

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention generally relates to a technique for controlling deceleration of a rotating package to stop the package in a yarn winding device that directly rotates the package.

2. Description of the Related Art

[0002] Yarn winding devices in which a package is directly rotated using an electric motor are known in the art (see e.g. JP 2007-238275 A). Such yarn winding devices generally do not have a mechanical braking system for stopping rotation of the package but stop the rotation of the package by performing deceleration control on the electric motor.

[0003] A yarn winding device known to the inventor performs the deceleration control at a constant deceleration rate (deceleration gradient) regardless of a diameter of the package (package diameter) inclusive of a yarn wound thereon as illustrated in FIG. 10. "Deceleration rate" means a time derivative (gradient of the graph illustrated in FIG. 10) of a rotational frequency (the number of rotations per second) of the package with the sign of the time derivative reversed from positive to negative and vice versa.

[0004] Concretely, a control is performed so as to maintain circumferential speed of the package substantially constant to achieve a substantially constant running speed of the yarn wound onto the package. Accordingly, although the rotational frequency of the package is relatively high when the package diameter is small, the rotational frequency gradually decreases as the thickness of the package increases as more yarn is wound thereon (as the package diameter increases).

[0005] A package having a smaller diameter has a relatively smaller moment of inertia and hence can be decelerated to a stop in a shorter time. Nevertheless, according to the conventional control (the control illustrated in FIG. 10) of controlling the electric motor by a constant deceleration rate, a deceleration time (period of time from a start of deceleration of a package to a stop of the package) undesirably prolongs as the package diameter decreases (as the rotational frequency of the package increases). FIG. 11 shows a relation between a package diameter and a deceleration time. Although generally a package having a smaller diameter can be decelerated to a stop in a shorter time, the package illustrated in FIG. 11 takes longer time to stop, which can result in a decrease in a productivity of the yarn winding device.

[0006] The moment of inertia of a package increases as the thickness of the package increases (as the package diameter increases) as more yarn is wound thereon. With the conventional control (the control illustrated in

FIG. 10) of controlling the electric motor by a constant deceleration rate, the deceleration time becomes shorter as the diameter of the package increases. Therefore, the conventional control requires that a package having increased thickness due to winding of a yarn thereon and hence having a larger moment of inertia be decelerated to a stop in a shorter time. As a result, the electric motor produces an excessively large braking torque. FIG. 12 illustrates a relation between a package diameter and a braking torque necessary to stop a rotating package. When the braking torque of the electric motor increases to a great extent, a high current instantaneously flows through both the electric motor and a motor driver (motor control device) of the electric motor. Consequently, loads placed on the electric motor and the motor driver increase, causing problems, such as generation of heat. Furthermore, slippage is likely to occur between the package and a bearing of the electric motor due to sudden braking of the package.

[0007] As described above, the conventional yarn winding devices are disadvantageous in that when the package diameter is small, the deceleration time prolongs, while when the package diameter is large, problems such as generation of heat and slippage occur.

[0008] Japanese Patent Application Laid-open No. S62-215476 discloses a countermeasure to this issue. The disclosed yarn winding device changes a deceleration gradient based on a function relating to the number of rotations of a bobbin holder or a bobbin diameter inclusive of a yarn wound thereon. It is expected that such a yarn winding device that changes the deceleration gradient based on the bobbin diameter inclusive of a yarn wound thereon can decelerate a package to a stop appropriately irrespective of the package diameter.

[0009] However, there are instances as in actual yarn winding device where rotation energy of a package or the like cannot be expressed using a simple function of a package diameter. In such instances, the deceleration control cannot be performed appropriately with the technique disclosed in Japanese Patent Application Laid-open No. S62-215476 that determines the deceleration gradient using the function.

[0010] The technique disclosed in Japanese Patent Application Laid-open No. S62-215476 has disadvantages in that it is difficult for an operator to grasp concretely how the package is decelerated to a stop along the deceleration gradient because the deceleration gradient is determined by the function. Consequently, the operator cannot change the setting of the deceleration gradient intuitively even in situations where the setting needs to be changed. Accordingly, it is difficult or impossible for an operator to change the setting of the deceleration gradient appropriately even when it is necessary to change the setting of the deceleration gradient. In this regard, no description about operator's necessity of adjusting the deceleration gradient or the like is provided in Japanese Patent Application Laid-open No. S62-215476. However, in practice, an optimum deceleration gradient varies de-

pending on various winding conditions, such as a type of a yarn and winding density of a package. Accordingly, appropriate deceleration control cannot be performed unless otherwise setting of the deceleration gradient is adjusted by an operator in a situation where a winding condition has been changed or the like.

SUMMARY OF THE INVENTION

[0011] It is an object of the present invention to provide a yarn winding device in which a rotating package can be stopped appropriately by enabling flexible and intuitive setting of a deceleration condition.

[0012] According to an aspect of the present invention, a yarn winding device includes a package drive section, a package-diameter obtaining section, a deceleration-condition storage section, and a control section. The package drive section directly rotates a package. The package-diameter obtaining section obtains a current package diameter of the package. The deceleration-condition storage section stores therein a plurality of deceleration conditions, each of which is associated with a hypothetical package diameter and used in controlling the package drive section to decelerate the package to a stop. The control section controls the package drive section to decelerate the package to a stop according to the current package diameter obtained by the package-diameter obtaining section and a deceleration condition associated with a hypothetical package diameter corresponding to the current package diameter.

[0013] Thus, the package drive section is controlled according to the deceleration condition that depends on the package diameter. Accordingly, the package can be decelerated to a stop appropriately. This leads to less heat generation by the package drive section and optimization of deceleration-to-stop time. Furthermore, the deceleration conditions can be set intuitively because the deceleration conditions are set based on the package diameters.

[0014] In the yarn winding device, the deceleration conditions stored in the deceleration-condition storage section preferably differ from each other in at least any one of a deceleration rate and a deceleration time. The deceleration rate is a time derivative of a rotational frequency of the package with a sign of the time derivative reversed from positive to negative and vice versa. The deceleration time is a period of time from a start of deceleration of the package to a stop of the package.

[0015] Accordingly, the deceleration rate or the deceleration time can be changed according to the package diameter, and hence the package can be decelerated to a stop appropriately.

[0016] In the yarn winding device, the deceleration-condition storage section preferably stores therein at least a first deceleration condition for hypothetical package diameters that belong to a first range and a second deceleration condition for a second range to which hypothetical package diameters greater than the hypothet-

ical package diameters belonging to the first range belong. The second deceleration condition includes a smaller deceleration rate and a longer deceleration time than that included in the first deceleration condition.

[0017] Thus, classifying package diameters into at least two ranges, for each of which a deceleration condition is set separately as described above, makes it possible to control the package drive section to decelerate the package to a stop with simple setting operation. When a package to be stopped has a larger package diameter, the package drive section is controlled to decelerate the package to a stop according to a deceleration condition set to have a smaller deceleration rate. Accordingly, a smaller load is placed on the package drive section. When a package to be stopped has a smaller package diameter, the package drive section is controlled to decelerate the package to a stop according to a deceleration condition set to have a higher deceleration rate. Accordingly, it is possible to bring the package to a stop in a shorter time.

[0018] In the yarn winding device, the first deceleration condition is preferably set such that a constant deceleration rate is applied to the package so long as the current package diameter belongs to the first range. The second deceleration condition is preferably set such that a constant deceleration rate is applied to the package so long as the current package diameter belongs to the second range.

[0019] Setting each of the deceleration conditions so as to apply a constant deceleration rate to the package so long as the package diameter is in a predetermined range as described above allows controlling the package drive section with simple setting operation.

[0020] In the yarn winding device, the first deceleration condition is preferably set such that a constant deceleration time is applied to the package so long as the current package diameter belongs to the first range. The second deceleration condition is preferably set such that a constant deceleration time is applied to the package so long as the current package diameter belongs to the second range.

[0021] Setting each of the deceleration conditions so as to apply a constant deceleration time to the package so long as the package diameter is in a predetermined range as described above allows controlling the package drive section with simple setting operation.

[0022] The yarn winding device preferably further includes a yarn feeding section and a yarn joining device. The yarn feeding section feeds a yarn to be wound onto the package. When the yarn is disconnected, the yarn joining device joins a yarn end of a yarn from the package and a yarn end of a yarn from the yarn feeding section together to bring the yarn into a connected state. The control section preferably controls the package drive section to decelerate the package to a stop before the yarn joining operation is performed by the yarn joining device.

[0023] Yarn winding devices that include a yarn joining device frequently decelerate rotation of a package to a

stop. In such yarn winding devices, by controlling the package drive section to decelerate the package to a stop according to the package diameter, reduction of a load placed on the package drive section and optimization of deceleration-to-stop time can be achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

FIG. 1 is a schematic diagram of a winder unit of an automatic winder according to an embodiment of the present invention;

FIG. 2 is a graph illustrating a relation between a package diameter and a rotational frequency of a package;

FIGS. 3A to 3C are respectively graphs describing a first deceleration condition, a second deceleration condition, and a third deceleration condition;

FIG. 4 is a graph illustrating a relation between the package diameter and a period of time over which the package is decelerated to a stop in the automatic winder illustrated in FIG. 1;

FIG. 5 is a graph illustrating a relation between the package diameter and a braking torque necessary to decelerate the package to a stop in the automatic winder illustrated in FIG. 1;

FIG. 6 is a flowchart of a joining operation performed by the automatic winder illustrated in FIG. 1;

FIGS. 7A to 7C are respectively graphs describing a first deceleration condition, a second deceleration condition, and a third deceleration condition all according to a modification of the embodiment;

FIG. 8 is a graph illustrating a relation between a package diameter and a period of time necessary to decelerate a package to a stop according to the modification;

FIG. 9 is a graph illustrating a relation between the package diameter and a braking torque necessary to decelerate the package to a stop according to the modification;

FIG. 10 is a graph illustrating a package stopping control according to a conventional technique;

FIG. 11 is a graph illustrating a relation between a package diameter and a period of time necessary to decelerate a package to a stop according to the conventional technique; and

FIG. 12 is a graph illustrating a relation between the package diameter and a braking torque necessary to decelerate the package to a stop according to the conventional technique.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] Exemplary embodiments of the present invention are described below with reference to the accompanying drawings. FIG. 1 is a schematic diagram of a winder

unit 10 of an automatic winder serving as a yarn winding device according to an embodiment of the present invention.

