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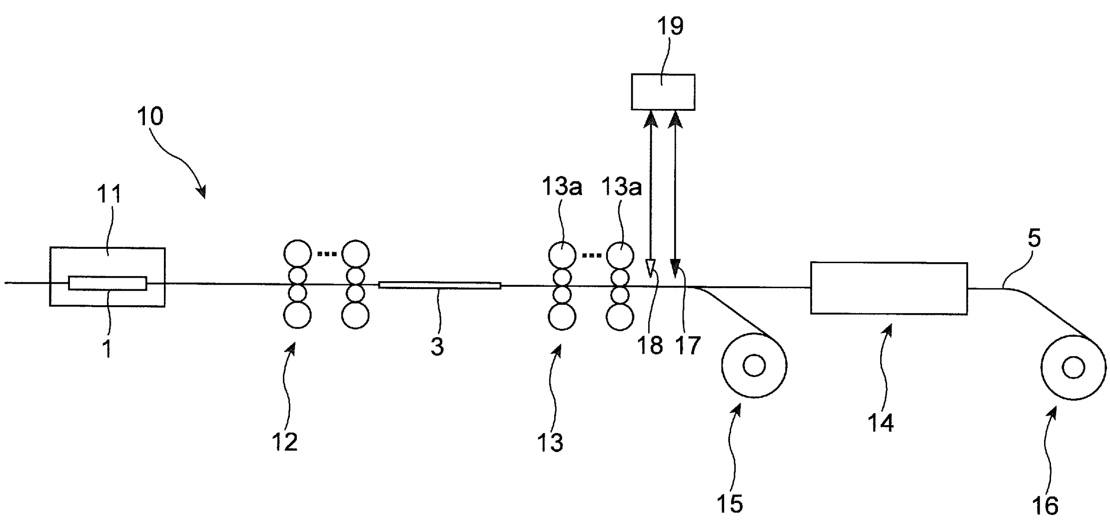
(54) STEEL SHEET MANUFACTURING METHOD AND STEEL SHEET MANUFACTURING DEVICE

(57) A method of manufacturing a strip has a step of selectively enlarging a place, at which a strip width is smaller than a predetermined width, of a hot strip that is formed from a steel.

FIG.1



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Description

Technical Field

[0001] The present invention relates to a method of manufacturing a strip and a device for manufacturing a strip.

Background Art

[0002] Among steel sheets (strips) and steel plates, for example, strips have a strip thickness of 0.4 to 6 mm, and are used widely as materials of automobiles, electrical machines, construction materials, and the like.

[0003] As the aforementioned strips, there are those at which a hot strip (a hot rolled coil) of a predetermined thickness is obtained by a hot rolling step of hot rolling a cast slab, and this hot strip (hot rolled coil) is shipped-out as is as a product, or there are those that are manufactured by further carrying out a cold rolling step or a heat treatment step on this hot strip (hot rolled coil).

[0004] Among the aforementioned hot strips, there are those at which fluctuations arise in the strip width at the time of rolling in the hot rolling step. Thus, in order to ensure the strip width of the product, the strip width of the hot strip is set to be wider than the strip width of the product, in consideration of the aforementioned fluctuations in the strip width. In this case, in order to make the final product be a predetermined strip width, strip width end portions are removed in an after-process. However, if the strip width is set to be wider than needed, the manufacturing yield deteriorates. On the other hand, if the strip width of the hot strip is set to be narrow in order to improve the manufacturing yield, there is the concern that the strip width will be insufficient at the final product due to fluctuations in the strip width.

[0005] A rolling method by which it is possible to enlarge the strip width of a strip is proposed in Japanese Patent Application Laid-Open (JP-A) No. H08-132104 for example. In this JP-A No. 08-132104, by carrying out rolling by a flat roller and a rolling roller in which plural groove portions are formed and that has a convex and concave cross-sectional shape, a strip in which both plural unrolled portions and rolled portions exist in the strip width direction is obtained, and, by carrying out rolling by flat rollers on this strip, only the unrolled portions of the strip are rolled, and further, the entire width of the strip is rolled by using flat rollers.

[0006] In JP-A No. H08-132104, because a rolling roller, in which plural groove portions are formed and that has a convex and concave cross-sectional shape, is used, there is the problem that costs are involved in maintaining the cross-sectional shape of the rolling roller. Further, it is difficult to accurately control the strip width over the entire length of the rolled material. Moreover, even in a case in which the strip width is enlarged by the above-described rolling, because there is the need to ensure a strip width at which a final product of a predetermined strip width can be obtained, the strip width after the enlargement is set in consideration of fluctuations in the strip width, and there is still the problem that the manufacturing yield deteriorates.

SUMMARY OF INVENTION

[0007] An object of embodiments of the present specification is to provide a method of manufacturing a strip and a device for manufacturing a strip that can manufacture a strip inexpensively and at a good yield.

[0008] In accordance with one aspect of the present specification, there is provided a method of manufacturing a strip, comprising a step of selectively enlarging a place, at which a strip width is smaller than a predetermined width, of a hot strip that is formed from a steel.

[0009] In accordance with another aspect of the present specification, there is provided a device for manufacturing a strip, comprising enlarging means for selectively enlarging a place, at which a strip width is smaller than a predetermined width, of a hot strip that is formed from a steel.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 is an explanatory drawing showing a schematic structure of a hot rolling line that implements a method of manufacturing a strip relating to a first embodiment of the present specification.

Fig. 2 is an explanatory drawing showing a schematic structure of a restraining/cooling device relating to the first embodiment.

Fig. 3 is an enlarged explanatory drawing of a restraining/cooling section shown in Fig. 2.

Fig. 4 is a continuous cooling transformation diagram (a CCT diagram) of a steel in the first embodiment.

Fig. 5 is an explanatory drawing showing a schematic structure of a hot rolling line that implements a method of manufacturing a strip relating to a second embodiment of the present specification.

Fig. 6 is an explanatory drawing showing a schematic structure of a restraining/cooling device relating to the second embodiment.

Fig. 7 is a graph showing enlargement ratios of the strip width of a hot strip in Examples.

DESCRIPTION OF EMBODIMENTS

[0011] As the result of assiduous research, the present inventors obtained the following knowledge.

(1) A strip can be manufactured inexpensively and at a good yield by selectively enlarging a place, at which a strip width is smaller than a predetermined width, of a hot strip.

(2) The strip width of a hot strip is enlarged by rapidly

cooling, in a state in which displacement in a strip thickness direction is restrained, a hot strip that is in a high-temperature state.

[0012] Embodiments of the present specification are based on the above-described findings. In accordance with one aspect of an embodiment, there is provided a method of manufacturing a strip comprising a step of selectively enlarging a place, at which a strip width is smaller than a predetermined width, of a hot strip that is formed from a steel. In accordance with this method of manufacturing, because a place, at which the strip width is smaller than a predetermined width, of the hot strip is selectively enlarged, the strip width of the hot strip that is needed in order to make the final product be a predetermined strip width can be set to be small. As a result, an improvement in the manufacturing yield can be devised, and a strip can be manufactured inexpensively.

[0013] At a place at which the strip width is enlarged, the strip thickness decreases in accordance with the enlarging of the strip width due to plastic strain. Thus, by utilizing the enlargement of the strip width and the decrease in the strip thickness, fluctuations in the strip width, fluctuations in the strip thickness, and fluctuations in shape such as a wave shape (displacement in the strip thickness direction) and meandering (displacement in the strip width direction) and the like, can be corrected locally, and a strip having excellent accuracy of shape can be manufactured.

[0014] In the method of manufacturing a strip of the embodiments of the present specification, the hot strip may be wound by a coiler at a hot rolling line, and the place at which the strip width is smaller than the predetermined width may be a distal end portion of a hot strip at which the strip width has become small due to excessive tension that arises at a time when tension is initially applied by the coiler to the hot strip that is to be wound by the coiler. By selectively enlarging a portion at which the strip width has become small due to excessive tension that arises at the time when tension is initially applied by the coiler, there is no need to make the strip width of the hot strip larger than needed in order to make the final product be a predetermined strip width, and a strip can be manufactured at a good yield.

[0015] In the method of manufacturing a strip of the embodiments of the present specification, the step of selectively enlarging the strip width of the place at which the strip width is smaller than the predetermined width may include a cooling step of cooling the place, at which the strip width is smaller than the predetermined width, of the hot strip in a state in which displacement of the hot strip in a strip thickness direction is restrained, at greater than or equal to a lower critical cooling speed at which martensitic transformation occurs, from an austenite temperature range at which single-phase austenite exists to less than a martensite transformation start temperature.

[0016] The austenite temperature range, the martensite transformation start temperature, and the lower critical cooling speed at which the martensitic transformation occurs are specified from the CCT diagram (continuous cooling transformation diagram) of the steel that structures the hot strip.

[0017] In accordance with the method of manufacturing a strip of this structure, the hot strip is cooled at a cooling speed that is greater than or equal to the lower critical cooling speed at which martensitic transformation occurs, from the austenite temperature range at which single-phase austenite exists to less than the martensite transformation start temperature. Therefore, the austenite phase phase-transforms to the martensite phase, and transformation expansion arises due thereto. Because the hot strip is cooled in a state in which displacement in the strip thickness direction is restrained, plastic strain arises in the strip width direction due to the aforementioned transformation expansion, and the strip width of the hot strip can be enlarged. Accordingly, there is no need to make the strip width of the hot strip greater than needed in order to make the final product be a predetermined strip width, and an improvement in the manufacturing yield can be devised.

[0018] In the cooling step, it is preferable for cooling to be carried out from the austenite temperature region, at which single-phase austenite exists, to less than the martensite transformation finish temperature, and it is preferable that the cooling speed be made to be greater than or equal to the upper critical cooling speed at which the entire hot strip becomes martensite.

