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PAPER WINDER AND PAPER WINDING METHOD

Abstract

A paper winder includes a first winding core that is provided in a first arm turning centering on a rotating shaft and on which the paper should be wound, a first motor that drives the first winding core, a second winding core that is provided in a second arm turning centering on the rotating shaft and on which the paper should be wound next to the first winding core, and a controller that performs rotation control for the first motor and a second motor. In the rotation control, after, according to the turning of the second arm, completion of the winding of the paper by the first winding core and after a position of the second winding core has reached a position where the paper should be wound, during an operation of a traverse cutter that cuts the paper near the second winding core, when a torque value of the second motor is equal to or larger than a torque reference value, the controller switches a control mode of the second motor from speed control to torque control and perform tension correction control for adjusting the torque value of the second motor such that tension of the paper falls within a target range.

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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates to a paper winder.

BACKGROUND ART

[0002] PTL 1 discloses a technique for continuously winding a web, which is a belt-shaped sheet-like object such as paper of a film, with a plurality of winding rolls. In this related art, the web is cut when the winding roll on which the web should be wound is replaced. Specifically, the web is cut in a state in which the web is in contact with the outer circumferential surface of a winding core on which the web should be wound anew.

CITATION LIST

Patent Literature

[0003] [PTL 1] JP 2015-048173 A

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

[0004] Incidentally, when paper is continuously wound by a plurality of winding cores, a traverse cutter is sometimes used for cutting paper when a winding roll is replaced after the winding of the paper by the winding cores has been completed. When the paper is cut by the traverse cutter, a state occurs in which both of the winding roll and a new winding core that should wind the paper wind the paper.

[0005] In this case, when an operation state is not suitable for the new winding core to wind the paper when the paper is cut by the traverse cutter, it is likely that creases, paper winding jumble, and the like occur on the paper wound by the new winding core.

[0006] An object of the present disclosure is to provide a technique that can improve stability of paper winding by a new winding core when a winding roll is replaced.

Advantageous Effects of the Invention

[0007] According to the present disclosure, when the torque value of the second motor is equal to or larger than the torque reference value at the operation time of the traverse cutter that cuts the paper, the control mode of the second motor is switched from the speed control to the torque control and the tension correction control for adjusting the torque value of the second motor such that the tension of the paper falls within the target range is performed. Consequently, it is possible to improve stability of paper winding by a new winding core when a winding roll is replaced.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. **1** is a diagram for explaining an outline of a paper winder according to an embodiment.

[0009] FIG. **2** is a diagram for explaining an outline of the paper winder according to the embodiment.

[0010] FIG. **3** is a diagram for explaining a specific example of the paper winder according to the

