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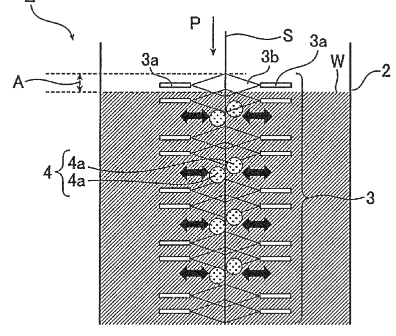
(54) METAL SHEET-QUENCHING APPARATUS, CONTINUOUS ANNEALING FACILITY, METAL SHEET-QUENCHING METHOD, COLD-ROLLED STEEL SHEET PRODUCTION METHOD, AND PLATED STEEL SHEET PRODUCTION METHOD

(57) Provided are a quenching apparatus for a metal sheet with which it is possible to inhibit shape defects from occurring in the metal sheet when quenching is performed regardless of the sheet passing speed or the sheet thickness of the metal sheet, continuous annealing equipment, a method for quenching a metal sheet, a method for manufacturing a cold rolled steel sheet, and a method for manufacturing a coated steel sheet.

A quenching apparatus for a metal sheet, the quenching apparatus having a water tank in which the metal sheet is passed and immersed in a liquid to cool the metal sheet, a water injection apparatus placed in the water tank, and plural restraining roll pairs with which the metal sheet that is passed in the water tank is restrained, in which the water injection apparatus has plural water injection nozzles arranged in a sheet passing direction of the metal sheet on front and back surface sides of the metal sheet so that cooling water is injected in facing directions from the front and back surface sides, and in which a position of each of the plural restraining roll pairs is separately adjusted with respect to the metal sheet in accordance with operation conditions.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a quenching apparatus for a metal sheet with which it is possible to inhibit shape defects from occurring in the metal sheet when quenching is performed by using continuous annealing equipment, in which annealing is performed while the metal sheet is continuously passed, and to continuous annealing equipment, a method for quenching a metal sheet, a method for manufacturing a cold rolled steel sheet, and a method for manufacturing a coated steel sheet.

Background Art

[0002] When a metal sheet such as a steel sheet is manufactured, material properties are imparted by, for example, allowing phase transformation to occur by cooling the metal sheet after having heated the metal sheet in continuous annealing equipment. Nowadays, there is a growing demand in the automobile industry for a high strength steel sheet (high tensile strength steel sheet) having reduced thickness to simultaneously achieve weight reduction and satisfactory crash safety in automobile bodies. Therefore, increased importance is placed on a rapid cooling technique, which is advantageous in manufacturing the high tensile strength steel sheet. Among various kinds of cooling methods, cooling methods utilizing water are widely used because such methods provide a high cooling rate at low cost. However, since such cooling methods have a potential to cause a temperature variation in the steel sheet due to such a high cooling rate, there is a problem in that shape defects such as warpage, wavy deformation, and the like may occur in the steel sheet due to out-of-plane deformation. To date, various methods have been proposed to prevent such shape defects from occurring when water quenching is performed on a steel sheet.

[0003] Patent Literature 1 proposes a method in which, to inhibit wavelike deformation from occurring in a metal sheet when rapid-cooling quenching is performed in a continuous annealing furnace, bridle rolls are installed upstream and downstream of a rapid-cooling quenching region to change tension applied to a steel sheet which is subjected to a rapid-cooling quenching process.

[0004] Patent Literature 2 proposes a method in which, by focusing on the fact that a shape defect occurs due to buckling occurring in a metal sheet because of thermal compressive stress in the width direction of the metal sheet generated at a quenching start point (cooling start point), out-of-plane deformation is inhibited by restraining the metal sheet from both surface sides of the metal sheet in the region in which the compressive stress in the width direction of the metal sheet is generated by cooling or in the vicinity of such a region.

[0005] In addition, Patent Literature 3 proposes a method in which, when the Ms temperature, at which the martensite transformation of a metal sheet starts, is defined as TMs (°C) and the Mf temperature, at which the martensite transformation of the metal sheet finishes, is defined as TMf (°C), the metal sheet that is being subjected to rapid-cooling quenching is restrained by using a restraining roll pair placed in a coolant while the temperature of the metal sheet is in the temperature range of (TMs + 150°C) to (TMf - 150°C).

[0006] Moreover, Patent Literature 4 proposes an apparatus having a water tank containing a liquid in which a metal sheet is immersed, an injection device having plural injection nozzles through which a liquid is injected onto the front and back surfaces of the metal sheet, and one or plural restraining roll pairs with which the metal sheet is restrained and a method in which the liquid is injected through all of the injection nozzles of the injection device in the direction toward the restraining rolls.

Citation List

Patent Literature

[0007]

PTL 1: Japanese Unexamined Patent Application Publication No. 2011-184773
PTL 2: Japanese Unexamined Patent Application Publication No. 2003-277833
PTL 3: Japanese Patent No. 6094722
PTL 4: Japanese Patent No. 6477852

Summary of Invention

Technical Problem

[0008] However, in the case of any one of the methods disclosed in Patent Literature 1 to Patent Literature 4, since the sheet thickness of the metal sheet or the sheet passing speed of the metal sheet in the water tank is not taken into consideration when the metal sheet is restrained by using the restraining rolls, there is a problem in that it is not possible to restrain the metal sheet by using the restraining rolls while the temperature of the metal sheet is in the temperature range of (TMs + 150°C) to (TMf - 150°C). As a result, there is a problem in that shape defects occur after the metal sheet has been subjected to quenching.

[0009] The present invention has been completed in view of the situation described above, and an object of the present invention is to provide a quenching apparatus for a metal sheet with which it is possible to inhibit shape defects from occurring in the metal sheet when quenching is performed regardless of the sheet passing speed or the sheet thickness of the metal sheet, continuous annealing equipment, a method for quenching a metal sheet, a method for manufacturing a cold rolled steel sheet, and a method for manufacturing a coated steel sheet.

Solution to Problem

[0010] The subject matter of the present invention to solve the problems described above is as follows.

[1] A quenching apparatus for a metal sheet, the quenching apparatus having a water tank in which the metal sheet is passed and immersed in a liquid to cool the metal sheet, a water injection apparatus placed in the water tank, and plural restraining roll pairs with which the metal sheet that is passed in the water tank is restrained, in which the water injection apparatus has plural water injection nozzles arranged in a sheet passing direction of the metal sheet on front and back surface sides of the metal sheet so that cooling water is injected in facing directions from the front and back surface sides, and in which a position of each of the plural restraining roll pairs is separately adjusted with respect to the metal sheet in accordance with operation conditions.

[2] The quenching apparatus for a metal sheet according to item [1], in which both largest and smallest values of a maximum height roughness Rz of surfaces of the plural restraining roll pairs are 5 um or more and 50 um or less.

[3] The quenching apparatus for a metal sheet according to item [1], in which a roll diameter of restraining rolls constituting the plural restraining roll pairs is 50 mm or more and 250 mm or less.

[4] The quenching apparatus for a metal sheet according to item [1], in which the plural restraining roll pairs are arranged such that, when a roll diameter of restraining rolls constituting a pair is defined as D (mm), a distance between central axes of the restraining rolls facing each other across the metal sheet is set to be ($D \times 1/4$) (mm) or more and D (mm) or less.

[5] Continuous annealing equipment having the quenching apparatus for a metal sheet according to any one of items [1] to [4], the quenching apparatus being placed on an exit side of a soaking zone of the continuous annealing equipment.

[6] A method for quenching a metal sheet, in which the metal sheet is continuously passed and immersed in a liquid so as to be cooled, and in which the metal sheet is restrained by using plural restraining roll pairs whose positions with respect to the metal sheet are adjusted while a temperature of the metal sheet is equal to or lower than (a martensite start temperature of the metal sheet + 150°C) and equal to or higher than (a martensite finish temperature of the metal sheet - 150°C).