[0019] Given that the strip passing speed of the hot strip at a restraining/cooling device is V m/sec, it is desirable to carry out the restraining of the displacement in the strip thickness direction over greater than or equal to (5V/14) m in the length direction of the hot strip (the strip).

[0020] In the method of manufacturing a strip of the embodiments of the present specification, given that a strip passing speed of the hot strip is V (m/sec), in the cooling step, cooling may be carried out at a cooling speed of greater than or equal to 140°C/sec in a state in which displacement of the hot strip in the strip thickness direction is restrained over greater than or equal to (5V/14) m in a length direction of the hot strip.

[0021] The method of manufacturing a strip of the embodiments of the present specification may be structured so as to have a finishing rolling step that manufactures the hot strip, and such that the temperature of the hot strip after this finishing rolling step is made to be in the austenite temperature range, and the cooling step is carried out in continuation with the finishing rolling step.

[0022] In accordance with the method of manufacturing a strip of this structure, there is no need to heat the hot strip to the austenite temperature range, and a reduction in the amount of energy that is consumed can be devised, and the manufacturing cost of the strip can be reduced. Further, because the finishing rolling step and the cooling step are carried out in continuation, the production efficiency can be improved.

[0023] In the method of manufacturing a strip of the embodiments of the present specification, displacement of the hot strip in the strip thickness direction may be restrained by, in a state in which tension is applied to the hot strip in a length direction of the hot strip, protruding the place, at which the strip width is smaller than the predetermined width, of the hot strip toward at least one direction side in the strip thickness direction of the hot strip from a plane that is parallel to a strip passing direction of the hot strip, over a strip width of the hot strip. By doing so, displacement of the hot strip in the strip thickness direction can be restrained by a simple structure. A roller may be used as the member that protrudes the hot strip toward at least one direction side in the strip thickness direction of the hot strip from a plane that is parallel to a strip passing direction of the hot strip, over the strip width of the hot strip.

[0024] The method of manufacturing a strip of the embodiments of the present specification may further comprise a heating step of selectively heating the place, at which the strip width is smaller than the predetermined width, of the hot strip until the austenite temperature range, wherein the cooling step may be carried out in continuation with the heating step.

[0025] In accordance with the method of manufacturing a strip of this structure, because the method has the heating step that heats the hot strip to the austenite temperature range, the temperature of the hot strip before cooling can be set relatively freely, and the conditions of the cooling step can be optimized, and fluctuations in the strip width, fluctuations in the strip thickness, and fluctuations in the shape such as a wave shape, meandering and the like can be corrected precisely.

[0026] In accordance with the method of manufacturing a strip of the embodiments of the present specification, the cooling step may be carried out repeatedly a plurality of times. In accordance with this method of manufacturing a strip, by carrying out the cooling step plural times, the plastic strain in the strip width direction becomes large, and the strip width can be enlarged further. Further, because the strip thickness also decreases accompanying the enlargement of the strip width, fluctuations in the strip width, fluctuations in strip thickness, and fluctuations in the shape such as a wave shape, meandering and the like can be reliably corrected by utilizing this enlargement in the strip width and decrease in the strip thickness.

[0027] The method of manufacturing a strip of the embodiments of the present specification may further comprise a step of, in a length direction of the hot strip, measuring a strip width.

[0028] In accordance with another aspect of the embodiments of the present specification, there is provided a device for manufacturing a strip, comprising enlarging means for selectively enlarging a place, at which a strip width is smaller than a predetermined width, of a hot strip that is formed from a steel.

[0029] In accordance with this device for manufacturing a strip, because a place, at which the strip width is smaller than a predetermined width, of the hot strip is selectively enlarged, the strip width of the hot strip that is needed in order to make the final product be a predetermined strip width can be set to be small. As a result, an improvement in the manufacturing yield can be devised, and a strip can be manufactured inexpensively.

[0030] At a place at which the strip width is enlarged, the strip thickness decreases in accordance with the enlarging of the strip width due to plastic strain. Thus, by utilizing the enlargement of the strip width and the decrease in the strip thickness, fluctuations in the strip width, fluctuations in the strip thickness, and fluctuations in shape such as a wave shape, meandering and the like, can be corrected locally, and a strip having excellent accuracy of shape can be manufactured.

[0031] In the device for manufacturing a strip of the embodiments of the present specification, the hot strip may be wound by a coiler at a hot rolling line, and the place at which the strip width is smaller than the predetermined width may be a distal end portion of a hot strip at which the strip width has become small due to excessive tension that arises at a time when tension is initially applied by the coiler to the hot strip that is to be wound by the coiler. By selectively enlarging a portion, at which the strip width has become small due to excessive tension that arises at the time when tension is initially applied by the coiler, there is no need to make the strip width of the hot strip larger than needed in order to make the final product be a predetermined strip width, and a strip can be manufactured at a good yield.

[0032] The enlarging means of the device for manufacturing a strip of the embodiment of the present specification may include:

restraining means for restraining displacement, in a strip thickness direction, of a hot strip that is formed from a steel;
cooling means for cooling the hot strip; and
control means for controlling the restraining means and the cooling means,
wherein, on the basis of data relating to a strip width in a length direction of the hot strip, the control means may control the restraining means and the cooling means such that the place, at which the strip width is smaller than the predetermined width, of the hot strip is selectively cooled in a state in which displacement of the hot strip in the strip thickness direction is restrained, at greater than or equal to a lower critical cooling speed at which martensitic transformation occurs, from an austenite temperature range at which single-phase austenite exists to less than a martensite transformation start temperature.

[0033] The enlarging means of the device for manufacturing a strip includes the restraining means for restraining deformation of the hot strip in the strip thickness direction, the cooling means for cooling the hot strip, and the control means for controlling the restraining means and the cooling means. The restraining means and the cooling means are controlled such that cooling is carried out in a state in which displacement of the hot strip in the strip thickness direction is restrained, at greater than or equal to a lower critical cooling speed at which martensitic transformation occurs, from the austenite temperature range single-phase austenite exists to less than the martensite transformation start temperature. Therefore, plastic strain can be brought about in the strip width direction at the hot strip, and the strip width can be enlarged. Further, by utilizing the aforementioned plastic strain, fluctuations in the strip width, fluctuations in the strip thickness, and fluctuations in shape such as a wave shape, meandering and the like can be corrected.

[0034] The device for manufacturing a strip of the embodiments of the present specification may further include strip width measuring means for measuring a strip width of the hot strip in the length direction of the hot strip, wherein, on the basis of data relating to the strip width in the length direction of the hot strip from the strip width measuring means, the control means may control the restraining means and the cooling means to carry out the cooling.

[0035] In accordance with the device for manufacturing a strip of this structure, by carrying out cooling of the hot strip on the basis of the measured data of the strip width measuring means, the strip width can be enlarged locally, and the strip can be manufactured at a good yield.

[0036] The device for manufacturing a strip of the embodiments of the present specification may comprise restraining means for restraining deformation of the hot strip in the strip thickness direction, cooling means for cooling the hot strip, control means for controlling the restraining means and the cooling means, and shape measuring means for measuring, in a length direction of the hot strip, at least one sheet shape information selected from strip width, strip thickness, a wave shape and an amount of meandering, wherein the control means may control the restraining means and the cooling means on the basis of the measured data measured by the shape measuring means, and may carry out cooling of the hot strip.

[0037] In accordance with the device for manufacturing a strip of this structure, by carrying out cooling of the hot strip on the basis of the measured data of the shape measuring means, the strip width is enlarged, the strip thickness is decreased, the strip width, the strip thickness, the wave shape, and the amount of meandering can be corrected locally, and a high-quality strip can be manufactured at a good yield.

[0038] The device for manufacturing a strip of the embodiments of the present specification may further comprise heating means for heating the hot strip to the austenite temperature range, wherein the control means is control means that also controls the heating means, and, on the basis of data relating to the strip width in the length direction of the hot strip, the control means may control the restraining means and the cooling means and the heating means so as to selectively heat the place, at which the strip width is smaller than the predetermined width, of the hot strip to the austenite temperature range, and to carry out the cooling in continuation with the heating.

[0039] In accordance with the device for manufacturing a strip of this structure, the temperature of the hot strip before cooling can be set relatively freely by the heating means, and the conditions of the cooling can be optimized, and fluctuations in the strip width, fluctuations in the strip thickness, and fluctuations in the shape such as a wave shape, meandering and the like can be corrected precisely.

[0040] In the device for manufacturing a strip of the embodiments of the present specification, the restraining means may include: tension applying means for applying tension to the hot strip in the length direction of the hot strip; and protruding means for protruding the hot strip toward at least one direction side in the strip thickness direction of the hot strip from a plane that is parallel to a strip passing direction of the hot strip, over a strip width of the hot strip. By doing so, displacement of the hot strip in the strip thickness direction can be restrained by a simple structure.

[0041] A roller may be used as a protruding member that protrudes the hot strip toward at least one direction side in the strip thickness direction of the hot strip from a plane that is parallel to the strip passing direction of the hot strip, over the strip width of the hot strip.

[0042] In the device for manufacturing a strip of the embodiments of the present specification, the protruding means may be a roller having an internal cooling mechanism. In accordance with the device for manufacturing a strip of this structure, also at a place that contacts the roller, the hot strip can be cooled, and can be reliably cooled at greater than or equal to the cooling speed at which the martensitic transformation occurs.

[0043] In the device for manufacturing a strip of the embodiments of the present specification, the rollers may be structured so as to be disposed alternately in the strip passing direction at the one surface and the other surface of the hot strip.

[0044] In accordance with the device for manufacturing a strip of this structure, displacement in the strip thickness direction can be reliably suppressed by the rollers that are disposed alternately in the strip passing direction at the one surface and the other surface of the hot strip, and plastic strain in the strip width direction can be reliably brought about due to transformation expansion.