embodiment.
[0011] FIG. **4** is a diagram for explaining a specific example of the paper winder according to the embodiment.
[0012] FIG. **5** is a flowchart showing a processing example of the paper winder according to the embodiment.
DESCRIPTION OF EMBODIMENTS
[0013] A paper winder and a paper winding method according to an embodiment of the present disclosure are explained with reference to the accompanying drawings. Elements common in the figures are denoted by the same reference numerals and signs and redundant explanation of the elements is omitted.
1. Overview
1-1. Configuration of a Paper Winder
[0014] FIG. **1** is a diagram for explaining an overview of a paper winder **1** according to an embodiment. The paper winder **1** is a turret-type device that continuously winds paper **50** with a plurality of winding cores. The paper **50** is, for example, thick paper having thickness of 800 μm or the like. The paper winder **1** includes a paper winding mechanism unit **2**, a paper cutting unit **3**, and a controller **100**.
[0015] The paper winding mechanism unit **2** includes an arm unit **10** (a first arm **10***a*, a second arm **10***b*, a third arm **10***c*, and a fourth arm **10***d*). Each of the arms has a mechanism of turning in at least one direction centering on a rotating shaft **10***e* provided at one end of the arm. These arms may have cross-shaped structure as shown in FIG. **1**(A).
[0016] Each of the arms repeatedly performs turning at a predetermined angle at every predetermined timing after an operation start of the paper winder **1**. Alternatively, the arm receives a turning instruction by the controller **100** explained below and performs the turning at the predetermined angle.
[0017] A first winding core **11** is provided at the other end of the first arm **10***a*. A second winding core **12** is provided at the other end of the second arm **10***b*. A guide roller **13** is provided at the other end of the third arm **10***c*. A guide roller **14** is provided at the other end of the fourth arm **10***d*.
[0018] The first winding core **11** is a winding core on which the paper **50** should be wound. The second winding core **12** is a winding core on which the paper **50** should be wound next to the first winding core **11**. For example, as shown in FIG. **1**(A), the second winding core **12** is located on the opposite side of the first winding core **11** via the rotating shaft **10***e*. When the position of one winding core of the first winding core **11** and the second winding core **12** is a position where the paper **50** should be wound, the paper **50** is wound by the winding core. The position where the paper **50** should be wound is, for example, the position of the first winding core **11** shown in FIG. **1**(A).
[0019] After completion of the winding of the paper **50** by the first winding core **11** and in a period from when, according to the turning of the second arm **10***b*, the position of the second winding core **12** has reached the position where the paper **50** should be wound until the paper **50** is cut, the guide roller **14** guides the paper **50** to be wound by the first winding core **11**. Although not illustrated, after the completion of the winding of the paper **50** by the second winding core **12** and in a period from when, according to the turning of the first arm **10***a*, the position of the first winding core **11** has reached again the position where the paper **50** should be wound until the paper **50** is cut, the guide roller **13** guides the paper **50** to be wound by the second winding core **12**.
[0020] The paper winding mechanism unit **2** further includes a first motor **21** and a second motor **22**. The first motor **21** is a motor that drives the first winding core **11**. The first motor **21** is fixed and attached to the first winding core **11**. The second motor **22** is a motor that drives the second winding core **12**. The second motor **22** is fixed and attached to the second winding core **12**. The first motor **21** and the second motor **22** receive a command by the controller **100** explained below and perform a driving start or a driving stop.

