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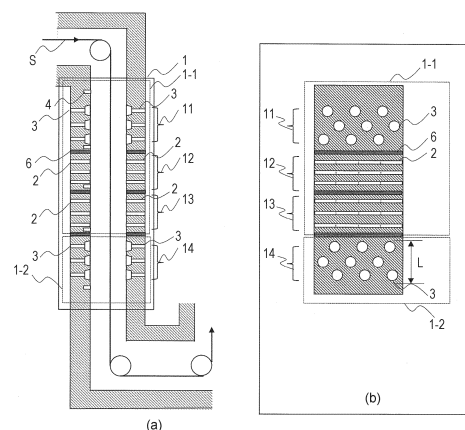
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(54) **METHOD FOR HEATING STEEL PLATE, METHOD FOR PRODUCING PLATED STEEL PLATE, DIRECT-FIRED HEATING FURNACE, AND CONTINUOUS HOT-DIP GALVANIZING EQUIPMENT**

(57) An object is to produce a galvanized steel sheet with stable quality free of bare spot.

A method for heating a steel sheet includes heating a front surface side and a rear surface side of a steel sheet that is passing through a direct fired furnace that has an oxidation zone where operation is conducted at an air ratio of 1 or more and a reduction zone where operation is conducted at an air ratio of less than 1, in which the heating is carried out with flames injected from at least one slit burner while the steel sheet passes through at least the oxidation zone.

FIG. 1



Description

Technical Field

- 5 **[0001]** The present invention relates to a method for heating a steel sheet, a method for producing a coated steel sheet, a direct fired furnace, and a continuous hot-dip galvanizing facility using a direct fired furnace.

Background Art

- 10 **[0002]** Solid-solution strengthening elements such as Si, Mn, P, and Al are often added to increase the tensile strength of steel sheets. In particular, Si offers advantages in that the cost for addition is low compared to other elements and that the strength can be increased without degrading the ductility of the steel. Thus, Si-containing steel is considered promising as high tensile strength steel sheets. However, the following problems arise when a large amount of Si is contained in the steel.
- 15 **[0003]** A high tensile strength steel sheet is annealed in a 600°C to 900°C temperature range in a reducing atmosphere in a step immediately preceding a coating step such as a hot-dip galvanizing step. Since Si is more easily oxidizable than Fe, Si concentrates in the steel sheet surface during this process. As a result, Si oxides form in the steel sheet surface and extensively degrade wettability with zinc, thereby causing bare spot. Furthermore, the concentration of Si in the surface extensively delays alloying in the alloying process following the hot-dip galvanization even if a galvanized coating has
- 20 adhered, resulting in degraded productivity.
- [0004]** In the past, to address these problems, Patent Literature 1 has proposed a precoating method that involves performing, in advance, an electroplating process on a steel sheet (raw material sheet) to be coated so as to form an Fe coating. Alternatively, Patent Literatures 2 and 3 have proposed an oxidation-reduction method that involves heating, in advance, a steel sheet in an oxidizing atmosphere to form an Fe oxide film on the surface thereof and then performing
- 25 annealing and coating in a reducing furnace.
- [0005]** However, in order to adopt the former precoating method, an electroplating facility needs to be installed on the entry side with respect to the annealing furnace in a continuous hot-dip galvanizing facility, and this implementation is difficult in view of the space and the facility investment cost.
- [0006]** In addition, the latter oxidation-reduction method is applicable to a conventional non-oxidizing furnace (NOF)- or
- 30 direct fired furnace (DFF)-system galvanizing line by adjusting the combustion atmosphere.
- [0007]** However, for example, in the case of conventional burners that have circular burner nozzle exits disclosed in Patent Literatures 4 and 5, the thickness of the Fe oxide film cannot be uniformly controlled during oxidation performed to ensure good coatability even when these burners are dispersedly distributed such as in a staggered pattern, resulting in bare spot defects.
- 35 **[0008]** Meanwhile, Patent Literature 6 has proposed a method of using slit burners in a horizontal furnace to achieve uniformity in the sheet width direction, in which these slit burners have a burner nozzle exit shape parallel to the steel sheet width direction. However, when slit burners are installed in an oxidizing furnace placed after a non-oxidizing furnace, the oxidizing furnace atmosphere flows into the non-oxidizing furnace since the furnace is of a horizontal type, thereby creating sheet temperature variation and nonuniformity in the Fe oxide film, and thus the effect of making flames uniform in the width
- 40 direction by using slit burners is not obtained.

Citation List

Patent Literature

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[0009]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2008-144264

Patent Literature 2: Japanese Unexamined Patent Application Publication No. 4-202630

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Patent Literature 3: Japanese Unexamined Patent Application Publication No. 7-34210

Patent Literature 4: Japanese Unexamined Patent Application Publication No. 62-29820

Patent Literature 5: Japanese Unexamined Patent Application Publication No. 9-59753

Patent Literature 6: Japanese Patent No. 3889019

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Summary of Invention

Technical Problem

5 **[0010]** However, according to the conventional precoating method, the thickness of the oxide film is still nonuniform due to the conventional burner nozzle shape and arrangement even when the atmosphere in the furnace during combustion is adjusted. Furthermore, even with slit burners, an Fe oxide film is nonuniformly formed when a horizontal furnace that sequentially includes a non-oxidizing furnace, an oxidizing furnace, and a reducing furnace is used in combination. Thus, the use of slit burners in the oxidizing furnace does not eliminate the nonuniformity.

10 **[0011]** The present invention has been made in view of the aforementioned problems and an object thereof is to produce a galvanized steel sheet with stable quality free of bare spot by a relatively simple method suitable for practical applications.

Solution to Problem

15 **[0012]** The gist of the present invention made to solve the aforementioned problems includes the following features.

[1] A method for heating a steel sheet, the method including heating a front surface side and a rear surface side of a steel sheet that is passing through a direct fired furnace that has an oxidation zone where operation is conducted at an air ratio of 1 or more and a reduction zone where operation is conducted at an air ratio of less than 1, in which the heating is carried out with flames injected from at least one slit burner while the steel sheet passes through at least the oxidation zone.

[2] The method for heating a steel sheet described in [1], in which the direct fired furnace conveys the steel sheet in a vertical direction and suctions combustion exhaust gas from an exhaust port installed under the slit burner.

25 [3] The method for heating a steel sheet described in [1] or [2], in which the air ratio in the oxidation zone is controlled to 1.00 or more and less than 1.50, and the air ratio in the reduction zone is controlled to 0.70 or more and less than 1.00.

[4] The method for heating a steel sheet described in any one of [1] to [3], in which the steel sheet is heated with the at least one slit burner in such a range that a temperature of the steel sheet passing the oxidation zone is 400°C or higher.

30 [5] A method for producing a coated steel sheet, the method including heat-treating a cold rolled steel sheet by the heating method described in any one of [1] to [3], and subjecting the cold rolled steel sheet to a coating treatment.

[6] The method for producing a coated steel sheet described in [5], in which the coating treatment uses one of an electrogalvanizing treatment, a hot-dip galvanizing treatment, and a galvannealing treatment.

35 [7] A direct fired furnace including an oxidation zone where operation is conducted at an air ratio of 1 or more, a reduction zone where operation is conducted at an air ratio of less than 1, and a control device capable of controlling the air ratios in the oxidation zone and the reduction zone, in which at least one portion of the oxidation zone is equipped with at least one slit burner disposed on a front surface side of the steel sheet and at least one slit burner disposed on a rear surface side of the steel sheet, each of the slit burners extending in a width direction of the steel sheet and injecting flames toward the steel sheet passing through the oxidation zone and the reduction zone.

40 [8] The direct fired furnace described in [7], in which the steel sheet is conveyed in a vertical direction, and combustion exhaust gas is suctioned from exhaust ports installed under the slit burners.

[9] The direct fired furnace described in [7] or [8], in which the air ratio in the oxidation zone is controlled to 1.00 or more and less than 1.50, and the air ratio in the reduction zone is controlled to 0.70 or more and less than 1.00.

[10] The direct fired furnace described in any one of [7] to [9], in which at least one of the slit burners is installed in a range where a temperature of the steel sheet passing through the oxidation zone is 400°C or higher.

