(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 597 806 A1

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
22.01.2020 Bulletin 2020/04

(51) Int Cl.:
D03D 51/06 *(2006.01)*

(21) Application number: **19182463.0**

(22) Date of filing: **26.06.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **19.07.2018 JP 2018135612**

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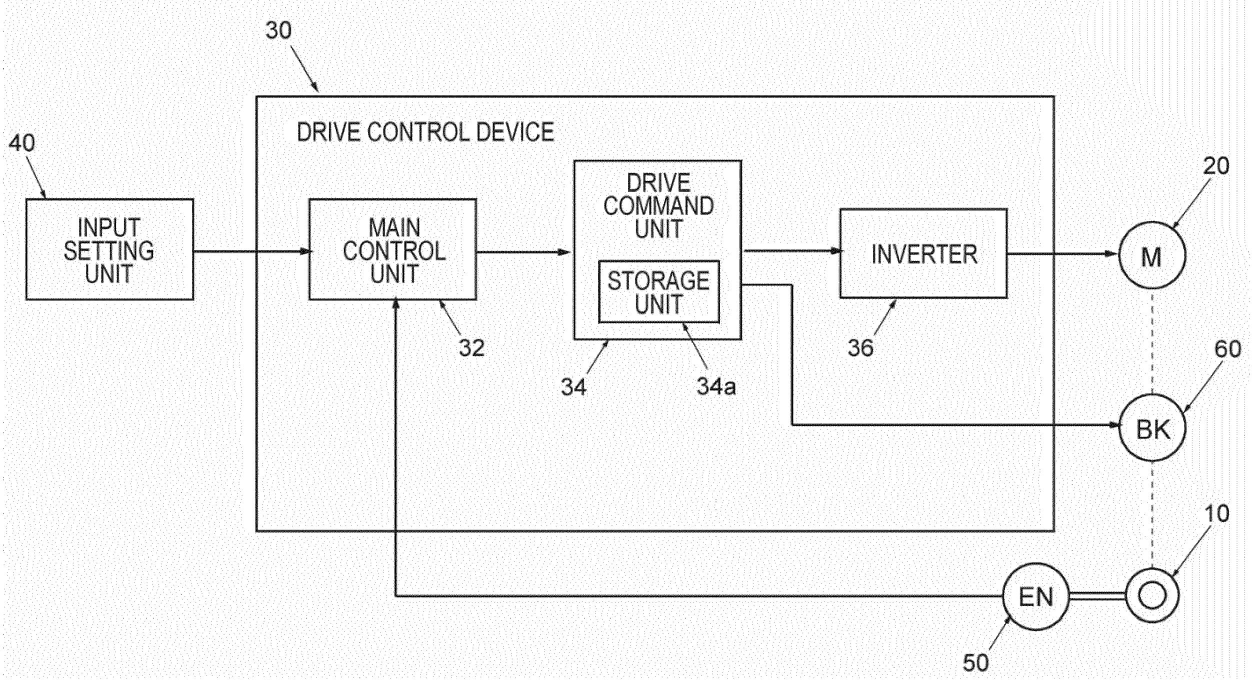
(54) ## METHOD FOR STOPPING LOOM AND LOOM FOR REALIZING STOPPING METHOD

(57) Rotation of a main shaft (10) is stopped by a first braking step that is started at a time point at which a stop command has been generated or later, the first braking step dropping a rotation rate of the main shaft (10) toward a predetermined stop rotation rate that is lower than a steady rotation rate by changing a command rotation rate two times or more; and a second braking step of actuating an electromagnetic brake (60) at a time point at which the rotation rate has reached the stop rotation rate or later and braking the main shaft (10). In addition, the command rotation rate is changed in the first braking step every period of one rotation or more of the main shaft (10).

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a loom including a control device that controls the rotation of a main shaft on the basis of a predetermined command rotation rate and an electromagnetic brake that brakes the main shaft, the control device being configured to control the rotation of the main shaft on the basis of a preset steady rotation rate in steady operation.

2. Description of the Related Art

[0002] In a loom in steady operation, the driving of a driving motor is controlled such that a main shaft is rotationally driven at a preset steady rotation rate, and the operation is performed. In addition, the loom includes a control device, and the control device controls the driving of the driving motor on the basis of a predetermined command rotation rate. The control device includes, for example, an inverter. The output frequency of the inverter is set to a frequency corresponding to the command rotation rate and hence the driving motor is controlled at a rotation rate corresponding to the command rotation rate. Thus, in the steady operation, the steady rotation rate serves as the command rotation rate and the driving of the driving motor is controlled (the main shaft is rotationally driven).

[0003] In addition, the loom typically includes an electromagnetic brake for stopping the rotation of the main shaft as disclosed in, for example, Japanese Unexamined Patent Application Publication No. 6-158478. In the loom, a stop command is generated when the operation is required to be stopped, the electromagnetic brake is actuated in response to the generation of the stop command, a braking force acts on the main shaft, and the rotation of the main shaft is stopped. In a typical loom, a braking operation (control on the electromagnetic brake etc.) is performed such that the rotation of the main shaft is stopped at a time point at which the main shaft has been rotated by about one rotation (or two rotations) by inertia since the time point at which the stop command has been generated. In other words, the braking operation is performed such that the rotation of the main shaft is stopped in a short stop period in which the main shaft is rotated by only about one rotation (or two rotations) by inertia (a braking period with the electromagnetic brake).

[0004] However, when the rotation of the main shaft is stopped in such a short stop period, an excessive load may be applied to a mechanical component (the main shaft, a part that is moved by the main shaft as a drive source, its drive transmission part, etc.) that is driven by the driving motor, or the electromagnetic brake in accordance with a weaving condition or the like.

[0005] To be specific, for example, when the steady rotation rate is set high, the mechanical component that moves (rotates) in accordance with the high rotation rate is to be stopped by the above-described motion in the short stop period. Hence, the braking operation is performed in a state in which a large load is applied to the mechanical component due to the inertia corresponding to the speed. Also with regard to the electromagnetic brake, a braking force so large that stops the main shaft rotating at such a high rotation rate (high rotation speed) within the above-described short stop period acts on the main shaft. Hence, the load to be applied to the electromagnetic brake in the braking operation becomes markedly large. Although the steady rotation rate is not set high as described above, for example, when the number of heald frames included in the mechanical component is large, the inertia of the mechanical component that is driven by the driving motor increases as the weight of the mechanical component increases. Hence, the braking operation is performed in a state in which a large load is applied to the mechanical component like the above-described situation.

