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(54) STEEL PLATE INCLUDING ZINC-ALUMINUM-MAGNESIUM COATING AND METHOD OF MANUFACTURING THE SAME

STAHLBLECH MIT EINER ZINK-ALUMINIUM-MAGNESIUM-BESCHICHTUNG UND VERFAHREN ZU SEINER HERSTELLUNG

TÔLE D’ACIER COMPORTANT UN REVÊTEMENT DE ZINC-ALUMINIUM-MAGNÉSIUM ET SON PROCÉDÉ DE FABRICATION

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Description

BACKGROUND

Technical Field

[0001] The present invention relates to a steel plate including a zinc-aluminum-magnesium coating and a manufacturing method thereof.

Background Art

[0002] Steel components may be generally deteriorated due to the environment in which they are used. For example, steel components are susceptible to air erosion in a low-temperature and humid environment, and are easily oxidized in a high-temperature environment, and problems such as faster corrosion may occur in an acidic environment. Therefore, the above-mentioned problems are generally solved by forming a coating on the steel components.

[0003] Zinc has excellent corrosion resistance, electrical conductivity and thermal conductivity, is easy to be processed, and may be used as a sacrificial anode to protect steel components, thereby greatly extending the service life of the steel components. Therefore, galvanizing is one of the earliest, most widely used, and most cost-effective surface treatment methods for protecting steel components such as steel plates or steel wires.

[0004] At present, ordinary galvanizing has become unable to meet industrial development and social needs, and people have also begun to try to improve the corrosion resistance and compression and deformation resistance of the coating by adding other trace elements. Over the past few decades, novel coatings with higher corrosion resistance have been developed successively. Steel components including a zinc-aluminum-magnesium coating are attracting attention due to their corrosion resistance 3~18 times higher than that of steel components including a pure zinc coating. However, the existing zinc-aluminum-magnesium coating has problems such as high brittleness, poor formability, and poor surface quality. Therefore, numerous research studies are being carried out on the zinc-aluminum-magnesium coating to solve the above problems while ensuring its corrosion resistance

[0005] Document CN 109 536 864 A discloses a method for manufacturing a steel plate with a Zn-Mg-Al coating with good corrosion resistance, made by hot dipping the steel in a coating bath. The method comprises a pretreatment of the cold rolled steel, dipping the steel into a hot dip bath with selected Zn-based composition and controlling the thickness by air wiping the treatment comprising a post-treatment including cooling step, levelling, passivating and drying.

[0006] Document EP 3 575 434 A1 discloses a Zn-based composition including amounts of La, Ce and Y to improve corrosion wherein these elements must be limited to an amount within 0.05 to 0.5% to improve corrosion in welded areas. Patent Documents CN 102 268 623 B, CN 103 173 707 A and US 2017/233859 A1 also deal with the problem of improving the corrosion resistance of coated steels. In these documents, different Zn-based compositions are described to achieve that effect.

SUMMARY

TECHNICAL PROBLEM

[0007] An objective of the present invention is to provide a steel plate including a zinc-aluminum-magnesium coating and a manufacturing method thereof.

[0008] An objective of the present invention is to provide a steel plate including a zinc-aluminum-magnesium coating and a manufacturing method thereof capable of solving at least one of the above problems.

TECHNICAL SOLUTIONS

[0009] A method for manufacturing a steel plate including a zinc-aluminum-magnesium coating according to the present invention includes: pretreating a cold-rolled steel plate; dipping the pretreated steel plate into a bath containing zinc, aluminum, and magnesium as main components for a dipping treatment so that at least one of two surfaces of the steel plate is coated with the bath to form a bath layer; controlling a thickness of the bath layer on the at least one surface of the steel plate by using an air knife; and cooling the steel plate coated with the bath layer. The bath may include following components in percentage by mass: 1.5~2.3% of Al, 1.2~1.8% of Mg, 0.01~0.08% of La and Ce in total, 0.01~0.08% of at least one of Cu, Cr, and Ni in total, and a balance of Zn and inevitable impurities, with a mass ratio of Al to Mg being 1.2~1.4, and a mass ratio of La to Ce being 2:1.

[0010] According to the present invention, the dipping treatment may be performed for 2~6 seconds.

[0011] In the present invention, the pretreating may include: placing the cold-rolled steel plate in a solution tank containing a solution therein to perform a chemical degreasing treatment on the cold-rolled steel plate for a degreasing time of 10~15 seconds, by using the solution containing 1~2 wt% of caustic soda (NaOH, sodium hydroxide) and having a solution temperature of 70~90 °C; placing the chemically-degreased steel plate in an electrolytic cell containing an electrolyte therein to perform an electrolytic degreasing treatment on the steel plate for a degreasing time of 4~8 seconds, by using the electrolyte containing 2~3 wt% of caustic soda and having an electrolyte temperature of 70~90 °C; and heat treating the electrolytic-degreased steel plate, the heat treating including: annealing the electrolytic-degreased steel plate at an annealing temperature of 680~850 °C for an annealing time of 30~90 seconds.

[0012] In the present invention, the controlling of the thickness of the bath layer may include controlling a mass of the bath layer on each of the at least one surface of the steel plate to be 30~300 g/m^2 and controlling the thickness thereof to be 4~43 μm.

[0013] In the present invention, the cooling of the steel plate coated with the bath layer may include: a first stage, cooling at a cooling rate of 10~20 °C/s; a second stage, rapidly cooling at a cooling rate of 30~100 °C/s; and a third stage, slowly cooling at a cooling rate of 5~10 °C/s.

[0014] In the present invention, the method may further include performing a skin-passing treatment on the cooled steel plate by using a skin-pass mill; performing a tension leveling treatment on the skin-passed steel plate by using a tension leveler; performing a passivation treatment on the tension-leveled steel plate by using a passivation coating machine; and performing a drying treatment on the passivated steel plate to obtain the steel plate including the zinc-aluminum-magnesium coating.

[0015] In an embodiment according to the present invention, the passivation treatment may be performed in a passivation amount of 0.02~1.0 g/m^2.

[0016] The present invention provides a steel plate including a zinc-aluminum-magnesium coating which is formed on at least one surface of the steel plate, wherein the zinc-aluminum-magnesium coating may include following components in percentage by mass: 1.5~2.3% of Al, 1.2~1.8% of Mg, 0.01~0.08% of La and Ce in total, 0.01~0.08% of at least one of Cu, Cr, and Ni in total, and a balance of Zn and inevitable impurities. The mass ratio of Al to Mg may be 1.2 to 1.4, and the mass ratio of La to Ce may be 2:1.

[0017] In the present invention, the thickness of the zinc-aluminum-magnesium coating on a single side may be 4~43 μm.

[0018] In an embodiment according to the present invention, the mass percentage of Al may be 1.5~2.0%.

ADVANTAGEOUS EFFECT

[0019] The zinc-aluminum-magnesium coating and the steel plate including the same according to the above-mentioned embodiment(s) of the present invention may avoid the increase in brittleness and the decrease in formability due to the high Al content and solve the problem of black spot defects on the surface of the coated steel plate, while ensuring the corrosion resistance of the steel component including the zinc-aluminum-magnesium coating.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] These and/or other aspects will become apparent and more readily appreciated through the following description of the exemplary embodiments, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a diagram illustrating a surface topography of a steel plate including a zinc-aluminum-magnesium coating according to an exemplary embodiment of the inventive concept;

FIG. 2 is a diagram illustrating a cross-sectional topography of a steel plate including a zinc-aluminum-magnesium coating according to an exemplary embodiment of the inventive concept;

FIG. 3 is a diagram illustrating a cross-sectional topography of a steel plate including a zinc-aluminum-magnesium coating after 0T bending test according to an exemplary embodiment of the inventive concept; and

FIG. 4 is a diagram illustrating a cross-sectional topography of a steel plate including a zinc-aluminum-magnesium coating after 0T bending test according to a comparative example.