45 [11] The direct fired furnace described in any one of [7] to [9], in which the oxidation zone includes a burner group having two or more slit burners for which the air ratio and a combustion rate are independently controllable.

[12] A continuous hot-dip galvanizing facility including the direct fired furnace described in any one of [7] to [9].

50 [13] The continuous hot-dip galvanizing facility described in [12], further including an alloying facility that alloys hot-dip galvanized coatings.

Advantageous Effects of Invention

55 **[0013]** According to the present invention, an excellent galvanized steel sheet having beautiful surface appearance free of bare spot is obtained. The present invention is particularly effective when a high-Si-content steel sheet, which is particularly difficult to galvanize, is used as the base material, and is useful as a method for improving the coating quality in the production of high-Si-content galvanized steel sheets.

Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 illustrates one embodiment of a direct fired furnace installed in a continuous hot-dip galvanizing apparatus of the present invention, in which (a) is a vertical sectional view of the direct fired furnace and (b) is a front view of an arrangement example of direct firing burners installed in walls of the direct fired furnace.

[Fig. 2] Fig. 2 is a schematic diagram illustrating a continuous hot-dip galvanizing facility according to an embodiment of the present invention.

[Fig. 3] Fig. 3 is a diagram conceptually illustrating the state of an actual steel sheet being combustion-heated with slit burners of the present invention.

[Fig. 4] Fig. 4 is a diagram illustrating one example of the structure of the direct fired furnace according to the present invention.

Description of Embodiments

[0015] A direct fired furnace that heats a steel sheet by using direct firing burners has high heat efficiency and is thus characterized by its ability to heat steel sheets to a particular temperature at a low cost. With a direct fired furnace, it is necessary to control the temperature of the steel sheet and, when high tensile strength steel such as high-Si steel is to be hot-dip galvanized, to control the atmosphere of the direct firing burners to an oxidizing atmosphere so as to ensure formation of an appropriate oxide film (Fe oxides) on the steel sheet surface. The coatability of high-Si steel can be improved by obtaining an appropriate amount of Fe oxides and then performing reduction annealing to internally oxidize Si.

[0016] However, when conventional burners having circular burner nozzle exits are used, the thickness of the Fe oxide film, which is needed to ensure satisfactory coatability, cannot be uniformly controlled in the steel sheet travelling direction and width direction despite the dispersed distribution of the burners such as in a staggered pattern, and bare spot defects occur.

[0017] The present invention has conceived of a method of controlling the thickness of the Fe oxide film uniformly in the travelling direction and width direction by using slit burners instead of circular burners.

[0018] In the description below, a direct fired furnace installed in a continuous hot-dip galvanizing facility and a method for heating a steel sheet according to embodiments of the present invention are described with reference to the drawings.

[0019] Fig. 1 illustrates one embodiment of a direct fired furnace (DFF) installed in an annealing facility of a continuous hot-dip galvanizing facility according to an embodiment of the present invention. Here, the type of the annealing facility is preferably a vertical furnace. In other words, it becomes possible to pass a steel sheet at a high speed by conveying the steel sheet in a vertical direction (including conveying the steel sheet while turning the steel sheet back and forth in the vertical direction) without expanding the scale of the facility in the horizontal direction. In addition, this also provides an advantage in that the atmosphere in the heating zone and the atmosphere in the soaking zone can be easily separated. Conveying in a vertical direction means that the sheet is conveyed in a perpendicular direction.

[0020] In Fig. 1, (a) is a vertical sectional view of a direct fired furnace, and (b) is a front view of an arrangement example of direct firing burners installed in walls of the direct fired furnace. In Fig. 1, 1 denotes a direct fired furnace (DFF), 1-1 denotes an oxidation zone of the DFF, 1-2 denotes a reduction zone of the DFF, 2 denotes a flame injection port associated with a slit burner, 3 denotes a flame injection port associated with a circular burner, S denotes a steel sheet (including a steel strip), 4 denotes a radiation thermometer, 5 denotes a flame, 6 denotes an exhaust port, L denotes the length of a steel sheet S heated region heated by a burner group 14 in the reduction zone from the burner most upstream to the burner most downstream in the steel strip S travelling direction, 11 denotes a burner group in the oxidation zone, 12 denotes a burner group in the oxidation zone, 13 denotes a burner group in the oxidation zone, and 14 denotes a burner group in the reduction zone. Although not illustrated in the drawings, there is also provided a control device that controls the air ratios in the oxidation zone and the reduction zone.

<Direct fired furnace installed in continuous hot-dip galvanizing facility>

[0021] Fig. 2 illustrates one example of a continuous hot-dip galvanizing facility. From the entry side of the facility, there are provided a preheating zone 20, a heating zone 21, a soaking zone 22, cooling zones 23 and 24, a coating bath (zinc pot) 25, and, if necessary, an alloying zone 26. A cooling zone 27 may be provided after the alloying zone 26. As such, when the heating furnace of the present application is applied to a part of the continuous hot-dip galvanizing facility, the steel sheet to be heated does not have to be a cut sheet and may have a steel strip (coil) shape. Although the steel sheet is not particularly limited, a cold rolled steel sheet is often used.

[0022] The direct fired furnace 1 of the present invention is assumed as a heating furnace to be introduced in the heating zone 21 in the continuous hot-dip galvanizing facility.

[0023] In this embodiment, multiple slit burners can also be independently controlled. The direct fired furnace 1 is constituted by the oxidation zone 1-1 and the reduction zone 1-2, and the oxidation zone 1-1 is constituted by three burner groups (zones) 11 to 13 in the steel sheet travelling direction. In this example, circular burners are installed in the burner group 11 in the oxidation zone, and the flame injection ports thereof are denoted by 3 in the drawings whereas slit burners are installed in the (oxidation zone) burner groups 12 and 13, and the flame injection ports thereof are denoted by 2 in the drawings. The reduction zone has only one burner group (reduction zone burner group) 14, and circular burners are installed therein. The flame injection ports of the circular burners are denoted by reference sign 3 in the drawings. For the burner groups 11, 12, and 13 in the oxidation zone 1-1, the combustion rate and the air ratio of the burners can be independently controlled for each burner group. The burner groups 11 to 13 in the oxidation zone are combusted under the conditions that give a combustion rate equal to or higher than a predetermined threshold.

[0024] The number of burners contained in each burner group is not limited. It is practical to divide the entire direct fired furnace into two to five groups and to control each as a group.

[0025] Furthermore, for example, as illustrated by the facility in Fig. 4, the slit burners may be provided not only in the oxidation zone but also in both the oxidation zone 1-1 and the reduction zone 1-2.

[0026] Here, the slit burners are arranged to face the steel sheet surfaces in the width direction of the steel sheet S passing through the oxidation zone 1-1. Moreover, in order to uniformly heat the steel sheet S without variation in the width direction, the slit burners are arranged to extend in the width direction of the steel sheet so that the flames 5 are injected toward the entire width of the steel sheet S. Furthermore, in order to comply with production of steel sheets S with various widths, the flame injection amount can be controlled for each of four regions divided in the width direction. Although the number of divided regions here is 4, the number is not limited to 4, and there may be cases in which no division is necessary depending on the width of the steel sheet and the flame injection structures of the slit burners. Meanwhile, the circular burners are dispersedly arranged to face the steel sheet surfaces.

<Slit burners>

[0027] Fig. 3 is a diagram conceptually illustrating the state of an actual steel sheet being combusted and heated with slit burners of the present invention, and in the description below, the slit burners are described by referring to what is illustrated in the drawing.

[0028] A slit burner refers to a burner having a burner flame injection port having an elongated rectangular shape that has a long opening portion in the width direction of the steel sheet S with respect to the length (also referred to as a slit gap B) of the opening in the steel sheet S travelling direction, and the specific dimensions thereof are not particularly limited. For example, when the length of the opening portion in the steel sheet S travelling direction, that is, the short side, is represented by B, the length of the opening portion in the width direction, that is, the long side, is about 2B to 200B. In the present invention, a burner that injects a slit-shaped flame, such as a burner having such a thin elongated rectangular flame injection port, is generally referred to as a "slit burner". Thus, no limitations are particularly imposed as to the inner structure and the injection port. Furthermore, with this flame injection port, the injection width of the flame 5 can be controlled by dividing the injection port in the width direction, and this can be used to adjust the injection width of the flame 5 according to the width of the subject steel sheet.

