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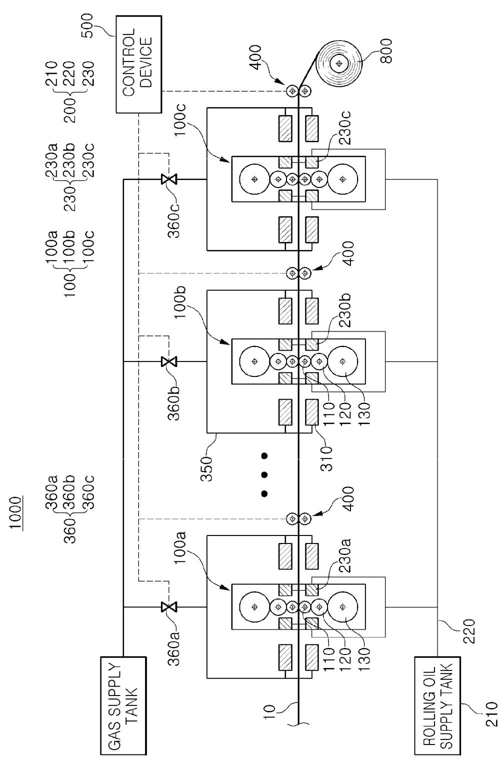
(54) ROLLING FACILITY AND ROLLING METHOD OF STAINLESS STEEL PLATE

(57) The present invention relates to a rolling facility and a rolling method of a stainless steel plate. The rolling facility according to the present invention comprises: a plurality of rolling roll sets which are composed of at least a pair of rolls facing each other with a workpiece being conveyed therebetween and are provided in a conveying direction of the workpiece; a plurality of rolling oil supply means, provided corresponding to each of the rolling roll sets, for supplying a rolling oil to the rolling roll sets; a plurality of cooling means, provided corresponding to each of the rolling roll sets, for supplying a gas to the workpiece and the rolling roll sets; a gloss measurement means, disposed between the rolling roll set most rearwardly disposed in the traveling direction of the workpiece and a winder for winding the workpiece, for measuring the surface gloss of the workpiece; and a control means, connected to the gloss measurement means and the plurality of cooling means, for controlling an amount of gas supplied by the plurality of cooling means according to the surface gloss measured by the gloss measurement means.

[FIG.2]



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Description

[Technical Field]

[0001] The present disclosure relates to a rolling mill and a method of rolling a stainless steel sheet.

[Background Art]

[0002] Continuous rolling, as a method for rolling a workpiece to a target thickness by allowing the workpiece, which becomes a rolled workpiece, to pass through a plurality of working rolls, provided in a conveying direction of a workpiece, once, is a rolling method providing significantly excellent productivity.

[0003] A working roll, used for continuous rolling, has a relatively large diameter as compared with a working roll used for reversible rolling, and viscosity of rolling oil is high. Moreover, since the number of rolling mills, arranged throughout an entire rolling line, is limited, a reduction rate per unit stand is high, which may be high reduction rolling conditions.

[0004] Thus, when a workpiece with high deformation resistance, such as stainless steel, is high-speed rolled under high reduction rolling conditions, a temperature in a roll bite is increased, so viscosity of rolling oil is lowered. Accordingly, lubrication performance of the rolling oil may be deteriorated, such that a surface defect such as a heat streak may occur.

[0005] A heat streak defect is a defect occurring when a surface is damaged due to surface adhesion between a roll and a workpiece, and is then transferred to a workpiece. Moreover, a heat streak defect is a defect frequently occurring in high strength and high reduction rolling conditions such as in rolling stainless steel.

[0006] Thus, in order to prevent such a defect from occurring, a roll is cooled using a coolant. In this case, as the roll is cooled, viscosity of an oil film of rolling oil is increased, while surface gloss of a workpiece is lowered.

[0007] In other words, in order to prevent a surface defect of a workpiece, it is necessary to maintain proper viscosity of rolling oil. However, as viscosity of rolling oil is increased, there may be a problem in which surface gloss of a workpiece is lowered. In the case in which a workpiece in which surface gloss is significantly important, such as stainless steel, is rolled, the problem described above may be a more sensitive issue.

[Disclosure]

[Technical Problem]

[0008] An aspect of the present disclosure is to improve quality while suppressing occurrence of a defect.

[0009] An aspect of the present disclosure is to perform high-speed rolling at a constant quality, and to improve productivity.

[Technical Solution]

[0010] According to an aspect of the present disclosure, a rolling mill and a method of rolling a stainless steel sheet are provided.

[0011] The rolling mill according to the present disclosure includes: a plurality of rolling roll sets, composed of at least a pair of rolls opposing each other with a workpiece being conveyed interposed therebetween, and provided in a conveying direction of the workpiece; a plurality of rolling oil supply devices, provided corresponding to each of the rolling roll sets, for supplying rolling oil to the rolling roll sets; a plurality of cooling devices, provided corresponding to each of the rolling roll sets, for supplying a gas to the workpiece and the rolling roll sets; a gloss measuring device, disposed between a rolling roll set most rearwardly disposed in a moving direction of the workpiece and a winder for winding the workpiece to measure surface gloss of the workpiece; and a control device, connected to the gloss measuring device and the plurality of cooling devices to control an amount of gas supplied by the plurality of cooling devices according to surface gloss measured by the gloss measuring device.

[0012] The gloss measuring device may be provided as a plurality of gloss measuring devices, the plurality of gloss measuring devices being provided between an outlet of a leading rolling roll set in the conveying direction of the workpiece and an inlet of a trailing rolling roll set and measuring surface gloss of the workpiece in real time, and the control device may be connected to the plurality of gloss measuring devices and the plurality of cooling devices to control an amount of gas, supplied by the cooling device followed by the gloss measuring device, based on an error between surface gloss measured by the gloss measuring device, and target surface gloss of the workpiece.

[0013] The gloss measuring device may measure surface gloss of the workpiece in real time, and the control device may receive the surface gloss, measured by the gloss measuring device, to generate a measured surface gloss value, and may control a supply amount of gas, supplied by the plurality of cooling devices, based on an error between a target surface gloss value of the workpiece, and the measured surface gloss value.

[0014] The control device may generate a total supply amount of gas based on an error between a target surface gloss value of the workpiece and the measured surface gloss value, may control a total amount of gas, supplied by the plurality of cooling devices, at least to be equal to the total supply amount of gas, and may control the plurality of cooling devices to supply different amounts of gas.

[0015] The cooling device may include: a cooling housing, provided in an inlet and an outlet of each of the rolling roll sets; a first supply pipe and a second supply pipe, connected to a gas supply tank, and provided in the cooling housing; a first nozzle, provided in the first supply pipe, and supplying gas to the workpiece; a second nozzle, provided in the second supply pipe, and supplying gas to a gap between the rolls, through which the workpiece passes; and a first flow control valve and a second flow control valve, provided in the first supply pipe and the second supply pipe and connected to the control device.

[0016] The control device may perform PI control, and may control at least one, of the first flow control valve and the second flow control valve, to increase a flow rate of at least one of the first supply pipe and the second supply pipe when the measured surface gloss value is greater than the target surface gloss value, and to reduce a flow rate of at least one of the first supply pipe and the second supply pipe when the measured surface gloss value is less than the target surface gloss value.