[7] A method for manufacturing a cold rolled steel sheet, in which a cold rolled steel sheet is quenched by using the method for quenching a metal sheet according to item [6].

[8] A method for manufacturing a coated steel sheet, in which the cold rolled steel sheet that has been manufactured by using the method for manufacturing a cold rolled steel sheet according to item [7] is subjected to a coating treatment.

[9] The method for manufacturing a coated steel sheet according to item [8], in which the coating treatment is performed by using a method of one of an electro-galvanizing treatment, a hot-dip galvanizing treatment, and a hot-dip galvannealing treatment.

Advantageous Effects of Invention

[0011] According to the quenching apparatus for a metal sheet, the method for quenching a metal sheet, and the method for manufacturing a steel sheet according to the present invention, it is possible to inhibit shape defects from occurring in the metal sheet when quenching is performed regardless of the sheet passing speed or the sheet thickness of the metal sheet.

Brief Description of Drawings

[0012]

[Fig. 1] Fig. 1 is a schematic diagram illustrating the constitution of a quenching apparatus according to the present invention.

[Fig. 2] Fig. 2 is a schematic diagram illustrating the constitution of restraining roll pairs in the quenching apparatus according to the present invention.

[Fig. 3] Fig. 3 is a schematic diagram illustrating the arrangement constitution of restraining rolls according to the present invention.

[Fig. 4] Fig. 4 is a schematic diagram illustrating warpage of a metal sheet.

[Fig. 5] Fig. 5 is a schematic diagram illustrating the constitution of a conventional quenching apparatus. Description of Embodiments

[0013] Hereafter, an embodiment of the present invention will be described with reference to the figures. Although cases where water, which is inexpensive and industrially useful, is used as a coolant will be described below, there is no particular limitation on the coolant as long as it is a liquid which can be used for cooling.

[0014] Fig. 1 is a diagram illustrating a quenching apparatus 1 for a metal sheet S according to an embodiment of the present invention. The quenching apparatus 1 is used for a cooling apparatus which is placed on the exit side of the soaking zone of a continuous annealing furnace (continuous annealing equipment). In the quenching apparatus 1, a water injection apparatus 3 is installed in a water tank 2 which contains water used for cooling in a manner such that some water injection nozzles 3a are exposed above the water surface (denoted by W in the figure). In the water injection apparatus 3, plural water injection nozzles 3a are arranged in the sheet passing direction (denoted by an arrow P in the figure) of the metal sheet S, which is continuously passed in the water tank 2, on the front and back surface sides of the metal sheet S with a predetermined gap being provided between the nozzles and the metal sheet, and plural restraining roll pairs 4 are arranged in the sheet passing direction with the water injection nozzles being interposed between the pairs. Here, although four restraining roll pairs 4 are illustrated in Fig. 1, there is no particular limitation as long as the number of pairs is two or more. Such plural restraining roll pairs 4 may have controlling systems for adjusting the positions of the pairs with respect to the metal sheet S in accordance with operation conditions.

[0015] There may be a case where the metal sheet S is to be quenched on the exit side of a continuous annealing furnace to achieve desired material properties. However, it is known that shape defects occur in the metal sheet S due to thermal shrinkage caused by rapid cooling for a quenching treatment. In particular, in the case where martensite transformation occurs in the metal sheet S, since rapid thermal shrinkage and transformation expansion occur simultaneously in the temperature range of the martensite start temperature (TMs (°C)) to the martensite finish temperature (TMf (°C)), stress generated in the metal sheet S peaks, which results in a deterioration in the shape of the metal sheet S. Here, it is possible to calculate TMs (°C) and TMf (°C) from the chemical composition of the metal sheet S.

[0016] In particular, in the case where it is possible to physically restrain the metal sheet S while the temperature of the metal sheet S which is being subjected to rapid cooling for quenching is equal to or lower than (TMs + 150°C) and equal to or higher than (TMf - 150°C), it is possible to stabilize the shape. In addition, it is more preferable that the temperature be equal to or lower than (TMs + 100°C) and equal to or higher than (TMf - 100°C).

[0017] In response to such a requirement, a technique utilizing restraining roll pairs 4 which are arranged so that the rolls constituting each roll pair face each other across the surfaces of the metal sheet S immersed in cooling water in a temperature range in which martensite transformation occurs is proposed. However, in the case of a simple constitution, that is, in the case where only one restraining roll pair 4 is used, it is necessary to place limitations on the sheet passing speed and sheet thickness of the metal sheet S to restrain the metal sheet S in the appropriate temperature range of the metal sheet S. Therefore, the present invention was focused on placing plural restraining roll pairs 4 in the cooling water.

[0018] Next, in the case of the present invention, by placing plural restraining roll pairs 4 as illustrated in Fig. 1, since there is an increase in the distance in which it is possible to restrain the metal sheet S, it is possible to restrain the metal sheet S with certainty while the temperature of the metal sheet S is equal to or lower than (TMs + 150°C) and equal to or higher than (TMf - 150°C), even if there is a change in the sheet passing speed or sheet thickness. In the case where restraining is performed outside of such a temperature range, since it is not possible to inhibit expansion due to transformation, there is a deterioration in the shape of the metal sheet S. In addition, since the sheet thickness and sheet passing speed of the metal sheet S vary in accordance with the specifications of the product and the heating and soaking abilities of the continuous annealing furnace, the number of the restraining roll pairs 4 to be placed should be determined so that it is possible to restrain the metal sheet S by using at least two or more restraining roll pairs 4 in the temperature ranges of (TMs + 150°C) to (TMf - 150°C) when the sheet passing speed and sheet thickness of the metal sheet S vary.

[0019] In the present invention, cooling is promoted by using a water injection apparatus 3 having plural water injection nozzles 3a. As illustrated in Fig. 1, the water injection apparatus 3, which is composed of plural water injection nozzles 3a, is arranged so as to cover a region from a position immediately above the water surface W to a position below the water surface. The water injection nozzles 3a are arranged at positions farther from the metal sheet S than those of the restraining roll pairs 4. Although there is no particular limitation on the distance between the water injection nozzles 3a and the metal sheet S, there is a risk that the water injection nozzles 3a come into contact with the metal sheet S due to warpage or vibration of the steel sheet (metal sheet S) in the case where the distance is small and, conversely, that cooling ability decreases due to a decrease in jet flow speed when the coolant reaches the steel sheet (metal sheet S) in the case where the distance is large. Therefore, the distance is to be taken into consideration. A position at which the coolant (denoted by 3b in the figure) injected through the water injection nozzle 3a located at the uppermost position of the water injection apparatus 3 impinges on the metal sheet S, that is, a jet flow impinging position, is at a distance A above the water surface W (as illustrated in Fig. 1), and it is preferable that the height be 10 mm.

[0020] Incidentally, it is not appropriate that the jet flow impinging position be excessively near to the water surface W because, since the jet flow impinging position is influenced by a variation in the position of the water surface W, a position at which a vapor film is removed is unstable, which results in the cooling capacity being largely influenced. On the other hand, it is not appropriate that the jet flow impinging position be excessively far from the water surface W because, since there is an increase in the temperature of the injected water while flowing down, there is a decrease in the cooling capacity in the region in which the water flows down, which results in the occurrence of transition boiling. Therefore, it is preferable that the distance between the water surface W and the jet flow impinging position, which is denoted by A, be about 5 mm to 50 mm (or 10 mm).

[0021] To date, it has been recommended that the water injection nozzles 3a be arranged so as to tilt at the positions nearest the restraining roll pair 4 (refer to Fig. 5) to inject water toward positions at which the restraining roll pair 4 and the metal sheet S come into contact with each other (hereinafter, referred to as "roll side") for the purpose of inhibiting a decrease in the cooling rate of the metal sheet S.