[0026] The winder unit 10 shown in FIG. 1 winds a yarn 20 unwound from a yarn feeding bobbin 21 onto a winding bobbin 22 while causing the yarn 20 to traverse to form a package 30 of a predetermined length and shape. The automatic winder (yarn winding device) according to the present embodiment includes a plurality of winder units 10 arranged side-by-side and a not shown machine control device.

[0027] Each of the winder units 10 includes a winding unit body 16 and a unit control section (control section) 50.

[0028] The unit control section 50 includes, for example, a not shown central processing unit (CPU), a random access memory (RAM), a read-only memory (ROM), and an input-output (I/O) port. Computer programs for controlling components of the winding unit body 16 are stored in the ROM. The machine control device is connected to the I/O port. An operator of the machine control device can manage or control collectively the winder units 10 as required.

[0029] The winding unit body 16 includes a cradle 23 and a yarn feeding section 19. The cradle 23 rotatably supports the package 30. The yarn feeding section 19 feeds the yarn 20 to the package 30. The winding unit body 16 includes an unwinding assisting device 12, a tension applying device 13, a yarn joining device 14, and a yarn-quality measuring device 15 that are arranged on a yarn feed path between the yarn feeding section 19 and the cradle 23 in this order from the side of the yarn feeding section 19.

[0030] The yarn feeding section 19 supports the yarn feeding bobbin 21 in a substantially upright state.

[0031] The unwinding assisting device 12 includes a regulating member 40 that is vertically driven. The regulating member 40 assists unwinding of the yarn 20 by coming into contact with the yarn 20 being unwound from the yarn feeding bobbin 21 to thereby apply an appropriate tension to the yarn 20. A not shown sensor for detecting a chase portion of the yarn feeding bobbin 21 is arranged near the regulating member 40. When this sensor detects lowering of the chase portion, the regulating member 40 is lowered with, for example, a not shown air cylinder following the lowering of the chase portion.

[0032] The tension applying device 13 applies a predetermined tension to the running yarn 20. A gate-type tension applying device can be used as the tension applying device 13. Movable combs 37 are arranged between fixed combs 36 in the gate-type tension applying device. The gate-type tension applying device can improve the quality of the package 30 by causing the yarn 20 to pass between the meshed combs 36 and 37 to thereby apply a uniform tension to the yarn 20. Apart from the gate-type tension applying device, for example, a disk-type tension applying device can be used as the tension applying device 13.

[0033] The yarn joining device 14 connects (joins) a lower yarn from the yarn feeding bobbin 21 and an upper yarn from the package 30 when the yarn is cut due to some reason. As a yarn joining device that joins the upper yarn and the lower yarn, a mechanical knotter or a yarn joining device that uses fluid, such as, compressed air can be used.

[0034] The yarn-quality measuring device 15 includes a clearer head 49 and an analyzer 47. The clearer head 49 includes a not shown yarn-thickness sensor for detecting a thickness of the yarn 20. The analyzer 47 processes a yarn-thickness signal output from the yarn-thickness sensor. The yarn-quality measuring device 15 detects a yarn defect, such as a slub, by monitoring the yarn-thickness signal output from the sensor. The yarn-quality measuring device 15 measures a length the yarn 20 has run. The yarn-quality measuring device 15 can determine the length of a yarn defect in this manner, and hence can detect a yarn defect accurately. A cutter 39 that cuts the yarn 20 immediately when the yarn-quality measuring device 15 detects a yarn defect is arranged near the clearer head 49.

[0035] A lower-yarn guiding pipe 25 that catches and guides a lower yarn, a yarn coming from the yarn feeding section 19, into the yarn joining device 14 is arranged below the yarn joining device 14. An upper-yarn guiding pipe 26 that catches and guides an upper yarn, a yarn coming from the package 30, to the yarn joining device 14 is arranged above the yarn joining device 14. The lower-yarn guiding pipe 25 and the upper-yarn guiding pipe 26 are pivotable about a shaft 33 and a shaft 35, respectively. A suction port 32 is arranged at a distal end of the lower-yarn guiding pipe 25. A suction mouth (yarn-end catcher) 34 is arranged at a distal end of the upper-yarn guiding pipe 26. A not shown appropriate negative-pressure source is connected to each of the lower-yarn guiding pipe 25 and the upper-yarn guiding pipe 26. With this configuration, suction flows can be produced at the suction port 32 and the suction mouth 34 to suck and catch yarn ends of the upper yarn and the lower yarn.

[0036] The cradle 23 includes a pair of bearings 60 and 61. The cradle 23 rotatably supports the winding bobbin 22 (and the package 30 formed by winding the yarn 20 thereonto) by arranging the winding bobbin 22 between the bearings 60 and 61.

[0037] The winding unit body 16 includes an arm-type traverse device 27 that causes the yarn 20 to traverse, and a contact roller 29 that rotates upon coming into contact with a peripheral surface of the winding bobbin 22 or a peripheral surface of the package 30.

[0038] The traverse device 27 includes an elongated arm member 28 configured to be swingable about a pivot shaft, a hook-shaped traverse guide 11 formed on a distal end of the arm member 28, and a traverse-guide drive motor 45 that drives the arm member 28. The traverse-guide drive motor 45 includes a servo motor and causes the yarn 20 to traverse by moving the arm member 28 in a reciprocating swinging manner as indicated by a dou-

ble-headed arrow in FIG. 1.

[0039] Meanwhile, the pivot shaft of the arm member 28 is substantially parallel to a plane where the winder unit 10 is installed. Alternatively, the traverse device 27 may be configured as an arm-type traverse device in which the pivot shaft of the arm member 28 is substantially perpendicular to the plane where the winder unit 10 is installed. The traverse device 27 is not limited to an arm-type traverse device, and can be a belt-type traverse device or a rotary traverse device, for instance.

[0040] A traverse control section 46 controls driving of the traverse-guide drive motor 45 according to an instruction from the unit control section 50.

[0041] The contact roller 29 is configured to come into contact with the surface of the package 30 to be rotated by rotation of the package 30 with the yarn 20, which is caused to traverse by the traverse guide 11, interposed between the contact roller 29 and the package 30. Accordingly, the yarn 20 is prevented from being traversed excessively, and the traverse device 27 can perform traversing of the yarn 20 appropriately.

[0042] A package drive motor (package drive section) 41, which is a servo motor, is mounted on the cradle 23. The bearing 61 is fixed to a motor shaft of the package drive motor 41. As being configured in this way, the package drive motor 41 directly rotates the winding bobbin 22 (and the package 30 with the yarn 20 wound thereonto) (what is called as a direct-drive system). A motor driver 42 controls operations of the package drive motor 41.

[0043] The motor driver 42 applies a predetermined voltage to the package drive motor 41 according to a rotational-frequency designating signal from the unit control section 50 to rotate the package drive motor 41 at a designated rotational frequency (the number of rotations per unit time). Accordingly, the package 30 can be rotated at a desired rotational frequency.

[0044] The cradle 23 can move the winding bobbin 22 toward and away from the contact roller 29 by pivoting about a rotation shaft (support shaft) 48. Hence, an increase in the package diameter due to winding of the yarn 20 onto the winding bobbin 22 can be accommodated by pivoting of the cradle 23. More specifically, winding of the yarn 20 can be performed in a state where the contact roller 29 is appropriately contacting the surface of the package 30 even when the thickness of the package 30 has increased with the yarn 20 wound thereon.

[0045] A not shown air cylinder is coupled to the cradle 23. The air cylinder applies an appropriate contact pressure between the package 30 and the contact roller 29. The unit control section 50 controls operations of the air cylinder.

[0046] An angle sensor 44 that detects an angle (rotation angle) of the cradle 23 is attached to the rotation shaft 48. A potentiometer, for instance, can be used as the angle sensor 44. The angle sensor 44 transmits an angle signal representing an angle of the cradle 23 to the unit control section 50.

[0047] In the automatic winder configured as de-

scribed above, the yarn 20 can be wound onto the winding bobbin 22 to form the package 30 of a predetermined shape by causing the package drive motor 41 to rotate the winding bobbin 22 while causing the traverse device 27 to traverse the yarn 20.

[0048] Control of stopping the rotation of the package 30 performed in the automatic winder according to the present embodiment is explained below.

[0049] The automatic winder according to the present embodiment does not include a mechanical braking system for stopping the package 30, but stops rotation of the package 30 by performing deceleration control on the package drive motor 41.

[0050] The unit control section 50 performs the control of bringing the package 30 to a stop. The unit control section 50 includes a deceleration-condition storage section 51 that stores therein a deceleration condition. The deceleration condition defines how a rotational frequency of the package 30 is to be reduced when the control of decelerating the package 30 to a stop is performed. The deceleration condition includes "deceleration rate" and "deceleration time". The deceleration rate is a time derivative of the rotational frequency of the package 30 with a sign of the time derivative reversed from positive to negative and vice versa. The deceleration time is a period of time from a start of deceleration of the package 30 to a stop of the package 30.

[0051] The deceleration condition can be presented in a graph where the rotational frequencies of the package 30 are plotted along the vertical axis, while time is plotted along the horizontal axis. The graphs illustrated in FIGS. 3A to 3C depict deceleration conditions employed in the present embodiment. As illustrated in FIGS. 3A to 3C, the deceleration conditions are set such that the rotational frequency of the package 30 linearly decreases with time in the present embodiment. The gradient of each of the graphs illustrated in FIGS. 3A to 3C corresponds to the deceleration rate.

