



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
11.10.2023 Bulletin 2023/41

(21) Application number: **21923050.5**

(22) Date of filing: **27.10.2021**

(51) International Patent Classification (IPC):
C21D 9/52 (2006.01) **C21D 9/573** (2006.01)
C22C 38/00 (2006.01) **C22C 38/06** (2006.01)
C22C 38/60 (2006.01) **C21D 1/18** (2006.01)
C21D 1/26 (2006.01)

(52) Cooperative Patent Classification (CPC):
C21D 1/18; C21D 1/26; C21D 9/52; C21D 9/573;
C22C 38/00; C22C 38/06; C22C 38/60

(86) International application number:
PCT/JP2021/039666

(87) International publication number:
WO 2022/163044 (04.08.2022 Gazette 2022/31)

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

(30) Priority: **29.01.2021 JP 2021012721**

(71) Applicant: **JFE Steel Corporation**
Tokyo 100-0011 (JP)

(72) Inventor: **YOSHIMOTO, Soshi**
Tokyo 100-0011 (JP)

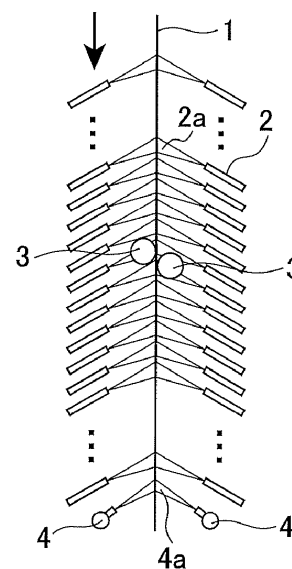
(74) Representative: **Haseltine Lake Kempner LLP**
Bürkleinstrasse 10
80538 München (DE)

(54) **METAL SHEET QUENCH-HARDENING APPARATUS AND QUENCH-HARDENING METHOD, AND STEEL SHEET PRODUCTION METHOD**

(57) Provided are a quenching apparatus and a quenching method for a metal sheet with which it is possible to inhibit shape defects from occurring in the metal sheet when quenching is performed and a method for manufacturing a steel sheet.

A quenching apparatus for a metal sheet, the apparatus being placed on an exit side of a soaking zone in a continuous annealing furnace, and the apparatus including a cooling fluid-spray device having plural spray nozzles for spraying mist onto both surfaces of a continuously transported metal sheet, and at least one pair of restraining rolls for restraining the metal sheet on both surfaces thereof in a region from a cooling start point to a cooling finish point in the cooling fluid-spray device.

FIG. 1



Description

Citation List

Technical Field

Patent Literature

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

5 **[0006]**

PTL 1: Japanese Unexamined Patent Application Publication No. 2000-178658

PTL 2: Japanese Unexamined Patent Application Publication No. 2009-127060

PTL 3: Japanese Patent No. 6094722

Background Art

Summary of Invention

[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 a continuous annealing system. Nowadays, there is a growing demand in the automobile industry for a high strength steel sheet (high tension steel sheet) having reduced thickness to simultaneously achieve weight reduction and satisfactory crash safety in automobile bodies. When such a high tension steel sheet is manufactured, a technique for rapidly cooling the steel sheet is important. In such a cooling process, mist, which is a mixture of a gas and water, a gas such as hydrogen, or the like is generally used as a coolant for the steel sheet. At this time, there is a problem of shape defects such as warpage, wavelike deformation, and the like occurring 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 quenching is performed on a steel sheet.

15 Technical Problem

[0007] However, from the results obtained by testing the methods according to Patent Literature 1 and Patent Literature 2, it has been clarified that there is only a small effect of inhibiting shape defects in the case where only the water flow density is controlled or only the temperature variation in the width direction is inhibited.

[0008] In addition, from the results obtained by testing the method according to Patent Literature 3, it has been clarified that there is room for improvement, because, in the case of a method for cooling a steel sheet by dipping the steel sheet in a liquid, since a cooling rate is likely to vary due to the degree of rapid cooling being excessively high, the temperature of the steel sheet tends to vary when the steel sheet passes through the restraining rolls, which may result in a large variation in warpage quantity in the longitudinal direction.

[0009] The present invention has been made to solve the problems described above, and an object of the present invention is to provide a quenching apparatus and a quenching method for a metal sheet with which it is possible to inhibit shape defects from occurring in the metal sheet when quenching is performed and to provide a method for manufacturing a steel sheet.

[0003] For example, Patent Literature 1 discloses a method in which, by appropriately controlling the water flow density in mist sprayed onto a strip, the metal strip is subjected to mist cooling in a film boiling state without transition boiling being induced.

[0004] In addition, Patent Literature 2 discloses a method in which, in a cooling zone in a vertical continuous annealing furnace, in which a strip is continuously annealed while being vertically transported, a temperature variation in the width direction of the strip is inhibited from occurring due to, for example, water contained in mist, which is sprayed onto the strip, dripping down along the surface of the strip.

[0005] Moreover, Patent Literature 3 discloses a method in which a metal sheet being subjected to rapid-cooling quenching is restrained by using a pair of restraining rolls placed in a coolant in a region where the temperature of the metal sheet is in a range from $(T_{Ms} + 150)$ (°C) to $(T_{Mf} - 150)$ (°C), where the Ms temperature, at which martensite transformation starts, is defined as T_{Ms} (°C) and the Mf temperature, at which martensite transformation finishes, is defined as T_{Mf} (°C).

Solution to Problem

[0010] The present inventors diligently conducted investigations to solve the problems described above and, as a result, obtained the following knowledge. In a method for manufacturing a metal sheet, there is a case where microstructure control is performed by allowing martensite transformation to occur in the metal sheet when quenching is performed, and, in such a case, since volume swelling occurs in the microstructure due to the occurrence of martensite transformation, there may be a case where the metal sheet has a complex, non-uniform recessed and projected shape. When a high tension steel sheet having a martensite microstructure is subjected to quenching, since the largest stress is applied to the steel sheet at a temperature almost within a temperature range from the Ms temperature to the Mf temperature, in which transformation swelling occurs along with thermal shrink-

age, there is a deterioration in the shape of the steel sheet. In addition, in this case, the higher the degree of rapid cooling, the more likely the cooling rate is to vary. Therefore, by using mist for cooling so that the degree of rapid cooling is not excessively high, and by arranging restraining rolls, with which a metal sheet is restrained, in a region in which the temperature of the metal sheet is from the Ms temperature to the Mf temperature, it is possible to sufficiently decrease the warpage quantity. Here, the term "Ms temperature" denotes the temperature at which martensite transformation starts, and the term "Mf temperature" denotes the temperature at which martensite transformation finishes.

