

CONTINUOUS WEB TRAVERSE WINDING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a continuous web traverse winding system for spirally winding a continuous web that is in the form of thin tape at a uniform pitch on a bobbin that is reciprocated, and in particular to a continuous web traverse winding system for winding a continuous web while preventing the occurrence of irregular winding in which the wound continuous web is bulged in the vicinity of the opposite ends thereof.

2. Description of the Related Art

In the conventional continuous web traverse winding system as shown in Fig. 8, a bobbin 10 having a cylindrical shaft 10a and a pair of circular collars 10b secured to the opposite ends of the shaft 10a is mounted on one end of a rotary winding shaft 21 that can be reciprocated in an axial direction. A stationary guide roll 12 is disposed adjacent to the bobbin 10 so that it supplies the bobbin 10 with a continuous web 14 in a constant speed. A proximity member 18 is mounted on the winding shaft 21 along a length thereof via a bracket 18a. A pair of proximity switches 16 is disposed so that the proximity member 18 is interposed therebetween. The proximity switches 16 are adapted to transmit a detection signal representing the proximity of the member 18 to a control unit (not shown) when it is detected by the switches 16. The control unit in turn sends a reversing or moving back instruction signal to a drive source for reciprocating the winding shaft.

In another form of the conventional winding system, the reversing position of the reciprocating movement of the above-mentioned slide drive mechanism is controlled by adjusting the number of rotations of a drive shaft of a ball screw mechanism as shown in Fig. 9. The bobbin 10 is mounted on one end of a winding shaft 21. The winding shaft 21 is driven to rotate by a winding motor 20 and is rotatably and slidably supported by a slide support 23. The slide support 23 is provided on a stationary bed 24 so that it can achieve a rectilinear movement in an axial direction of a winding shaft 21 via a linear guide and its linear movement is controlled in position and speed by means of the ball screw mechanism 22 that is driven by a servo-motor 26. A master sequencer 30 monitors the number of rotations of the servo-motor 26 to determine the reversing position of the reciprocating movement of the winding shaft 21 and sends a

normal or reversal rotation signal to a winding control sequencer 34 via a relay 32. The winding control sequencer 34 monitors the number of rotations of the winding motor 20 to send to a servo-amplifier 38 via a relay 36 a control signal that is computed for synchronizing the speed of the reciprocal movement of the winding shaft 21 with the rotational speed of the bobbin 10 and said normal or reversal rotation signal. The servo amplifier 38 is controlled by the signal from the relay 36 to send an amplified drive output to the servo motor 26. The reversing position of the winding shaft 21 can be manually adjusted by means of a reversing position adjusting button 39 that is connected with the master sequencer 30.

Since the above-mentioned conventional continuous web traverse winding system usually includes a plurality of winding devices that are simultaneously operated, a plurality of control units which are in parallel provided are connected to the output of the master sequencer 30 as shown in Fig. 10.

The structure of each of parallel control units is identical with that which has been described with reference to Fig. 9.

In the above-mentioned continuous web traverse winding systems, a problem of irregular winding may occur in which wound continuous web 14 is bulged at the opposite ends of the bobbin 10 by a dimension A. This causes a gap B between the collar 10b of the bobbin 10 and the winding continuous web 14 at the outer periphery of the wound continuous web 14 to become smaller by B-A. Accordingly, when the diameter of the wound web becomes larger, the continuous web 14 is brought into contact with the collar 10b resulting in unqualified wound web such as broken edge of the continuous web or collapsing of the wound web into the gap.

In order to eliminate the foregoing problems, the gap B had been preset larger in the above-mentioned conventional system. This prevents the contact between the continuous web 14 and the collar 10b. Further, an operator visually monitors the reversing position of the reciprocating bobbin 10 to actuate the reversing position adjusting button 39. However the width of winding of the continuous web 14 becomes smaller to provide an allowance for the gap B and the length of the continuous web that can be wound on one bobbin becomes less. Since manual operation may cause variations in reversing position and operation error, the above-mentioned unqualified winding can not be completely eliminated.