DETAILED DESCRIPTION

[0021] The principle of the present invention will be further described in detail below in conjunction with the accompanying drawings and exemplary embodiments, so as to make the technical solution of the present invention clearer.

[0022] A zinc-aluminum-magnesium coating may be coated on a surface of a steel component to serve as a corrosionresistant layer of the steel component to improve the corrosion resistance of the steel component. A conventional zinc-aluminum-magnesium coating generally has a high Al content, which leads to decreased formability of a final product. In addition, the high contents of Al and Mg in the zinc-aluminum-magnesium coating may cause surface quality defects due to oxidation. In order to solve the above problems, it is necessary to control the contents of Al and Mg in the coating, without negative influence on the corrosion resistance of the coating.

[0023] According to the present invention, the zinc-aluminum-magnesium coating may include zinc (Zn), aluminum (Al), magnesium (Mg), lanthanum (La), and cerium (Ce), and further includes at least one element of copper (Cu), chromium (Cr), and nickel (Ni). In addition to the above elements, inevitable impurities may also be included in the zinc-aluminum-magnesium coating. Specifically, according to the present invention, the zinc-aluminum-magnesium coating includes following chemical components in percentage by mass: 1.5~2.3% of Al, 1.2~1.8% of Mg, 0.01~0.08% of La and Ce in total, 0.01~0.08% of at least one of Cu, Cr, and Ni in total, and a balance of Zn and inevitable impurities, wherein the mass ratio of Al to Mg in the zinc-aluminum-magnesium coating is controlled to be 1.2~1.4 and the mass ratio of La to Ce is controlled to be 2:1.

[0024] In an embodiment according to the present invention, the mass percents of the chemical components in the zinc-aluminum-magnesium coating are intended to encompass any sub-range or any specific value within the above-mentioned ranges. Specifically, in the zinc-aluminum-magnesium coating, the mass percentage of Al is preferably 1.5~2.0%, more preferably 1.5~1.8%; the mass percentage of Mg is preferably 1.2~1.7%, more preferably 1.2~1.5%; the mass percentage of La and Ce in total is preferably 0.01~0.07%, more preferably 0.03~0.05%; the mass percentage of at least one of Cu, Cr, and Ni in total is preferably 0.01~0.07%, more preferably 0.01~0.05%.

[0025] According to the present invention, the mass percentage of Al in the zinc-aluminum-magnesium coating is controlled to be 1.5~2.3%, and the mass percentage of Mg is controlled to be 1.2~1.8%. In this case, the contents of Al and Mg in the zinc-aluminum-magnesium coating may be controlled at a relatively low level, thereby avoiding the problems of the increase in brittleness and the decrease in formability due to the high Al content, and solving the problem of serious surface oxidation of steel components containing zinc-aluminum-magnesium coatings due to the high contents of Al and Mg. In addition, in order to ensure the corrosion resistance of the steel component including the zinc-aluminum-magnesium coating, the mass ratio of Al to Mg is controlled to be 1.2~1.4, and a certain content of La and Ce in a mass ratio of 2:1 is added to the zinc-aluminum-magnesium coating in the present invention The addition of La and Ce not only further improves the corrosion resistance of the zinc-aluminum-magnesium coating, but also prevents the surface oxidation of the dipping bath during dipping and improves the surface quality. However, excessive La and Ce may lead to complicated composition of the dipping bath and increase the difficulty in the zinc pot management. In addition, independent (separate) addition of La and Ce and combined addition of La and Ce have different effects on the corrosion resistance of the zinc-aluminum-magnesium coating. Through research, the present inventors have found that the combined addition of La and Ce may better (further) improve the corrosion resistance of the zinc-aluminum-magnesium coating. Therefore, in the present invention, the zinc-aluminum-magnesium coating contains 0.01%~0.08 mass% of La and Ce in total, and the mass ratio of La to Ce is 2:1.

[0026] In addition to the above elements, other trace elements may be further included in the zinc-aluminum-magnesium coating to further improve the corrosion resistance and other properties of the zinc-aluminum-magnesium coating. In the present invention, the zinc-aluminum-magnesium coating includes at least one element of Cu, Cr, and Ni. Among the above trace elements, Cu may refine the grains of the zinc-aluminum-magnesium coating, improve the strength of the coating, improve the surface friction resistance of the coating, and improve the corrosion resistance of the coating; Cr may improve the hardness of the coating, improve the surface quality, and increase the corrosion resistance of the coating; and Ni may improve the corrosion resistance of the coating and inhibit surface oxidation. In order to impart the effects of these elements and avoid the influence of excessive amounts of the above-mentioned elements on the performance of the bath, the total mass percentage of the above-mentioned trace elements is controlled to 0.01~0.08%.

[0027] A steel component including a zinc-aluminum-magnesium coating and a manufacturing method thereof according to the present invention will be described in more detail below with reference to specific embodiments. In the following description, a steel plate will be described as an example of the steel component.

[0028] In an embodiment according to the present invention, the steel plate including the zinc-aluminum-magnesium coating is manufactured through the following steps.

[0029] First, the steel plate is pretreated as follows. Specifically, a cold-rolled steel plate is placed in a solution tank containing a solution therein to perform a chemical degreasing treatment on the cold-rolled steel plate for a degreasing time of 10~15 seconds by using the solution containing 1~2 wt% of caustic soda (NaOH, sodium hydroxide) and having a solution temperature of 70~ 90 °C; then, the above-mentioned chemically-degreased steel plate is placed in an electrolytic cell containing an electrolyte therein to perform an electrolytic degreasing treatment on the steel plate for a degreasing time of 4~8 seconds by using the electrolyte containing 2~3 wt% of caustic soda and having an electrolyte temperature of 70~90 °C; and then, the above-mentioned electrolytic-degreased steel plate is annealed in a continuous annealing furnace at an annealing temperature of 680~850 °C for an annealing time of 30~90 seconds.

[0030] Next, the above-mentioned pretreated steel plate is dipped into a zinc-aluminum-magnesium bath having chemical components of the above-mentioned contents, such that at least one of two surfaces of the above-mentioned annealed steel plate is coated with the aforementioned bath uniformly to form a bath layer, wherein the dipping time is 2~6 seconds.

[0031] Then, a thickness of the bath layer of the above-mentioned hot-dipped steel plate is controlled by using an air knife, such that the mass of the bath layer on each of the at least one surface is 30~300 g/m^2 (thickness corresponding thereto is 4~43 μm), wherein the pressure of the air knife is 0.1~0.5 MPa.

[0032] Next, a post-dipping cooling treatment is performed on the above-mentioned steel plate hot-dipped with the bath layer(s) by using a fan. In the cooling treatment, the post-dipping cooling process has a great influence on the structure of the coating, an improper cooling process is likely to lead to the formation of Mg_2Zn_{11} phase in the coating, and thus lead to the formation of black spots on the surface of the coating. Therefore, in order to avoid this defect, a subsection cooling process is employed, which includes cooling at a cooling rate of 10~20 °C/s in a first stage, rapidly cooling at a cooling rate of 30~100 °C/s in a second stage, and then slowly cooling at a cooling rate of 5~10 °C/s in a third stage.

[0033] Then, a skin-passing treatment is performed on the above-mentioned cooled steel plate including the zinc-aluminum-magnesium coating, for example, by using a skin-pass mill, with a skin-passing pressure of 100~200 tons (T).