[0006] If a large load is applied to the mechanical component or the electromagnetic brake in this way every time when the rotation of the main shaft is stopped, the mechanical component may be broken or a braking member such as a brake shoe of the electromagnetic brake may wear early. If the wear of the braking member of the electromagnetic brake progresses, the braking force decreases, and hence the braking member is required to be replaced.

[0007] With regard to the load that is applied to a mechanical element or the like such as one described above, a long stop period may be set instead of a short stop period such as one described above, and the rotation speed of the main shaft may be reduced in such a long stop period (at a more gentle speed-reduction gradient) to stop the rotation. However, when a braking operation is performed to stop the rotation of the main shaft in such a long stop period, the braking with the electromagnetic brake is performed for the long period every braking operation, and due to this, the braking member of the electromagnetic brake may wear early like the above-described situation.

[0008] Therefore, as disclosed in Japanese Unexamined Patent Application Publication No. 2007-332477, a braking operation may be performed by using a combination of regenerative braking and braking with the electromagnetic brake. To be specific, in the braking operation disclosed in Japanese Unexamined Patent Application Publication No. 2007-332477, when the stop command is generated as described above, the rotation speed of the main shaft is reduced first by the regenerative braking, and then the rotation of the main shaft is stopped by actuation of the electromagnetic brake. With the braking operation, since the rotation rate of the main shaft is lower than the steady rotation rate at the time point at which the electromagnetic brake starts acting, the load that is applied to the mechanical element or the like is reduced although the braking period with the electromagnetic brake is a short period such as one described above.

[0009] However, with the braking operation disclosed in Japanese Unexamined Patent Application Publication No. 2007-332477, the inverter of the control device may be burn-damaged. To be specific, in the case of the braking operation disclosed in Japanese Unexamined Patent Application Publication No. 2007-332477, the braking operation is performed such that the entirety of the stop period from the generation of the stop command until the rotation of the main shaft is stopped is a short period. Therefore, the braking operation is set such that the braking period with the electromagnetic brake is a short period and the braking period by the regenerative braking is a short period. That is, the braking operation is set such that the regenerative braking of dropping the rotation rate of the main shaft to the rotation rate at which the electromagnetic brake is actuated is performed in a short period. Hence, the regenerative braking is performed to continuously reduce the rotation speed of the main shaft (at a steep speed-reduction gradient) in the short period.

[0010] When the regenerative braking is performed, regenerative electric power is generated from the driving motor toward the inverter by the regenerative braking. When the generation of such regenerative electric power causes a problem, a capacitor or a resistor (hereinafter, also referred to as "resistor or the like") is typically provided in a circuit that is connected to the inverter. The generated regenerative electric power is absorbed in a manner stored in the capacitor or in a manner converted into thermal energy by the resistor and released to the outside, to prevent the excessive regenerative electric power from flowing to the inverter.

[0011] However, for example, when the rotation rate in steady operation is high as described above (when there is a large difference between the steady rotation rate and the rotation rate of the main shaft at the time point at which the electromagnetic brake is actuated, the rotation rate being determined with regard to the above-described load), and when the regenerative braking is continuously performed in a short period as described above, the regenerative electric power to be generated is markedly large. Thus, the regenerative electric power may not be completely absorbed by the resistor or the like. In this case, a problem due to the regenerative braking may occur such that the excessive regenerative electric power flows to the inverter and the inverter is burn-damaged. To prevent such burn-damage of the inverter, a resistor or the like having a large capacity may be employed. In this case, however, the apparatus cost may increase.

SUMMARY OF THE INVENTION

[0012] Accordingly, an object of the present invention is to provide a method for stopping a loom, based on that a braking operation is performed by using a combination of regenerative braking and braking with an electromagnetic brake as described above, the method reducing a load that is applied to a mechanical element or the like such as one described above and not causing a problem due to the regenerative braking such as one described above; and also to provide a loom that can realize the stopping method.

[0013] To attain the object, a method for stopping a loom and a loom for realizing the stopping method according to the present invention presuppose a loom including a control device that controls rotation of a main shaft on the basis of a predetermined command rotation rate, and an electromagnetic brake that brakes the main shaft, the control device being configured to control the rotation of the main shaft on the basis of a preset steady rotation rate in steady operation.

[0014] The method for stopping the loom according to the present invention includes a first braking step that is started at a time point at which a stop command has been generated or later, the first braking step dropping a rotation rate of the main shaft toward a predetermined stop rotation rate that is lower than the steady rotation rate by changing the command rotation rate two times or more; and a second braking step of actuating the electromagnetic brake at a time point at which the rotation rate has reached the stop rotation rate or later and braking the main shaft, the second braking step stopping the rotation of the main shaft. The command rotation rate is changed in the first braking step every period of one rotation or more of the main shaft.

[0015] In addition, a loom according to the present invention includes an angle detector that detects a rotation angle of the main shaft and a storage unit that stores rotation rate information that is information relating to the command rotation rate and that is obtained using a predetermined stop rotation rate and a predetermined number of times of change of the command rotation rate, the number of times of change being two or more, and period information that is information for determining a period in which the command rotation rate is changed and that the period is set to a period of one rotation or more of the main shaft. Furthermore, the control device of the loom includes a drive command unit that receives an input of angle information that is obtained on the basis of a detection signal from the angle detector, that obtains, for a first change time point of the command rotation rate based on generation of a stop command and a second or later change time point of the command rotation rate obtained on the basis of the angle information and the period information with reference to the first change time point, the command rotation rate corresponding to each of the change time points from the rotation rate information, and that outputs a drive command based on each of the obtained command rotation rates at corresponding one of the change time points; and a drive unit that drives the driving motor on the basis of the drive command from the drive command unit.

[0016] Note that the "stop rotation rate" is determined as a rotation rate lower than the steady rotation rate, and is determined as a rotation rate such that a load that is applied to a mechanical element or the like such as one described above due to the braking with the electromagnetic brake is within a permissible load range even when the braking period with the electromagnetic brake is a short period like one described above. The "permissible load" described here is substantially a load that does not cause the above-described problem caused by the excessive load that is applied to the mechanical element or the like due to the braking with the electromagnetic brake when the braking period with the electromagnetic brake is a short period such as one described above.

