A driving device driving motors of rolling rolls that corrects asymmetry between top and bottom roll driving systems of a twin-drive rolling mill in which top and bottom rolling rolls are driven by upper and lower motors, respectively, so that torques propagate to the top and bottom rolling rolls simultaneously. To this end, an upper/lower axis system imbalance correction section that corrects inequalities of torques propagating to the top and bottom rolling rolls is provided in either one or both of an upper motor control section that controls the upper motor and a lower motor control section that controls the lower motor in a driving device of motors for rolling rolls used in a rolling mill. The top and bottom rolling rolls are driven by the upper motor and the lower motor, respectively, and one of the upper motor and the lower motor is located on a rolled material. Thus, torques propagate to the top and bottom rolling rolls simultaneously.
FIG. 6

Graph 1: Torque vs. Time for Top and Bottom Rolling Rolls

Graph 2: Difference between Top and Bottom Torque vs. Time
FIG. 7

[Graph showing frequency response with gain in dB on the y-axis and frequency in Hz on the x-axis. Two graphs are shown, one for top rolling roll and another for bottom rolling roll, with difference between top and bottom at the bottom graph.]
FIG. 10

![Graphs showing torque over time for different rolling motions.]

- TOP ROLLING ROLL
- BOTTOM ROLLING ROLL

- DIFFERENCE BETWEEN TOP AND BOTTOM
DRIVING DEVICE OF MOTORS FOR ROLLING ROLLS

TECHNICAL FIELD

[0001] The present invention relates to a driving device of motors for rolling rolls and, more particularly, to a driving device of motors for rolling rolls that is used in a twin-drive type rolling mill in which top and bottom rolling rolls are driven by separate motors.

BACKGROUND ART

[0002] In a twin-drive type rolling mill in which top and bottom rolling rolls are driven by an upper motor and a lower motor, respectively, each of the motors is controlled by an independent control system. Therefore, loads of the upper and lower motors become nonuniform and thermal imbalance of the motors and bows in a rolled material caused by differences in upper and lower torques may occur. Therefore, to make the loads of the upper and lower motors uniform and to prevent upward bows and downward bows of a rolled material, there is known a load balance control method that involves monitoring standard values or measured values of load currents of the upper and lower motors and making the standard values or the measured values uniform (refer to Patent Document 1, for example).

[0003] A motor for rolling has mechanical loads of a multiple mass point spring system composed of spindles, couplings, rolls, gears and the like. When the natural frequency of a rolling roll driving system including motors and the speed response frequency of a speed controller of motors for rolling become close to each other, the rolling mill driving system including a control system and a mechanical system becomes an unstable system due to the resonance of the two and the phenomenon of excessive torsional vibration may occur.

[0004] To cope with such torsional vibration, it is general practice to evaluate the natural frequency of each of the top and bottom roll axis systems in the design stage and to design the speed response frequency and natural frequency to provide sufficiently different values so as to avoid the resonance phenomenon. Also, there is known a technique that involves incorporating a model of a mechanical system in a control system, estimating the behavior of the mechanical system, and correcting a torque standard, whereby vibration is suppressed (refer to Patent Document 2, for example).

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0007] In a twin-drive type rolling mill in which top and bottom rolling rolls are driven by an upper motor and a lower motor, respectively, as is apparent from the schematic configuration of the twin-drive type rolling mill shown in FIG. 5, due to problems of the lubrication of universal couplings 54, 55, 56, 57 that connect a top rolling roll 50 and an upper motor 51 together and a bottom rolling roll 52 and a lower motor 53 together and the like, it is impossible to increase the inclination angles of spindles 58, 59 between the universal couplings 54 and 55 or between the universal couplings 56 and 57. Therefore, the gap between the upper and lower motors 51, 53 is reduced by arranging either the upper motor 51 or the lower motor 53 more forward, that is, toward the rolled material 60 side compared to the other, whereby it is necessary to reduce the inclination angles of the spindles 58, 59. In consideration of the foregoing, arranging the upper motor 51 more forward than the lower motor 53 is referred to as the top forward method, and arranging the lower motor 53 more forward than the upper motor 51 is referred to as the bottom forward method.