[0045] In the device for manufacturing a strip of the embodiments of the present specification, there may be a structure in which the rollers have a large diameter roller and presser rollers that are positioned at strip passing direction both sides of the large diameter roller, and displacement of the hot strip in the strip thickness direction is restrained due to the hot strip being pressed-against the outer peripheral surface of the large diameter roller by the presser rollers.

[0046] In accordance with the device for manufacturing a strip of this structure, displacement of the hot strip in the strip thickness direction can be suppressed due to the hot strip being pressed-against the outer peripheral surface of the large diameter roller so as to run therealong by the presser rollers that are positioned at the strip passing direction both sides of the large diameter roller. Accordingly, plastic strain can be reliably brought about in the strip width direction by the transformation expansion.

[0047] In the device for manufacturing a strip of the embodiments of the present specification, the roller may have projections at the roller surface. In accordance with the device for manufacturing a strip of this structure, the contact of the hot strip with the roller is made uniform, and displacement of the hot strip in the strip thickness direction can be suppressed reliably.

[0048] A method of manufacturing a strip and a device for manufacturing a strip that are embodiments of the present specification are described concretely hereinafter with reference to the appended drawings.

(First Embodiment)

[0049] In a first embodiment, a strip, which is formed from carbon steel and that phase-transforms from the austenite phase to the martensite phase in a cooling step, is manufactured. Concretely, a strip (strip thickness: 0.4 to 6 mm) is manufactured from a hot strip 5 that is manufactured by using the hot rolling line shown in Fig. 1.

[0050] A hot rolling line 10 shown in Fig. 1 has a heating furnace 11 that heats a slab 1, a roughing mill 12 that rough-rolls the heated slab 1 and makes it into a rough-rolled material 3, a finishing mill 13 that rolls the rough-rolled material 3 and manufactures the hot strip 5 that has a predetermined thickness (in the present embodiment, 1.2 to 6 mm), and a cooling device 14 that cools the hot strip 5 after the finishing rolling to a predetermined temperature. Note that a first coiler 15 is disposed at the stage before the cooling device 14, and a second coiler 16 is disposed at the stage after the cooling device 14, respectively.

[0051] As shown in Fig. 1, the finishing mill 13 has plural rolling stands 13a. A strip width meter 17, which measures the strip width of the hot strip 5, and a thermometer 18, which measures the temperature of the hot strip 5, are disposed at the exit side of the finishing mill 13. Strip width data and temperature data that are measured by the strip width meter 17 and the thermometer 18 are transferred to a computer 19. Due thereto, strip width data per longitudinal direction position of the hot strip 5 is stored in the computer 19.

[0052] The hot strip 5 that is manufactured at this hot rolling line 10 is wound by the first coiler 15 after the rolling at the finishing mill 13, or is wound by the second coiler 16 after being cooled to a predetermined temperature by the cooling device 14.

[0053] The hot strip 5 that is wound by the first coiler 15 or the second coiler 16 in this way (the hot rolled coil) is conveyed to a restraining/cooling device 20 shown in Fig. 2 by a coil car (not illustrated) or a crane (not illustrated) or the like.

[0054] As shown in Fig. 2, the restraining/cooling device 20 has an uncoiler 21 to which the coil of the hot strip 5 is mounted, a heating section 22 that heats the hot strip 5, a restraining/cooling section 30 that restrains and cools the heated hot strip 5, and a coiler 23 that winds-up the hot strip 5 that has been restrained and cooled. Note that this is a structure in which the hot strip 5 is conveyed to the heating section 22 and the restraining/cooling section 30 by the coiler 23 and the uncoiler 21. Tension is applied to the hot strip 5 in a length direction 51 of the hot strip 5 by the coiler 23 and the uncoiler 21. The coiler 23 and the uncoiler 21 are examples of the tension applying means. Further, the hot strip 5 is conveyed in a strip passing direction 52 by the coiler 23 and the uncoiler 21.

[0055] Further, at the restraining/cooling device 20 that is the present embodiment, thermometers 26a, 26b are disposed at the entrance side and the exit side of the heating section 22, and a strip width meter 27 and a thermometer 28 are disposed at the exit side of the restraining/cooling section 30.

[0056] As shown in Fig. 3, the restraining/cooling section 30 has restraining rollers 31 that restrain displacement of the hot strip 5 in the strip thickness direction, and cooling members 37 that cool the hot strip 5 that is restrained.

[0057] In the present embodiment, the restraining rollers 31 have a large diameter roller 32, and presser rollers 35 that are positioned at the strip passing direction both sides of this large diameter roller 32.

[0058] Tension is applied to the hot strip 5 in the length direction 51 of the hot strip 5 by the coiler 23 and the uncoiler 21. In the state in which tension is applied in this way, displacement of the hot strip 5 in the strip thickness direction is restrained over the strip width of the hot strip 5, due to the hot strip 5 being protruded by the large diameter roller 32 toward a one direction (in the present embodiment, the upper surface direction of the hot strip 5 (the upper side direction in the drawing)) side in a strip thickness direction 53 of the hot strip 5 from a plane that is parallel to the strip passing direction 52 of the hot strip 5. The large diameter roller 32 is an example of the protruding means. At the restraining rollers 31 of this structure, displacement of the hot strip 5 in the strip thickness direction is restrained even more due to the hot strip 5 being pressed-against the outer peripheral surface of the large diameter roller 32 by the presser rollers 35 that are positioned at the strip passing direction both sides of the large diameter roller 32.

[0059] Further, an internal cooling mechanism 33 is provided at the large diameter roller 32, and there is a structure in which a coolant (cooling water in the present embodiment) is sprayed onto the hot strip 5 that is pressed-against the outer peripheral surface, and the hot strip 5 can be cooled. Moreover, plural projections (not illustrated) are formed at the outer peripheral surface of the large diameter roller 32 in order to make the contact with the hot strip 5 uniform.

[0060] A plurality of the cooling members 37 are disposed at the outer peripheral side of the large diameter roller 32, and have cooling nozzles that spray a coolant (cooling water in the present embodiment) onto the hot strip 5 that is pressed-against the large diameter roller 32.

[0061] Further, the restraining/cooling device 20 of the present embodiment has a control section 24 that controls operations of the uncoiler 21, the coiler 23, the heating section 22, the restraining rollers 31 and the cooling means 37, and adjusts the conveying speed of the hot strip 5, the state of heating by the heating section 22, and the state of restraining and the state of cooling at the restraining/cooling section 30.

[0062] This control section 24 is structured so as to control the operations of the uncoiler 21, the coiler 23, the heating section 22, the restraining rollers 31 and the cooling means 37 on the basis of strip width data per length direction position of the hot strip 5 that is stored in the computer 19 of the above-described hot rolling line 10.

[0063] A method of manufacturing a strip, which is the present embodiment and which uses the above-described hot rolling line 10 and restraining/cooling device 20, is described next.

[0064] The strip that is manufactured in the present embodiment is structured by carbon steel that phase-transforms from the austenite phase to the martensite phase.

[0065] Fig. 4 shows an example of a continuous cooling transformation diagram (CCT diagram) of carbon steel that structures the strip (the hot strip 5) in the present embodiment. In accordance with this continuous cooling transformation diagram (CCT diagram), the austenite temperature region in which single-phase austenite exists is greater than or equal to 800°C. Further, the martensite transformation start temperature (Ms point) is 220°C.

[0066] When the average cooling speed in the cooling step becomes greater than 25°C/sec., martensitic transformation occurs, and the hot strip 5 becomes a martensite structure. In a case in which the average cooling speed in the cooling step is greater than 140°C/sec., approximately the entire hot strips 5 becomes a martensite structure. Namely, the lower critical cooling speed is 25°C/sec., and the upper critical cooling speed is 140°C/sec. Note that the continuous cooling transformation diagram (CCT diagram) of carbon steel of Fig. 4 is common also to the second embodiment that is described later.

[0067] The austenite temperature region, the martensite transformation start temperature (Ms point), the martensite transformation finish temperature (Mf point), the lower critical cooling speed and the upper critical cooling speed differ in accordance with the component composition of the steel that structures the strip that is to be manufactured. Therefore, the cooling temperature band and the cooling speed in the restraining/cooling treatment of the hot strip 5 are set on the basis of the CCT diagram and in accordance with the component composition of the steel that structures the strip that is to be manufactured.

[0068] In the method of manufacturing a strip that is the present embodiment, first, the hot strip 5 of a predetermined thickness is obtained by the finishing mill 13 of the hot rolling line 10. At this time, the strip width and temperature are measured per length direction position of the hot strip 5 by the strip width meter 17 and the thermometer 18 that are set at the exit side of the finishing mill 13, and these results of measurement are transferred to the computer 19.

[0069] By correcting the measured strip width data by the temperature data, the computer 19 computes the strip width per length direction position of the hot strip 5, and specifies the length direction positions of the hot strip 5 at which the strip width is insufficient with respect to the target strip width size of the product (hereinafter called insufficient strip width positions), and the amounts of insufficiency of the strip width.

[0070] The hot strip 5 that has been rolled at the finishing mill 13 is wound onto and is made into a rolled coil at the first coiler 15 or, after having passed-through the cooling device 14, the second coiler 16, and is conveyed by a coil car (not illustrated) or a crane (not illustrated) or the like, and is mounted to the uncoiler 21 of the restraining/cooling device 20 shown in Fig. 2.

[0071] The hot rolled coil that is mounted to the uncoiler 21 is unrolled, and is conveyed to the heating section 22 of the restraining/cooling device 20.

[0072] Here, information that are the aforementioned insufficient strip width positions, which have been computed from the strip width data and the temperature data stored in the computer 19 of the hot rolling line 10, and the amounts of insufficiency of the strip width, are transferred to the control section 24 of the restraining/cooling device 20.