[0021] When the position of one winding core of the first winding core **11** and the second winding core **12** is the position where the paper **50** should be wound, the winding of the paper **50** by the winding core is realized by driving a motor corresponding to the winding core.
[0022] The paper cutting unit **3** includes a first touch arm **30** and a second touch arm **40**. The first touch arm **30** is a mechanical device for, such that the second winding core **12** can wind the cut paper **50**, pressing the paper **50** against the outer circumferential surface of the second winding core **12** when the paper **50** is cut.
[0023] The first touch arm **30** includes a mechanism that turns based on a rotating shaft **30***a* provided at one end of the first touch arm **30**. Here, a motion of the first touch arm **30** turning in the clockwise direction at the viewpoint of FIG. **1** is referred to as forward movement and a motion of the first touch arm **30** turning in the counterclockwise direction at the viewpoint of FIG. **1** is referred to as backward movement. The first touch arm **30** moves forward before the paper **50** is cut and moves backward after the paper **50** is cut.
[0024] Specifically, as shown in FIG. **1**(B), the first touch arm **30** moves forward simultaneously with completion of an operation of the paper winding mechanism unit **2**. The first touch arm **30** moves backward simultaneously with completion of cutting of the paper **50** by a traverse cutter **40***c* explained below.
[0025] When moving forward, the first touch arm **30** presses the paper **50** against the outer circumferential surface of the second winding core **12** with a nip roll **30***b* provided at the other end of the first touch arm **30**. Consequently, the second winding core **12** can wind the cut paper **50**.
[0026] The second touch arm **40** is a mechanical device that cuts the paper **50**. The second touch arm **40** includes a mechanism that turns based on a rotating shaft **40***a* provided at one end of the second touch arm **40**. A motion of the second touch arm **40** turning in the counterclockwise direction at the viewpoint of FIG. **1** is referred to as forward movement and a motion of the second touch arm **40** turning in the clockwise direction at the viewpoint of FIG. **1** is referred to as backward movement. The second touch arm **40** moves forward before the paper **50** is cut and moves backward after the paper **50** is cut.
[0027] Specifically, as shown in FIG. **1**(B), the second touch arm **40** moves forward simultaneously with the completion of the operation of the paper winding mechanism unit **2**. The second touch arm **40** moves backward simultaneously with the completion of the cutting of the paper **50** by the traverse cutter **40***c* explained below.
[0028] The second touch arm **40** includes a winding core fixture **40***b* in which the second winding core **12** provided at the other end of the second touch arm **40** can be fit and fixed. The second winding core **12** is fixed by the winding core fixture **40***b* when the paper **50** is cut.
[0029] The second touch arm **40** includes the traverse cutter **40***c* provided between one end of the second touch arm **40** and the other end of the second touch arm **40**. The traverse cutter **40***c* is a cutting machine that cuts the paper **50**. The traverse cutter **40***c* is housed in the second touch arm **40** except when cutting the paper **50** and is used only when cutting the paper **50**. An image during the use of the traverse cutter **40***c* is represented, for example, as shown in FIG. **1**(B).
[0030] The traverse cutter **40***c* cuts the paper **50** near the second winding core **12** after the second winding core **12** has reached the position where the paper **50** should be wound. For example, as shown in FIG. **1**(B), a position where the paper **50** is cut is a position between one end (the rotating shaft **40***a*) of the second touch arm **40** and the other end (the winding core fixture **40***b*) of the second touch arm **40** and near the second winding core **12**. An overview of a method of cutting the paper **50** by the traverse cutter **40***c* is explained below.
[0031] The controller **100** is a controller that performs rotation control for the first motor **21** and the second motor **22**. The controller is, for example, a PLC (Programmable Logic Controller). The controller **100** includes a driver that drives the first motor **21** and the second motor **22**. Further, the controller **100** stores a paper winding program (not shown). The controller **100** executes the paper winding program, whereby a function of the rotation control for the first motor **21** and the second

motor **22** is realized.
[0032] The controller **100** is connected to each of the first motor **21**, the second motor **22**, the arm unit **10**, the first touch arm **30**, and the second touch arm **40**. The controller **100** and the respective kinds of equipment are respectively connected by, for example, cables.
[0033] The controller **100** receives at least a turning start flag of the second arm **10***b* from the arm unit **10**. The controller **100** receives at least a forward movement start flag of the first touch arm **30** from the first touch arm **30**. Further, the controller **100** receives at least a backward movement start flag of the second touch arm **40** from the second touch arm **40**. Details of the rotation control for the first motor **21** and the second motor **22** by the controller **100** are explained below.
1-2. Operation Example of the Traverse Cutter
[0034] FIG. **2** is a diagram for explaining an overview of a method of cutting by the traverse cutter **40***c* in the paper winder **1** according to the embodiment. Specifically, in FIG. **2**, an operation example of the traverse cutter **40***c* that cuts the paper **50** near the second winding core **12** after the completion of the winding of the paper **50** by the first winding core **11** and after, according to the turning of the second arm **10***b*, the position of the second winding core **12** has reached the position where the paper **50** should be wound is shown in time series.
[0035] As shown in FIG. **2**, the traverse cutter **40***c* cuts the paper **50** in a direction (a cutting direction) orthogonal to the longitudinal direction of the paper **50** in a state in which the paper **50** is pressed against the outer circumferential surface of the second winding core **12** by the nip roll **30***b*. Since cutting speed of the traverse cutter **40***c* is adjusted to winding speed of the paper **50**, the paper **50** being wound by the first winding core **11** is cut by the traverse cutter **40***c* at a slant angle of 45 degrees with respect to a winding direction.
[0036] In the traverse cutter **40***c*, a movable range **60** is provided with respect to the cutting direction. As shown in FIG. **2**, the traverse cutter **40***c* cuts the paper **50** according to the movable range **60**. Note that, when the width of the paper **50** is represented as W [m] and the speed of the paper **50** being wound by the first winding core **11** is represented as V [m/min], a cutting time of the traverse cutter **40***c* is represented by the following Expression (1).