[0029] It is effective to provide one slit burner in the steel sheet travelling direction; however, oxidization can be more efficiently carried out by arranging several slit burners in a tandem pattern. The arrangement intervals of the tandem pattern are not particularly limited; however, creating intervals of about 3B to 10B reduces interference of the flames 5 and the temperature variation.

[0030] Furthermore, since most of the Fe oxide film is generated in the range where the sheet temperature reaches 400°C or higher, it is preferable to use at least one slit burner in this range of the oxidation zone 1-1 where the sheet temperature reaches this range. It is yet more preferable to use slit burners in the range of 450°C or higher. Meanwhile, since the oxidation amount rapidly increases at high temperatures such as a temperature higher than 650°C, slit burners are preferably used in places where the sheet temperature is 650°C or lower. The temperature is preferably 600°C or lower and more preferably 550°C or lower. In order to heat the steel sheet S with slit burners upon reaching a preferable temperature range, the sheet temperature of the steel sheet S passing through the DFF 1 can be predicted and monitored by performing calculation in advance from the steel type, the sheet thickness, the sheet width, the line speed, the air ratio, the combustion rate, etc. In addition, it is also possible to install radiation thermometers in several places in the sheet passing direction of the oxidation zone 1-1 to actually measure the sheet temperature.

[0031] Due to the reasons described above, the slit burners are preferably used on the downstream side in the sheet passing direction in the oxidation zone 1-1 where the sheet temperature is high. Slit burners may be applied to all of the burners in the oxidation zone 1-1; however, the slit gap B of the slit burner exit is narrower than that of circular burners, and regular maintenance is necessary due to clogging of foreign matter such as fragments of burner tiles and deformation of the slit caused by the high temperature of the flame 5. Thus, conventional circular burners may be disposed on the upstream side in the oxidation zone 1-1 where the sheet temperature is low and slit burners may be disposed on the

downstream side. When circular burners are used on the upstream side, a direct firing heating system in which flames perpendicularly collide with the steel sheet is preferable from the viewpoint of the heating efficiency.

[0032] Furthermore, the arrangement of the flame injection ports 2 associated with the slit burners may be shifted, in other words, may be offset, in the steel sheet S travelling direction between the front and rear surfaces of the steel sheet S.

Offset prevents the flames 5 extending beyond the steel sheet S edges from interfering with one another. Thus, it is possible to more uniformly heat the steel sheet S than when offset is not made. The offset amount is in the range of about B to 3B. At an excessively large offset amount, the heating temperature may differ between the front surface and the rear surface. In a vertical furnace, burners are arranged in the vertical direction, and flames become unstable due to interference of the flames injected from the burners on the downstream side (the furnace lower side) and the combustion gas, thereby degrading the stability and the temperature uniformity in the width and longitudinal directions of the steel sheet. In the case of circular burners, the interference of the flames and the combustion gas can be moderated by forming a staggered pattern; however, in the case of slit burners, interference from the downstream side is inevitable since there is no break in the flame in the width direction. To address this, in the present invention, slit-shaped exhaust ports are preferably provided in the section where the slit burners are installed, and interference of the flames and the combustion gas tends to be mitigated by providing slit-shaped exhaust ports. One set of rear and front exhaust ports is preferably installed at least in each connecting portion between the zones. The exhaust port is preferably installed under the slit burner, and the combustion exhaust gas is suctioned from the exhaust port. Specifically, combustion exhaust gas refers to high-temperature gas that is generated as a result of the reaction between the fuel and air and that contains, as main components, carbon dioxide, which is a reaction product, and nitrogen contained in water vapor and air as well as trace components such as unreacted excess fuel components, oxygen, and reaction intermediates. As long as the line length and the heating capacity satisfy the required performance, an exhaust port may be installed between individual slit burners constituting each zone.

[0033] Irrespective of the oxidation zone 1-1 or the reduction zone 1-2, the burner combustion rate is a value obtained by dividing the amount of the fuel gas actually introduced into the burner by the amount of the burner fuel gas at the maximum combustion load, and when the burner is combusted at the maximum combustion load, the combustion rate is 100%. In the present invention, the combustion rate of the burner is not particularly limited; however, when the combustion load of the burner is low, a stable combustion state is no longer obtained and thus the combustion rate is preferably equal to or higher than the threshold described below. The predetermined threshold of the combustion rate is the ratio of the amount of the fuel gas at the lower limit of the combustion load at which the stable combustion state can be maintained relative to the amount of the fuel gas at the maximum combustion load. The threshold of the combustion rate differs depending on the burner structure, etc., and can be easily determined by performing a combustion test, for example. Normally, the threshold is about 30%.

<Air ratios in oxidation zone and reduction zone>

[0034] Whether to perform or halt combustion can be freely selected for each of the burner groups 11 to 13 in the oxidation zone 1-1. For combustion, the combustion rate is preferably equal to or larger than the predetermined set value, and, in order to stably oxidize the steel sheet surface, the operation must be carried out in the oxidation zone 1-1 at an air ratio of 1 or more. Operation is preferably carried out at an air ratio of 1.00 or more in the oxidation zone 1-1. Operation is more preferably carried out at an air ratio of 1.05 or more and most preferably 1.10 or more in the oxidation zone 1-1. In order to prevent formation of excessive oxide films, generation of nitrogen oxides, and blowing out of the flames, operation is preferably carried out at an air ratio of less than 1.50 in the oxidation zone 1-1. Operation is more preferably carried out at an air ratio of 1.40 or less and most preferably 1.30 or less in the oxidation zone 1-1. The air ratio is the value obtained by dividing the amount of air actually introduced into the burner by the amount of air necessary to completely combust the fuel gas.

[0035] Furthermore, the air ratio of the circular burners of the burner group 14 in the reduction zone 1-2 needs to be less than 1; furthermore, operation is preferably carried out at an air ratio of 0.70 or more and less than 1.00 with which it is possible to also control the combustion rate. When the burner group 14 in the reduction zone 1-2 is combusted at an air ratio of 0.70 or more and less than 1.00, the Fe oxides generated in the steel sheet surface are reduced and reduced Fe can be generated in the surface layer. Specifically, at an air ratio of less than 0.70, degradation of the fuel consumption rate and steel sheet contamination due to soot occur; thus, the air ratio is preferably 0.70 or more. More preferably, the air ratio is 0.75 or more and most preferably 0.80 or more. Meanwhile, at an air ratio of 1.00 or more, the oxygen concentration in the combustion gas increases, and the steel sheet becomes oxidized. The presence of the reduced Fe in the steel sheet surface layer portion prevents adhesion of the oxides to the rolls as the steel sheet S exited the direct fired furnace 1 comes into contact with the rolls in the RT furnace (annealing furnace), and thus can prevent defects (pickups) caused by oxide adhesion. To achieve this, the air ratio is preferably less than 1.00. More preferably, the air ratio is 0.95 or less and most preferably 0.90 or less.

[0036] The number of the burner groups to be combusted is determined for various steel sheets S to be passed

therethrough by taking into account the heating load, the amount of the oxides formed, etc. The air ratio and the combustion rate of the burner groups to be combusted are set to values within the aforementioned ranges so as to decrease the sheet temperature fluctuation in the steel sheet S travelling direction for various steel sheets S. As a result, for example, enough Fe oxides necessary to internally oxidize Si can be stably generated in the steel sheet S travelling direction. Decreasing the sheet temperature fluctuation in the steel sheet S travelling direction also contributes to stabilizing the oxide reducing action in the burner group 14 in the subsequent reduction zone 1-2. Furthermore, decreasing the sheet temperature fluctuation also prevents insufficient reduction of the Fe oxides in the RT furnace, contributes to the internal oxidation of Si, and also contributes to suppressing adhesion of the oxides to the rolls in the RT furnace.

[0037] In this embodiment, the burner groups 11 to 13 in the oxidation zone 1-1 are oxidizing burners, the burner group 14 in the reduction zone 1-2 is reducing burners, the regions heated by the burner groups 11 to 13 in the oxidation zone 1-1 are the oxidation zone, and the region heated by the burner group 14 in the reduction zone 1-2 is the reduction zone.