[0034] Next, a tension leveling treatment is performed on the above-mentioned skin-passed steel plate including the zinc-aluminum-magnesium coating by using a tension leveler with a tension of 10~15 tons.

[0035] Then, a passivation treatment is performed on the above-mentioned tension-leveling-treated steel plate including the zinc-aluminum-magnesium coating, by using a passivation coating machine with a passivation amount of 0.02~1.0 g/m^2 (both sides).

[0036] Finally, a drying treatment is performed on the above-mentioned passivated steel plate including the zinc-aluminum-magnesium coating for a drying time of 10~15 seconds at a drying temperature of 50~100 °C.

[0037] Through the above method, the steel plate including the zinc-aluminum-magnesium coating according to the present invention is finally obtained.

[0038] The steel plate including the zinc-aluminum-magnesium coating of the present invention will be described below with reference to specific Examples.

Example 1

[0039] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 15 seconds by using a solution containing 1 wt% of caustic soda and having a temperature of 70 °C; an electrolytic degreasing treatment was performed on the steel plate for 4 seconds by using an electrolyte containing 2.0 wt% of caustic soda and having a temperature of 70 °C; and the electrolytic-degreased steel plate was annealed for 80 seconds at a temperature of 750 °C.

[0040] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 1 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0041] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 1, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0042] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 20 °C/s in the first stage, rapidly cooling at a cooling rate of 70 °C/s in the second stage, and then slowly cooling at a cooling rate of 7 °C/s in the third stage.

[0043] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 2

[0044] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 14 seconds by using a solution containing 1 wt% of caustic soda and having a temperature of 75 °C; an electrolytic degreasing treatment was performed on the steel plate for 5 seconds by using an electrolyte containing 2 wt % of caustic soda and having a temperature of 75 °C; and the electrolytic-degreased steel plate was annealed for 90 seconds at a temperature of 680 °C.

[0045] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 2 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0046] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 2, the mass of the bath layer on a single side is each 30 g/m^2 (the thickness corresponding thereto is 4 μm).

[0047] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 10 °C/s in the first stage, rapidly cooling at a cooling rate of 100 °C/s in the second stage, and then slowly cooling at a cooling rate of 5 °C/s in the third stage.

[0048] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 3

[0049] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 14 seconds by using a solution containing 1 wt% of caustic soda and having a temperature of 75 °C; an electrolytic degreasing treatment was performed on the steel plate for 5 seconds by using an electrolyte containing 2 wt% of caustic soda and having a temperature of 75 °C; and the electrolytic-degreased steel plate was annealed for 90 seconds at a temperature of 680 °C.

[0050] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 3 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0051] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 3, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0052] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 10 °C/s in the first stage, rapidly cooling at a cooling rate of 100 °C/s in the second stage, and then slowly cooling at a cooling rate of 5 °C/s in the third stage.

[0053] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 4

[0054] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 13 seconds by using a solution containing 1 wt% of caustic soda and having a temperature of 80 °C; an electrolytic degreasing treatment was performed on the steel plate for 6 seconds by using an electrolyte containing 2 wt% of caustic soda and having a temperature of 80 °C; and the electrolytic-degreased steel plate was annealed for 30 seconds at a temperature of 820 °C.

[0055] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 4 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0056] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 4, the mass of the bath layer on a single side is each 300 g/m^2 (the thickness corresponding thereto is 43 μm).

[0057] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 20 °C/s in the first stage, rapidly cooling at a cooling rate of 50 °C/s in the second stage, and then slowly cooling at a cooling rate of 10 °C/s in the third stage.

[0058] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 5

[0059] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 13 seconds by using a solution containing 1 wt% of caustic soda and having a temperature of 80 °C; an electrolytic degreasing treatment was performed on the steel plate for 6 seconds by using an electrolyte containing 2 wt% of caustic soda and having a temperature of 80 °C; and the electrolytic-degreased steel plate was annealed for 30 seconds at a temperature of 820 °C.

[0060] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 5 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0061] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 5, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0062] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 20 °C/s in the first stage, rapidly cooling at a cooling rate of 50 °C/s in the second stage, and then slowly cooling at a cooling rate of 10 °C/s in the third stage.

[0063] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 6

[0064] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 12 seconds by using a solution containing 1 wt% of caustic soda and having a temperature of 85

°C; an electrolytic degreasing treatment was performed on the steel plate for 7 seconds by using an electrolyte containing 2 wt% of caustic soda and having a temperature of 85 °C; and the electrolytic-degreased steel plate was annealed for 80 seconds at a temperature of 750 °C.

[0065] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 6 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0066] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 6, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0067] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 20 °C/s in the first stage, rapidly cooling at a cooling rate of 70 °C/s in the second stage, and then slowly cooling at a cooling rate of 7 °C/s in the third stage.

[0068] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 7

[0069] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 11 seconds by using a solution containing 1 wt% of caustic soda and having a temperature of 90 °C; an electrolytic degreasing treatment was performed on the steel plate for 8 seconds by using an electrolyte containing 2 wt% of caustic soda and having a temperature of 90 °C; and the electrolytic-degreased steel plate was annealed for 80 seconds at a temperature of 750 °C.

[0070] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 7 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0071] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 7, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0072] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 20 °C/s in the first stage, rapidly cooling at a cooling rate of 70 °C/s in the second stage, and then slowly cooling at a cooling rate of 7 °C/s in the third stage.

[0073] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 8

[0074] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 14 seconds by using a solution containing 1.5 wt% of caustic soda and having a temperature of 70 °C; an electrolytic degreasing treatment was performed on the steel plate for 5 seconds by using an electrolyte containing 2.5 wt% of caustic soda and having a temperature of 70 °C; and the electrolytic-degreased steel plate was annealed for 80 seconds at a temperature of 750 °C.

[0075] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 8 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0076] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 8, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0077] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 20 °C/s in the first stage, rapidly cooling at a cooling rate of 70 °C/s in the second stage, and then slowly cooling at a cooling rate of 7 °C/s in the third stage.

[0078] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 9

[0079] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 12 seconds by using a solution containing 1.5 wt% of caustic soda and having a temperature of 80 °C; an electrolytic degreasing treatment was performed on the steel plate for 6 seconds by using an electrolyte containing 2.5 wt% of caustic soda and having a temperature of 75 °C; and the electrolytic-degreased steel plate was annealed for 70 seconds at a temperature of 820 °C.

[0080] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 9 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0081] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 9, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0082] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 20 °C/s in the first stage, rapidly cooling at a cooling rate of 100 °C/s in the second stage, and then slowly cooling at a cooling rate of 10 °C/s in the third stage.

[0083] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 10

[0084] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 11 seconds by using a solution containing 1.5 wt% of caustic soda and having a temperature of 85 °C; an electrolytic degreasing treatment was performed on the steel plate for 7 seconds by using an electrolyte containing 2.5 wt% of caustic soda and having a temperature of 80 °C; and the electrolytic-degreased steel plate was annealed for 70 seconds at a temperature of 820 °C.

[0085] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 10 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0086] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 10, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0087] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 20 °C/s in the first stage, rapidly cooling at a cooling rate of 100 °C/s in the second stage, and then slowly cooling at a cooling rate of 10 °C/s in the third stage.

[0088] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 11

[0089] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 10 seconds by using a solution containing 1.5 wt% of caustic soda and having a temperature of 90 °C; an electrolytic degreasing treatment was performed on the steel plate for 8 seconds by using an electrolyte containing 2.5 wt% of caustic soda and having a temperature of 85 °C; and the electrolytic-degreased steel plate was annealed for 70 seconds at a temperature of 820 °C.

[0090] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 11 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0091] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 11, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0092] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 10 °C/s in the first stage, rapidly cooling at a cooling rate of 50 °C/s in the second stage, and then slowly cooling at a cooling rate of 5 °C/s in the third stage.