[0011] The present invention has been made on the basis of the knowledge and the idea described above and has the following features.

[1] A quenching apparatus for a metal sheet, the apparatus being placed on an exit side of a soaking zone in a continuous annealing furnace, and the apparatus comprising: a cooling fluid-spray device having plural spray nozzles for spraying mist onto both surfaces of a continuously transported metal sheet; and at least one pair of restraining rolls for restraining the metal sheet on both surfaces thereof in a region from a cooling start point to a cooling finish point of the cooling fluid-spray device.

[2] The quenching apparatus for a metal sheet according to item [1], in which the plural spray nozzles are arranged so that the mist is sprayed onto the metal sheet across a whole temperature range from a martensite start temperature to a martensite finish temperature of the metal sheet.

[3] The quenching apparatus for a metal sheet according to item [1] or [2], further including a dewatering spray nozzle arranged on a downstream side of an exit of the cooling fluid-spray device.

[4] A quenching method for a metal sheet, the method comprising spraying mist onto both surfaces of a continuously transported metal sheet to cool the metal sheet while restraining the metal sheet on both surfaces thereof at least in a region in which a temperature of the metal sheet being cooled is from a martensite start temperature to a martensite finish temperature.

[5] The quenching method for a metal sheet according to item [4], in which a water flow density of the mist is 100 L/m²·min or more and 800 L/m²·min or less.

[6] A method for manufacturing a steel sheet, the method including continuously annealing a steel sheet and quenching the annealed steel sheet by using the quenching method for a metal sheet according to item [4] or [5] to manufacture one of a high strength cold rolled steel sheet, a galvanized steel sheet, an electrogalvanized steel sheet, and a galvanized steel sheet.

Advantageous Effects of Invention

[0012] According to the quenching apparatus and the quenching method for a metal sheet and the method for manufacturing a steel sheet according to the present invention, it is possible to effectively inhibit shape defects from occurring in the metal sheet when quenching is performed.

Brief Description of Drawings

[0013]

[Fig. 1] Fig. 1 is a diagram illustrating an example of the quenching apparatus and the quenching method for a metal sheet according to the present invention.

[Fig. 2] Fig. 2 is a diagram illustrating an example of a supply system for supplying air and water to mist-spray nozzles in the quenching apparatus for a metal sheet according to the present invention.

[Fig. 3] Fig. 3 is a diagram illustrating an example of a two-fluid nozzle.

[Fig. 4] Fig. 4(a) and Fig. 4(b) are diagrams illustrating examples of a mist-spray nozzle.

[Fig. 5] Fig. 5(a) and Fig. 5(b) are diagrams illustrating mist cooling according to the quenching apparatus and the quenching method for a metal sheet according to the present invention and conventional water quenching, respectively.

[Fig. 6] Fig. 6 is a diagram illustrating another example of the quenching apparatus and the quenching method for a metal sheet according to the present invention.

[Fig. 7] Fig. 7 is a graph illustrating the effect of the quenching apparatus and the quenching method for a metal sheet according to the present invention in contradistinction to the comparative examples.

[Fig. 8] Fig. 8 is a diagram illustrating the definition of the warpage quantity of a metal sheet in Fig. 7.

Description of Embodiments

[0014] Hereafter, embodiments of the quenching apparatus and the quenching method for a metal sheet and the method for manufacturing a steel sheet according to the present invention will be specifically described with reference to the figures.

[0015] Fig. 1 is a diagram illustrating the quenching apparatus for a metal sheet according to an embodiment of the present invention. This quenching apparatus is used for cooling equipment placed on the exit side of the soaking zone of a continuous annealing furnace. This cooling equipment is placed in order to allow, in the case where the metal sheet which is the object to be cooled is a steel sheet, an austenite phase to transform into a martensite phase during cooling of the steel sheet, thereby achieving the mechanical properties of a final product. Therefore, this cooling equipment has an ability of per-

forming cooling in a temperature range including a temperature range from the martensite start temperature to the martensite finish temperature.

[0016] As illustrated in Fig. 1, the quenching apparatus for a metal sheet according to the present embodiment includes a cooling fluid-spray device composed of plural mist-spray nozzles (spray nozzles) 2, at least one pair of restraining rolls 3, which restrain a metal sheet 1 in a cooling region in the cooling fluid-spray device, and dewatering spray nozzles 4. The mist-spray nozzles 2 spray mist 2a, which is a coolant (cooling fluid), onto the continuously threaded metal sheet 1 (for example, a steel sheet) on both surface sides of the metal sheet 1 to perform rapid cooling. The restraining rolls 3 restrain the metal sheet 1 in a region from a cooling start point, which is the entrance of the cooling fluid-spray device, to a cooling finish point, which is the exit of the cooling fluid-spray device, to prevent deformation. The dewatering spray nozzles 4 are placed on the downstream side of the exit of the cooling fluid-spray device and spray a gas 4a such as air, nitrogen, or the like onto the metal sheet 1 from the exit side of the metal sheet 1 to remove dripping water from the metal sheet 1.

[0017] Here, the term "mist" denotes atomized water or liquid and an aggregation of minute droplets having a droplet diameter of about 0.01 μm to several hundred μm suspended in a gas. In the present embodiment, by spraying a mixture of water and air, the mist described above is formed. As a result of air being sprayed onto the metal sheet, which is an object to be cooled, at the same time as the minute droplets of water adhere to the metal sheet, it is possible to achieve a sufficient cooling rate. In addition, since water and air reach the metal sheet in a mixture state, it is possible to moderate and stabilize a cooling rate compared with a case where only water is sprayed.

[0018] Here, in the case where the droplet diameter of the mist is less than 10 μm , since the droplets tends to be vaporized, there may be a case where it is not possible to achieve a sufficient cooling rate. In addition, in the case where the droplet diameter of the mist is more than 100 μm , since there is a case where water in a droplet state adheres to and remains on the metal sheet, cooling non-uniformity tends to occur. Therefore, it is preferable that the droplet diameter of the mist be 10 μm or more and 100 μm or less.

[0019] As the mist-spray nozzle 2, for example, a commercially available product such as a PSN slit nozzle produced by H. IKEUCHI Co., Ltd., Knife Jet KJIS (internal mixing-type) produced by KYORITSU GOKIN CO., LTD., or the like may be used.