[0022] However, in the case where the water injection nozzles are arranged so as to tilt as illustrated in Fig. 5, the apparatus (water tank 2) increases in length and size. Therefore, experiments and the like were conducted to investigate necessary conditions. As a result, it was found that there is a decrease in cooling rate at the roll side only in the case where a vapor film is retained and that there is almost no decrease in cooling rate in the case where a vapor film does not exist. In particular, in the case where the metal sheet S made of high tensile strength steel, for which the present invention is intended, is quenched, the martensite start temperature (TMs (°C)) is about 400°C, and the martensite finish temperature (TMf (°C)) is about 300°C. Therefore, it is assumed that a temperature range in which restraining is performed by using the restraining roll pairs 4 in a quenching process is about 150°C to 550°C. In such a temperature range, which corresponds to a range from a nucleate boiling range to a transition boiling range, a vapor film does not exist (nucleate boiling), or a vapor film is considerably unstable (transition boiling). Therefore, since it is possible to break the vapor film by using a small amount of water injection, it is not necessary to arrange the nozzles so as to tilt toward the restraining roll pair, and water injected onto the metal sheet S at a right angle does not pose a problem.

[0023] In addition, such conditions are satisfied in the case where the quenched material is a metal sheet S having a martensite start temperature (TMs (°C)) of 450°C or lower or preferably 400°C or lower.

[0024] As pointed out conventionally, there is a significant decrease in cooling rate at the roll side in the case where a vapor film is not removed when restraining is performed by using rolls at a high temperature. However, since it is preferable that restraining not be performed in such a temperature range for the first time, such a phenomenon poses no problem.

[0025] Therefore, in the present invention, by providing a moving system with which the restraining roll pairs 4 move independently from each other in a direction for the restraining rolls 4a to push the metal sheet S or to draw away from the metal sheet S, it is possible to achieve a stable cooling state, even in the case where the water injection nozzles 3a are arranged in a manner such that cooling water is injected in facing directions from the front and back surface sides of the metal sheet S. To inject the cooling water through the water injection nozzles 3a in facing directions across the metal sheet S, it is necessary to arrange the water injection nozzles 3a almost perpendicularly to the sheet passing direction of the metal sheet S. Specifically, when the inclination angle of the water injection nozzle 3a with respect to the metal sheet S is defined as θ, the expression "almost perpendicularly" denotes a case where θ is 80° or more and 100° or less, preferably 82° or more and 98° or less, or more preferably 87° or more and 93° or less.

[0026] Specifically, restraining roll pairs 4 which are located at positions where the temperature of the metal sheet S is in a temperature range in which transition boiling may occur are withdrawn, and the metal sheet S is restrained by using the other restraining roll pairs 4. Here, each of the restraining roll pairs 4 may have a system with which the pair moves independently from other pairs, and instead each of the rolls (restraining roll 4a) constituting the pair may have a system with which the roll moves independently from the other roll.

[0027] Incidentally, restraining roll pairs to be withdrawn or used should be determined in accordance with operation conditions. The expression "operation conditions" denotes heat treatment conditions and cooling conditions; and, in particular, the sheet passing speed, the sheet thickness, the quenching start temperature, and the warpage of the metal sheet are items having large influences. In the case of an identical steel grade, and in the case where the heat treatment conditions before quenching is performed and a distance between a position at which the heat treatment is finished and a position at which cooling is started are identical, it is preferable that such a determination be made in accordance with the sheet passing speed and the sheet thickness. Examples of a method for determining restraining roll pairs to be used include the method described above (the restraining roll pairs to be used are determined in accordance with positions corresponding to the preferable temperature range described in paragraph 0018 which are derived in accordance with the sheet passing speed and the sheet thickness) and a method in which preferable restraining roll pairs are selected to be used on the basis of accumulated data regarding the relationship between the combination of operation conditions and restraining roll pairs used and shape stability.

[0028] That is, when the metal sheet S is quenched, by adjusting the positions of the plural restraining roll pairs 4 with respect to the metal sheet S in accordance with operation conditions, that is, in accordance with the sheet passing speed and the sheet thickness, it is possible to restrain the metal sheet S with certainty while the temperature of the metal sheet S is equal to or lower than (TMs + 150°C) and equal to or higher than (TMf - 150°C), that is, in the preferable temperature range. Although the sheet passing speed and the sheet thickness may be used as the operation conditions, the product of the sheet passing speed and the sheet thickness (hereinafter, referred to as "LSD") may also be used. In this case, when any one of the sheet passing speed and the sheet thickness varies (increases or decreases), LSD also varies. When the positions of the plural restraining roll pairs 4 are adjusted, for example, the restraining roll pairs to be used, the distance between the restraining roll pairs, the intermesh value, the offset value described below, and the like are adjusted.

[0029] In the case of a method for improving shape by using restraining rolls, there may be a case where scrape occurs due to roll slip. It is considered to be because there may be a case where the metal sheet S is severely vibrated due to the water jet flow impinging on the metal sheet S in a turbulent flow state and because, since a water film tends to enter a gap between the restraining roll 4a and the metal sheet S, slip may occur due to a so-called hydroplaning phenomenon. As a countermeasure for the former case, it is preferable that the metal sheet S be restrained by using plural restraining roll pairs 4 because this results in a significant improvement in vibration level. Moreover, as a countermeasure for the latter case, by increasing the maximum height roughness Rz of the surface of the restraining rolls 4a to 5 um or more, it is possible to prevent slip from occurring due to an improvement in water-dissipation capability.

[0030] However, in the case where Rz is larger than a certain value, the effect of preventing slip becomes saturated, and flaws tend to occur due to roughness. Therefore, the upper limit of Rz is set to be 50 um or less. Here, the maximum height roughness Rz is prescribed in Japanese Industrial Standards "JIS B 0601 Surface Roughness (2001)" and derived in accordance with "JIS B 0633" from a profile in the width direction of the metal sheet S, that is, the longitudinal direction of the restraining rolls 4a, obtained by using a two-dimensional roughness meter. In addition, the measurement method adopted by a measurement device may be of a contact type or a non-contact type as long as the obtained measurement results satisfy the prescription in "JIS B 0601 surface roughness".

[0031] There is also a preferable range for the diameter (D (mm)) of the restraining rolls 4a for the reasons described below. In the case where the diameter of the restraining rolls 4a is large, since the water flow becomes unstable due to an increase in the degree of interference with the water flow, the state of the removal of a vapor film becomes unstable, which results in the shape of the metal sheet S becoming unstable. In addition, it is not preferable that there be an increase in roll diameter because this results in an increase in the length of the coolant jet flow which is disturbed by the rolls, which makes it difficult to achieve a sufficient cooling length. Therefore, it is preferable that the roll diameter be 250 mm or less. On the other hand, in the case where the roll diameter is excessively small, since deflection occurs in the rolls when restraining the metal sheet S, there is a decrease in force for restraining the metal sheet S, which results in the effect of correcting shape not being realized. Therefore, it is preferable that the roll diameter be 50 mm or more.

[0032] Incidentally, Fig. 2 and Fig. 3 illustrate an example of the arrangement constitution of the restraining roll pairs 4. In the restraining roll pair 4, which is composed of two restraining rolls 4a that are arranged respectively on the front and back surface sides of the metal sheet S so as to face each other across the metal sheet S, it is preferable that a distance in the sheet passing direction P of the metal sheet S be provided between the central axes of the restraining rolls 4a (offset) constituting the pair. At this time, it is not necessary that the directions of the movement of the central axes be the same in all the restraining roll pairs 4; that is, the movement direction of the restraining roll 4a on one side may be upward in one pair while the movement direction of the restraining roll 4a on the same side is downward in another pair. It is not possible to push the metal sheet S in the case where such a distance is not provided, and, in the case where such a distance is provided, since the pushing-in distances are variable, there is an increase in restraining force. However, in the case where the distance in the sheet passing direction of the metal sheet provided between the central axes of the restraining rolls 4a constituting each pair, that is, an offset value (denoted by B in the figure), is excessively large, since it is not possible to restrain the metal sheet S at the target positions simultaneously on the front and back surface sides of the metal sheet S, it is not possible to realize the restraining effect. For these reasons, it is preferable that the distance in the sheet passing direction of the metal sheet provided between the central axes of the restraining rolls 4a on the front and back surface sides constituting the pair (offset value) be $(D \times 1/4)$ (mm) or more and D (mm) or less. Here, "D" denotes the diameter (mm) of the restraining roll 4a as described above. In the case where the offset value is more than D (mm), it is possible to increase the pushing-in distance of rolls, but it is not possible to realize the effect of roll restraining. That is, the effect of correcting shape by applying bending and unbending forces to the sheet almost simultaneously is not realized. On the other hand, in the case where the offset value is less than (D $\times$ 1/4) (mm), while the effect of roll restraining is large, there is an insufficient effect of correcting shape due to a sufficient push-in distance in the metal sheet pushing-in direction not being achieved, and it is not possible for a thick metal sheet to pass through a gap between the rolls.