[0017] The gloss measuring device may include: a measuring housing, installed on a conveying path of the workpiece; a measuring roll, provided to move in the measuring housing and in a state of contact or non-contact with the workpiece; a light emitting unit, provided in the measuring roll, and allowing light to be incident on a surface of the workpiece; and a light receiving unit, provided in the measuring roll, and measuring light reflected from a surface of the workpiece.

[0018] Gas, stored in the gas supply tank, may be liquefied nitrogen.

[0019] Another aspect of the present disclosure is to provide a rolling method of a stainless steel sheet, allowing a surface of a stainless steel sheet to have a target surface gloss value by including a plurality of rolling roll sets, provided as a pair of rolls opposing each other, in a moving direction of the steel sheet, and the rolling method includes: fluid supplying, for supplying rolling oil and gas for cooling to each of the rolling roll sets; surface measuring, for measuring a surface gloss value of the steel sheet in real time, between an outlet of a rolling roll set most rearwardly disposed in a moving direction of the steel sheet and a front end of a winder of the steel sheet; and flow rate controlling, for controlling an amount of gas, supplied in the fluid supplying, according to a difference between the measured surface gloss value, measured in the surface measuring, and a target surface gloss value.

[0020] In the surface measuring, a surface gloss value of the steel sheet may be measured in real time between an outlet of a leading rolling roll set in a conveying direction of the steel sheet and an inlet of a trailing rolling roll set, and, in the flow rate controlling, an amount of gas, supplied to each of the rolling roll sets, may be controlled according to a difference between each measured surface gloss value, measured in the surface measuring, and a target surface gloss value set for each of the rolling roll sets.

[0021] In the flow rate controlling, when the measured surface gloss value, measured in the surface measuring, exceeds 110% or is less than 90%, of a target surface gloss value for the rolling roll set, passing immediately before reaching a position in which surface gloss of the steel sheet is measured, a supply amount of gas, supplied in the fluid supplying, may be changed.

[0022] In the flow rate controlling, the supply amount of gas may be controlled by PI control, and the supply amount (u(t)) of gas at random times may be determined by $u(t) = k_p e(t) + k_i \int_0^t e(\tau)\, d\tau$, where kp is a proportional control gain,

ki is an integral control gain, and

e (t) is a value of a difference between a measured surface gloss value and a target surface gloss value at random times.

[Advantageous Effects]

[0023] As set forth above, according to an exemplary embodiment, during rolling, defect occurrence, in detail, surface defect occurrence may be suppressed.

[0024] Moreover, while high-speed rolling may be performed at a constant quality, productivity and quality may be improved.

[Description of Drawings]

[0025]

FIG. 1 is a conceptual diagram of a rolling mill according to an exemplary embodiment.

FIG. 2 is a conceptual diagram of a rolling mill according to another exemplary embodiment.

FIG. 3 is a conceptual diagram of a cooling device of the present disclosure.

FIG. 4 is a conceptual diagram of a gloss measuring device of the present disclosure.

FIG. 5 is a conceptual diagram of a rolling method of a stainless steel sheet according to the present disclosure.

FIG. 6 illustrates a difference between a measured surface gloss value, measured by a gloss measuring device of the present disclosure, and a target surface gloss value.

[Best Mode for Invention]

[0026] To help understand the description of embodiments of the present disclosure, elements denoted by the same reference numerals in the drawings are used for the same elements, and relevant components, among components having the same function in each of embodiments, are denoted by the same or an extension number.

[0027] To clarify the gist of the present disclosure, description of elements and techniques known in the art will be omitted, and the present disclosure will be described in detail with reference to the accompanying drawings.

[0028] The spirit of the present disclosure is not limited to the embodiments proposed, and may be suggested as other elements added, changed, and deleted by those skilled in the art, which is also included within the scope of the same concept as the present disclosure.

[0029] In FIG. 1, a rolling mill 1000 according to an exemplary embodiment is illustrated. The rolling mill 1000 according to an exemplary embodiment may include a rolling roll set 100 including working rolls 110 opposing each other with a workpiece 10, being conveyed, interposed therebetween, an intermediate roll 120, and a backup roll 130.

[0030] The rolling roll set 100 may be provided as a plurality of rolling roll sets in a conveying direction of the workpiece 10, and is referred to as a first rolling roll set 100a, a second rolling roll set 100b, and a third rolling roll set 100c for convenience of explanation. Each rolling roll set may include at least a pair of working rolls 110, a pair of intermediate rolls 120, and a pair of backup rolls 130.

[0031] However, the present disclosure is not limited thereto, and the configuration and the number of rolling roll sets may be appropriately changed and applied by those skilled in the art.

[0032] Rolling oil is supplied to each rolling roll set by a rolling oil supply device 200. The rolling oil supply device 200 may include a rolling oil supply tank 210 accommodating rolling oil, a rolling oil supply pipe 220 provided as a moving path of the rolling oil accommodated in the rolling oil supply tank, and a rolling oil supply housing 230 connected to the rolling oil supply pipe 220 and disposed around the rolling roll set.

[0033] The rolling oil supply housing 230 is provided in each of an inlet and an outlet of the working roll 110, and may include a nozzle (not shown) injecting rolling oil into a roll. Moreover, the rolling oil supply housing 230 may include a first housing 230a supplying rolling oil to the first rolling roll set 100a, a second housing 230b supplying rolling oil to the second rolling roll set 100b, and a third housing 230c supplying rolling oil to the third rolling roll set 100c.

[0034] Due to the configuration described above, rolling oil, supplied by the rolling oil supply device 200, may act between a roll and a workpiece to help smooth rolling. However, as the working time continues and a temperature of the roll rises, a temperature of the rolling oil may also rise.

[0035] In this case, viscosity of rolling oil is lowered, so a lubrication function may be lost, and a surface defect such as a heat streak may occur in a workpiece. In order to prevent a surface defect of a workpiece, described above, it is necessary to cool the workpiece 10 and the roll to a certain level.

[0036] To this end, in order to supply liquefied nitrogen as gas for cooling to a workpiece and roll, a cooling housing 310 may be provided in one side of the rolling oil supply housing 230. Moreover, the cooling housing 310 is also provided corresponding to the first rolling roll set 100a, the second rolling roll set 100b, and the third rolling roll set 100c on a one-by-one basis, in a manner similar to the rolling oil supply housing 230.

[0037] However, a type of the gas for cooling is not limited to the present disclosure, and the number of the cooling housing 310 provided in the first rolling roll set 100a is also not limited to the present disclosure and may be suitably modified and applied by those skilled in the art.

[0038] The gas supply tank 600 and the cooling housing 310, accommodating gas for cooling, may be connected by a pipe unit 350. Moreover, the pipe unit 350 may be provided with a valve unit 360 to control a flow rate of gas.

[0039] The valve unit 360 may include a first valve unit 360a, a second valve unit 360b, and a third valve unit 360c, to control gas for cooling to be supplied to the first rolling roll set, the second rolling roll set, and the third rolling roll set.

[0040] Moreover, the first valve unit 360a, the second valve unit 360b, and the third valve unit 360c are connected to the control device 500, and the control device 500 may control the first valve unit 360a, the second valve unit 360b, and the third valve unit 360c according to a surface gloss value of a workpiece, measured by the gloss measuring device 400, to control a flow rate of gas for cooling.