[0020] Fig. 2 is a schematic diagram illustrating a supply system for supplying air and water to the mist-spray nozzles 2 in the quenching apparatus for a metal sheet according to the present embodiment. In addition, Fig. 3 is a schematic diagram illustrating a two-fluid nozzle used as the mist-spray nozzle 2 in the present embodiment. In the present embodiment, although a case where the

mist is generated by using the two-fluid nozzles illustrated in Fig. 3 as the mist-spray nozzle 2 is used as an example in the description, the mist-spray nozzle is not limited to such an example as long as mist is sprayed at a flow rate in a preferable range.

[0021] In the case where the two-fluid nozzles are used as the mist-spray nozzles 2, as illustrated in Fig. 2, compressed air which is pressurized and fed by a compressor 52 is supplied to the mist-spray nozzles 2 through a compressed-air pipework 5. In addition, water which is pressurized and fed by a pump 63 is supplied from a water tank 62 to the mist-spray nozzles 2 through a water pipework 6. Here, the opening degrees of a supply valve 51 installed in the compressed-air pipework 5 and a supply valve 61 installed in the water pipework 6 and the operation of the pump 63 are controlled by a flow rate-controlling device 7. As described above, it is sufficient that the compressed air and the water be supplied to the mist-spray nozzles 2 in such a manner that the pressures and amounts of the compressed air and the water are within the allowable ranges in accordance with the specifications of the mist-spray nozzles 2. In addition, to prevent the mist-spray nozzles 2 from clogging, a filter may be installed in the water pipework 6 in such a manner that the filter is placed between the supply valve 61 and the mist-spray nozzles 2.

[0022] Here, in the case where the air-to-water volume ratio of the mist sprayed through the mist-spray nozzles 2 is less than 50, since there is a marked increase in the amount of water adhering to and remaining on the metal sheet 1 in the form of residues, cooling non-uniformity tends to occur. In addition, in the case where such an air-to-water volume ratio is more than 1000, since there is an excessive decrease in the droplet diameter of the mist, there may be a case where it is not possible to achieve a cooling rate necessary for achieving the properties which the metal sheet 1 is required to have. Therefore, it is preferable that the air-to-water volume ratio of the mist sprayed through the mist-spray nozzles 2 be 50 to 1000.

[0023] In the case of the quenching apparatus for a metal sheet according to the present embodiment, the mist-spray nozzles 2 are arranged in 80 rows at intervals of 200 mm in the transportation direction of the steel sheet (longitudinal direction of the steel sheet).

[0024] However, the arrangement of the mist-spray nozzles 2 is not limited to the example described above as long as the nozzles are arranged so that cooling non-uniformity does not occur in the width direction of the metal sheet 1. For example, as illustrated in Fig. 4(a), in the case where slit nozzles 2A having a width larger than that of the metal sheet 1 are used as the mist-spray nozzles 2, it is preferable that the slit nozzles be arranged in such a manner that the nozzle interval I in the transportation direction of the steel sheet is 100 mm to 600 mm. This is because, in the case where the nozzle interval I in the transportation direction of the steel sheet is less than 100 mm, since the mist-spray regions of the nozzles

interfere with each other, there may be a case where it is difficult to predict a cooling rate, and, in the case where the nozzle interval l in the transportation direction of the steel sheet is more than 600 mm, there may be a case where it is not possible to achieve a sufficient cooling rate.

[0025] In addition, as illustrated in Fig. 4(b), in the case where nozzles 2B having a spray pattern of a spot shape or a cone shape are used as the mist-spray nozzles 2, it is preferable that plural nozzles 2B be arranged in the width direction of the metal sheet 1 in accordance with the specifications of the nozzles. At this time, it is preferable that the nozzles 2B be arranged in such a manner that the mist-spray regions of the nozzles are arranged with no separation or with sufficient overlap so that a uniform cooling rate distribution in the width direction of the metal sheet 1 is achieved. In addition, as illustrated in Fig. 4(b), it is preferable that the plural nozzles 2B be arranged in the width direction of the metal sheet 1 be attached to a header 21 when being used.

[0026] In addition, the mist-spray nozzles 2 may be arranged in a zigzag manner, and the inclination angle of the mist-spray direction from the mist-spray nozzle 2 with respect to the metal sheet 1 or the spread angle of a cone-shaped spray may be adjusted in accordance with the width of the metal sheet 1, which is the object to be cooled, or the like.

[0027] Also in the case where plural nozzles are used in one set in which the nozzles are arranged in the width direction of the metal sheet 1 to achieve uniform cooling ability in the width direction of the metal sheet 1 as described above, it is preferable that such nozzle sets be arranged in such a manner that the interval l between the nozzle sets in the transportation direction of the steel sheet is 100 mm to 600 mm. This is because, in the case where the interval l between the nozzle sets in the transportation direction of the steel sheet is less than 100 mm, since the mist-spray regions of the nozzles interfere with each other, there may be a case where it is difficult to predict a cooling rate, and, in the case where the interval l between the nozzle sets in the transportation direction of the steel sheet is more than 600 mm, there may be a case where it is not possible to achieve a sufficient cooling rate.

[0028] Here, in the present invention, it is important that the relation between the cooling ability of the cooling fluid-spray device (mist-spray nozzles 2) and the position of the restraining rolls 3 be controlled so that the metal sheet 1 is restrained by using the restraining rolls 3 in a temperature range in which the shape of the metal sheet 1 is most susceptible to being deteriorated. Therefore, in the quenching apparatus and the quenching method for a metal sheet according to the present embodiment, it is preferable that the amount of the mist and the water temperature of the mist, which are adjusted to control the cooling ability, be set as described below.

[0029] First, in the case where quenching is performed by using a method in which mist 2a is sprayed from the plural mist-spray nozzles 2 onto the surface of the metal

sheet 1, it is preferable that the water flow density of the mist 2a be 100 L/m²·min or more and 800 L/m²·min or less. This is because, in the case where the water flow density of the mist 2a is less than 100 L/m²·min, it is not possible to achieve satisfactory mechanical properties of the steel sheet, and, since there is an increase in the distance from the cooling start position to the position of the restraining roll, there is an increase in the size of the equipment. In addition, in the case where the water flow density of the mist 2a is more than 800 L/m²·min, since unstable cooling occurs due to a decrease in cooling time from the start of cooling to the arrival at the restraining roll, the shape of the steel sheet may be deteriorated to such an extent that it is not possible to correct the shape by using the restraining rolls.

[0030] In addition, it is more preferable that the water flow density of the mist 2a be 200 L/m²·min or more and 500 L/m²·min or less.

