(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 276 037 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
07.04.2021 Bulletin 2021/14

(21) Application number: **16767930.7**

(22) Date of filing: **19.02.2016**

(51) Int Cl.:
C23C 2/02 *(2006.01)*
C21D 1/76 *(2006.01)*
C21D 9/46 *(2006.01)*
C21D 9/56 *(2006.01)*
C23C 2/28 *(2006.01)*
C23C 2/40 *(2006.01)*
C22C 18/04 *(2006.01)*
C22C 38/00 *(2006.01)*
C22C 38/14 *(2006.01)*

(86) International application number:
PCT/JP2016/000899

(87) International publication number:
WO 2016/152018 (29.09.2016 Gazette 2016/39)

(54) METHOD OF MANUFACTURING A HOT-DIP GALVANIZED STEEL SHEET

VERFAHREN ZUR HERSTELLUNG VON FEUERVERZINKTEM STAHLBLECH

PROCÉDÉ DE FABRICATION DE TÔLE D’ACIER GALVANISÉE PAR IMMERSION À CHAUD

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

(30) Priority: **23.03.2015 JP 2015060139**

(43) Date of publication of application:
31.01.2018 Bulletin 2018/05

(73) Proprietor: **JFE Steel Corporation**
Tokyo, 100-0011 (JP)

(72) Inventors:
- **TAKEDA, Gentaro**
Tokyo 100-0011 (JP)
- **MIYAKE, Masaru**
Tokyo 100-0011 (JP)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

(56) References cited:
WO-A1-2013/153791
WO-A1-2014/087452
WO-A1-2014/132638
JP-A- 2002 003 953
JP-A- 2007 092 140
JP-A- 2008 275 185
JP-A- 2013 095 952
US-A1- 2009 123 651

EP 3 276 037 B1

Description

TECHNICAL FIELD

[0001] This disclosure relates to a method of producing hot-dip galvanized steel sheets using a continuous hot-dip galvanizing apparatus including an annealing furnace in which a heating zone, a soaking zone, and a cooling zone are arranged in this order and a hot-dip galvanizing line adjacent to the cooling zone.

BACKGROUND

[0002] In recent years, the demand for high tensile strength steel sheets (high tensile steel sheets) which contribute to lighter-weight structures and the like is increasing in the fields of automobiles, household appliances, building products, and so forth. As high tensile strength steel materials, for example, it is known that a steel sheet with favorable hole expansion formability can be produced through inclusion of Si in steel, and a steel sheet with favorable ductility where retained austenite (γ) forms easily can be produced through inclusion of Si or Al in steel.

[0003] However, in the case of producing a galvannealed steel sheet using, as a base material, a high tensile strength steel sheet containing a large amount of Si (particularly, 0.2 mass% or more), the following problem arises. The galvannealed steel sheet is produced by, after heat-annealing the base material steel sheet at a temperature of about 600 °C to 900 °C in a reducing atmosphere or a non-oxidizing atmosphere, hot-dip galvanizing the steel sheet and further heat-alloying the galvanized coating.

[0004] Si in the steel is an oxidizable element, and is thus selectively oxidized in a typically used reducing atmosphere or non-oxidizing atmosphere, and concentrated at the surface of the steel sheet in the form of an oxide. This oxide decreases wettability with molten zinc in the galvanizing process, and causes non-coating. With an increase of the Si concentration in the steel wettability decreases rapidly and non-coating occurs frequently. Even in the case where non-coating does not occur, there is still a problem of poor coating adhesion. Moreover, if Si in the steel is selectively oxidized and concentrated at the surface of the steel sheet, a significant alloying delay arises in the alloying process after the hot-dip galvanizing, leading to considerably lower productivity.

[0005] WO2007/043273 A1 (PTL 1) describes the following technique in relation to the problems set forth above. In a continuous annealing and hot-dip coating method that uses an annealing furnace having an upstream heating zone, a downstream heating zone, a soaking zone, and a cooling zone arranged in this order and a hot-dip molten bath, Si is internally oxidized and concentration of Si at the surface of the steel sheet is prevented by performing annealing under conditions including: heating or soaking the steel sheet at a steel sheet temperature in a range of 300 °C or higher by indirect heating; setting the atmosphere inside the furnace in each zone to an atmosphere of 1 vol% to 10 vol% hydrogen with the balance being nitrogen and incidental impurities; setting the steel sheet end-point temperature during heating in the upstream heating zone to 550 °C or higher and 750 °C or lower and the dew point in the upstream heating zone to lower than -25 °C; setting the dew point in the subsequent downstream heating zone and soaking zone to -30 °C or higher and 0 °C or lower; and setting the dew point in the cooling zone to lower than -25 °C. PTL 1 also describes humidifying mixed gas of nitrogen and hydrogen and introducing the mixed gas into the downstream heating zone and/or the soaking zone.

US 2009/0123651 A1 (PTL 2) describes a continuous annealing and hot dip plating method using an annealing furnace having, in order, a front heating zone, rear heating zone, soaking zone, and cooling zone and a hot dip plating bath, comprising heating or soaking the steel sheet at a steel sheet temperature of a temperature range of at least 300° C or more by indirect heating, wherein an atmosphere of the zones is comprised of hydrogen H: 1 to 10 vol % and a balance of nitrogen and unavoidable impurities, a steel sheet peak temperature during heating at the front heating zone is 550 to 750° C, the dew point is less than -25° C in the front heating zone, the dew points of the following rear heating zone and soaking zone is -30° C to 0° C, and wherein a dew point of the cooling zone less than -25° C. JP 2008 275 185 A (PTL 3) describes a humidified gas supply method for mixing a saturated moist gas supplied from a humidifying passage having a humidifier and a dry gas supplied from a dry gas passage to produce the humidified gas of predetermined flow rate and predetermined moisture amount, and supplying the same to a humidified gas use destination from the humidified gas supply passage, the pressure and temperature of the saturated moist gas are measured, and a flow rate of the saturated moist gas and a flow rate of the dry gas are respectively set on the basis of the moisture amount of the saturated moist gas and the moisture amount and flow rate of the humidified gas calculated on the basis of the measured pressure and temperature.

WO 2014/132638 A1 (PTL 4) describes a method for manufacturing hot dip galvanized steel sheets using a continuous hot dip galvanization device provided with a direct fire-type heating zone in which burners are disposed facing the surface of the steel sheet, wherein the dew point of the gas input in the burners is adjusted and hot dip galvanized steel sheets of excellent plating appearance can be obtained even with Si-containing steel.

CITATION LIST

Patent Literature

[0006]

PTL 1: WO2007/043273 A1
PTL 2: US 2009/0123651 A1
PTL 3: JP 2008 275 185 A
PTL 4: WO2014/132638 A1

SUMMARY

(Technical Problem)

[0007] In production of a high tensile strength steel sheet, humidified gas is supplied to the soaking zone in addition to reducing or non-oxidizing dry gas, as described in PTL 1, in order to raise the dew point in the soaking zone. In contrast, in production of a normal strength steel sheet (hereinafter, referred to as a "normal steel sheet"), only reducing or non-oxidizing dry gas is supplied to the soaking zone and humidified gas is not supplied. Therefore, in a situation such as when a high tensile strength steel sheet and a normal steel sheet are to be produced consecutively, it is necessary to switch between use and non-use of humidified gas during operation.

[0008] We recognized that the problem set forth below occurs when switching between use and non-use of humidified gas during operation. Specifically, we realized that if gas in a humidifying system is simply stopped during non-use of humidified gas, water from a humidifying device may spread and condense, and excessively humidified gas may accumulate in pipes of the humidifying system. Consequently, condensation or excessively humidified gas in the pipes may be sprayed into the soaking zone upon switching from non-use of the humidifying system to use of the humidifying system, and this may cause problems such as damage to a hearth roll and pick-up in the soaking zone, and formation of a water drop pattern on the steel sheet. Moreover, this may cause non-coating to occur in subsequent hot-dip galvanizing and may lead to poorer coating appearance.