[0073] At the time when an insufficient strip width position of the hot strip 5 passes-through the heating section 22, the control section 24 operates the heating section 22, and locally (selectively) heats the insufficient strip width position of the hot strip 5. At this time, the heating temperature is in the austenite temperature region, and, in the present embodiment, is set to greater than or equal to 800°C and less than or equal to 950°C. Note that, in the present embodiment, because the thermometer 26a is disposed at the entrance side of the heating section 22, heating is carried out on the basis of this temperature data such that the temperature of the insufficient strip width position becomes greater than or equal to 800°C and less than or equal to 950°C.

[0074] The hot strip 5 that has passed-through the heating section 22 is conveyed to the restraining/cooling section 30. At the time when an insufficient strip width position of the hot strip 5 passes-through the restraining/cooling section 30, the control section 24 gives commands to the restraining rollers 31 and the cooling means 37 to execute restraining/cooling treatment of the hot strip 5. Concretely, in the state in which tension is written on the hot strip 5 in the length direction 41 of the hot strip 5 by the uncoiler 21 and the coiler 23, the hot strip 5 is pressed-against the surface of the large diameter roller 32 by the presser rollers 35 and is set in a state in which displacement of the hot strip 5 in the strip thickness direction is suppressed, and cooling of the hot strip 5 is carried out by the cooling means 37 and the internal cooling mechanism 33 of the large diameter roller 32.

[0075] At the time when the hot strip 5 is pressed-against the large diameter roller 32 and displacement of the hot strip 5 in the strip thickness direction is suppressed, it is desirable to ensure that the length over which displacement in the strip thickness direction is restrained, i.e., the contact length of the hot strip 5 with the large diameter roller 32, be greater than or equal to (5V/14)m (where V is the strip passing speed (m/sec) of the hot strip at the restraining/cooling device 20). By ensuring that the contact length is greater than or equal to this, displacement in the strip thickness direction is effectively suppressed, and the strip width can be enlarged. The reasons for this are as follows.

[0076] When cooling the hot strip 5, the martensitic transformation starts at the point in time when the temperature of the hot strip 5 becomes the MS point, and ends at the point in time when the temperature of the hot strip 5 becomes the MF point. The difference between the MS point and the MF point is usually around 50°C, and the cooling speed during this time is desirably greater than or equal to 140°C/sec as shown in Fig. 4. During this time, by restraining displacement in the strip thickness direction and carrying out cooling, plastic strain arises in the strip width direction due to the transformation expansion at the time when the austenite phase transforms to the martensite phase, and the strip width of the hot strip 5 can be enlarged.

[0077] Accordingly, if the restraining/cooling treatment of the hot strip 5 is carried out at the time when an insufficient strip width position of the hot strip 5 passes-through the restraining/cooling section 30, the strip width of the insufficient strip width position of the hot strip 5 can be enlarged selectively.

[0078] If strip thickness direction displacement during a period of time of the time band from the MS point to the MF point is restrained, the effect of enlarging the strip width of the hot strip 5 can be achieved, but, in order to achieve the strip width enlarging effect to the utmost, it is desirable to restrain strip thickness direction displacement over the entire time band from the MS point to the MF point. Accordingly, given that the strip passing speed of the restraining/cooling device 20 is V m/sec, the time of the hot strip from the MS point to the MF point is a maximum (50°C ÷ 140°C/sec) = (5/14)sec, and therefore, it is desirable to restrain displacement in the strip thickness direction for this time or more.

Due to the above, in the present embodiment, it is desirable that the contact length of the hot strip 5 with the large diameter roller 32 of the restraining/cooling device 20 be made to be greater than or equal to (V m/sec)×(5/14)sec = (5V/14)m.

[0079] Note that, at this time, the cooling speed is made to be greater than or equal to the lower critical cooling speed at which the martensitic transformation occurs, and, in the present embodiment, is greater than or equal to 25°C/sec., and is preferably in a range of greater than or equal to 25°C/sec. and less than 250°C/sec. The reason for less than 250°C/sec. is because it is difficult to make the cooling speed be a cooling speed of greater than or equal to that when carrying out water cooling. Further, as described above, the cooling speed at the cooling means 37 is preferably made to be greater than or equal to the upper critical cooling speed (greater than or equal to 140°C/sec in Fig. 4) at which the entire hot strip 5 becomes a martensite structure.

[0080] The hot strip 5 that has passed-through the restraining/cooling section 30 is wound-up by the coiler 23. Here, the strip width and temperature per length direction position of the hot strip 5 are measured by the strip width meter 27 and the thermometer 28 that are set at the exit side of the restraining/cooling section 30, and these results of measurement are transferred to a computer 29.

[0081] By correcting the measured strip width data by the temperature data, the computer 29 computes the strip width per length direction position of the hot strip 5, and judges whether or not there are places where the strip width is insufficient with respect to the target strip width size of the product, and, in a case in which the strip width is insufficient, specifies the length direction position of the hot strip 5 at which the strip width is insufficient (the insufficient strip width position) and the amount of insufficiency of the strip width.

[0082] In a case in which there exists a place where the strip width is insufficient with respect to the target strip width size of the product, the hot rolled coil that was wound on the coiler 23 is again mounted to the uncoiler 21, and the above-described restraining/cooling treatment is executed repeatedly plural times until a predetermined strip width is obtained at the entire length of the hot strip 5.

[0083] Thereafter, due to a cold rolling step, a heat treatment step, and the like being carried out on the hot strip 5 that has been obtained in this way, a strip having a predetermined strip thickness and strip width is manufactured.

[0084] In accordance with the method of manufacturing a strip and the restraining/cooling device 20 that are the present embodiment and that are structured as described above, from the austenite temperature range (greater than or equal to 800°C and less than or equal to 950°C in the present embodiment) to less than the martensite transformation start temperature, and preferably less than the martensite finish temperature (250°C in the present embodiment), the hot strip 5 is cooled at a cooling speed (greater than or equal to 25°C/sec. in the present embodiment) that is greater than or equal to the lower critical cooling speed at which the martensitic transformation occurs. Therefore, in the cooling step, transformation expansion occurs due to the austenite phase phase-transforming to the martensite phase. Here, in the method of manufacturing a strip that is the present embodiment, because cooling is carried out in a state in which displacement of the hot strip 5 in the strip thickness direction is restrained, plastic strain arises in the strip width direction due to the aforementioned transformation expansion, and the strip width of the hot strip 5 enlarges.

[0085] Due thereto, there is no need to make the strip width of the hot strip 5 excessively large in order to ensure the strip width of the strip, and an improvement in the manufacturing yield can be devised.

[0086] Further, because the insufficient strip width positions of the hot strip 5 are selectively subjected to the restraining/cooling treatment, the strip widths of the insufficient strip width positions of the hot strip 5 can be enlarged selectively, and, as a result, the strip can be manufactured inexpensively.

[0087] Note that the hot strip 5 is wound by the coiler 15 or the coiler 16 at the hot rolling line 10 shown in Fig. 1. It is easy for insufficiency in the strip width to arise at the hot strip distal end portions due to excessive tension that arises at the time when tension is first applied by the coiler 15 or the coiler 16 to the hot strip 5 that is to be wound by the coiler 15 or the coiler 16. Therefore, it is preferable to selectively restrain/cool at least the insufficient strip width positions that arise in this way.

[0088] Further, in the method of manufacturing a strip and the restraining/cooling device 20 of the present embodiment, the hot strip 5 is heated in the austenite temperature range (greater than or equal to 800°C and less than or equal to 950°C) by the heating section 22 of the restraining/cooling device 20. Therefore, the conditions of the restraining/cooling treatment can be optimized, and the strip width can be corrected precisely. Further, if the insufficient strip width positions of the hot strip 5 are heated selectively, the strip can be manufactured inexpensively.

[0089] Moreover, in the method of manufacturing a strip and the restraining/cooling device 20 of the present embodiment, there is a structure in which the measured data of the strip width meter 17 and the thermometer 18 that are disposed at the exit side of the finishing mill 13 are transferred to the computer 19, and, at the computer 19, due to the measured strip width data being corrected by the temperature data, the insufficient strip width positions of the hot strip 5 and the amounts of insufficiency of the strip width are specified, and, at the restraining/cooling device 20, these insufficient strip width positions are heated and restrained/cooled. Therefore, at the insufficient strip width positions of the hot strip 5, the strip width can be reliably enlarged, and the strip width of the hot strip 5 that is needed in order to make the final product be a predetermined strip width can be made to be small.

[0090] Moreover, in the method of manufacturing a strip and the restraining/cooling device 20 of the present embodiment, there is a structure in which the strip width and the temperature are measured per length direction position of the hot strip 5 by the strip width meter 27 and the thermometer 28 that are set at the exit side of the restraining/cooling section 30, and the strip width per length direction position of the hot strip 5 is computed from these measured data, and, in a case in which there is a place at which the strip width is insufficient with respect to the target strip width size of the product, the restraining/cooling treatment is repeatedly executed plural times. Therefore, a predetermined strip width can be obtained at the entire length of the hot strip 5, and the strip width of the hot strip 5 that is needed in order to make the final product be a predetermined strip width can be made to be even smaller.

[0091] Further, at the restraining/cooling device 20 that is the present embodiment, the restraining rollers 31 that are provided at the restraining/cooling section 30 are structured by the large diameter roller 32, and the presser rollers 35 that are positioned at the strip passing direction both sides of the large diameter roller 32. Therefore, due to the hot strip 5 being pressed-against the outer peripheral surface of the large diameter roller 32 so as to run therealong by the presser rollers 35 that are positioned at the strip passing direction both sides of the large diameter roller 32, displacement of the hot strip 5 in the strip thickness direction can be suppressed, and plastic strain is reliably brought about in the strip width direction due to the transformation expansion, and the strip width can be enlarged.

[0092] Moreover, at the restraining/cooling device 20 that is the present embodiment, because the large diameter roller 32 has the internal cooling mechanism 33, the hot strip 5, which is pressed-against the outer peripheral surface of the large diameter roller 32 so as to run therealong, can be heated at greater than or equal to the lower critical cooling speed at which the martensitic transformation occurs, and plastic strain is reliably brought about in the strip width direction by the transformation expansion, and the strip width can be enlarged.