[0031] In addition, it is preferable that the temperature of the cooling water constituting the droplets of the mist 2a be higher than 0°C and 60°C or lower or particularly preferably 10°C or higher and 50°C or lower from the viewpoint of facility maintenance and achieving a sufficient cooling rate. This is because, in the case where the temperature is 0°C or lower, facility damage may occur due to freezing, and, in the case where the temperature is higher than 60°C, since there is a decrease in cooling rate and there is an increase in the distance from the cooling start position to the position of the restraining roll, there is an increase in the size of the equipment.

[0032] In the case of a vertical mist cooling device, since water contained in the mist 2a flows down along the metal sheet 1 to cause a negative effect on the cooling of a lower part, it is preferable that measures be taken to prevent water from dripping, and, for example, it is possible to control such a situation by spraying the mist 2a and the gas 4a at an upward angle of about 30 degrees.

[0033] At this time, for the reasons described above, to arrange the restraining rolls practically and effectively in accordance with the cooling ability, it is preferable that the cooling rate of the metal sheet 1 be 50°C/sec or higher and 500°C/sec or lower. In the case where the cooling rate is lower than 50°C/sec, since there is an increase in the distance from the cooling start position to the position of the restraining roll, there is an increase in the size of the equipment. On the other hand, in the case where the cooling rate is higher than 500°C/sec, since unstable cooling occurs due to a decrease in cooling time from the start of cooling to the arrival at the restraining roll, the shape of the steel sheet may be deteriorated to such an extent that it is not possible to correct the shape by using the restraining rolls.

[0034] As described above, by using the mist 2a and by controlling the cooling rate to be within the preferable range, it is possible to improve the effect of shape correction due to the restraining rolls 3.

[0035] In the present embodiment, when quenching is

performed by using a method in which the mist 2a is sprayed onto the surface of the metal sheet 1 through the plural mist-spray nozzles 2 to cool the metal sheet, the restraining rolls 3, which restrain the metal sheet 1, are arranged in a region in which the temperature of the metal sheet 1 is equal to or higher than the Ms temperature and equal to or lower than the Mf temperature. Here, the term "Ms temperature" denotes the temperature at which martensite transformation of the metal sheet 1 starts, and the term "Mf temperature" denotes the temperature at which martensite transformation of the metal sheet 1 finishes. Incidentally, it is possible to calculate the Ms temperature and the Mf temperature from the chemical composition of the metal sheet 1.

[0036] The restraining rolls 3 are pressed against the front and back surfaces of the metal sheet 1 to prevent deformation from occurring in the metal sheet 1 when quenching is performed. It is preferable that two rolls constituting one pair of the restraining rolls 3 be arranged with a distance between the central axes thereof in the transporting direction of the metal sheet 1. By arranging the restraining rolls 3 with a distance between the central axes thereof, since it is possible to increase the restraining force applied to the metal sheet 1, it is possible to increase the shape-correcting ability. For example, it is preferable that the restraining rolls 3 be arranged in the transporting direction with a distance of 40 mm or more and 150 mm or less or more preferably 80 mm or more and 100 mm or less between the central axes thereof.

[0037] In addition, it is preferable that the metal sheet 1 be pushed by the restraining rolls 3 so that the metal sheet 1 winds around the restraining rolls 3 when the metal sheet passes through the rolls. As a result of the metal sheet 1 being pushed by the restraining rolls 3, it is possible to increase the ability for correcting the shape of a steel sheet, and it is possible to prevent the restraining rolls 3 from rotating idly. It is preferable that the push-in amount applied by one restraining roll 3 be 0 mm or more and 2.5 mm or less or more preferably 0.5 mm or more and 1.0 mm or less, where a case where the metal sheet 1 passes through in a straight line as illustrated in Fig. 1 is defined as a case of a reference position (0 mm).

[0038] Fig. 5(a) and Fig. 5(b) are diagrams illustrating mist cooling according to the quenching apparatus and the quenching method for a metal sheet according to the present embodiment and conventional water quenching, respectively, in contradistinction to each other. In the case where cooling is performed moderately by using a mist cooling method from the Ms temperature to the Mf temperature as illustrated in Fig. 5(a), the distance L from the position of the Ms temperature to the position of the Mf temperature is longer than that in the case of a conventional water quenching method illustrated in Fig. 5(b). Therefore, it is possible to flexibly respond to a change in the threading speed or thickness of the metal sheet 1 in such a manner that the restraining rolls 3 are used in an appropriate temperature range or that the number of the restraining rolls 3 to be used for restraining is in-

creased or decreased more easily than in the case of a conventional water quenching method.

[0039] For example, when the thickness multiplied by the threading speed is 1.5 (m/sec)·mm and the difference between the Ms temperature and the Mf temperature is 100°C, in the case where water quenching illustrated in Fig. 5(b) is performed at a cooling rate of 1500°C/(sec·mm), the distance L from the position of the Ms temperature to the position of the Mf temperature is 100 mm. On the other hand, in the case of the mist cooling illustrated in Fig. 5(a), since the cooling rate is about 300°C/(sec·mm), it is possible to increase the distance L from the position of the Ms temperature to the position of the Mf temperature to 500 mm. Therefore, by arranging plural restraining rolls 3 in the distance L (500 mm) from the position of the Ms temperature to the position of the Mf temperature, it is possible to restrain the metal sheet 1 in a temperature range from the Ms temperature to the Mf temperature with certainty, thereby performing shape correction with certainty. In addition, it is also easy to flexibly respond to a temporary change in restraining position due to a change in threading speed, thickness, or the like.

[0040] Here, in the case of the quenching apparatus and quenching method for a metal sheet according to the present embodiment illustrated in Fig. 5(a), when the distance L from the position of the Ms temperature to the position of the Mf temperature is less than 200 mm, as in the case of water quenching illustrated in Fig. 5(b), it is difficult to flexibly respond to a change in the threading speed or thickness of the metal sheet 1. Therefore, there may be a case where it is not possible to sufficiently realize the effect of shape correction due to the restraining rolls 3. In addition, when the distance L from the position of the Ms temperature to the position of the Mf temperature is more than 1000 mm, since martensite transformation does not sufficiently occur, there may be a case where it is not possible to achieve desired material properties. Therefore, to effectively realize the effect of shape correction due to the restraining rolls 3 in a region from the Ms temperature to the Mf temperature, it is preferable that the distance L from the position of the Ms temperature to the position of the Mf temperature be about 200 mm to 1000 mm.

