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(54) **ROLLING EQUIPMENT AND METHOD FOR OPERATING ROLLING DEVICE**

WALZVORRICHTUNG UND WALZVORRICHTUNGSBETRIEBSVERFAHREN

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a rolling equipment, and a rolling device operation method.

BACKGROUND

[0002] Regarding a rolling device (reverse mill) for rolling a metal strip by moving the metal strip, which is passed through a pair of rolling mill rolls, back and forth, rolling is normally performed while pressing and rotating the rolling mill rolls in a state where the metal strip is wound around an unwinding device and a winding device which are provided on both sides of the rolling mill rolls in a traveling direction of the metal strip, and applying tension to the metal strip by the unwinding device and the winding device. With such a rolling device, it is necessary to set the state where a tip part of the metal strip is wound around the winding device when starting to roll the metal strip. Therefore, a portion of the metal strip which is located closer to the winding device than the rolling mill rolls when starting to roll the metal strip cannot be rolled and this portion thereby cannot be formed into a product.

[0003] So, there has been proposed a configuration for improving yield of the metal strip. For example, Patent Document 1 describes that a leader piece (lead material) is bonded to a tip part of the metal strip by means of welding and this leader piece is wound up by the winding device, so that the rolling is thereby started while applying exit-side tension to the metal strip via the leader piece. Accordingly, an attempt is made to roll the metal strip from a position closer to its tip side and thereby improve the yield by starting the rolling in the state where the leader piece is bonded to the metal strip.

Citation List

Patent Literature

[0004] Patent Document 1: JP4508949 B A rolling equipment with the features in the pre-characterizing portion of Claim 1 and a rolling device operation method with the features in the pre-characterizing portion of Claim 10 are disclosed in US 6 014 882 A.

SUMMARY

Technical Problem

[0005] However, when the lead material is used as in Patent Document 1, it is necessary to perform roll the bonding operation for each metal strip every time. So, it is burdensome and requires much cost and bonding equipment is also needed.

[0006] Therefore, it is desirable that the yield be im-

proved with a simpler configuration.

[0007] In light of the above-described circumstances, it is an object of at least one embodiment of the present invention to provide a control device of a rolling device, rolling equipment, and a rolling device operation method which are capable of improving the yield of the metal strip with a simple configuration.

Solution to Problem

[0008] The rolling equipment and the method for operating a rolling device according to the present invention are defined in the independent claims. Further advantageous features are set out in the dependent claims.

Advantageous Effects

[0009] According to at least one embodiment of the present invention, a rolling equipment and a rolling device operation method which are capable of improving the yield of the metal strip with a simple configuration are provided.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

FIG. 1 is a schematic configuration diagram of rolling equipment including a control device according to one embodiment.

FIG. 2 is a flowchart illustrating processing by the control device according to one embodiment.

FIG. 3 is a schematic diagram illustrating a state of rolling mill rolls and a metal strip when starting to roll the metal strip.

FIG. 4 is a schematic diagram illustrating a state of the rolling mill rolls and the metal strip when starting to roll the metal strip.

FIG. 5 is a schematic diagram illustrating a state of the rolling mill rolls and the metal strip when starting to roll the metal strip.

FIG. 6 is a diagram illustrating time changes in a roll speed V_m of the rolling mill rolls and entrance-side tension T_e applied to the metal strip when starting to roll the metal strip.

FIG. 7 is a flowchart illustrating part of processing by the control device according to one embodiment.

FIG. 8 is a flowchart illustrating part of processing by the control device according to one embodiment.

DETAILED DESCRIPTION

[0011] Some embodiments of the present invention will now be described in detail with reference to the accompanying drawings. It is intended, however, that dimensions, materials, shapes, relative positions and the like of components described in the embodiments or illustrated in the drawings shall be interpreted as illustrative only

and not limitative of the scope of the present invention.

[0012] Firstly, an overall configuration of rolling equipment including a rolling device according to some embodiments will be explained.

[0013] FIG. 1 is a schematic configuration diagram of rolling equipment including a control device according to one embodiment. Referring to FIG. 1, rolling equipment 1 includes a rolling device 2 and a control device 30 for controlling the rolling device 2.

[0014] The rolling device 2 illustrated in FIG. 1 is a rolling device (reverse mill) for rolling a metal strip 50 by moving the metal strip 50, which is passed through a pair of rolling mill rolls 16A, 16B, back and forth. The rolling device 2 includes a rolling mill 10 including the pair of rolling mill rolls (work rolls) 16A, 16B provided to sandwich the metal strip 50, which is a material to be rolled, an unwinding device 4 provided on an entrance side of the rolling mill rolls 16A, 16B in a traveling direction of the metal strip 50, and a winding device 14 provided on an exit side of the rolling mill rolls 16A, 16B in the traveling direction of the metal strip 50; and is configured to roll the metal strip 50 by the pair of rolling mill rolls 16A, 16B.

[0015] The rolling mill 10 includes, in addition to the pair of rolling mill rolls (work rolls) 16A, 16B, a pair of intermediate rolls 18A, 18B and a pair of backup rolls 20A, 20B, where the intermediate rolls 18A, 18B and the backup rolls 20A, 20B sandwich the pair of rolling mill rolls 16A, 16B and are provided respectively on opposite sides of the metal strip 50. The intermediate rolls 18A, 18B and the backup rolls 20A, 20B are configured to support the rolling mill rolls 16A, 16B. Furthermore, the rolling mill 10 includes a pressing device 22 for pressing the metal strip 50, which is sandwiched by the outside pair of rolling mill rolls 16A, 16B, by applying load to the pair of rolling mill rolls 16A, 16B. The pressing device 22 may include a hydraulic cylinder.

[0016] A motor 11 is connected to the rolling mill rolls 16A, 16B via a spindle or the like which is not illustrated in the drawing and the rolling mill rolls 16A, 16B are designed to be driven and rotated by the motor 11. When rolling the metal strip 50, a frictional force is generated between the rolling mill rolls 16A, 16B and the metal strip 50 as the motor 11 rotates the rolling mill rolls 16A, 16B while the pressing device 22 presses the metal strip 50; and this frictional force causes the metal strip 50 to be fed towards the exit side of the rolling mill rolls 16A, 16B.

[0017] The unwinding device 4 is configured to uncoil the metal strip 50 towards the rolling mill 10. The winding device 14 is configured to wind up the metal strip 50 from the rolling mill 10. The unwinding device 4 and the winding device 14 are designed to be driven by motors 5, 15, respectively.

[0018] The unwinding device 4 is configured to apply entrance-side tension to the metal strip 50 when rolling the metal strip 50. Furthermore, the winding device 14 is configured to apply exit-side tension to the metal strip 50 when rolling the metal strip 50. Specifically, it is designed to apply the entrance-side tension and the exit-side ten-

sion to the metal strip 50 by having the motors 5, 15 drive the unwinding device 4 and the winding device 14 appropriately. It is possible to suppress meandering of the metal strip 50 during the rolling by appropriately applying the entrance-side tension and the exit-side tension to the metal strip 50.

[0019] Incidentally, the rolling is stopped immediately before a tail end of the metal strip 50 uncoiled from the unwinding device 4; and when the rolling is completed in the state where the metal strip 50 is pressed by the rolling mill rolls 16A, 16B, the metal strip 50 is then uncoiled from the winding device 14 and fed towards the rolling mill 10; and while the unwinding device 4 winds up the metal strip 50, the rolling is performed by making the metal strip 50 advance in an opposite traveling direction to the previous traveling direction. Specifically speaking, the role of the unwinding device 4 and the role of the winding device 14 are switched to each other depending on the traveling direction of the metal strip 50.

[0020] The rolling device 2 further includes: an entrance-side pinch roll 6 and a side guide 8 for guiding the metal strip 50 which is introduced from the unwinding device 4 into the rolling mill 10; and an exit-side pinch roll 12 for guiding the metal strip 50 fed from the rolling mill 10 towards the winding device 14.

[0021] Furthermore, the rolling device 2 is equipped with various kinds of measuring instruments. The rolling device 2 illustrated in FIG. 1 is provided with, for example, speed sensors 32, 36 for measuring speeds of the motors 5, 11, respectively, a tension sensor 34 for measuring the entrance-side tension which acts on the metal strip 50, a pressed position sensor 37 for detecting a position pressed by the rolling mill rolls 16A, 16B, a strip-edge position detector 38 for measuring positions of widthwise strip edges of the metal strip 50 on the exit side of the rolling mill rolls 16A, 16B, and a speed sensor 40 for measuring a speed of the metal strip 50 on the exit side of the rolling mill rolls 16A, 16B. Signals indicating the measurement results of these measuring instruments are designed to be sent to the control device 30. Incidentally, instead of the tension sensor 34 for measuring the entrance-side tension, an ammeter for measuring an electric current of the motor 5 to drive the unwinding device 4 may be provided to calculate the entrance-side tension based on the measurement result of the ammeter.

[0022] The control device 30 may be designed to receive the signals indicating the measurement results from the above-described various types of measuring instruments and control operations of, for example, the motor 11 for driving the rolling mill rolls 16A, 16B, the motor 5 for driving the unwinding device 4, and/or the pressing device 22.

[0023] The control device 30 may include, for example, a CPU, a memory (RAM), an auxiliary storage unit, and an interface. The control device 30 is designed to receive the signals from the above-described various types of measuring instruments via the interface. The CPU is con-

figured to process the thus-received signals. The CPU is also configured to process programs expanded in the memory.

[0024] The processing content of the control device 30 may be implemented as programs to be executed by the CPU and stored in the auxiliary storage unit. When executing the programs, these programs are expanded in the memory. The CPU is designed to read the programs from the memory and execute commands included in the programs.

[0025] Next, control of the rolling device 2 by the above-described control device 30 will be explained. The control of the rolling device 2 which will be explained below is the control performed when starting the rolling of the metal strip 50 which is wound around the unwinding device 4. Incidentally, the rolling device 2 may be operated by manually executing part or whole of the processing by the control device 30 which will be explained below.

[0026] FIG. 2 is a flowchart illustrating processing by the control device 30 according to one embodiment. Each of FIG. 3 to FIG. 5 is a schematic diagram illustrating a state of the rolling mill rolls 16A, 16B and the metal strip 50 when starting to roll the metal strip 50 under the control of the control device 30. FIG. 6 is a diagram illustrating time changes in a speed (circumferential speed) V_m of the rolling mill rolls 16A, 16B and entrance-side tension T_e applied to the metal strip 50 when starting to roll the metal strip 50 under the control of the control device 30.