[0041] In this case, since accurate and precise control for each rolling operation of the workpiece 10 may be performed to allow the rolling oil supply housing 230, the cooling housing 310, and the valve unit 360 to correspond to the first rolling roll set 100a, the second rolling roll set 100b, and the third rolling roll set 100c on a one-by-one basis, quality may be improved.

[0042] Meanwhile, if a temperature of a workpiece and a roll is decreased by gas for cooling in order to prevent a surface defect such as heat streak during a rolling process, a temperature of the rolling oil is also decreased. Thus, viscosity of the rolling oil is gradually increased. In this case, if the viscosity of the rolling oil is increased, a problem in which surface gloss of the workpiece 10 is reduced may occur. In the case of stainless steel, surface gloss is more significant, so the problem described above is required to be solved.

[0043] Thus, in the present disclosure, surface gloss of the workpiece 10, which is to be a rolled workpiece, is measured in real time, and the surface gloss is compared with a target surface gloss value. Then, based on the comparison, a supply amount of gas for cooling is controlled.

[0044] To this end, the gloss measuring device 400 measures surface gloss of the workpiece 10 in real time between the third rolling roll set 100c and the winder 800, and the control device 500 receives the surface gloss, measured by the gloss measuring device 400, to generate a measured surface gloss value, and may control an amount of gas for cooling, supplied through the cooling housing 310, based on an error between a target surface gloss value of the workpiece, and the measured surface gloss value, measured by the gloss measuring device

400.

[0045] In this case, the target surface gloss value of the workpiece 10 is a desired surface gloss value, and the measured surface gloss value, measured by the gloss measuring device 400, is at least equal to the target surface gloss value to achieve a desired surface quality.

[0046] When the gloss measuring device 400 is disposed between the third rolling roll set 100c and the winder 800 to measure surface gloss of the workpiece, an amount of gas for cooling, supplied by the third rolling roll set 100c, may be more sensitively controlled as compared with an amount of gas for cooling, supplied by the first rolling roll set 100a and the second rolling roll set 100b.

[0047] However, it is not limited to the present disclosure, and may be suitably modified and applied by those skilled in the art.

[0048] Meanwhile, as illustrated in FIG. 2, it may be configured to measure surface gloss of the workpiece 10 in an outlet of each rolling roll set. In other words, the gloss measuring device 400 is provided between an outlet of the first rolling roll set 100a and an inlet of the second rolling roll set 100b, between an outlet of the second rolling roll set and an inlet of the third rolling roll set, and between an outlet of the third rolling roll set and the winder 800.

[0049] Thus, information on surface gloss, measured by the gloss measuring device 400 provided between the outlet of the first rolling roll set 100a and the inlet of the second rolling roll set 100b may be information on the workpiece 10, only passing through the first rolling roll set 100a, and other gloss measuring devices also measure surface gloss in a similar manner.

[0050] Thus, the control device 500 may receive information on surface gloss of the workpiece 10 for each rolling operation, and may control a supply amount of gas for cooling for each rolling operation. Thus, if surface gloss of the workpiece 10, passing through the first rolling roll set 100a, is significantly lower or higher than a target value, a flow rate of gas for cooling is controlled through the first valve unit 360a in the operation described above to adjust viscosity of rolling oil to an appropriate level.

[0051] Thus, a rolling state is checked at the beginning of rolling of the workpiece 10 to significantly reduce a defect rate, and an amount of gas for cooling, to be supplied to the second rolling roll set 100b and the third rolling roll set 100c, may be expected, based on a measured surface gloss value by the first rolling roll set 100a.

[0052] Hereinafter, an exemplary embodiment of the cooling device 300 of the present disclosure will be described with reference to FIG. 3.

[0053] The cooling device 300 according to the present disclosure may include a cooling housing 310, provided in an inlet and an outlet of each of the first rolling roll set, the second rolling roll set, and the third rolling roll set (100a, 100b, and 100c of FIGS. 1 and 2), and the cooling housing 310 may be provided as a plurality of cooling housings as needed in a single rolling roll set.

[0054] The cooling housing 310 is provided with a pipe unit 350, connected to the gas supply tank 600 and provided as a moving path of gas for cooling, and the pipe unit 350 may include a first supply pipe 320 and a second supply pipe 330, passing through one surface of the workpiece 10.

[0055] The first supply pipe 320 is provided with a plurality of first nozzles 321 in a longitudinal direction, and the first nozzle 321 is provided to allow an injection hole to oppose one surface of the workpiece 10 and may supply gas for cooling to the workpiece 10.

[0056] Moreover, the second supply pipe 330 is provided with a plurality of second nozzles 331 in a longitudinal direction, and the second nozzle 331 is disposed to allow an injection hole to oppose a gap between the working rolls 110 and supply gas for cooling to the working roll 110 or to a gap between working rolls 110 vertically opposing each other.

[0057] Due to the first supply pipe 320 and the second supply pipe 330 configured as described above, gas for cooling, supplied to a workpiece and a working roll, may be individually controlled, so individual cooling control may be performed according to a cooling state of a workpiece and a working roll.

[0058] Moreover, on each of the first supply pipe 320 and the second supply pipe 330, a first flow control valve 322 and a second flow control valve 332 may be provided. The first flow control valve 322 and the second flow control valve 332 are connected to a control device 500, and whether the first flow control valve and the second flow control valve are open or closed is controlled by the control device 500, so a flow rate of gas for cooling, supplied by the gas supply tank 600, may be controlled.

[0059] The control device 500 calculates a difference between a measured surface gloss value and a target surface gloss value, and thus may calculate a total supply amount of gas for cooling according to a difference value therbetween. Moreover, in order to achieve the total supply amount, as illustrated in FIG. 2 or FIG. 3, an amount of gas for cooling, supplied by the first nozzle or the second nozzle (321 or 331 of FIG. 3) installed in the cooling housing 310, sequentially disposed in a conveying direction of the workpiece 10, may be the same or different from each other.

[0060] In other words, as illustrated in FIG. 2, an amount of gas supplied by the first nozzle or the second nozzle installed in the cooling housing 310 supplying gas for cooling to the first rolling roll set 100a, an amount of gas supplied by the first nozzle or the second nozzle installed in the cooling housing 310 supplying gas for cooling to the second rolling roll set 100b, and an amount of gas supplied by the first nozzle or the second nozzle installed in the cooling housing 310 supplying gas for cooling to the third rolling roll set 100c, may be the same or different from each other.

[0061] In detail, when different gas for cooling is supplied in each rolling operation, in consideration of characteristics of the workpiece 10, rolling conditions, and the like, individual rolling process control may be performed, and an error between a measured surface gloss value and a target surface gloss value may be further reduced. Thus, rolling productivity and surface quality may be improved.

[0062] For example, gas is supplied to the first rolling roll set 100a, the second rolling roll set 100b, and the third rolling roll set 100c, to allow the sum of an amount of gas for cooling, supplied through the first nozzle or the second nozzle provided in the cooling housing 310 installed in the first rolling roll set 100a, the second rolling roll set 100b, and the third rolling roll set 100c, to be at least equal to a total amount of gas for cooling, having been calculated. Meanwhile, an amount of gas for cooling, supplied to the first rolling roll set 100a, among the first rolling roll set 100a, the second rolling roll set 100b, and the third rolling roll set 100c, is the smallest, while an amount of gas for cooling, supplied to the third rolling roll set 100c, may be the greatest.