[0041] Moreover, the mist 2a may be used across the whole length of the region in which it is necessary to cool the metal sheet 1 including a region in which the temperature of the metal sheet 1 is higher than the Ms temperature and a region in which the temperature of the metal sheet 1 is lower than the Mf temperature.

[0042] To prevent roll flaws from occurring in the metal sheet 1, it is preferable that the restraining rolls 3 be rotated in the circumferential direction by electric power. Moreover, to adjust the ability for correcting the shape of the metal sheet 1, it is preferable that the restraining rolls 3 be openable and closable, that is, that the push-in amount of the metal sheet 1 be controllable, as needed.

[0043] It is sufficient that the restraining rolls 3 be made

of a material which is excellent in terms of thermal conductivity and which has sufficient strength to resist a load placed on the rolls when the rolls are pressed onto the metal sheet 1. Examples of the material of the restraining rolls 3 include SUS304 or SUS310 prescribed in Japanese Industrial Standards JIS G 4304 "Hot-rolled stainless steel plate, sheet and strip", ceramic, or the like.

[0044] Hereafter, with reference to Fig. 6, an example in which three or more of the restraining rolls 3 are used will be described. In the description below, description similarly applicable to the case where one pair of the restraining rolls 3 are used may be omitted.

[0045] In the example in Fig. 6, the front and back surfaces of the metal sheet 1 are restrained by four (two pairs of) restraining rolls 3. In the case where plural pairs of restraining rolls are used, for the same reasons as in the case where only two (one pair of) restraining rolls are used, it is preferable that the metal sheet 1 be pushed by the restraining rolls. It is preferable that the push-in amount by each of the restraining rolls be 0 mm or more and 2.5 mm or less or particularly preferably 0.5 mm or more and 1.0 mm or less. It is not necessary that the number of the restraining rolls 3 on the front surface of the metal sheet 1 be the same as the number of the restraining rolls 3 on the back surface. However, to equally apply restraining force to both surfaces of the metal sheet 1, it is preferable that the same number of the restraining rolls 3 be arranged on both surfaces of the metal sheet 1 so as to form pairs or that the difference in the number of restraining rolls 3 between the front and back surfaces of the metal sheet 1 be 1.

[0046] In an example in which three or more of the restraining rolls are used, it is possible to achieve a higher ability for correcting the shape of a steel sheet when cooling is performed compared with the case where only two (one pair of) restraining rolls are used. In particular, even in the case where a high strength steel sheet, in which deformation tends to occur, is cooled, by using three or more of restraining rolls 3, it is possible to inhibit, with a higher degree of certainty, deformation such as warpage occurring in the steel sheet when cooling is performed. On the other hand, in the case where the number of the restraining rolls is excessively large, there is a problem regarding facility conditions or a problem of a decrease in the cooling ability of the spray device. Therefore, it is sufficient that the number of the restraining rolls be appropriately decided in consideration of such problems.

[0047] In addition, as in the case of the present embodiment, when cooling with the mist 2a and the restraining rolls 3 are simultaneously used, there may be a case where the mist 2a adheres to and remains on the restraining rolls 3 in the form of residues and the amount of such mist 2a varies in the width direction of the metal sheet 1 (that is, the axial direction of the restraining rolls 3). As a result, since cooling non-uniformity occurs, there may be a decrease in the effect of shape correction due to the restraining rolls 3. Therefore, to solve such a problem, a dewatering mechanism (not illustrated), with which

droplets adhering to and remaining on the restraining rolls 3 in the form of residues are removed, may be placed in the vicinity of the restraining rolls 3. Specifically, as the examples of such a dewatering mechanism, a blade-like obstruction, a wiper, an air nozzle, or the like may be used.

[0048] As described above, since the present invention is intended to reduce a complex, non-uniform recessed and projected shape caused by volume swelling occurring in a microstructure due to martensite transformation occurring when the steel sheet is rapidly cooled, it is preferable that the present invention be used in a method for manufacturing a high strength steel sheet (high tension steel sheet).

[0049] More specifically, it is preferable that the present invention be used to manufacture a steel sheet having a tensile strength of 580 MPa or higher. Although there is no particular limitation on the upper limit of the tensile strength, it is sufficient that the tensile strength be, for example, 1600 MPa or less.

[0050] Examples of the high strength steel sheet (high tension steel sheet) described above include a high strength cold rolled steel sheet and steel sheets which are manufactured by performing surface treatment on such a high strength cold rolled steel sheet, that is, a galvanized steel sheet, an electrogalvanized steel sheet, a galvanized steel sheet, and the like.

[0051] The specific examples of the chemical composition of the high strength steel sheet include 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, at least one of Cr, Mo, Nb, V, Ni, Cu, and Ti: 0.50 or less each as needed, B and Sb: 0.01% or less each as needed, and the balance being Fe and incidental impurities.

[0052] Incidentally, the embodiments of the present invention are not limited to the examples in which a steel sheet is rapidly cooled, and the embodiments may be used for the quenching of metal sheets in general other than steel sheets.

EXAMPLES

[0053] A manufacturing test of a steel sheet was performed by using the quenching apparatus and the quenching method for a metal sheet and the method for manufacturing a steel sheet according to the present invention, and the effects were verified. Therefore, the results will be described.

(Example 1)

[0054] By using the quenching apparatus for a metal sheet illustrated in Fig. 1, a high tension cold rolled steel sheet having a thickness of 1.0 mm, a width of 1000 mm, and a tensile strength of a 1470 MPa class was manu-

factured under the conditions of a threading speed of 1.0 m/s, a quenching start temperature of 800°C, a water flow density of mist of 400 L/m²·min, and a temperature at the time of passing the restraining rolls of 350°C.

[0055] Here, the chemical composition of the high tension cold rolled steel sheet having a tensile strength of a 1470 MPa class contained, by mass%, C: 0.20%, Si: 1.0%, Mn: 2.3%, P: 0.005%, and S: 0.002%.

[0056] Incidentally, the Ms temperature of such a high tension cold rolled steel sheet is 400°C, and the Mf temperature of such a steel sheet is 300°C. Therefore, as described above, since the temperature at the time of passing the restraining rolls may be set to be within a range from 400°C to 300°C, the temperature at the time of passing the restraining rolls was set to be 350°C as described above.

[0057] Here, the restraining rolls were arranged in the threading direction with a distance of 80 mm between the central axes thereof, and the push-in amount of the metal sheet 1 by each of the all the restraining rolls 3 was 0.5 mm.