[0027] In one embodiment as illustrated in FIG. 2, the control device 30 firstly adjusts the position of the pair of rolling mill rolls 16A, 16B so that a gap between the pair of rolling mill rolls 16A, 16B (the gap between the rolls) becomes larger than a strip thickness of the metal strip 50 (step S102). Under this circumstance, the pressing device 22 may be operated to adjust the position of the pair of rolling mill rolls 16A, 16B as the necessity arises. Then, while maintaining the state where the gap between the rolls is larger than the strip thickness, a tip part 51 (see FIG. 3) of the metal strip 50 is passed through the pair of rolling mill rolls 16A, 16B (step S104).

[0028] FIG. 3 is a schematic diagram illustrating the state of the rolling mill rolls 16A, 16B and the metal strip 50 when step S104 is completed. When step S104 is completed as illustrated in FIG. 3, the tip part 51 of the metal strip 50 has been passed through the pair of rolling mill rolls 16A, 16B in the state where a gap d_0 between the pair of rolling mill rolls 16A, 16B is larger than a strip thickness H_0 of the metal strip 50 before being rolled. Furthermore, the tip part 51 of the metal strip 50 is positioned on the exit side of the rolling mill rolls 16A, 16B and has not reached the winding device 14, yet. Therefore, exit-side tension T_d which acts on the metal strip 50 is zero. Furthermore, at this point in time, the entrance-side tension T_e is not caused to act on the metal strip 50, so that the entrance-side tension T_e is also zero.

[0029] Next, the pair of rolling mill rolls 16A, 16B is used to press the metal strip 50 in the state where the exit-side tension T_d applied on the metal strip 50 is zero

(step S106; time t_0 in FIG. 6). In step S106, the pressing device 22 is operated based on the measurement result of the pressed position sensor 37 so that the gap between the rolls will become an appropriate value for the rolling.

FIG. 4 illustrates a schematic diagram illustrating the state of the rolling mill rolls 16A, 16B and the metal strip 50 when step S108 is completed. A gap d_1 between the rolls upon the completion of step S108, as illustrated in FIG. 4, is smaller than the strip thickness H_0 of the metal strip 50 before being rolled.

[0030] Then, the rolling is started by setting the entrance-side tension T_e , which is applied to the metal strip 50 by the unwinding device 4, as larger than zero (step S108; time t_1 in FIG. 6) and starting the rotation of the pair of rolling mill rolls 16A, 16B (step S110; time t_2 in FIG. 6). Incidentally, in steps S108 and S110, the exit-side tension T_d is maintained as zero.

[0031] In step S108, the entrance-side tension T_e which acts on the metal strip 50 is set as larger than zero by appropriately adjusting an electric current value of the motor 5 for driving the unwinding device 4. Under this circumstance as illustrated in FIG. 6, the entrance-side tension T_e is set as a specified value T_{e1} larger than zero; and the specified value T_{e1} may be maintained as a constant value until the entrance-side tension T_e starts increasing in step S114 (time t_3 in FIG. 6) described later.

[0032] In step S109, the rotation of the rolling mill rolls 16A, 16B is started by appropriately adjusting an electric current value of the motor 11 for driving the rolling mill rolls 16A, 16B. Incidentally, once the rolling is started in step S110, the metal strip 50 advances towards the direction indicated with an arrow in FIG. 4.

[0033] FIG. 5 is a schematic diagram illustrating the state of the rolling mill rolls 16A, 16B and the metal strip 50 when the rolling is started in step S110. Referring to FIG. 5, a portion of the metal strip 50 which is pressed by the rolling mill rolls 16A, 16B and has advanced to the exit side of the rolling mill rolls 16A, 16B has a thinner strip thickness H_1 than the strip thickness H_0 before being rolled.

[0034] According to the above-described embodiment as explained above, after passing the tip part 51 of the metal strip 50 between the pair of rolling mill rolls 16A, 16B, the metal strip 50 is pressed by the pair of rolling mill rolls 16A, 16B in the state where the exit-side tension T_d applied on the metal strip 50 is zero; and the rolling of the metal strip 50 is started by starting the rotation of the rolling mill rolls 16A, 16B while applying the entrance-side tension T_e , which is larger than zero, to the metal strip 50. So, although the exit-side tension T_d is zero, it is possible to perform the rolling appropriately while suppressing meandering of the metal strip 50. Therefore, it is possible to start the rolling from a portion of the metal strip 50 close to its tip part without using, for example, the lead material as described in Patent Document 1 and improve the yield of the metal strip 50 with the simple configuration.

[0035] The rest of the flow in FIG. 2 will be explained.

[0036] After starting the rolling by starting the rotation of the rolling mill rolls 16A, 16B in step S110, the speed (roll speed V_m) of the rolling mill rolls 16A, 16B is increased (step S112; time t_2 to t_4 in FIG. 6). Then, the entrance-side tension T_e applied to the metal strip 50 is increased at and after time t_2 (step S114; time t_3 in FIG. 6); and the entrance-side tension T_e is adjusted so that the entrance-side tension T_e will not exceed a specified range (step S116; time t_3 to t_5 in FIG. 6).

[0037] In step S112, the speed (roll speed V_m) of the rolling mill rolls 16A, 16B is increased by appropriately adjusting the electric current value of the motor 11 for driving the rolling mill rolls 16A, 16B. In steps S114 and S116, the entrance-side tension T_e which acts on the metal strip 50 is increased within a specified range by appropriately adjusting the electric current value of the motor 5 for driving the unwinding device 4.

[0038] It becomes possible to perform the rolling while suppressing meandering of the metal strip 50 even in the state where the exit-side tension T_d is zero, by applying the entrance-side tension T_e to the metal strip 50 as described above; however, on the other hand, if the entrance-side tension T_e of the metal strip 50 is excessively large, a phenomenon in which the metal strip 50 does not advance towards the exit side of the rolling mill rolls 16A, 16B tends to easily occur (that is, slipping tends to easily occur) and, therefore, the appropriate rolling can no longer be performed in some cases.

[0039] In this regard, by increasing the entrance-side tension T_e applied to the metal strip 50 (step S114) and making adjustments within an appropriate range so as not to cause slipping (step S116) as described above, it is possible to perform the rolling more appropriately while more effectively suppressing meandering of the metal strip 50 during the rolling in the state of no tension on the exit side.

[0040] Furthermore, if the entrance-side tension T_e were increased in a state where the roll speed V_m is low, the speed of the metal strip 50 relative to the roll speed V_m would be reduced and, therefore, the phenomenon in which the metal strip 50 does not advance towards the exit side of the rolling mill rolls 16A, 16B may tend to easily occur in some cases. In this regard, the entrance-side tension T_e can be increased stably by increasing the roll speed V_m to a certain degree in step S112 (for example, increasing the roll speed V_m to a roll speed V_{m1} which is 40% to 60%, inclusive, of a target roll speed V_{m2} [see FIG. 6]) and then increasing the entrance-side tension T_e in steps S114 to S116 as described above.

[0041] Step S116 in which the entrance-side tension T_e is adjusted not to exceed the specified range is repeatedly executed until the tip part of the metal strip 50 reaches the winding device 14 (No in step S118). On the other hand, if the exit-side tension T_d becomes larger than zero (Yes in step S118; that is, when the metal strip 50 starts being wound up by the winding device 14), the control according to the flow illustrated in FIG. 2 (the flow for performing the rolling appropriately in the state of no

tension on the exit side) is stopped and normal control is performed for the case where the exit-side tension T_d is larger than zero.

[0042] Next, the above-described processing in step S116 will be specifically explained. In step S116, the entrance-side tension T_e is adjusted not to exceed the specified range as described above.

[0043] In some embodiments in step S116, the entrance-side tension T_e is adjusted so that the exit-side speed V_d of the metal strip 50 becomes equal to or higher than the roll speed (rotational speed) V_m of the rolling mill rolls 16A, 16B. In this case, the control device 30 adjusts the electric current value of the motor 5 appropriately on the basis of the exit-side speed V_d measured by the speed sensor 40 and the roll speed V_m calculated from the speed of the motor 11 which is measured by the speed sensor 36 so that the entrance-side tension T_e is maintained within an appropriate range.

[0044] The fact that the exit-side speed V_d of the metal strip 50 is lower than the rotational speed V_m of the rolling mill rolls 16A, 16B means that the metal strip 50 on the exit side of the rolling mill rolls 16A, 16B is not advancing towards the rolling mill rolls 16A, 16B (that is, the metal strip 50 is starting to slip, or is likely to slip, along the rolling mill rolls 16A, 16B); and in this case, the rolling may not be sometimes performed appropriately. In this regard, the above-described embodiment is designed to adjust the entrance-side tension T_e applied to the metal strip 50 so that the exit-side speed V_d of the metal strip 50 becomes equal to or higher than the roll speed (rotational speed) V_m of the rolling mill rolls 16A, 16B. So, it is possible to perform the rolling more appropriately while appropriately suppressing slipping (sliding) of the metal strip 50 along the rolling mill rolls 16A, 16B in the state of no tension on the exit side.

[0045] Furthermore, the rotational speed V_m of the rolling mill rolls 16A, 16B may be measured a specified number of times for every specified period and the entrance-side tension T_e applied to the metal strip 50 may be adjusted by using all or some measurement results for the specified number of times so that the exit-side speed V_d of the metal strip 50 becomes equal to or higher than the roll speed (rotational speed) V_m of the rolling mill rolls 16A, 16B.

[0046] In some embodiments in step S116, the exit-side speed V_d of the metal strip 50 measured a plurality of number of times for every specified period is acquired and the entrance-side tension T_e is adjusted based on the measurement results of the exit-side speed V_d for the plurality of number of times.

[0047] The exit-side speed V_d of the metal strip 50 can be an index indicating whether sliding of the metal strip 50 along the rolling mill rolls 16A, 16B will occur or not. In this regard, the above-described embodiment is designed to measure the exit-side speed V_d of the metal strip 50 the plurality of number of times for every specified period. So, changes in the exit-side speed V_d with the passage of time can be recognized. Therefore, by ad-

justing the entrance-side tension T_e applied to the metal strip 50 on the basis of the measurement results of the exit-side speed V_d for the plurality of number of times, it is possible to perform the rolling appropriately while appropriately suppressing slipping of the metal strip 50 along the rolling mill rolls 16A, 16B in the state of no tension on the exit side.

[0048] In some embodiments, the increase of the entrance-side tension T_e is stopped when it is detected that the metal strip 50 is not advancing towards the exit side of the rolling mill rolls 16A, 16B in the state where the exit-side tension T_d applied on the metal strip 50 is zero.

[0049] The fact that the metal strip 50 is not advancing towards the exit side of the rolling mill rolls 16A, 16B indicates that the metal strip 50 is starting to slip along the rolling mill rolls 16A, 16B or may possibly slip along the rolling mill rolls 16A, 16B in the near future (a predictor of slipping). In this regard, the above-described embodiment is designed to stop increasing the entrance-side tension T_e when it is detected that the metal strip 50 is not advancing towards the exit side of the rolling mill rolls 16A, 16B. So, it is possible to perform the rolling appropriately while more reliably suppressing slipping of the metal strip 50 along the rolling mill rolls 16A, 16B in the state of no tension on the exit side.