[0009] In light of the problems set forth above, it would be helpful to provide a method of producing hot-dip galvanized steel sheets that can inhibit roll pick-up in a soaking zone caused by condensation or the like in a humidified gas pipe and with which favorable coating appearance can be obtained.

(Solution to Problem)

[0010] In order to solve the problems set forth above, we conducted detailed studies in relation to means for preventing the formation of condensation and the accumulation of excessively humidified gas in humidified gas pipes during non-use of humidified gas (i.e., while supply of humidified gas to a soaking zone is stopped). We discovered that the above objective can be achieved through the inventive method according to claim 1. Preferred embodiments of the inventive method are defined in the dependent claims 2-4.

(Advantageous Effect)

[0011] Through the disclosed method of producing hot-dip galvanized steel sheets, it is possible to inhibit roll pick-up in a soaking zone caused by condensation or the like in a humidified gas pipe and obtain favorable coating appearance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] In the accompanying drawings:

FIG. 1 is a schematic view illustrating a configuration of a continuous hot-dip galvanizing apparatus 100 used in an embodiment of the present invention;
FIG. 2 is a schematic view illustrating a supply system for supplying mixed gas and dry gas to a soaking zone 12 in FIG. 1; and
FIG. 3 is an enlarged schematic view illustrating a humidifying device 50 and a draining device 80 in FIG. 2.

DETAILED DESCRIPTION

[0013] A configuration of a continuous hot-dip galvanizing apparatus 100 used in an embodiment is described with reference to FIG. 1. The continuous hot-dip galvanizing apparatus 100 includes an annealing furnace 20 in which a heating zone 10, a soaking zone 12, and cooling zones 14 and 16 are arranged in this order, a hot-dip galvanizing bath 22 adjacent to the cooling zone 16 that serves as a hot-dip galvanizing line, and an alloying line 24 adjacent to the hot-dip galvanizing bath 22. The heating zone 10 in this embodiment includes a first heating zone 10A (upstream heating zone) and a second heating zone 10B (downstream heating zone). The cooling zone includes a first cooling zone 14 (rapid cooling zone) and a second cooling zone 16 (slow cooling zone). A snout 18 connected to the second cooling zone 16 has its tip immersed in the hot-dip galvanizing bath 22, thus connecting the annealing furnace 20 and the hot-dip galvanizing bath 22.

[0014] A steel strip P is introduced into the first heating zone 10A from a steel strip introduction port in a lower part of the first heating zone 10A. One or more hearth rolls are arranged in upper and lower parts of each of the zones 10, 12, 14, and 16. In the case where the steel strip P is folded back by 180 degrees at one or more hearth rolls, the steel strip P is conveyed vertically a plurality of times inside a corresponding zone of the annealing furnace 20, forming a plurality of passes. While FIG. 1 illustrates an example of having 10 passes in the soaking zone 12, 2 passes in the first cooling zone 14, and 2 passes in the second cooling zone 16, the numbers of passes are not limited to those in this example, and may be set as appropriate depending on the processing conditions. At some hearth rolls, the steel strip P is not folded back but changed in direction at a right angle to move to the next zone. The steel strip P is thus annealed in the annealing furnace 20 by being conveyed through the heating zone 10, the soaking zone 12, and the cooling zones 14 and 16 in this order.

[0015] Adjacent zones in the annealing furnace 20 communicate through a communication portion connecting the upper parts or lower parts of the respective zones. In this embodiment, the first heating zone 10A and the second heating zone 10B communicate through a throat (restriction portion) connecting the upper parts of the respective zones. The second heating zone 10B and the soaking zone 12 communicate through a throat connecting the lower parts of the respective zones. The soaking zone 12 and the first cooling zone 14 communicate through a throat connecting the lower parts of the respective zones. The first cooling zone 14 and the second cooling zone 16 communicate through a throat connecting the lower parts of the respective zones. Although the height of each throat may be set as appropriate, it is preferable that the height of each throat is as low as possible to enhance the independence of the atmosphere in each zone. Gas in the annealing furnace 20 flows from downstream to upstream and is discharged from the steel strip introduction port in the lower part of the first heating zone 10A.

(Heating zone)

[0016] In this embodiment, the second heating zone 10B is a direct fired furnace (DFF). The DFF may be a commonly known DFF. Burners are distributed in the inner wall of the direct fired furnace in the second heating zone 10B so as to face the steel strip P (note that these burners are not illustrated in FIG. 1). It is preferable that the burners are divided into groups, and that the combustion rate and the air ratio in each group are independently controllable. Combustion exhaust gas in the second heating zone 10B is supplied into the first heating zone 10A, and the steel strip P is preheated by the heat of the gas.

[0017] The combustion rate is a value obtained by dividing the amount of fuel gas actually introduced into a burner by the amount of fuel gas of the burner under its maximum combustion load. The combustion rate at the time of combustion by the burner under its maximum combustion load is 100 %. When the combustion load is low, the burner cannot maintain a stable combustion state. Accordingly, the combustion rate is preferably adjusted to 30 % or more.

[0018] The air ratio is a value obtained by dividing the amount of air actually introduced into a burner by the amount of air necessary for complete combustion of fuel gas. In this embodiment, the heating burners in the second heating zone 10B are divided into four groups (#1 to #4), and the three groups (#1 to #3) upstream in the steel sheet traveling direction are made up of oxidizing burners, and the last group (#4) is made up of reducing burners. The air ratio of the oxidizing burners and the air ratio of the reducing burners are independently controllable. The air ratio of the oxidizing burners is preferably adjusted to 0.95 or more and 1.5 or less. The air ratio of the reducing burners is preferably adjusted to 0.5 or more and less than 0.95. The temperature in the second heating zone 10B is preferably adjusted to 800 °C to 1200 °C.

(Soaking zone)

[0019] In this embodiment, the soaking zone 12 is capable of indirectly heating the steel strip P using a radiant tube (RT) (not illustrated) as heating means. The average temperature Tr (°C) in the soaking zone 12 is measured by inserting a thermocouple into the soaking zone 12 and is preferably adjusted to 700 °C to 900 °C.

[0020] Reducing gas or non-oxidizing gas is supplied to the soaking zone 12. H_2/N_2 mixed gas is typically used as the reducing gas. An example is gas (dew point: about -60 °C) having a composition containing 1 vol% to 20 vol% H_2 with the balance being N_2 and incidental impurities. An example of the non-oxidizing gas is gas (dew point: about -60 °C) having a composition containing N_2 and incidental impurities.

[0021] In this embodiment, the reducing gas or non-oxidizing gas supplied to the soaking zone 12 is in two forms: mixed gas and dry gas. Herein, "dry gas" refers to reducing gas or non-oxidizing gas that has a dew point of about -60 °C to -50 °C and that is not humidified by a humidifying device. On the other hand, "mixed gas" refers to gas obtained through mixing of gas that is humidified by the humidifying device and gas that is not humidified by the humidifying device in a specific mixing ratio such as to have a dew point of -20 °C to 10 °C.

[0022] A supply system for supplying mixed gas and dry gas to the soaking zone 12 is described with reference to FIG. 2. The supply system includes, from upstream, a first pipe 31, a second pipe 32, a third pipe 33, a fourth pipe 34, a fifth pipe 35, and a sixth pipe 36, and also includes a gas distribution device 40, a humidifying device 50, a gas mixing device 60, and a draining device 80.

[0023] Dry gas that is supplied from a gas supply source (not illustrated) passes through the first pipe 31.

[0024] The gas distribution device 40 is connected to the first pipe 31 and distributes dry gas that has passed through the first pipe 31 in a freely variable ratio to the following three systems: the second pipe 32, the third pipe 33, and the fourth pipe 34. The second pipe 32, the third pipe 33, and the fourth pipe 34 branch from the gas distribution device 40 and dry gas that has been distributed by the gas distribution device 40 passes therethrough. Specifically, one portion of dry gas that has passed through the first pipe 31 is supplied to the humidifying device 50 through the second pipe 32, another portion of this dry gas is supplied to the gas mixing device 60 through the third pipe 33, and the remaining portion of this dry gas is supplied straight to the soaking zone 12 through the fourth pipe 34. The gas distribution device 40 cuts off distribution to the second pipe 32 and the third pipe 33 during non-use of mixed gas described further below.