[0017] In the method for stopping the loom, the first braking step may be performed on the basis of a preset rotation rate drop amount and the period. Furthermore, in the loom, the rotation rate information may include a preset rotation rate drop amount.

[0018] With the method for stopping the loom and the loom according to the present invention, the braking operation from the time point at which the stop command has been generated until the rotation of the main shaft is stopped is performed in the first braking step of the braking (that is, the regenerative braking) of changing the command rotation rate and hence changing the rotation rate of the main shaft (reducing the rotation speed of the main shaft), and the second braking step of the braking with the electromagnetic brake. The speed reduction in the first braking step (the regenerative braking) is performed to lower the rotation rate of the main shaft to the stop rotation rate. The stop rotation rate is determined as a rotation rate lower than the steady rotation rate, and is determined as a rotation rate such that a load that is applied at the braking with an electromagnetic brake is within the above-described permissible load range even when the braking period with the electromagnetic brake is a short period like one described above. Accordingly, with such a braking operation, a problem in which the mechanical component is broken or a problem in which the braking member of the electromagnetic brake wears early due to the load that is applied at the braking with the electromagnetic brake does not occur.

[0019] Based on this, according to the present invention, the braking in the first braking step is performed by changing the command rotation rate two times or more. That is, in the first braking step, the operation of dropping the rotation rate of the main shaft from the steady rotation rate toward the stop rotation rate is performed by the regenerative braking that is performed a plurality of times in a divided manner. Accordingly, the drop amount of the rotation rate by the single regenerative braking is a small amount, and the regenerative electric power generated by the single regenerative braking is also small.

[0020] In addition, according to the present invention, the change of the command rotation rate that is performed two times or more is performed every period of one rotation or more. That is, the plurality of times of the regenerative braking in the first braking step each are performed every period of one rotation or more of the main shaft from the start of the previous braking to the start of the next braking. Accordingly, the small regenerative electric power generated by each regenerative braking is completely absorbed by the resistor or the like in the period. Consequently, for example, even when the rotation rate in steady operation is high as described above, a situation in which the resistor or the like cannot completely absorb the regenerative electric power generated by the regenerative braking does not occur. Thus, a problem caused by the regenerative braking as described above does not occur.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

Fig. 1 is a block diagram of the periphery of a drive control device of a loom of the present invention; and
Fig. 2 is an explanatory view illustrating a sequential flow until the rotation of a main shaft is stopped by a method for stopping the loom of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] An embodiment of the present invention is described below with reference to Figs. 1 and 2.

[0023] As illustrated in Fig. 1, a loom includes a main shaft 10, a driving motor 20 that rotationally drives the main shaft 10, and a drive control device 30 that controls the driving of the driving motor 20. The loom also includes a warp shedding device (not illustrated) that forms/closes a warp shed, and a reed (not illustrated). In a typical loom, the warp shedding device and so forth are coupled to the main shaft 10 via a drive transmission mechanism (not illustrated). Thus, the warp shedding device and so forth are driven during weaving in a predetermined mode while the main shaft 10 serves as a drive source.

[0024] In addition, the loom includes an input setting unit 40 for inputting and setting set values, such as a steady rotation rate that is the rotation rate of the main shaft 10 in steady operation and a shedding pattern indicative of a shedding order of a heald frame in the warp shedding device. The input setting unit 40 is connected to the drive control device 30.

[0025] The drive control device 30 includes a main control unit 32 that is connected to the input setting unit 40, and a drive command unit 34 that is connected to the main control unit 32. The drive command unit 34 includes a storage unit 34a that stores the set values such as the steady rotation rate. The set values such as the steady rotation rate are input to and set in the input setting unit 40, and are transmitted to and stored in the drive command unit 34 from the input setting unit 40 via the main control unit 32.

[0026] The drive control device 30 also includes an inverter 36 that controls the driving of the driving motor 20.

The inverter 36 is connected to the drive command unit 34. With the connection, the drive control device 30 outputs a frequency command signal (a drive command) corresponding to a target rotation rate of the main shaft 10 from the drive command unit 34 to the inverter 36, controls the inverter 36 on the basis of the frequency command signal, and hence controls the driving of the driving motor 20. To be specific, for example, in steady operation of the loom, the drive command unit 34 outputs the frequency command signal corresponding to the steady rotation rate stored in the storage unit 34a to the inverter 36 in the drive control device 30. The inverter 36 generates an output frequency corresponding to the frequency command signal, and controls the driving of the driving motor 20 such that the driving motor 20 is driven at the rotation rate corresponding to the steady rotation rate. That is, the driving motor 20 is controlled to be driven at the rotation rate corresponding to the output frequency of the inverter 36.

[0027] The loom also includes an angle detector 50 that detects the rotation angle of the main shaft 10. The angle detector 50 detects the rotation angle in units of one rotation of the main shaft 10. The angle detector 50 is connected to the main control unit 32 of the drive control device 30. The angle detector 50 outputs a detection signal based on the detected rotation angle of the main shaft 10 to the main control unit 32. The main control unit 32 obtains angle information on the main shaft 10 on the basis of the input detection signal, and outputs an angle signal based on the angle information to the drive command unit 34.

[0028] The loom also includes an electromagnetic brake 60 for stopping the rotation of the main shaft 10 by causing a braking force to act on the main shaft 10. The electromagnetic brake 60 is connected to the drive command unit 34. With the connection, the electromagnetic brake 60 receives the input of a braking command signal that is output from the drive command unit 34, and causes a braking force to act on the main shaft 10.

[0029] In the above-described loom, according to the present invention, the drive control device 30 provides control to perform a braking operation from a time point at which a stop command has been generated until the rotation of the main shaft 10 is stopped by using braking (regenerative braking) that changes a command rotation rate serving as the basis of the frequency command signal from the drive command unit 34 and hence changes the rotation rate (a main shaft rotation rate) (reduces the speed) of the main shaft 10, and braking (electromagnetic braking) with the electromagnetic brake 60. The regenerative braking is performed by reducing the rotation rate of the main shaft 10 that rotates at the steady rotation rate to a stop rotation rate that is determined as a rotation rate lower than the steady rotation rate. Then, the drive control device 30 controls the dropping of the main shaft rotation rate toward the stop rotation rate by the regenerative braking that is performed a plurality of times in a divided manner. Further, the plurality of times of the regenerative braking each are performed every period of one rotation or more of the main shaft 10 from the start of previous braking to the start of next braking. A specific configuration of the drive control device 30 is as follows.