[00001] [Math . 1]

$$\frac{W}{V} \qquad (1)$$

[0037] For example, when the width of the paper **50** is 2.01 [m] and the speed of the paper **50** is set to 20 [m/min], the cutting time of the traverse cutter **40***c* is 6.03 [s].
[0038] After the cutting of the paper **50** by the traverse cutter **40***c*, two separated pieces of the paper **50** are respectively wound by the first winding core **11** and the second winding core **12**. Consequently, the winding roll after the completion of the winding of the paper **50** by the first winding core **11** can be replaced in a state in which the paper winder **1** is continuously operated.
2. Specific Example
2-1. An Example of Rotation Control for the Motors
[0039] FIG. **3** is a diagram for explaining a specific example of the paper winder **1** according to the embodiment. Specifically, FIG. **3** shows an example of rotation control for the first motor **21** and the second motor **22** in the controller **100** of the paper winder **1**. Note that, in processing of a portion shown in FIG. **3**(A), a mechanical operation is performed in a chain reaction manner and control by the controller **100** is not performed. Based on this, an example of rotation control for the first motor **21** and the second motor **22** by the controller **100** is explained below.
[0040] At timing shown in FIG. **3**(B), the controller **100** receives, from the arm unit **10**, the turning start flag of the second arm **10***b* after the completion of the winding of the paper **50** by the first winding core **11**.
[0041] The controller **100** sets a control mode of the second motor **22** to drive the second motor **22**. Specifically, the controller **100** sets the control mode of the second motor **22** to speed control. The speed control means controlling rotating speed of a motor to drive the motor within a target speed

range.
[0042] When the control mode of the second motor **22** is set to the speed control, a driving state of the second motor **22** is transitioned in the order of a stop state and an acceleration state. Consequently, the second motor **22** can be driven. Thereafter, the second motor **22** is controlled such that the second motor **22** is driven at speed within the target speed range.
[0043] The controller **100** switches the control mode of the second motor **22** from speed control to torque control at timing during the operation of the traverse cutter **40***c* and when a torque value of the second motor **22** satisfies a predetermined condition. The torque control means controls a motor to drive at generated torque within a range of target torque.
[0044] The timing during the operation of the traverse cutter **40***c* and when the torque value of the second motor **22** satisfies the predetermined condition is, for example, a position shown in FIG. **3**(C). The predetermined condition means a condition that the torque value of the second motor **22** is equal to or larger than a torque reference value. Details of setting of the torque reference value are explained below.
[0045] Here, a method of the controller **100** grasping the timing during the operation of the traverse cutter **40***c* is conceived. A time period during the operation of the traverse cutter **40***c* is calculated by Expression (1) described above. Therefore, the controller **100** has to grasp only operation start time of the traverse cutter **40***c*. The operation start time of the traverse cutter **40***c* is, for example, time obtained by adding a predetermined time period (a first time period) to turning start time (timing shown in FIG. **3**(B)) of the second arm **10***b* after the completion of the winding of the paper **50** by the first winding core **11**. Alternatively, the operation start time of the traverse cutter **40***c* is time obtained by adding a predetermined time period (a second time period) to forward movement start time (timing shown in FIG. **3**(D)) of the first touch arm **30**.
[0046] Note that the first time period and the second time period may be information concerning predetermined time periods or may be information concerning time periods acquired by measurement.
[0047] Based on this, the controller **100** sets, as the turning start time of the second arm **10***b*, the turning start flag of the second arm **10***b* received from the second arm **10***b*. Alternatively, the controller **100** sets, as the forward movement start time of the first touch arm **30**, the forward movement start flag of the first touch arm **30** received from the first touch arm **30**. The controller **100** adds the first time period to the turning start time of the second arm **10***b*. Alternatively, the controller **100** adds the second time period to the forward movement start time of the first touch arm **30**. Consequently, the controller **100** can grasp the operation start time of the traverse cutter **40***c*.
[0048] Further, the controller **100** performs tension correction control for the second motor **22** at the timing during the operation of the traverse cutter **40***c* and when the torque value of the second motor **22** satisfies the predetermined condition explained above. That is, at the timing, the controller **100** switches the control mode of the second motor **22** from the speed control to the torque control and performs the tension correction control for the second motor **22**. The tension correction control means adjusting a torque value of a motor such that the tension of the paper **50** falls within a target range.
[0049] After switching the control mode of the second motor **22** from the speed control to the torque control and after the completion of the operation of the traverse cutter **40***c*, the controller **100** sets a control mode of the first motor **21** to stop the driving of the first motor **21**. Specifically, the controller **100** switches the control mode of the first motor **21** from torque control to stop. When the control mode of the first motor **21** is set to the stop, a driving state of the first motor **21** is transitioned in the order of a deceleration state and a stop state. Consequently, the driving of the first motor **21** can be stopped.
[0050] Here, a method of the controller **100** grasping operation completion time of the traverse cutter **40***c* is conceived. The operation completion time of the traverse cutter **40***c* may be, for