[0008] FIG. 5 shows the schematic configuration of a rolling roll driving system of the top forward method in which the upper motor 51 is arranged more forward than the lower motor 53. As shown in this drawing, in a twin-drive type rolling mill, the mechanical makeup of the upper and lower driving axis systems does not become identical and the two have different transfer functions. For this reason, as in the control method of motors for rolling rolls disclosed in Patent Document 1, the torques that propagate to the top surface and bottom surface of a rolled material 60 become transiently unequal even when the motor output torques are controlled to be identical for the upper and lower driving axis systems and this may cause bows in the rolled material 60 or damage thereeto, for example. Incidentally, reference numerals 61, 62 of FIG. 5 denote backup rolls that back up the top rolling roll 50 and the bottom rolling roll 52, respectively, and reference numeral 63 denotes a connection between the lower motor 53 and the universal coupling 57.

[0009] In load balance control that has been used to eliminate the nonuniformity of upper and lower torques in a twin-drive type rolling mill, upper and lower torques (load currents) in motors are monitored and made uniform, and no consideration is given to the inequalities of upper and lower torques that occur when the torques propagate to the rolling rolls from the motors.

[0010] The technique of incorporating a model of a mechanical system in a control system, which is disclosed in Patent Document 2, is used in torsional vibration suppression and control and the like as described above. However, in the monitoring and controlling of the behavior of upper and lower mechanical axis systems, this technique is apt to be directly affected by modeling errors. Furthermore, models of both of upper and lower mechanical systems and control feedback values are also necessary, and the control system becomes complicated.

[0011] The present invention has been made to solve problems as described above, and provides a driving device of motors for rolling rolls that corrects inequalities of torques propagating to top and bottom rolling rolls of a twin-drive type rolling mill and accomplishes the synchronism of torque transmission to the top and bottom rolling rolls.

Means for Solving the Problems

[0012] A driving device of motors for rolling rolls used in a rolling mill in which top and bottom rolling rolls are driven by an upper motor and a lower motor, respectively, and either the upper motor or the lower motor is arranged to a rolled material side compared to the other motor, is characterized in that either one or both of an upper motor control section that controls the upper motor and a lower motor control section that controls the lower motor are provided with an upper/
lower axis system imbalance correction section that corrects inequalities of torques propagating to the top and bottom rolling rolls.

ADVANTAGES OF THE INVENTION

[0013] According to the present invention, it is possible to make equal the transfer functions of the driving systems of the top and bottom rolling rolls including control systems and mechanical systems and to accomplish the synchronism of torque transmission to the top and bottom rolling rolls. Therefore, it is possible to make equal torques propagating to the top surface and bottom surface of a rolled material, and this eliminates the possibility of causing bows in a rolled materials or damage thereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a schematic control block diagram showing a driving device of motors for rolling rolls related to Embodiment 1 of the present invention.
[0015] FIG. 2 is a schematic control block diagram showing a driving device of motors for rolling rolls related to Embodiment 2 of the present invention.
[0016] FIG. 3 is a schematic control block diagram showing a driving device of motors for rolling rolls related to Embodiment 3 of the present invention.
[0017] FIG. 4 is a schematic control block diagram of the load balance calculation section.
[0018] FIG. 5 is a schematic control block diagram showing a prior driving device of motors for rolling rolls.
[0019] FIG. 6 shows simulated waveforms of torques propagating to the top and bottom rolling rolls without a correction.
[0020] FIG. 7 shows the gain characteristics of the top and bottom roll axis systems without a correction.
[0021] FIG. 8 is a block diagram of a roll axis system represented by a mass points system (the number of mass points is set equal to n).
[0022] FIG. 9 is a block diagram of a roll axis system approximated by a two-mass point system.
[0023] FIG. 10 shows simulated waveforms of torques propagating to the top and bottom rolling rolls with a correction.
[0024] FIG. 11 shows the gain characteristics of the top and bottom roll axis systems with a correction.