[0030] Regarding the stop rotation rate first, when the rotation of the main shaft 10 is to be stopped by electromagnetic braking, the stop rotation rate is a rotation rate that is determined with regard to a load that is applied to a warp shedding device and so forth coupled to the main shaft 10 or a mechanical element or the like such as a drive transmission mechanism. Of course the stop rotation rate is a rotation rate that is lower than the steady rotation rate. For example, if the steady rotation rate is set to a markedly high rotation rate as compared with the rotation rate of a typical loom, when electromagnetic braking is applied on the main shaft 10 that is rotated at the steady rotation rate, the load that is applied to the mechanical element or the like becomes excessive and the above-described problem may occur. With regard to the load that is applied to the mechanical element or the like by the electromagnetic braking, the rotation rate that does not cause the above-described problem and that is permissible (a permissible rotation rate) is obtained, and then the stop rotation rate is determined as a rotation rate equal to or lower than the permissible rotation rate.

[0031] In this embodiment, an example is provided in which the steady rotation rate is set to 1800 rpm as a markedly high rotation rate as described above. The example is described below. The load that is applied to the mechanical element or the like during electromagnetic braking varies depending on the specifications and weaving conditions of the loom. In this embodiment, the permissible rotation rate that is obtained on the basis of the load is 1000 rpm. Based on this, the stop rotation rate is determined as a rotation rate equal to or lower than the permissible rotation rate as described above, and the permissible rotation rate is determined at 1000 rpm that is the upper limit of the permissible rotation rate. The set value of the stop rotation rate is input to and set in the input setting unit 40 and stored in the storage unit 34a of the drive command unit 34 similarly to the set value of the steady rotation rate and so forth.

[0032] The drop of the main shaft rotation rate by the regenerative braking from the steady rotation rate toward the stop rotation rate is caused by regenerative braking that is performed a plurality of times in a divided manner as described above. Hence, in the dropping process, the frequency command signal serving as the drive command that is output from the drive command unit 34 is changed a plurality of times to perform the regenerative braking a plurality of times. That is, the command rotation rate serving as the basis of the frequency command signal is changed a plurality of times. In this way, a change of the command rotation rate represents a change of the frequency command signal that is output from the drive command unit 34.

[0033] A drop amount of the command rotation rate (a rotation rate drop amount) in every change is determined such that the regenerative electric power generated by the regenerative braking due to the change does not exceed the permissible amount of the regenerative electric power that can be absorbed by the resistor or the like. In this embodiment, the rotation rate drop amount is uniformly determined as 200 rpm. In other words, in this embodiment, when the main shaft rotation rate is dropped from 1800 rpm that is the steady rotation rate to 1000 rpm that is the stop rotation rate, the command rotation rate is changed four times by dropping the command rotation rate by 200 rpm each.

[0034] Then, in this embodiment, to drop the main shaft rotation rate, the rotation rate drop amount determined as 200 rpm as described above is stored as a set value in the drive control device 30. In addition, the drive command unit 34 of the drive control device 30 calculates the command rotation rate every change by subtracting the rotation rate drop amount (200 rpm) from the command rotation rate serving as the basis of the previously output frequency command signal. That is, the drive command unit 34 of this embodiment has a function for calculating the command rotation rate every change (a calculation function) in this way. Note that the set value of the rotation rate drop amount (200 rpm) is input to and set in the input setting unit 40 and stored in the storage unit 34a of the drive command unit 34 similarly to the set values of the steady rotation rate and so forth. The rotation rate drop amount stored in the storage unit 34a of the drive command unit 34 in this way corresponds to rotation rate information according to the present invention.

[0035] Moreover, each regenerative braking is performed every period of one rotation or more of the main shaft 10 from the start of previous braking to the start of next braking. That is, the change of the command rotation rate (the output of the changed frequency command signal) that is performed a plurality of times is performed such that the change (output) is performed every period of one rotation or more of the main shaft 10.

[0036] However, when the regenerative braking is performed due to the change of the command rotation rate, the regenerative electric power is generated as described above. Hence, the above-described resistor or the like has to be in a state in which the resistor or the like can absorb the regenerative electric power generated in this way, at each change time point of the command rotation rate (an output time point of the frequency command signal). Therefore, in this period, the resistor or the like needs to be determined as being in the aforementioned state at each change time point of the command rotation rate. In this embodiment, the period (a set period) is uniformly determined as a period corresponding to two rotations of the main shaft 10. That is, in this embodiment, the command rotation rate is changed every two rotations of the main shaft 10 since the previous change time point of the command rotation rate (dropped by 200 rpm each). The set value of the set period is input to and set in the input setting unit 40 and stored in the storage unit 34a of the drive command unit 34 similarly to the above.

[0037] Furthermore, the storage unit 34a of the drive command unit 34 stores an information reading program (hereinafter, merely referred to as "program") for reading the set period determined as described above at each change time point of the command rotation rate (each output time point of the frequency command signal) and stored in the storage unit 34a. Based on this, the drive command unit 34 performs the next change of the command rotation rate on the basis of the set period read by using the program. The set value of the set period and the program stored in the storage unit 34a of the drive command unit 34 in this way correspond to period information according to the present invention.

[0038] Note that, in this embodiment, the set period is a period uniformly corresponding to two rotations of the main shaft 10 as described above. Thus, for the set period stored in the storage unit 34a, only one (common) period (the period corresponding to two rotations of the main shaft 10) is set. In this embodiment, the program is set to read the common set period at each change time point of the command rotation rate. At each change time point, the common set period is read from the storage unit 34a in the drive command unit 34 using the program.

[0039] In the loom including the above-described drive control device 30, a stop operation of stopping the loom (the main shaft 10) from the steady operation state in which the main shaft 10 is rotated at the steady rotation rate is performed, for example, by an operator operating a stop button of the input setting unit 40. In this case, a stop signal is output from the input setting unit 40 to the main control unit 32. The stop operation is also performed when weaving abnormality (for example, a weaving defect, such as warp yarn breakage or defective weft insertion) during weaving occurs. In this case, an abnormality signal is output to the main control unit 32 from a detecting device (not illustrated) that detects the weaving abnormality.