example, backward movement start time (timing shown in FIG. **3**(E)) of the second touch arm **40**. The controller **100** sets, as the backward movement start time of the second touch arm **40**, the backward movement start flag of the second touch arm **40** received from the second touch arm **40**. Consequently, the controller **100** can grasp the operation completion time of the traverse cutter **40***c*.

2-2. Setting Example of the Torque Reference Value

[0051] As shown in FIG. **4**, the controller **100** sets the torque reference value after a driving start of the second motor **22**. The torque reference value is a torque value of the first motor **21** at the time when the tension of the paper **50** at the time of winding of the paper **50** by the first winding core **11** is within the target range. The torque value of the first motor **21** used for the setting of the torque reference value may be predetermined data or may be data acquired from the first winding core **11** immediately before the paper **50** is wound by the second winding core **12**.

[0052] Further, the torque reference value may be a value obtained by adding at least a mechanical loss of the second motor **22** to the torque value of the first motor **21**. The mechanical loss means a mechanical loss that depends on rotating speed of a motor. The mechanical loss is different depending on an individual difference of the second motor **22** and is periodically calculated during the driving of the second motor **22**. The mechanical loss used for the setting of the torque reference value is periodically updated

[0053] The controller **100** determines whether the torque value of the second motor **22** is equal to or larger than the torque reference value during the operation of the traverse cutter **40***c*. When determining that the torque value of the second motor **22** is equal to or larger than the torque reference value, as shown in FIG. **4**, the controller **100** switches the control mode of the second motor **22** from the speed control to the torque control. Further, as shown in FIG. **4**, the controller **100** switches the control mode of the second motor **22** from the speed control to the torque control and performs the tension correction control for the second motor **22**.

2-3. Effects

[0054] As explained above, in the paper winder **1** according to the embodiment, when the torque value of the second motor **22** is equal to or larger than the torque reference value during the operation of the traverse cutter **40***c*, the control mode of the second motor **22** is switched from the speed control to the torque control and the tension correction control for adjusting the torque value of the second motor **22** such that the tension of the paper **50** falls within the target range is performed. Consequently, it is possible to improve stability of winding of the paper **50** by a new winding core at a replacement time of a winding roll.

3. Processing Example

[0055] FIG. **5** is a flowchart showing a processing example of the controller **100** in the paper winder **1** according to the embodiment.

[0056] In step S**100**, the controller **100** sets the control mode of the second motor **22** to the speed control based on the turning start flag of the second arm **10***b*. Thereafter, the processing proceeds to step S**110**.

[0057] In step S**110**, the controller **100** sets the torque reference value for performing the rotation control for the second motor **22**. Thereafter, the processing proceeds to step S**120**.

[0058] In step S**120**, the controller **100** determines whether the traverse cutter **40***c* is operating. When it is determined that the traverse cutter **40***c* is operating (step S**120**; Yes), the processing proceeds to step S**130**. Otherwise (step S**120**; No), the processing returns to step S**120**.