[0093] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 12

[0094] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 13 seconds by using a solution containing 2 wt% of caustic soda and having a temperature of 70 °C; an electrolytic degreasing treatment was performed on the steel plate for 6 seconds by using an electrolyte containing 3 wt% of caustic soda and having a temperature of 70 °C; and the electrolytic-degreased steel plate was annealed for 70 seconds at a temperature of 820 °C.

[0095] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 12 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0096] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 12, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0097] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 10 °C/s in the first stage, rapidly cooling at a cooling rate of 50 °C/s in the second stage, and then slowly cooling at a cooling rate of 5 °C/s in the third stage.

[0098] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 13

[0099] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 11 seconds by using a solution containing 2 wt% of caustic soda and having a temperature of 80 °C; an electrolytic degreasing treatment was performed on the steel plate for 7 seconds by using an electrolyte containing 3 wt% of caustic soda and having a temperature of 75 °C; and the electrolytic-degreased steel plate was annealed for 70 seconds at a temperature of 820 °C.

[0100] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 13 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0101] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 13, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0102] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 10 °C/s in the first stage, rapidly cooling at a cooling rate of 50 °C/s in the second stage, and then slowly cooling at a cooling rate of 5 °C/s in the third stage.

[0103] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Example 14

[0104] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 10 seconds by using a solution containing 2 wt% of caustic soda and having a temperature of 85 °C; an electrolytic degreasing treatment was performed on the steel plate for 8 seconds by using an electrolyte containing 3 wt% of caustic soda and having a temperature of 80 °C; and the electrolytic-degreased steel plate was annealed for 70 seconds at a temperature of 820 °C.

[0105] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Example 14 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0106] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Example 14, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0107] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 10 °C/s in the first stage, rapidly cooling at a cooling rate of 50 °C/s in the second stage, and then slowly cooling at a cooling rate of 5 °C/s in the third stage.

[0108] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Comparative Examples 1-5

[0109] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 15 seconds by using a solution containing 2 wt% of caustic soda and having a temperature of 90 °C; an electrolytic degreasing treatment was performed on the steel plate for 8 seconds by using an electrolyte containing 2 wt% of caustic soda and having a temperature of 90 °C; and the electrolytic-degreased steel plate was annealed for 70 seconds at a temperature of 820 °C.

[0110] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in each of Comparative Examples 1-5 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0111] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In each of Comparative Examples 1-5, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0112] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 20 °C/s in the first stage, rapidly cooling at a cooling rate of 100 °C/s in the second stage, and then slowly cooling at a cooling rate of 10 °C/s in the third stage.

[0113] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

Comparative Example 6

[0114] First, the steel plate was pretreated as follows: a chemical degreasing treatment was performed on a cold-rolled steel plate for 15 seconds by using a solution containing 2 wt% of caustic soda and having a temperature of 90 °C; an electrolytic degreasing treatment was performed on the steel plate for 8 seconds by using an electrolyte containing

2 wt% of caustic soda and having a temperature of 90 °C; and the electrolytic-degreased steel plate was annealed for 70 seconds at a temperature of 820 °C.

[0115] Next, the pretreated steel plate was dipped in a zinc-aluminum-magnesium bath including chemical components having contents shown in Comparative Example 6 in Table 1 below to form bath layers on the front and back surfaces of the steel plate.

[0116] Then, the thickness of the bath layers of the hot-dipped steel plate was controlled by an air knife. In Comparative Example 6, the mass of the bath layer on a single side is each 70 g/m^2 (the thickness corresponding thereto is 10 μm).

[0117] Next, the steel plate was post-dipping cooling treated. In the cooling treatment, the specific process is: cooling at a cooling rate of 10 °C/s in the first stage, rapidly cooling at a cooling rate of 10 °C/s in the second stage, and then slowly cooling at a cooling rate of 5 °C/s in the third stage.

[0118] Then, the skin-passing treatment, the tension leveling treatment, the passivation treatment and the drying treatment were performed on the steel plate, subsequently.

[Table 1]

Number	Composition of Coating (wt. %)							Weight of Coating (g/m^2, single side)
	Al	Mg	La+Ce	Cu	Cr	Ni	Zn	
Example 1	2.0	1.5	0.05	0.01	-	-	balance	70
Example 2	2.0	1.5	0.05	0.04	-	-	balance	30
Example 3	2.0	1.5	0.05	0.04	-	-	balance	70
Example 4	2.0	1.5	0.05	-	0.04	-	balance	300
Example 5	2.0	1.5	0.05	-	0.04	-	balance	70
Example 6	2.0	1.5	0.05	-	-	0.04	balance	70
Example 7	2.0	1.5	0.01	-	-	0.04	balance	70
Example 8	2.0	1.5	0.08	-	-	0.04	balance	70
Example 9	2.0	1.5	0.05	0.04	0.04	-	balance	70
Example 10	2.0	1.5	0.05	0.04	-	0.04	balance	70
Example 11	2.0	1.5	0.05	-	0.04	0.04	balance	70
Example 12	2.0	1.5	0.05	0.02	0.02	0.02	balance	70
Example 13	1.5	1.2	0.05	0.04			balance	70
Example 14	2.3	1.8	0.05	-	0.04	-	balance	70
Comparative Example 1	0.2	-	-	-	-	-	balance	70
Comparative Example 2	2.0	1.5	-	0.04	0.04	-	balance	70
Comparative Example 3	2.0	1.5	La: 0.05	0.04	0.04	-	balance	70
Comparative Example 4	8.0	2.5	-	-	-	-	balance	70
Comparative Example 5	8.0	2.5	0.05	0.04	0.04		balance	70
Comparative Example 6	2.0	1.5	0.05	0.04	0.04	-	balance	70

Evaluation Examples

[0119] A neutral salt spray test and a coating formability test (0T bending test) were performed on the above-described steel plates including the hot-dip coatings obtained in Examples 1 to 14 and Comparative Examples 1 to 6, respectively. The properties of the steel plates including the hot-dip coatings were thus evaluated, and the results are shown in Tables 2 and 3 below. The neutral salt spray test was performed in accordance with Chinese Standard GB/T10125-2012, through which, the time at which 5% red rust on the steel plate including the hot-dip coating appears was measured.

[Table 2]

Number	Time (h) at which 5% red rust appears on the coated steel plate, in the neutral salt spray test
Example 1	1720
Example 2	750
Example 3	1800
Example 4	3310
Example 5	1820
Example 6	1770
Example 7	1700
Example 8	1850
Example 9	1980
Example 10	1840
Example 11	1860
Example 12	1920
Example 13	1690
Example 14	1830
Comparative Example 1	210
Comparative Example 2	1510
Comparative Example 3	1550
Comparative Example 4	2000
Comparative Example 5	2050
Comparative Example 6	1610

[0120] It can be seen from Table 2 that the times, at which 5% red rust on the steel plates including the hot-dip coatings of Examples 1-14 appears, are much longer than that of Comparative Example 1 (coating composition: GI). As for the steel plates of Comparative Example 1 and Examples having the same coating weight, the times at which 5% red rust appears on the steel plates of Examples are more than 8.05 times longer than that of Comparative Example 1. The steel plate of Example 2 has only a coating weight of 30 g/m^2 on one side, and in this case, the time at which 5% red rust appears on the coated steel plate is approximately 3.6 times longer than that of Comparative Example 1 (coating weight on one side: 70 g/m^2). In Examples 2-14, the times, at which 5% red rust appears on the coated steel plates with Cu, Cr, and Ni elements added, are increased compared with that without Cu, Cr, and Ni elements. Therefore, as can be seen from Table 2, the corrosion resistance of the steel plate including the hot-dip coating may be improved by adding La and Ce and a small amount of Cu, Cr and/or Ni to the Zn-Al-Mg-RE composition. Comparative Examples 2 and 3 show the case where neither La nor Ce is included in the coating and the case where only La is included in the coating, respectively. From the results shown in Table 2, it can be seen that the coating with La and Ce added in a mass ratio of 2:1 may have a better corrosion resistance. In Comparative Examples 4 and 5, the contents and mass ratio of Al and Mg in the hot-dip coatings do not meet the above numerical ranges, and the contents of Al and Mg in the hot-dip coatings of Examples 1 to 14 are lower than that of Comparative Examples 4 and 5. As can be seen from Table 2, by adding elements such as RE, Cu, Cr, and/or Ni, the times at which 5% red rust appears on the coated steel plates of Examples 1 to 14 are close to that of Comparative Examples 4 and 5. This means that the hot-dip coating according to the present invention can provide the same corrosion resistance as the coating having higher Al content.