DESCRIPTION OF SYMBOLS

[0025] 1 upper motor control section
[0026] 2 upper motor speed controller
[0027] 3 upper motor torque current limiter
[0028] 4 upper motor current controller
[0029] 5.51 upper motor
[0030] 6 upper motor speed sensor
[0031] 7 upper motor torque control means
[0032] 8 lower motor control section
[0033] 9 lower motor speed controller
[0034] 10 lower motor torque current limiter
[0035] 11 lower motor current controller
[0036] 12.53 lower motor
[0037] 13 lower motor speed sensor
[0038] 14 lower motor torque control means
[0039] 15 top roll axis system
[0040] 16 bottom roll axis system
[0041] 17 upper motor speed standard section
[0042] 18 lower motor speed standard section
[0043] 19 upper/lower axis system imbalance correction section
[0044] 20,60 rolled material
[0045] 21 top roll driving system
[0046] 22 bottom roll driving system
[0047] 30 load balance calculation section
[0048] 50 top rolling roll
[0049] 52 bottom rolling roll
[0050] 58.59 spindle
[0051] 54.55,56,57 universal coupling
[0052] 61.62 backup roll
[0053] 63 connection

BEST MODE FOR CARRYING OUT THE INVENTION

[0054] With reference to the accompanying drawings, a description will be given below of preferred embodiments of a driving device of motors for rolling rolls related to the present invention.

Embodiment 1

[0055] Embodiment 1 of the present invention will be described on the basis of FIG. 1. FIG. 1 is a schematic control block diagram showing a driving device of motors for rolling rolls related to Embodiment 1 of the present invention, and shows an embodiment of the top forward method in which an upper motor is arranged more forward than a lower motor.

[0056] In FIG. 1, an upper motor control section 1 is composed of an upper motor speed controller 2, an upper motor torque current limiter 3, and an upper motor current controller 4. An upper motor 5 is controlled by this upper motor control section 1, and the rotation speed thereof is detected by an upper motor speed sensor 6. Incidentally, as will be described later, the upper motor torque current limiter 3 and the upper motor current controller 4 constitute upper motor torque control means 7 that controls the torque of the upper motor 5 so that a deviation of an actual speed of the upper motor from a speed standard for the upper motor becomes zero.

[0057] A lower motor control section 8 is composed of a lower motor speed controller 9, a lower motor torque current limiter 10, and a lower motor current controller 11. A lower motor 12 is controlled by this lower motor control section 8, and the rotation speed thereof is detected by a lower motor speed sensor 13. Incidentally, as will be described later, the lower motor torque current limiter 10 and the lower motor current controller 11 constitute lower motor torque control means 14 that controls the torque of the lower motor 12 so that a deviation of an actual speed of the lower motor from a speed standard for the lower motor becomes zero. Reference numeral 15 denotes a top roll axis system extending from the upper motor 5 to a top rolling roll (not shown), and reference numeral 16 denotes a bottom roll axis system extending from the lower motor 12 to a bottom rolling roll (not shown).

[0058] There is provided an upper motor speed standard section 17 that issues commands for the speed standard for the upper motor 5 to the upper motor control section 1, and there is provided a lower motor speed standard section 18 that issues commands for the speed standard for the lower motor 12 to the lower motor control section 8. Furthermore, an upper/lower axis system imbalance correction section 19 that performs operations described below is provided in the rear of the upper motor speed standard section 17.
As described above, the upper motor 5 and the lower motor 12 are each controlled by the motor control sections 1, 8 that are independent of each other, and output torques of each of the motors 5, 12 propagate through the top roll axis system 15 and the bottom roll axis system 16, respectively, and reach a rolled material 20. As a result of this, the rolled material 20 is rolled. Incidentally, the upper/lower axis system imbalance correction section 19, the upper motor control section 1, the upper motor 5, the upper motor speed sensor 6, and the top roll axis system 15 constitute a top roll driving system 21, and the lower motor control section 8, the lower motor 12, the lower motor speed sensor 13, and the bottom roll axis system 16 constitute a bottom roll driving system 22.

The driving device of motors for rolling rolls related to Embedment 1 is constructed as described above, and the operation thereof will be described next.

First, in the top roll driving system 21, an upper motor torque current standard 1A is obtained by inputting to the upper motor speed controller 2 a deviation of an actual speed SP3 of the upper motor 5 detected by the upper motor speed sensor 6 from a corrected speed standard SP2 obtained by inputting a speed standard SP1 from the upper motor speed standard section 17 to the upper/lower axis system imbalance correction section 19. Furthermore, power is supplied to the upper motor 5 via the upper motor torque current limiter 3 and the upper motor current controller 4. As a result of this, the torque of the upper motor 5 is controlled so that a deviation of the actual speed SP3 of the upper motor 5 from the upper motor speed standard SP1 becomes zero.