(Example 2)

[0058] By using the quenching apparatus illustrated in Fig. 6, an operation was performed under the same conditions as in the case of Example 1. Here, each pair of opposing restraining rolls was arranged in the threading direction with a distance of 80 mm between the central axes thereof, and the push-in amount of the metal sheet 1 by each of the all the restraining rolls 3 was 0.5 mm.

(Comparative example 1)

[0059] As a comparative example, with the exception that the cooling apparatus according to Patent Literature 1 was used, the high tension cold rolled steel sheet described above was manufactured under the same conditions as in the case of the examples.

(Comparative example 2)

[0060] As a comparative example, with the exception that the cooling apparatus according to Patent Literature 2 was used, the high tension cold rolled steel sheet described above was manufactured under the same conditions as in the case of the examples.

(Comparative example 3)

[0061] As a comparative example, with the exception that the cooling apparatus according to Patent Literature 3 was used, the high tension cold rolled steel sheet described above was manufactured under the same conditions as in the case of the examples.

[0062] Then, in each of the cases (Examples 1 to 2, and Comparative examples 1 to 3), 10 samples were taken from the cooled steel sheet at intervals of 100 m

in the longitudinal direction, and the warpage quantity of each of the 10 samples was investigated. Here, Fig. 8 is a diagram illustrating the definition of the warpage quantity. Specifically, when the steel sheet was placed on a horizontal plane, the height of the highest position thereon was defined as the warpage quantity.

[0063] The results of Examples 1 to 2 and Comparative examples 1 to 3 are shown in Fig. 7.

[0064] In the case of Examples 1 to 2, the warpage quantities of the steel sheets were decreased to a range from 2.0 mm to 8.0 mm, that is, the warpage quantity was decreased to 10 mm or less across the whole length of each of the steel sheets. In contrast, in the case of Comparative examples 1 to 2, the warpage quantities of the steel sheets were distributed in a range of 10.0 mm to 14.0 mm, that is, the effect of inhibiting deformation was insufficient across the whole length of each of the steel sheets. In addition, in the case of Comparative example 3, the warpage quantity of the steel sheet was distributed in a range of 4.0 mm to 14.0 mm, that is, the warpage quantity was not decreased to 10 mm or less across the whole length of the steel sheet.

[0065] From the results described above, the effectiveness of the quenching apparatus and the quenching method for a metal sheet and the method for manufacturing a steel sheet according to the present invention was clarified.

Reference Signs List

[0066]

1	metal sheet
2 (2A, 2B)	mist-spray nozzle (spray nozzle)
2a	mist
21	header
3	restraining roll
4	dewatering spray nozzle
4a	gas
5	compressed-air pipework
51	supply valve
52	compressor
6	water pipework
61	supply valve
62	water tank
63	pump
7	flow rate-controlling device

Claims

1. A quenching apparatus for a metal sheet, the apparatus being placed on an exit side of a soaking zone in a continuous annealing furnace, and the apparatus comprising:

a cooling fluid-spray device having plural spray nozzles for spraying mist onto both surfaces of

a continuously transported metal sheet; and
at least one pair of restraining rolls for restraining
the metal sheet on both surfaces thereof in a
region from a cooling start point to a cooling fin-
ish point of the cooling fluid-spray device.

5

2. The quenching apparatus for a metal sheet accord-
ing to Claim 1, wherein the plural spray nozzles are
arranged so that the mist is sprayed onto the metal
sheet across a whole temperature range from a mar-
tensite start temperature to a martensite finish tem-
perature of the metal sheet. 10
3. The quenching apparatus for a metal sheet accord-
ing to Claim 1 or 2, further comprising a dewatering
spray nozzle arranged on a downstream side of an
exit of the cooling fluid-spray device. 15
4. A quenching method for a metal sheet, the method
comprising spraying mist onto both surfaces of a
continuously transported metal sheet to cool the met-
al sheet while restraining the metal sheet on both
surfaces thereof at least in a region in which a tem-
perature of the metal sheet being cooled is from a
martensite start temperature to a martensite finish
temperature. 20 25
5. The quenching method for a metal sheet according
to Claim 4, wherein a water flow density of the mist
is 100 L/m²·min or more and 800 L/m²·min or less. 30
6. A method for manufacturing a steel sheet, the meth-
od comprising continuously annealing a steel sheet
and quenching the annealed steel sheet by using
the quenching method for a metal sheet according
to Claim 4 or 5 to manufacture one of a high strength
cold rolled steel sheet, a galvanized steel sheet, an
electrogalvanized steel sheet, and a galvannealed
steel sheet. 35