[0059] In step S**130**, the controller **100** determines whether the torque value of the second motor **22** is equal to or larger than the torque reference value. When it is determined that the torque value of the second motor **22** is equal to or larger than the torque reference value (step S**130**; Yes), the processing proceeds to step S**140**. Otherwise (step S**130**; No), the processing returns to step S**130**.

[0060] In step S**140**, the controller **100** switches the control mode of the second motor **22** from the speed control to the torque control. Thereafter, the processing proceeds to step S**150**.

[0061] In step S**150**, the controller **100** executes the tension correction control for the second motor

22. Thereafter, the processing proceeds to step S**160**. Note that the processing in step S**150** is performed simultaneously with the processing in step S**140** explained above.
[0062] In step S**160**, the controller **100** switches the control mode of the first motor **21** from the torque control to the stop.
REFERENCE SIGNS LIST
[0063] **1** . . . paper winder, **2** . . . paper winding mechanism unit, **3** . . . paper cutting unit, **10** . . . arm unit, **10***a* . . . first arm, **10***b* . . . second arm, **10***c* . . . third arm, **10***d* . . . fourth arm, **11** . . . first winding core, **12** . . . second winding core, **13** . . . guide roller, **21** . . . first motor, **22** . . . second motor, **30** . . . first touch arm, **30***a* . . . rotating shaft, **30***b* . . . nip roll, **40** . . . second touch arm, **40***a* . . . rotating shaft, **40***b* . . . winding core fixture, **40***c* . . . traverse cutter, **50** . . . paper, **60** . . . movable range, **100** . . . controller

Claims

1. A paper winder that winds a paper, the paper winder comprising: a first winding core that is provided in a first arm turning centering on a rotating shaft and on which the paper should be wound; a first motor that drives the first winding core; a second winding core that is provided in a second arm turning centering on the rotating shaft and on which the paper should be wound next to the first winding core; a second motor that drives the second winding core; and a controller that performs rotation control for the first motor and the second motor, wherein the controller is configured to, in the rotation control, after completion of the winding of the paper by the first winding core and after, according to the turning of the second arm, a position of the second winding core has reached a position where the paper should be wound, during an operation of a traverse cutter that cuts the paper near the second winding core, when a torque value of the second motor is equal to or larger than a torque reference value, switch a control mode of the second motor from speed control to torque control and perform tension correction control for adjusting the torque value of the second motor such that tension of the paper falls within a target range.
2. The paper winder according to claim 1, wherein the torque reference value is a torque value of the first motor at a time when the tension of the paper at a time of the winding of the paper by the first winding core immediately before the paper is wound by the second winding core is within the target range.
3. The paper winder according to claim 1, wherein the torque reference value is a value obtained by adding at least a mechanical loss of the second motor to the torque value of the first motor immediately before the paper is wound by the second winding core.
4. The paper winder according to claim 3, wherein the mechanical loss is periodically updated during the driving of the second motor.
5. The paper winder according to claim 1, wherein the controller is further configured to, in the rotation control, after switching the control mode of the second motor from the speed control to the torque control and after completion of the operation of the traverse cutter, set a control mode of the first motor to stop the driving of the first motor.
6. A paper winding method for winding a paper, comprising: determining, after completion of winding of the paper by a first winding core that is provided in a first arm turning centering on a rotating shaft and on which the paper should be wound and after a position of a second winding core that is provided in a second arm turning centering on the rotating shaft and on which the paper should be wound next to the first winding core has reached a position where the paper should be wound, during an operation of a traverse cutter that cuts the paper near the second winding core, whether a torque value of a second motor that drives the second winding core is equal to or larger than a torque reference value; switching a control mode of the second motor from speed control to torque control when it is determined that the torque value of the second motor is equal to or larger

than the torque reference value; and performing tension correction control for adjusting the torque value of the second motor such that tension of the paper falls within a target range.