[0040] When the stop signal or the abnormality signal is input to the main control unit 32, the main control unit 32 generates a stop command and outputs the stop command to the drive command unit 34. The timing at which the stop command is generated is determined as a predetermined timing in one cycle of the loom (one rotation of the main shaft 10).

[0041] In response to the input of the stop command, the drive command unit 34 calculates a command rotation rate corresponding to a first change time point of the command rotation rate (a first calculation rotation rate) by the calculation function on the basis of the steady rotation rate and the rotation rate drop amount that is the rotation rate information stored in the storage unit 34a. To be specific, the drive command unit 34 calculates the first calculation rotation rate (1600 rpm) by subtracting the rotation rate drop amount (200 rpm) from the steady rotation rate (1800 rpm). The drive command unit 34 changes the command rotation rate from the steady rotation rate to the first calculation rotation rate at a predetermined start timing of the regenerative braking after the timing at which the stop command is generated (for example, at a time point at which the rotation angle of the main shaft 10 has reached 360° (0°) the first time since the input of the stop command), and outputs a frequency command signal serving as a drive command based on the first calculation rotation rate to the inverter 36. Consequently, the inverter 36 controls the driving of the driving motor 20 in accordance with an output frequency based on the frequency command signal, and hence the main shaft rotation rate is dropped from 1800 rpm that is the steady rotation rate to 1600 rpm. The predetermined start timing of the regenerative braking corresponds to a first change time point of a command rotation rate according to the present invention.

[0042] Furthermore, the drive command unit 34 determines a second change time point of the command rotation rate on the basis of the set period (the period information) read using the program, at the first change time point of the command rotation rate. To be specific, the drive command unit 34 determines the second change time point of the command rotation rate at a time point at which a period corresponding to two rotations of the main shaft 10 has elapsed since the first change time point of the command rotation rate. Then, the drive command unit 34 monitors the rotation angle of the main shaft 10 from the rotation angle at the first change time point of the command rotation rate on the basis of the angle signal (angle information) output from the main control unit 32.

[0043] In addition, the drive command unit 34 calculates a command rotation rate corresponding to the second change time point of the command rotation rate (a second calculation rotation rate), at a predetermined calculation timing of the command rotation rate, between the first change time point of the command rotation rate and the second change time point of the command rotation rate. To be specific, the calculation timing is determined as a time point at which the rotation angle of the main shaft 10 has reached 100° the second time since the first change time point of the command rotation rate. Then, at a time point at which it is determined that the rotation angle of the main shaft 10 has reached the calculation timing as the result of the monitoring, the drive command unit 34 reads the rotation rate drop amount stored in the storage unit 34a again. The drive command unit 34 calculates the second calculation rotation rate (1400 rpm) by subtracting the read rotation rate drop amount (200 rpm) from the first calculation rotation rate (1600 rpm).

[0044] At a time point at which it is determined that the rotation angle of the main shaft 10 has reached the second change time point of the command rotation rate as the result of the monitoring, the drive command unit 34 changes the command rotation rate from the first calculation rotation rate to the second calculation rotation rate, and outputs a frequency command signal based on the second calculation rotation rate to the inverter 36. Accordingly, the main shaft rotation rate is dropped from 1600 rpm to 1400 rpm.

[0045] Thereafter, the drive command unit 34 repeats similar control, calculates command rotation rates (calculation rotation rates) corresponding to third and fourth change time points of the command rotation rate, and changes the command rotation rate at each of the change time points. Accordingly, the main shaft rotation rate is dropped by 200 rpm each from 1400 rpm to 1000 rpm that is the stop rotation rate. A braking step by the regenerative braking that drops the main shaft rotation rate from the steady rotation rate toward the stop rotation rate by changing the command rotation rate a plurality of times as described above corresponds to a first braking step according to the present invention.

[0046] The drive command unit 34 calculates a command rotation rate (a calculation rotation rate) corresponding to the next change time point of the command rotation rate, at a calculation timing between a change time point of the command rotation rate and the next change time point of the command rotation rate as described above. Then, at each calculation time point, the drive command unit 34 has a function of comparing the calculated calculation rotation rate with the stop rotation rate stored in the storage unit 34a, and determining whether both values meet each other or not. When the drive command unit 34 determines that the calculation rotation rate meets the stop rotation rate as the result of the comparison, the drive command unit 34 invalidates the calculation function at the calculation time point of the calculation rotation rate or later, and sets an actuation flag of the electromagnetic braking with the electromagnetic brake 60, in the drive command unit 34.

[0047] Accordingly, at a time point at which the calculation rotation rate (1000 rpm) corresponding to the fourth change time point of the command rotation rate has been calculated, the calculation function of the drive command unit 34 at the calculation time point or later is invalidated. Thus, at the calculation time point or later, although the rotation angle of the main shaft 10 reaches the calculation timing, the calculation rotation rate is not calculated because the calculation function is invalidated.

[0048] Furthermore, at the calculation time point, the actuation flag of the electromagnetic braking is set in the drive command unit 34. Then, in the state in which the actuation flag of the electromagnetic braking is set in the drive command unit 34, when it is determined that the rotation angle of the main shaft 10 has reached the fourth change time point of the command rotation rate as the result of monitoring the rotation angle of the main shaft 10 as described above, the drive command unit 34 actuates the electromagnetic brake 60 to apply the electromagnetic braking on the main shaft 10. That is, a second braking step by the electromagnetic brake 60 is started. Accordingly, the main shaft rotation rate is dropped from the stop rotation rate, and the rotation of the main shaft 10 is stopped in the second braking step. Thereafter, the invalidated state of the calculation function of the drive command unit 34 is reset at the next start time point of the loom.

[0049] Regarding the dropping of the main shaft rotation rate of this embodiment as described above, the actual change of the main shaft rotation rate has a shape indicated by a broken line in Fig. 2. Also, a solid line in Fig. 2 indicates a process of the change of the command rotation rate that is performed a plurality of times.

[0050] As described above, with the method for stopping the loom according to this embodiment, the operation of the loom is stopped by dropping the main shaft rotation rate to the stop rotation rate by the regenerative braking in the first braking step, and then stopping the rotation of the main shaft 10 by the electromagnetic braking in the second braking step. Thus, with the method for stopping the loom, the electromagnetic braking is applied to the main shaft 10 after the main shaft rotation rate has been dropped to the stop rotation rate by the regenerative braking, and hence a load that is applied to the mechanical element or the like by the electromagnetic braking is reduced.