40

45

50

55

FIG. 1

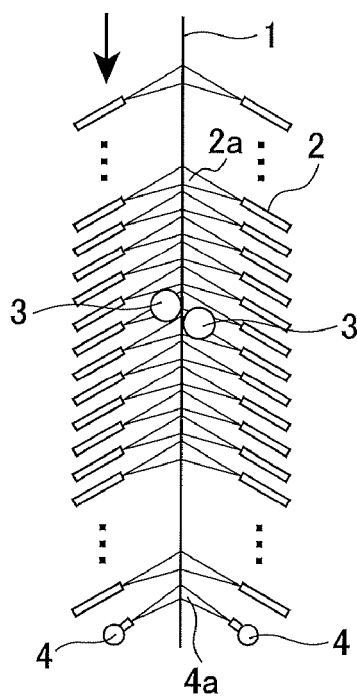


FIG. 2

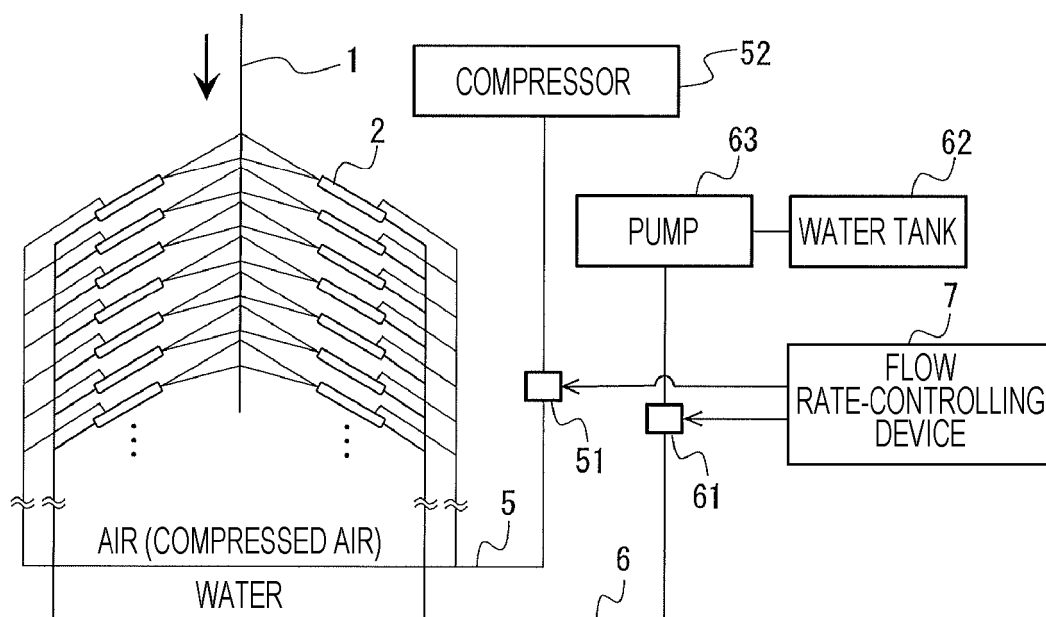


FIG. 3

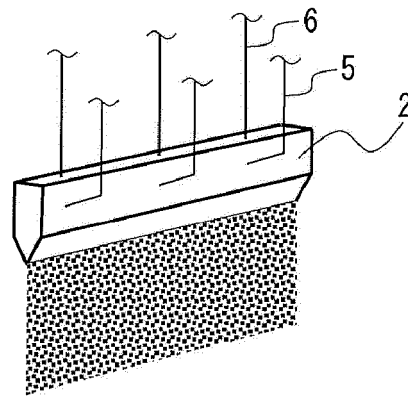


FIG. 4

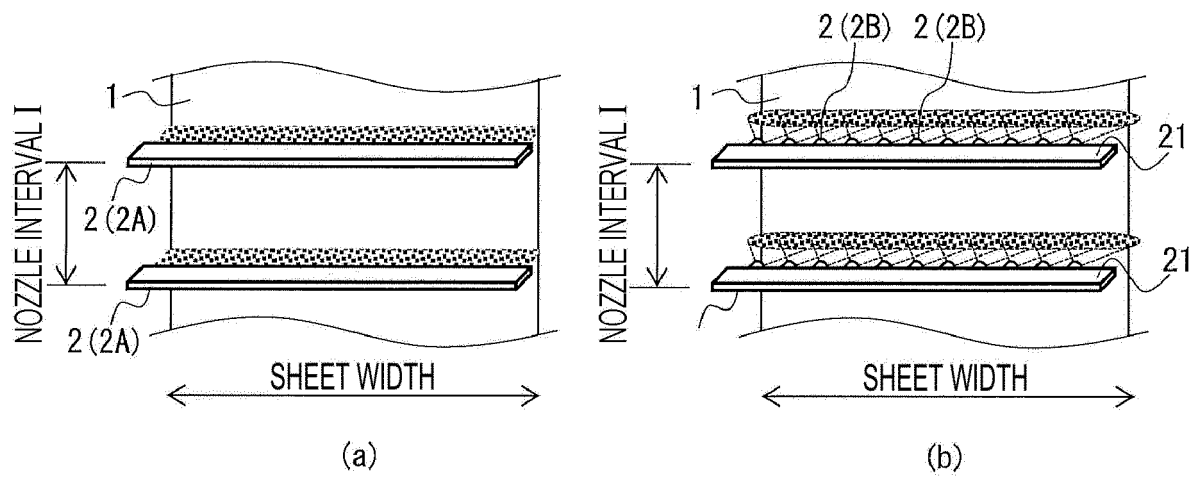


FIG. 5

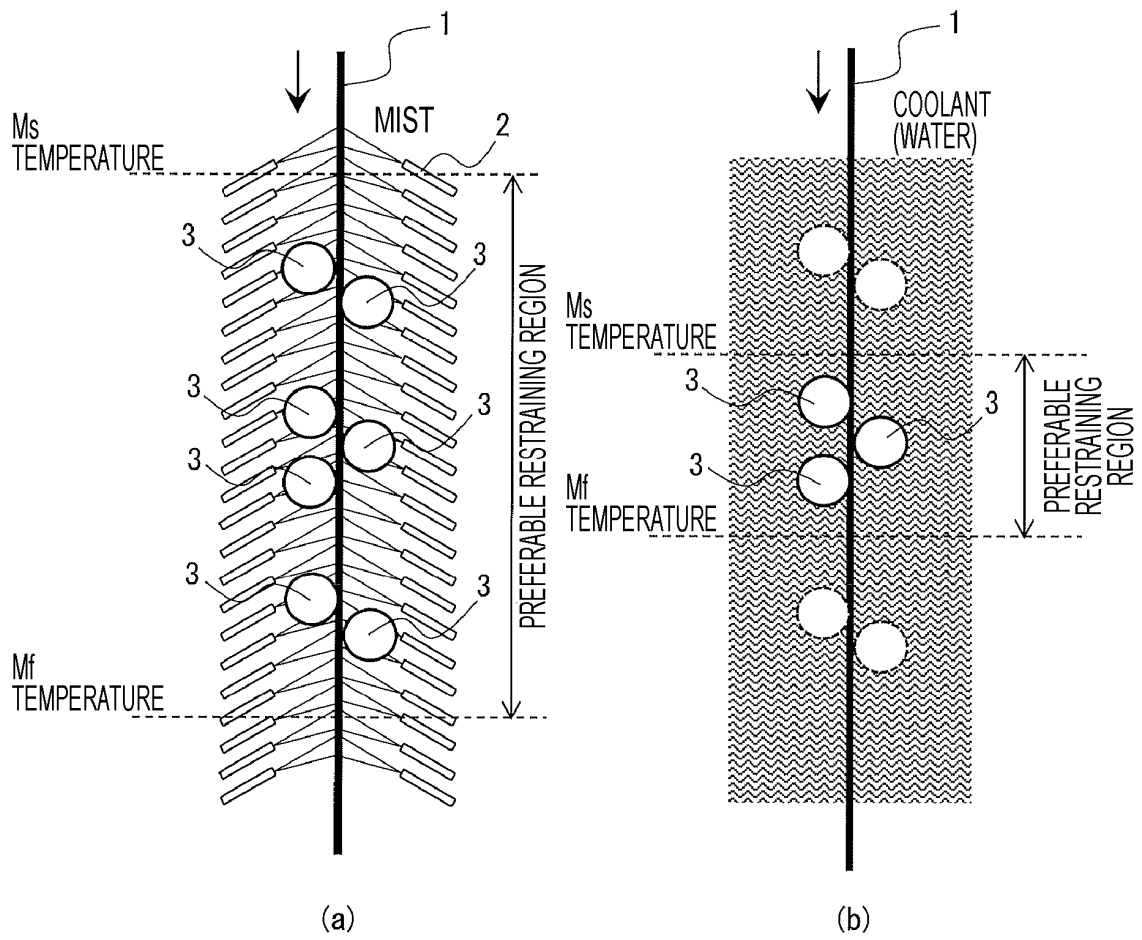


FIG. 6

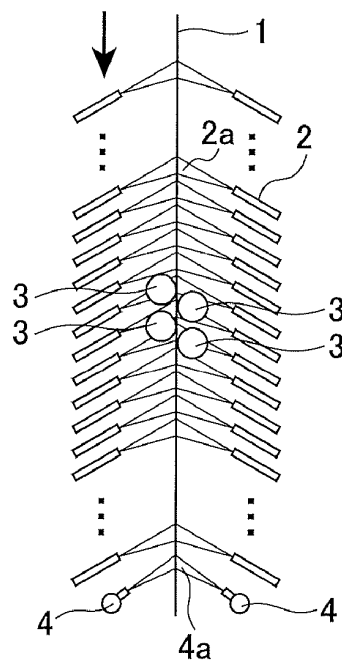


FIG. 7

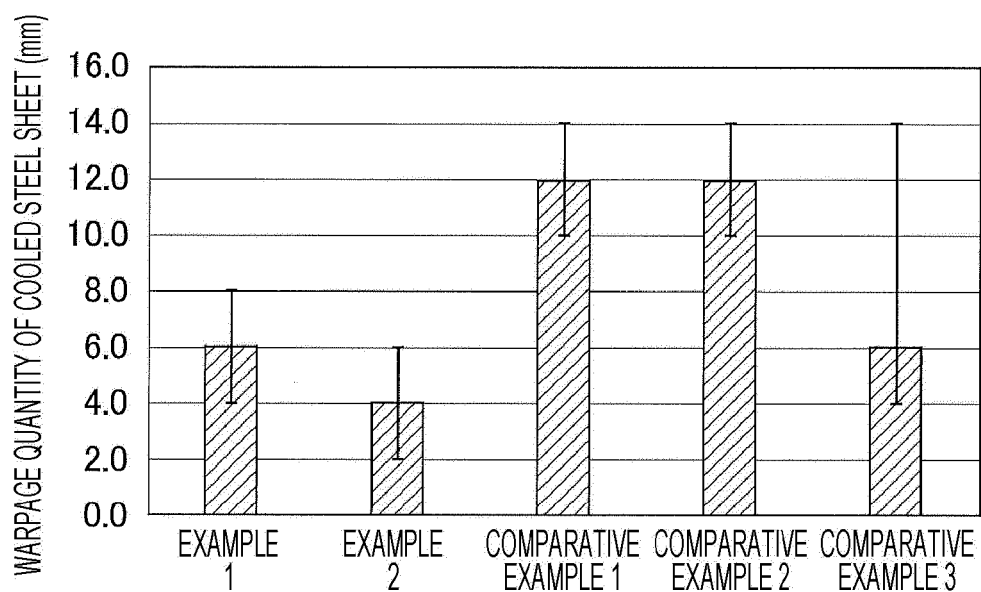
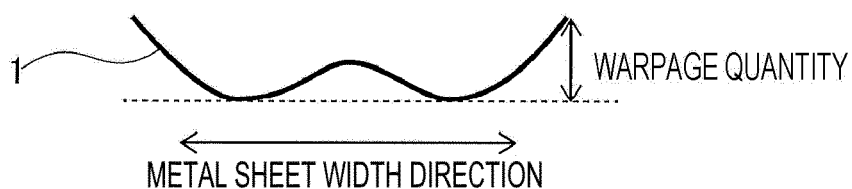


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/039666

A. CLASSIFICATION OF SUBJECT MATTER

C21D 9/52(2006.01)i; **C21D 9/573**(2006.01)i; C22C 38/00(2006.01)n; C22C 38/06(2006.01)n; C22C 38/60(2006.01)n;
C21D 1/18(2006.01)i; **C21D 1/26**(2006.01)i

FI: C21D9/573 101Z; C21D9/52 101; C21D1/18 A; C21D1/26 G; C22C38/00 301U; C22C38/60; C22C38/06

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-C21D9/66; C22C38/00-C22C38/60; C21D1/18; C21D1/26

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 1971-2021
 Registered utility model specifications of Japan 1996-2021
 Published registered utility model applications of Japan 1994-2021

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.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 176682/1979 (Laid-open No. 95573/1981) (KAWASAKI STEEL CORPORATION) 29 July 1981 (1981-07-29), claims, page 1, line 12 to page 3, line 17, page 4, line 4 to page 6, line 5, fig. 2	1-6