It is therefore an object of the invention to provide a continuous web traverse winding system in which correction of irregular winding that has been manually conducted is automated.

It is another object of the present invention to provide a continuous web traverse winding system in which unqualified winding such as edge breaking is eliminated.

It is further object of the present invention to provide a continuous web winding system that is capable of increasing the length of the continuous web which can be wound on one bobbin.

SUMMARY OF THE INVENTION

In order to achieve the above-mentioned object, the present invention provides a continuous web traverse winding system for winding a plurality of continuous webs on a plurality of bobbins, each having a cylindrical shaft and having a pair of disc-shaped collars at opposite ends thereof, including a plurality of winding devices, which are simultaneously operated, each device comprising: a stationary guide roll for supplying a continuous web to each bobbin for winding it in a constant speed; a slide support which is provided so that it is slidable with respect to the stationary bed in an axial direction of the bobbin; a winding motor having a rotary shaft on which the bobbin is mounted, which is fixedly supported on the slide support; a slide drive mechanism having a reversible servo-motor for reciprocally sliding the slide support in an axial direction of the bobbin; and a winding control sequencer which monitors the number of rotations of said winding motor for supplying a normal or reverse rotation signal to the servo-motor, said sequencer being adapted to generate the normal or reverse rotation signal in accordance with a control relationship preset to correct the reversing position of the continuous web which changes with the increase in the external diameter of the continuous web wound on the bobbin.

The second invention is characterized in that said control relationship is represented as follows:

$$A = \{ L_0^2 - 1/4 \times (D_1 + D_g)^2 \}^{0.5} \times P / (\pi \times D_1) / 2 \\ - \{ L_0^2 - 1/4 \times (D + D_g)^2 \}^{0.5} \times P / (\pi \times D) / 2$$

wherein L_0 denotes the distance between the centers of the guide roll and the bobbin; D_1 denotes the external diameter of the bobbin; D_g denotes the external diameter of the guide roll; P denotes the traverse pitch of the continuous web wound by the bobbin; D denotes an external diameter of the continuous web wound by the bobbin at any selected time and in which the reversing position at the external diameter of D is offset in a negative direction in accordance with said relationship A from an original reversing position of the continuous web at both extremities of reciprocal movement of the bobbin.

The third invention is characterized in that said winding control sequencer also monitors the rotation of the servo-motor and supplies a signal to said servo motor via a servo-amplifier.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view for explaining the process of winding a continuous web on a bobbin;

Fig. 2 is a longitudinal sectional view relevant to Fig. 1;

Fig. 3 is an evolutionary view showing one turn of the continuous web wound on the bobbin, which is cut in an axial direction of the bobbin and is evolved on the plan view;

Fig. 5 is a block diagram showing an output side circuit when a plurality of winding devices are in parallel operated in one embodiment of a continuous traverse winding system of the present invention;

Fig. 6 is a sectional view showing a bobbin on which a continuous web is wound in one embodiment of a continuous traverse winding system of the present invention;

Fig. 7 is a graph showing an experimental example of the continuous web traverse winding system of the present invention;

Fig. 8 is a plan view showing a part of a conventional continuous web traverse winding system;

Fig. 9 is a schematic circuit diagram showing another example in a conventional continuous web traverse winding system;

Fig. 10 is a block diagram showing an output side circuit when a plurality of winding devices are in parallel operated in a conventional continuous traverse winding system; and

Fig. 11 is a sectional view showing a bobbin on which a continuous web is wound in a conventional continuous traverse winding system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to Fig. 1, there is shown a plan view for explaining the process for winding a continuous web on a bobbin. A bobbin 10 comprises a cylindrical shaft 10a and a pair of circular disc-like collars 10b mounted on the opposite ends of the shaft 10a. The bobbin 10 is rotated by a mechanism which will be described below to wind a continuous web 14 which in the form of thin metal tape while it is reciprocated in an axial direction. A stationary guide roll 12 is adapted to supply the continuous web 14 and is rotatably secured to a supply apparatus (not shown).