On the other hand, in the bottom roll driving system 22, a lower motor torque current standard TB is obtained by inputting to the lower motor speed controller 9 a deviation of an actual speed SP5 of the lower motor 12 detected by the lower motor speed sensor 13 from a speed standard SP4 from the lower motor speed standard section 18. Furthermore, power is supplied to the lower motor 12 via the lower motor torque current limiter 10 and the lower motor current controller 11. As a result of this, the torque of the lower motor 12 is controlled so that a deviation of the actual speed SP5 of the lower motor 12 from the lower motor speed standard SP4 becomes zero.

Torques supplied from the upper motor 5 and the lower motor 12 are caused to propagate to the top surface and bottom surface of the rolled material 20 via the top roll axis system 15 and the bottom roll axis system 16, respectively. As described in the conventional art, the transfer function Gd(s) of the top roll axis system 15 and the transfer function Go(s) of the bottom roll axis system 16 do not become identical due to mechanical restrictions of a twin-drive type rolling mill. The torques that propagate to the top surface and bottom surface of the rolled material 20 become transiently unequal even when the torques supplied from the upper motor 5 and the lower motor 12 are controlled to be identical and this may cause bows in the rolled material 20 or damage thereto, for example. To eliminate this, in this embodiment, the transfer function Go(s) is set as given by C2(s) = C2(s)/[1+G2(s)]/[1-C2(s)]. In this equation, G2(s) is the open-loop transfer function of a speed feedback loop in Embedment 1. That is, because in Embedment 1 the upper/lower axis system imbalance correction section 19 is installed in the front of the upper motor speed feedback loop, the transfer function is set as given by C2(s) = C2(s)/[1+G2(s)]/[1-C2(s)]. Incidentally, because Embedment 2 is the same as Embedment 1 in other constituent features, the description thereof is omitted.

According to Embedment 2, the effects of Embedment 1 are produced and it is possible to cause the upper/lower axis system imbalance correction section 19 to approach the machine side. Therefore, it is possible to further increase the effect of the correction of inequalities of torques propagating to the top and bottom rolling rolls.

Next, Embedment 3 of the present invention will be described. In Embedment 3, the synchronism of torque transmission to the top and bottom rolling rolls is increased by using the upper/lower axis system imbalance correction section 19 of Embedment 2 in combination with load balance control.

FIG. 3 is a schematic control block diagram showing a driving device of motors for rolling rolls related to Embedment 3. The driving device of motors for rolling rolls related to Embedment 3 quickly corrects an imbalance of the torque current standards 1A and TB for the upper motor 5 and the lower motor 12, respectively, by inputting the upper and
lower motor torque current standards to a load balance calculation section 30 and directly adding correction amounts to the upper torque current standard. Incidentally, because Embodiment 3 is the same as Embodiment 2 in other constituent features, the description thereof is omitted.

[0070] FIG. 4 shows a schematic control block diagram of the load balance calculation section 30. Corrections are performed by multiplying a deviation of the upper and lower torque current standards TA and TB by a load balance calculation limiter 30a and a load balance calculation rate 30b, performing proportional control 30c, and performing an addition to the current standard TA for the upper motor 5. Furthermore, as shown in FIG. 3, by arranging the upper/lower axis system imbalance correction section 19 in the rear of the load balance calculation section 30, it becomes possible to further increase the synchronism of torque transmission to the top and bottom rolling rolls.

[0071] As described above, according to Embodiment 3, it becomes possible to obtain the synchronism of torque transmission to the top and bottom rolling rolls, with the effect obtained by Embodiment 1 or Embodiment 2 further increased.

[0072] This embodiment is more effective when a correction term, which will be described later in Embodiment 4, is used in a simplified manner.

Embodiment 4

[0073] Next, Embodiment 4 of the present invention will be described. In Embodiment 4, the top and bottom roll axis systems in Embodiments 1 to 3 are approximated by spring and mass systems, whereby the transfer function of a correction term in an upper/lower axis system imbalance correction section 19 is expressed by physical parameters of the spring and mass systems.