[0038] When the length of the reducing atmosphere is small, the Fe oxide film remains in the surface layer, and the pickup preventing effect becomes insufficient. In contrast, when the length of the reducing atmosphere is large, a surface concentration layer of Si and the like is formed in the steel sheet surface during the subsequent reduction annealing, and the coatability is impaired.

<Length of reduction zone>

[0039] The length (reduction zone length) of the burner group 14 in the reduction zone 1-2 in the steel sheet S travelling direction is preferably 150 mm or more and, in view of the uniformity in the width direction, is more preferably 300 mm or more. The length is yet more preferably 500 mm or more and most preferably 1000 mm or more. The upper limit of the length of the reduction zone is not particularly specified, but at an excessively large length, the heating amount ΔT_{rd} in the reduction zone increases, and thus the heating amount ΔT_{ox} in the oxidation zone needs to be decreased. Thus, an excessively long reduction zone is disadvantageous for securing the oxidation amount, and thus the length is preferably 10 m or less. The length is more preferably 5 m or less and still more preferably 3 m or less. This is also advantageous in terms of cost. The length of the burner group 14 in the reduction zone 1-2 in the steel sheet travelling direction is the length ("L" in Fig. 1) of the steel sheet S heated region heated by the burner group 14, the region extending from the flame injection port 3 associated with the circular burner most upstream to the flame injection port 3 associated with the circular burner most downstream in the burner group in the reduction zone 1-2 in the steel sheet travelling direction. Here, even when the slit burners are used in the burner group 14 in the reduction zone 1-2, the reduction zone length is preferably what is described above.

<Length of oxidation zone>

[0040] The length (oxidation zone length) of the burner groups 11 to 13 in the oxidation zone 1-1 in the steel sheet travelling direction to be secured should be long enough to ensure the necessary amount of internal oxidation. However, since the oxidation amount changes according to the steel type to be passed, the temperature history, the sheet passing speed, and the steel sheet size, it is necessary to secure a zone length at which the necessary oxidation amount can be ensured even under the conditions least suitable for oxidation among production conditions.

[0041] In the present invention, the steel sheet S is oxidized and then reduced in the direct fired furnace 1. In particular, the oxidation amount formed in the oxidation zone must be precisely controlled in the steel sheet S travelling direction and width direction. In order to control the oxidation amount to an appropriate amount with respect to steel sheets of various steel types, temperature history, sheet passing speed, and size to be passed, the burners arranged to face the surface of the steel sheet S must be divided into at least two groups in the steel sheet travelling direction and the combustion rate and the air ratio need to be independently controllable group by group. In determining the burner group, slit burners and circular burners are preferably not mixed in one group but are preferably separated to be in separate groups and controlled separately.

[0042] The action and effect intended by the present invention are still obtained even when the burners are controlled as one group in the reduction zone. Thus, in the present invention, the burners arranged to face the surface of the steel sheet S in the oxidation zone 1-1 may be divided into two or more burner groups in the steel sheet S travelling direction so that the combustion rate and the air ratio can be independently controlled.

[0043] The thickness of the Fe oxide film formed in the oxidation zone 1-1 changes depending on the Si content and the sheet thickness of the subject steel sheet S and is preferably 100 to 500 nm. When the thickness is less than 100 nm, the function as a barrier layer that inhibits diffusion and concentration of Si to the surface may become insufficient, and thus the thickness of the Fe oxide film is preferably 100 nm or more. The thickness of the Fe oxide film is more preferably 150 nm or more and yet more preferably 200 nm or more. Meanwhile, once the thickness exceeds 500 nm, the function as a barrier layer remains substantially unchanged, and there is a disadvantage of an increase fuel consumption due to a longer heating time in the oxidation zone 1-1. Thus, the thickness of the Fe oxide film is preferably 500 nm or less. The thickness of

the Fe oxide film is more preferably 450 nm or less and yet more preferably 400 nm or less.

[0044] The thickness of the Fe oxide film can be relatively easily estimated by monitoring the sheet temperature at the entry and the exit of the direct fired furnace 1 and performing correction on the basis of the steel type, the sheet thickness, the line speed, the air ratio in the oxidation zone 1-1, and the combustion rate in the oxidation zone 1-1. By adjusting mainly the combustion rate in the oxidation zone 1-1 on the basis of this value, stable oxidizing conditions can be determined and secured, and, as a result, a steel sheet S free of bare spot defects can be obtained.

[0045] The steel sheet S oxidized and reduced in the direct fired furnace 1 is then reduction-annealed in the RT furnace, cooled, and dipped in a hot-dip galvanizing bath to be hot-dip galvanized, and then subjected to an alloying treatment as necessary. The process of the reduction annealing and thereafter may be a typical process. The coating method is not particularly limited, and electrogalvanizing may be performed instead of the hot-dip galvanizing.

[0046] Since an appropriate amount of Fe oxides are formed and then the surface layer is reduced to generate reduced Fe in the direct fired furnace 1, the Fe oxides are reduced and Si is internally oxidized in the subsequent reduction annealing step, and adhesion of the oxides to the rolls can be prevented. Thus, press marks caused by roll pickups, Si surface layer concentration, and coating defects caused by insufficient reduction of Fe oxides do not occur.

[0047] The hot-dip galvanized steel sheet to be produced by the present invention is effective when large amounts of metal elements, such as Si, more easily oxidizable than Fe are contained. Specifically, it is prominently effective in producing a high-Si-content hot-dip galvanized steel sheet containing 0.1 to 3.0 mass% of Si.

[0048] An annealing furnace (RT furnace), a cooling zone, a hot-dip galvanizing facility, an alloying treatment facility, etc., are placed downstream of the direct fired furnace 1. The annealing furnace, the cooling zone, the hot-dip galvanizing facility, the alloying treatment facility, etc., are not particularly limited and may be those which are commonly employed. A preheating furnace is sometimes placed upstream of the direct fired furnace 1.

EXAMPLES

[0049] A test was conducted by using a CGL equipped with a direct fired furnace (DFF) 1 having heating burners organized into four burner groups (11 to 14): three burner groups (11 to 13) disposed on the upstream side in the steel strip S travelling direction and constituting an oxidation zone 1-1 and the last one burner group (14) constituting a reduction zone 1-2. Furthermore, the test was conducted for two cases: (A) the case where the air ratio and the combustion rate were individually controlled for each burner group in the oxidation zone 1-1 and (B) the case where the burner groups 11 to 13 in the oxidation zone were collectively controlled by using the same conditions. Here, the air ratio and the combustion rate in the reduction zone were controlled separately from the oxidation zone. Fig. 1 illustrates one example of the burner arrangement. In Fig. 1, flame injection ports 3 associated with circular burners were disposed in the burner group 11 in the oxidation zone and the burner group 14 in the reduction zone, and the flame injection ports 2 associated with slit burners were disposed in the burner groups 12 and 13 in the oxidation zone. The test was conducted by changing the burner type according to the conditions for each of the burner groups. Gas having a composition indicated in Table 1 was used as the fuel gas for the burners. The length of each burner group ("L" in Fig. 1) was 3 m, and the slit gap B was 20 mm.

[0050] The steel chemical composition of the steel strip S used in the test is indicated in Table 2.

[0051] Other test conditions were as follows: sheet thickness: 1.0 mm, sheet width: 1000 mm, the DFF 1 entry side average sheet temperature: 200°C, DFF 1 exit side average temperature: 650°C, annealing temperature (RT furnace): 850°C, coating bath temperature: 463°C, coating Al concentration: 0.135%, alloying temperature: 550°C. Speed of the steel strip S (LS) was examined in three levels: 60 mpm, 90 mpm, and 120 mpm. The burners were used at a combustion rate of 30% or more.

[0052] The roll mark defect (pickup) caused by excessive oxidation was evaluated, and, for the coating appearance, quality deviation in the steel sheet travelling direction and width direction and temperature deviation in the steel sheet travelling direction were evaluated. The ratings A and B indicate pass, and the rating C indicates fail.