[0052] As described above, according to the conventional control (the control illustrated in FIG. 10) that applies the constant deceleration rate, the deceleration time undesirably prolongs when the package diameter is small, while loads placed on the package drive motor 41 and the motor driver 42 undesirably increase when the package diameter is large. Put another way, an optimum deceleration condition for a package having a smaller package diameter differs from that for a package having a larger package diameter.

[0053] In this regard, the unit control section 50 according to the present embodiment changes the deceleration condition according to the package diameter. This will be explained more concretely below.

[0054] In the present embodiment, package diameters are classified into three ranges. More specifically, as illustrated in FIG. 2, a range of relatively small package diameters is defined as a "first range", a range of package diameters (medium-size package diameters) larger than those of the first range is defined as a "second range",

and a range of package diameters still larger than those of the second range is defined as a "third range".

[0055] As already described above, the rotational frequency of the package 30 decreases (the package 30 rotates more slowly) as the yarn 20 is wound onto the package 30 and the package diameter increases. Accordingly, the rotational frequency of the package 30 of a diameter that belongs to the second range is smaller than the rotational frequency of the package 30 of a diameter that belongs to the first range. The rotational frequency of the package 30 of a diameter that belongs to the third range is smaller than the rotational frequency of the package 30 of a diameter that belongs to the second range.

[0056] A plurality of deceleration conditions can be stored in the deceleration-condition storage section 51. Each of the deceleration conditions can be associated with any one of the package diameter ranges (the first range, the second range, and the third range). More specifically, a first deceleration condition (the graph illustrated in FIG. 3A) associated with the first range, a second deceleration condition (the graph illustrated in FIG. 3B) associated with the second range, and a third deceleration condition (the graph illustrated in FIG. 3C) associated with the third range can be stored in the deceleration-condition storage section 51.

[0057] A deceleration rate (the gradient of the graph illustrated in FIG. 3A) set in the first deceleration condition is greater than a deceleration rate (the gradient of the graph illustrated in FIG. 3B) set in the second deceleration condition. The deceleration rate (the gradient of the graph illustrated in FIG. 3B) set in the second deceleration condition is greater than a deceleration rate (the gradient of the graph illustrated in FIG. 3C) set in the third deceleration condition. A deceleration time over which the package 30 is to be decelerated to a stop under the first deceleration condition is likely to be shorter than a deceleration time over which the package 30 is to be decelerated to a stop under the second deceleration condition because the deceleration rates are set as described above. The deceleration time over which the package 30 is to be decelerated to a stop under the second deceleration condition is likely to be shorter than a deceleration time over which the package 30 is to be decelerated to a stop under the third deceleration condition.

[0058] The unit control section 50 performs deceleration-to-stop control on the package 30 by switching among the deceleration conditions according to the current package diameter.

[0059] More specifically, when the current package diameter belongs to the first range (i.e., the package diameter is relatively small), the unit control section 50 performs deceleration control on the package 30 according to the first condition. When the current package diameter belongs to the second range (i.e., the package diameter is medium-sized), the unit control section 50 performs deceleration control on the package 30 according to the

second condition. When the current package diameter belongs to the third range (i.e., the package diameter is large), the unit control section 50 performs deceleration control on the package 30 according to the third condition.

[0060] When control is performed as described above, the deceleration condition having a higher deceleration rate is applied to the package 30 when the package diameter is small (i.e., the moment of inertia of the package 30 is small), and hence the package 30 can be decelerated to a stop quickly. FIG. 4 illustrates a relation between the diameter of the package 30 and a period of time over which the package 30 is decelerated to a stop. As depicted in FIG. 4, the control according to the present embodiment can reduce the deceleration time of the package when the package diameter is small as compared with that of the conventional control (the control illustrated in FIG. 10) that applies a constant deceleration rate. Accordingly, the control according to the embodiment can reduce the time required to bring the package 30 to a stop, thereby increasing productivity of the automatic winder.

[0061] Meanwhile, the deceleration condition having a lower deceleration rate is applied to the package 30 when the package diameter is large (i.e., the moment of inertia of the package 30 is large), and hence the package 30 can be decelerated to a stop slowly. FIG. 5 illustrates a relation between the diameter of the package 30 and a braking torque necessary to stop the package 30. As depicted in FIG. 5, the control according to the present embodiment can reduce the braking torque produced in the package drive motor 41 when the package diameter is large as compared with that of the conventional control (control illustrated in FIG. 10) that applies a constant deceleration rate. Accordingly, loads on the package drive motor 41 and the motor driver 42 are prevented from instantaneously increasing to be excessively high. The package 30 having a larger moment of inertia is not braked suddenly, and hence slippage between the package 30 and the bearing 61 does not occur.

[0062] According to the present embodiment, the deceleration condition can be set according to a package diameter as described above, which leads to an optimum deceleration-to-stop control.

[0063] As illustrated in FIG. 3A, irrespective of the package diameter, the first deceleration condition is set so as to apply a constant deceleration rate (i.e., to make the gradient of the graph constant) so long as the package diameter is in the first range. As illustrated in FIG. 3B, irrespective of the package diameter, the second deceleration condition is set so as to apply a constant deceleration rate (i.e., to make the gradient of the graph constant) so long as the package diameter is in the second range. As illustrated in FIG. 3C, irrespective of the package diameter, the third deceleration condition is set so as to apply a constant deceleration rate (i.e., to make the gradient of the graph constant) so long as the package diameter is in the third range.

[0064] The deceleration conditions are set so as to ap-

ply a constant deceleration rate so long as the package diameter is in a predetermined range as described above. Therefore, the deceleration conditions can be set easily, and control operations to be performed by the unit control section 50 are also simplified.

[0065] Meanwhile, Japanese Patent Application Laid-open No. S62-215476 discloses a technique that determines a deceleration gradient (deceleration rate) using a function of a package diameter. However, in this technique, it is difficult to make adjustment so as to apply a deceleration rate that is optimum for both of a situation where the package diameter is smaller and a situation where the package diameter is larger, and hence the deceleration conditions cannot be set intuitively. In this regard, no description about operator's necessity of adjusting the deceleration gradient or the like is provided in Japanese Patent Application Laid-open No. S62-215476.

[0066] In contrast, in the present embodiment, hypothetical package diameters are classified into three ranges, and a deceleration condition is set separately for each range. Accordingly, an operator can intuitively set the deceleration conditions that depend on the package diameters.

[0067] For instance, an operator can perform test winding to set the first deceleration condition, the second deceleration condition, and the third deceleration condition. More specifically, the operator prepares a package having a small diameter belonging to the first range, a package having a medium diameter belonging to the second range, and a package having a large diameter belonging to the third range, and performs deceleration-to-stop control on each of the packages.

[0068] When an undesirable amount of heat is produced by the package drive motor 41 or in the motor driver 42 or when slippage occurs between the package 30 and the bearing 61, the operator decreases the current deceleration rate. On the other hand, when such a problem does not occur, the operator increases the current deceleration rate. The operator can intuitively set an optimum deceleration rate for each of the first range, the second range, and the third range. Thus, the operator can easily set optimum deceleration conditions according to the package diameter.

[0069] Meanwhile, the operator can set the deceleration conditions by appropriately operating the machine control device described above. The machine control device transmits the set deceleration conditions (the first deceleration condition, the second deceleration condition, and the third deceleration condition) to the unit control section 50 of each of the winder units 10. Each of the unit control section 50 stores the received deceleration conditions in the deceleration-condition storage section 51. The deceleration conditions in the plurality of winder units 10 of the automatic winder can be set at one time in this manner. As a matter of course, the automatic winder may be configured such that the deceleration conditions of each of the winder units 10 are set separately.

[0070] Operations to be performed during a joining op-

eration of the yarn winding device according to the present embodiment are described below with reference to the flowchart illustrated in FIG. 6.

[0071] As described above, the yarn joining device 14 performs joining of yarns when the yarn 20 has broken between the yarn feeding section 19 and the package 30.

[0072] When the yarn-quality measuring device 15 has detected that the yarn 20 between the yarn feeding section 19 and the package 30 is disconnected, the unit control section 50 causes the traverse device 27 to stop traversing (Step S101).

[0073] Subsequently, the unit control section 50 obtains a current diameter of the package 30 (current package diameter) (Step S102). In the present embodiment, the unit control section 50 obtains the current package diameter based on a total length of the yarn 20 wound onto the package 30, and a winding speed and a yarn type (the thickness of the yarn 20 or the like) of the yarn 20. Accordingly, the unit control section 50 can be considered to function as a package-diameter obtaining section 52.

[0074] More specifically, if the winding speed and the yarn type are known, the package diameter can be empirically calculated based on the winding speed and the yarn type, and the length of the yarn 20 wound onto the package 30. The package diameter can be calculated without involving complicated computation if a relation between lengths of the wound yarn 20 and package diameters is set in advance in the unit control section 50. Meanwhile, in the present embodiment, the length of the yarn 20 wound onto the package 30 is measured by the yarn-quality measuring device 15.

[0075] Subsequently, the unit control section 50 determines to which one of the first range, the second range, and the third range the current package diameter obtained at Step S102 belongs (Step S103).

[0076] Subsequently, the unit control section 50 reads out from the deceleration-condition storage section 51 a deceleration condition associated with the range to which the current package diameter belongs (Step S104).

[0077] The unit control section 50 outputs a rotational-frequency designating signal to the motor driver 42 according to the deceleration condition associated with the range of the package diameter. Hence, deceleration control can be performed on the package drive motor 41 using a deceleration rate according to the package diameter, thereby stopping rotation of the package 30 (Step S105). Thus, deceleration-to-stop control according to the package diameter can be implemented.

[0078] When the rotation of the package 30 is stopped, the unit control section 50 performs the joining of yarns by causing the lower-yarn guiding pipe 25 and the upper-yarn guiding pipe 26 to carry an upper yarn and a lower yarn to the yarn joining device 14, and driving the yarn joining device 14 (Step S106).