[0033] In addition, there is no particular limitation on the movement I (I.M: intermesh value) of the restraining roll pair 4 in the metal sheet S pushing-in direction, and such an optimum movement should be separately set for each of the restraining roll pairs 4 in accordance with the strength and arrangement of the metal sheet S to be restrained and the number of the restraining roll pairs 4. However, in the case where the movement in the pushing-in direction is small, since slip tends to occur, there is an increased risk of scrape occurring. On the other hand, in the case where the movement is large, the occurrence of shape defects may be promoted. Therefore, there is an appropriate value. In the case where a steel sheet is used as the metal sheet S, when the sheet thickness is defined as t (mm), it is preferable that the movement of the restraining roll pair 4 in the metal sheet S-pushing-in direction be -t (mm) to (+10 $\times$ t) (mm). Here, as specifically described with reference to Fig. 3, in the case where the movement I of the restraining rolls 4a in the metal sheet S pushing-in direction is less than -t (mm) (refer to Fig. 3(a)), it is not possible to realize the effect of restraining the metal sheet S. In addition, in the case where the movement of the restraining rolls 4a in the metal sheet S pushing-in direction is more than (+10 $\times$ t) (mm) (refer to Fig. 3(b)), there is a risk that it is not possible for the metal sheet S to pass through the gap between the rolls due to an excessively strong biting force.

[0034] The position of the restraining roll pair 4 may be adjusted in accordance with information about the warpage of the metal sheet S. There is no particular limitation on the information about the warpage of the metal sheet S, and such information may be based on predicted values or measured values. In the case where the warpage of the metal sheet S is measured, examples of the measurement position of the warpage include three positions, that is, a position upstream of the water tank 2, a position downstream of the water tank 2, and an offline position, and a combination thereof may be used. The measurement of the warpage of the metal sheet S may be performed by using a laser-type distance meter or the like. It is advantageous that the measurement is performed before the metal sheet S is cooled because this makes it possible to determine the conditions applied for the restraining roll pairs 4 (restraining roll pairs to be used, distances between the restraining roll pairs, intermesh values, offset values, and the like), without delay. In the case where the measurement is performed after the metal sheet S has been cooled, although it is not possible to avoid a delay in determining the conditions due to a time lag, since the determination is made on the basis of information about the practical warpage of the metal sheet S, it is possible to appropriately adjust the restraining roll pairs 4. In the case where the warpage of the metal sheet S is measured offline, there is an increased delay in determining the conditions applied for the restraining roll pairs 4, but there is an advantage in that, for example, it is possible to perform manual measurement.

[0035] That is, when the metal sheet S is quenched, the positions of the plural restraining roll pairs 4 with respect to the metal sheet S may be adjusted in accordance with operation conditions including not only the sheet passing speed and the sheet thickness but also the information about warpage of the metal sheet S. In addition, also in this case where the positions of the plural restraining roll pairs 4 are adjusted, the restraining roll pairs to be used, the distances between the restraining roll pairs, the intermesh values, the offset values, and the like may be adjusted as in the case of the restraining roll pair 4.

[0036] In addition, regarding adjacent restraining roll pairs 4, the expression "distance between restrain roll pairs 4" (denoted by C in Fig. 2) denotes the distance between the center of the lower restraining roll 4a of the upper restraining roll pair 4 and the center of the upper restraining roll 4a of the lower restraining roll pair 4.

[0037] Under the assumption that the restraining rolls 4a in a restraining roll pair 4 have a moving system with which the rolls move toward or draw away from the sheet passing direction P of the metal strip S, in the case where one restraining roll pair is withdrawn, technically, the distance between the restraining roll pairs 4 is doubled and the number of the restraining roll pairs 4 is halved. However, in the case where the original distance C between the restraining roll pairs 4 is not appropriately set in advance, it is not possible to realize the effect of correcting shape.

[0038] The appropriate range of the distance C is set to be D (mm) or more and 10 $\times$ D (mm) or less. It is not preferable that the distance C between the restraining roll pairs 4 be less than D (mm) because, in this case, since water which is injected through the water injection nozzles 3a is disturbed by the restraining roll pairs 4 before the water reaches the metal sheet S, sufficient cooling capacity is not achieved, which results in an increase in the size of the equipment due to an increase in distance necessary for shape correction. In addition, since there is an increase in the number of points at which the metal sheet S and the restraining roll pairs 4 come into contact, there is an increased risk of the occurrence of surface defects such as pressing flaws, slip flaws, and the like. On the other hand, in the case where the distance C is more than 10 $\times$ D (mm), since there is an increase in distance between a point at which the metal sheet S is restrained by one restraining roll pair 4 and a point at which the metal sheet S is restrained by the next restraining roll pair 4, it is not possible to realize the effect due to plural restraining roll pairs 4 being placed.

[0039] The restraining rolls 4a should be made of a material having excellent thermal conductivity and strength sufficient to endure a load placed on the rolls when the rolls compress the metal sheet. Examples of such a material include heat-resistant steel (for example, KHR12C), stainless steel (SUS304, SUS310), ceramics, and the like, but CFRP easily realizes the effect of roll restraining and is advantageous especially for achieving satisfactory cooling capacity because the deflection of a roll made of CFRP is small even in the case where the roll diameter is small.

[0040] As described above, since the present invention is intended to reduce complex and nonuniform, wavy shape which occurs due to microstructure volume expansion caused by martensite transformation occurring when the metal sheet S is rapidly cooled, it is preferable that the present invention be used in a method for manufacturing a cold rolled steel sheet. In addition, the relevant cold rolled steel sheet may be subjected to a coating treatment. Examples of the coating treatment which may be performed include an electro-galvanizing treatment, a hot-dip galvanizing treatment, and a hot-dip galvannealing treatment.

[0041] More specifically, it is preferable that the present invention be used for manufacturing a high strength steel sheet (high tensile strength steel sheet) having a tensile strength of 580 MPa or higher. There is no particular limitation on the upper limit of the tensile strength as long as the roll material or the like withstands high strength, and, in the case where stainless steel (SUS304, SUS310), ceramics, or the like is used for the rolls, it is expected for the effects to be realized even when the tensile strength is about 3000 MPa.

[0042] Examples of the high strength steel sheet (high tensile strength steel sheet) described above include a high strength cold rolled steel sheet and steel sheets which are manufactured by performing a surface treatment on the high strength cold rolled steel sheet, that is, a hot-dip galvanized steel sheet, an electro-galvanized steel sheet, a hot-dip galvannealed steel sheet, and the like. That is, it is preferable that a high strength cold rolled steel sheet, a hot-dip galvanized steel sheet, an electro-galvanized steel sheet, and a hot-dip galvannealed steel sheet be manufactured by performing continuous annealing utilizing the quenching apparatus for the metal sheet S and the method for quenching the metal sheet S according to the present invention.

[0043] Specific examples of the high strength steel sheet include one having a chemical composition containing, by mass%, C: 0.04% or more and 0.25% or less, Si: 0.01% or more and 2.50% or less, Mn: 0.80% or more and 3.70% or less, P: 0.001% or more and 0.090% or less, S: 0.0001% or more and 0.0050% or less, sol.Al: 0.005% or more and 0.065% or less, optionally at least one of Cr, Mo, Nb, V, Ni, Cu, and Ti in an amount of 0.5% or less each, optionally at least one of B and Sb in an amount of 0.01% or less each, and a balance of Fe and incidental impurities.