[0093] Further, at the restraining/cooling device 20 that is the present embodiment, because the plural projections are formed at the outer peripheral surface of the large diameter roller 32, contact of the large diameter roller 32 and the hot strip 5 is made uniform, and displacement of the hot strip 5 in the strip thickness direction can be reliably suppressed.

(Second Embodiment)

[0094] A method of manufacturing a strip and a restraining/cooling device that are a second embodiment are described next.

[0095] In the same way as in the first embodiment, the method of manufacturing a strip that is the second embodiment manufactures a strip that is formed from carbon steel that phase-transforms from the austenite phase to the martensite phase in a cooling step. Concretely, a strip (strip thickness: 0.4 to 6 mm) is manufactured from the hot strip 5 that is manufactured by using a hot rolling line 110 shown in Fig. 5.

[0096] The hot rolling line 110 shown in Fig. 5 has a heating furnace 111 that heats the slab 1, a roughing mill 112 that rough-rolls the heated slab 1 and makes it into the rough-rolled material 3, a finishing mill 113 that rolls the rough-rolled material 3 and manufactures the hot strip 5 that has a predetermined thickness (in the present embodiment, 1.2 to 6 mm), a restraining/cooling device 120 that carries out restraining/cooling treatment on the hot strip 5 after the finishing rolling, and a coiler 116 that is disposed at the stage after the restraining/cooling device 120.

[0097] As shown in Fig. 6, the restraining/cooling device 120 has restraining rollers 131 that suppress displacement of the hot strip 5 in the strip thickness direction, and cooling means 137 that cool the hot strip 5.

[0098] The restraining rollers 131 are disposed alternately in the strip passing direction at the one surface and the other surface of the hot strip 5, and are disposed in a so-called staggered form.

[0099] The cooling means 137 is cooling nozzles that are disposed between the restraining rollers 131, and cools the hot strip 5 by spraying a coolant (cooling water in the present embodiment) onto the hot strip 5.

[0100] A method of manufacturing a strip, which is the present embodiment and that uses the hot rolling line 110 and the restraining/cooling device 120 that have the above-described structures, is described next.

[0101] In the same way as in the first embodiment, the strip that is manufactured in the present embodiment is structured from carbon steel that phase-transforms from the austenite phase to the martensite phase, and has the continuous cooling transformation diagram (CCT diagram) shown in Fig. 4.

[0102] In the method of manufacturing a strip that is the present embodiment, first, the hot strip 5 of a predetermined thickness is obtained by finishing rolling by the finishing mill 113 of the hot rolling line 110. Here, the temperature of the hot strip 5 that is conveyed-out from the finishing mill 113 is in the austenite temperature range at which single-phase austenite exists (in the present embodiment, greater than or equal to 800°C and less than or equal to 950°C).

[0103] The hot strip 5 that has been rolled at the finishing mill 113 is conveyed to the restraining/cooling device 120. At the restraining/cooling device 120, due to the one surface and the other surface of the hot strip 5 that is passing-through being supported by the restraining rollers 131, there is a state in which displacement of the hot strip 5 in the strip thickness direction is suppressed, and cooling of the hot strip 5 by the cooling means 137 is carried out. In this case, displacement of the strip (the hot strip 5) in the strip thickness direction from the first restraining roller 131 to the last restraining roller 131 is restrained.

[0104] At this time, at the cooling means 137, the cooling speed of the hot strip 5 is made to be greater than or equal to the lower critical cooling speed at which the martensitic transformation occurs, and, in the present embodiment, is greater than or equal to 25°C/sec., and is preferably in a range of greater than or equal to 25°C/sec. and less than 250°C/sec.. The reason for less than 250°C/sec is because it is difficult to make the cooling speed be a cooling speed of greater than or equal to that when carrying out water cooling. Further, it is preferable that the cooling speed at the cooling means 137 be made to be greater than or equal to the upper critical cooling speed at which the entire hot strip 5 becomes a martensite structure.

[0105] Then, the hot strip 5 that has passed-through the restraining/cooling device 120 is wound-up by the coiler 116.

[0106] Thereafter, due to a cold rolling step, a heat treatment step, and the like being carried out on the hot strip 5 that has been obtained in this way, a strip having a predetermined strip thickness and strip width is manufactured.

[0107] In accordance with the method of manufacturing a strip and the restraining/cooling device 120 that are the present embodiment and are structured as described above, in the same way as in the first embodiment, from the austenite temperature range (greater than or equal to 800°C and less than or equal to 950°C in the present embodiment) to less than the martensite transformation start temperature, and preferably less than the martensite transformation finish temperature (250°C in the present embodiment), a state is set in which displacement of the hot strip 5 in the strip thickness direction is restrained, and cooling is carried out at a cooling speed (greater than or equal to 25°C/sec. in the present embodiment) that is greater than or equal to the lower critical cooling speed at which the martensitic transformation occurs. Therefore, plastic strain is brought about in the strip width direction due to the transformation expansion that accompanies the transformation to the martensite phase, and the strip width of the hot strip 5 can be enlarged.

[0108] Moreover, in the present embodiment, because the restraining/cooling treatment is carried out at the entire length of the hot strip 5, the strip width can be enlarged over the entire length of the hot strip 5.

[0109] Further, in the present embodiment, there is a structure in which the temperature of the hot strip 5 that has been rolled by the finishing mill 113 is made to be in the austenite temperature range (in the present embodiment, greater than or equal to 800°C and less than or equal to 950°C), and the restraining/cooling treatment is carried out by the restraining/cooling device 120 that is set at the stage after the finishing mill 113 of the heat rolling line 110. Therefore, there is no need to re-heat the hot strip 5, and reduction in the amount of energy that is consumed can be devised, and the manufacturing cost of the strip can be reduced. Further, because the finishing rolling step and the restraining/cooling treatment are carried out in continuation, the production efficiency can be improved.

[0110] In the above-described embodiments, description is given with the object being carbon steel that has the continuous cooling transformation diagram (CCT diagram) shown in Fig. 4, but embodiments of the present specification is not limited to this, and the object may be another steel that phase-transforms from the austenite phase to the martensite phase. In this case, it suffices to specify the austenite temperature range, the martensite transformation start temperature (Ms), the martensite transformation finish temperature (Mf), the lower critical cooling speed at which the martensitic transformation occurs, the upper critical cooling speed at which the entire hot strip 5 becomes a martensite structure, and the like, and to prescribe the cooling start temperature, the cooling end temperature and the cooling speed of the hot strip, by using the continuous cooling transformation diagram (CCT diagram) of the steel that is the object.

[0111] Further, in the above-described embodiments, description is given of using the hot rolling lines that are shown in Fig. 1 and Fig. 5. However, embodiments of the present specification is not limited to this, and may be structured such that a hot strip is manufactured by using a hot rolling line of another structure, and restraining/cooling treatment is carried out on this hot strip.

[0112] Moreover, in the first embodiment, description is given of measuring the strip width of the hot strip, and carrying out the restraining/cooling treatment on the basis of this measured data. However, embodiments of the present specification is not limited to this, and other shape information such as the strip thickness, the wave shape, the amount of meandering, or the like may be measured, and the restraining/cooling treatment may be carried out on the basis of this measured data. In this case, strip thickness fluctuations, the wave shape, meandering, and the like can be corrected accurately by utilizing enlargement of the strip width and reduction of the strip thickness.

EXAMPLES

[0113] By using the hot rolling line 10 and the restraining/cooling device that were described in the first embodiment, manufacturing of a hot strip was carried out, and the enlargement ratio of the strip width was confirmed.

[0114] S45 (C: 0.45 mass%, Mn: 0.5 mass%, P: 0.025 mass%, S: 0.025 mass%) was used as the type of steel. Note that the austenite temperature range of this S45 is greater than or equal to 900°C, the martensite transformation start temperature (Ms) is 420°C, and the martensite transformation finish temperature (Mf) is 270°C. Further, the lower critical cooling speed at which the martensitic transformation occurs is 100°C/sec., and the upper critical cooling speed at which the entire hot strip becomes a martensite structure is 250°C/sec.

[0115] A hot strip of a size of a strip thickness of 1.2 to 6 mm and a strip width of 550 to 2500 mm was manufactured at a strip passing speed of 100 to 1200 mpm, and the relationship between the strip thickness and the enlargement ratio of the strip width due to the restraining/cooling treatment was confirmed. The contact length of the hot strip 5 with the large diameter roller in this case was made to be 8 m. Note that the enlargement ratio of the strip width was determined by (amount of enlargement of strip width) / (strip width before restraining/cooling treatment). The results are shown in Fig. 7.

[0116] It was confirmed that, due to the restraining/cooling treatment, the strip width was enlarged in a range of 0.3 to 0.5%.

[0117] The disclosure of Japanese Patent Application No. 2014-225008 filed on November 5, 2014 is, in its entirety, incorporated by reference into the present specification. All publications, patent applications, and technical standards mentioned in the present specification are incorporated by reference into the present specification to the same extent as if such individual publication, patent application, or technical standard was specifically and individually indicated to be incorporated by reference.

[0118] Although various, typical embodiments have been described above, the present invention is not limited to these embodiments. The scope of the present invention is to be limited only by the following claims.

Claims

1. A method of manufacturing a strip, comprising a step of selectively enlarging a place, at which a strip width is smaller than a predetermined width, of a hot strip that is formed from a steel.

2. The method of manufacturing a strip of Claim 1, wherein the hot strip is wound by a coiler at a hot rolling line, and the place at which the strip width is smaller than the predetermined width is a hot strip distal end portion at which the strip width has become small due to excessive tension that arises at a time when tension is initially applied by the coiler to the hot strip that is to be wound by the coiler.