[0079] When the joining operation is completed, the unit control section 50 causes the package 30 to resume rotation and simultaneously causes the traverse device

27 to resume traversing of the yarn 20 (Step S107). By these operations, winding of the yarn 20 onto the package 30 is resumed.

[0080] As described above, the automatic winder according to the present embodiment can perform appropriate deceleration control according to a package diameter during the joining operation, thereby minimizing time for bringing the package 30 to a stop and reducing the total duration of the joining operation. As a result, productivity of the winder unit 10 in producing of the package 30 can be increased.

[0081] As described above, the automatic winder according to the present embodiment includes the package drive motor 41, the package-diameter obtaining section 52, the deceleration-condition storage section 51, and the unit control section 50. The package drive motor 41 directly rotates the package 30. The package-diameter obtaining section 52 obtains a current package diameter. The deceleration-condition storage section 51 stores therein a plurality of deceleration conditions, each of which is associated with a hypothetical package diameter and used in controlling the package drive motor 41 to decelerate the package 30 to a stop. The unit control section 50 controls the package drive motor 41 to decelerate the package 30 to a stop according to the package diameter obtained by the package-diameter obtaining section 52 and the deceleration condition associated with a hypothetical package diameter corresponding to the current package diameter.

[0082] The package drive motor 41 is controlled according to the deceleration condition that depends on the package diameter as described above. Accordingly, the package 30 can be decelerated to a stop appropriately. This leads to less heat generation by the package drive motor 41 and the like and optimization of deceleration-to-stop time. The deceleration conditions can be set intuitively because the deceleration conditions are set as being associated with package diameters.

[0083] In the automatic winder according to the present embodiment, the deceleration conditions stored in the deceleration-condition storage section 51 differ from each other in at least any one of the deceleration rate and the deceleration time. The deceleration rate is a time derivative of the rotational frequency of the package 30 with a sign of the time derivative reversed from positive to negative and vice versa. The deceleration time is a period of time from a start of deceleration of the package 30 to a stop of the package 30.

[0084] With this configuration, the deceleration rate or the deceleration time can be changed according to the package diameter. Accordingly, the package 30 can be decelerated to a stop appropriately.

[0085] In the automatic winder according to the present embodiment, the deceleration-condition storage section 51 stores therein at least the first deceleration condition for hypothetical package diameters that belong to the first range, and the second deceleration condition for the second range to which hypothetical package diameters

greater than the hypothetical package diameters belonging to the first range belong. The second deceleration condition includes a smaller deceleration rate and a longer deceleration time than that included in the first deceleration condition.

[0086] As described above, package diameters are classified into at least two ranges, for each of which a deceleration condition is set separately. Accordingly, the package drive motor 41 can be decelerated to a stop with simple setting operation. When a package to be stopped has a larger package diameter, the package drive motor 41 is decelerated to a stop according to the deceleration condition set to have a smaller deceleration rate. Accordingly, a smaller load is placed on the package drive motor 41. When a package to be stopped has a smaller package diameter, the package drive motor 41 is decelerated to a stop according to the deceleration condition set to have a higher deceleration rate, thereby bringing the package 30 to a stop in a shorter time.

[0087] In the automatic winder according to the present embodiment, the first deceleration condition is set such that a constant deceleration rate is applied to the package 30 so long as the current package diameter belongs to the first range. The second deceleration condition is set such that a constant deceleration rate is applied to the package 30 so long as the current package diameter belongs to the second range.

[0088] Configuring each of the deceleration conditions so as to apply a constant deceleration rate to the package 30 so long as the package diameter is in a predetermined range as described above allows controlling the package drive motor 41 with simple setting operation.

[0089] The automatic winder according to the present embodiment includes the yarn feeding section 19 and the yarn joining device 14. The yarn feeding section 19 feeds the yarn 20 to be wound onto the package 30. When the yarn 20 is disconnected, the yarn joining device 14 joins a yarn end of the yarn 20 from the package 30 and a yarn end of the yarn 20 from the yarn feeding section 19 together to bring the yarn 20 into a connected state. The unit control section 50 controls the package drive motor 41 to decelerate the package 30 to a stop before the yarn joining operation is performed by the yarn joining device 14.

[0090] Yarn winding devices that include the yarn joining device 14 frequently decelerate rotation of the package 30 to a stop. In such yarn winding devices, by controlling the package drive motor 41 to decelerate the package 30 to a stop according to the package diameter, reduction of a load to be placed on the package drive motor 41 and optimization of deceleration-to-stop time can be achieved.

[0091] A modification of the present embodiment will be described below. Elements that are identical or similar to those of the embodiment described above in configuration are denoted by like reference numerals as those of the embodiment and repeated descriptions are omitted.

[0092] In the embodiment described above, control is

performed by applying a constant deceleration rate when the package diameter is in a predetermined range. In contrast, in the modification, as illustrated in FIGS. 7A to 7C, control is performed such that a package is decelerated to a stop over a constant deceleration time when the package diameter is in a predetermined range.

[0093] The modification will be described more specifically below. In the modification, a deceleration time (the graph illustrated in FIG. 7A) set in the first deceleration condition is shorter than a deceleration time (the graph illustrated in FIG. 7B) in the second deceleration condition. The deceleration time (the graph illustrated in FIG. 7B) set in the second deceleration condition is shorter than a deceleration time (the graph illustrated in FIG. 7C) included in the third deceleration condition.

[0094] More specifically, the deceleration conditions are set such that when the package diameter belongs to the first range (when the package diameter is small), the package 30 is decelerated to a stop over a deceleration time that is shorter than that of the package 30 whose package diameter belongs to the second range (when the package diameter is medium-sized). When the package diameter belongs to the second range (when the package diameter is medium-sized), the package 30 is decelerated to a stop over a deceleration time that is shorter than that of the package 30 whose package diameter belongs to the third range (when the package diameter is large).

[0095] The deceleration rate at which the package 30 is to be decelerated to a stop under the first deceleration condition is likely to be greater than the deceleration rate at which the package 30 is to be decelerated to a stop under the second deceleration condition because the deceleration times are set as described above. The deceleration rate at which the package 30 is to be decelerated to a stop under the second deceleration condition is likely to be greater than the deceleration rate at which the package 30 is to be decelerated to a stop under the third deceleration condition. Accordingly, the modification can also yield the similar effect to that yielded by the embodiment.

[0096] As illustrated in FIG. 7A, in the modification, irrespective of the package diameter, the first deceleration condition is set so as to decelerate the package 30 to a stop over a constant deceleration time so long as the package diameter is in the first range. As illustrated in FIG. 7B, irrespective of the package diameter, the second deceleration condition is set so as to decelerate the package 30 to a stop over a constant deceleration time so long as the package diameter is in the second range. As illustrated in FIG. 7C, irrespective of the package diameter, the third deceleration condition is set so as to decelerate the package 30 to a stop over a constant deceleration time so long as the package diameter is in the third range.

[0097] The deceleration conditions are set so as to decelerate the package 30 to a stop over a constant deceleration time so long as the package diameter is in a pre-

determined range as described above. Accordingly, the deceleration conditions can be set easily, and control operations to be performed by the unit control section 50 are also simplified.

[0098] Meanwhile, in the above-described embodiment, the value of braking torque suddenly changes at each of a boundary between the first range and the second range and a boundary between the second range and the third range as illustrated in FIG. 5. This is because a deceleration rate changes greatly at each of the boundaries between the first range, the second range, and the third range because the deceleration conditions are set so as to keep the deceleration rate constant so long as the package diameter is in a predetermined range.

[0099] In this regard, by setting the deceleration conditions so as to decelerate the package 30 to a stop over a constant deceleration time so long as the package diameter is in a predetermined range as in the modification, as illustrated in FIG. 9, changes in the braking torque in response to an increase in the package diameter can be smoothed as compared with those illustrated in FIG. 5. Accordingly, the modification provides more appropriate control than the embodiment does.

[0100] In the automatic winder according to the modification, the first deceleration condition is set such that a constant deceleration time is applied to the package 30 so long as the package 30 has a diameter belonging to the first range. The second deceleration condition is preferably set such that a constant deceleration time is applied to the package 30 so long as the package 30 has a diameter belonging to the second range.

[0101] Setting each of the deceleration conditions so as to apply a constant deceleration time to the package 30 so long as the package diameter is in a predetermined range as described above allows controlling the package drive motor 41 with simple setting operation.

[0102] The embodiment and the modification of the present invention are described above. The configurations discussed above can be modified as described below, for example.

[0103] A method of obtaining the package diameter is not limited to the method described above, and the package diameter can be obtained using various other methods. For instance, the package diameter can be obtained by causing the angle sensor 44 to detect a rotation angle of the cradle 23. This is because the angle of the cradle 23 changes as the thickness of the package 30 increases with an increasing amount of the yarn 20 wound thereon. In this case, the angle sensor 44 of the cradle 23 can be considered as the package-diameter obtaining section.

[0104] Alternatively, for instance, a time from when winding of the yarn 20 is started can be measured. If the winding speed and the yarn type (the thickness of the yarn 20 or the like) are known, the package diameter can be empirically calculated based on an elapsed time from when winding of the yarn 20 is started. To calculate the package diameter based on the elapsed time, one approach is to store in advance a relation between elapsed

times from a start of winding and package diameters in the unit control section 50. Meanwhile, measurement of the elapsed time from a start of winding is desirably suspended while winding is suspended for yarn breakage, yarn joining operation, or the like. By suspending measurement in this manner, the package diameter can be obtained more accurately.

[0105] Further alternatively, a yarn speed sensor may be arranged at some point on a running path of the yarn 20 to calculate the package diameter based on a running speed of the yarn 20 detected by the yarn speed sensor. More specifically, a winding angle is calculated based on the running speed and a traverse speed of the yarn 20. Furthermore, the circumferential speed of the package 30 is calculated based on the winding angle and the yarn speed. The package diameter can be calculated based on the number of rotations of the package 30 and the circumferential speed of the package 30.