[0025] First, supply of dry gas is described. Dry gas that has passed through the fourth pipe 34 is supplied into the soaking zone 12 via dry gas supply ports 72A, 72B, 72C, and 72D that are disposed in the soaking zone 12. The position and number of dry gas supply ports is not specifically limited and may be set as appropriate in consideration of various conditions. However, it is preferable that a plurality of dry gas supply ports is arranged at the same height position and that dry gas supply ports are arranged uniformly in the steel strip traveling direction.

[0026] Next, supply of mixed gas is described. The humidifying device 50 is connected to the second pipe 32 and dry gas that has passed through the second pipe 32 is introduced therein. The fifth pipe 35 extends from the humidifying device 50 and humidified gas that has been humidified by the humidifying device 50 passes therethrough.

[0027] The gas mixing device 60 is connected to the third pipe 33 and the fifth pipe 35, and prepares mixed gas having a desired dew point by mixing dry gas that has passed through the third pipe and humidified gas that has passed through the fifth pipe in a given ratio that can be varied. The sixth pipe 36 is a mixed gas pipe that extends from the gas mixing device 60, and mixed gas discharged from the gas mixing device 60 passes therethrough. Mixed gas that has passed through the sixth pipe 36 is supplied into the soaking zone 12 via one or more mixed gas supply ports that are disposed in the soaking zone 12. In this embodiment, mixed gas is supplied by two systems: a system of mixed gas supply ports 70A, 70B, and 70C and a system of mixed gas supply ports 71A, 71B, and 71C. The position and number of mixed gas supply ports is not specifically limited and may be set as appropriate in consideration of various conditions. It is preferable that, as in this embodiment, a plurality of mixed gas supply ports is arranged at each of two or more different height positions and that mixed gas supply ports are arranged uniformly in the steel strip traveling direction. The dew point of the mixed gas can be measured by a mixed gas dew point meter 74 disposed in the sixth pipe.

[0028] Next, configurations of the humidifying device 50 and the draining device 80, which is a disclosed feature, are described with reference to FIG. 3. The humidifying device 50 includes a tube-shaped module 52 and a circulating constant-temperature water bath 54. Vapor permeable membranes 51 are disposed in the module 52. The vapor permeable membranes 51 in this embodiment are fluorine or polyimide hollow fiber membranes. Although only two vapor permeable membranes 51 are illustrated in FIG. 3, about 50 to 500 membranes are arranged substantially in parallel. In the module 52, the dry gas that has passed through the second pipe 32 flows through the inside 53A of the vapor permeable membranes, whereas pure water adjusted to a specific temperature in the circulating constant-temperature water bath 54 circulates at the outside 53B of the vapor permeable membranes. Specifically, the outside 53B of the vapor permeable membranes in the module is in communication with the circulating constant-temperature water bath 54 via passages 55A and 55B.

[0029] The fluorine or polyimide hollow fiber membranes are each a type of ion exchange membrane with affinity for water molecules. When moisture concentration differs between the inside and outside of the hollow fiber membrane, a force for equalizing the moisture concentration difference arises and, with this force as a driving force, moisture permeates through the membrane to move to the side with lower moisture concentration. Accordingly, dry gas is humidified to obtain humidified gas when the dry gas passes through the inside 53A of the vapor permeable membranes in the module 52. The temperature of dry gas varies with seasonal or daily air temperature change. In this embodiment, however, heat exchange is possible by ensuring a sufficient contact area between gas and water through the vapor permeable membranes 51. Accordingly, regardless of whether the dry gas temperature is higher or lower than the circulating water temperature, the dry gas is humidified to the same dew point as the set water temperature, thus achieving highly accurate dew point control. The dew point of the humidified gas can be controlled to any value in the range of 5 °C to 50 °C. When the dew point of the humidified gas is higher than the temperature of a pipe, there is a possibility that condensation occurs in the pipe and that condensation enters directly into the furnace. A humidified gas pipe is, therefore, heated/heat-retained to at least the dew point of the humidified gas and at least the external air temperature.

[0030] Note that the internal configuration of the module 52 is not limited to the configuration illustrated in FIG. 3. For example, the vapor permeable membranes may alternatively be fluorine or polyimide flat membranes. In such a configuration, the dry gas that has passed through the second pipe 32 is humidified by, while the dry gas passes through one space in the module that is separated by the vapor permeable membranes, circulating water through another space in the module using the circulating constant-temperature water bath 54.

[0031] A feature of the continuous hot-dip galvanizing apparatus 100 in this embodiment is that the continuous hot-dip galvanizing apparatus 100 includes the draining device 80 for draining water from the space at the outside 53B of the vapor permeable membranes in the module when mixed gas is not supplied to the soaking zone. FIG. 3 illustrates an example of the draining device 80. The draining device 80 includes a first isolation valve 82, a second passage 84, a second isolation valve 86, and a drainage tank 88. The first isolation valve 82 is disposed in the passage 55B through which water passes when moving toward the circulating constant-temperature water bath 54 from the outside 53B of the vapor permeable membranes in the module. The second passage 84 branches from the passage 55B at a section that is further upstream than the first isolation valve 82 (i.e., toward the outside 53B of the vapor permeable membranes). A tip of the second passage 84 is positioned above the drainage tank 88. The second isolation valve 86 is disposed in the second passage 84. The drainage tank 88 holds water that is drained from the second passage 84.

[0032] While humidified gas is being produced, the first isolation valve 82 is fully opened, the second isolation valve 86 is fully closed, and the circulating constant-temperature water bath 54 is used to circulate water at the outside 53B of the vapor permeable membranes in the module. While humidified gas is not being produced, water circulation is stopped, the second isolation valve 86 is fully opened, and the first isolation valve 82 is fully closed to drain water toward the drainage tank 88 from the space at the outside 53B of the vapor permeable membranes in the module. In a situation in which it is not possible to position the module 52 at least 200 mm higher than the top of the drainage tank 88, it is preferable that a suction device or the like is disposed at the drainage tank side in order to drain water in the humidifying device.

[0033] In production of a high tensile strength steel sheet, mixed gas containing humidified gas is supplied to the soaking zone 12 in addition to dry gas. Herein, this state is referred to as a "first operational state". In contrast, in production of a normal steel sheet, only dry gas is supplied to the soaking zone 12, and mixed gas is not supplied. Herein, this state is referred to as a "second operational state".

[0034] When humidified gas is not required in the second operational state, distribution of dry gas to the second pipe 32 and the humidifying device 50 can be stopped so that dry gas does not flow through the inside 53A of the vapor permeable membranes in the module. However, if water circulation using the circulating constant-temperature water bath 54 is allowed to continue over a long period, condensation occurs in pipes upstream and downstream of the module 52 (i.e., in the second pipe 32 and the fifth pipe 35), and further downstream in the sixth pipe 36. Even supposing that these pipes are heated/heat-retained, excessively humidified gas accumulates in the pipes since the inside of the pipes is in a constantly saturated state with moisture. Moreover, even supposing that water circulation is stopped, the same problems may arise if the space at the outside 53B of the vapor permeable membranes in the module is left in a water-filled state for a long period.

[0035] Therefore, switching between the first operational state and the second operational state is performed as follows. In the first operational state, water is circulated using the circulating constant-temperature water bath 54 and humidified gas is produced in a state in which the first isolation valve 82 is fully opened and the second isolation valve 86 is fully closed. In the second operational state, distribution of dry gas to the second pipe 32 is stopped and water circulation using the circulating constant-temperature water bath 54 is stopped, and subsequently water is drained from the space at the outside 53B of the vapor permeable membranes in the module using the draining device 80. Specifically, the second isolation valve 86 is fully opened and the first isolation valve 82 is fully closed. In other words, in the second operational state, a state in which water is not present in the space at the outside 53B of the vapor permeable membranes is obtained and water is not circulated using the circulating constant-temperature water bath 54. However, note that temperature adjustment of the circulating constant-temperature water bath 54 may be continued.