[0050] Furthermore, an advancement of the metal strip 50 may be measured a specified number of times for every specified period and the fact that the metal strip 50 is not advancing towards the exit side of the rolling mill rolls 16A, 16B may be detected based on all or some measurement results for the specified number of times.

[0051] The fact that the metal strip 50 is not advancing towards the exit side of the rolling mill rolls 16A, 16B may be detected by, for example, monitoring the metal strip 50 near the rolling mill rolls 16A, 16B by using a camera.

[0052] Alternatively, the fact that the metal strip 50 is not advancing towards the exit side of the rolling mill rolls 16A, 16B may be detected by, for example, using the exit-side speed V_d measured a specified number of times for every specified period.

[0053] In one embodiment in step S116, the exit-side speed V_d measured the specified number of times for every specified period is acquired; and when all differences between an exit-side speed V_{di} measured i -th time and an exit-side speed $V_{d(i-1)}$ measured $(i-1)$ th time are negative, the metal strip 50 is considered to be not advancing towards the exit side of the rolling mill rolls 16A, 16B and the increase of the entrance-side tension T_e is stopped.

[0054] FIG. 7 is a flowchart of step S116 according to this embodiment.

[0055] In step S202 to step S208 of the flowchart illustrated in FIG. 7, $\alpha_i = (V_{di} - V_{d(i-1)}) / \Delta T$ is calculated based on the exit-side speed V_{di} measured regarding each of a specified number of times ($i=1, 2, 3$) for every specified period ΔT (that is, the difference between the exit-side speed V_{di} measured i -th time and the exit-side speed $V_{d(i-1)}$ measured $(i-1)$ th time is calculated); and then

whether $\alpha_i < 0$ or not (that is, whether $(V_{di} - V_{d(i-1)}) < 0$ or not) is determined regarding all values of $i=1, 2, 3$ (step S210).

[0056] When $\alpha_i < 0$ is not satisfied regarding all the values of $i=1, 2, 3$ (that is, when at least one α_i is equal to or more than zero) (No in step S210), it is determined that because the exit-side speed V_d is not always decreasing, but may sometimes increase, the possibility of occurrence of slipping is low. So, the entrance-side tension T_e continues to be increased (step S216). On the other hand, when $\alpha_i < 0$ is satisfied regarding all the values of $i=1, 2, 3$ (Yes in step S210), it is determined that the exit-side speed V_d is gradually decreasing and the possibility of slipping of the metal strip 50 is high; and, therefore, the increase of the entrance-side tension T_e is stopped (step S212). Furthermore, when the increase of the entrance-side tension T_e is stopped in this manner, the entrance-side tension T_e is decreased by a specified amount (step S214).

[0057] Furthermore, in one embodiment, step S116 may be designed so that the above-described exit-side speed V_d measured the specified number of times for every specified period is acquired; and when an integrated value of differences between the exit-side speed V_{di} measured i -th time and the exit-side speed $V_{d(i-1)}$ measured $(i-1)$ th time is less than a specified value, the increase of the entrance-side tension T_e is stopped by recognizing that the metal strip 50 is not advancing towards the exit side of the rolling mill rolls 16A, 16B.

[0058] FIG. 8 is a flowchart of step S116 according to this embodiment.

[0059] In step S222 to step S228 of the flowchart illustrated in FIG. 8, $\Sigma \Delta V_i = \Sigma (V_{di} - V_{d(i-1)})$ (the integrated value of the differences between the exit-side speed V_{di} measured i -th time and the exit-side speed $V_{d(i-1)}$ measured $(i-1)$ th time) is calculated based on the exit-side speed V_{di} measured regarding each of the specified number of times ($i=1, 2, 3$) for every specified period ΔT . Then, whether $\Sigma \Delta V_i$ is smaller than a specified value C (where C is a negative number) or not is determined (step S230).

[0060] When $\Sigma \Delta V_i$ is equal to or more than the above-mentioned specified value C (No in step S230), it is determined that the exit-side speed V_d does not tend to decrease and the possibility of occurrence of slipping is low; and, therefore, the entrance-side tension T_e continues to be increased (step S236). On the other hand, when $\Sigma \Delta V_i$ is less than the above-mentioned specified value C (Yes in step S230), it is determined that the exit-side speed V_d tends to decrease and the possibility of slipping of the metal strip 50 is high; and, therefore, the increase of the entrance-side tension T_e is stopped (step S232). Furthermore, when the increase of the entrance-side tension T_e is stopped in this way, the entrance-side tension T_e is decreased by a specified amount (step S234).

[0061] Accordingly, the possibility that slipping may occur in the near future can be found based on the difference between the exit-side speed V_{di} measured i -th time and the exit-side speed $V_{d(i-1)}$ measured $(i-1)$ th time or

the integrated value of the differences between the exit-side speed V_d measured i -th time and the exit-side speed $V_{d(i-1)}$ measured $(i-1)$ th time; and it is designed to stop increasing the entrance-side tension T_e when the above-described possibility is high. So, it is possible to perform the rolling appropriately while more reliably suppressing slipping of the metal strip 50 along the rolling mill rolls 16A, 16B in the state of no tension on the exit side.

[0062] Incidentally, the embodiment illustrated in FIG. 7 and FIG. 8 is designed to perform the control relating to the adjustment of the entrance-side tension T_e by using the exit-side speed V_d measured the specified number of times for every specified period; however, other embodiments may be designed to perform the control relating to the adjustment of the entrance-side tension T_e by using the exit-side speed V_d measured for a specified length of time for every specified period.

[0063] Some embodiments are configured so that the exit-side speed V_d of the metal strip 50 and the roll speed V_m which is the circumferential speed of the rolling mill rolls 16A, 16B are acquired and the entrance-side tension T_e is adjusted based on the difference $(V_d - V_m)$ between the exit-side speed V_d of the metal strip 50 and the roll speed V_m .

[0064] The difference $(V_d - V_m)$ between the exit-side speed V_d of the metal strip 50 and the roll speed V_m can be an index indicating whether sliding of the metal strip 50 along the rolling mill rolls 16A, 16B will occur or not. In this regard, the above-described embodiment is designed so that the entrance-side tension T_e applied to the metal strip 50 is adjusted based on the difference $(V_d - V_m)$ between the exit-side speed V_d of the metal strip 50 and the roll speed V_m ; and it is thereby possible to perform the rolling appropriately while appropriately suppressing slipping of the metal strip 50 along the rolling mill rolls 16A, 16B in the state of no tension on the exit side.

[0065] Some embodiments may be configured to decrease the entrance-side tension T_e by a specified amount after stopping increasing the entrance-side tension T_e (for example, after step S116 in FIG. 2 or steps S212, S232 in FIG. 7 and FIG. 8).

[0066] For example, the flowcharts illustrated in FIG. 7 and FIG. 8 are designed to decrease the entrance-side tension T_e by the specified amount (step S214 or S234) after stopping increasing the entrance-side tension T_e in step S212 or S232.

[0067] Accordingly, by decreasing the entrance-side tension T_e by the specified amount after stopping increasing the entrance-side tension T_e in order to suppress slipping, it is possible to perform the rolling appropriately while more reliably suppressing slipping of the metal strip 50 along the rolling mill rolls 16A, 16B in the state of no tension on the exit side.

[0068] The outlines of the control device of the rolling device, the rolling equipment, and the rolling device operation method according to some embodiments will be described below.

(1) A control device of a rolling device according to at least one embodiment of the present invention is a control device for controlling a rolling device which includes a pair of rolling mill rolls provided to sandwich a metal strip and an unwinding device uncoiling the metal strip at an entrance side of the rolling mill rolls in a traveling direction of the metal strip and which is configured to roll the metal strip by the pair of rolling mill rolls,

wherein after passing a tip part of the metal strip through the pair of rolling mill rolls in a state where a gap between the pair of rolling mill rolls is larger than a strip thickness of the metal strip, the control device is configured to: press the metal strip by the pair of rolling mill rolls in a state where exit-side tension applied to the metal strip is zero; make entrance-side tension applied to the metal strip by the unwinding device become larger than zero; and start rotation of the pair of rolling mill rolls.

[0069] The above-described configuration (1) is designed so that after passing the tip part of the metal strip through the pair of rolling mill rolls, the metal strip is pressed by the pair of rolling mill rolls in the state where the exit-side tension applied to the metal strip is zero; and rolling of the metal strip is started by starting the rotation of the rolling mill rolls while applying the entrance-side tension larger than zero to the metal strip. So, even though the exit-side tension is zero, the metal strip can be rolled appropriately while suppressing meandering of the metal strip. Therefore, it is possible to start the rolling from a portion of the metal strip close to its tip part without using the lead material of the like and improve the yield of the metal strip with the simple configuration.

[0070] (2) According to the invention, in the above-described configuration (1), the control device is configured to increase the entrance-side tension within a specified range after starting the rotation of the rolling mill rolls in the state where the exit-side tension applied to the metal strip is zero.

[0071] According to the above-described configuration (2), it is designed so that after starting the rotation of the rolling mill roll, the entrance-side tension is increased within the specified range in the state where the exit-side tension applied to the metal strip is zero. So, it is possible to perform the rolling more appropriately while suppressing meandering of the metal strip more effectively during the rolling in the state of no tension on the exit side.

[0072] (3) According to some embodiments in the above-described configuration (2), the control device is configured to adjust the entrance-side tension so that an exit-side speed V_d of the metal strip becomes equal to or higher than a rotational speed V_m of the rolling mill rolls.

[0073] The fact that the exit-side speed V_d of the metal strip is lower than the rotational speed V_m of the rolling mill rolls means that the metal strip on the exit side of the rolling mill rolls is not advancing relative to the rolling mill rolls (that is, the metal strip is starting slipping, or is likely to slip, along the rolling mill rolls); and in this case, it is sometimes impossible to perform the rolling appropriate-

ly. In this regard, the above-described configuration (3) is designed so that the entrance-side tension applied to the metal strip is adjusted so that the exit-side speed V_d of the metal strip becomes equal to or higher than the rotational speed V_m of the rolling mill rolls. So, it is possible to perform the rolling more appropriately while appropriately suppressing slipping (sliding) of the metal strip along the rolling mill rolls in the state of no tension on the exit side.

[0074] (4) According to some embodiments in the above-described configuration (2) or (3), the control device is configured to: acquire the exit-side speed V_d of the metal strip which is measured a plurality of number of times for every specified period; and adjust the entrance-side tension based on a result of the measurement of the exit-side speed V_d conducted the plurality of number of times.

