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(54) STEEL PLATE COMPRISING ZINC-ALUMINUM-MAGNESIUM COATING AND MANUFACTURING METHOD THEREFOR

(57) A steel plate comprising a zinc-aluminum-magnesium coating and a manufacturing method therefor. The method may comprise: pretreating a cold-rolled steel plate; immersing the pretreated steel plate in a plating solution containing zinc, aluminum and magnesium as main components for immersion plating treatment, so that the plating solution is coated on at least one of the two surfaces of the steel plate to form a plating solution layer; using an air knife to control the thickness of the plating solution layer on the at least one surface of the

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steel plate; and cooling the steel plate coated with the plating solution layer. The plating solution may comprise the 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, and 0.01-0.08% of at least one of Cu, Cr and Ni, with the balance being Zn and inevitable impurities, wherein the mass ratio of Al to Mg is 1.2 to 1.4, and the mass ratio of La to Ce is 2:1.

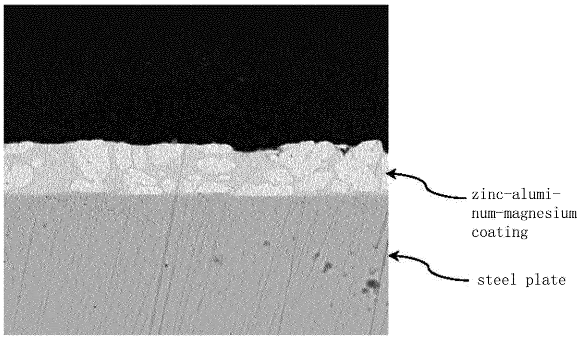


FIG. 2

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.

SUMMARY

TECHNICAL PROBLEM

[0005] An objective of the present invention is to provide a steel plate including a zinc-aluminum-magnesium coating and a manufacturing method thereof.

[0006] 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

[0007] A method for manufacturing a steel plate including a zinc-aluminum-magnesium coating according to the present invention may include: 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.

[0008] In an embodiment according to the present invention, the dipping treatment may be performed for 2~6 seconds.

[0009] In an embodiment according to 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.

[0010] In an embodiment according to 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.

[0011] In an embodiment according to 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.

[0012] In an embodiment according to 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.

[0013] 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.

[0014] An embodiment according to 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.

[0015] In an embodiment according to the present invention, the thickness of the zinc-aluminum-magnesium coating on a single side may be 4~43 μm.

[0016] In an embodiment according to the present invention, the mass percentage of Al may be 1.5~2.0%.

ADVANTAGEOUS EFFECT

[0017] 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

[0018] 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

[0019] 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.

[0020] A zinc-aluminum-magnesium coating may be coated on a surface of a steel component to serve as a corrosion-resistant 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.

[0021] In an embodiment according to the present invention, the zinc-aluminum-magnesium coating may include zinc (Zn), aluminum (Al), magnesium (Mg), lanthanum (La), and cerium (Ce), and may further include 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 an embodiment of the present invention, the zinc-aluminum-magnesium coating may include 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.

[0022] 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%.

[0023] In an embodiment 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 an embodiment according to 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 an embodiment according to the present invention, the zinc-aluminum-magnesium coating may contain 0.01%~0.08 mass% of La and Ce in total, and the mass ratio of La to Ce is 2:1.

[0024] 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. For example, in an embodiment according to the present invention, the zinc-aluminum-magnesium coating may further include 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 may be controlled to 0.01~0.08%.

[0025] 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. However, the embodiment according to the present invention is not limited thereto, and for example, the steel component may also be a steel wire or the like.

[0026] In an embodiment according to the present invention, the steel plate including the zinc-aluminum-magnesium coating is manufactured through the following steps.

[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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.

[0031] 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).

[0032] 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.

[0033] 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).

[0034] 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.

[0035] Through the above method, the steel plate including the zinc-aluminum-magnesium coating according to the present invention is finally obtained.

[0036] The steel plate including the zinc-aluminum-magnesium coating of the present invention will be described below with reference to specific Examples.

Example 1

[0037] 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.

[0038] 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.

[0039] 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).

[0040] 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.

[0041] 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

[0042] 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.

[0043] 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.

[0044] 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).

[0045] 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.

[0046] 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

[0047] 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.

[0048] 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.

[0049] 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).

[0050] 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.

[0051] 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

[0052] 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.

[0053] 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.

[0054] 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).

[0055] 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.

[0056] 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

[0057] 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.

[0058] 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.

[0059] 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).

[0060] 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.

[0061] 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

[0062] 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.

[0063] 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.

[0064] 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).

[0065] 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.

[0066] 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

[0067] 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.

[0068] 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.

[0069] 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).

[0070] 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.

[0071] 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

[0072] 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.

[0073] 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.

[0074] 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).

[0075] 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.