[0036] Switching in this manner can prevent condensation and accumulation of excessively humidified gas in pipes upstream and downstream of the module 52 (i.e., the second pipe 32 and the fifth pipe 35), and further downstream in the sixth pipe 36, while in the second operational state. Accordingly, condensation and excessively humidified gas do not enter the soaking zone 12 upon switching from the second operational state to the first operational state. This can inhibit the occurrence of roll pick-up in the soaking zone 12 and, as a result, enables favorable coating appearance to be obtained.

[0037] When switching from the second operational state to the first operational state (when switching from production of a normal steel sheet to production of a high tensile strength steel sheet), water circulation using the circulating constant-temperature water bath 54 is restarted and subsequently distribution of dry gas to the second pipe 32 is restarted.

[0038] The gas flow rate Qrd of dry gas supplied to the soaking zone 12 via the fourth pipe 34 in the first operational state and the second operational state is measured by a gas flowmeter (not illustrated) disposed in the fourth pipe 34. Although no specific limitations are placed on the gas flow rate Qrd, the gas flow rate Qrd is about 0 Nm^3/hr to 600 Nm^3/hr. This maintains the furnace pressure in the soaking zone 12 at an appropriate pressure (higher than the direct fired zone) but without the furnace pressure becoming excessively high.

[0039] The gas flow rate Qrw of mixed gas supplied to the soaking zone 12 via the sixth pipe 36 in the first operational state is measured by a gas flowmeter (not illustrated) disposed in the sixth pipe 36. Although no specific limitations are placed on the gas flow rate Qrw the gas flow rate Qrw is about 100 Nm^3/hr to 500 Nm^3/hr. This maintains the furnace pressure in the soaking zone 12 at an appropriate pressure (higher than the direct fired zone) but without the furnace pressure becoming excessively high.

[0040] It is preferable that the dew point in the soaking zone 12 is constantly controlled to -20 °C or higher and 0 °C or lower in the first operational state. Dew point meters are installed at at least one location (dew point measurement position 75A) near lower part hearth rolls 73B (lowest part of the soaking zone) and at least one location (dew point measurement position 75B) below upper part hearth rolls 73A at a higher position than half way up the soaking zone in a height direction (upper part of the soaking zone). Controlling the dew point in the soaking zone 12 to -20°C or higher enables an appropriate alloying temperature in subsequent alloying treatment and enables desired mechanical properties to be obtained. On the other hand, since the steel substrate of the steel strip starts oxidizing when the dew point in the soaking zone 12 is +10 °C or higher, the upper limit of the dew point is preferably 0 °C in terms of uniformity of the dew point distribution in the soaking zone 12 and minimization of the dew point variation range.

[0041] Mixed gas having a freely selected dew point can be supplied into the soaking zone 12 by adjusting the mixing proportions of gases in the gas mixing device 30. Mixed gas having a high dew point may be supplied to the soaking zone 1 2 if the dew point in the soaking zone 12 is about to fall below the target range. Conversely, mixed gas having a low dew point may be supplied to the soaking zone 12 if the dew point in the soaking zone 12 is about to rise above the target range. In this manner, the dew point in the soaking zone 12 can be constantly controlled to -20 °C or higher and 0 °C or lower in the first operational state.

(Cooling zone)

[0042] In this embodiment, the cooling zones 14 and 16 cool the steel strip P. The steel strip P is cooled to about 480 °C to 530 °C in the first cooling zone 14, and cooled to about 470 °C to 500 °C in the second cooling zone 16.

[0043] The cooling zones 14 and 16 are also supplied with the aforementioned reducing gas or non-oxidizing gas, but in the case of the cooling zones 14 and 16, only dry gas is supplied. Although no specific limitations are placed on supply of dry gas to the cooling zones 14 and 16, it is preferable that the dry gas is supplied from supply ports at at least two locations in a height direction and at least two locations in a longitudinal direction to enable uniform supply into the cooling zone. The total gas flow rate Qcd of dry gas supplied to the cooling zones 14 and 16 is measured by one or more gas flowmeters (not illustrated) disposed in pipes. Although no specific limitations are placed on the total gas flow rate Qcd, the total gas flow rate Qcd is about 200 Nm^3/hr to 1,000 Nm^3/hr. This maintains the furnace pressure in the soaking zone 12 at an appropriate pressure (higher than the direct fired zone) but without the furnace pressure becoming excessively high.

(Hot-dip galvanizing bath)

[0044] The hot-dip galvanizing bath 22 can be used to apply a hot-dip galvanized coating onto the steel strip P exiting from the second cooling zone 16. The hot-dip galvanizing may be performed according to a usual method.

(Alloying line)

[0045] The alloying line 24 can be used to heat-alloy the galvanized coating applied onto the steel strip P. The alloying treatment may be performed according to a usual method. In this embodiment, the alloying temperature is kept from being high, thus preventing a decrease in tensile strength of the produced galvannealed steel sheet. However, the alloying line 24 and the alloying treatment performed thereby are not essential to the disclosed techniques because the effects of inhibiting roll pick-up in the soaking zone caused by condensation or the like in a humidified gas pipe and obtaining favorable coating appearance can be achieved even when the alloying treatment is omitted.

EXAMPLES

(Experimental conditions)

[0046] The continuous hot-dip galvanizing apparatus illustrated in FIGS. 1 to 3 was used to anneal steel strips having chemical compositions shown in Table 1 under annealing conditions shown in Table 2, and then hot-dip galvanize and alloy the steel strips. Steel sample ID A is normal steel and steel sample ID B is high tensile strength steel. In the example and comparative example, annealing, hot-dip galvanizing, and alloying treatment were performed continuously with a sheet passing order shown in Table 2.

[0047] A DFF was used as the second heating zone. Heating burners were divided into four groups (#1 to #4) where the three groups (#1 to #3) upstream in the steel sheet traveling direction were made up of oxidizing burners and the last group (#4) was made up of reducing burners, and the air ratios of the oxidizing burners and reducing burners were set to the values shown in Table 2. The length of each group in the steel sheet conveyance direction was 4 m.

[0048] An RT furnace having a volume Vr of 700 m^3 was used as the soaking zone. The average temperature Tr in the soaking zone was set to the value shown in Table 2. Gas (dew point: -50 °C) having a composition containing 15 vol% H_2 with the balance being N_2 and incidental impurities was used as dry gas. A portion of the dry gas was humidified by a humidifying device having 10 hollow fiber membrane-type humidifying modules to prepare mixed gas. In each of the modules, the maximum dry gas flow rate was 500 L/min and the maximum water circulation rate was 10 L/min. A circulating constant-temperature water bath capable of supplying a total of 100 L/min of pure water was used as a common water bath for each of the modules. Dry gas supply ports and mixed gas supply ports were arranged at the positions illustrated in FIG. 2. The draining device illustrated in FIG. 3 was also set-up.

[0049] In the example and comparative example, gas was supplied to the soaking zone by adopting the second operational state during passing of a sheet with steel sample ID A and adopting the first operational state during passing of a sheet with steel sample ID B. The dry gas flow rate Qrd, mixed gas flow rate Qrw, and mixed gas dew point shown in Table 2 are each a stable value during passing of a corresponding sheet.

[0050] In the comparative example, supply of dry gas to the second pipe was stopped during passing of a sheet with steel sample ID A in the second operational state, but water circulation using the circulating constant-temperature water bath was continued. In contrast, during passing of a sheet with steel sample ID A in the second operational state in the example, distribution of dry gas to the second pipe was stopped and water circulation using the circulating constant-temperature water bath was stopped, and subsequently water was drained from space at the outside of vapor permeable membranes in the modules using the draining device.

[0051] The dry gas (dew point: -50 °C) was supplied to the first and second cooling zones at the lowest part of each of the zones with the flow rate shown in Table 2.