3. The method of manufacturing a strip of Claim 1 or Claim 2, wherein the step of selectively enlarging the strip width of the place at which the strip width is smaller than the predetermined width includes a cooling step of cooling the place, at which the strip width is smaller than the predetermined width, of the hot strip in a state in which displacement of the hot strip in a strip thickness direction is restrained, at greater than or equal to a lower critical cooling speed at which martensitic transformation occurs, from an austenite temperature range at which single-phase austenite exists to less than a martensite transfor-

mation start temperature.

4. The method of manufacturing a strip of Claim 3, wherein displacement of the hot strip in the strip thickness direction is restrained by, in a state in which tension is applied to the hot strip in a length direction of the hot strip, protruding the place, at which the strip width is smaller than the predetermined width, of the hot strip toward at least one direction side in the strip thickness direction of the hot strip from a plane that is parallel to a strip passing direction of the hot strip, over a strip width of the hot strip.

5. The method of manufacturing a strip of Claim 3 or Claim 4, further comprising a heating step of selectively heating the place, at which the strip width is smaller than the predetermined width, of the hot strip until the austenite temperature range, wherein the cooling step is carried out in continuation with the heating step.

6. The method of manufacturing a strip of any one of Claim 3 through Claim 5, wherein, given that a strip passing speed of the hot strip is V (m/sec), in the cooling step, cooling is carried out at a cooling speed of greater than or equal to 140°C/sec in a state in which displacement of the hot strip in the strip thickness direction is restrained over greater than or equal to (5V/14) m in a length direction of the hot strip.

7. The method of manufacturing a strip of any one of Claim 3 through Claim 6, wherein the cooling step is carried out repeatedly a plurality of times.

8. The method of manufacturing a strip of any one of Claim 1 through Claim 7, further comprising a step of, in a length direction of the hot strip, measuring a strip width.

9. A device for manufacturing a strip, comprising enlarging means for selectively enlarging a place, at which a strip width is smaller than a predetermined width, of a hot strip that is formed from a steel.

10. The device for manufacturing a strip of Claim 9, wherein the hot strip is wound by a coiler at a hot rolling line, and the place at which the strip width is smaller than the predetermined width is a hot strip distal end portion at which the strip width has become small due to excessive tension that arises at a time when tension is initially applied by the coiler to the hot strip that is to be wound by the coiler.

11. The device for manufacturing a strip of Claim 9 or Claim 10, wherein the enlarging means includes:

restraining means for restraining displacement, in a strip thickness direction, of a hot strip that is formed from a steel;
cooling means for cooling the hot strip; and
control means for controlling the restraining means and the cooling means,
wherein, on the basis of data relating to a strip width in a length direction of the hot strip, the control means controls the restraining means and the cooling means such that the place, at which the strip width is smaller than the predetermined width, of the hot strip is selectively cooled in a state in which displacement of the hot strip in the strip thickness direction is restrained, at greater than or equal to a lower critical cooling speed at which martensitic transformation occurs, from an austenite temperature range at which single-phase austenite exists to less than a martensite transformation start temperature.

12. The device for manufacturing a strip of Claim 11, further comprising strip width measuring means for measuring a strip width of the hot strip in the length direction of the hot strip, wherein, on the basis of data relating to the strip width in the length direction of the hot strip from the strip width measuring means, the control means controls the restraining means and the cooling means to carry out the cooling.

13. The device for manufacturing a strip of Claim 11 or Claim 12, further comprising heating means for heating the hot strip to the austenite temperature range, wherein the control means is control means that also controls the heating means, and
wherein on the basis of data relating to the strip width in the length direction of the hot strip, the control means controls the restraining means, the cooling means and the heating means so as to selectively heat the place, at which the strip width is smaller than the predetermined width, of the hot strip to the austenite temperature range, and to carry out the cooling in continuation with the heating.

14. The device for manufacturing a strip of any one of Claim 11 through Claim 13, wherein the restraining means includes:

tension applying means for applying tension to the hot strip in the length direction of the hot strip; and
protruding means for protruding the hot strip toward at least one direction side in the strip thickness direction of the hot strip from a plane that is parallel to a strip passing direction of the hot strip, over a strip width of the hot strip.

15. The device for manufacturing a strip of Claim 14, wherein the protruding means is a roller having an internal cooling mechanism.