[0044] Incidentally, it is possible to use the embodiment of the present invention for rapidly cooling metal sheets in general. In addition, the present invention is not limited to the embodiment which is described as an example and in which cooling is performed by using a water immersion method, and it is possible to use the present invention as a method for preventing deformation from occurring in a steel sheet due to transformation by physically restraining the steel in processes in general regardless of whether the relevant process is a heating process or a cooling process.

EXAMPLES

[0045] Hereafter, examples in which metal sheets were manufactured by using the quenching apparatus for a metal sheet, the method for quenching a metal sheet, and a method for manufacturing a steel sheet according to the present embodiment will be described.

[0046] By using the quenching apparatus 1 illustrated in Fig. 1 basically, high tensile strength cold rolled steel sheets (metal sheets S) having a sheet thickness of 1.0 mm to 2.3 mm, a width of 1000 mm, a tensile strength of 1470 MPa class were manufactured under the conditions of a sheet passing speed (refer to "LS" in Table 1) of 60 mpm to 108 mpm, a quenching start temperature of 800°C, a cooling water injection flow rate of 1000 T/hr, and a water temperature of 30°C. In addition, although the quenching apparatus 1 illustrated in Fig. 1 has four restraining roll pairs 4 which are vertically arranged, one to three restraining roll pairs were vertically arranged in the present examples.

[0047] Incidentally, the representative chemical composition of the high tension cold rolled steel sheet having a tensile strength of 1470 MPa class contained, by mass%, C: 0.20%, Si: 1.0%, Mn: 2.3%, P: 0.005%, and S: 0.002%. Here, the Ms temperature (TMs (°C)) of such a high tension cold rolled steel sheet is 400°C, and the Mf temperature (TMf (°C)) of the steel sheet is 300°C. In this case, the temperature range of the steel sheet in which restraining utilizing the restraining roll pairs 4 is effective is 150°C to 550°C.

[0048] In addition, the roll diameter (D) of the restraining rolls 4a was 150 mm. The distance in the sheet passing direction provided between the central axes of the restraining rolls 4a in a restraining roll pair 4 was 75 mm (B in Fig. 2 = 75 mm) (refer to "Offset Value" in Table 1), whereas the offset value was varied in some cases (Examples 7 to 10). In the case of examples 1 to 14, the restraining roll pairs 4 were placed at a position located 0.3 m (first restraining roll pair) and a position located 0.75 m (second restraining roll pair) from the water surface W whose position was set to be 0 m, the distance was measured in the sheet passing direction P. That is, C in Fig. 2 was 0.45 m. Examples 15 and 16 are examples in which one more restraining roll pair was added at a position located 1.05 m (third restraining roll pair) from the water surface. Each of the restraining roll pairs 4 was designed so as to be withdrawn (corresponding to the case of I.M =-50 mm in Table 1, where the sign "-" denotes the withdrawing direction (direction of drawing away from the metal sheet S) so that it was possible to select each pair to be used or not to be used (by moving the rolls) in accordance with conditions. That is, "-50.0 mm" in the column "I.M" denotes a case where the relevant restraining roll pair 4 is completely separated from the metal sheet S so as to exert no restraining force on the metal sheet S. Here, "I.M" in Table 1 denotes "I" in Fig. 3.

[0049] Incidentally, in the case where the restraining roll pairs 4 were used to push the metal sheet S without withdrawing the restraining roll pairs 4, the base condition was set to be a case where movement of restraining rolls in metal sheet S pushing-in direction was 0 mm. That is, in the case where "0.0 mm" in the column "I.M" in Table 1 denotes a state in which the restraining roll pair 4 pushed the metal sheet S. In more detail, in the case where I.M is "0.0 mm", the surfaces of the restraining rolls 4a in the restraining roll pair 4 reach the central position of the metal sheet S. In other words, in the case where I.M is "0.0 mm", the surfaces of the restraining rolls 4a in the restraining roll pair 4 are moved in the metal sheet pushing-in direction by a distance of half the sheet thickness of the metal sheet S. On the other hand, in the case of example 7 and example 9, the movement in the metal sheet pushing-in direction was changed. This was because, under the conditions of the two cases, since the heights of the restraining rolls 4a on the front and back surface sides of the metal sheet S were the same (offset value was 0), it was not possible physically for the restraining rolls to push the metal sheet. Although, it was possible theoretically to move the metal sheet from the pass line by a distance of half the sheet thickness, since there was a risk of an excessive increase in load, allowance was taken into consideration in setting.

[0050] The evaluations of the examples were conducted from the viewpoint of the warpage quantity (mm) and surface quality of the metal sheet S which had been cooled. As illustrated in Fig. 4, the warpage quantity (denoted by K in Fig. 4) of the metal sheet S was measured in the width direction of the metal sheet S. In addition, the surface quality of the metal sheet S was evaluated by performing surface-appearance observation on three samples in total having the same width as that of the metal sheet S and a length of 1 m which were taken from the front end, central position, and tail end in the sheet passing direction of the metal sheet S. On the basis of the results of the observation performed on the front and back surfaces of the three samples, a case where the number of defects including surface flaws and the like was two or less in total was judged as good (denoted by "o" in Table 1), and a case where the number of the defects was three or more in total was judged as a case with flaws occurring (denoted by "×" in Table 1).

[Table 1]

Example	LS [mpm]	Sheet Thickness [mm]	LSD [mpm·mm]	Maximum Height Roughness [μm]		Offset Value in Restraining Roll Pair (8) [mm]	Injection Direction of Water Injection Nozzle (with Respect to Metal Sheet)	First Restraining Roll Pair		Second Restraining Roll Pair		Third Restraining Roll Pair		Warpage Quantity [mm]	Surface Quality
				Rz min	Rz max			Distance [m]	I.M (I) [mm]	Distance [m]	I.M (I) [mm]	Distance [m]	I.M (I) [mm]		
Comparative Example 1	60	1.0	60	-	-	-	90°	-	-	-	-	-	-	34.5	○
Comparative Example 2	60	1.0	60	25.3	29.6	75	90°	-	-	0.75	0.0	-	-	15.2	○
Comparative Example 3	60	1.8	108	25.3	29.6	75	90°	-	-	0.75	0.0	-	-	2.1	○
Comparative Example 4	100	1.8	180	25.3	29.6	75	90°	-	-	0.75	0.0	-	-	4.3	○
Comparative Example 5	100	1.8	180	25.3	29.6	75	60°	-	-	0.75	0.0	-	-	16.3	○
Example 1	60	1.0	60	25.3	29.6	75	90°	0.30	0.0	0.75	-50.0	-	-	2.9	○
Example 2	60	1.8	108	25.3	29.6	75	90°	0.30	-50.0	0.75	0.0	-	-	2.2	○
Example 3	100	1.8	180	25.3	29.6	75	90°	0.30	-50.0	0.75	0.0	-	-	4.6	○
Example 4	60	1.0	60	25.3	29.6	75	90°	0.30	0.0	0.75	0.0	-	-	3.4	○
Example 5	50	1.6	80	25.3	29.6	75	90°	0.30	0.0	0.75	0.0	-	-	3.7	○
Example 6	60	1.8	108	25.3	29.6	75	90°	0.30	0.0	0.75	0.0	-	-	15.5	○
Example 7	60	1.8	108	25.3	29.6	0	90°	0.30	-50.0	0.75	-3.0	-	-	11.0	○
Example 8	60	1.8	108	25.3	29.6	200	90°	0.30	-50.0	0.75	0.0	-	-	4.2	○
Example 9	108	1.0	108	25.3	29.6	0	90°	0.30	-50.0	0.75	-1.0	-	-	3.7	○
Example 10	108	1.0	108	25.3	29.6	200	90°	0.30	-50.0	0.75	0.0	-	-	10.5	○
Example 11	60	1.8	108	5.6	13.3	75	90°	0.30	-50.0	0.75	0.0	-	-	2.5	○