[0063] Thus, considering that the workpiece 10 is air-cooled while being transferred from the first rolling roll set 100a to the third rolling roll set 100c, minimum cooling may be performed in the first rolling roll set 100a. Thus, the workpiece 10 may be prevented from being excessively cooled before reaching the third rolling roll set 100c.

[0064] However, it is not limited to the present disclosure, and may be suitably modified and applied by those skilled in the art.

[0065] Meanwhile, in FIG. 4, a gloss measuring device 400 according to an exemplary embodiment is illustrated.

[0066] The gloss measuring device 400 may include a measuring housing 410 installed on a conveying path of the workpiece 10, a measuring roll 420 provided to move in a direction of the workpiece 10 in the measuring housing 410 and in a state of contact or non-contact with a surface of the workpiece 10, a light emitting unit 430 provided in the measuring roll, and allowing light to be incident on a surface of the workpiece, and a light receiving unit 440 provided in the measuring roll and measuring light reflected from a surface of the workpiece.

[0067] In this case, a guide member 450 allowing the measuring roll 420 to be lifted or lowered may be provided on both sides of the measuring housing 410. The guide member 450 is connected to a rotating shaft (not shown) of the measuring roll 420, and may be connected by a bearing member (not shown) to allow the measuring roll 420 to rotate.

[0068] The guide member 450 may allow the measuring roll 420 to be in contact with or in non-contact with a surface of the workpiece 10 by increasing or reducing its own length, and may be provided as a rack and a pinion gear, a linear guide, and the like, within the scope of such technical ideas. However, a type thereof is not limited to the present disclosure.

[0069] The measuring roll 420 is provided with a measuring groove 460 in one side opposing the workpiece 10. The measuring groove 460 is a groove which is concave inwardly of a body of the measuring roll 420, and the light emitting unit 430 to allow light to be incident on a surface of the workpiece 10 and the light receiving unit 440 measuring light reflected from the surface of the workpiece 10 may be provided in the measuring groove 460.

[0070] As described above, gloss of a surface of the workpiece 10 is measured through an intensity ratio of incident light and reflected light, by the light emitting unit 430 and the light receiving unit 440. Moreover, as described above, when the light emitting unit 430 and the light receiving unit 440 are provided in the measuring groove 460, light, reflected from an external source, may be blocked, so accuracy of measurement may be further improved.

[0071] Moreover, in order to prevent fine damage of a surface of the workpiece 10 by a measuring roll 420, in contact with the surface of the workpiece 10, a buffer member (not shown), formed of a workpiece with high ductility, may be provided in an outer circumference of the measuring roll 420.

[0072] Meanwhile, another aspect of the present disclosure is to provide a rolling method for rolling to allow a surface of a stainless steel sheet to have a target surface gloss value by including a plurality of rolling roll sets, provided as a pair of rolls opposing each other, in a moving direction of the steel sheet.

[0073] In this case, the rolling roll set may include a pair of working rolls, directly pressing a surface of a steel sheet, and may further include a pair of intermediate rolls, pressing the working roll, and a pair of backup rolls. Hereinafter, the pair of working rolls, the pair of intermediate rolls, and the pair of backup rolls are referred to as a rolling roll set.

[0074] As illustrated in FIG. 5, a rolling method according to an exemplary embodiment may include: fluid supplying (S910) for supplying rolling oil and gas for cooling to each of the rolling roll sets; surface measuring (S920) for measuring a surface gloss value of the steel sheet in real time, between an outlet of a rolling roll set most rearwardly disposed in a moving direction of the steel sheet and a front end of a winder of the steel sheet; and flow rate controlling (S930) for controlling an amount of gas, supplied in the fluid supplying, according to a difference between a measured surface gloss value, measured in the surface measuring, and a target surface gloss value.

[0075] In the surface measuring (S920), surface gloss one time may be measured between a rolling roll set most rearwardly disposed in a conveying direction of a steel sheet and a winder for winding the steel sheet, or surface gloss multiple times may be measured in an outlet of each of the rolling roll sets.

[0076] When the former is referred to as final surface measurement and the latter is referred to as individual surface measurement, in a method using the final surface measurement, gas for cooling, supplied to a rolling roll set most rearwardly disposed, may be most sensitively controlled. In this regard, because the gas for cooling, supplied by the rolling roll set most rearwardly disposed, has the greatest effect on surface gloss of the steel sheet.

[0077] Meanwhile, in a method using the individual surface measurement, surface gloss of a steel sheet for each rolling operation may be controlled. Thus, a surface defect of a workpiece may be recognized at the beginning of a process, and a surface of a steel sheet according to each rolling operation may be controlled.

[0078] The surface gloss value, measured in the surface measuring (S920) as described above, may be used for controlling an amount of gas for cooling in the flow rate controlling (S930) . Here, in the case of the final surface measurement in the surface measuring (S920), a flow rate may be controlled according to final surface gloss in the flow rate controlling. Alternatively, in the case of the individual surface measurement, a flow rate may be controlled according to individual surface gloss in the flow rate controlling.

[0079] Moreover, in the flow rate controlling, an amount of gas for cooling, supplied to each of the rolling roll sets, may all be the same, or may all be different. However, when an amount of gas for cooling, supplied to a rolling roll set, is adjusted to be different for each rolling operation according to characteristics of a steel sheet and rolling conditions, precise control in which process characteristics are reflected may be performed, so quality may be improved.

[0080] However, it is not limited to the present disclosure, and may be suitably modified and applied by those skilled in the art.

[0081] Meanwhile, an amount of gas for cooling, controlled in the flow rate controlling, may be controlled by a difference between a measured surface gloss value of a steel sheet, and a target surface gloss value to be achieved. The control described above, as illustrated in FIG. 6, may be performed, when the measured surface gloss value exceeds 110% of the target surface gloss value, or is less than 90% thereof.

[0082] In other words, only when an error value, a difference between a measured surface gloss value and a target surface gloss value, is outside of ±10% of the target surface gloss value (greater than or less than), an amount of gas for cooling to be supplied is changed. Alternatively, when the error value is in a normal range (D), that is, ±10%, gas for cooling suitable for a corresponding target surface gloss value is supplied as it is.

[0083] In this case, when the measured surface gloss value exceeds 110% of the target surface gloss value, a supply amount of gas for cooling is increased. Alternatively, when the measured surface gloss value is less than 90% of the target surface gloss value, a supply amount of gas for cooling is reduced, so temperatures of a steel sheet, a working roll, and rolling oil are controlled. Thus, surface gloss of the steel sheet may be controlled in a normal range.

[0084] However, when the measured surface gloss value exceeds 110% of the target surface gloss value, or is less than 90% thereof, the error value is out of the normal range (D). In this case, an amount of gas for cooling may be controlled by PI control.

[0085] In this regard, when a workpiece of a rolled workpiece is stainless 304 steel white coil, a thickness of an inlet workpiece is 3.0 to 4.0 mmt, a total reduction rate is 50% to 60%, and rolling oil, having been used, is mineral oil with viscosity of 12 to 18 cSt(@40°C) and a saponification value (SV) of 40 to 45 mgKOH/g, as a result of measurement of surface gloss of a steel sheet, an average value is 210 and a standard deviation is 20. Here, there is a variation of about 10%. Thus, the case, in which an error value is between ±10%, indicates a normal range, and a supply amount of gas for cooling is not changed in the normal range.