[0053] In the present invention, the same techniques used in the method disclosed in Patent Literature 7 below were used. The roll mark defect (pickup) caused by excessive oxidation was inspected with an optical surface defect meter in a 1 m² field of view of a surface of a steel sheet in a randomly extracted steel strip S. The aforementioned surface defect meter can detect marks with a diameter of 0.5 mm or more, and the detected marks were assumed to be depression defects caused by contacting the pickups, in other words, roll mark defects.

[Patent Literature 7] Japanese Patent No. 6607339

A (good): Zero per 1 m² (no roll mark defect occurred)

B (fair): 1 or 2 defects per 1 m² (minor roll mark defects were observed)

C (poor): 3 or more defects per 1 m² (roll mark defects were present)

[0054] The coating appearance was evaluated by measuring the variation in the Fe concentration (alloying rate) in the coating in the steel sheet surface after the alloying treatment with respect to the target value. The smaller the variation with

respect to the target value of the Fe concentration in the coating, the better the rating of the coating appearance. Here, the Fe concentration was measured by the same technique as the method disclosed in Patent Literature 8 below, that is, the method of calculating the Fe concentration from the change in the diffraction peak angle of the alloy phase constituting the coating layer by X-ray diffractometry.

[Patent Literature 8] Japanese Patent No. 5962615

A (good): Less than $\pm 0.5\%$ (bare spot or alloying variation was not found)

B (fair): Less than $\pm 1\%$ (minor bare spot and/or alloying variation was found)

C (poor): $\pm 1\%$ or more (prominent bare spot and/or prominent alloying variation was found)

[0055] The ratings A and B indicate pass, and the rating C indicates fail.

[0056] Furthermore, a 1000 mm-long sample was taken in the width direction from each of three selected places in the travelling direction, that is, the tip portion, the center portion, and the end portion of the steel strip S, and evaluated for the roll mark and the coating appearance at the width center portion thereof, and the obtained results were used to evaluate the quality in the travelling direction and the width direction. In addition, a width $\times$ 1000 mm sample was taken from the center portion of the steel strip S, and, in this sample, five points, i.e., the center point in the width direction, the 1/4-width and 3/4-width points, and two end points, were evaluated for the roll mark and the coating appearance. The obtained results were used to evaluate the quality in the width direction. $\odot$: Only the rating A was given in the evaluation of roll mark and coatability under the same conditions.

$\circ$: The rating of A or B was given in the evaluation of roll mark and coatability under the same conditions.

Δ : Only the rating B was given in the evaluation of roll mark and coatability under the same conditions.

$\times$: The rating C was included in the evaluation of roll mark and coatability under the same conditions.

[0057] A sample that is evaluated as pass in the present invention is the one that was not rated C for any of the roll mark defect and the coating appearance but was rated $\odot$, $\circ$, and/or Δ in both the width direction and the travelling direction. A sample that was rated Δ or higher in both the width direction and the travelling direction was rated pass ($\circ$) and a sample that included the rating $\times$ was rated fail ($\times$).

[0058] Condition Nos. 1 to 8 and 15 were produced under the condition that the line speed of the steel strip S was 60 mpm.

[0059] Condition 1 is a comparative example in which only circular burners were used. In addition to the use of the circular burners, the combustion rate was less than 30%, and the combustion state of the burners was unstable. Furthermore, the burner groups 11 to 13 in the oxidation zone were collectively controlled, and the quality variation was large in the width direction and the travelling direction.

[0060] Condition 2 is the case in which slit burners were used in the burner groups 11 to 13 in contrast to the circular burners in condition 1. The combustion state of the burners was unstable as with condition 1, but since the slit burners were used, improvements were made for both the roll mark defect and the coating appearance, and the quality variation slightly improved in both the width direction and the travelling direction.

[0061] Condition 3 is the case in which the air ratio and the combustion rate could be controlled for each of the burner groups in contrast to conditions 1 and 2 in which the burner groups 11 and 13 were collectively controlled. In this manner, only the necessary combustion burners (in this case, only the burner group 13) can be operated. However, since the operated burner group 13 was circular burners in condition 3, combustion variation was likely to occur, and the surface quality tended to be poor compared to condition 1.

[0062] Condition 4 is the case in which the control was executed for each burner group as in condition 3 but the burner shape was changed from circular to slit burners. As a result, the surface quality improved, and the quality became more uniform in the width direction and the travelling direction.

[0063] Condition 5 is the case in which slit burners were used under the same control as condition 4 but the air ratio of the burner group 13 decreased to 0.90. In this example, although uniformity was obtained in the width direction and the travelling direction compared to condition 3, many defects appeared and the sample was rated fail.

[0064] Condition 6 is the case in which the air ratio of the burner group 13 was excessive, that is, 1.65, compared to condition 5. The extent of the defects was reduced, and the sample was rated pass.

[0065] Condition 7 is the case in which the air ratio in the reduction zone of the burner group 14 was as high as 1.00 compared to condition 4. In this case also, the uniformity was relatively satisfactory as with condition 5, but many defects appeared and the sample was rated fail.

[0066] Condition 8 is the case in which the air ratio in the reduction zone was low compared to condition 7. The extent of the defects was reduced compared to condition 7, and the sample was rated pass.

[0067] Conditions 9 and 10 were examples in which production was carried out under the condition that the line speed of the steel strip S was 90 mpm, and in both examples, the air ratio and the combustion rate were controlled for each burner

group.

[0068] Condition 9 uses circular burners in combination with slit burners in the oxidation zone. However, since no slit burners were used in the range where the steel sheet temperature reached 400°C, the surface quality was rated pass but was poor in some places.

[0069] In condition 10, only slit burners were used in the oxidation zone, and the surface quality was better than in condition 9.

[0070] Conditions 11 to 13 were examples in which production was carried out under the condition that the line speed of the steel strip S was 120 mpm. In any of these conditions, slit burners were used in the oxidation zone.

[0071] In condition 11, burner groups were collectively controlled instead of separately; however, since slit burners were used, the surface quality was rated pass as with condition 2 despite the use of circular burners in some part.

[0072] Condition 12 is an example according to the present invention in which the surface quality was better than that in condition 11 since the control was carried out for each burner group.

[0073] Condition 13 is an example in which slit burners were used not only in the oxidation zone but also in the reduction zone. As a result, the surface quality improved further.

[0074] Condition 14 is an example in which slit burners were used in a horizontal annealing furnace operated as an oxidation zone. Since the furnace was a horizontal furnace, the line speed was decreased compared to the example according to the present invention, and the production was carried out at 30 mpm. Although slit burners were used in the oxidation zone and the excessive oxidation defects and coating appearance were rated pass, the mechanism could not convey the steel sheet in a vertical direction and was not equipped with exhaust ports; thus, minor bare spot and alloying nonuniformity occurred in the width direction and the longitudinal direction since the exhaust gas partly flowed into the upstream non-oxidizing furnace.

[0075] Condition 15 is an example in which the operation was carried out under the same conditions as condition 2 but the exhaust ports installed between the zones were closed (equivalent to the state where no exhaust ports were provided) and the combustion gas was not suctioned. As a result, interference between the flames degraded stability and increased defects compared to condition 2; however, the surface quality was rated pass.

[0076] The aforementioned examples confirm that by using slit burners in the oxidation zone, the surface quality is improved, and by optimizing the control method and the combustion conditions, better surface quality is obtained.