[0052] The temperature of the molten bath was set to 460 °C, the Al concentration in the molten bath was set to 0.130 %, and the coating weight was adjusted to 45 g/m^2 per surface by gas wiping. The line speed was set to 80 mpm to 100 mpm. After the hot-dip galvanizing, alloying treatment was performed in an induction heating-type alloying furnace so that the coating alloying degree (Fe content) was 10 % to 13 %. The alloying temperature in the treatment was as shown in Table 2.

(Evaluation method)

[0053] Evaluation of the coating appearance was conducted through inspection by an optical surface defect meter (detection of non-coating defects or overoxidation defects of ϕ0.5 or more) and visual determination of alloying unevenness. Samples passing all criteria were rated "excellent", samples having a low degree of alloying unevenness were rated "good", and samples failing at least one of the criteria were rated "poor". The results are shown in Table 2.

[0054] In addition, the tensile strength of a galvannealed steel sheet produced under each set of conditions was measured. Normal steel with steel sample ID A was evaluated to pass when the tensile strength was 270 MPa or more, and high tensile strength steel with steel sample ID B was evaluated to pass when the tensile strength was 980 MPa or more. The results are shown in Table 2.

(Evaluation results)

[0055] In Comparative Example No. 1, mixed gas was supplied to raise the dew point of the soaking zone during passing of a sheet with steel sample ID B, and thus it was not necessary to excessively raise the alloying temperature and there was no problem in terms of tensile strength. However, moisture that had condensed in pipes was supplied into the soaking zone when supply of humidified gas was started for passing of the second sheet. This caused localized elevation of the dew point near the hearth rolls, leading to the occurrence of roll pick-up, and scratches due to this roll pick-up were formed in the steel strip surface. This resulted in poorer coating appearance for the second passed sheet through to the fourth passed sheet. In contrast, it was possible to perform switching of humidified gas without formation of condensation in pipes in Example No. 2. As a result, all the evaluation criteria were passed.

[Table 1]

[0056]

Table I

(Mass%)							
Steel sample ID	C	Si	Mn	P	S	Nb	Ti
A	0.001	0.01	0.15	0.01	0.005	0.005	0.03
B	0.11	1.5	2.7	0.01	0.001	0.001	0.001

[Table 2]

[0057]

Table 2

No.	Sheet passing order	Steel sample ID	Healting zone (DFF)			Soaking zone (RTF)							Cooling zone	Aloying treatment	Coating appearance	Tensile Strength (MPa)	Classification
			Oxylcing burner ratio	Reducing burner in ratio	Discharge side teraperature (°C)	Upper part dew port (°C)	Lowest part dew port (°C)	Average temperature Tr (°C)	Dry gas flow rate Qrd (Nm^3/hr)	Mixed gas flow rate Qrw (Nm^3/hr)	Mixed gas dew port (°C)	Water circulation in humudifying device	Gas flow rate Qcd (Nm^3/hr)	Alloying temperature (°C)			
1	1	A	0 95	085	680	-29,3	-39 8	800	452	0	-	Yes	480	500	Excellent	308	Comparative example
	2	B	1.15	0.85	721	1.2	-9.2	830	280	170	5.0	Yes	472	508	Poor	1080	
	3	B	1.15	0.85	723	-1.11	-18.5	831	282	170	5.0	Yes	475	520	Poor	1030	
	4	A	095	0.85	680	-27.4	-34.3	800	455	0	-	Yes	462	501	Poor	310	
2	1	A	095	0.85	680	-32.5	-38.2	801	470	0	-	No	470	512	Excellent	305	Example
	2	B	1.15	0.85	721	-12.3	-16.2	830	272	200	5.0	Yes	472	513	Excellent	10.45	
	3	B	1.15	0.85	723	-13.5	-18.4	849	305	170	5.0	Yes	468	510	Excellent	1052	
	4	A	095	0.85	680	-27.2	-35.9	810	460	0	-	No	470	503	Excellent	301	
	5	B	1.15	0.85	725	-11.3	-16.1	852	241	250	5.0	Yes	467	509	Excellent	1030	
	6	A	0.95	0.85	680	-28.2	-365	811	465	0	-	No	480	500	Excellent	303	

INDUSTRIAL APPLICABILITY

[0058] Through the disclosed method of producing hot-dip galvanized steel sheets, it is possible to inhibit roll pick-up in a soaking zone caused by condensation or the like in a humidified gas pipe and obtain favorable coating appearance.

REFERENCE SIGNS LIST

[0059]

100	continuous hot-dip galvanizing apparatus
10	heating zone
10A	first heating zone (upstream)
10B	second heating zone (downstream, direct fired furnace)
12	soaking zone
14	first cooling zone (rapid cooling zone)
16	second cooling zone (slow cooling zone)
18	snout
20	annealing furnace
22	hot-dip galvanizing bath
24	alloying line
31	first pipe
32	second pipe
33	third pipe
34	fourth pipe
35	fifth pipe
36	sixth pipe
40	gas distribution device
50	humidifying device
51	vapor permeable membrane
52	module
53A	inside of vapor permeable membrane (one space)
53B	outside of vapor permeable membrane (other space)
54	circulating constant-temperature water bath
55A, 55B	passage
60	gas mixing device
70A, 70B, 70C	mixed gas supply port
71A, 71B, 71C	mixed gas supply port
72A, 72B, 72C, 72D	dry gas supply port
73A	upper part hearth roll
73B	lower part hearth roll
74	mixed gas dew point meter
75A, 75B	dew point measurement position
80	draining device
82	first isolation valve
84	second passage
86	second isolation valve
88	drainage tank
P	steel strip

Claims

1. A method of producing hot-dip galvanized steel sheets using a continuous hot-dip galvanizing apparatus (100) comprising:

   an annealing furnace (20) in which a heating zone (10), a soaking zone (12), and a cooling zone (14, 16) are arranged in this order;
   a hot-dip galvanizing line (22) adjacent to the cooling zone (14, 16);

a first pipe (31) through which a reducing or non-oxidizing dry gas passes;
a gas distribution device (40) that is connected to the first pipe (31) and that distributes dry gas that has passed through the first pipe (31);
a second pipe (32), a third pipe (33), and a fourth pipe (34) that branch from the gas distribution device (40) and through which dry gas that has been distributed by the gas distribution device (40) passes;
a humidifying device (50) that is connected to the second pipe (32) and into which dry gas that has passed through the second pipe (32) is introduced;
a fifth pipe (35) that extends from the humidifying device (50) and through which humidified gas that has been humidified by the humidifying device (50) passes;
a gas mixing device (60) that is connected to the third pipe (33) and the fifth pipe (35) and that prepares mixed gas by mixing dry gas that has passed through the third pipe (33) and humidified gas that has passed through the fifth pipe (35);
a sixth pipe (36) that extends from the gas mixing device (60) and through which the mixed gas passes;
a mixed gas supply port (70A, 70B, 70C, 71A, 71B, 71C) disposed in the soaking zone (12) for supplying mixed gas that has passed through the sixth pipe (36) into the soaking zone (12); and
a dry gas supply port (72A,72B, 72C, 72D) disposed in the soaking zone (12) for supplying dry gas that has passed through the fourth pipe (34) into the soaking zone (12), wherein
the humidifying device (50) includes a module (52) including a vapor permeable membrane (51), and is configured to humidify the dry gas that has passed through the second pipe (32) by, while the dry gas passes through a space (53A) in the module (52) that is separated by the vapor permeable membrane (51), circulating water through another space (53B) in the module (52) using a circulating constant-temperature water bath (54), and the continuous hot-dip galvanizing apparatus (100) further comprises a draining device (80) for draining water from the other space (53B) in the module (52) when the mixed gas is not supplied to the soaking zone (12), wherein the method comprises:

annealing a steel strip (P) by conveying the steel strip (P) through the heating zone (10), the soaking zone (12), and the cooling zone (14, 16) inside of the annealing furnace (20), in this order; and
applying a hot-dip galvanized coating onto the steel strip (P) exiting from the cooling zone (14, 16) using the hot-dip galvanizing line (22), wherein the method is carried out consecutively in

a first operational state, in which a high tensile strength steel sheet is produced and in which the mixed gas and the dry gas are supplied to the soaking zone (12) and water circulation is performed using the circulating constant-temperature water bath (54), and
a second operational state, in which a normal tensile strength steel sheet is produced and in which only the dry gas is supplied to the soaking zone (12) and the mixed gas is not supplied, distribution of the dry gas to the second pipe (32) is stopped, water is drained from the other space (53B) in the module (52) using the draining device (80), and water circulation with the circulating constant-temperature water bath (54) is not performed.