(continued)

Example	LS [mpm]	Sheet Thickness [mm]	LSD [mpm·mm]	Maximum Height Roughness [μm]		Offset Value in Restraining Roll Pair (8) [mm]	Injection Direction of Water Injection Nozzle (with Respect to Metal Sheet)	First Restraining Roll Pair		Second Restraining Roll Pair		Third Restraining Roll Pair		Warpage Quantity [mm]	Surface Quality
				Rz min	Rz max			Distance [m]	I.M (l) [mm]	Distance [m]	I.M (l) [mm]	Distance [m]	I.M (l) [mm]		
Example 12	60	1.8	108	4.8	12.3	75	90°	0.30	-50.0	0.75	0.0	-	-	2.3	× Slip Flaw
Example 13	60	1.8	108	42.7	48.5	75	90°	0.30	-50.0	0.75	0.0	-	-	1.9	○
Example 14	60	1.8	108	45.1	51.2	75	90°	0.30	-50.0	0.75	0.0	-	-	1.8	× Rough Surface
Example 15	90	2.3	207	25.3	29.6	75	90°	0.30	0.0	0.75	0.0	1.05	-50.0	11.5	○
Example 16	90	2.3	207	25.3	29.6	75	90°	0.30	-50.0	0.75	0.0	1.05	0.0	3.1	○

[0051] Hereafter, comparative examples 1 to 5 and examples 1 to 16 given in Table 1 will be described.

[0052] In the case of comparative example 1, the restraining roll pair 4 was not placed, and the metal sheet S was cooled by injecting water through the water injection nozzles 3a in the direction perpendicular to the sheet passing direction P of the metal sheet S. The warpage quantity of the metal sheet S was 34.5 mm, which means a shape defect occurred.

[0053] In the case of comparative examples 2 to 5, the number of restraining roll pairs 4 was one, and, in the case of comparative example 5, the water injection direction was 60° with respect to the steel sheet. In the case of comparative examples 3 and 4, since the restraining roll pair 4 was placed within the preferable temperature range for restraining derived from the transformation temperature of the metal sheet, there was an improvement in warpage quantity. In the case of comparative examples 2 and 5, there was no improvement in warpage. From these results, it was clarified that, in the case of one restraining roll pair 4, it was not possible to respond to a change in the product of the sheet passing speed and sheet thickness of the metal sheet S (LSD). In addition, there was a deterioration in shape in the case of an oblique water injection direction. The reason for this is because, since there was a substantial decrease in cooling capacity, there was an increase in the temperature of the metal sheet S which passed through the restraining roll pair 4.

[0054] On the other hand, examples 1 to 6 show the results of the cases where two restraining roll pairs 4 were placed. In addition, in the case of examples 1 to 3, the restraining roll pair 4 to be used was selected (the movement conditions of the restraining roll pairs 4 were selected) in accordance with LSD, and, as a result, it was clarified that it is possible to respond a wide range of a change in LSD. Here, a metal sheet for which the present invention is mainly intended is a steel sheet, and it is possible to organize the sheet cooling state in accordance with LSD. Therefore, the larger the LSD, the more difficult it is to cool the metal sheet, and the larger the distances from the cooling start position to the martensite start position and the martensite finish position. Therefore, it is preferable to select the restraining roll pairs 4 placed at lower positions in Fig. 1. To the contrary, the smaller the LSD, the easier it is to cool the metal sheet, and the smaller the distance from the cooling start position to the martensite start position and the martensite finish position. Therefore, it is preferable to select the restraining roll pairs 4 placed at upper positions in Fig. 1.

[0055] In contrast, in the case of examples 4 to 6 where the two restraining roll pairs 4 were both used, there was a deterioration in the warpage of the metal sheet S under some conditions. Therefore, the withdrawal function of the restraining rolls 4a (moving function of the restraining roll pairs 4) is necessary to respond to changes in sheet passing speed and sheet thickness.

[0056] In the case of examples 7 to 14, on the basis of the conditions of example 2, the offset value (distance in the sheet passing direction P of the metal strip S between the restraining rolls 4a in a restraining roll pair 4) and the maximum height roughness Rz of the restraining rolls 4a are changed. In the case of an offset value of 0 (example 7 and example 9), as described above, due to the limitations on the movement in the sheet pushing-in direction of the restraining rolls 4a, there was a deterioration in warpage quantity compared with the results of example 2. On the other hand, in the case of example 8 and example 10 where the offset value was 200 mm, there was a deterioration in the warpage quantity of the metal sheet S under the condition of a sheet thickness of 1 mm. From these results, it was clarified that it is necessary to appropriately set the offset value.

[0057] Moreover, from the results of examples 11 to 14, it was clarified that there may be a deterioration in the external appearance of the metal sheet S depending on the maximum height roughness Rz of the restraining rolls 4a. It was clarified that, to maintain the external appearance of the surface of the metal sheet S, both the largest and smallest values of the maximum height roughness Rz should be set to be 5 um to 50 μm.

[0058] Example 15 is an example in which quenching was performed with reference to examples 4 to 6. By using the plural restraining roll pairs 4, it was possible to realize the effect of correcting shape of the metal sheet S to some extent. In the case of example 16, by selecting roll pairs to be used from the plural restraining roll pairs 4 in accordance with the product of the sheet passing speed and sheet thickness of the metal sheet S (LSD) and the measurement results of the warpage of the metal sheet S to thereby adjust the positions at which the metal sheet S was restrained and the distance between the restraining roll pairs, it is possible to suppress the warpage quantity of the metal sheet S to be 3.1 mm. Here, although, in this example (example 16), restraining roll pairs to be used were selected to thereby adjust the distance between the restraining roll pairs, the items to be adjusted may be the intermesh values and offset values. Regarding the measurement of the warpage of the metal sheet S, by placing a laser displacement meter at any position in the sheet passing direction P of the metal sheet S, and by using the measurement results of the warpage derived from such a laser displacement meter, various kinds of conditions applied for the plural restraining roll pairs 4 may be determined.

[0059] The present inventors diligently conducted investigations to solve the problems described above and to thereby complete the quenching apparatus for a metal sheet, a method for quenching a metal sheet, and a method for manufacturing a steel sheet according to the present invention and, as a result, the following knowledge was obtained.

[0060] Although, to achieve a good shape of the metal sheet S, restraining the metal sheet S by using restraining rolls 4a to inhibit out-of-plane deformation occurring in the metal sheet S in the temperature range of (T_{Ms} + 150) (°C) to (T_{Mf} - 150) (°C) is effective, it is necessary to place significant limitations on the sheet passing speed and sheet thickness of the metal sheet S to satisfy such conditions by using only one restraining roll pair 4. In response to such a problem, the idea that, by using plural restraining roll pairs 4, it is possible to relax significantly the limitations on the conditions under which the metal sheet S passes through the restraining roll pairs 4 in the good temperature range was conceived.

[0061] Although, to respond to changes in the LS, sheet thickness, and the like of the metal sheet S, plural restraining roll pairs 4 should be placed as described above, there may be a case where the shape of the metal sheet S is not stabilized or scrape or the like occurs due to the restraining roll pairs 4, unless the restraining roll pairs 4 are placed under appropriate conditions.

[0062] The destabilization of the shape of the metal sheet S is caused by the unstableness of the cooling capacity, and this was presumed to be because of the destabilization of the vapor film-removing capability due to a water flow. Generally, it is known that, when cooling is performed for water quenching, the contact state between the metal sheet S and water (boiling state) varies in accordance with the temperature range of the metal sheet S in the cooling process; that is, film boiling, transition boiling, and nucleate boiling occur in this order as the temperature decreases, which results in a variation in cooling rate and cooling uniformity. In addition, it was considered that, to realize rapid cooling while maintaining temperature uniformity, performing cooling only in the nucleate boiling range is important and, for such a purpose, removing a vapor film uniformly is important. To realize this, a method in which slit nozzles are placed on the front and back surface sides of the metal sheet S to spray a water flow onto the surfaces has been put into practice.