[0051] Also, in the first braking step, as described above, the main shaft rotation rate from the steady rotation rate toward the stop rotation rate is dropped by the regenerative braking and the regenerative braking is performed a plurality of times in a divided manner, and the change amount of the command rotation rate (the rotation rate drop amount) in each regenerative braking is 200 rpm. Accordingly, the regenerative electric power that is generated by each regenerative braking is reduced. In addition, the command rotation rate is changed every period corresponding to two rotations of the main shaft 10. Consequently, the regenerative electric power that is generated by each regenerative braking is substantially absorbed by the above-described resistor or the like until the next regenerative braking is started. Thus, for example, even when the steady rotation rate is high as described above, a situation in which the resistor or the like cannot completely absorb the regenerative electric power generated by the regenerative braking does not occur.

[0052] In the above description, an embodiment of a loom according to the present invention (hereinafter, referred to as "the embodiment") has been described. However, the present invention is not limited to the one described in the embodiment, and other embodiments (modifications) described below can be implemented.

[0053] (1) In the embodiment, the present invention has been described as the example in which the steady rotation rate is as high as 1800 rpm. However, the steady rotation rate does not have to be high, and the present invention may be applied to a case with a low steady rotation rate. That is, the load applied to the mechanical element or the like may become excessive when the electromagnetic braking is applied to the main shaft not only in the case of a high steady rotation rate is high, but also in the case of a low steady rotation rate. In such a case, the present invention may be applied. To be specific, even when the steady rotation rate is 1000 rpm or lower, if the weight of the mechanical element or the like is large due to a reason such as a large number of heald frames in the warp shedding device, the inertia is also large. Consequently, the load that is applied to the mechanical element or the like by the electromagnetic braking becomes excessive, and in such a case, the present invention may be applied.

[0054] (2) Regarding the stop rotation rate, in the embodiment, the permissible rotation rate is obtained with regard to the load that is applied to the mechanical element or the like by the electromagnetic braking as described above, and the stop rotation rate is determined as the upper limit thereof (= the permissible rotation rate). However, according to the present invention, the stop rotation rate is desirably determined as long as the stop rotation rate is equal to or lower than the permissible rotation rate obtained as described above. Hence, the stop rotation rate may be determined as a rotation rate lower than the permissible rotation rate (preferably, a rotation rate close to the upper limit thereof).

[0055] (3) The main shaft rotation rate is dropped from the steady rotation rate toward the stop rotation rate by the regenerative braking that is performed a plurality of times in a divided manner according to the present invention. In this embodiment, the change amount of the command rotation rate (the rotation rate drop amount) in each regenerative braking is uniformly 200 rpm. The rotation rate drop amount may be determined such that the regenerative electric power generated by the regenerative braking due to the change of the command rotation rate (dropping the command rotation rate by the rotation rate drop amount) does not exceed the permissible amount of the regenerative electric power that can be absorbed by the resistor or the like. Thus, the rotation rate drop amount is not limited to aforementioned 200 rpm, and may be desirably determined within a range not exceeding the permissible amount.

[0056] To be specific, for example, even when the rotation rate drop amount is 400 rpm that is larger than 200 rpm of the embodiment, as long as the resultantly generated regenerative electric power does not exceed the permissible amount, 400 rpm can be employed as the rotation rate drop amount. In this case, when the steady rotation rate and the stop rotation rate are the same as those of the embodiment and the rotation rate drop amount is uniform like the embodiment, the regenerative braking is performed two times.

[0057] The rotation rate drop amount is not limited to the uniformly determined amount as described above. For example, regarding the above-described rotation rate drop amounts of 200 rpm and 400 rpm, when the steady rotation rate and the stop rotation rate are the same as those of the embodiment, the rotation rate drop amount of the first regenerative braking may be 400 rpm and then the rotation rate drop amount of the subsequent regenerative braking may be changed to 200 rpm. In this case, the regenerative braking by the rotation rate drop amount of 200 rpm is performed two times at the second time or later.

[0058] (4) Regarding the command rotation rate serving as the basis of the drive command (the frequency command signal) that is output at each change time point, in the embodiment, the rotation rate drop amount is stored in the storage unit and the command rotation rate is obtained by the calculation using the rotation rate drop amount. However, in the present invention, the command rotation rate corresponding to each change time point is not limited to the one obtained by the calculation using the rotation rate drop amount, and may be one that is previously stored in the storage unit and that is read at a corresponding change time point.

[0059] To be specific, for example, when the main shaft rotation rate is to be dropped four times in a divided manner by 200 rpm each from 1800 rpm (the steady rotation rate) to 1000 rpm (the stop rotation rate) similarly to the embodiment, the changed rotation rates (intermediate rotation rates) 1600 rpm, 1400 rpm, and 1200 rpm in the process of the dropping are stored as the command rotation rates in the storage unit. Furthermore, the intermediate rotation rates and the stop rotation rate are stored in the storage unit in association with the number of times of changes of the command rotation rate since the generation of the stop command. Then, at each change time point, the command rotation rate (the intermediate rotation rate, the stop rotation rate) corresponding to the number of times of the change of the command rotation rate at that change time point may be read.

[0060] (5) Regarding the period (the set period) from the output of the drive command (the frequency command signal) to the output of the next drive command, in the embodiment, the set period is uniformly determined as the period corresponding to two rotations of the main shaft. According to the present invention, the set period is determined to satisfy the condition that the above-described resistor or the like can absorb the regenerative electric power that is generated by the regenerative braking at each output (change) time point (an absorption possible state).

[0061] Then, the period in which the absorption possible state (an absorption possible period) is taken varies depending on the performance capable of absorbing the regenerative electric power of the resistor or the like to be employed. Hence, when the set period is determined as a period corresponding to the absorption possible period, the set period varies depending on the performance of the resistor or the like although the rotation rate drop amount is the same. To be specific, comparing with the embodiment, when the resistor or the like having high performance is employed, the set period is set to a period shorter than that of the embodiment although the rotation rate drop amount is the same 200 rpm. Note that, since the set period is determined in units of one rotation of the main shaft, in this case, the set period is a period corresponding to one rotation of the main shaft. When the resistor or the like having low performance is employed, the set period is set to a period longer than that of the embodiment.

