser when a flange 21 on the right side approaches

the entry position of the wire 17. Distance L0 between the entry position of the wire 17 and the distance sensor 20 (L) on the left side is referred to as an off-set amount on the left side. Distance R0 between the entry position of the wire 17 and the distance sensor 20 (R) on the right side is referred to as an off-set amount on the right side. The off-set amount on the left side and the off-set amount on the right side are each set at an appropriate value in view of the travelling speed of the traverser and the reaction speed of the distance sensors 20 (L) and 20 (R). Certain time is needed from the time when the distance sensor 20 (L) or the distance sensor 20 (R) detects the flange 21 to the time when the traverser starts reversing due to inertia of the traverser. As a result, when the off-set amount on the left side and the off-set amount on the right side are too small, there are fears that the reversal of the traverser may be delayed.

[0032] Each of the distance sensors 20 is used to sequentially measure a winding radius r of the wire 17 at a plurality of locations in a rotation axis 13 direction of the bobbin 11. While measurement intervals of the winding radius r can freely be set, it is preferable to measure the winding radius r for each rotation of the bobbin 11 (for each pitch the traverser of the bobbin 11 advances).

[0033] Typical examples of the distance sensors 20 include laser-type displacement sensors or ultrasonic wave-type proximity sensors. The distance sensors 20 are, however,

not limited to these.

[0034] Each of the distance sensors 20 is preferably arranged between an entry position of the wire 17 and a flange 21. The reason for this is that it is preferable for control of the traverser to detect the flange 21 by use of each of the distance sensors 20 before the flange 21 reaches the entry position of the wire 17. It is determined that each of the distance sensors 20 detects the flange 21 when values of the winding radius r measured by each of the distance sensors 20 exceed a threshold obtained by deducting a specified value from the value of the radius of the flange 21.

[0035] Values of the winding radius r are measured by each of the distance sensors 20 every time the traverser of the bobbin 11 advances per pitch. Accordingly, the values of the winding radius r are obtained one by one. The values of the winding radius r are stored in the memory 22. It is possible to control the traverser when there are values of the winding radius r measured at least three locations. To improve accuracy, an example using the values of the winding radius r measured at 16 locations will now be described. For instance, the latest values of the winding radius r measured at 16 locations are stored in the memory 22 in the order of winding. When each of the distance sensors 20 detects the flange 21, the stored latest values of the winding radius r (winding radius r_1 to r_{15} measured at 15 locations except the position that is the nearest to

the flange 21) are used for controlling the traverser to be described later.

[0036] With reference to detection of the flange 21, a specified value smaller than the radius of the flange 21 is set to have a threshold so that each of the distance sensors 20 recognizes a location where the measured values exceed the threshold as the flange 21.

[0037] In the wire winding device 10, the reversing position of the traverser is changed by a controlling means 23 based on values r_1 to r_{15} of the winding radius of the wire 17 stored in the memory 22. Next, the traverser is reversed at the reversing position instructed by the controlling means 23.

[0038] A controlling method of a traverser in the wire winding device 10 equipped with the left-sided distance sensor 20 (L) and the right-sided distance sensor 20 (R) shown in FIG. 2 will now be described as one example. In FIG. 2, the bobbin 11 moves rightward while winding the wire 17. The left-sided distance sensor 20 (L) is used to control the traverser in FIG. 2. When the bobbin 11 is moving rightward, the right-sided distance sensor 20 (R) is not used to control the traverser. When the bobbin 11 is moving leftward, however, the right-sided distance sensor (R) is used to control the traverser (FIG. 3 and FIG. 4 are similar to FIG. 2).

[0039] FIG. 2 shows a moment when the left-sided distance sensor (L) has detected the left-sided flange 21 after the

rightward movement of the bobbin 11. For instance, the values of the winding radius r at 15 locations (these values are the latest values r_1 to r_{15} of the winding radius measured at 15 locations) that have been measured by the distance sensor 20 (L) and have been stored in the past which is the closest to the moment are used to control the traverser.

[0040] A value r_0 of the winding radius at the time when the flange 21 has been detected is a value of a radius of the flange 21. This value is excluded because this value is not a value of the winding radius. From a side which is near the flange 21, for instance, an average of the values r_1 to r_5 of the winding radius measured at five locations is "an average of values of the winding radius r on the flange side." For instance, an average of values r_6 to r_{15} of the winding radius measured at 10 locations located on a side far from the flange 21 is "an average of the winding radius r on the center side."

[0041] An average of the values r_1 to r_5 of the winding radius on the flange side is a and an average of the values r_6 to r_{15} of the winding radius on the center side is b .

When a value of $(a-b)$ is larger than the set threshold of thickening in winding, the value is judged to be thickening in winding, resulting in narrowing of a traverse width (the reversing position of the traverser is kept away from the flange 21). When the value of $(a-b)$ is between the set threshold of thickening in winding and the set threshold of

thinning in winding, the traverse width is not changed (the reversing position of the traverser is not changed). In addition, when the value of $(a-b)$ is smaller than the set threshold of thinning in winding, it is judged to be thinning in winding, resulting in widening of the traverse width (making the reversing position of the traverser closer to the flange 21).

[0042] When the bobbin 11 is moving rightward, the reversing position of the traverser is set at a position where the bobbin 11 has further moved by a left-sided offset amount $L0$ after the left-sided distance sensor 20 (L) detects the left-sided flange 21. This means that the traverser is reversed at a position where the entry position of the wire 17 comes in contact with the left-sided flange 21. When the bobbin 11 is moving leftward, the reversing position of the traverser is set at a position where the bobbin 11 has further moved by a right-sided offset amount $R0$ after the right-sided distance sensor 20 (R) detects the right-sided flange 21. This means that the traverser is reversed at a position where the entry position of the wire 17 comes in contact with the right-sided flange 21.