[0086] Meanwhile, a supply amount of gas for cooling at random times may be calculated according to [Equation 1].

[Equation 1]

$$u(t) = k_p e(t) + k_i \int_0^t e(\tau)\, d\tau$$

Here,

u(t) = an injection amount of liquefied nitrogen at random times,
e(t) = a value of a difference between a measured surface gloss value and a target surface gloss value, at random times,
k_p = a proportional control gain, and
k_i = an integral control gain.

[0087] Here, a proportional control gain, and an integral control gain are values determined by a steel type, rolling conditions, and the like.

[0088] When an amount of gas for cooling is calculated by [Equation 1], an error which may be accumulated as a process is performed, so a surface quality of a steel sheet may be improved.

Claims

1. A rolling mill, comprising:

a plurality of rolling roll sets, composed of at least a pair of rolls opposing each other with a workpiece being conveyed interposed therebetween, and provided in a conveying direction of the workpiece;
a plurality of rolling oil supply devices, provided corresponding to each of the rolling roll sets, for supplying rolling oil to the rolling roll sets;
a plurality of cooling devices, provided corresponding to each of the rolling roll sets, for supplying a gas to the workpiece and the rolling roll

sets;

a gloss measuring device, disposed between a rolling roll set most rearwardly disposed in a moving direction of the workpiece and a winder for winding the workpiece to measure surface gloss of the workpiece; and

a control device, connected to the gloss measuring device and the plurality of cooling devices to control an amount of gas supplied by the plurality of cooling devices according to surface gloss measured by the gloss measuring device.

2. The rolling mill of claim 1, wherein the gloss measuring device is provided as a plurality of gloss measuring devices, the plurality of gloss measuring devices being provided between an outlet of a leading rolling roll set in the conveying direction of the workpiece and an inlet of a trailing rolling roll set and measuring surface gloss of the workpiece in real time, and
the control device is connected to the plurality of gloss measuring devices and the plurality of cooling devices to control an amount of gas, supplied by the cooling device followed by the gloss measuring device, based on an error between surface gloss measured by the gloss measuring device, and target surface gloss of the workpiece.

3. The rolling mill of claim 1, wherein the gloss measuring device measures surface gloss of the workpiece in real time, and
the control device receives the surface gloss, measured by the gloss measuring device, to generate a measured surface gloss value, and controls a supply amount of gas, supplied by the plurality of cooling devices, based on an error between a target surface gloss value of the workpiece, and the measured surface gloss value.

4. The rolling mill of claim 3, wherein the control device generates a total supply amount of gas based on an error between a target surface gloss value of the workpiece and the measured surface gloss value, controls a total amount of gas, supplied by the plurality of cooling devices, at least to be equal to the total supply amount of gas, and controls the plurality of cooling devices to supply different amounts of gas.

5. The rolling mill of any one of claims 2 to 4, wherein the cooling device includes:

a cooling housing, provided in an inlet and an outlet of each of the rolling roll sets;

a first supply pipe and a second supply pipe, connected to a gas supply tank, and provided in the cooling housing; a first nozzle, provided in the first supply pipe, and supplying gas to the workpiece;

a second nozzle, provided in the second supply pipe, and supplying gas to a gap between the rolls, through which the workpiece passes; and

a first flow control valve and a second flow control valve, provided in the first supply pipe and the second supply pipe and connected to the control device.

6. The rolling mill of claim 5, wherein the control device performs PI control, and controls at least one, of the first flow control valve and the second flow control valve, to increase a flow rate of at least one of the first supply pipe and the second supply pipe when the measured surface gloss value is greater than the target surface gloss value, and to reduce a flow rate of at least one of the first supply pipe and the second supply pipe when the measured surface gloss value is less than the target surface gloss value.

7. The rolling mill of any one of claims 1 to 4, wherein the gloss measuring device includes:

a measuring housing, installed on a conveying path of the workpiece;

a measuring roll, provided to move in the measuring housing and in a state of contact or non-contact with the workpiece;

a light emitting unit, provided in the measuring roll, and allowing light to be incident on a surface of the workpiece; and

a light receiving unit, provided in the measuring roll, and measuring light reflected from a surface of the workpiece.

8. The rolling mill of claim 5, wherein gas, stored in the gas supply tank, is liquefied nitrogen.

9. A rolling method of a stainless steel sheet, allowing a surface of a stainless steel sheet to have a target surface gloss value by including a plurality of rolling roll sets, provided as a pair of rolls opposing each other, in a moving direction of the steel sheet,
the rolling method, comprising:

fluid supplying, for supplying rolling oil and gas for cooling to each of the rolling roll sets;

surface measuring, for measuring a surface gloss value of the steel sheet in real time, between an outlet of a rolling roll set most rearwardly disposed in a moving direction of the steel sheet and a front end of a winder of the steel sheet; and

flow rate controlling, for controlling an amount of gas, supplied in the fluid supplying, according to a difference between the measured surface gloss value, measured in the surface measuring, and a target surface gloss value.

10. The rolling method of a stainless steel sheet of claim 9, wherein, in the surface measuring, a surface gloss value of the steel sheet is measured in real time between an outlet of a leading rolling roll set in a conveying direction of the steel sheet and an inlet of a trailing rolling roll set, and
in the flow rate controlling, an amount of gas, supplied to each of the rolling roll sets, is controlled according to a difference between each measured surface gloss value, measured in the surface measuring, and a target surface gloss value set for each of the rolling roll sets.