[0075] The exit-side speed V_d of the metal strip can be an index indicating whether sliding of the metal strip along the rolling mill rolls will occur or not. In this regard, the above-described configuration (4) is designed so that the exit-side speed V_d of the metal strip is measured the plurality of number of times for every specified period and, therefore, changes in the exit-side speed V_d with the passage of time can be recognized. Accordingly, by adjusting the entrance-side tension applied to the metal strip on the basis of the measurement results of the exit-side speed V_d for the plurality of number of times, it is possible to perform the rolling appropriately while appropriately suppressing slipping of the metal strip along the rolling mill rolls in the state of no tension on the exit side.

[0076] (5) According to some embodiments in the above-described configurations (2) to (4), the control device is configured to stop increasing the entrance-side tension when it is detected that the metal strip is not advancing towards an exit side of the rolling mill rolls in the state where the exit-side tension applied to the metal strip is zero.

[0077] The fact that the metal strip is not advancing towards the exit side of the rolling mill rolls indicates that the metal strip is starting to slip along the rolling mill rolls or may possibly slip along the rolling mill rolls in the near future (a predictor of slipping). In this regard, the above-described configuration (5) is designed to stop increasing the entrance-side tension when it is detected the metal strip is not advancing towards the exit side of the rolling mill rolls. So, it is possible to perform the rolling appropriately while more reliably suppressing slipping of the metal strip along the rolling mill rolls in the state of no tension on the exit side.

[0078] (6) According to some embodiments in the above-described configuration (4) or (5), the control device is configured to: acquire the exit-side speed V_d measured a specified number of times for every specified period; and stop increasing the entrance-side tension when all differences between an exit-side speed V_{d_i} measured i -th time and an exit-side speed $V_{d_{(i-1)}}$ measured $(i-1)$ th time are negative.

[0079] The above-described configuration (6) is designed to stop increasing the entrance-side tension when all differences between the exit-side speed V_{d_i} measured i -th time and the exit-side speed $V_{d_{(i-1)}}$ measured $(i-1)$ th time are negative, that is, when the exit-side speed V_d is gradually decreasing while measuring the exit-side speed V_d the specified number of times for every specified period and there is a high possibility that slipping may occur in the near future. So, it is possible to perform the rolling appropriately while more reliably suppressing slipping of the metal strip along the rolling mill rolls in the state of no tension on the exit side.

[0080] (7) According to some embodiments in the above-described configuration (4) or (5), the control device is configured to: acquire the exit-side speed V_d measured a specified number of times for every specified period; and stop increasing the entrance-side tension when an integrated value of differences between an exit-side speed V_{d_i} measured i -th time and an exit-side speed $V_{d_{(i-1)}}$ measured $(i-1)$ th time is less than a specified value.

[0081] The above-described configuration (7) is designed to stop increasing the entrance-side tension when the integrated value of differences between the exit-side speed V_{d_i} measured i -th time and an exit-side speed $V_{d_{(i-1)}}$ measured $(i-1)$ th time is less than the specified value, that is, when the exit-side speed V_d is gradually decreasing while measuring the exit-side speed V_d the specified number of times for every specified period and there is a high possibility that slipping may occur in the near future. So, it is possible to perform the rolling appropriately while more reliably suppressing slipping of the metal strip along the rolling mill rolls in the state of no tension on the exit side.

[0082] (8) According to some embodiments in the above-described configurations (5) to (7), the control device is configured to decrease the entrance-side tension by a specified amount after stopping increasing the entrance-side tension.

[0083] The above-described configuration (8) is designed to decrease the entrance-side tension by the specified amount after stopping increasing the entrance-side tension in order to suppress slipping. So, it is possible to perform the rolling appropriately while further reliably suppressing slipping of the metal strip along the rolling mill rolls in the state of no tension on the exit side.

[0084] (9) According to some embodiments in any one of the above-described configurations (2) to (5), the control device is configured to: acquire the exit-side speed V_d of the metal strip and a roll speed V_m which is a circumferential speed of the rolling mill rolls; and adjust the entrance-side tension based on a difference ($V_d - V_m$) between the exit-side speed V_d of the metal strip and the roll speed V_m .

[0085] The difference ($V_d - V_m$) between the exit-side speed V_d of the metal strip and the roll speed V_m can be an index indicating whether sliding of the metal strip along the rolling mill rolls will occur or not. In this regard, the above-described configuration (9) is designed so that

by adjusting the entrance-side tension applied to the metal strip on the basis of the difference ($V_d - V_m$) between the exit-side speed V_d of the metal strip and the roll speed V_m , it is possible to perform the rolling appropriately while suppressing slipping of the metal strip along the rolling mill rolls appropriately in the state of no tension on the exit side.

[0086] (10) Rolling equipment according to at least one embodiment of the present invention includes:

a rolling device which includes a pair of rolling mill rolls provided to sandwich a metal strip and an unwinding device uncoiling the metal strip at an entrance side of the rolling mill rolls in a traveling direction of the metal strip and which is configured to roll the metal strip by the pair of rolling mill rolls; and the control device described in any one of the above-described items (1) to (9).

[0087] The above-described configuration (10) is designed so that after passing the tip part of the metal strip through the pair of rolling mill rolls, the metal strip is pressed by the pair of rolling mill rolls in the state where the exit-side tension applied to the metal strip is zero; and the rotation of the rolling mill rolls is started while applying the entrance-side tension, which is larger than zero, to the metal strip, thereby starting to roll the metal strip. So, even though the exit-side tension is zero, it is possible to perform the rolling appropriately while suppressing meandering of the metal strip. Therefore, it is possible to start the rolling from a portion of the metal strip close to its tip part without using the lead material of the like and improve the yield of the metal strip with the simple configuration.

[0088] (11) A rolling device operation method according to at least one embodiment of the present invention is a method for operating a rolling device which includes an unwinding device for applying entrance-side tension to a metal strip and a pair of rolling mill rolls provided to sandwich the metal strip at an exit side of the unwinding device in a traveling direction of the metal strip and which is configured to roll the metal strip by the pair of rolling mill rolls, wherein the rolling device operating method includes:

a strip-passing step of passing a tip part of the metal strip through the pair of rolling mill rolls in a state where a gap between the pair of rolling mill rolls is larger than a strip thickness of the metal strip;
a pressing step of causing the pair of rolling mill rolls to press the metal strip after the strip-passing step in a state where exit-side tension applied to the metal strip is zero;
a tension application step of causing the unwinding device to make entrance-side tension applied to the metal strip become larger than zero after the pressing step in the state where the exit-side tension applied to the metal strip is zero; and

a roll start step of starting rotation of the pair of rolling mill rolls after the tension application step in the state where the exit-side tension applied to the metal strip is zero.

[0089] The above-described method (11) is designed so that after passing the tip part of the metal strip through the pair of rolling mill rolls, the metal strip is pressed by the pair of rolling mill rolls in the state where the exit-side tension applied to the metal strip is zero; and the rotation of the rolling mill rolls is started while applying the entrance-side tension, which is larger than zero, to the metal strip, thereby starting to roll the metal strip. So, even though the exit-side tension is zero, it is possible to perform the rolling appropriately while suppressing meandering of the metal strip. Therefore, it is possible to start the rolling from a portion of the metal strip close to its tip part without using the lead material of the like and improve the yield of the metal strip with the simple configuration.

[0090] (12) According to the invention, by the above-described method (11), the entrance-side tension is increased within a specified range after the roll start step in the state where the exit-side tension applied to the metal strip is zero.

[0091] The above-described method (12) is designed so that after starting the rotation of the rolling mill rolls, the entrance-side tension is increased within the specified range in the state where the exit-side tension applied to the metal strip is zero. So, it is possible to perform the rolling more appropriately by more effectively suppressing meandering of the metal strip during the rolling in the state of no tension on the exit side.

[0092] (13) According to some embodiments by the above-described method (12), the entrance-side tension is adjusted so that an exit-side speed V_d of the metal strip becomes equal to or higher than a rotational speed V_m of the rolling mill rolls.

[0093] The fact that the exit-side speed V_d of the metal strip is lower than the rotational speed V_m of the rolling mill rolls means that the metal strip on the exit side of the rolling mill rolls is not advancing relative to the rolling mill rolls; and in this case, it may sometimes be impossible to perform the rolling appropriately. In this regard, the above-described method (13) is designed to adjust the entrance-side tension applied to the metal strip so that the exit-side speed V_d of the metal strip becomes equal to or higher than the rotational speed V_m of the rolling mill rolls. So, it is possible to perform the rolling appropriately while appropriately suppressing slipping (sliding) of the metal strip along the rolling mill rolls in the state of no tension on the exit side. in the state of no tension on the exit side.

[0094] (14) According to some embodiments by the above-described method (12) or (13), the exit-side speed V_d of the metal strip which is measured a plurality of number of times for every specified period is acquired and the entrance-side tension is adjusted based on a

result of the measurement of the exit-side speed V_d conducted the plurality of number of times.

[0095] The exit-side speed V_d of the metal strip can be an index indicating whether sliding of the metal strip along the rolling mill rolls will occur or not. In this regard, the above-described method (14) is designed so that the exit-side speed V_d of the metal strip is measured the plurality of number of times for every specified period and, therefore, changes in the exit-side speed V_d with the passage of time can be recognized. Accordingly, by adjusting the entrance-side tension applied to the metal strip on the basis of the measurement results of the exit-side speed V_d conducted the plurality of number of times, it is possible to perform the rolling appropriately while suppressing slipping of the metal strip along the rolling mill rolls appropriately in the state of no tension on the exit side.

[0096] (15) According to some embodiments by any one of the above-described methods (12) to (14), the increase of the entrance-side tension is stopped when it is detected that the metal strip is not advancing towards an exit side of the rolling mill rolls in the state where the exit-side tension applied to the metal strip is zero.

[0097] The fact that the metal strip is not advancing towards the exit side of the rolling mill rolls indicates that the metal strip is starting to slip along the rolling mill rolls or may possibly slip along the rolling mill rolls in the near future (a predictor of slipping). In this regard, the above-described method (15) is designed to stop increasing the entrance-side tension when it is detected the metal strip is not advancing towards the exit side of the rolling mill rolls. So, it is possible to perform the rolling appropriately while more reliably suppressing slipping of the metal strip along the rolling mill rolls in the state of no tension on the exit side.

[0098] (16) According to some embodiments by the above-described method (14) or (15), the exit-side speed V_d measured a specified number of times for every specified period is acquired; and the increase of the entrance-side tension is stopped when all differences between an exit-side speed V_{d_i} measured i -th time and an exit-side speed $V_{d_{(i-1)}}$ measured $(i-1)$ th time are negative.

[0099] The above-described method (16) is designed to stop increasing the entrance-side tension when all the differences between the exit-side speed V_{d_i} measured i -th time and the exit-side speed $V_{d_{(i-1)}}$ measured $(i-1)$ th time are negative, that is, when the exit-side speed V_d is gradually decreasing while measuring the exit-side speed V_d the specified number of times for every specified period and there is a high possibility that slipping may occur in the near future. So, it is possible to perform the rolling appropriately while more reliably suppressing slipping of the metal strip along the rolling mill rolls in the state of no tension on the exit side.