[0062] Since the set period is desirably determined as long as the set period satisfies the condition (the period longer than the absorption possible period) as described above, when the shortest period that satisfies the condition is a period corresponding to n rotations (n is an integer equal to or larger than 1) of the main shaft, the set period may be a period corresponding to n+1 rotations of the main shaft or longer. Note that the set period is preferably determined in the shortest period with regard to the entirety of the stop period from the generation of the stop command until the rotation of the main shaft is stopped.

[0063] Furthermore, the magnitude of the regenerative electric power that is generated during the regenerative braking is proportional to the rotation rate drop amount. Hence, the set period is determined as a period corresponding to the rotation rate drop amount to satisfy the condition. As described above, the rotation rate drop amount in each regenerative braking in the first braking step is not limited to 200 rpm according to the embodiment, and does not have to be uniform. Therefore, each set period in the first braking step is not limited to the uniform period such as one in the embodiment, and may be determined as a period that varies depending on each rotation rate drop amount.

[0064] Note that the set period may be uniformly determined as long as the set period satisfies the condition although the rotation rate drop amount in each regenerative braking is not uniform as described above. Moreover, even when the rotation rate drop amount in each regenerative braking is uniform, each set period does not have to be uniformly determined, and each set period may be determined as a different period.

[0065] As described above, the set period can be desirably determined as long as the set period satisfies the condition in accordance with the performance of the resistor or the like or the rotation rate drop amount.

[0066] (6) The present invention is not limited to the above-described embodiments, and may be modified in various ways within the scope of the present invention.

Claims

1. A method for stopping a loom, the loom including a control device (30) that controls rotation of a main shaft (10) on the basis of a predetermined command rotation rate, and an electromagnetic brake (60) that brakes the main shaft (10), the control device (30) being configured to control the rotation of the main shaft (10) on the basis of a preset steady rotation rate in steady operation, the method comprising:

    a first braking step that is started at a time point at which a stop command has been generated or later, the first braking step dropping a rotation rate of the main shaft (10) toward a predetermined stop rotation rate that is lower than the steady rotation rate by changing the command rotation rate two times or more; and

a second braking step of actuating the electromagnetic brake (60) at a time point at which the rotation rate has reached the stop rotation rate or later and braking the main shaft (10), the second braking step stopping the rotation of the main shaft (10),

wherein the command rotation rate is changed in the first braking step every period of one rotation or more of the main shaft (10).

2. The method for stopping the loom according to Claim 1,
wherein the first braking step is performed on the basis of a preset rotation rate drop amount and the period.

3. A loom including a driving motor (20) that rotationally drives a main shaft (10), an angle detector (50) that detects a rotation angle of the main shaft (10), a control device (30) that controls driving of the driving motor (20) on the basis of a predetermined command rotation rate, and an electromagnetic brake (60) that brakes the main shaft (10), the control device (30) being configured to control rotation of the main shaft (10) on the basis of a preset steady rotation rate in steady operation,
wherein the control device (30) includes

a storage unit (34a) that stores rotation rate information that is information relating to the command rotation rate and that is obtained using a predetermined stop rotation rate and a predetermined number of times of change of the command rotation rate, the number of times of change being two or more, and period information that is information for determining a period in which the command rotation rate is changed and that the period is set to a period of one rotation or more of the main shaft (10),

a drive command unit (34) that receives an input of angle information that is obtained on the basis of a detection signal from the angle detector (50), that obtains, for a first change time point of the command rotation rate based on generation of a stop command and a second or later change time point of the command rotation rate obtained on the basis of the angle information and the period information with reference to the first change time point, the command rotation rate corresponding to each of the change time points from the rotation rate information, and that outputs a drive command based on each of the obtained command rotation rates at corresponding one of the change time points, and

a drive unit that drives the driving motor (20) on the basis of the drive command from the drive command unit (34).