2. The method of producing hot-dip galvanized steel sheets according to claim 1, **characterized in that**, when switching from the second operational state to the first operational state, water circulation using the circulating constant-temperature water bath (54) is restarted and subsequently distribution of the dry gas to the second pipe (32) is restarted.

3. The method of producing hot-dip galvanized steel sheets according to claim 1 or 2, **characterized in that** a dew point in the soaking zone (12) is controlled to -20 °C or higher and 0 °C or lower in the first operational state.

4. The method of producing hot-dip galvanized steel sheets according to any one of claims 1 to 3, **characterized by** heat-alloying the galvanized coating applied onto the steel strip (P) using an alloying line (24) adjacent to the hot-dip galvanizing line (22).

Patentansprüche

1. Verfahren zum Herstellen feuerverzinkter Stahlbleche unter Einsatz einer Durchlauf-Feuerverzinkungsvorrichtung (100), umfassend:

einen Glühofen (20), in dem eine Heiz-Zone (10), eine Halte-Zone (12) und eine Abkühl-Zone (14, 16) in dieser Reihenfolge angeordnet sind;

eine Feuerverzinkungs-Anlage (22), die an die Abkühl-Zone (14, 16) angrenzt;
ein erstes Rohr (31), durch das ein reduzierendes oder nicht oxidierendes trockenes Gas strömt;
eine Gas-Verteilungsvorrichtung (40), die mit dem ersten Rohr (31) verbunden ist und die trockenes Gas verteilt, das das erste Rohr (31) durchströmt hat;
ein zweites Rohr (32), ein drittes Rohr (33) und ein viertes Rohr (34), die von der Gas-Verteilungsvorrichtung (40) abzweigen und durch die trockenes Gas strömt, das von der Gas-Verteilungsvorrichtung (40) verteilt worden ist;
eine Befeuchtungsvorrichtung (50), die mit dem zweiten Rohr (32) verbunden ist und in die trockenes Gas eingeleitet wird, das das zweite Rohr (32) durchströmt hat;
ein fünftes Rohr (35), das sich von der Befeuchtungsvorrichtung (50) aus erstreckt und durch das befeuchtetes Gas strömt, das von der Befeuchtungsvorrichtung (50) befeuchtet worden ist;
eine Gas-Mischvorrichtung (60), die mit dem dritten Rohr (33) und dem fünften Rohr (35) verbunden ist und die gemischtes Gas durch Mischen von trockenem Gas, das das dritte Rohr (33) durchströmt hat, und befeuchtetem Gas erzeugt, das das fünfte Rohr (35) durchströmt hat;
ein sechstes Rohr (36), das sich von der Gas-Mischvorrichtung (60) aus erstreckt und durch das das gemischte Gas strömt;
einen Mischgas-Zuführanschluss (70A, 70B, 70C, 71A, 71B, 71C), der in der Halte-Zone (12) angeordnet ist, um gemischtes Gas, das das sechste Rohr (36) durchströmt hat, in die Halte-Zone (12) einzuleiten; und
einen Trockengas-Zuführanschluss (72A, 72B, 72C, 72D), der in der Halte-Zone (12) angeordnet ist, um trockenes Gas, das das vierte Rohr (34) durchströmt hat, in die Halte-Zone (12) einzuleiten; wobei
die Befeuchtungsvorrichtung (50) ein Modul (52) einschließt, das eine dampfdurchlässige Membran (51) enthält und so ausgeführt ist, dass sie das trockene Gas, das das zweite Rohr (32) durchströmt hat, befeuchtet, indem sie, während das trockene Gas einen Raum (53A) in dem Modul (52) durchströmt, der durch die dampfdurchlässige Membran (51) abgetrennt ist, Wasser unter Verwendung eines zirkulierenden Wasserbades (54) mit konstanter Temperatur durch einen anderen Raum (53B) in dem Modul (52) zirkulieren lässt, und
die Durchlauf-Feuerverzinkungsvorrichtung (100) des Weiteren eine Ableitvorrichtung (80) zum Ableiten von Wasser aus dem anderen Raum (53B) in dem Modul (52) umfasst, wenn das gemischte Gas der Halte-Zone (12) nicht zugeführt wird, wobei das Verfahren umfasst:

> Glühen eines Stahlstreifens (P) durch Transportieren des Stahlstreifens (P) durch die Heiz-Zone (10), die Halte-Zone (12) und die Abkühl-Zone (14, 16) im Inneren des Glühofens (20) in dieser Reihenfolge; und
> Aufbringen einer Feuerverzinkungs-Beschichtung auf den aus der Abkühl-Zone (14, 16) austretenden Stahlstreifen (P) unter Verwendung der Feuerverzinkungsanlage (22), wobei das Verfahren fortlaufend in

einem ersten Betriebszustand, in dem ein Stahlblech mit hoher Zugfestigkeit hergestellt wird und in dem das gemischte Gas und das trockene Gas der Halte-Zone (12) zugeführt werden und Wasserzirkulation unter Verwendung des zirkulierenden Wasserbades (54) mit konstanter Temperatur durchgeführt wird, sowie
einem zweiten Betriebszustand durchgeführt wird, in dem ein Stahlblech mit normaler Zugfestigkeit hergestellt wird und in dem nur das trockene Gas der Halte-Zone (12) zugeführt wird und das gemischte Gas nicht zugeführt wird, Verteilung des trockenen Gases zu dem zweiten Rohr (32) unterbrochen wird, Wasser aus dem anderen Raum (53B) in dem Modul (52) unter Verwendung der Ableitvorrichtung (80) abgeleitet wird und Wasserzirkulation mit dem zirkulierenden Wasserbad (54) mit konstanter Temperatur nicht durchgeführt wird.

2. Verfahren zur Herstellung feuerverzinkter Stahlbleche nach Anspruch 1, **dadurch gekennzeichnet, dass**, beim Wechsel von dem zweiten Betriebszustand in den ersten Betriebszustand Wasserzirkulation unter Verwendung des zirkulierenden Wasserbad des (54) mit konstanter Temperatur wieder aufgenommen wird und anschließend Verteilung des trockenen Gases zu dem zweiten Rohr (32) wieder aufgenommen wird.

3. Verfahren zum Herstellen feuerverzinkter Stahlbleche nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass**, ein Taupunkt in der Halte-Zone (12) in dem ersten Betriebszustand auf -20 °C oder darüber und 0 °C oder darunter gesteuert wird.

4. Verfahren zum Herstellen feuerverzinkter Stahlbleche nach einem der Ansprüche 1 bis 3, **gekennzeichnet durch** Wärmelegieren der auf den Stahlstreifen (P) aufgebrachten Verzinkungs-Beschichtung unter Verwendung einer Legierungsanlage (24), die an die Feuerverzinkungsanlage (22) angrenzt.