[0063] In addition, from the results of the investigation conducted by the present inventors, it was found that multiple parallel jet flows provided by using water injection nozzles 3a for injecting a coolant which are arranged in plural parallel lines are significantly unstable due to peripheral flows. In the case where the jet flows are unstable, since the positions at which the jet flows impinge on the metal sheet S also are unstable, the removal of the vapor film becomes unstable. Therefore, it was found that, in the case where the restraining rolls 4a are simply added, since the state of the removal of the vapor film becomes unstable, there may be a deterioration in the shape of the metal sheet S on the contrary. On the other hand, it was considered that scratch occurring in the surface of the metal sheet S is a defect caused by the slip of the restraining rolls 4a and that such a defect is caused by a hydroplaning phenomenon occurring in the case where a water film is formed between the restraining rolls 4a and the metal sheet S.

Reference Signs List

[0064]

- 1 quenching apparatus
- 2 water tank
- 3 water injection apparatus
- 3a water injection nozzle
- 3b coolant injected through water injection nozzle
- 4 restraining roll pair
- 4a restraining roll
- D roll diameter
- P sheet passing direction
- Rz maximum height roughness
- S metal sheet
- K warpage quantity
- W water surface
- A distance from water surface to cooling start point
- B distance between central axes of one pair of restraining rolls facing each other (offset value)
- C distance between restraining roll pairs
- I movement of restraining rolls in metal sheet pushing-in direction (I.M)

Claims

1. A quenching apparatus for a metal sheet, the quenching apparatus having

a water tank in which the metal sheet is passed and immersed in a liquid to cool the metal sheet,
a water injection apparatus placed in the water tank, and
plural restraining roll pairs with which the metal sheet that is passed in the water tank is restrained,
wherein the water injection apparatus has plural water injection nozzles arranged in a sheet passing direction of the metal sheet on front and back surface sides of the metal sheet so that cooling water is injected in facing

directions from the front and back surface sides, and
wherein a position of each of the plural restraining roll pairs is separately adjusted with respect to the metal sheet in accordance with operation conditions.

2. The quenching apparatus for a metal sheet according to Claim 1, wherein both largest and smallest values of a maximum height roughness Rz of surfaces of the plural restraining roll pairs are 5 um or more and 50 um or less.

3. The quenching apparatus for a metal sheet according to Claim 1, wherein a roll diameter of restraining rolls constituting the plural restraining roll pairs is 50 mm or more and 250 mm or less.

4. The quenching apparatus for a metal sheet according to Claim 1, wherein the plural restraining roll pairs are arranged such that, when a roll diameter of restraining rolls constituting a pair is defined as D (mm), a distance between central axes of the restraining rolls facing each other across the metal sheet is set to be ($D \times 1/4$) (mm) or more and D (mm) or less.

5. Continuous annealing equipment having the quenching apparatus for a metal sheet according to any one of Claims 1 to 4, the quenching apparatus being placed on an exit side of a soaking zone of the continuous annealing equipment.

6. A method for quenching a metal sheet, wherein the metal sheet is continuously passed and immersed in a liquid so as to be cooled, and wherein the metal sheet is restrained by using plural restraining roll pairs whose positions with respect to the metal sheet are adjusted while a temperature of the metal sheet is equal to or lower than (a martensite start temperature of the metal sheet + 150°C) and equal to or higher than (a martensite finish temperature of the metal sheet - 150°C).

7. A method for manufacturing a cold rolled steel sheet, wherein a cold rolled steel sheet is quenched by using the method for quenching a metal sheet according to Claim 6.

8. A method for manufacturing a coated steel sheet, wherein the cold rolled steel sheet that has been manufactured by using the method for manufacturing a cold rolled steel sheet according to Claim 7 is subjected to a coating treatment.

9. The method for manufacturing a coated steel sheet according to Claim 8, wherein the coating treatment is performed by using a method of one of an electro-galvanizing treatment, a hot-dip galvanizing treatment, and a hot-dip galvannealing treatment.