[Table 3]

Number	Surface quality of coating	0T Bending Test Results
Example 1	○	○
Example 2	○	○

(continued)

Number	Surface quality of coating	0T Bending Test Results
Example 3	○	○
Example 4	○	○
Example 5	○	○
Example 6	○	○
Example 7	○	○
Example 8	○	○
Example 9	○	○
Example 10	○	○
Example 11	○	○
Example 12	○	○
Example 13	○	○
Example 14	○	○
Comparative Example 1	○	○
Comparative Example 2	○	○
Comparative Example 3	○	○
Comparative Example 4	○	X
Comparative Example 5	○	X
Comparative Example 6	X	○
Note: ◦ denotes that the surface quality is good; X denotes that the surface quality is poor and black spot defects exist on the surface of the steel plate.		

[0121] In 0T bending test, ◦ denotes that the coating has neither crack nor delamination in the 0T bending (i.e., the surface quality is qualified), while X denotes that the coating has crack or delamination in the 0T bending (the surface quality is unqualified). As can be seen from Table 3, after performing the 0T bending test, the zinc-aluminum-magnesium-coated steel plates of Comparative Examples 4 and 5 having higher Al contents may have crack in the coatings. In addition, although Comparative Example 6 and Example 9 have the same coating composition, the coating surface quality of the zinc-aluminum-magnesium-coated steel plate of Comparative Example 6 is poor and black spot defects appear because different cooling processes are used in Comparative Example 6 and Example 9. As can be seen from the above table, the steel plates including the hot-dip coatings according to the present invention all exhibit excellent surface quality and improved formability.

[0122] Hereinafter, the above-mentioned experimental results will be further described with reference to FIGS. 1 to 4.

[0123] FIG. 1 is a diagram illustrating a surface topography of a steel plate including a zinc-aluminum-magnesium coating according to an exemplary embodiment of the inventive concept, FIG. 2 is a diagram illustrating a cross-sectional topography of a steel plate including a zinc-aluminum-magnesium coating according to an exemplary embodiment of the inventive concept, FIG. 3 is a diagram illustrating a cross-sectional topography of a steel plate including a zinc-aluminum-magnesium coating after 0T bending test according to an exemplary embodiment of the inventive concept, and FIG. 4 is a diagram illustrating a cross-sectional topography of a steel plate including a zinc-aluminum-magnesium coating after 0T bending test of Comparative Example 5.

[0124] It can be seen from FIG. 1 that the steel plate including the hot-dip coating according to the present invention has an excellent surface topography with few or no surface defects on its surface. In addition, it can be seen from FIG. 2 that the steel plate including the hot-dip coating according to the present invention includes a zinc-rich phase and a eutectic structure in the cross section thereof. In addition, it can be seen from FIG. 3 that the steel plate including the hot-dip coating according to the present invention does not have crack in the coating after the 0T bending test, but it can be seen from FIG. 4 that the steel plate including the zinc-aluminum-magnesium coating of Comparative Example 5 shows crack in the coating after the 0T bending test (as shown in area A in Fig. 4).

[0125] The zinc-aluminum-magnesium coating and the steel plate including the same according to the above-mentioned embodiment(s) of the present invention may avoid the increase in brittleness and the decrease in formability due to the high Al content and solve the problem of black spot defects on the surface of the coated steel plate, while ensuring the corrosion resistance of the steel component including the zinc-aluminum-magnesium coating.

[0126] Therefore, the scope of the present invention is defined by the appended claims.

Claims

1. A method for manufacturing a steel plate including a zinc-aluminum-magnesium coating, the method comprises:

   pretreating a cold-rolled steel plate;
   dipping the pretreated steel plate into a bath containing zinc, aluminum, and magnesium as main components for a hot-dipping treatment so that at least one of two surfaces of the steel plate is coated with the bath to form a bath layer;
   controlling a thickness of the bath layer on the at least one surface of the steel plate by using an air knife;
   cooling the steel plate coated with the bath layer, wherein the cooling comprises: a first stage, cooling at a cooling rate of 10~20 °C/s; a second stage, rapidly cooling at a cooling rate of 30~100 °C/s; and a third stage, slowly cooling at a cooling rate of 5~10 °C/s;
   performing a skin-passing treatment on the cooled steel plate by using a skin-pass mill;
   performing a tension leveling treatment on the skin-passed steel plate by using a tension leveler;
   performing a passivation treatment on the tension-leveled steel plate by using a passivation coating machine; and
   performing a drying treatment on the passivated steel plate to obtain the steel plate including the zinc-aluminum-magnesium coating;
   wherein the bath comprises following components in percentage by mass: 1.5~2.3% of Al, 1.2~1.8% of Mg, 0.01~0.08% of La and Ce in total, 0.01-0.08% of at least one of Cu, Cr, and Ni in total, and a balance of Zn and inevitable impurities, with a mass ratio of Al to Mg being 1.2~1.4, and a mass ratio of La to Ce being 2:1; and
   wherein the controlling of the thickness of the bath layer comprises: controlling a mass of the bath layer on the at least one surface of the steel plate to be 30~300 g/m^2, and controlling the thickness thereof to be 4~43 μm.

2. The method of claim 1, wherein the hot-dipping treatment is performed for 2~6 seconds.

3. The method of claim 1, wherein the pretreating comprises:

   placing the cold-rolled steel plate in a solution tank containing a solution therein to perform a chemical degreasing treatment on the cold-rolled steel plate for a degreasing time of 10~15 seconds, by using the solution containing 1~2 wt% of caustic soda and having a solution temperature of 70~90 °C;
   placing the chemically-degreased steel plate in an electrolytic cell containing an electrolyte therein to perform an electrolytic degreasing treatment on the steel plate for a degreasing time of 4~8 seconds, by using the electrolyte containing 2~3 wt% of caustic soda and having an electrolyte temperature of 70~90 °C; and
   heat treating the electrolytic-degreased steel plate, the heat treating including: annealing the electrolytic-degreased steel plate at an annealing temperature of 680~850 °C for an annealing time of 30~90 seconds.

4. The method of claim 1, wherein the passivation treatment is performed in a passivation amount of 0.02~1.0 g/m^2.

5. A steel plate including a zinc-aluminum-magnesium coating, the zinc-aluminum-magnesium coating being formed on at least one surface of the steel plate, wherein the zinc-aluminum-magnesium coating comprises following components in percentage by mass: 1.5~2.3% of Al, 1.2~1.8% of Mg, 0.01~0.08% of La and Ce in total, 0.01~0.08% of at least one of Cu, Cr, and Ni in total, and a balance of Zn and inevitable impurities, with a mass ratio of Al to Mg being 1.2~1.4, and a mass ratio of La to Ce being 2:1;
   wherein the zinc-aluminum-magnesium coating formed on the at least one surface of the steel plate has a thickness of 4~43 μm.