[0100] (17) According to some embodiments by the above-described method (14) or (15), the exit-side speed V_d measured a specified number of times for every specified period is acquired; and the increase of the entrance-

side tension is stopped when an integrated value of differences between an exit-side speed V_{d_i} measured i -th time and an exit-side speed $V_{d_{(i-1)}}$ measured $(i-1)$ th time is less than a specified value.

[0101] The above-described method (17) is designed to stop increasing the entrance-side tension when the integrated value of the differences between the exit-side speed V_{d_i} measured i -th time and the exit-side speed $V_{d_{(i-1)}}$ measured $(i-1)$ th time is less than the specified value, that is, when the exit-side speed V_d is gradually decreasing while measuring the exit-side speed V_d the specified number of times for every specified period and there is a high possibility that slipping may occur in the near future. So, it is possible to perform the rolling appropriately while more reliably suppressing slipping of the metal strip along the rolling mill rolls in the state of no tension on the exit side.

[0102] (18) According to some embodiments by any one of the above-described methods (15) to (17), the entrance-side tension is decreased by a specified amount after stopping increasing the entrance-side tension.

[0103] By the above-described method (18), it is designed to decrease the entrance-side tension by the specified amount after stopping increasing the entrance-side tension in order to suppress slipping. So, it is possible to perform the rolling appropriately while further reliably suppressing slipping of the metal strip along the rolling mill rolls in the state of no tension on the exit side.

Reference Signs List

[0104]

35	1	Rolling equipment
	2	Rolling device
	4	Unwinding device
	5	Motor
	6	Entrance-side pinch roll
40	8	Side guide
	10	Rolling mill
	11	Motor
	12	Exit-side pinch roll
	14	Winding device
45	15	Motor
	16A	Rolling mill roll
	16B	Rolling mill roll
	18A	Intermediate roll
	18B	Intermediate roll
50	20A	Backup roll
	20B	Backup roll
	22	Pressing device
	30	Control device
	32	Speed sensor
55	34	Tension sensor
	36	Speed sensor
	37	Pressed position sensor
	38	Strip-edge position detector

- 40 Speed sensor
50 Metal strip
51 Tip part

Claims

1. A rolling equipment including:

a rolling device (2) comprising a pair of rolling mill rolls (16A, 16B) provided to sandwich a metal strip (50) and an unwinding device (4) for uncoiling the metal strip at an entrance side of the rolling mill rolls in a traveling direction of the metal strip, the rolling device being configured to roll the metal strip by the pair of rolling mill rolls, and a control device (30) for controlling the rolling device;

characterized in that,

after passing a tip part of the metal strip through the pair of rolling mill rolls in a state where a gap between the pair of rolling mill rolls is larger than a strip thickness of the metal strip, the control device is configured to:

press the metal strip by the pair of rolling mill rolls in a state where exit-side tension applied to the metal strip is zero;
make entrance-side tension applied to the metal strip by the unwinding device become larger than zero;
start rotation of the pair of rolling mill rolls;
and
after starting rotation of the rolling mill rolls, increase the entrance-side tension within a specified range in the state where the exit-side tension applied to the metal strip is zero.

2. The rolling equipment according to claim 1, wherein the control device (30) is configured to adjust the entrance-side tension so that an exit-side speed V_d of the metal strip (50) becomes equal to or higher than a rotational speed V_m of the rolling mill rolls (16A, 16B).
3. The rolling equipment according to claim 1 or 2, wherein the control device (30) is configured to: acquire the exit-side speed V_d of the metal strip (50) which is measured a plurality of number of times for every specified period; and adjust the entrance-side tension based on a result of the measurement of the exit-side speed V_d conducted the plurality of number of times.
4. The rolling equipment according to any one of claims 1 to 3, wherein the control device (30) is configured to stop

increasing the entrance-side tension when it is detected that the metal strip (50) is not advancing towards an exit side of the rolling mill rolls (16A, 16B) in the state where the exit-side tension applied to the metal strip is zero.

5. The rolling equipment according to claim 3 or 4, wherein the control device (30) is configured to: acquire the exit-side speed V_d measured a specified number of times for every specified period; and stop increasing the entrance-side tension when all differences between an exit-side speed V_{di} measured i -th time and an exit-side speed $V_{d(i-1)}$ measured $(i-1)$ th time are negative.
6. The rolling equipment according to claim 3 or 4, wherein the control device (30) is configured to: acquire the exit-side speed V_d measured a specified number of times for every specified period; and stop increasing the entrance-side tension when an integrated value of differences between an exit-side speed V_{di} measured i -th time and an exit-side speed $V_{d(i-1)}$ measured $(i-1)$ th time is less than a specified value.
7. The rolling equipment according to any one of claims 4 to 6, wherein the control device (30) is configured to decrease the entrance-side tension by a specified amount after stopping increasing the entrance-side tension.
8. The rolling equipment according to any one of claims 1 to 4, wherein the control device (30) is configured to: acquire the exit-side speed V_d of the metal strip (50) and a roll speed V_m which is a circumferential speed of the rolling mill rolls (16A, 16B); and adjust the entrance-side tension based on a difference ($V_d - V_m$) between the exit-side speed V_d of the metal strip and the roll speed V_m .
9. A method for operating a rolling device including an unwinding device (4) for applying entrance-side tension to a metal strip (50) and a pair of rolling mill rolls (16A, 16B) provided to sandwich the metal strip at an exit side of the unwinding device in a traveling direction of the metal strip, the rolling device being configured to roll the metal strip by the pair of rolling mill rolls,
the rolling device operating method comprising:

a strip-passing step (S104) of passing a tip part of the metal strip through the pair of rolling mill rolls in a state where a gap between the pair of rolling mill rolls is larger than a strip thickness of the metal strip;
the method **characterized by** the following con-

secutive steps:

a pressing step (S106) of causing the pair of rolling mill rolls to press the metal strip after the strip-passing step in a state where exit-side tension applied to the metal strip is zero; 5
a tension application step (S108) of causing the unwinding device to make entrance-side tension applied to the metal strip become larger than zero after the pressing step in the state where the exit-side tension applied to the metal strip is zero; and 10
a roll start step (S110) of starting rotation of the pair of rolling mill rolls after the tension application step in the state where the exit-side tension applied to the metal strip is zero; 15
wherein after the roll start step, the entrance-side tension is increased (S114) 20 within a specified range in the state where the exit-side tension applied to the metal strip is zero.

10. The rolling device operating method according to claim 9, 25 wherein the entrance-side tension is adjusted (S116) so that an exit-side speed V_d of the metal strip (50) becomes equal to or higher than a rotational speed V_m of the rolling mill rolls (16A, 16B). 30
11. The rolling device operating method according to claim 9 or 10, 35 wherein the exit-side speed V_d of the metal strip (50) which is measured a plurality of number of times for every specified period is acquired and the entrance-side tension is adjusted (S116) based on a result of the measurement of the exit-side speed V_d conducted the plurality of number of times.
12. The rolling device operating method according to any one of claims 9 to 11, 40 wherein the increase of the entrance-side tension is stopped when it is detected that the metal strip (50) is not advancing towards an exit side of the rolling mill rolls (16A, 16B) in the state where the exit-side tension applied to the metal strip is zero. 45

Patentansprüche

1. Walzanlage mit:

einer Walzvorrichtung (2), die ein Paar von Walzwerkwalzen (16A, 16B), die zum sandwichartigen Einfassen eines Metallbandes (50) vorgesehen sind, und eine Abwicklungsvorrichtung (4) zum Abspulen des Metallbandes auf 55

einer Eingangsseite der Walzwerkwalzen in einer Transportrichtung des Metallbandes umfasst, wobei die Walzvorrichtung dazu eingerichtet ist, das Metallband mittels dem Paar von Walzwerkwalzen zu walzen, und einer Steuervorrichtung (30) zum Steuern der Walzvorrichtung;

gekennzeichnet dadurch, dass

die Steuervorrichtung, nachdem ein Spitzenteil des Metallstreifens das Paar von Walzwerkwalzen in einem Zustand durchquert hat, in dem eine Lücke zwischen dem Paar von Walzwerkwalzen größer als eine Banddicke des Metallbandes ist, dazu eingerichtet ist, das Metallband mittels dem Paar von Walzwerkwalzen in einem Zustand zu pressen, in dem die auf das Metallband angewendete ausgangsseitige Spannung Null ist; die auf das Metallband von der Abwicklungsvorrichtung angewendete eingangsseitige Spannung größer als Null zu machen; die Rotation des Paares von Walzwerkwalzen zu starten und die eingangsseitige Spannung innerhalb eines spezifizierten Bereichs nach dem Starten der Rotation der Walzwerkwalzen in einem Zustand zu erhöhen, in dem die auf das Metallband (50) angewendete ausgangsseitige Spannung Null ist.

2. Walzanlage nach Anspruch 1, wobei die Steuervorrichtung (30) dazu eingerichtet ist, die eingangsseitige Spannung so zu justieren, dass eine ausgangsseitige Geschwindigkeit V_d des Metallbandes (50) größer oder gleich einer Rotationsgeschwindigkeit V_m der Walzwerkwalzen (16A, 16B) wird.
3. Walzanlage nach Anspruch 1 oder 2, 40 wobei die Steuervorrichtung (30) dazu eingerichtet ist: die ausgangsseitige Geschwindigkeit V_d des Metallbandes (50), die für jeden spezifizierten Zeitraum mehrere Male gemessen wird, zu erfassen; und die eingangsseitige Spannung auf der Grundlage der mehreren Male durchgeführten Messung der ausgangsseitigen Geschwindigkeit V_d zu justieren.
4. Walzanlage nach einem der Ansprüche 1 bis 3, 50 wobei die Steuervorrichtung (30) dazu eingerichtet ist, die Erhöhung der eingangsseitigen Spannung zu stoppen, wenn detektiert wird, dass das Metallband (50) nicht zur Ausgangsseite der Walzwerkwalzen (16A, 16B) in dem Zustand vorläuft, in dem die auf das Metallband angewendete ausgangsseitige Spannung Null ist.
5. Walzanlage nach Anspruch 3 oder 4, wobei die Steuervorrichtung (30) dazu eingerichtet

ist: die für jeden spezifizierten Zeitraum eine spezifizierte Anzahl von Malen gemessene ausgangsseitige Geschwindigkeit V_d zu erfassen; und die Erhöhung der eingangsseitigen Spannung zu stoppen, wenn alle Differenzen zwischen einer zu einem i -ten Zeitpunkt gemessenen ausgangsseitigen Geschwindigkeit V_{di} und einer zum $(i-1)$ -ten Zeitpunkt gemessenen ausgangsseitigen Geschwindigkeit $V_{d(i-1)}$ negativ sind.