[0043] In FIG. 2, since the wire 17 is a state in which the winding state is uniform (a state in which there is neither thickening in winding nor thinning in winding) and the winding radius r is constant, the value of $(a-b)$ is within a range of the set threshold. As a result, the reversing

position of the traverser is not changed.

[0044] In FIG. 3, the winding state of the wire 17 near the left-sided flange 21 is in a non-uniform state and the value of the winding radius r of the wire 17 becomes larger near the flange 21 (thickening in winding is occurring). In such a case, when the wire 17 is further wound at the location of thickening in winding near the flange 21 to be laminated, thickening in winding is never resolved. Accordingly, to resolve the thickening in winding, the traverser is controlled in such a manner which will be described later.

[0045] FIG. 3 shows a moment when the bobbin 11 is moving rightward and the left-sided distance sensor 20 (L) detects the left-sided flange 21. As illustrated in FIG. 2, for instance, an average of values r_1 to r_5 of the winding radius on the flange side is a . In addition, an average of values r_6 to r_{15} of the winding radius at 10 locations located far from the flange 21 is b .

[0046] In the case of FIG. 3, since the winding radius r becomes larger near the flange 21 (thickening in winding is occurring), the value of $(a-b)$ is larger than the set threshold. As a result, the reversal position of the traverser is changed so as to narrow the traverse width.

[0047] A position X where the traverser is reversed when thickening in winding is occurring may be set beforehand based on experience. In this case, the reversing position X is fixed. Alternatively, the reversing position X may

vary in accordance with the value of $(a-b)$. In this case, the reversing position X is variable. To make the reversing position X variable means that for instance, when the value of $(a-b)$ is large, the degree of thickening in winding is high, resulting in an increase in the degree of narrowing the traverse width. Conversely, when the value of $(a-b)$ is small, the degree of thickening in winding is low, resulting in a decrease in the degree of narrowing the traverse width. To keep the winding state of the wire 17 ideally flat, it is preferable that the reversing position X is variable.

[0048] As mentioned above, it is possible to rapidly modify the state of thickening in winding of the wire 17 near the left-sided flange 21 by controlling the traverser. In addition, to make the modification of the winding state faster and more accurate, it is preferable to modify the reversing position of the traverser for each movement of the bobbin 11.

[0049] FIG. 4 shows that the winding state of the wire 17 near the left-sided flange 21 is non-uniform and the winding radius r of the wire 17 becomes smaller near the flange 21 (thinning in winding is occurring). In such a case, the traverser is controlled as stated below so that thinning in winding may be resolved .

[0050] In the case of FIG. 4, since the winding radius r becomes smaller near the flange 21, the value $(a-b)$ is smaller than the set threshold. As a result, the reversing

position of the traverser is changed so as to widen the traverse width.

[0051] The position where the traverser is reversed when thinning in winding is occurring may be previously set based on experience. In this case, the reversing position is fixed. Alternatively, the reversing position may be variable in accordance with the value of $(a-b)$. In this case, the reversing position is variable. To make the reversing position X variable means that for instance, when the value of $(a-b)$ is large, the degree of thinning in winding is high, resulting in an increase in the degree of widening the traverse width. Conversely, when the value of $(a-b)$ is small, the degree of thickening in winding is low, resulting in a decrease in the degree of widening the traverse width. To keep the winding state of the wire 17 ideally flat, it is preferable that the reversing position X is variable.

[0052] The wire winding device of the present invention enables to automatically perform flat wiring in a uniform winding state by the aforementioned control of the traverser.

INDUSTRIAL APPLICABILITY

[0053] The winding device of the present invention is widely utilized for winding all kinds of wires such as metal wires, wire ropes (metallic twisted wires), electric wires, optical fibers, metal pipes, resin wires, resin

pipes, yarns, and ropes.

DESCRIPTION OF REFERENCE NUMERALS

[0054] 10: wire winding device; 11: bobbin; 12: rotating means of bobbin; 13: rotation axis of bobbin; 14: traverser; 15: reciprocating means; 16: pulse motor; 17: wire; 18: guide pulley; 19: layer of surface; 20: distance sensor; 21: flange; 22: memory; 23: controlling means for pulse motor; 24: encoder; 25: ball screw

CLAIMS

1. A wire winding device for winding a wire on a cylindrical bobbin having a flange on each end, comprising:

- a rotating means for rotating the bobbin;
- a traverser for moving one of an entry position of the wire into the bobbin and the bobbin in parallel to a rotation axis of the bobbin;
- a plurality of distance sensors for each measuring a winding radius of the wire;
- a memory for storing values of the winding radius measured by each of the plurality of distance sensors; and
- a controlling means for calculating a reversing position where the traverser for traversing the bobbin reverses based on the values of the winding radius stored in the memory,

wherein each of the distance sensors is arranged between the entry position of the wire into the bobbin and the flange.

2. The wire winding device according to claim 1, wherein each of the plurality of distance sensors detects the flange before the flange reaches the entry position of the wire when the flange approaches the entry position of the wire.

3. The wire winding device according to claim 1 or claim 2, wherein the reversing position of the traverser is set based on the values of the winding radius at the time when each of the plurality of distance sensors detects the flange.

4. The wire winding device according to any one of claims 1 to 3, wherein the reversing position of the traverser is set based on the values of the winding radius at least three locations stored in the memory in the order of winding.

5. The wire winding device according to any one of claims 1 to 4, wherein the reversing position of the traverser is modified for each reversal of one of the traverser of the bobbin and the traverser of the wire.

6. The wire winding device according to any one of claims 1 to 5, wherein abrasive grains are fixed to a surface of the wire.