Revendications

1. **1.** Procédé de production de tôles d'acier galvanisé par immersion à chaud utilisant un appareil de galvanisation par immersion à chaud continue (100) comprenant :

   un four de recuit (20) dans lequel une zone de chauffage (10), une zone de trempe (12), et une zone de refroidissement (14, 16) sont agencées dans cet ordre ;
   une ligne de galvanisation par immersion à chaud (22) adjacente à la zone de refroidissement (14, 16) ;
   un premier tuyau (31) à travers lequel passe un gaz sec réducteur ou non-oxydant ;
   un dispositif de distribution de gaz (40) qui est connecté au premier tuyau (31) et qui distribue du gaz sec qui est passé à travers le premier tuyau (31) ;
   un deuxième tuyau (32), un troisième tuyau (33), et un quatrième tuyau (34) qui bifurquent à partir du dispositif de distribution de gaz (40) et à travers lesquels passe du gaz sec qui a été distribué par le dispositif de distribution de gaz (40) ;
   un dispositif d'humidification (50) qui est connecté au deuxième tuyau (32) et dans lequel du gaz sec qui est passé à travers le deuxième tuyau (32) est introduit ;
   un cinquième tuyau (35) qui s'étend depuis le dispositif d'humidification (50) et à travers lequel passe du gaz humidifié qui a été humidifié par le dispositif d'humidification (50) ;
   un dispositif de mélange de gaz (60) qui est connecté au troisième tuyau (33) et au cinquième tuyau (35) et qui prépare du gaz mélangé en mélangeant du gaz sec qui est passé à travers le troisième tuyau (33) et du gaz humidifié qui est passé à travers le cinquième tuyau (35) ;
   un sixième tuyau (36) qui s'étend depuis le dispositif de mélange de gaz (60) et à travers lequel passe le gaz mélangé ;
   un orifice d'alimentation en gaz mélangé (70A, 70B, 70C, 71A, 71B, 71C) disposé dans la zone de trempe (12) pour alimenter du gaz mélangé qui est passé à travers le sixième tuyau (36) dans la zone de trempe (12) ; et
   un orifice d'alimentation en gaz sec (72A, 72B, 72C, 72D) disposé dans la zone de trempe (12) pour alimenter du gaz sec qui est passé à travers le quatrième tuyau (34) dans la zone de trempe (12), dans lequel
   le dispositif d'humidification (50) comprend un module (52) comprenant une membrane perméable à la vapeur (51), et est configuré pour humidifier le gaz sec qui est passé à travers le deuxième tuyau (32) en, pendant que le gaz sec passe à travers un espace (53A) dans le module (52) qui est séparé par la membrane perméable à la vapeur (51), faisant circuler de l'eau à travers un autre espace (53B) dans le module (52) en utilisant un bain d'eau en circulation à température constante (54), et
   l'appareil de galvanisation par immersion à chaud continue (100) comprend en outre un dispositif de drainage (80) pour drainer de l'eau depuis l'autre espace (53B) dans le module (52) lorsque le gaz mélangé n'est pas alimenté dans la zone de trempe (12), dans lequel le procédé comprend les étapes consistant à :

      recuire une bande d'acier (P) en transportant la bande d'acier (P) à travers la zone de chauffage (10), la zone de trempe (12), et la zone de refroidissement (14, 16) à l'intérieur du four de recuit (20), dans cet ordre ; et
      appliquer un revêtement galvanisé par immersion à chaud sur la bande d'acier (P) sortant de la zone de refroidissement (14, 16) en utilisant la ligne de galvanisation par immersion à chaud (22), dans lequel le procédé est effectué consécutivement dans un premier état de fonctionnement, dans lequel une tôle d'acier à haute résistance à la traction est produite et dans lequel le gaz mélangé et le gaz sec sont alimentés dans la zone de trempe (12) et une mise en circulation d'eau est effectuée en utilisant le bain d'eau en circulation à température constante (54), et

   un second état de fonctionnement, dans lequel une tôle d'acier à résistance à la traction normale est produite et dans lequel seul le gaz sec est alimenté dans la zone de trempe (12) et le gaz mélangé n'est pas alimenté, une distribution du gaz sec au deuxième tuyau (32) est arrêtée, de l'eau est drainée depuis l'autre espace (53B) dans le module (52) en utilisant le dispositif de drainage (80), et une mise en circulation d'eau avec le bain d'eau en circulation à température constante (54) n'est pas effectuée.

2. **2.** Procédé de production de tôles d'acier galvanisé par immersion à chaud selon la revendication 1, **caractérisé en ce que**,
   lors du passage du second état de fonctionnement au premier état de fonctionnement, une mise en circulation d'eau en utilisant le bain d'eau en circulation à température constante (54) est redémarrée et une distribution ultérieure du gaz sec vers le deuxième tuyau (32) est redémarrée.

3. Procédé de production de tôles d'acier galvanisé par immersion à chaud selon la revendication 1 ou 2, **caractérisé en ce que**
un point de rosée dans la zone de trempe (12) est commandé à -20°C ou plus et 0°C ou moins dans le premier état de fonctionnement.

4. Procédé de production de tôles d'acier galvanisé par immersion à chaud selon l'une quelconque des revendications 1 à 3, **caractérisé par**
l'alliage à chaud du revêtement galvanisé appliqué sur la bande d'acier (P) en utilisant une ligne d'alliage (24) adjacente à la ligne de galvanisation par immersion à chaud (22).