[0074] FIG. 6 shows examples of a simulation of torque waveforms at top and bottom rolling roll end and a waveform of upper and lower torque difference that are obtained when external forces corresponding to rated torques of the motors are applied in a stepped manner to the motors and rolling roll end of a twin-drive type rolling mill, that is, during the entry of a material into the rolls. In this example, the top roll axis system and the bottom roll axis system are approximated by a four-mass point spring and mass system and a five-mass point spring and mass system, respectively, and the primary natural torsional frequency of the top roll axis system and the bottom roll axis system is approximately 13.6 Hz and approximately 11.8 Hz, respectively. An imbalance occurs gradually in the torques transmitted to the top and bottom rolling rolls after a point in time of 0.2 second when the stepped load is applied and a torque difference that is as great as 0.8 Pu maximum that is needed torque standard for the motors occurs via the rolled material. It is apparent that the main components of vibrations are primary torsional frequencies of the top and bottom rolling rolls. FIG. 7 shows the gain characteristics of the top and bottom roll axis systems and a difference in the gains between the top and bottom roll axis systems (20 log(G_{top})/G_{bot}(s))). By providing an imbalance correction term that compensates for this gain difference between the top and bottom axis systems in either one or both of the upper motor control system and the lower motor control system, it is possible to eliminate inequalities of upper and lower torques.

[0075] The spring and mass systems used as the transfer functions of the top and bottom roll axis systems in a correction term can approximate a mechanical axis system by increasing the number of mass points of the axis system model. However, when a correction term is actually applied to a control system, the order of a transfer function is increased by an increase in the number of mass points and the transfer function becomes very complex, with the result that increasing the number of mass points lacks feasibility in terms of restrictions on the sampling intervals in the control system and that the number of adjusting parameters of the correction term also increases. FIG. 8 shows for reference a block diagram of a roll axis system obtained when the number of mass points is set equal to n.

[0076] Because a certain level of torque difference poses no problem in actual operation and it is unnecessary to completely eliminate inequalities of upper and lower torques, it is possible to simplify a correction term by reducing the number of mass points. In this embodiment, the dimension of a correction term is made low by approximating the top and bottom roll axis systems each by a two-mass point system, making the application of a correction term to the existing control system sufficiently possible and reducing the imbalance of the upper and lower torques due to the most remarkable primary torsional frequency. FIG. 9 shows a block diagram of a roll axis system approximated by a two-mass point system. From FIG. 9, the transfer function of torques from a motor to a roll end in the case where a roll axis system is approximated by a two-mass point system becomes as given by:

\[ G(s) = \frac{J_1 \cdot C \cdot s + J_2 \cdot K}{J_1 \cdot J_2 \cdot s^2 + (J_1 + J_2) \cdot C \cdot s + (J_1 + J_2) \cdot K} \]

[Expression 1]

[0077] Therefore, from the transfer function simplified to the two-mass point system given in expression 1, the transfer function of the correction term is found as given by:

\[ C_1(s) = G_{top}(s)/G_{bot}(s) \]

\[ = \frac{J_{top} \cdot C_{top} \cdot s + J_{top} \cdot K_{top}}{J_{bot} \cdot J_{top} \cdot s^2 + (J_{bot} + J_{top}) \cdot C \cdot s + (J_{bot} + J_{top}) \cdot K_{top}} \times \frac{J_{bot} \cdot J_{top} \cdot s^2 + (J_{bot} + J_{top}) \cdot C \cdot s + (J_{bot} + J_{top}) \cdot K_{top}}{J_{top} \cdot C_{top} \cdot s + J_{top} \cdot K_{top}} \times \frac{J_{bot} \cdot C_{bot} \cdot s + J_{bot} \cdot K_{bot}}{J_{bot} \cdot C_{bot} \cdot s + J_{bot} \cdot K_{bot}} \]

\[ A_{com} \]

\[ = \frac{J_{top} \cdot (J_{bot} + J_{top})}{J_{top} \cdot (J_{bot} + J_{top})} \]

[Expression 2]

where, \(J_{top}, J_{bot}\) are the motor-side and roll-side inertia of the top roll axis system, \(K_{bot}\) is the spring constant of the top roll axis system, \(C_{top}\) is the attenuation coefficient of the top roll axis system, \(J_{top}, J_{bot}\) are the motor-side and roll-side inertia of the bottom roll axis system, \(K_{bot}\) is the spring constant of the bottom roll axis system, and \(C_{bot}\) is the attenuation coefficient of the bottom roll axis system. These coefficients are all adjustable. \(A_{com}\) is a correction coefficient to make the deviation of the correction term zero, and is expressed by the following expression.