6. The steel plate of claim 5, wherein the mass percentage of Al is 1.5~2.0%.

Patentansprüche

1. Verfahren zum Herstellen einer Stahlplatte mit einer Zink-Aluminium-Magnesium-Beschichtung, wobei das Verfah-

ren die Schritte aufweist:

Vorbehandeln einer kaltgewalzten Stahlplatte;
Eintauchen der vorbehandelten Stahlplatte in ein Bad, das Zink, Aluminium und Magnesium als Hauptkomponenten enthält, für eine Schmelztauchbehandlung, so dass mindestens eine von zwei Oberflächen der Stahlplatte mit dem Bad beschichtet wird, um eine Badschicht zu bilden;
Steuern einer Dicke der Badschicht auf der mindestens einen Oberfläche der Stahlplatte unter Verwendung einer Luftrakel;
Kühlen der mit der Badschicht beschichteten Stahlplatte, wobei das Kühlen aufweist: eine erste Stufe zum Kühlen mit einer Kühlgeschwindigkeit von 10 ~ 20°C/s; eine zweite Stufe zum schnellen Kühlen mit einer Kühlgeschwindigkeit von 30 ~ 100°C/s; und eine dritte Stufe zum langsamen Kühlen mit einer Kühlgeschwindigkeit von 5 ~ 10°C/s;
Ausführen einer Dressierbehandlung bezüglich der gekühlten Stahlplatte unter Verwendung eines Dressierwalzwerks;
Ausführen einer Streckrichtbehandlung bezüglich der dressierten Stahlplatte unter Verwendung einer Streckrichteinrichtung;
Ausführen einer Passivierungsbehandlung bezüglich der streckgerichteten Stahlplatte unter Verwendung einer Passivierungsbeschichtungsmaschine; und
Ausführen einer Trocknungsbehandlung bezüglich der passivierten Stahlplatte, um die Stahlplatte zu erhalten, die die Zink-Aluminium-Magnesium-Beschichtung aufweist,
wobei das Bad die folgenden Komponenten in Masseprozent enthält: 1,5 ~ 2,3% Al, 1,2 ~ 1,8% Mg, 0,01 ~ 0,08% La und Ce insgesamt, 0,01 ~ 0,08% mindestens eines Elements unter Cu, Cr und Ni insgesamt und als Rest Zn und unvermeidbare Verunreinigungen, wobei das Massenverhältnis von Al zu Mg 1,2 ~ 1,4 und das Massenverhältnis von La zu Ce 2:1 beträgt, und
wobei das Steuern der Dicke der Badschicht aufweist: Steuern einer Masse der Badschicht auf der mindestens einen Oberfläche der Stahlplatte auf 30 ~ 300 g/m^2 und Steuern ihrer Dicke auf 4 ~ 43 μm.

2. Verfahren nach Anspruch 1, wobei die Schmelztauchbehandlung für 2 ~ 6 Sekunden ausgeführt wird.

3. Verfahren nach Anspruch 1, wobei das Vorbehandeln aufweist:

Einbringen der kaltgewalzten Stahlplatte in einen Lösungstank, der eine Lösung enthält, um eine chemische Entfettungsbehandlung bezüglich der kaltgewalzten Stahlplatte für eine Entfettungszeit von 10 ~ 15 Sekunden unter Verwendung der Lösung auszuführen, die 1 ~ 2 Gew.-% Natronlauge enthält und eine Lösungstemperatur von 70 ~ 90°C aufweist;
Anordnen der chemisch entfetteten Stahlplatte in einer elektrolytischen Zelle, die einen Elektrolyten enthält, zum Ausführen einer elektrolytischen Entfettungsbehandlung bezüglich der Stahlplatte für eine Entfettungszeit von 4 ~ 8 Sekunden, unter Verwendung des Elektrolyten, der 2 ~ 3 Gew.-% Natronlauge enthält und eine Elektrolyttemperatur von 70 ~ 90°C aufweist; und
Wärmebehandeln der elektrolytisch entfetteten Stahlplatte, wobei die Wärmebehandlung das Glühen der elektrolytisch entfetteten Stahlplatte bei einer Glühtemperatur von 680 ~ 850°C für eine Glühzeit von 30 ~ 90 Sekunden aufweist.

4. Verfahren nach Anspruch 1, wobei die Passivierungsbehandlung mit einer Passivierungsmenge von 0,02 ~ 1,0 g/m^2 ausgeführt wird.

5. Stahlplatte mit einer Zink-Aluminium-Magnesium-Beschichtung, wobei die Zink-Aluminium-Magnesium-Beschichtung auf mindestens einer Oberfläche der Stahlplatte ausgebildet ist, wobei die Zink-Aluminium-Magnesium-Beschichtung die folgenden Komponenten in Masseprozent enthält: 1,5 ~ 2,3% Al, 1,2 ~ 1,8% Mg, 0,01 ~ 0,08% La und Ce insgesamt, 0,01 ~ 0,08% mindestens eines der Elemente Cu, Cr und Ni insgesamt und einen Rest aus Zn und unvermeidbaren Verunreinigungen, wobei das Massenverhältnis von Al zu Mg 1,2 ~ 1,4 und das Massenverhältnis von La zu Ce 2:1 beträgt,
wobei die auf der mindestens einen Oberfläche der Stahlplatte ausgebildete Zink-Aluminium-Magnesium-Beschichtung eine Dicke von 4 ~ 43 μm hat.

6. Stahlplatte nach Anspruch 5, wobei der Massenanteil von Al 1,5 ~ 2,0% beträgt.

Revendications

1. Procédé de fabrication d'une tôle d'acier incluant un revêtement de zinc-aluminium-magnésium, le procédé comprenant :

   le prétraitement d'une tôle d'acier laminée à froid ;
   le trempage de la tôle d'acier prétraitée dans un bain contenant du zinc, de l'aluminium et du magnésium en tant que constituants principaux pour un traitement de trempage à chaud de sorte qu'au moins une parmi deux surfaces de la tôle d'acier est revêtue par le bain pour former une couche de bain ;
   la régulation d'une épaisseur de la couche de bain sur l'au moins une surface de la tôle d'acier en utilisant une lame d'air ;
   le refroidissement de la tôle d'acier revêtue de la couche de bain, dans lequel le refroidissement comprend : un premier stade, refroidissement à une vitesse de refroidissement de 10~20 °C/s ; un deuxième stade, refroidissement rapide à une vitesse de refroidissement de 30~100 °C/s ; et un troisième stade, refroidissement lent à une vitesse de refroidissement de 5~10 °C/s ;
   la réalisation d'un traitement au skin-pass sur la tôle d'acier refroidie en utilisant un laminoir de type skin-pass ;
   la réalisation d'un traitement de planage par étirage sur la tôle d'acier traitée au skin-pass en utilisant d'une machine de planage par étirage ;
   la réalisation d'un traitement de passivation sur la tôle d'acier traitée par planage par étirage en utilisant une machine de revêtement de passivation ; et
   la réalisation d'un traitement de séchage sur la tôle d'acier passivée pour obtenir la tôle d'acier incluant le revêtement de zinc-aluminium-magnésium ;
   dans lequel le bain comprend les constituants suivants en pourcentages massiques : 1,5~2,3 % d'Al, 1,2~1,8 % de Mg, 0,01~0,08 % de La et Ce au total, 0,01~0,08 % d'au moins un parmi Cu, Cr et Ni au total, et une quantité restante de Zn et des impuretés inévitables, avec un rapport massique d'Al à Mg de 1,2~1,4, et un rapport massique de La à Ce de 2:1 ; et
   dans lequel la régulation de l'épaisseur de la couche de bain comprend : la régulation d'une masse de la couche de bain sur l'au moins une surface de la tôle d'acier de sorte à ce qu'elle soit de 30~300 g/m^2, et la régulation de l'épaisseur de celle-ci de sorte ce qu'elle soit de 4~43 μm.