[0106] In the embodiment, as an example, the deceleration conditions that cause a rotational frequency of the package 30 to linearly decrease with respect to time as illustrated in FIGS. 3A to 3C have been described, the deceleration conditions are not limited thereto. As a matter of course, a deceleration condition that causes a rotational frequency of the package 30 to decrease in a curve with respect to time can alternatively be employed.

[0107] No particular limitation is imposed on a form of the deceleration conditions to be stored in the deceleration-condition storage section 51. For instance, "deceleration rate," "deceleration time," and/or the like can be stored as numerical data. Alternatively, graphs such as those illustrated in FIGS. 3A to 3C can be stored as two-dimensional tables.

[0108] In the above-described embodiment, package diameters are classified into the three ranges, for each of which a deceleration condition is set separately. Alternatively, package diameters may be classified into two ranges or four or more ranges. The greater the number of ranges, the more finely deceleration conditions can be set, leading to optimum deceleration-to-stop control. However, as the number of ranges increases, the number of deceleration conditions that need to be set also increases, thereby placing greater burden on the operator. Accordingly, in terms of operator's ease in setting the deceleration conditions, it is preferable that the number of ranges be as less as three as in the embodiment.

[0109] No particular limitation is imposed on the type of the package drive motor 41 (package drive section), and various types of motors, such as a stepping motor and an induction motor, can be used as the package drive motor 41.

[0110] Although the embodiment employs a configuration in which the package drive motor 41 rotates the package 30, the technique of the present invention is also applicable to a configuration in which the package 30 is rotated by rotation of the contact roller 29 that is driven to rotate. When this configuration is employed, the package drive motor 41 is used only to brake the package

30. More specifically, during normal winding, the package drive motor 41 is placed in a state where no voltage is applied, while the package 30 is rotated by rotation of the contact roller 29 that is driven to rotate. When it is required to stop the package 30, the cradle 23 is caused to pivot to separate the package 30 from the contact roller 29. In this state, a predetermined voltage is applied to the package drive motor 41 while simultaneously controlling rotational frequency of the package drive motor 41, thereby decelerating the package 30 to a stop. This configuration can also decelerate the package 30 to a stop according to the package diameter, thereby implementing optimum deceleration-to-stop control.

Claims

1. A yarn winding device comprising:

a package drive section (41) adapted to directly drive a package (30);
 a package-diameter obtaining section (52) adapted to obtain a current package diameter of the package (30);
 a deceleration-condition storage section (51) adapted to store therein a plurality of deceleration conditions, each of the deceleration conditions being associated with a hypothetical package diameter, the deceleration condition being used in controlling the package drive section (41) to decelerate the package (30) to a stop; and
 a control section (50) adapted to control the package drive section (41) to decelerate the package (30) to a stop according to the current package diameter obtained by the package-diameter obtaining section (52) and a deceleration condition associated with a hypothetical package diameter corresponding to the current package diameter.

2. The yarn winding device according to Claim 1, wherein the deceleration conditions stored in the deceleration-condition storage section (51) differ from each other in at least any one of a deceleration rate and a deceleration time, the deceleration rate being a value of a time derivative of a rotational frequency of the package (30) with a sign of the time derivative reversed from positive to negative and vice versa, the deceleration time being a period of time from a start of deceleration of the package (30) to a stop of the package (30).

3. The yarn winding device according to Claim 2, wherein the deceleration-condition storage section (51) is adapted to store at least a first deceleration condition for hypothetical package diameters that belong to a first range and a second deceleration

condition for a second range to which hypothetical package diameters greater than the hypothetical package diameters belonging to the first range belong, and

the second deceleration condition includes a smaller deceleration rate and a longer deceleration time than that included in the first deceleration condition.

4. The yarn winding device according to Claim 3, wherein
 the first deceleration condition is set such that a constant deceleration rate is applied to the package (30) so long as the current package diameter belongs to the first range, and
 the second deceleration condition is set such that a constant deceleration rate is applied to the package (30) so long as the current package diameter belongs to the second range.

5. The yarn winding device according to Claim 3, wherein
 the first deceleration condition is set such that a constant deceleration time is applied to the package (30) so long as the current package diameter belongs to the first range, and
 the second deceleration condition is set such that a constant deceleration time is applied to the package (30) so long as the current package diameter belongs to the second range.

6. The yarn winding device according to any one of Claims 1 to 5, further comprising:

a yarn feeding section (19) adapted to feed a yarn (20) to be wound onto the package (30); and

a yarn joining device (14) that is adapted to, when the yarn (20) is disconnected, join a yarn end of the yarn (20) from the package (30) and a yarn end of the yarn (20) from the yarn feeding section (19) together to bring the yarn (20) into a connected state, wherein

the control section (50) is adapted to control the package drive section (41) so as to decelerate the package (30) to a stop before yarn joining is performed by the yarn joining device (14).