FIG. 1

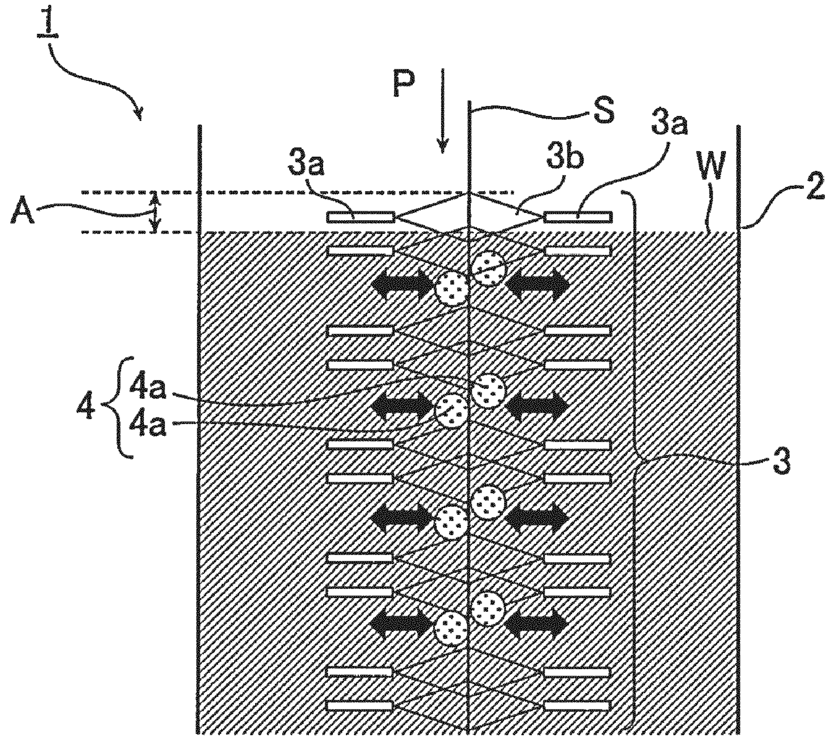


FIG. 2

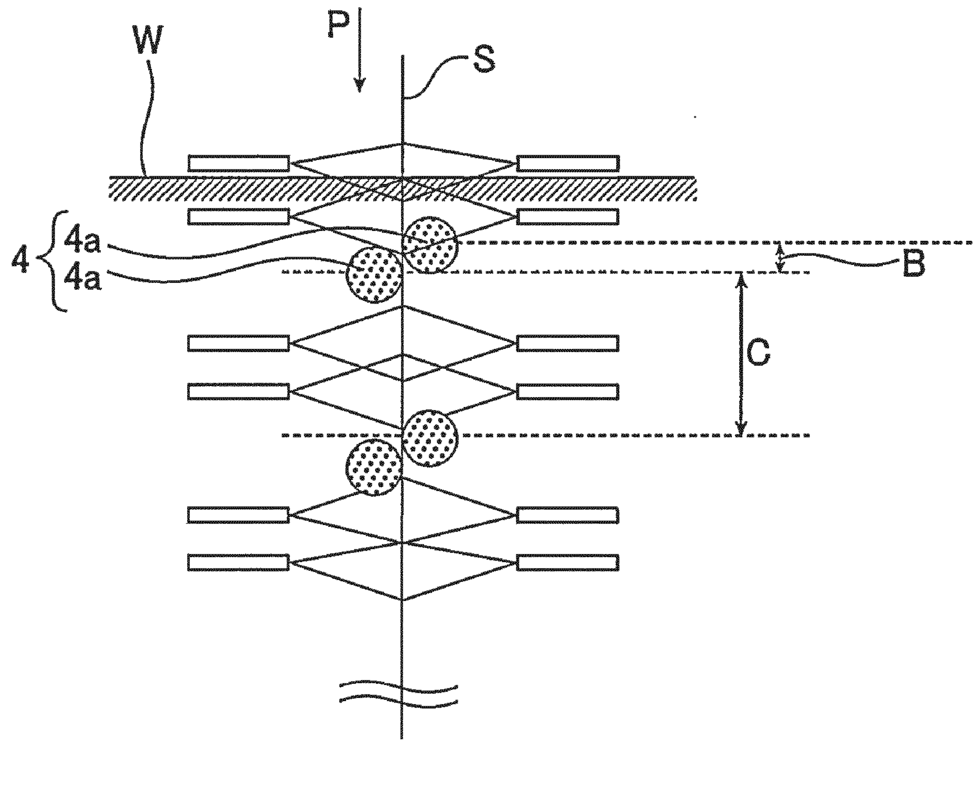
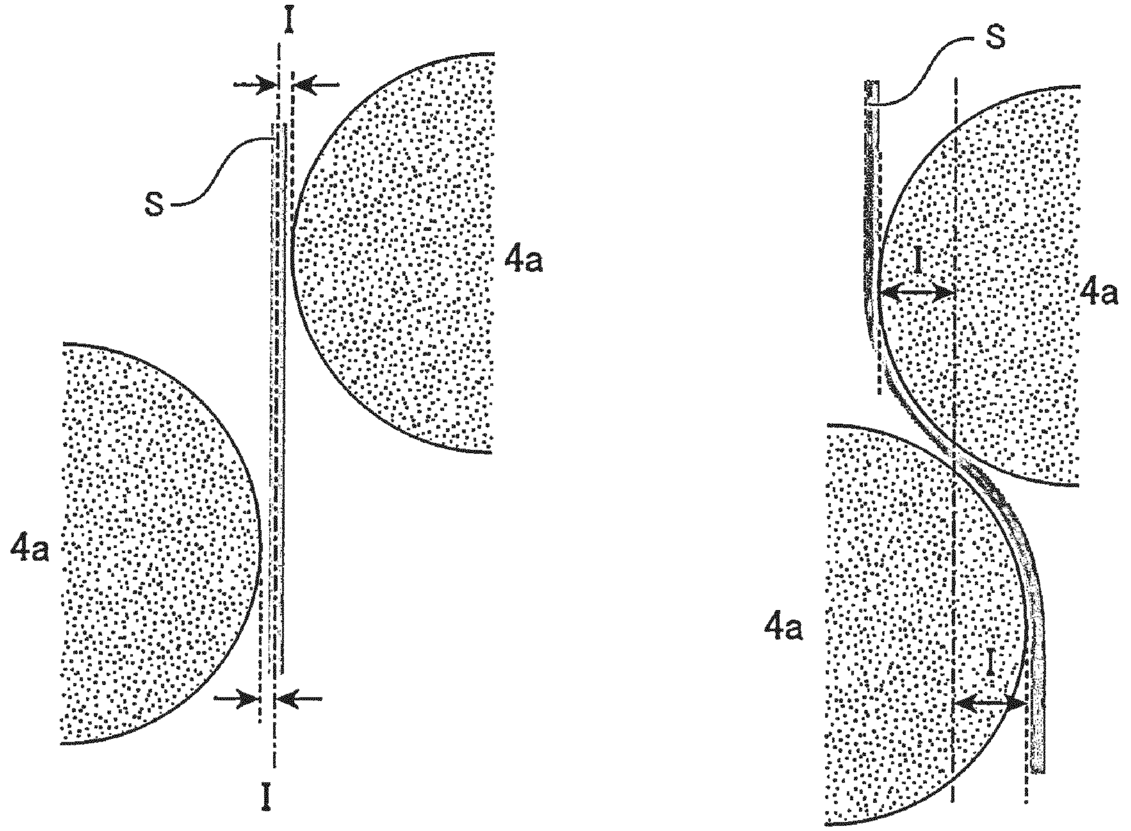


FIG. 3



(a) IN THE CASE OF I = -t (mm)   (b) IN THE CASE OF I = +10 × t (mm)

FIG. 4

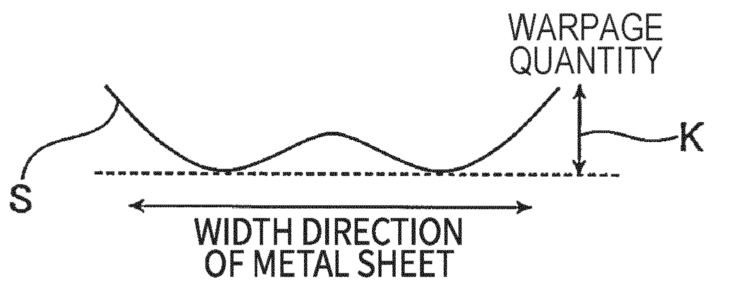
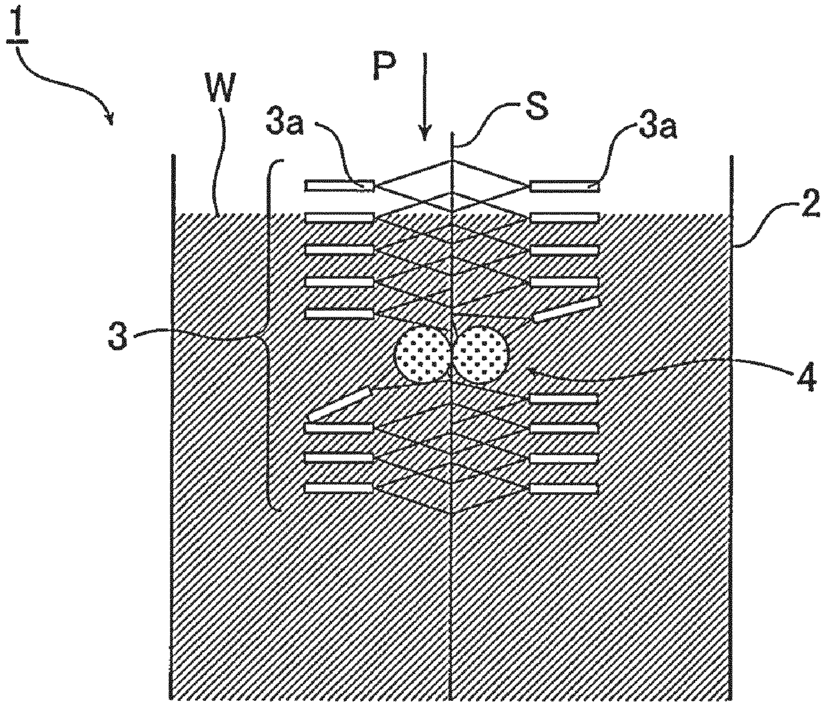


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/019933

A. CLASSIFICATION OF SUBJECT MATTER

C21D 9/573(2006.01)i; ***C22C 38/00***(2006.01)i; ***C22C 38/60***(2006.01)i; ***C21D 1/00***(2006.01)i; ***C21D 1/63***(2006.01)i
FI: C21D9/573 101Z; C21D1/00 123A; C21D1/63; C22C38/00 301U; C22C38/00 301T; C22C38/60

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)

C21D9/52-9/66; C22C38/00; C22C38/60; C21D1/00; C21D1/63

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2017/115742 A1 (JFE STEEL CORP.) 06 July 2017 (2017-07-06) claims, paragraphs [0015], [0031]-[0040], fig. 6-9	1-2, 4-5
Y		3
A		6-9
Y	WO 2021/085335 A1 (JFE STEEL CORP.) 06 May 2021 (2021-05-06) claims	3
A		1-2, 4-9
A	WO 2016/084283 A1 (JFE STEEL CORP.) 02 June 2016 (2016-06-02)	1-9
A	JP 56-5932 A (NIPPON KOKAN KK) 22 January 1981 (1981-01-22)	1-9

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

* Special categories of cited documents:
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"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
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"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
21 June 2022	**05 July 2022**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

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