[Table 1]

(Unit: vol%)							
CO ₂	H ₂ O	CO	N ₂	H ₂	O ₂	CH ₄	C ₂ H ₄
2.7	0	7.5	5.9 5	6.5	0.2	25.0	2.2

[Table 2]

(mass%)										
C	Si	Mn	P	S	Cu	Al	Cr	Mo	Nb	N
0.12	1.50	1.25	0.013	0.04	Tr	Tr	Tr	Tr	0.033	0.001

[Table 3]

Condition No.	LS (mm)	Control method	Furnace type	Oxidation zone												Reduction zone				DFF exit side average sheet temperature [°C]	Excessive oxidation defects (roll marks etc.)	Coating appearance	Width direction quality	Longitudinal direction quality	Rating	Remarks			
				11				12				13				14													
				Entry side average sheet temperature [°C]	Burner type	Air ratio [%]	Combustion ratio [%]	Exhaust port	Entry side average sheet temperature [°C]	Burner type	Air ratio [%]	Combustion ratio [%]	Exhaust port	Entry side average sheet temperature [°C]	Burner type	Air ratio [%]	Combustion ratio [%]	Exhaust port	Entry side average sheet temperature [°C]								Burner type	Air ratio [%]	Combustion ratio [%]
1	60	B	Vertical	198	Circular	1.05	24	None	321	Circular	1.05	24	None	442	Circular	1.05	24	None	552	Circular	0.80	50	650	A to C	B to C	x	x	x	Comparative Example
2	60	B	Vertical	200	Slit	1.05	24	Present	323	Slit	1.05	24	Present	444	Slit	1.05	24	Present	499	Circular	0.80	50	651	A to B	B	○	△	○	Example
3	60	A	Vertical	201	Circular	Not used	None	None	203	Circular	Not used	None	None	205	Circular	1.05	90	None	553	Circular	0.80	80	648	C	C	x	x	x	Comparative Example
4	60	A	Vertical	199	Slit	Not used	Present	Present	204	Slit	Not used	Present	Present	280	Slit	1.05	90	Present	550	Circular	0.80	80	650	A	A	⊙	⊙	○	Example
5	60	A	Vertical	201	Circular	Not used	Present	Present	203	Slit	Not used	Present	Present	281	Slit	0.90	90	Present	499	Circular	0.90	80	650	B to C	C	x	x	x	Comparative Example
6	60	A	Vertical	202	Circular	Not used	Present	Present	204	Slit	Not used	Present	Present	286	Slit	1.65	90	Present	460	Circular	0.90	80	649	B	B	△	△	○	Example
7	60	A	Vertical	198	Circular	Not used	Present	Present	202	Slit	Not used	Present	Present	282	Slit	1.10	72	Present	550	Circular	1.00	50	650	C	C	x	x	x	Comparative Example
8	60	A	Vertical	200	Circular	Not used	Present	Present	202	Slit	Not used	Present	Present	284	Slit	1.10	72	Present	544	Circular	0.65	50	659	B	B	△	△	○	Example
9	90	A	Vertical	200	Circular	Not used	Present	Present	203	Slit	1.10	49	Present	375	Circular	1.10	59	None	498	Circular	0.90	75	649	B	A to B	△	○	○	Example
10	90	A	Vertical	200	Circular	Not used	Present	Present	203	Slit	1.10	49	Present	376	Slit	1.10	59	Present	551	Circular	0.90	75	650	A	A	⊙	⊙	○	Example
11	120	B	Vertical	200	Circular	1.15	50	Present	316	Slit	1.15	50	Present	430	Slit	1.15	50	Present	499	Circular	0.85	100	650	B	A to B	○	△	○	Example
12	120	A	Vertical	201	Circular	1.05	32	Present	274	Slit	1.15	50	Present	389	Slit	1.10	70	Present	550	Circular	0.85	100	648	A to B	A	○	⊙	○	Example
13	120	A	Vertical	200	Slit	1.10	32	Present	273	Slit	1.15	50	Present	388	Slit	1.15	70	Present	550	Slit	0.85	100	652	A	A	⊙	⊙	○	Example
14	30	B	Horizontal	405	Slit	1.05	30	None	450	Slit	1.05	27	None	490	Slit	1.05	25	None	530	Slit	0.80	25	600	B	B	△	△	○	Example
15	60	B	Vertical	200	Slit	1.05	24	Present (closed)	323	Slit	1.05	24	Present (closed)	444	Slit	1.05	24	Present (closed)	499	Circular	0.80	50	651	B	B	△	△	○	Example

Control method: A: controlled group-by-group
B: controlled collectively

Reference Signs List

[0077]

- 5 1 direct fired furnace (DFF)
- 1-1 oxidation zone
- 1-2 reduction zone
- 2 flame injection port associated with slit burner
- 3 flame injection port associated with circular burner
- 10 4 radiation thermometer
- 5 flame
- 6 exhaust port
- S steel sheet
- L length of a steel sheet region heated by a burner group 14 from a burner most upstream to a burner most downstream
- 15 in the burner group in the steel strip travelling direction
- 11 burner group in oxidation zone
- 12 burner group in oxidation zone
- 13 burner group in oxidation zone
- 14 burner group in reduction zone
- 20 B slit gap
- 20 preheating zone
- 21 heating zone (direct firing heating)
- 22 soaking zone
- 23 cooling zone
- 25 24 cooling zone
- 25 coating bath (zinc pot)
- 26 alloying zone
- 27 cooling zone

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Claims

- 1. A method for heating a steel sheet, the method comprising heating a front surface side and a rear surface side of a steel sheet that is passing through a direct fired furnace that has an oxidation zone where operation is conducted at an air ratio of 1 or more and a reduction zone where operation is conducted at an air ratio of less than 1, wherein the heating is carried out with flames injected from at least one slit burner while the steel sheet passes through at least the oxidation zone.
- 35
- 2. The method for heating a steel sheet according to Claim 1, wherein the direct fired furnace conveys the steel sheet in a vertical direction and suctions combustion exhaust gas from an exhaust port installed under the slit burner.
- 40
- 3. The method for heating a steel sheet according to Claim 1 or 2, wherein the air ratio in the oxidation zone is controlled to 1.00 or more and less than 1.50, and the air ratio in the reduction zone is controlled to 0.70 or more and less than 1.00.
- 45
- 4. The method for heating a steel sheet according to any one of Claims 1 to 3, wherein the steel sheet is heated with the at least one slit burner in such a range that a temperature of the steel sheet passing the oxidation zone is 400°C or higher.
- 50
- 5. A method for producing a coated steel sheet, the method comprising heat-treating a cold rolled steel sheet by the heating method according to any one of Claims 1 to 3, and subjecting the cold rolled steel sheet to a coating treatment.
- 6. The method for producing a coated steel sheet according to Claim 5, wherein the coating treatment uses one of an electrogalvanizing treatment, a hot-dip galvanizing treatment, and a galvannealing treatment.
- 55
- 7. A direct fired furnace comprising:

an oxidation zone where operation is conducted at an air ratio of 1 or more, a reduction zone where operation is

conducted at an air ratio of less than 1, and a control device capable of controlling the air ratios in the oxidation zone and the reduction zone,

wherein at least one portion of the oxidation zone is equipped with:

at least one slit burner disposed on a front surface side of the steel sheet and at least one slit burner disposed on a rear surface side of the steel sheet, each of the slit burners extending in a width direction of the steel sheet and injecting flames toward the steel sheet passing through the oxidation zone and the reduction zone.

8. The direct fired furnace according to Claim 7, wherein the steel sheet is conveyed in a vertical direction, and combustion exhaust gas is suctioned from exhaust ports installed under the slit burners.

9. The direct fired furnace according to Claim 7 or 8,

wherein the air ratio in the oxidation zone is controlled to 1.00 or more and less than 1.50, and the air ratio in the reduction zone is controlled to 0.70 or more and less than 1.00.

10. The direct fired furnace according to any one of Claims 7 to 9, wherein at least one of the slit burners is installed in a range where a temperature of the steel sheet passing through the oxidation zone is 400°C or higher.

11. The direct fired furnace according to any one of Claims 7 to 9, wherein the oxidation zone includes a burner group having two or more slit burners for which the air ratio and a combustion rate are independently controllable.

12. A continuous hot-dip galvanizing facility comprising the direct fired furnace according to any one of Claims 7 to 9.

13. The continuous hot-dip galvanizing facility according to Claim 12, further comprising an alloying facility that alloys hot-dip galvanized coatings.