FIG.1

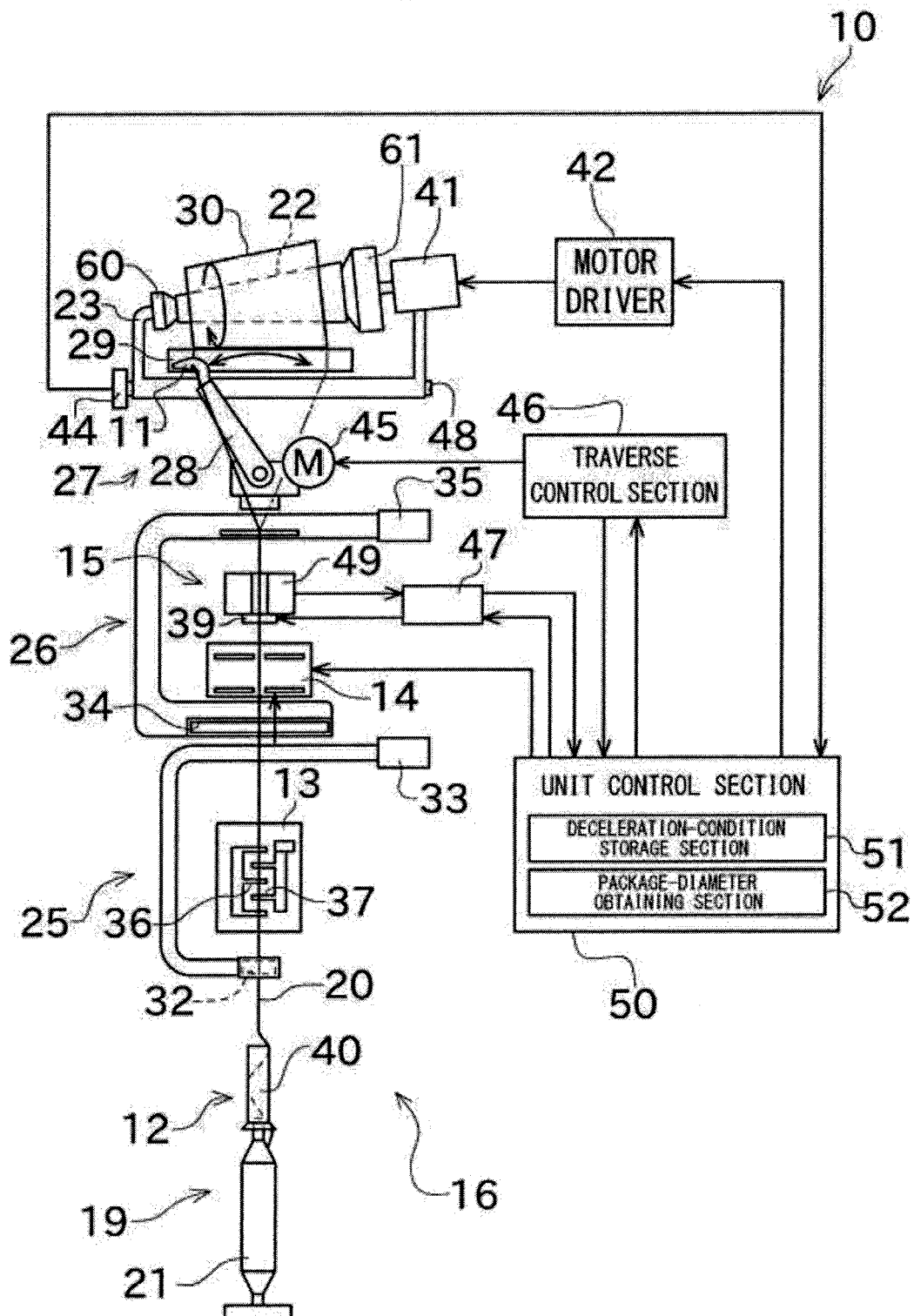


FIG.2

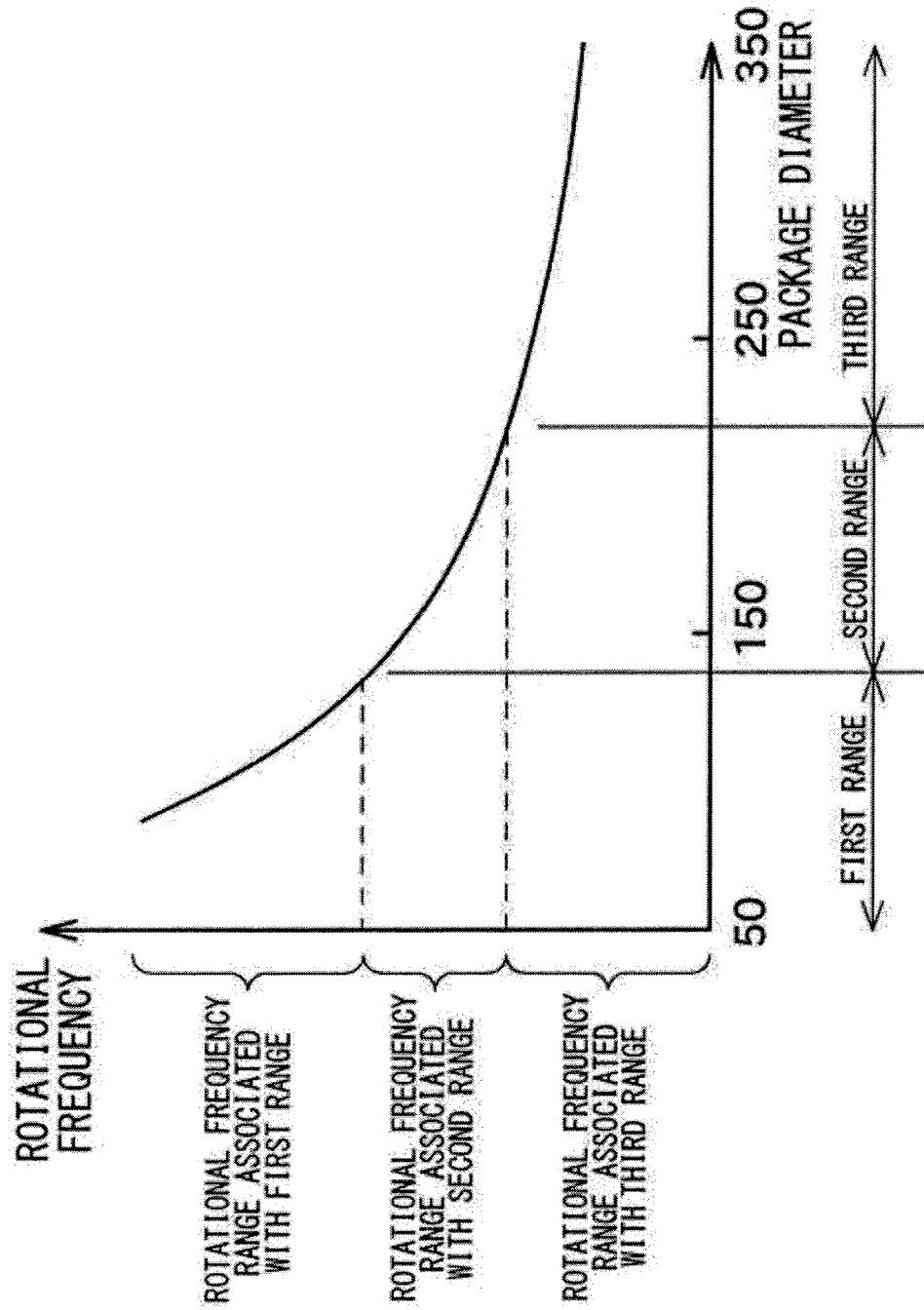


FIG.3A

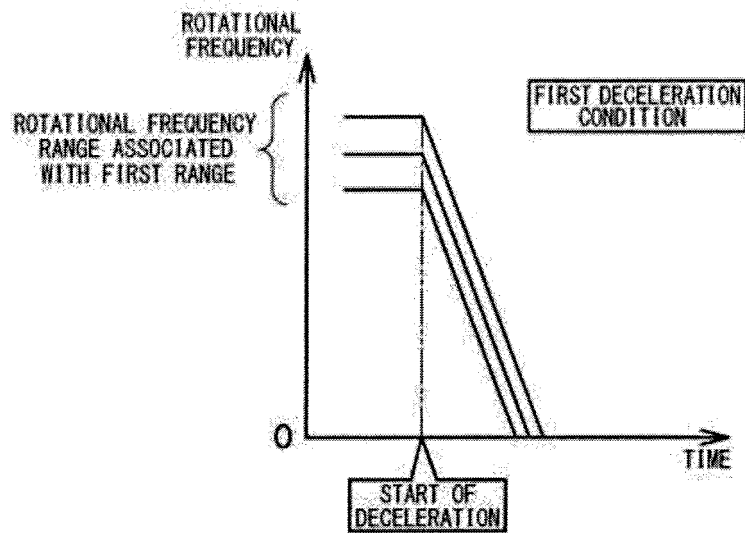


FIG.3B

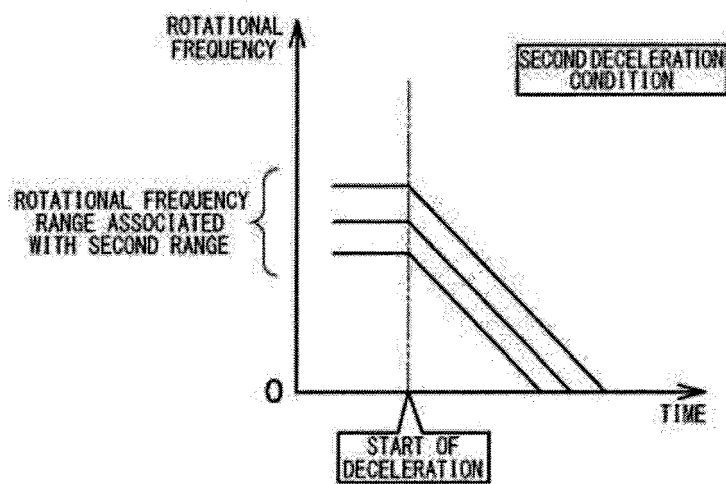


FIG.3C

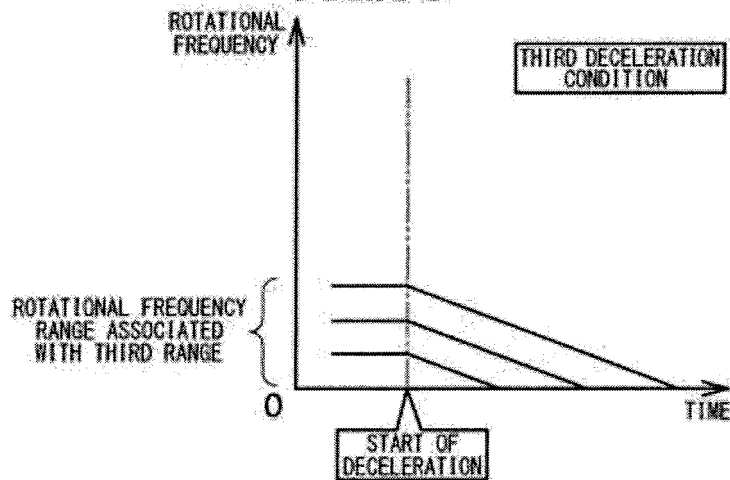


FIG.4

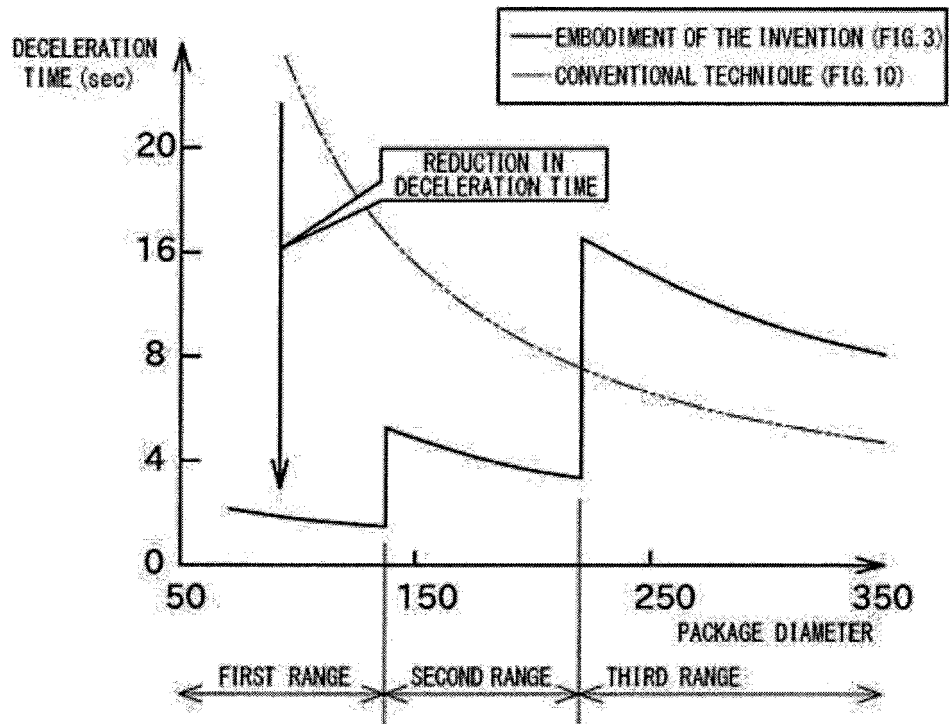


FIG.5