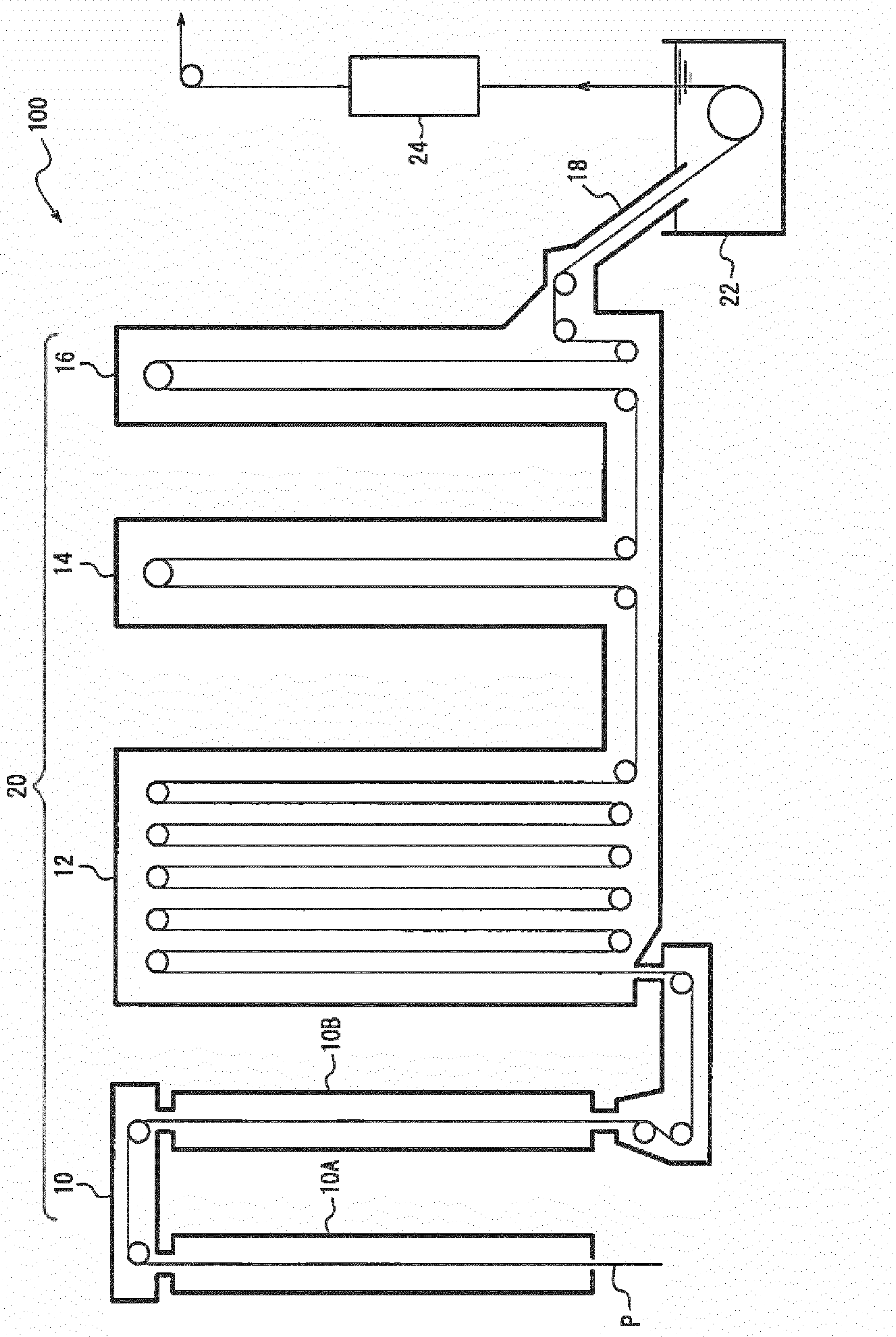
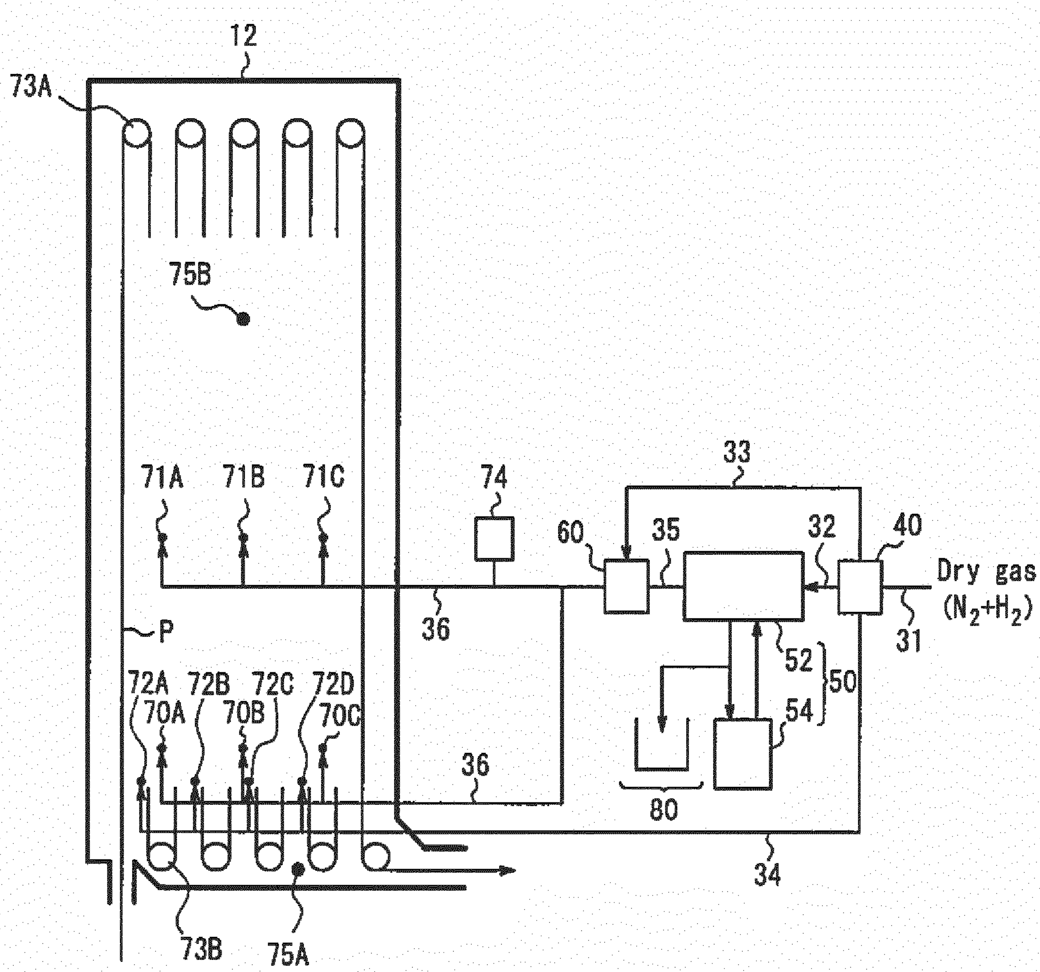


FIG. 1

FIG. 2


12
73A
75B
71A
71B
71C
74
33
60
35
32
40
Dry gas
(N_2+H_2)
36
31
P
52
50
72A
72B
72C
72D
70A
70B
70C
54
36
80
34
73B
75A

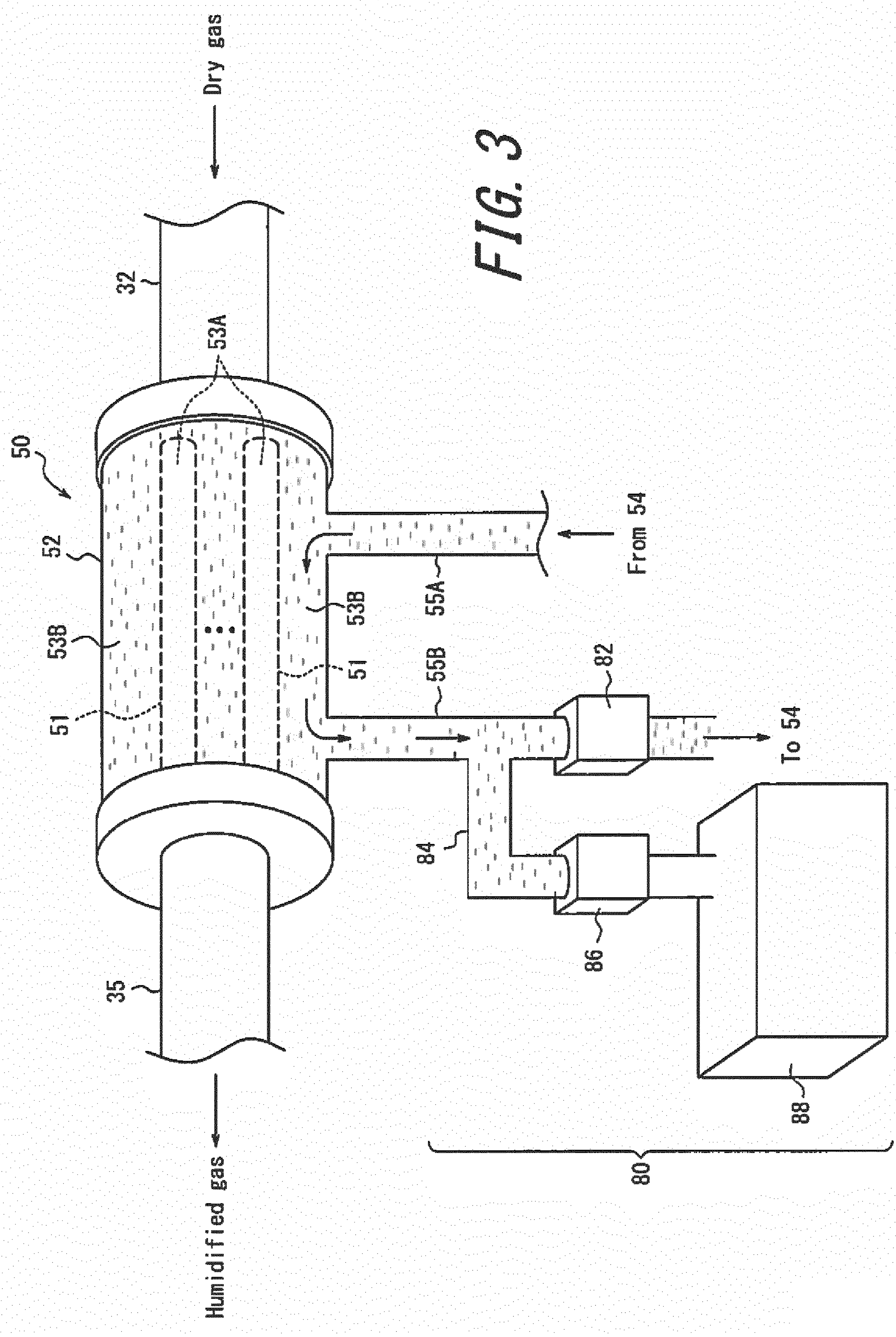

Dry gas
Humidified gas
From 54
To 54
50
52
53A
53B
51
32
35
55A
55B
82
84
86
88
80

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- WO 2007043273 A1 **[0005] [0006]**
- US 20090123651 A1 **[0005] [0006]**
- JP 2008275185 A **[0005] [0006]**
- WO 2014132638 A1 **[0005] [0006]**