2. Procédé selon la revendication 1, dans lequel le traitement par trempage à chaud est réalisé pendant 2~6 secondes.

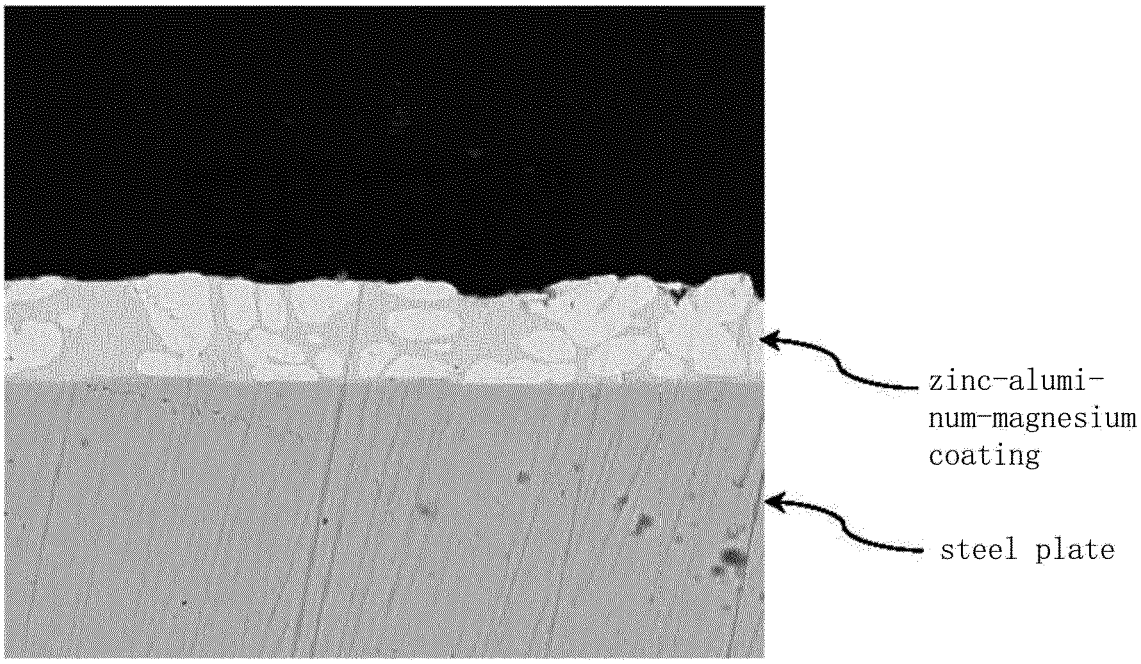
3. Procédé selon la revendication 1, dans lequel le prétraitement comprend :

   le placement de la tôle d'acier laminée à froid dans une cuve de solution contenant une solution à l'intérieur pour réaliser un traitement de dégraissage chimique sur la tôle d'acier laminée à froid pendant une durée de dégraissage de 10~15 secondes, en utilisant la solution contenant 1~2 % en masse de soude caustique et ayant une température de solution de 70~90 °C ;
   le placement de la tôle d'acier dégraissée chimiquement dans une cellule électrolytique contenant une solution à l'intérieur pour réaliser un traitement de dégraissage électrolytique sur la tôle d'acier pendant une durée de dégraissage de 4~8 secondes, en utilisant l'électrolyte contenant 2~3 % en masse de soude caustique et ayant une température d'électrolyte de 70~90 °C ; et
   le traitement thermique de la tôle d'acier dégraissée par électrolyse, le traitement thermique incluant : le recuit de la tôle d'acier dégraissée par électrolyse à une température de recuit de 680~850 °C pendant une durée de recuit de 30~90 secondes.

4. Procédé selon la revendication 1, dans lequel le traitement de passivation est réalisé à une teneur de passivation de 0,2~1,0 g/m^2.

5. Tôle d'acier incluant un revêtement de zinc-aluminium-magnésium, le revêtement de zinc-aluminium-magnésium étant formé sur au moins une surface de la tôle d'acier, dans laquelle le revêtement de zinc-aluminium-magnésium comprend les constituants suivants en pourcentages massiques : 1,5~2,3 % d'Al, 1,2~1,8 % de Mg, 0,01~0,08 % de La et Ce au total, 0,01~0,08 % d'au moins un parmi Cu, Cr et Ni au total, et une quantité restante de Zn et des impuretés inévitables, avec un rapport massique d'Al à Mg de 1,2~1,4, et un rapport massique de La à Ce de 2:1 ; dans laquelle le revêtement de zinc-aluminium-magnésium formé sur l'au moins une surface de la tôle d'acier a une épaisseur de 4~43 μm.