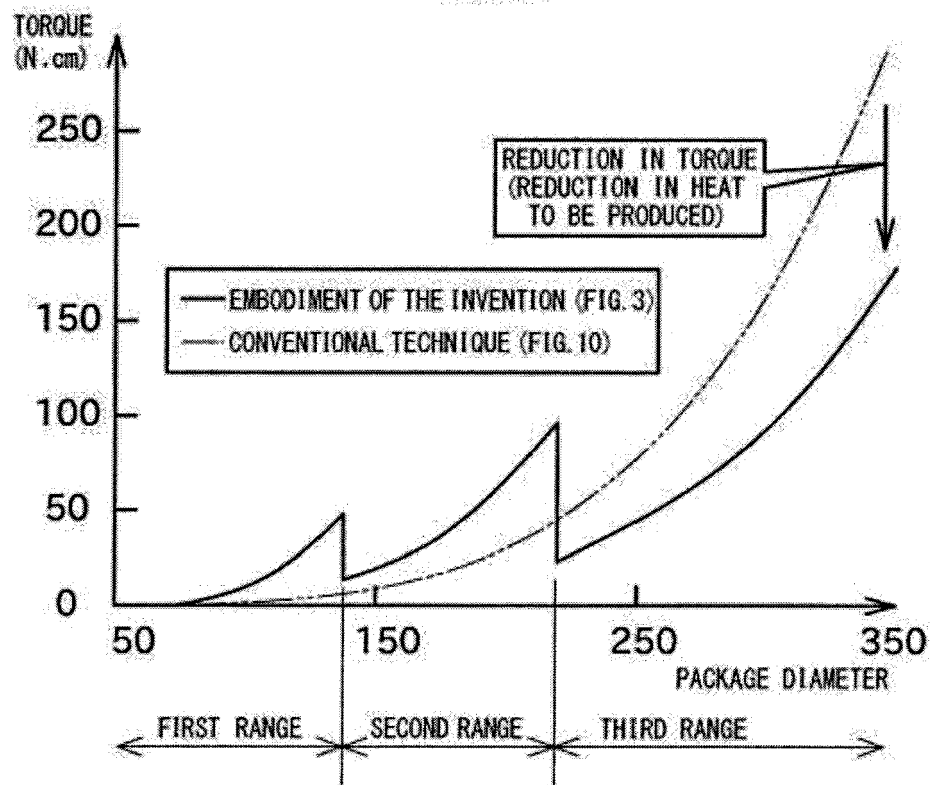


FIG.6

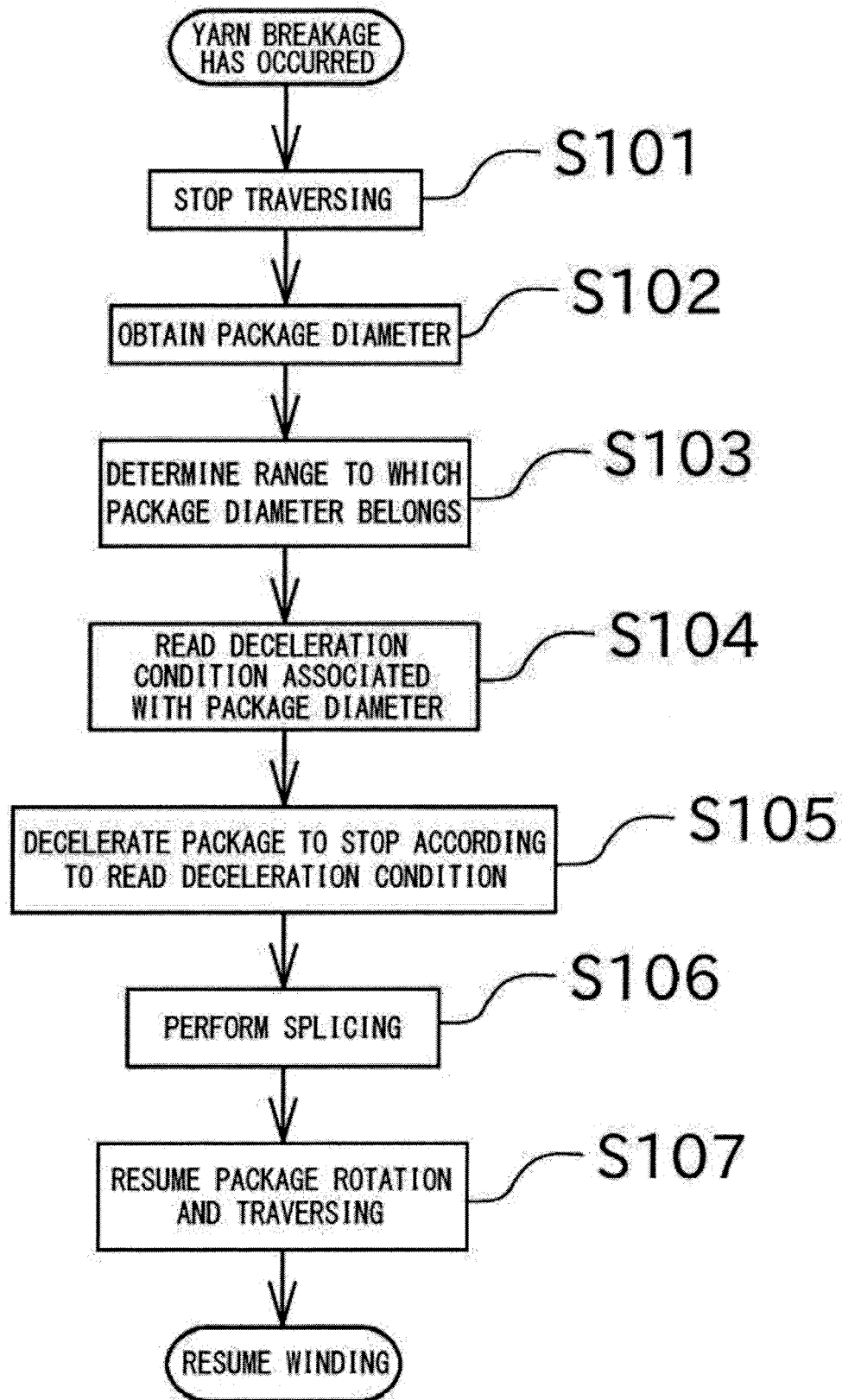


FIG.7A

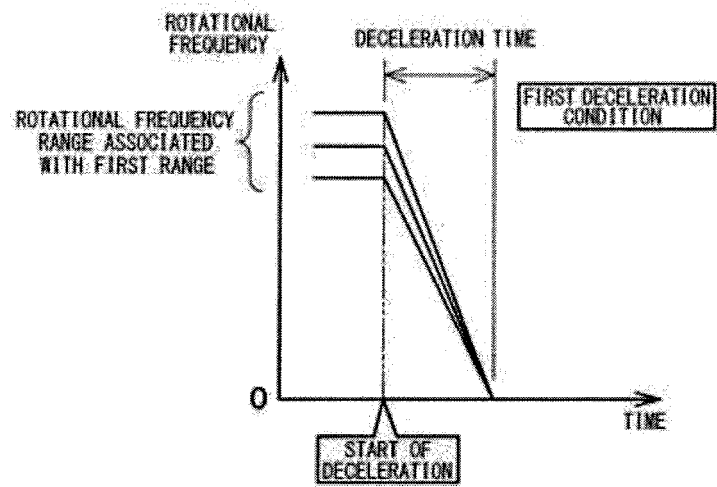


FIG.7B

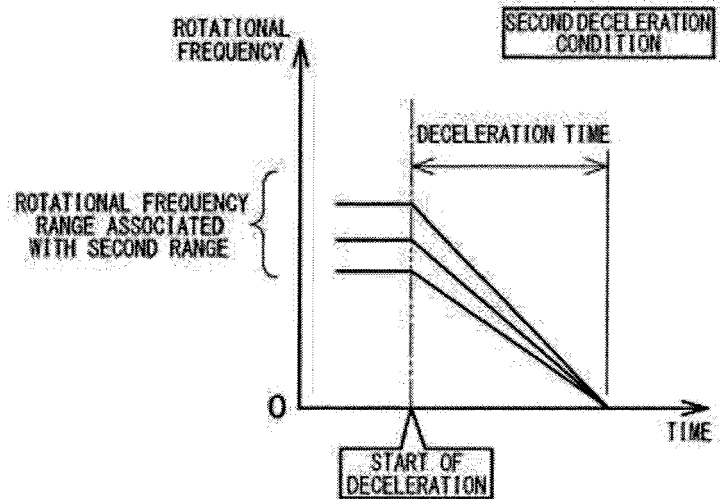


FIG.7C

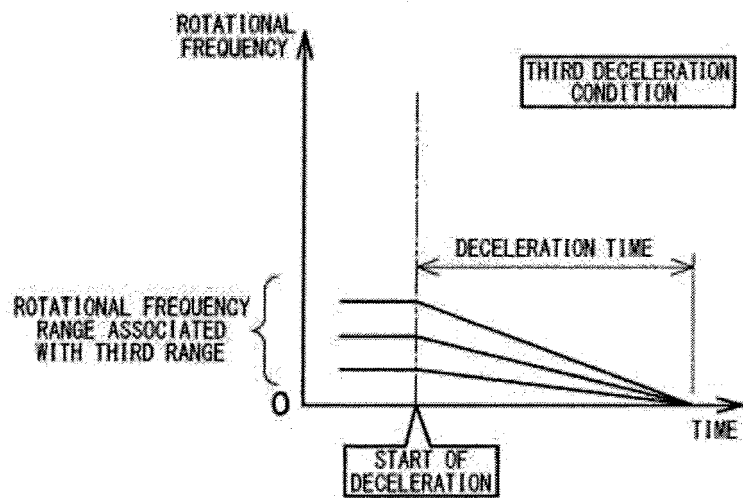


FIG.8

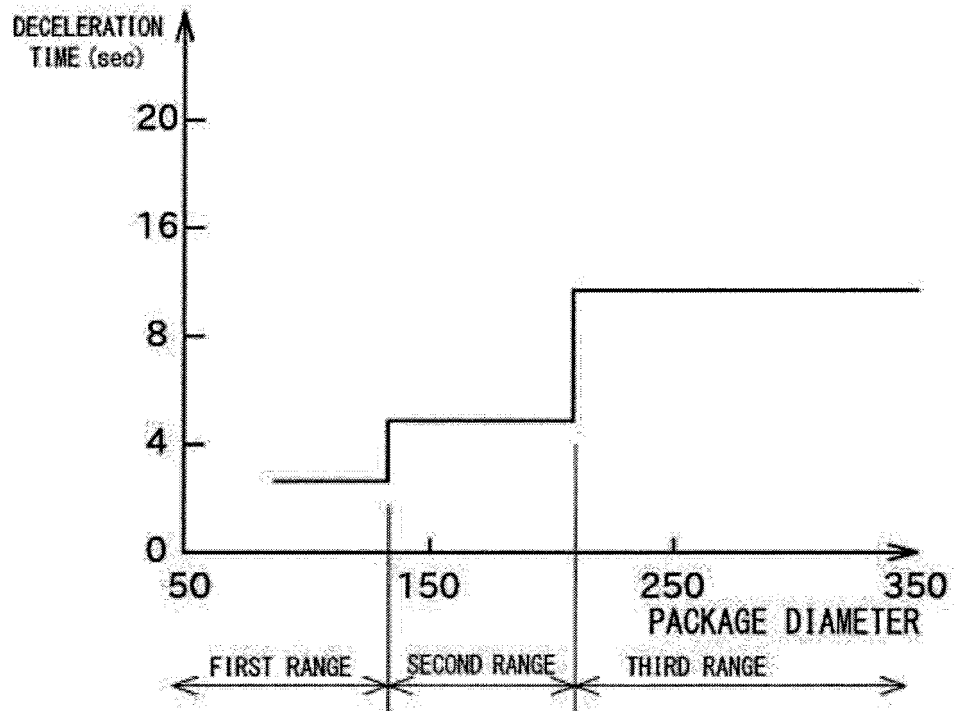


FIG.9

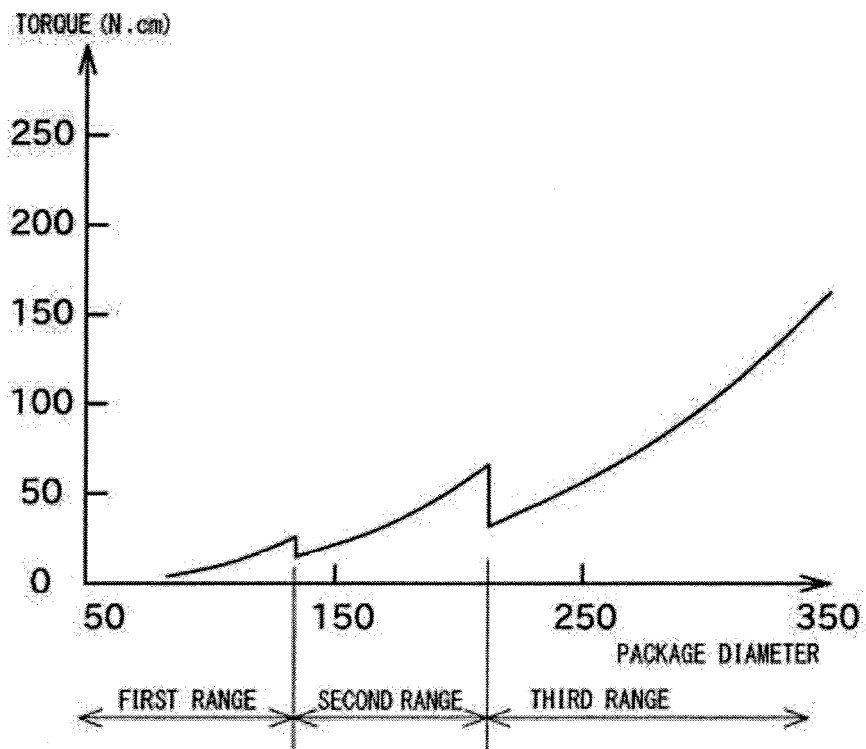