[0078] Results of a simulation of torque waveforms at top and bottom rolling roll ends and a waveform of upper and
lower torque difference obtained when expression 2 is inserted into the top roll axis system as a correction term are shown in FIG. 10, and the gain characteristics of the top roll axis system including the correction term, the bottom roll axis system, and the correction term are shown in FIG. 11. It is apparent that due to the imbalance correction term, it has become possible to make the primary torsional frequency of the top roll axis system almost equal to that of the bottom roll axis system, with the result that it has become possible to make the maximum value of a torque difference in the top and bottom rolling rolls to 0.3 PU. That is, the results show that the effect of the correction is sufficient even when the top and bottom roll axis systems are approximated by a two-mass point system. A correction term is calculated beforehand in this manner and the fine tuning of each of the above-described parameters is performed during the installation and adjustment of actual equipment, whereby it is possible to expect a higher-accuracy correction. Techniques for adjusting each of the parameters by the actual measurement of torques transmitted to roll ends by use of strain gauges and the actual measurement of a transfer function by use of a transfer function measuring device are conceivable as methods of on-site adjustment of a correction term.

[0079] As described above, according to Embodiment 4, the effects obtained in Embodiments 1 to 3 are produced and it is possible to further increase the effect of the correction of inequalities of torques propagating to the top and bottom rolling rolls by performing prior evaluation and verification of the effect of the correction of a correction term by a transfer function by a simulation.

[0080] Incidentally, in Embodiment 1 the description was given of the embodiment in which the upper/lower axis system imbalance correction section 19 is arranged in the rear of the upper motor speed standard SP1 and in Embodiment 2 the description was given of the embodiment in which the upper/lower axis system imbalance correction section 19 is arranged within the upper motor speed feedback loop. In the present invention, however, the upper/lower axis system imbalance correction section 19 may be arranged in the same position as described above in the bottom roll driving system 22, and may also be arranged in the same position as described above in both of the top roll driving system 21 and the bottom roll driving system 22. Furthermore, in each of the above-described embodiments, the graphical description was given of the embodiments in which the present invention is applied to the driving device of motors for rolling rolls in a top forward type rolling mill. However, the present invention may also be applied to a driving device of motors for rolling rolls in a bottom forward type rolling mill and hence the present invention includes various kinds of design changes.

INDUSTRIAL APPLICABILITY

[0081] The present invention can be applied to a driving device of motors for rolling rolls in a twin-drive type rolling mill in which the top and bottom rolling rolls are driven by separate motors.

1. A driving device driving motors of rolling rolls in a rolling mill in which top and bottom rolling rolls are driven by an upper motor and a lower motor, respectively, and one of the upper motor and the lower motor is located on a rolled material side, as compared to the other motor, comprising:
a upper motor control section that controls the upper motor, and
a lower motor control section that controls the lower motor, wherein at least one of the upper control section and the lower control section includes an upper/lower axis system imbalance correction section that corrects inequalities of torques propagating to the top and bottom rolling rolls.

2. The driving device driving motors of rolling rolls according to claim 1, wherein the upper motor control section comprises an upper motor speed controller that receives, as an input, deviation of actual speed of the upper motor from a speed standard for the upper motor and obtains a torque standard for the upper motor, and upper motor torque control means that controls torque of the upper motor so that the deviation of the actual speed of the upper motor from the speed standard for the upper motor becomes zero,

the lower motor control section comprises a lower motor speed controller that receives, as an input, deviation of actual speed of the lower motor from a speed standard for the lower motor and obtains a torque standard for the lower motor, and lower motor torque control means that controls torque of the lower motor so that the deviation of the actual speed of the lower motor from the speed standard for the lower motor becomes zero, and

the upper/lower axis system imbalance correction section comprises an upper/lower axis system imbalance control section that corrects inequalities of torques propagating to the upper and lower motor control section and the lower motor control section.

3. The driving device driving motors of rolling rolls according to claim 1, wherein the upper motor control section comprises an upper motor speed controller that receives, as an input, deviation of actual speed of the upper motor from a speed standard for the upper motor and obtains a torque standard for the upper motor, and upper motor torque control means that controls torque of the upper motor so that the deviation of the actual speed of the upper motor from the speed standard for the upper motor becomes zero,

the lower motor control section comprises a lower motor speed controller that receives, as an input, deviation of actual speed of the lower motor from a speed standard for the lower motor and obtains a torque standard for the lower motor, and lower motor torque control means that controls torque of the lower motor so that the deviation of the actual speed of the lower motor from the speed standard for the lower motor becomes zero, and

the upper/lower axis system imbalance correction section comprises an upper/lower axis system imbalance control section that corrects inequalities of torques propagating to the upper and lower motor control section and the lower motor control section.