The offset of the reversing position of the continuous web which changes in association with the outer diameter of the continuous web that has been wound on the bobbin 10 will be mathematically analyzed and described. It is assumed that the line speed be constant and there be no time lag in both mechanical and electrical systems as preconditions.

In Fig. 1, L_0 denotes a distance between the centers of the guide roll and the bobbin; D_1 an external diameter of the shaft 10a; D an external diameter of the continuous web which is wound on the bobbin at any selected time; P a traverse pitch of the continuous web wound on the bobbin 10 which is kept constant by synchronizing the speed of the rectilinear movement of the bobbin 10 with the rotational speed of the winding motor 20 by means of a control unit which will be described below. θ denotes a winding spiral angle of the continuous web 14 value of which changes from $+\theta$ to $-\theta$ immediately after the rectilinear movement of the bobbin 10 reverses from a direction M to a direction O in Fig. 1. δ denotes a distance at which the bobbin 10 advances while the continuous web 14 changes its winding spiral angle by θ . Accordingly, the bobbin 10 will advance by 2δ in a direction represented by O while the winding spiral angle changes from $+\theta$ to $-\theta$.

Fig. 2 is an elevation view correspond to Fig. 1. L denotes a distance between a separation point of the continuous web 4 from the stationary guide roll 12 and a contact point of the web 14 with the wound continuous web 14 on the bobbin. The stationary guide roll 12 has an external diameter D_g and the wound continuous web 14 has an external diameter of D .

Now, 2δ will be obtained from the following. The relation is established from Fig. 1.

$$\delta = L \times \tan \theta \dots (1)$$

Therefore,

$$2\delta = 2(L \times \tan \theta) \dots (2)$$

From Fig. 2, we obtain

$$\begin{aligned} L &= \{ L_0^2 - (D/2 + D_g/2)^2 \}^{0.5} \\ &= \{ L_0^2 - 1/4 \times (D + D_g)^2 \}^{0.5} \dots (3) \end{aligned}$$

Referring now to Fig. 3, there is shown an evolutionary view in which one turn of the wound web 14 on the bobbin 10 is cut in an axial direction of the bobbin 10 and is evolved on a plane. The dimension of the web 14 in a vertical direction is πD since it is an outer peripheral length of the external diameter D . P denotes a traverse pitch and θ is a winding spiral angle. The following relation is established

$$\tan \theta = P / (\pi \times D) \dots (4)$$

Therefore, by putting expressions (3) and (4) into (2), 2δ is converted as follows:

$$2\delta = 2 \times \left[\left\{ L_0^2 - 1 / 4 \times (D + D_g)^2 \right\}^{0.5} \times P / (\pi \times D) \right] \\ = \left\{ L_0^2 - 1 / 4 \times (D + D_g)^2 \right\}^{0.5} \times P / (\pi \times D) / 2 \quad \dots\dots\dots (5)$$

Now, reversing position of the changing continuous web 14 will be determined as follow.

In Fig. 1, it is assumed that a first reversing position of the continuous web 14 be zero and the direction O be positive (+), an external diameter of the shaft 10a be represented by D_1 . The external diameter of the wound continuous web 14 on the bobbin 10 at any selected time, the distance by which the bobbin 10 advances in a direction O on a first reversing and the distance by which the bobbin 10 advances in a direction O when the external diameter of the winding is D are represented by D, Y_1 and $Y (=2\delta)$, respectively.