6. Walzanlage nach Anspruch 3 oder 4, wobei die Steuervorrichtung (30) dazu eingerichtet ist: die für jeden spezifizierten Zeitraum eine spezifizierte Anzahl von Malen gemessene ausgangsseitige Geschwindigkeit V_d zu erfassen; und die Erhöhung der eingangsseitigen Spannung zu stoppen, wenn ein integrierter Wert von Differenzen zwischen einer zum i -ten Zeitpunkt gemessenen ausgangsseitigen Geschwindigkeit V_{di} und einer zum $(i-1)$ -ten Zeitpunkt gemessenen ausgangsseitigen Geschwindigkeit $V_{d(i-1)}$ kleiner als ein spezifizierter Wert ist.

7. Walzanlage nach einem der Ansprüche 4 bis 6, wobei die Steuervorrichtung (30) dazu eingerichtet ist, die eingangsseitige Spannung um einen spezifizierten Betrag nach dem Stoppen der Erhöhung der eingangsseitigen Spannung abzusenken.

8. Walzanlage nach einem der Ansprüche 1 bis 4, wobei die Steuervorrichtung (30) dazu eingerichtet ist: die ausgangsseitige Geschwindigkeit V_d des Metallbandes (50) und eine Walzengeschwindigkeit V_m , die eine Umfangsgeschwindigkeit der Walzwerkwalzen (16A, 16B) ist, zu erfassen; und die eingangsseitige Spannung auf der Grundlage einer Differenz ($V_d - V_m$) zwischen der ausgangsseitigen Geschwindigkeit V_d des Metallbandes und der Walzengeschwindigkeit V_m zu justieren.

9. Verfahren zum Betreiben einer Walzvorrichtung, die eine Abwicklungsvorrichtung (4) zum Anwenden eingangsseitiger Spannung auf ein Metallband (50) und ein Paar von Walzwerkwalzen (16A, 16B), die zum sandwichartigen Einfassen des Metallbandes vorgesehen sind, auf einer Ausgangsseite der Abwicklungsvorrichtung in einer Transportrichtung des Metallbandes enthält, wobei die Walzvorrichtung dazu eingerichtet ist, das Metallband mittels dem Paar von Walzwerkwalzen zu walzen, wobei das Walzvorrichtungsbetriebsverfahren umfasst:

einen Bandlaufschrift (S104), bei dem ein Spitzenteil des Metallbandes durch das Paar von Walzwerkwalzen in einem Zustand läuft, in dem eine Lücke zwischen dem Paar von Walzwerkwalzen größer als eine Banddicke des Metall-

bandes ist;

wobei das Verfahren durch die folgenden aufeinander folgenden Schritte gekennzeichnet ist: einen Pressschritt (S106), bei dem das Paar von Walzwerkwalzen das Metallband nach dem Bandlaufschrift in einem Zustand zu pressen hat, in dem die auf das Metallband angewendete ausgangsseitige Spannung Null ist

einen Spannungsanwendungsschritt (S108), bei dem die Abwicklungsvorrichtung die auf das Metallband angewendete eingangsseitige Spannung nach dem Pressschritt in dem Zustand größer als Null zu machen hat, in dem die auf das Metallband angewendete ausgangsseitige Spannung Null ist; und einen Walzstartschritt (S110), bei dem die Rotation des Paares von Walzwerkwalzen nach dem Spannungsanwendungsschritt in dem Zustand gestartet wird, in dem die auf das Metallband angewendete ausgangsseitige Spannung Null ist;

wobei die eingangsseitige Spannung innerhalb eines spezifizierten Bereichs nach dem Walzstartschritt in dem Zustand erhöht wird (S114), in dem die auf das Metallband angewendete ausgangsseitige Spannung Null ist.

10. Walzvorrichtungsbetriebsverfahren nach Anspruch 9,

wobei die eingangsseitige Spannung so justiert wird (S116), dass eine ausgangsseitige Geschwindigkeit V_d des Metallbandes (50) größer oder gleich einer Rotationsgeschwindigkeit V_m der Walzwerkwalzen (16A, 16B) wird.

11. Walzvorrichtungsbetriebsverfahren nach Anspruch 9 oder 10,

wobei die ausgangsseitige Geschwindigkeit V_d des Metallbandes (50), die für jeden spezifizierten Zeitraum mehrere Male gemessen wird, erfasst wird und die eingangsseitige Spannung auf der Grundlage eines Ergebnisses der mehrere Male durchgeführten Messung der ausgangsseitigen Spannung V_d justiert wird (S116).

12. Walzvorrichtungsbetriebsverfahren nach einem der Ansprüche 9 bis 11,

wobei die Erhöhung der eingangsseitigen Spannung gestoppt wird, wenn detektiert wird, dass das Metallband (50) nicht zu einer Ausgangsseite der Walzwerkwalzen (16A, 16B) hin in dem Zustand fortläuft, in dem die auf das Metallband angewendete ausgangsseitige Spannung Null ist.

Revendications

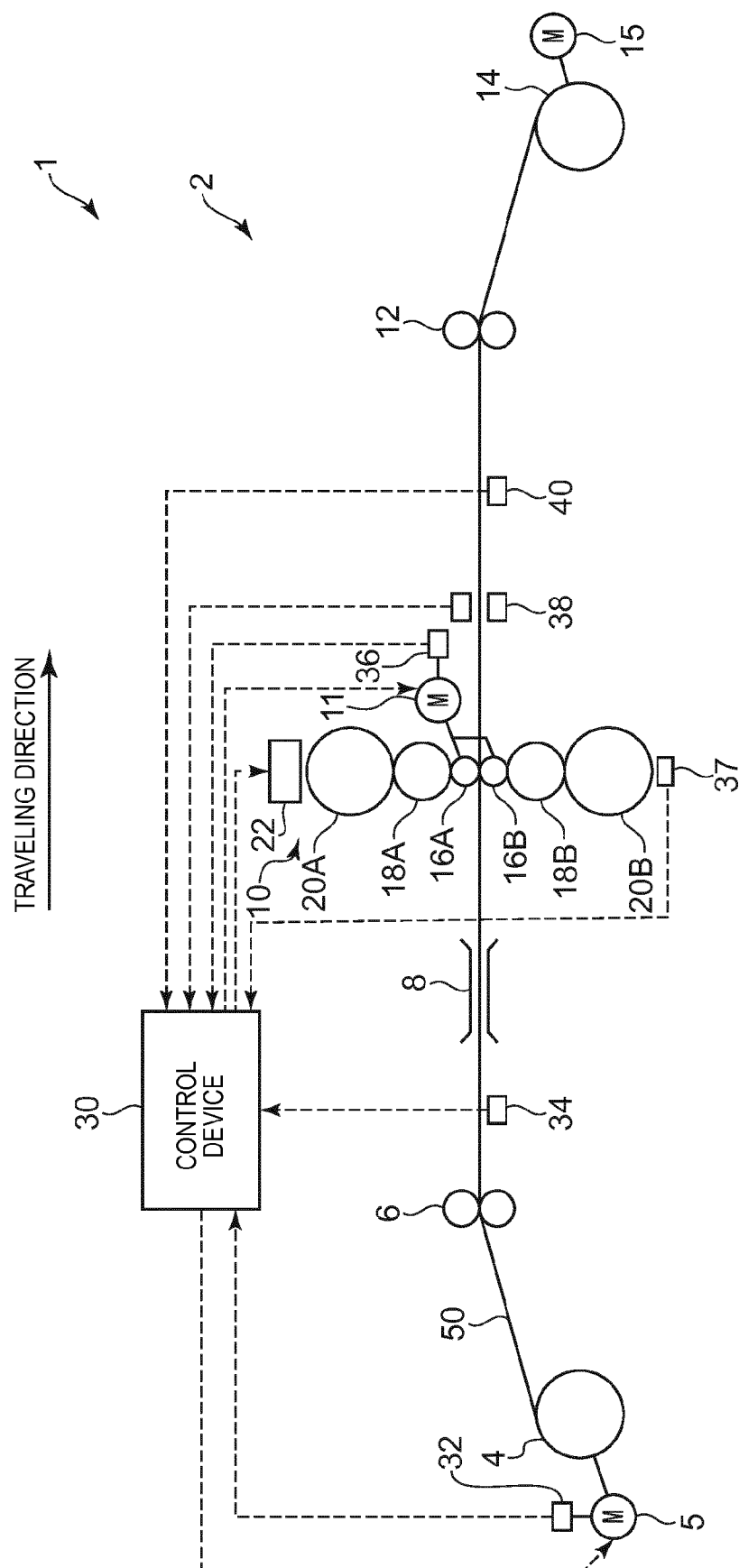
1. Équipement de laminage incluant :