4. The driving device driving motors of rolling rolls according to claim 1, further comprising a load balance calculation section that suppresses load imbalance of the upper and lower motors by adding an imbalance correction amount, calculated from torque current standards for the upper motor and the lower motor, directly to the torque current standards, wherein the load balance calculation section precedes the upper/lower axis system imbalance correction section.

5. The driving device driving motors of rolling rolls according to claim 1, wherein the upper/lower axis system imbalance correction section corrects inequalities of torques propa-
gating to the top and bottom rolling rolls by using physical parameters of a spring and mass system that approximately express a top roll axis system extending from the upper motor to the top rolling roll and a bottom roll axis system extending from the lower motor to the bottom rolling roll.

6. The driving device driving motors of rolling rolls according to claim 5, wherein the spring and mass system that approximately expresses the top and bottom roll axis systems is a two-mass point system.

7. The driving device driving motors of rolling rolls according to claim 2, further comprising a load balance calculation section that suppresses load imbalance of the upper and lower motors by adding an imbalance correction amount, calculated from torque current standards for the upper motor and the lower motor, directly to the torque current standards, wherein the load balance calculation section precedes the upper/lower axis system imbalance correction section.

8. The driving device driving motors of rolling rolls according to claim 3, wherein the driving device further comprises

a load balance calculation section that suppresses load imbalance of the upper and lower motors by adding an imbalance correction amount, calculated from torque current standards for the upper motor and the lower motor, directly to the torque current standards, wherein the load balance calculation section precedes in front of the upper/lower axis system imbalance correction section.

9. The driving device driving motors of rolling rolls according to claim 2, wherein the upper/lower axis system imbalance correction section corrects inequalities of torques propagating to the top and bottom rolling rolls by using physical parameters of a spring and mass system that approximately express a top roll axis system extending from the upper motor to the top rolling roll and a bottom roll axis system extending from the lower motor to the bottom rolling roll.

10. The driving device driving motors of rolling rolls according to claim 3, wherein the upper/lower axis system imbalance correction section corrects inequalities of torques propagating to the top and bottom rolling rolls by using physical parameters of a spring and mass system that approximately express a top roll axis system extending from the upper motor to the top rolling roll and a bottom roll axis system extending from the lower motor to the bottom rolling roll.

11. The driving device driving motors of rolling rolls according to claim 4, wherein the upper/lower axis system imbalance correction section corrects inequalities of torques propagating to the top and bottom rolling rolls by using physical parameters of a spring and mass system that approximately express a top roll axis system extending from the upper motor to the top rolling roll and a bottom roll axis system extending from the lower motor to the bottom rolling roll.

12. The driving device driving motors of rolling rolls according to claim 7, wherein the upper/lower axis system imbalance correction section corrects inequalities of torques propagating to the top and bottom rolling rolls by using physical parameters of a spring and mass system that approximately express a top roll axis system extending from the upper motor to the top rolling roll and a bottom roll axis system extending from the lower motor to the bottom rolling roll.

13. The driving device driving motors of rolling rolls according to claim 8, wherein the upper/lower axis system imbalance correction section corrects inequalities of torques propagating to the top and bottom rolling rolls by using physical parameters of a spring and mass system that approximately express a top roll axis system extending from the upper motor to the top rolling roll and a bottom roll axis system extending from the lower motor to the bottom rolling roll.

14. The driving device driving motors of rolling rolls according to claim 9, wherein the spring and mass system that approximately expresses the top and bottom roll axis systems is a two-mass point system.

15. The driving device driving motors of rolling rolls according to claim 10, wherein the spring and mass system that approximately expresses the top and bottom roll axis systems is a two-mass point system.

16. The driving device driving motors of rolling rolls according to claim 11, wherein the spring and mass system that approximately expresses the top and bottom roll axis systems is a two-mass point system.

17. The driving device driving motors of rolling rolls according to claim 12, wherein the spring and mass system that approximately expresses the top and bottom roll axis systems is a two-mass point system.

18. The driving device driving motors of rolling rolls according to claim 13, characterized in that the spring and mass system that approximately expresses the top and bottom roll axis systems is a two-mass point system.

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