FIG.10

CONVENTIONAL TECHNIQUE

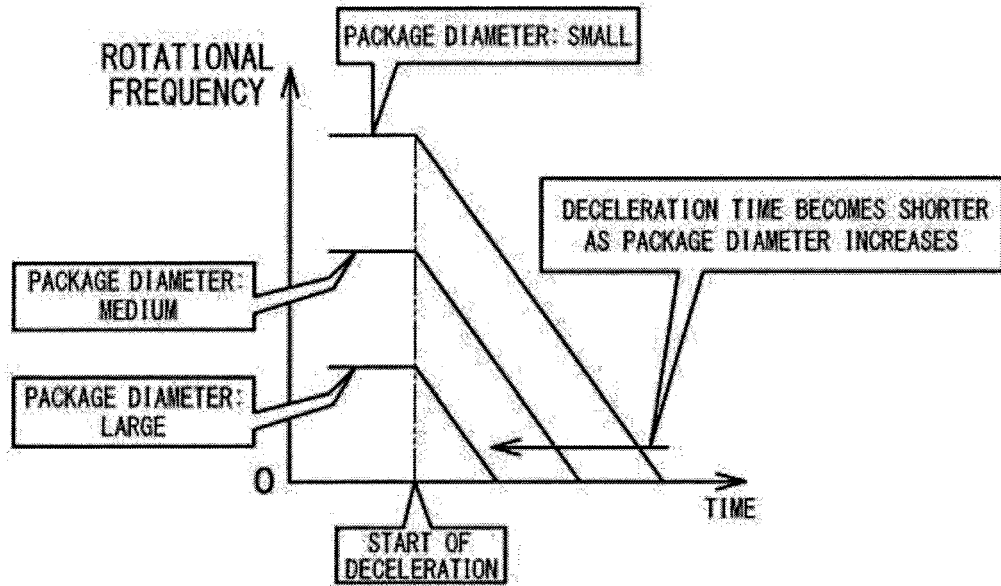


FIG.11

CONVENTIONAL TECHNIQUE

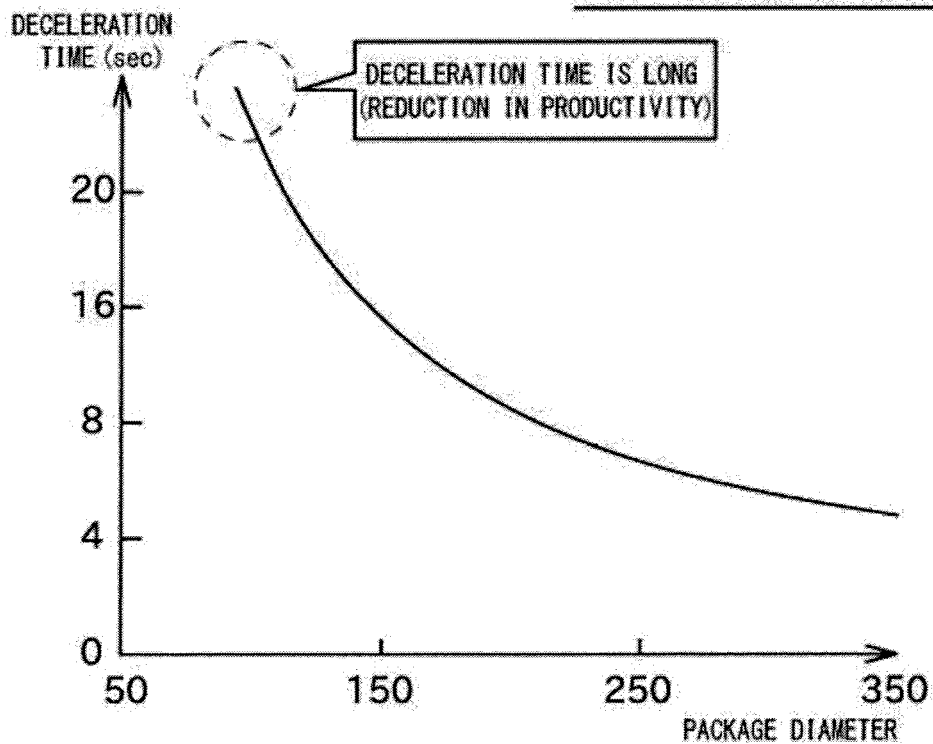
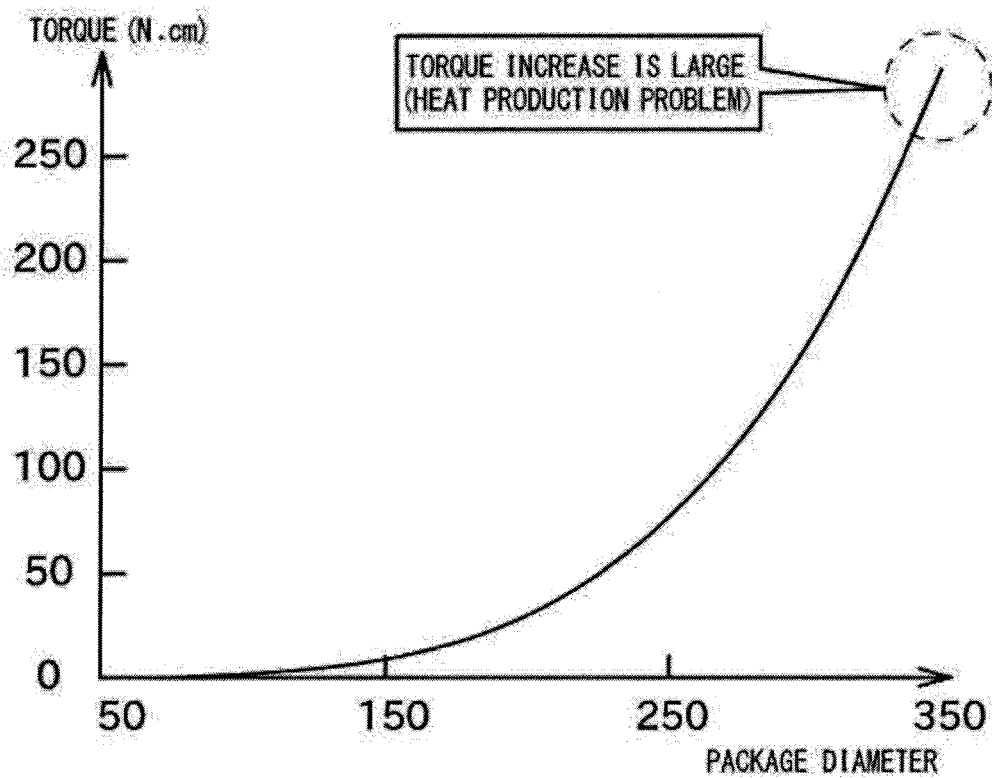


FIG.12

CONVENTIONAL TECHNIQUE



REFERENCES CITED IN THE DESCRIPTION

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