- un dispositif (2) de laminage comprenant une paire de cylindres (16A, 16B) de laminoir prévus pour prendre en sandwich une bande métallique (50) et un dispositif (4) de débobinage pour dérouler la bande métallique au niveau d'un côté d'entrée des cylindres de laminoir dans un sens de déplacement de la bande métallique, le dispositif de laminage étant configuré pour laminier la bande métallique par la paire de cylindres de laminoir, et
- un dispositif (30) de commande pour commander le dispositif de laminage ;
- caractérisé en ce que**
- après le passage d'une partie d'extrémité de la bande métallique à travers la paire de cylindres de laminoir dans un état où un espace entre la paire de cylindres de laminoir est plus grand qu'une épaisseur de bande de la bande métallique, le dispositif de commande est configuré pour :
- presser la bande métallique par la paire de cylindres de laminoir dans un état où une tension côté sortie appliquée à la bande métallique est zéro ;
- amener la tension côté entrée appliquée à la bande métallique par le dispositif de débobinage à devenir supérieure à zéro ;
- démarrer la rotation de la paire de cylindres de laminoir ; et
- augmenter la tension côté entrée à l'intérieur d'une plage spécifiée après le démarrage de la rotation des cylindres de laminoir dans l'état où la tension côté sortie appliquée à la bande métallique est zéro.
2. Équipement de laminage selon la revendication 1, dans lequel le dispositif (30) de commande est configuré pour ajuster la tension côté entrée de manière à ce qu'une vitesse côté sortie Vd de la bande métallique (50) devienne égale ou supérieure à une vitesse de rotation Vm des cylindres (16A, 16B) de laminoir.
 3. Équipement de laminage selon la revendication 1 ou 2, dans lequel le dispositif (30) de commande est configuré pour : acquérir la vitesse côté sortie Vd de la bande métallique (50) qui est mesurée une pluralité de nombre de fois pour chaque période spécifiée ; et ajuster la tension côté entrée sur la base d'un résultat de la mesure de la vitesse côté sortie Vd effectuée la pluralité de nombre de fois.
 4. Équipement de laminage selon l'une quelconque des revendications 1 à 3, dans lequel le dispositif (30) de commande est configuré pour arrêter d'augmenter la tension côté entrée lorsqu'il est détecté que la bande métallique (50) n'avance pas vers un côté sortie des cylindres (16A, 16B) de laminoir dans l'état où la tension côté sortie appliquée à la bande métallique est zéro.
 5. Équipement de laminage selon la revendication 3 ou 4, dans lequel le dispositif (30) de commande est configuré pour : acquérir la vitesse côté sortie Vd mesurée un nombre spécifié de fois pour chaque période spécifiée ; et arrêter d'augmenter la tension côté entrée lorsque toutes les différences entre une vitesse côté sortie Vdi mesurée une $i^{\text{ème}}$ fois et une vitesse côté sortie Vd(i-1) mesurée une (i-1) $^{\text{ème}}$ fois sont négatives.
 6. Équipement de laminage selon la revendication 3 ou 4, dans lequel le dispositif (30) de commande est configuré pour : acquérir la vitesse côté sortie Vd mesurée un nombre spécifié de fois pour chaque période spécifiée ; et arrêter d'augmenter la tension côté entrée lorsqu'une valeur intégrée de différences entre une vitesse côté sortie Vdi mesurée une $i^{\text{ème}}$ fois et une vitesse côté sortie Vd(i-1) mesurée une (i-1) $^{\text{ème}}$ fois est inférieure à une valeur spécifiée.
 7. Équipement de laminage selon l'une quelconque des revendications 4 à 6, dans lequel le dispositif (30) de commande est configuré pour diminuer la tension côté entrée d'une quantité spécifiée après avoir arrêté d'augmenter la tension côté entrée.
 8. Équipement de laminage selon l'une quelconque des revendications 1 à 4, dans lequel le dispositif (30) de commande est configuré pour : acquérir la vitesse côté sortie Vd de la bande métallique (50) et une vitesse de cylindres Vm qui est une vitesse circonférentielle des cylindres (16A, 16B) de laminoir ; et ajuster la tension côté entrée sur la base d'une différence (Vd-Vm) entre la vitesse côté sortie Vd de la bande métallique et la vitesse de cylindres Vm.
 9. Procédé de fonctionnement d'un dispositif de laminage incluant un dispositif (4) de débobinage pour appliquer une tension côté entrée à une bande métallique (50) et une paire de cylindres (16A, 16B) de laminoir prévus pour prendre en sandwich la bande métallique au niveau d'un côté sortie du dispositif de débobinage dans un sens de déplacement de la bande métallique, le dispositif de laminage étant configuré pour laminier la bande métallique par la paire de cylindres de laminoir, le procédé de fonctionnement de dispositif de laminage comprenant :

une étape (S104) de passage de bande pour faire passer une partie d'extrémité de la bande métallique à travers la paire de cylindres de laminoir dans un état où un espace entre la paire de cylindres de laminoir est supérieur à une épaisseur de bande de la bande métallique ; le procédé **caractérisé par** les étapes consécutives suivantes :

sion côté sortie appliquée à la bande métallique est zéro.

- une étape (S106) de pressage pour amener la paire de cylindres de laminoir à presser la bande métallique après l'étape de passage de bande dans un état où la tension côté sortie appliquée à la bande métallique est zéro ;
- une étape (S108) d'application de tension pour amener le dispositif de débobinage à amener la tension côté entrée appliquée à la bande métallique à devenir supérieure à zéro après l'étape de pressage dans l'état où la tension côté sortie appliquée à la bande métallique est zéro ; et
- une étape (S110) de démarrage de cylindres pour démarrer la rotation de la paire de cylindres de laminoir après l'étape d'application de tension dans l'état où la tension côté sortie appliquée à la bande métallique est zéro ;
- dans lequel la tension côté entrée est augmentée (S114) à l'intérieur d'une plage spécifiée après l'étape de démarrage de cylindres dans l'état où la tension côté sortie appliquée à la bande métallique est zéro.
10. Procédé de fonctionnement de dispositif de laminage selon la revendication 9, dans lequel la tension côté entrée est ajustée (S116) de manière à ce qu'une vitesse côté sortie V_d de la bande métallique (50) devient égale ou supérieure à une vitesse de rotation V_m des cylindres (16A, 16B) de laminoir.
11. Procédé de fonctionnement de dispositif de laminage selon la revendication 9 ou 10, dans lequel la vitesse côté sortie V_d de la bande métallique (50) qui est mesurée une pluralité de nombre de fois pour chaque période spécifiée est acquise et la tension côté entrée est ajustée (S116) sur la base d'un résultat de la mesure de la vitesse côté sortie V_d effectuée la pluralité de nombre de fois.
12. Procédé de fonctionnement de dispositif de laminage selon l'une quelconque des revendications 9 à 11, dans lequel l'augmentation de la tension côté entrée est arrêtée lorsqu'il est détecté que la bande métallique (50) n'avance pas vers un côté sortie des cylindres (16A, 16B) de laminoir dans l'état où la ten-