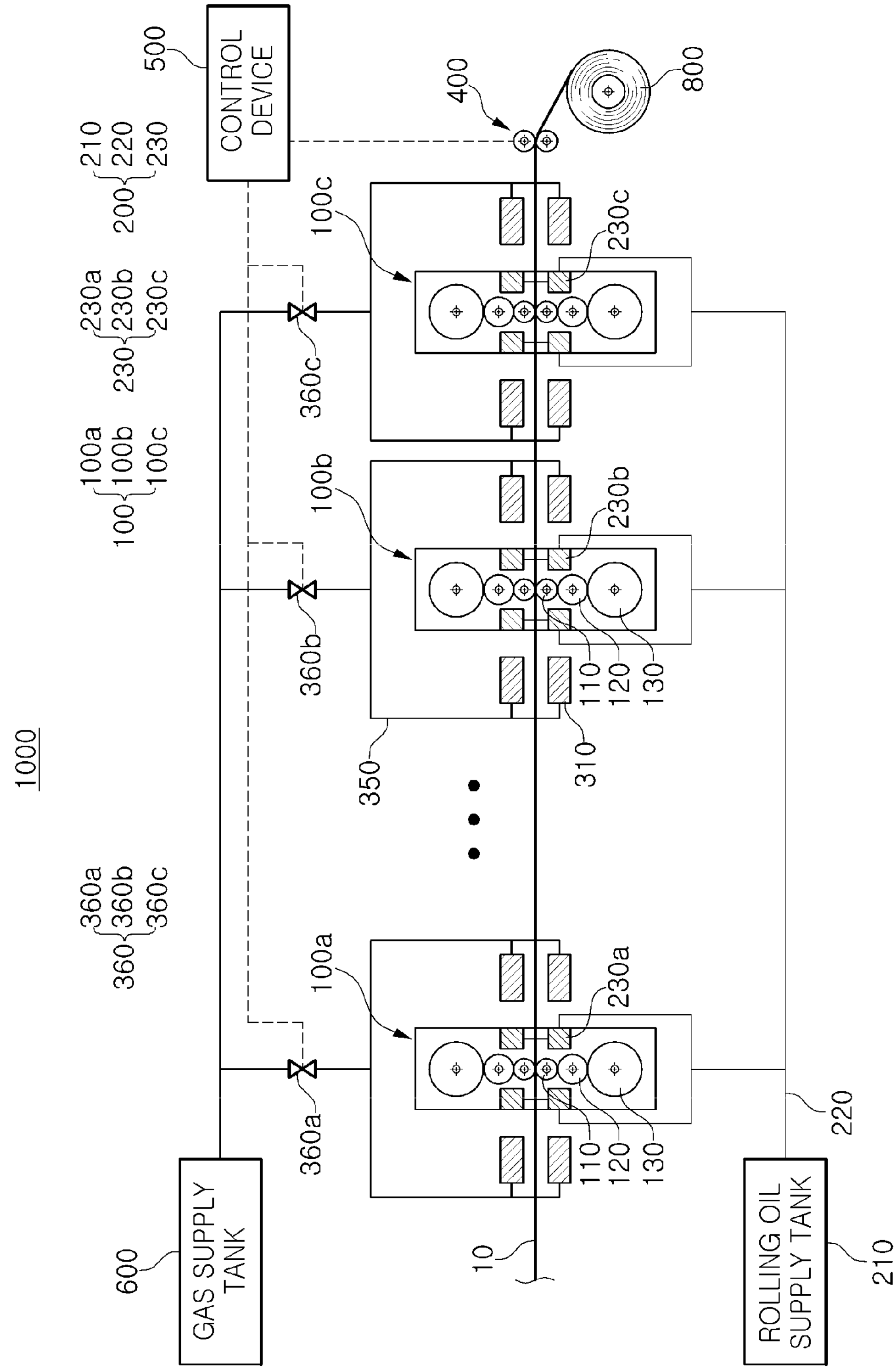
11. The rolling method of a stainless steel sheet of claim 9 or 10, wherein, in the flow rate controlling, when the measured surface gloss value, measured in the surface measuring, exceeds 110% or is less than 90%, of a target surface gloss value for the rolling roll set, passing immediately before reaching a position in which surface gloss of the steel sheet is measured, a supply amount of gas, supplied in the fluid supplying, is changed.

12. The rolling method of a stainless steel sheet of claim 11, wherein, in the flow rate controlling, the supply amount of gas is controlled by PI control, and
the supply amount (u(t)) of the gas at random times is determined by

$$u(t) = k_p e(t) + k_i \int_0^t e(\tau)\, d\tau ,$$

where k_p is a proportional control gain,
k_i is an integral control gain, and
e (t) is a value of a difference between a measured surface gloss value and a target surface gloss value, at random times.

[FIG.1]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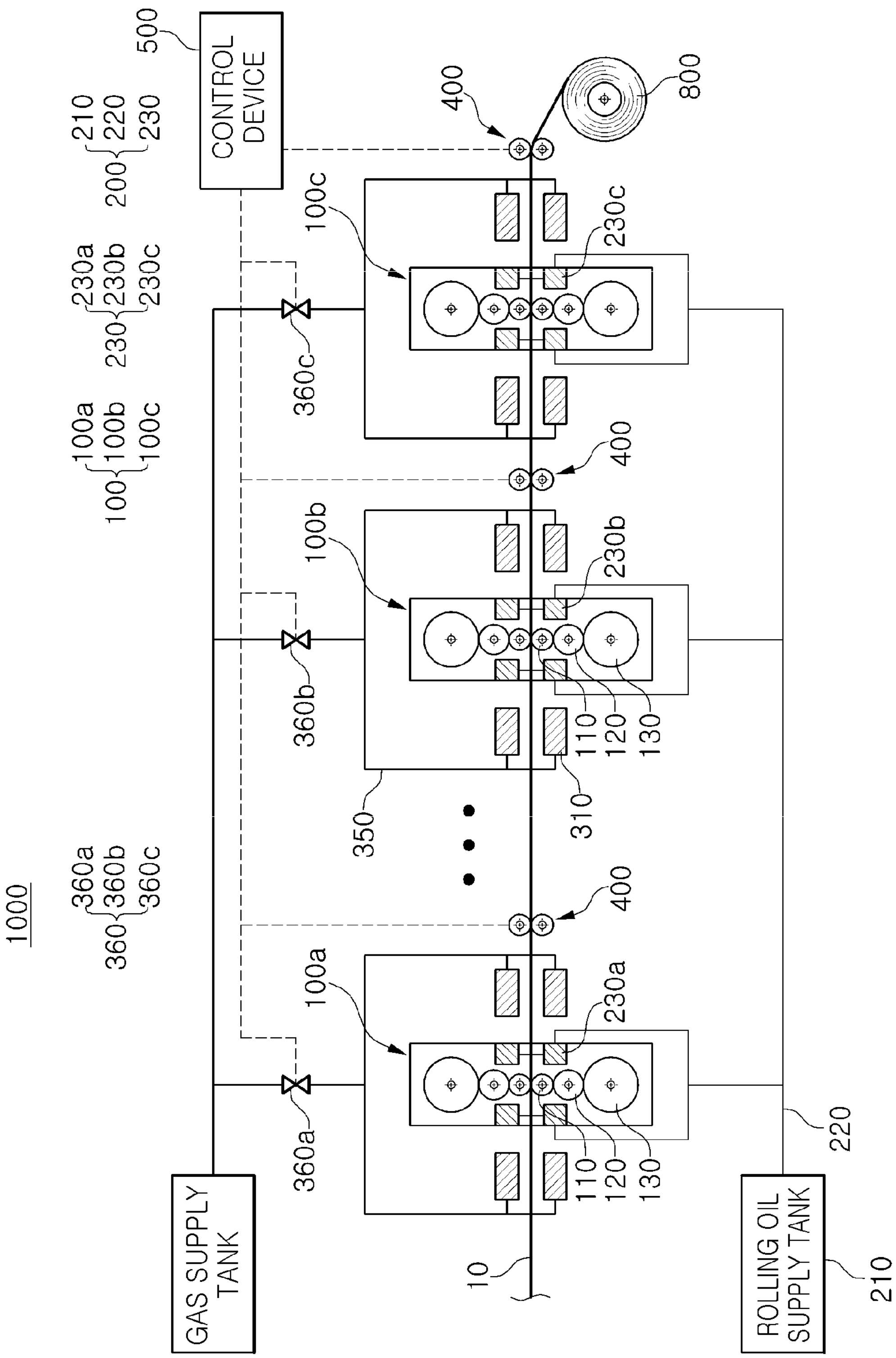
CONTROL DEVICE
500
GAS SUPPLY TANK
600
ROLLING OIL SUPPLY TANK
210
220
400
800
10
100a
100b
100c
110
120
130
230a
230b
230c
310
350
360a
360b
360c
200 { 210 220 230
230 { 230a 230b 230c
100 { 100a 100b 100c
360 { 360a 360b 360c

[FIG.2]