Y	JP 2008-150685 A (SUMITOMO METAL INDUSTRIES, LIMITED) 03 July 2008 (2008-07-03) claims, paragraphs [0001], [0021]-[0028], [0053], fig. 1	1-6
A	JP 2019-90106 A (JFE STEEL CORPORATION) 13 June 2019 (2019-06-13) entire text, all drawings	1-6
A	JP 62-501300 A (BERTIN ET COMPAGNIE) 21 May 1987 (1987-05-21) entire text, all drawings	1-6
A	US 2016/0304984 A1 (FIVES STEIN) 20 October 2016 (2016-10-20) entire text, all drawings	1-6

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search 14 December 2021	Date of mailing of the international search report 11 January 2022
Name and mailing address of the ISA/JP Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan	Authorized officer Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2021/039666

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 56-95573 U1	29 July 1981	(Family: none)	
JP 2008-150685 A	03 July 2008	(Family: none)	
JP 2019-90106 A	13 June 2019	(Family: none)	
JP 62-501300 A	21 May 1987	WO 1986/002384 A1 entire text, all drawings EP 0197079 A1 FR 2571384 A1 AU 5011185 A	
US 2016/0304984 A1	20 October 2016	WO 2015/083047 A1 entire text, all drawings EP 3077554 A1 FR 3014447 A1 CN 105793446 A KR 10-2016-0095064 A PL 3077554 T3 ES 2764095 T3	

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2000178658 A [0006]
- JP 2009127060 A [0006]
- JP 6094722 B [0006]