FIG.1

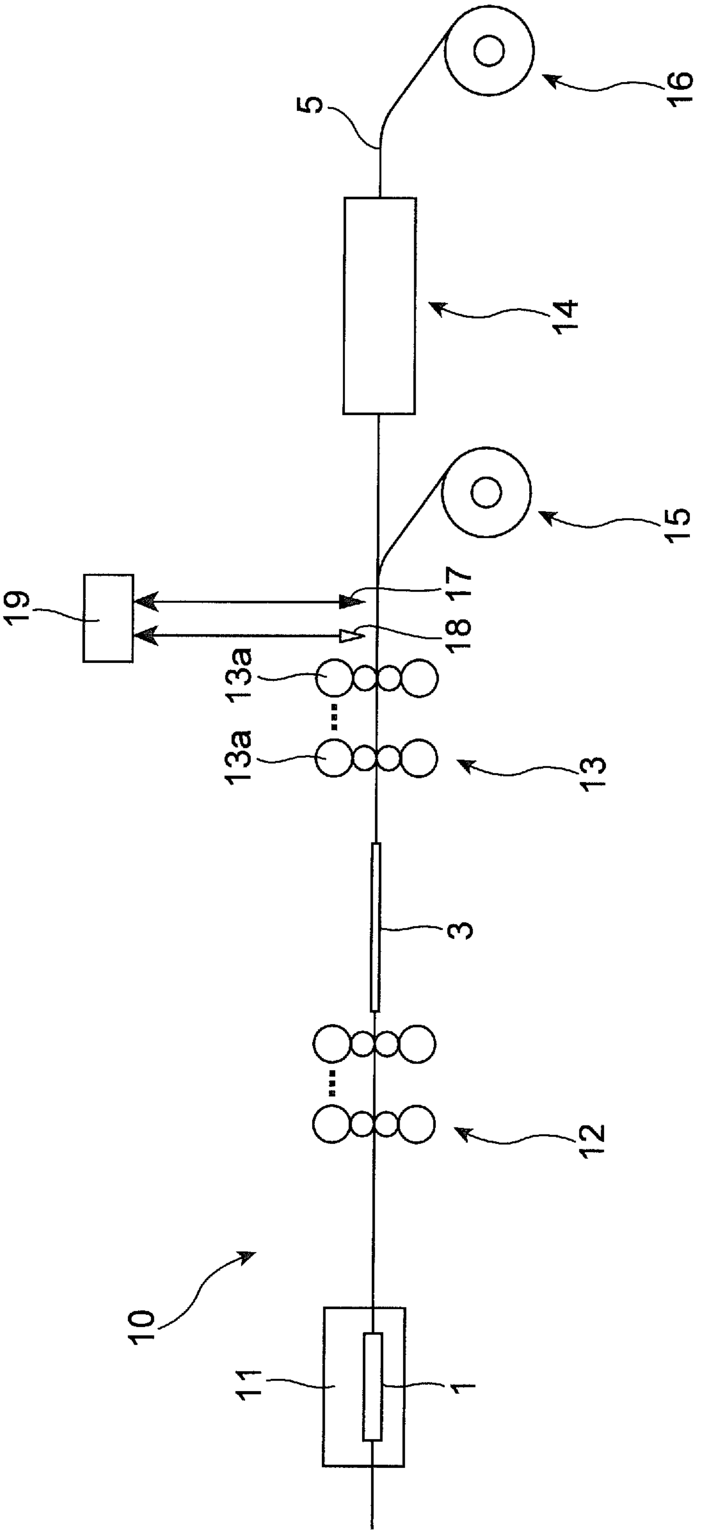


FIG.2

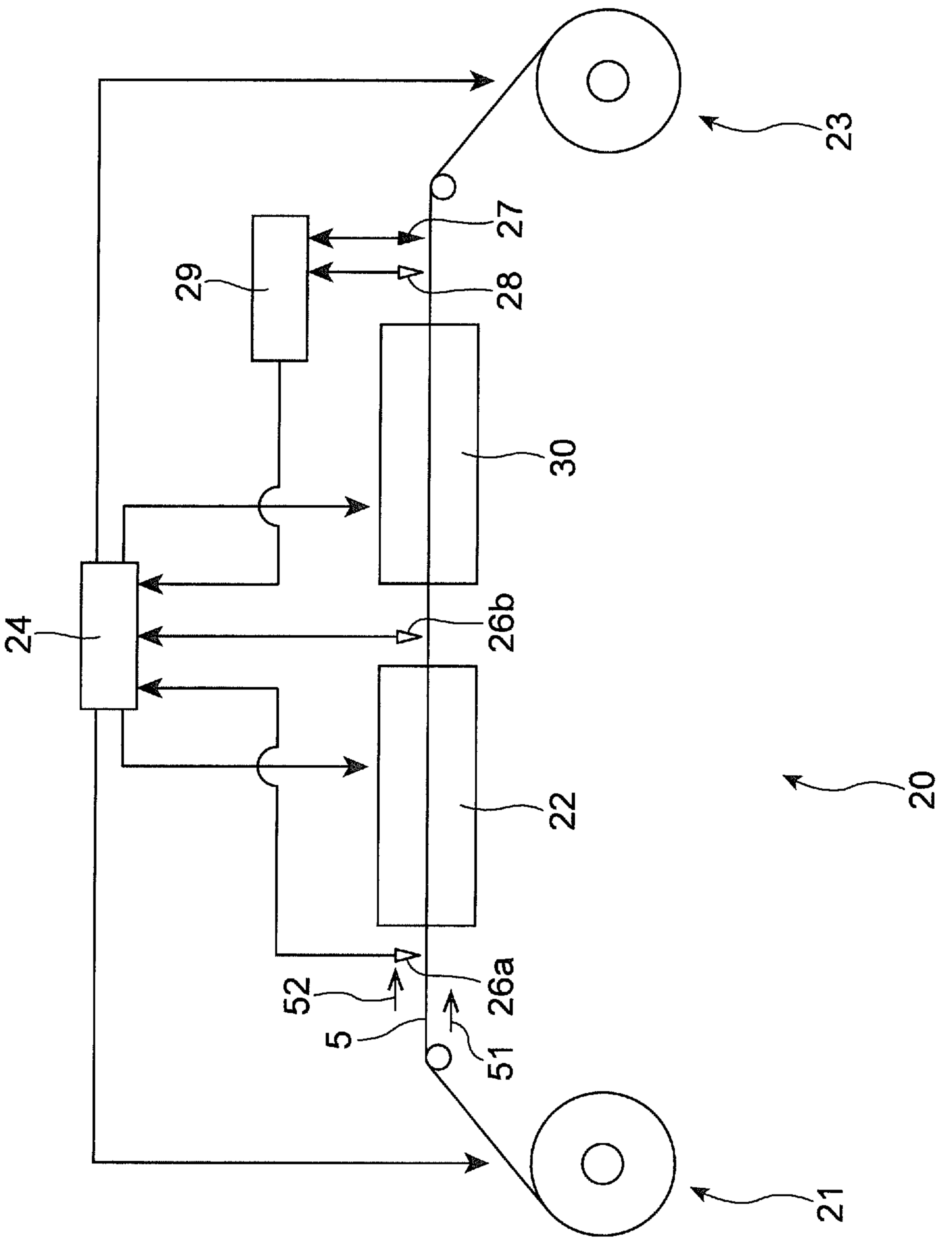


FIG.3

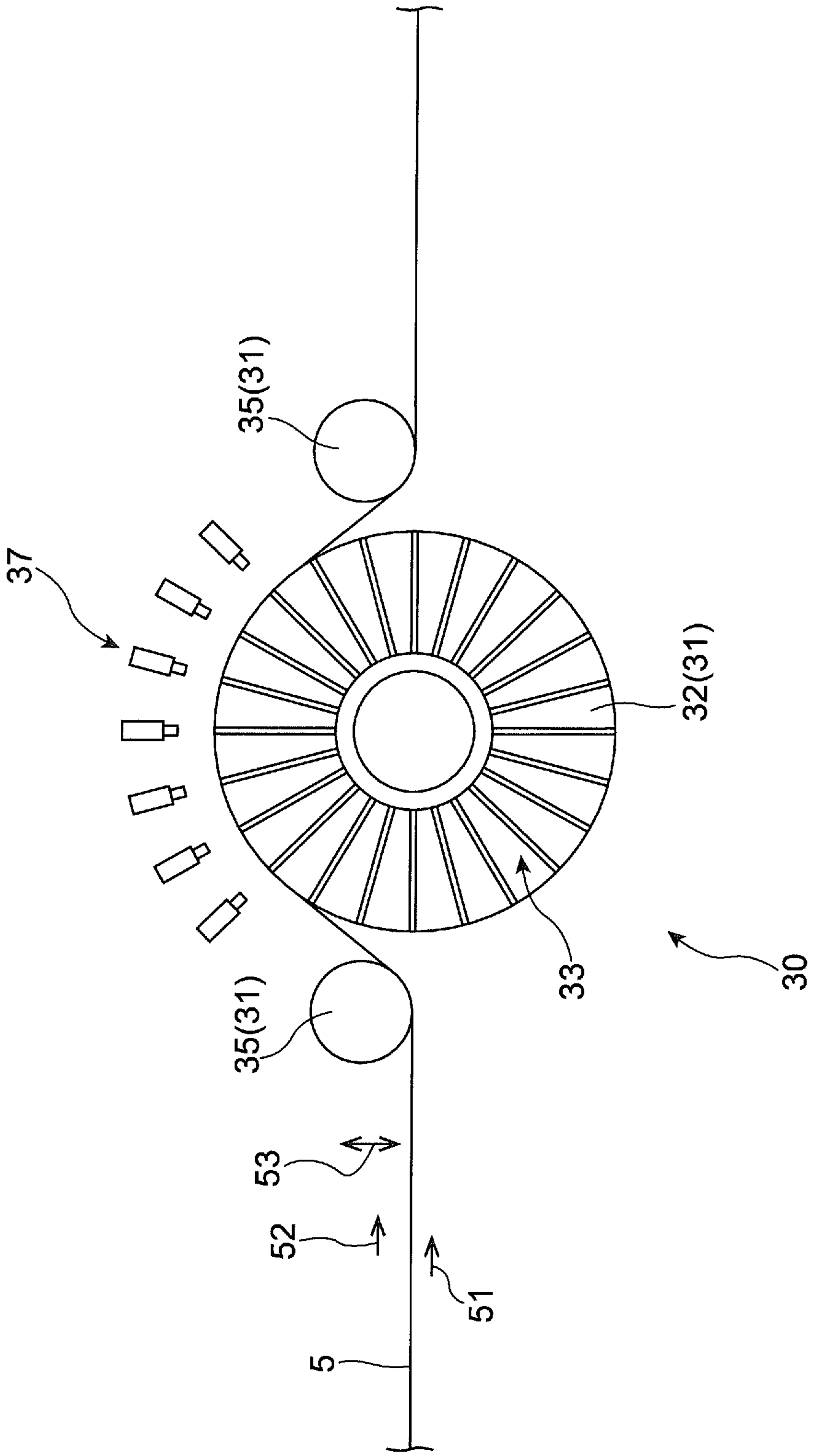
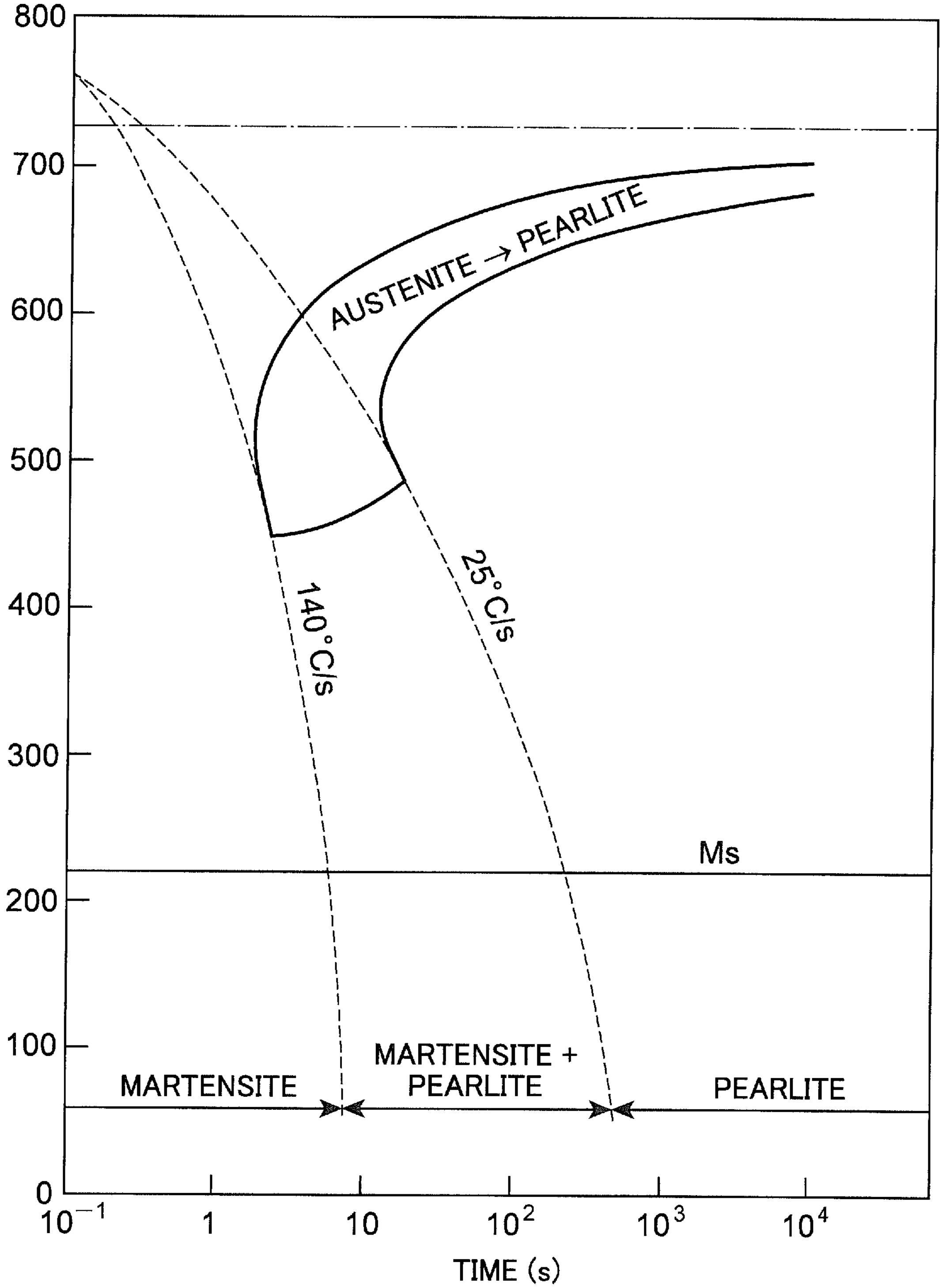


FIG.4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700
600
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400
300
200
100
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140°C/s
25°C/s
Ms
MARTENSITE
MARTENSITE +
PEARLITE
PEARLITE
10^{-1}
1
10
10^2
10^3
10^4
TIME (s)