1000
CONTROL DEVICE
500
GAS SUPPLY TANK
ROLLING OIL SUPPLY TANK
200 { 210 220 230
230 { 230a 230b 230c
100 { 100a 100b 100c
360 { 360a 360b 360c
100a
100b
100c
230a
230b
230c
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360b
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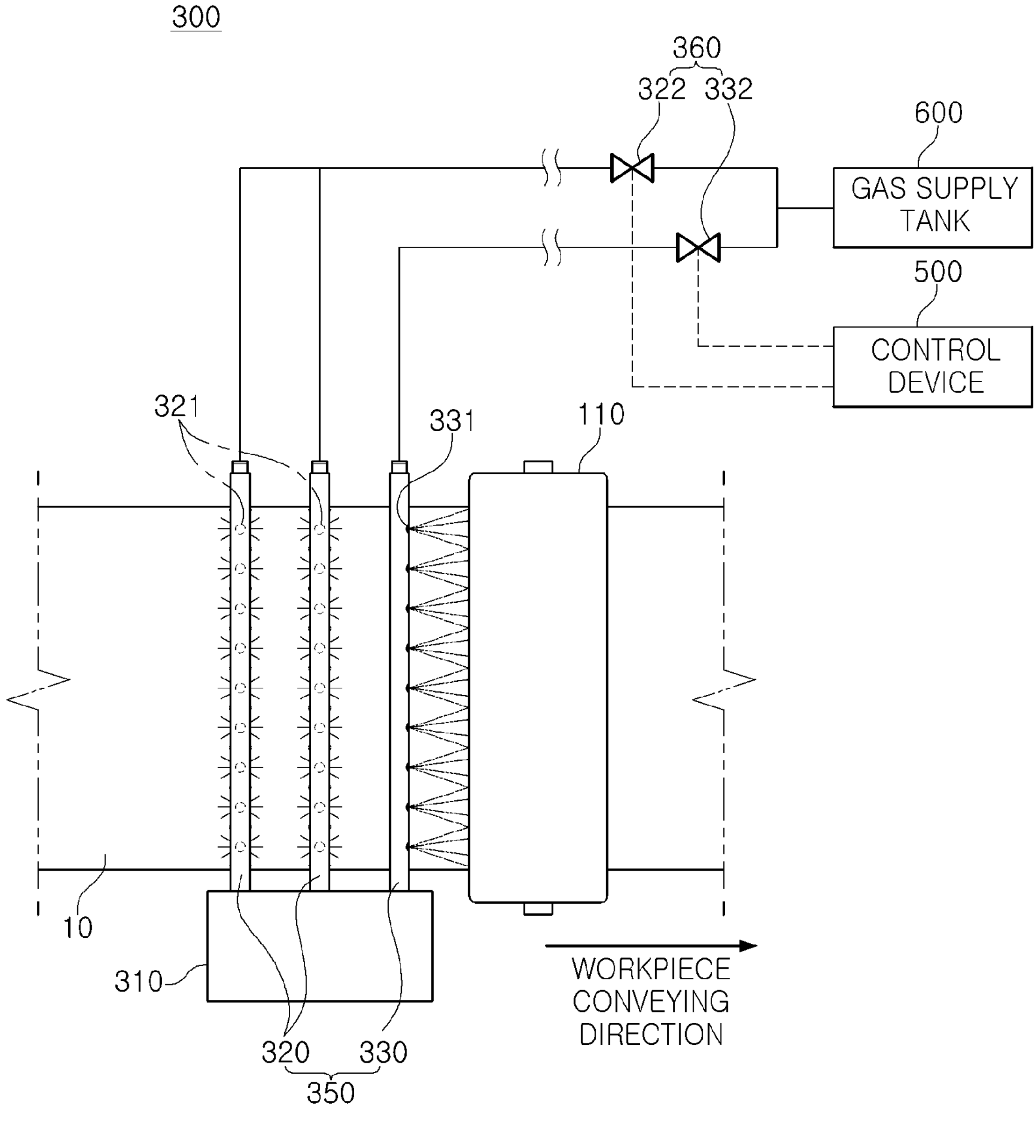
210
310
350

[FIG.3]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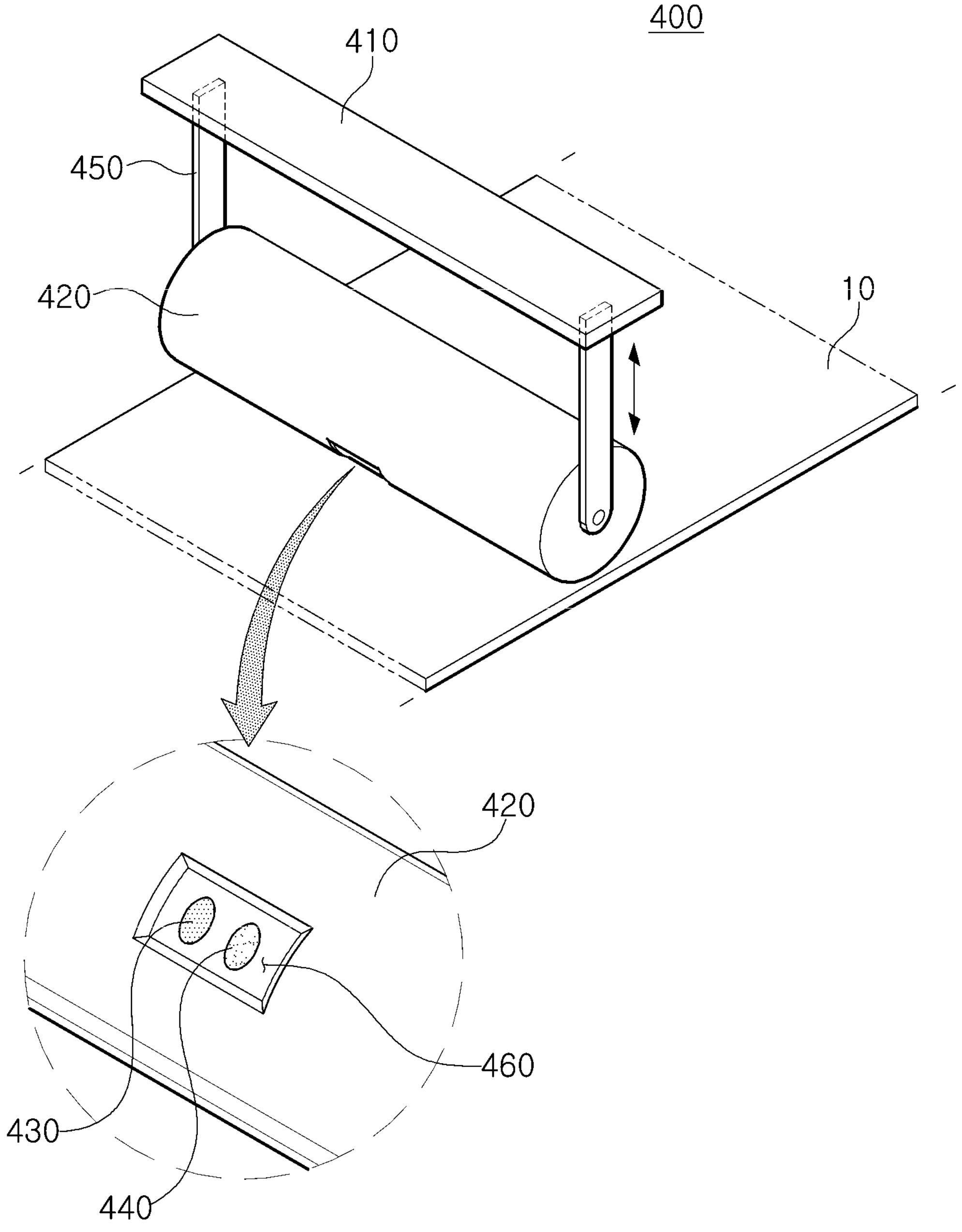
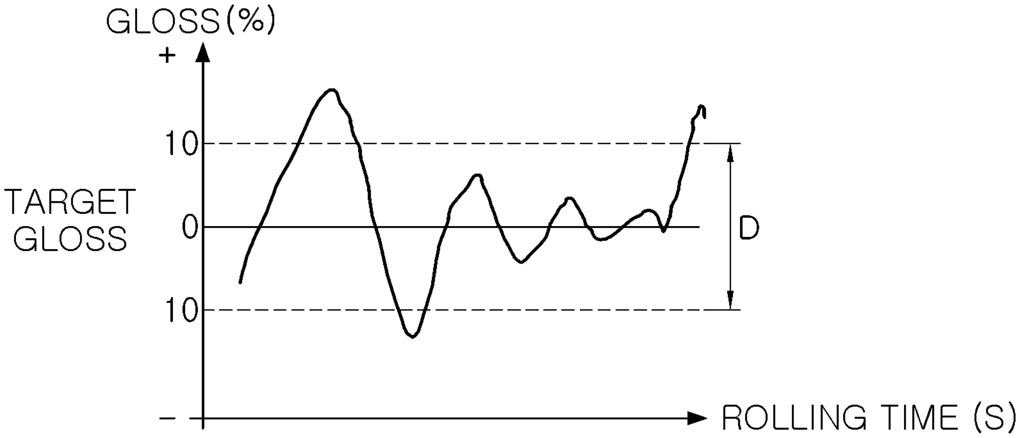
360
322
332
600
GAS SUPPLY TANK
500
CONTROL DEVICE
321
331
110
10
310
320
330
350
WORKPIECE CONVEYING DIRECTION