6. Tôle d'acier selon la revendication 5, dans laquelle le pourcentage massique d'Al est de 1,5~2,0 %.


zinc-aluminum-magnesium coating
steel plate

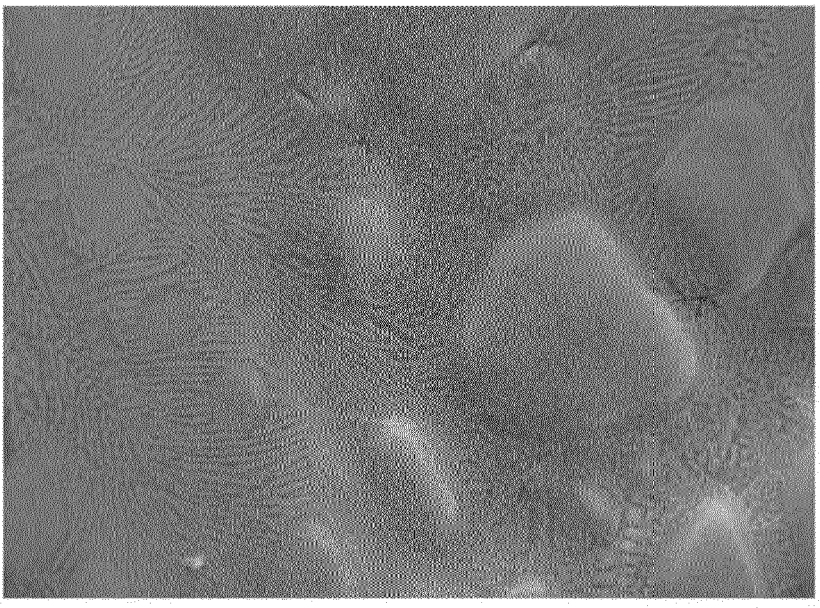


FIG. 1

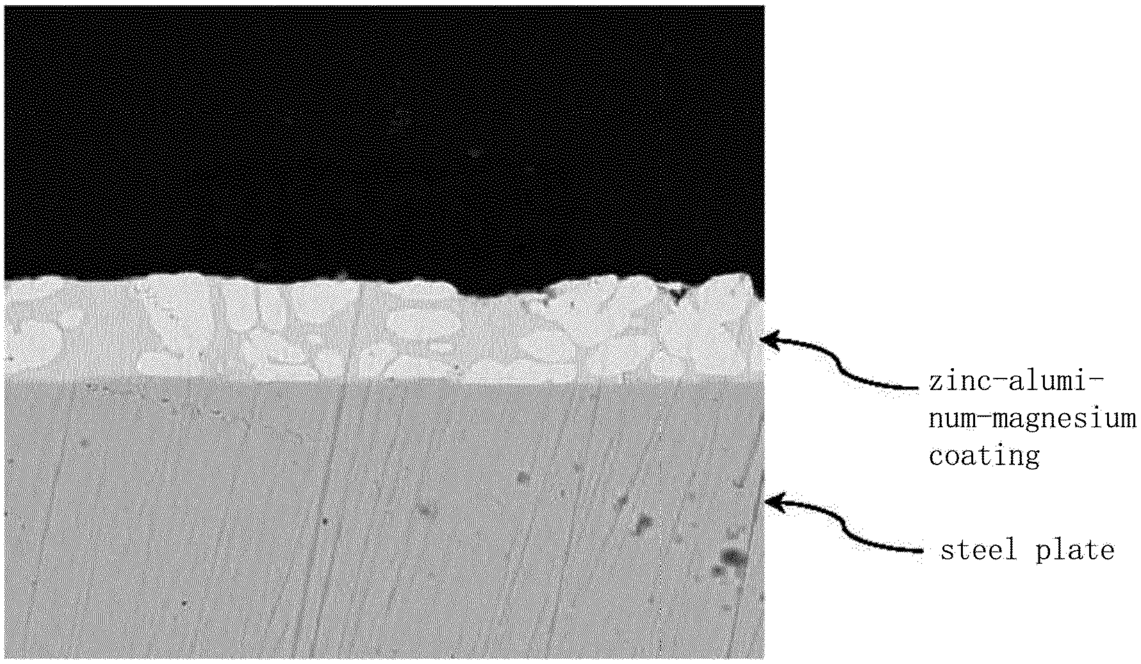


FIG. 2

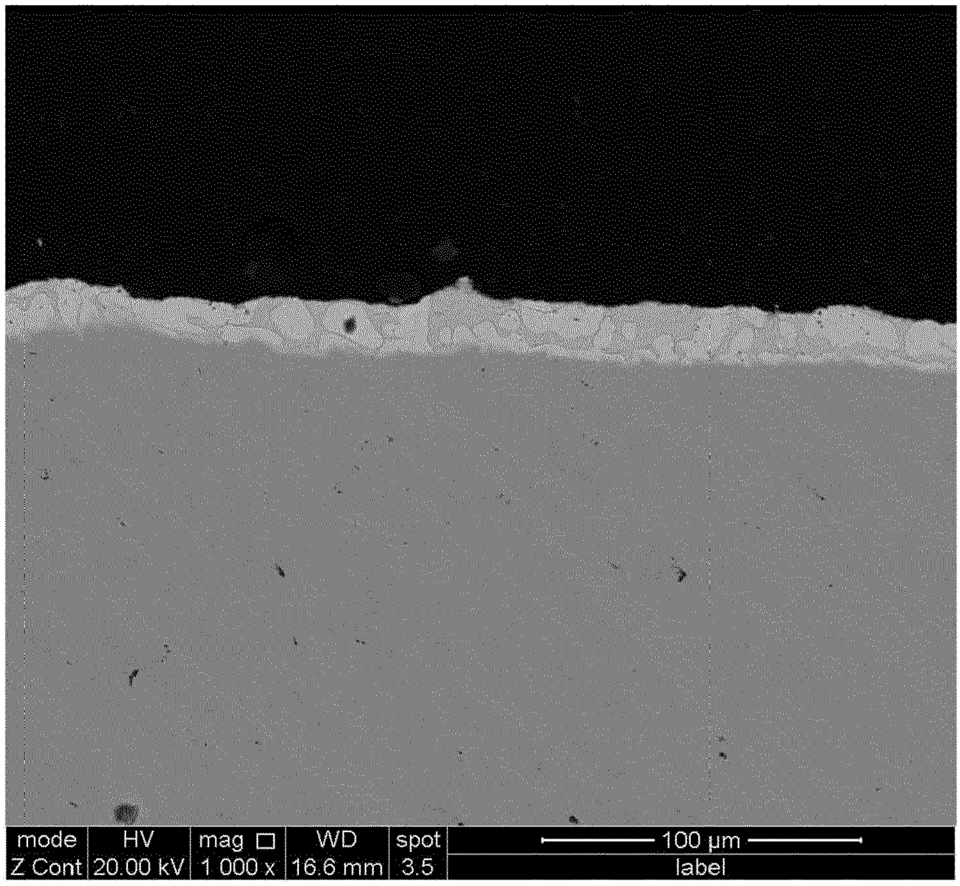


FIG. 3

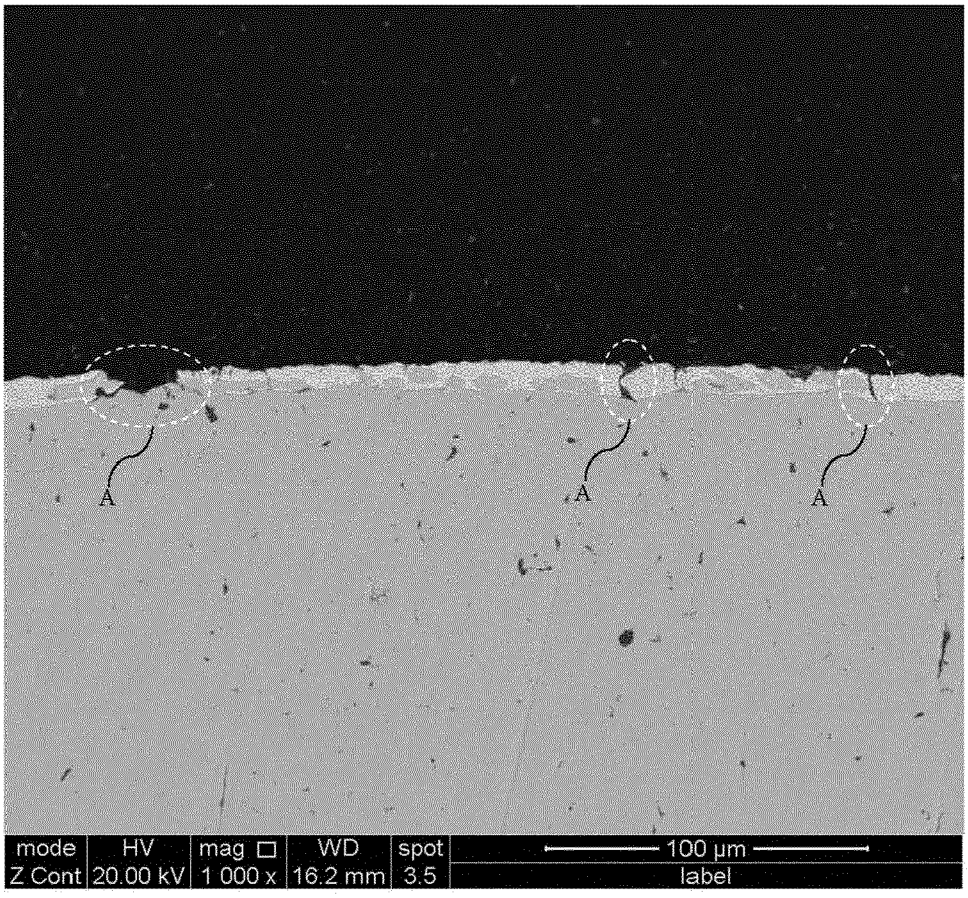

A
A
A
mode
Z Cont
HV
20.00 kV
mag ☐
1 000 x
WD
16.2 mm
spot
3.5
100 μm
label

FIG. 4

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- CN 109536864 A **[0005]**
- EP 3575434 A1 **[0006]**
- CN 102268623 B **[0006]**
- CN 103173707 A **[0006]**
- US 2017233859 A1 **[0006]**