FIG.5

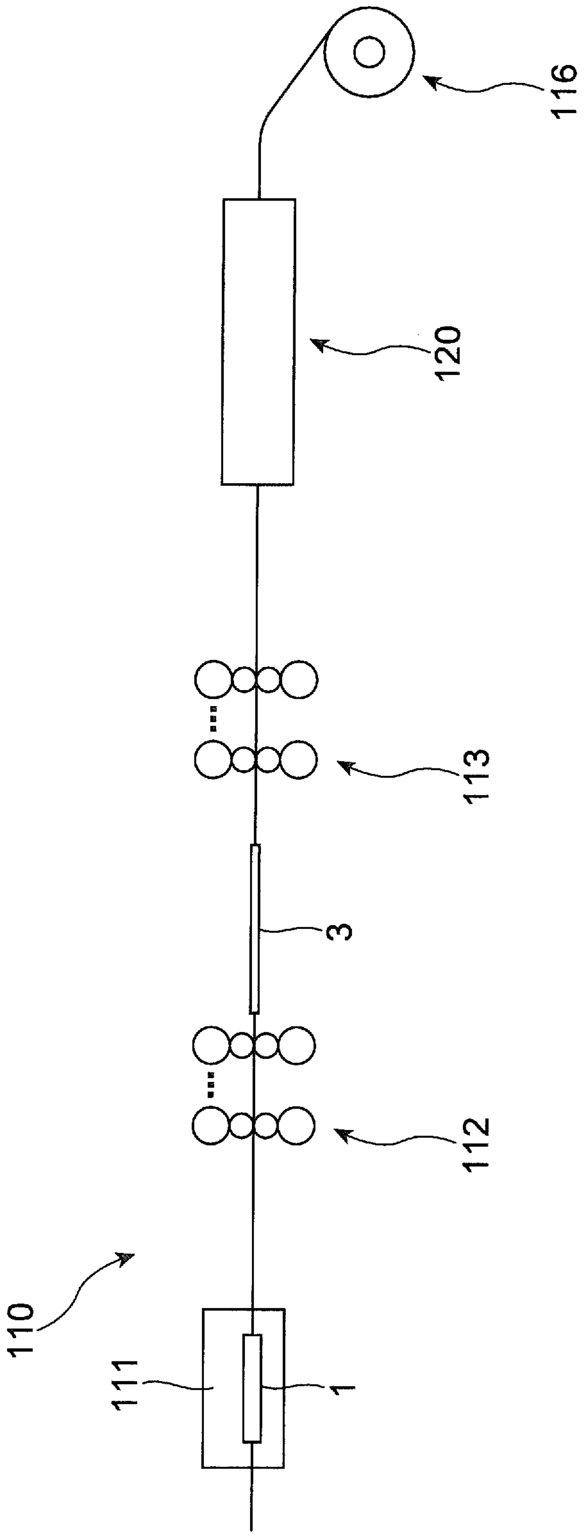


FIG.6

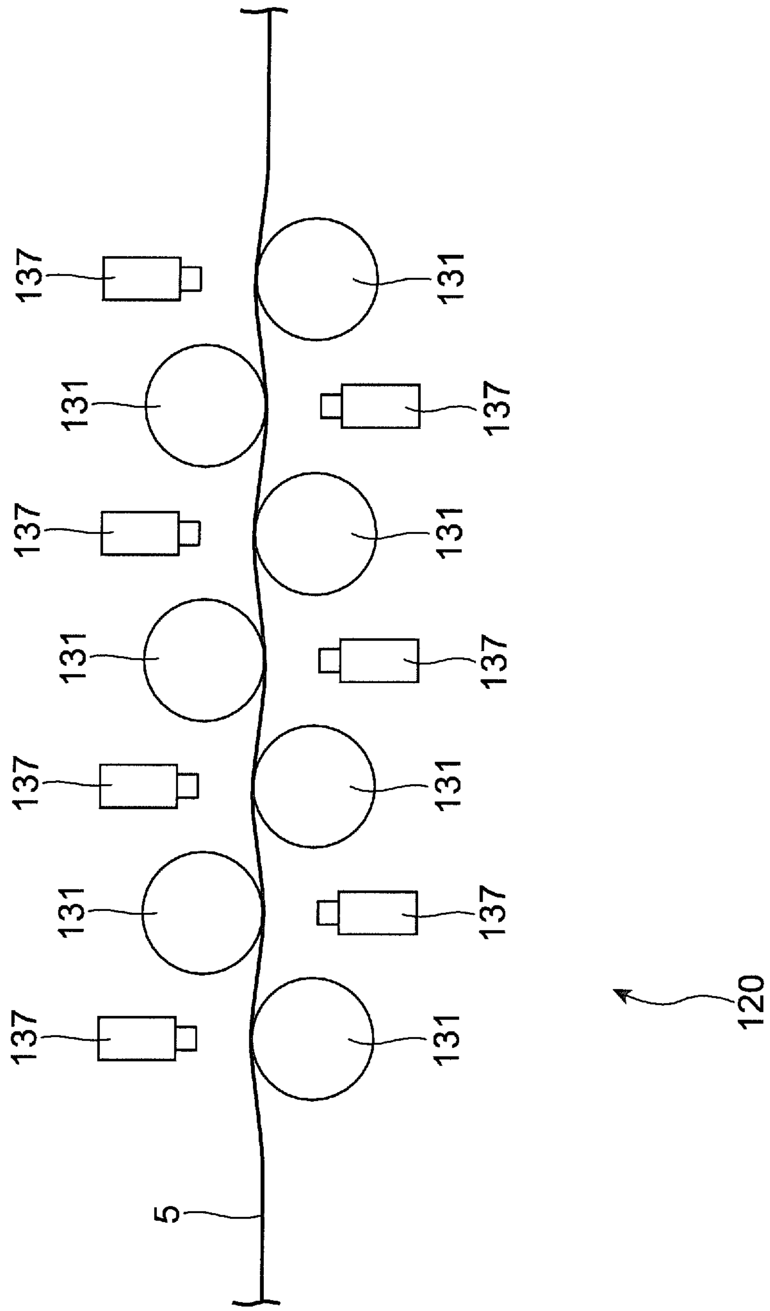
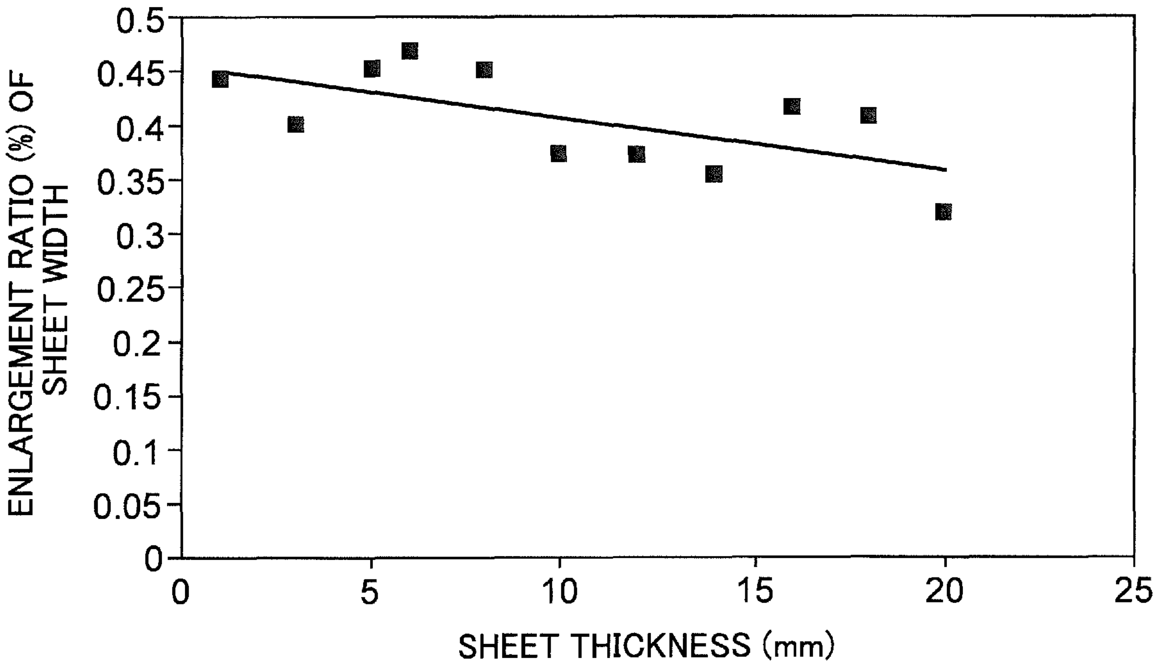


FIG.7


ENLARGEMENT RATIO (%) OF SHEET WIDTH
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0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
SHEET THICKNESS (mm)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/079873

A. CLASSIFICATION OF SUBJECT MATTER
C21D9/573(2006.01)i, *B21B1/26*(2006.01)i, *B21B45/02*(2006.01)i, *C21D1/18*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C21D9/573, B21B1/26, B21B37/00, B21B45/02, B21C51/00, C21D1/18, C21D8/02, C21D9/46

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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 Y A	JP 10-137828 A (Nippon Steel Corp.), 26 May 1998 (26.05.1998), claims; paragraph [0046] & US 6269668 B1 column 23, line 64 to column 24, line 10; claims & WO 1997/034715 A1 & EP 826437 A1 & KR 10-0245409 B1	1,8-9 2,10 3-7,11-15
Y	JP 10-263671 A (Sumitomo Metal Industries, Ltd.), 06 October 1998 (06.10.1998), paragraphs [0002] to [0005] (Family: none)	2,10

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"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)
"O" document referring to an oral disclosure, use, exhibition or other means
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Date of the actual completion of the international search	Date of mailing of the international search report
14 December 2015 (14.12.15)	22 December 2015 (22.12.15)

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/079873

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 11-347619 A (Kawasaki Steel Corp.), 21 December 1999 (21.12.1999), paragraph [0032] & US 6301946 B1 column 8, lines 50 to 58 & TW 429175 B	2,10
A	JP 5-271791 A (NKK Corp.), 19 October 1993 (19.10.1993), claims (Family: none)	1-15

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2014225008 A **[0117]**