A which is the reverse point when the wound web has an external diameter D is represented as follows:

$$A = Y_1 - Y \quad \dots\dots\dots (6)$$

Y is represented by expression (5) since $Y=2\delta$. Y_1 is an expression when D in the right side of the expression (5) is D_1 . Therefore,

$$A = \left\{ L_0^2 - 1 / 4 \times (D_1 + D_g)^2 \right\}^{0.5} \times P / (\pi \times D_1) / 2 \\ - \left\{ L_0^2 - 1 / 4 \times (D + D_g)^2 \right\}^{0.5} \times P / (\pi \times D) / 2 \quad \dots\dots\dots (7)$$

In other words, the second reversing position of the continuous web 14 when the external diameter of the windings is D is offset from the first reversing position by A that is represented by expression (7). Therefore, the offset of the reversing position can be canceled by shifting the reversing position by A in a negative (-) direction.

Now, the bulged irregular winding due to lag in an electrical system will be explained.

The delay time of the electrical system in the conventional continuous web traverse winding system as shown in Fig. 9 comprises about 40 milli-secs. of the internal processing time in the master sequencer 30, about 40 milli-secs. of the internal processing time in the winding control sequencer 34, about 1 milli-sec. of the relay 32 and 36, and about 10 milli-secs. of signals transmission by the servo-amplifier 38, which is a total of about 111 milli-secs. This time lag causes the bobbin 10, the reversing position of which is controlled, to be reversed in a position which is outwardly offset from the reversing position determined. This is one of causes of the bulged irregular winding.

Now, a preferable embodiment of a continuous web traverse winding system in accordance with the present invention will be explained with reference to the drawings.

Referring now to Fig. 4, there is shown a circuit diagram of main components of the continuous web traverse winding system of the present embodiment.

In Fig. 4, the bobbin 10 comprises a cylindrical shaft 10a and a pair of circular disc-shaped collars 10b mounted on opposite ends of the shaft and is mounted on one end of the winding shaft 21. A stationary guide roll 12 is adapted to supply the continuous web 14 to the bobbin 10 and is secured to the a supply side apparatus (not shown).

The winding shaft 21 is rotatably and slidably supported on a slide support 23 and is driven to rotate by means of a winding motor 20 secured to the slide support 23. The winding motor 20 transmits a signal representative of the number of rotations of the shaft 21 to each of winding control sequencers 34. The slide support 23 is provided on the fixed bed via the linear guide so that it is linearly movable in an axial direction of the winding shaft 21, and is controlled in position and speed by the ball screw mechanism 22 that is driven by the servo-motor 26. The number of rotations of the servo-motor 26 is monitored by each of the winding control sequencer 34.

Each of the winding control sequencers 34 computes the reversing position that is corrected in accordance with programmed relation (7) based upon the numbers of rotations of the winding motor 20 and the servo motor 26 as well as the speed of rectilinear movement of the winding shaft 21 which is synchronized with the number of rotations of the winding motor 20. Each of the winding control sequencer 34 transmits to the servo-amplifier 38 a control signal that is based upon the results of the computations. In response to a signal from the sequencer 34, the servo-amplifiers 38 transmits an amplified drive output to the servo motor 26. Other control data such as corrections of lag times caused by the mechanical and electrical systems can be see by a touch panel 33 that is connected with each of the winding control sequencers 34.

The above-mentioned continuous web traverse winding system of the present embodiment comprises a plurality of parallel control units as shown in Fig. 5 for simultaneously operating a plurality of winding devices. The structure of each of the winding devices is identical with that of Fig. 4.

The continuous web traverse winding system of the present embodiment has a total lag time of 30 milli-secs in the electrical system comprising 20 milli-secs of internal processing time in the winding control sequence 34 and 10 milli-secs. of signal

transmission by the servo-amplifier 38. The lag time of the electrical system is shortened to 27 % of that of the above-mentioned conventional continuous web traverse winding system.

Since the reversing position is corrected by both the control based upon the above-mentioned relation (7) and shortening of the lag time in the electrical system as shown in Fig. 6(a), the bulged irregular winding represented by a dotted line is eliminated, resulting in that the gap H is enlarged by the dimension α . This enables the continuous web 14 to be wound on the bobbin 10 by an excess corresponding to α . Accordingly, the length of the continuous web that is wound on one bobbin can be increased.