4. The loom according to Claim 3,
wherein the rotation rate information includes a preset rotation rate drop amount.

FIG. 1

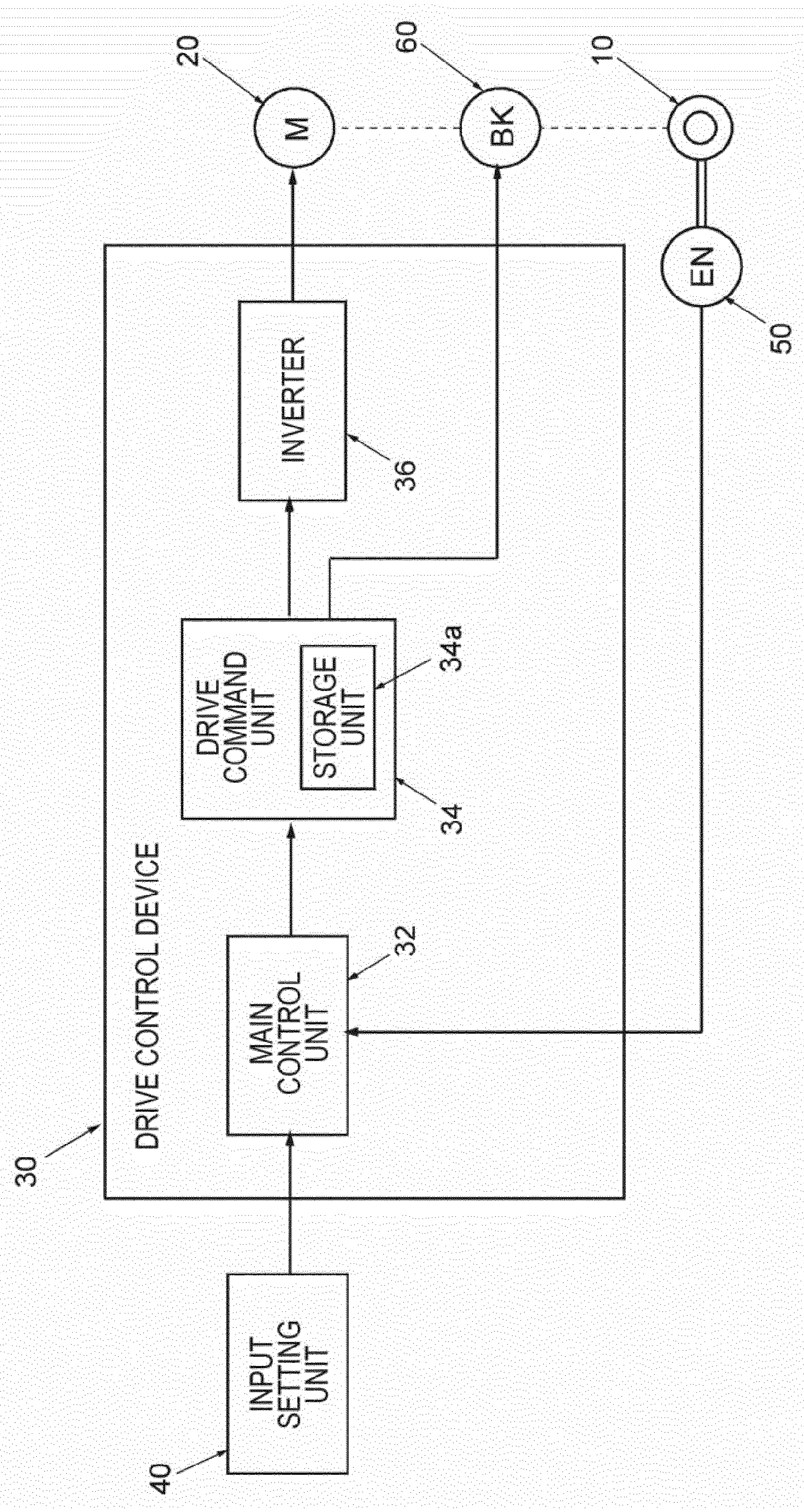
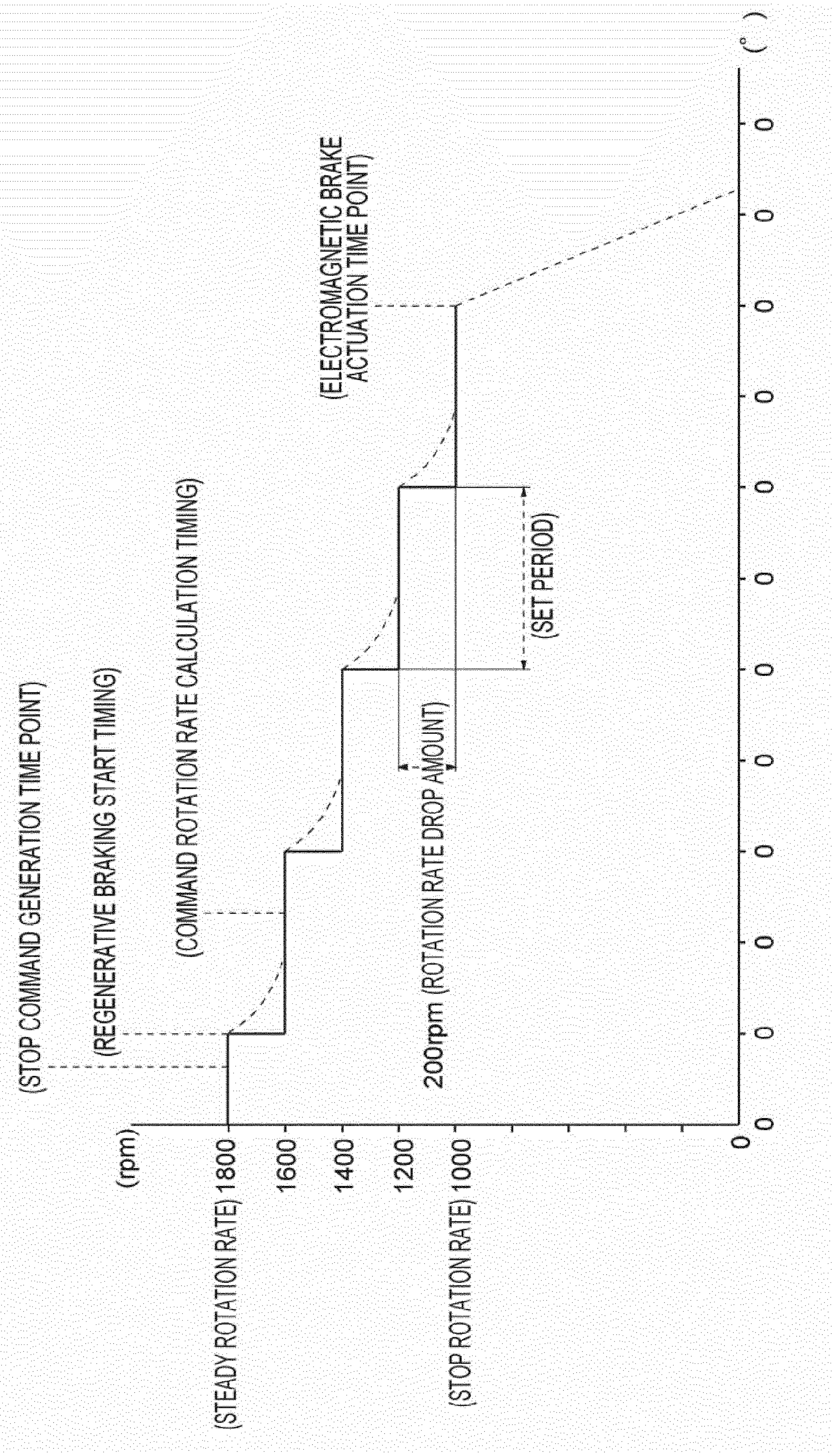

20
M
60
BK
10
EN
50
INVERTER
36
DRIVE COMMAND UNIT
STORAGE UNIT
34a
34
DRIVE CONTROL DEVICE
MAIN CONTROL UNIT
32
30
INPUT SETTING UNIT
40

FIG. 2


(STOP COMMAND GENERATION TIME POINT)
(REGENERATIVE BRAKING START TIMING)
(COMMAND ROTATION RATE CALCULATION TIMING)
(ELECTROMAGNETIC BRAKE ACTUATION TIME POINT)
(SET PERIOD)
200rpm (ROTATION RATE DROP AMOUNT)
(rpm)
(STEADY ROTATION RATE) 1800
1600
1400
1200
(STOP ROTATION RATE) 1000
0
0
0
0
0
0
0
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(°)

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EUROPEAN SEARCH REPORT

Application Number
EP 19 18 2463

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
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