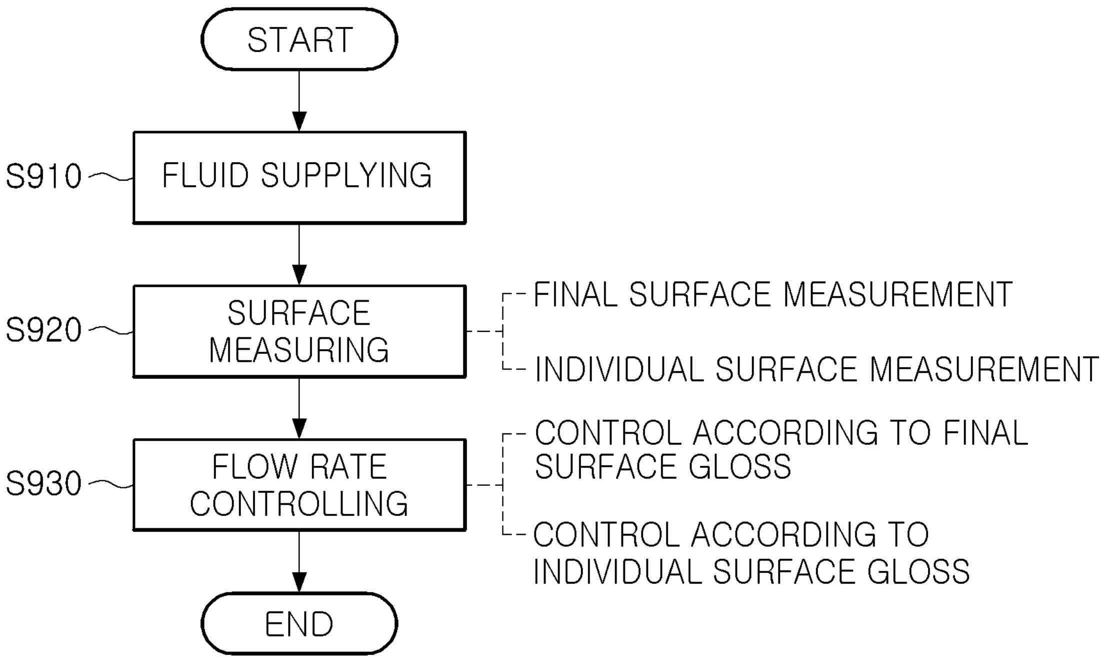
[FIG.4]



[FIG.5]


GLOSS(%)
+
10
TARGET GLOSS
0
10
D
–
ROLLING TIME (S)

[FIG.6]


START
S910
FLUID SUPPLYING
S920
SURFACE MEASURING
FINAL SURFACE MEASUREMENT
INDIVIDUAL SURFACE MEASUREMENT
S930
FLOW RATE CONTROLLING
CONTROL ACCORDING TO FINAL SURFACE GLOSS
CONTROL ACCORDING TO INDIVIDUAL SURFACE GLOSS
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2017/007607

A. CLASSIFICATION OF SUBJECT MATTER

B21B 1/24(2006.01)i, B21B 13/02(2006.01)i, B21B 27/10(2006.01)i, B21B 45/02(2006.01)i, B21B 38/00(2006.01)i, B21B 37/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B21B 1/24; C21D 1/74; B21B 45/02; B21B 1/22; B21B 27/00; B21B 13/00; B21B 45/06; B21B 27/10; B21B 3/02; B21B 13/02; B21B 38/00; B21B 37/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: material, rolling roll set, rolling oil supply means, cooling means, brilliance measuring means, control means, quantity of gas, rolling facilities

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 10-258301 A (KAWASAKI STEEL CORP.) 29 September 1998 See paragraphs [0012]-[0020]; claims 1-3; and figures 2-3.	1-12
Y	JP 08-215709 A (NIPPON STEEL CORP.) 27 August 1996 See paragraphs [0012]-[0013]; and figure 3.	1-12
Y	KR 10-2014-0000550 A (POSCO) 03 January 2014 See paragraphs [0034]-[0045], [0072]; and figure 1.	1-12
Y	KR 10-2007-0000498 A (UGINE & ALZ FRANCE) 02 January 2007 See paragraphs [0024]-[0049], [0060]; and figure 1.	7
A	JP 07-060305 A (NKK CORP.) 07 March 1995 See paragraphs [0023]-[0032]; and figures 3-5.	1-12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 SEPTEMBER 2017 (25.09.2017)	**26 SEPTEMBER 2017 (26.09.2017)**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2017/007607

Patent document cited in search report	Publication date	Patent family member	Publication date
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KR 10-2007-0000498 A	02/01/2007	AT 389470 T	15/04/2008
		BR PI0509222 A	04/09/2007
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		DE 602005005462 T2	09/04/2009
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		EP 1735116 B1	19/03/2008
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		JP 2007-530282 A	01/11/2007
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		WO 2005-102548 A1	03/11/2005
JP 07-060305 A	07/03/1995	JP 3252553 B2	04/02/2002

Form PCT/ISA/210 (patent family annex) (January 2015)