Although the mechanism to cause the bobbin 10 to be rectilinearly moved comprises the ball screw mechanism 22 in the embodiment, it may comprise a rack and pinion mechanism. Although the position of the guide roll is fixed and the bobbin is reciprocated in the preferred embodiment, the position of the bobbin may be fixed and the guide roll may be reciprocated.

An experiment of the continuous web traverse winding systems of the embodiment will be described.

In the experiment, the reversing points for respective winding diameters are measured in both cases in which correction of the reversing point is conducted and not conducted based upon the control relationship.

In the graph of Fig. 8, an abscissa denotes the diameter of winding in mm and an ordinate denotes the offset of the reversing position in mm. Square points denote the measurements when correction based upon the control relation is not made. Circular points denote the measurements when correction is made based upon the control relation. A dotted line denotes a theoretical line when correction based upon the control relation is not made. A dot and chain line denotes a theoretical line when correction based upon the control relation is made.

It is apparent from the comparison between the cases correction was made or not made as shown in Fig. 8 that the offsets of the reversing points for respective winding diameters are remarkably reduced by the correction based upon the control relationship.

The present invention provides the advantages that will be described.

Since a normal or reverse rotation instruction signal that is generated in accordance with the control relationship controls the servo motor to correct the reversing position and a simple structure of the control circuit shortens the period of time which is taken for arithmetic operation and signal transfer, correction of bulged irregular winding which has been previously manually

conducted can be automated. Accordingly, unqualified winding such as edge breaking or collapse of the wound web which has been otherwise caused by variations in manual operation or wrong operation can be eliminated. The gap between the collars of the bobbin and the wound continuous web that has been given in excess for bulged irregular winding can be reduced. Accordingly, the length of the continuous web that can be wound on the bobbin can be increased. This causes facility operation efficiency, the amount of production per unit time and production efficiency to be increased.



Claims

CONTINUOUS WEB TRAVERSE WINDING SYSTEM

1. A continuous web traverse winding system for winding a plurality of continuous webs on a plurality of bobbins, each having a cylindrical shaft and having a pair of disc-shaped collars at opposite ends thereof, including a plurality of winding devices, which are simultaneously operated, each device comprising: a stationary guide roll for supplying a continuous web to each bobbin for winding it in a constant speed; a slide support which is provided so that it is slidable with respect to the stationary bed in an axial direction of the bobbin; a winding motor having a rotary shaft on which the bobbin is mounted, which is fixedly supported on the slide support; a slide drive mechanism having a reversible servo-motor for reciprocally sliding the slide support in an axial direction of the bobbin; and a winding control sequencer which monitors the number of rotations of said winding motor for supplying a normal or reverse rotation signal to the servo-motor, said sequencer being adapted to generate the normal or reverse rotation signal in accordance with a control relationship preset to correct the reversing position of the continuous web which changes with the increase in the external diameter of the continuous web wound on the bobbin.

2. A continuous web traverse winding system as defined in Claim 1 in which said control relationship is represented as follows:

$$A = \{L0^2 - 1/4 \times (D1 + Dg)^2\}^{0.5} \times P / (\pi \times D1) / 2$$

$$- \{L0^2 - 1/4 \times (D + Dg)^2\}^{0.5} \times P / (\pi \times D) / 2$$

wherein L0 denotes the distance between the centers of the guide roll and the bobbin; D1 denotes the external diameter of the bobbin; Dg denotes the external diameter of the guide roll; P denotes the traverse pitch of the continuous web wound by the bobbin; D denotes an external diameter of the continuous web wound by the bobbin at any selected time and in which the reversing position at the external diameter of D is offset in a negative direction in accordance with said relationship A from an original reversing position of the continuous web at both extremities of reciprocal movement of the bobbin.

3. A continuous web traverse winding system as defined in Claim 1 or 2 in which said winding control sequencer also monitors the rotation of the servo-motor and supplies a signal to said servo motor via a servo-amplifier.