FIG. 1

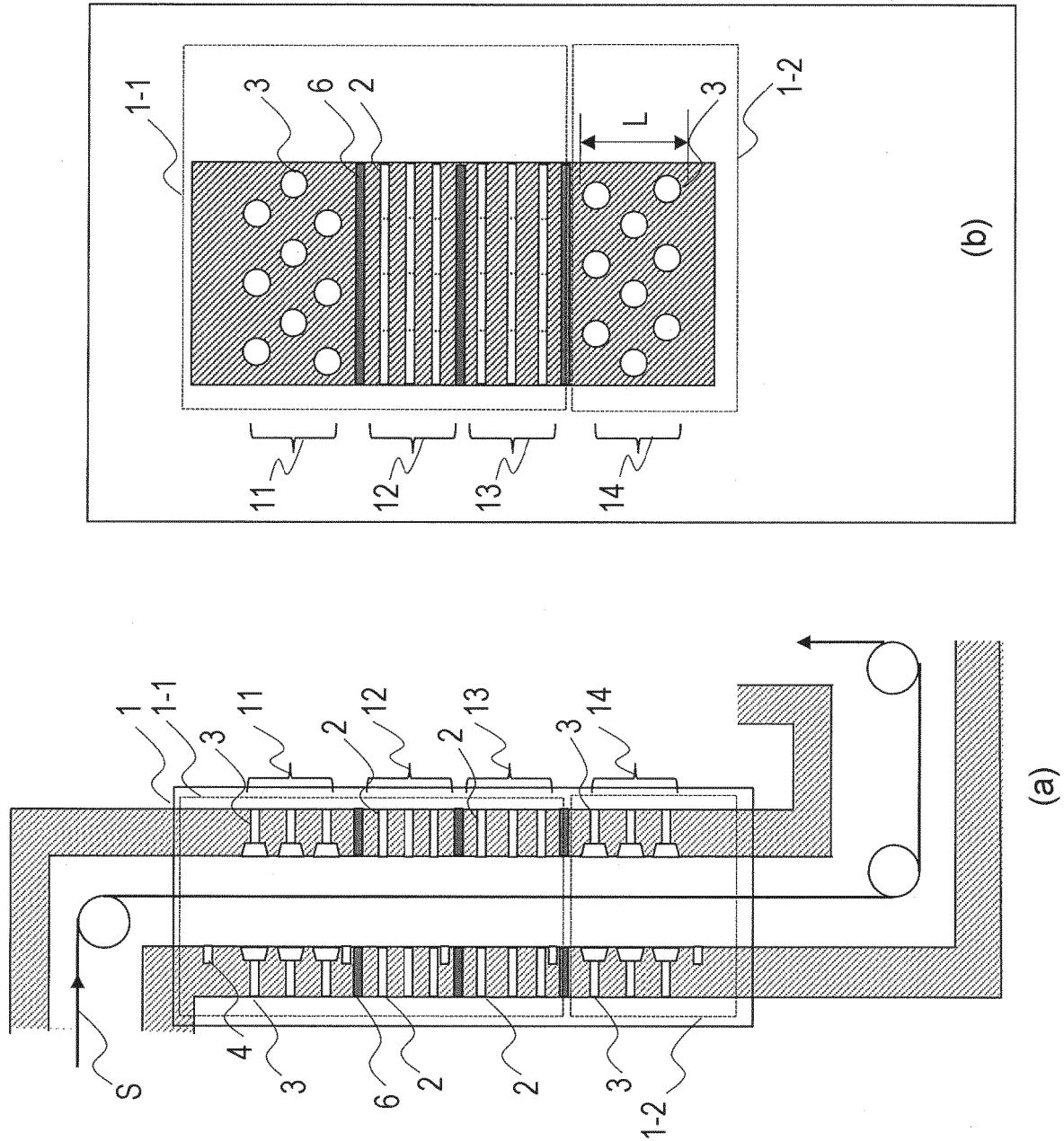


FIG. 2

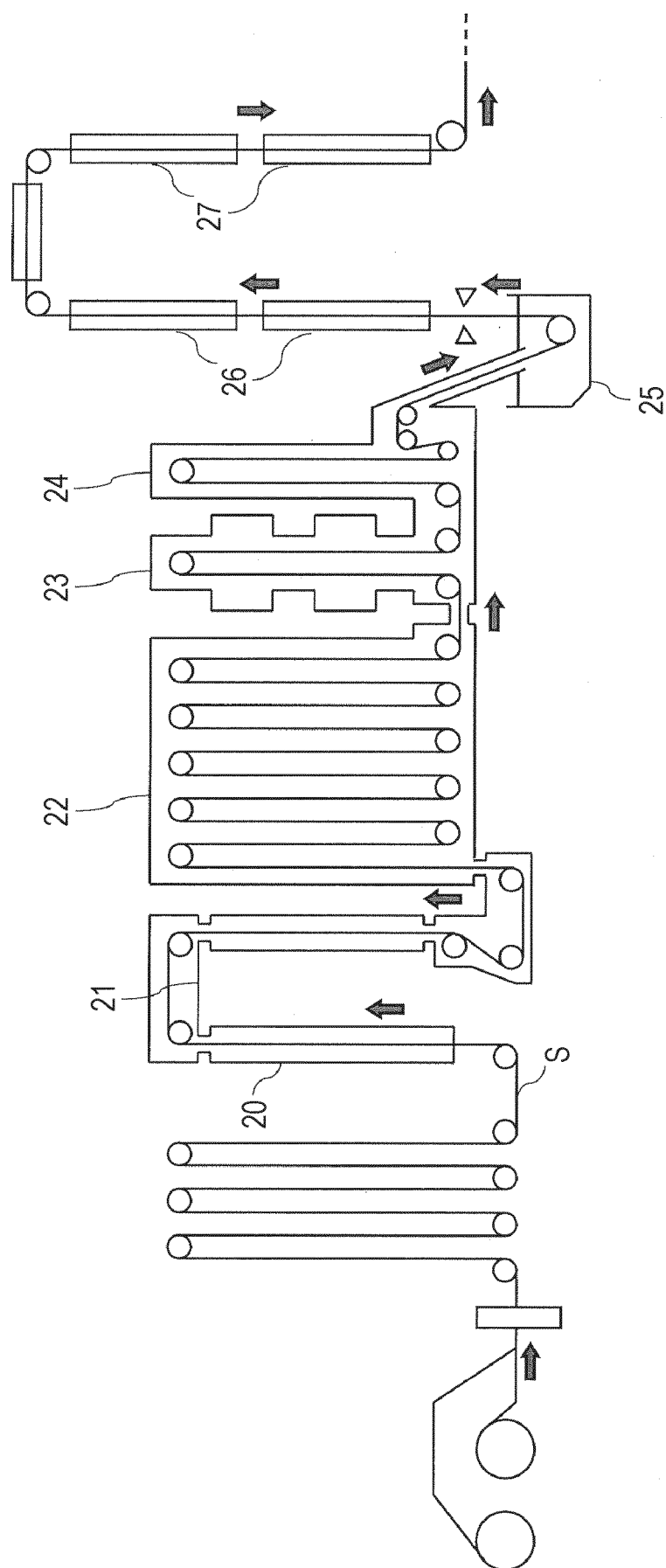
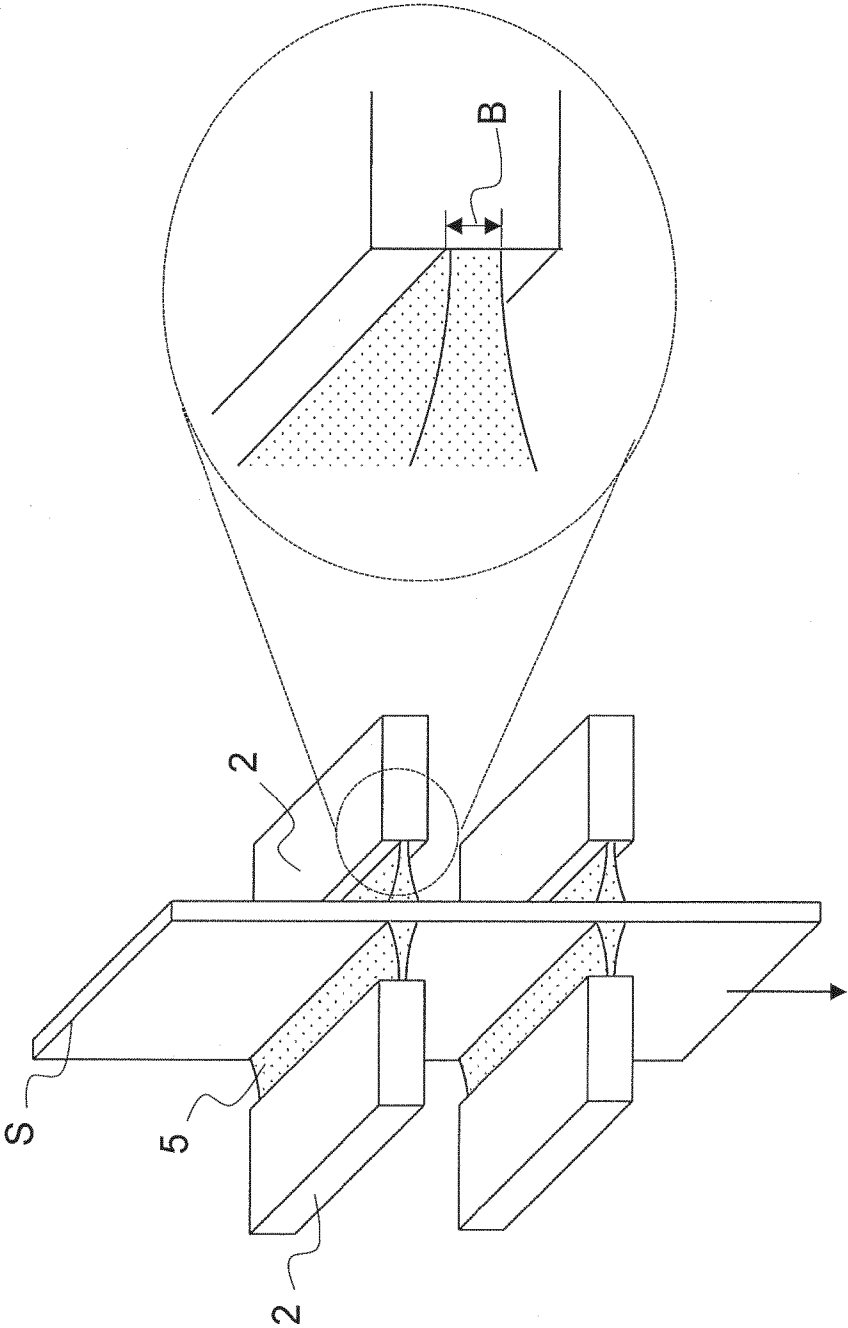
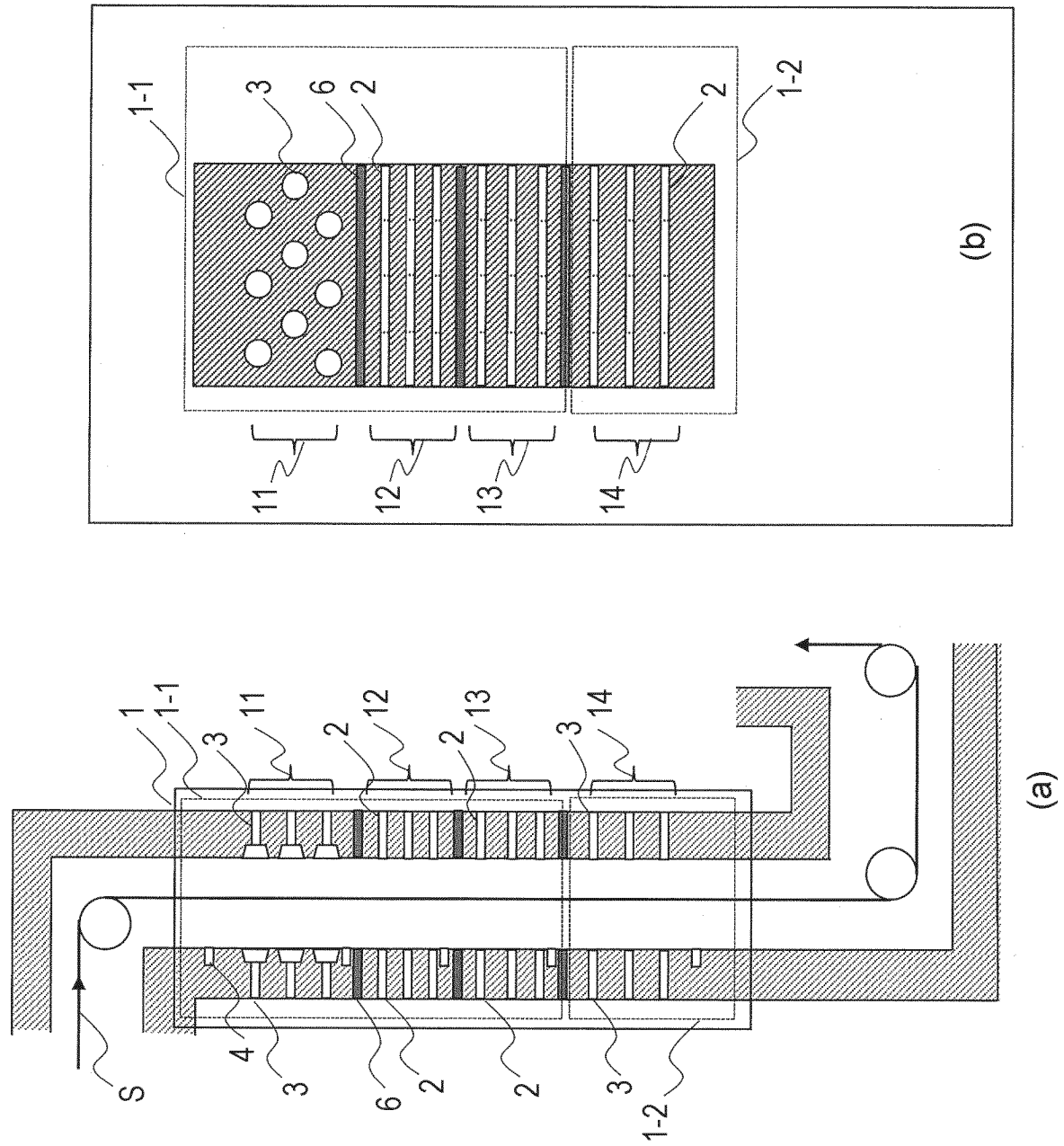


FIG. 3





4. G. E.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/024887

A. CLASSIFICATION OF SUBJECT MATTER

C21D 9/46(2006.01)i; *C21D 9/56*(2006.01)i; *C25D 5/36*(2006.01)i; *C22C 38/00*(2006.01)i; *C22C 38/12*(2006.01)i; *C22C 38/26*(2006.01)i; *C23C 2/02*(2006.01)i; *C23C 2/06*(2006.01)i; *C23C 2/28*(2006.01)i; *C23C 2/40*(2006.01)i; *F23N 5/00*(2006.01)i

FI: C21D9/56 101D; C21D9/46 H; C22C38/00 301T; C22C38/12; C22C38/26; C23C2/02; C23C2/06; C23C2/28; C23C2/40; C25D5/36; F23N5/00 D; F23N5/00 S

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)

C21D9/56; C21D9/46; C22C38/00; C22C38/12; C22C38/26; C23C2/02; C23C2/06; C23C2/28; C23C2/40; C25D5/36; F23N5/00

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 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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 A	JP 2008-1934 A (KABUSHIKI KAISHA KOBE SEIKO SHO) 10 January 2008 (2008-01-10) claims, paragraphs [0014], [0025], [0028]-[0033], [0045], [0046], [0049]	1, 3-7, 9, 10, 12, 13 2, 8, 11
Y A	JP 2020-190017 A (JFE STEEL CORP.) 26 November 2020 (2020-11-26) claims, paragraphs [0067], [0068]	1, 3-7, 9, 10, 12, 13 2, 8, 11
Y A	JP 2021-147648 A (JFE STEEL CORP.) 27 September 2021 (2021-09-27) claims, paragraphs [0067], [0071]	1, 3-7, 9, 10, 12, 13 2, 8, 11
Y A	WO 2021/166350 A1 (JFE STEEL CORP.) 26 August 2021 (2021-08-26) paragraphs [0058], [0059], [0067], [0085], claims	1, 3-7, 9, 10, 12, 13 2, 8, 11

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

01 August 2023

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Name and mailing address of the ISA/JP

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/024887

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2023/024887

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JP	2020-190017	A	26 November 2020	(Family: none)	
JP	2021-147648	A	27 September 2021	(Family: none)	
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Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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