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FIG. 2

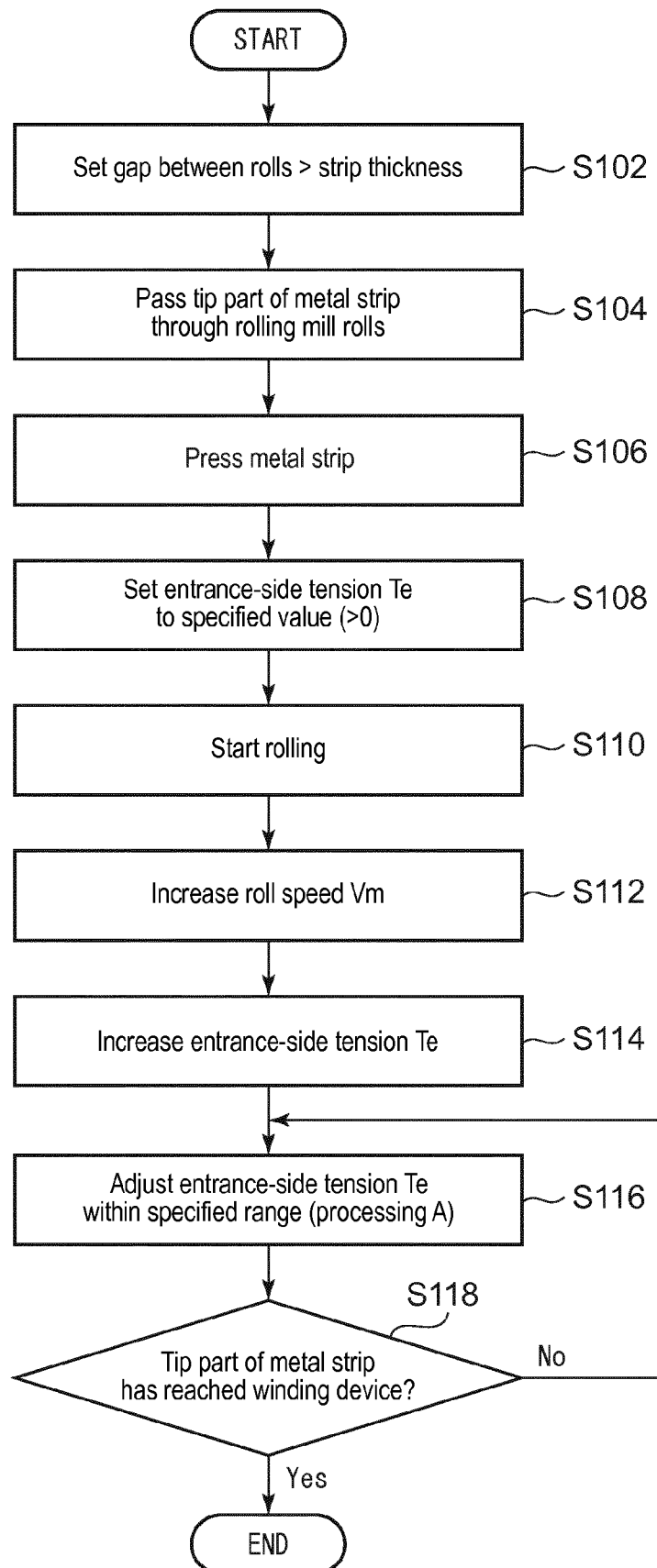


FIG. 3

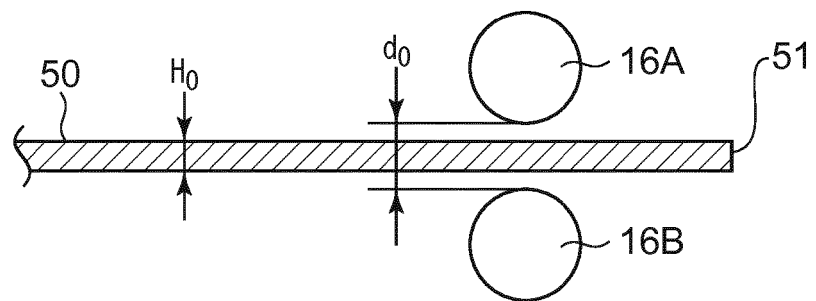


FIG. 4

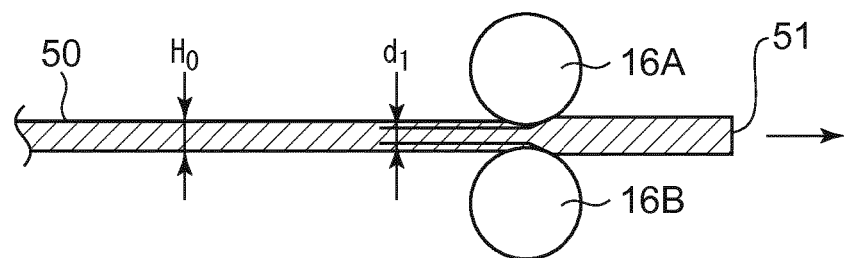


FIG. 5

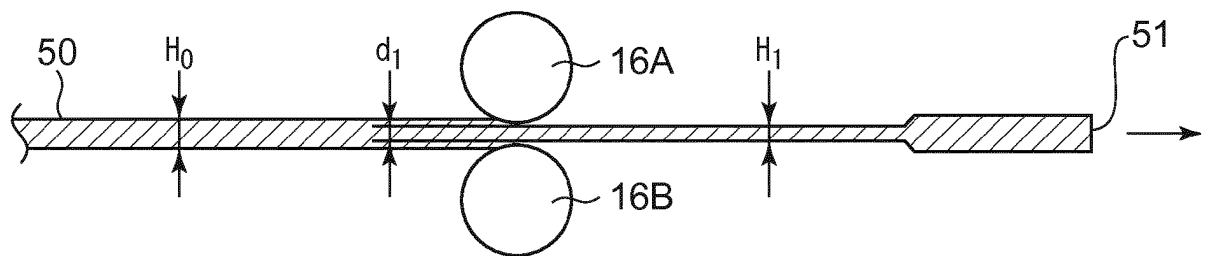


FIG. 6

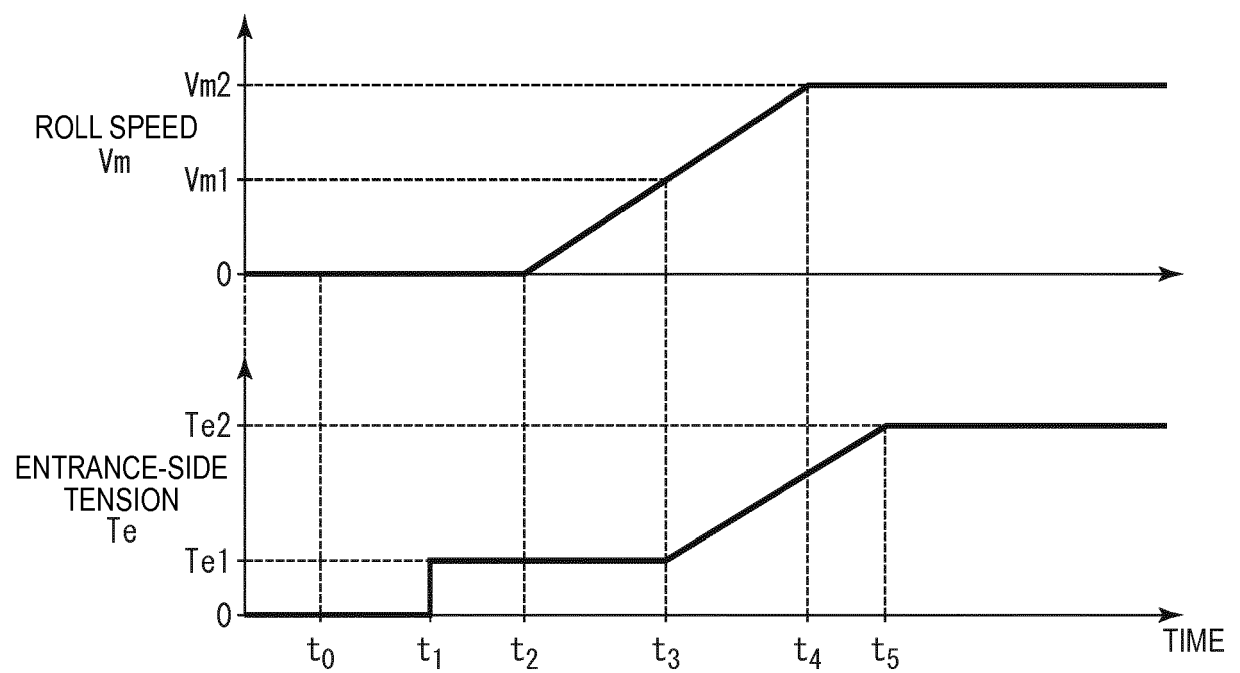


FIG. 7

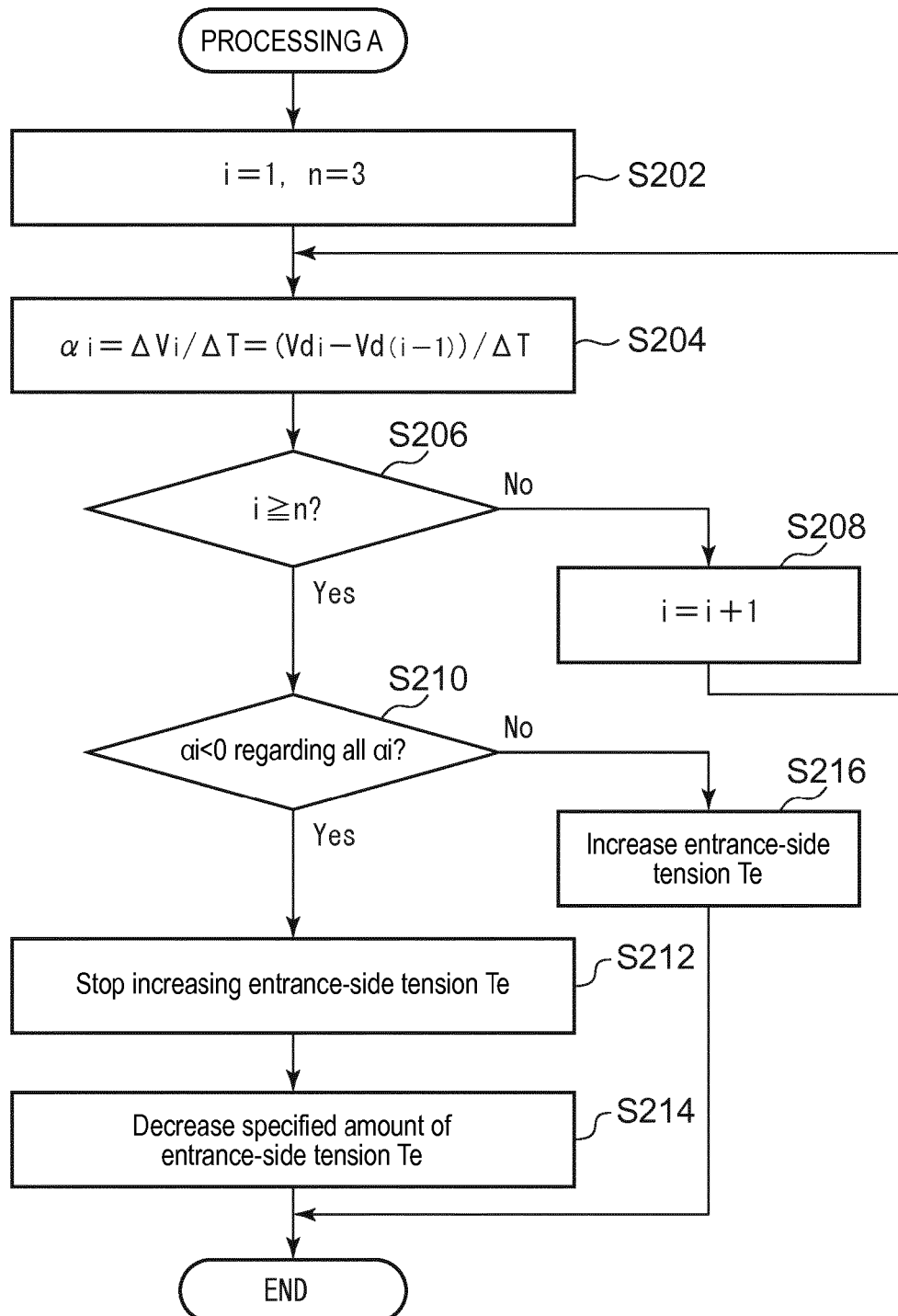
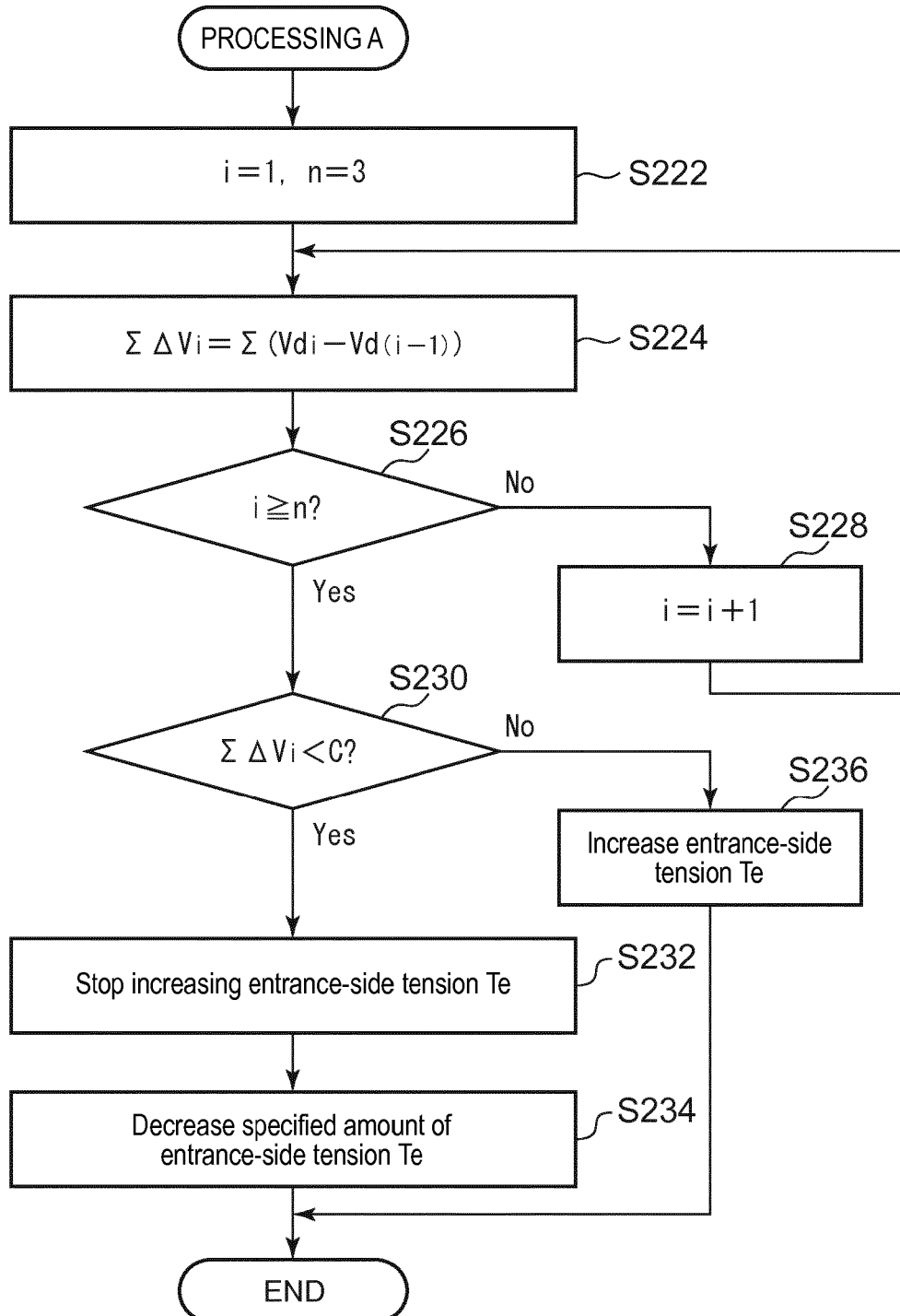


FIG. 8



REFERENCES CITED IN THE DESCRIPTION

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