[0076] 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

[0077] 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.

[0078] 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.

[0079] 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).

[0080] 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.

[0081] 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

[0082] 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.

[0083] 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.

[0084] 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).

[0085] 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.

[0086] 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

[0087] 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.

[0088] 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.

[0089] 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).

[0090] 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.

[0091] 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

[0092] 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.

[0093] 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.

[0094] 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).

[0095] 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.

[0096] 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

[0097] 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.

[0098] 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.

[0099] 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).

[0100] 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.

[0101] 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

[0102] 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.

[0103] 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.

[0104] 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).

[0105] 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.

[0106] 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

[0107] 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.

[0108] 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.

[0109] 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).

[0110] 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.

[0111] 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

[0112] 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.

[0113] 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.

[0114] 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).

[0115] 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.

[0116] 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

[0117] 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

(continued)

Number	Time (h) at which 5% red rust appears on the coated steel plate, in the neutral salt spray test
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

[0118] 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	○	o
Example 2	○	○
Example 3	○	○
Example 4	○	○
Example 5	○	○

(continued)

Number	Surface quality of coating	0T Bending Test Results
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.		

[0119] 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.

[0120] Hereinafter, the above-mentioned experimental results will be further described with reference to FIGS. 1 to 4.

[0121] 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.

[0122] 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).

[0123] 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.

[0124] Although the present invention has been specifically shown and described with reference to exemplary embodiments of the present invention, those skilled in the art will understand that various changes in form and detail can be made here without departing from the spirit and scope of the present invention as defined by the claims and their equivalents. The embodiments should be considered only in a descriptive sense and not for limiting purposes. Therefore, the scope of the present invention is not defined by the detailed description of the present invention but by the claims, and all differences within the scope will be interpreted as being included in the present invention.

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 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,
   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.

2. The method of claim 1, wherein the 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 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.

5. The method of claim 1, 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.

6. The method of claim 1, further comprising:

   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.

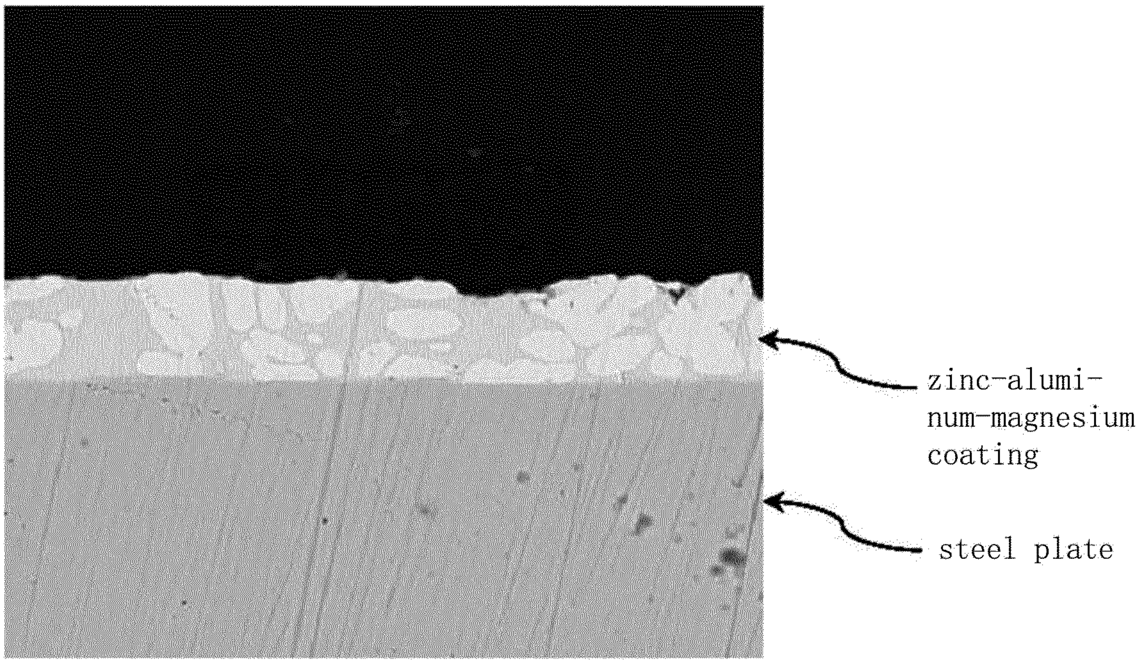
7. The method of claim 6, wherein the passivation treatment is performed in a passivation amount of 0.02~1.0 g/m^2.

8. 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.

9. The steel plate of claim 8, wherein the zinc-aluminum-magnesium coating formed on the at least one surface of the steel plate has a thickness of 4~43 μm.

10. The steel plate of claim 8, wherein the mass percentage of Al is 1.5~2.0%.


zinc-aluminum-magnesium coating
steel plate

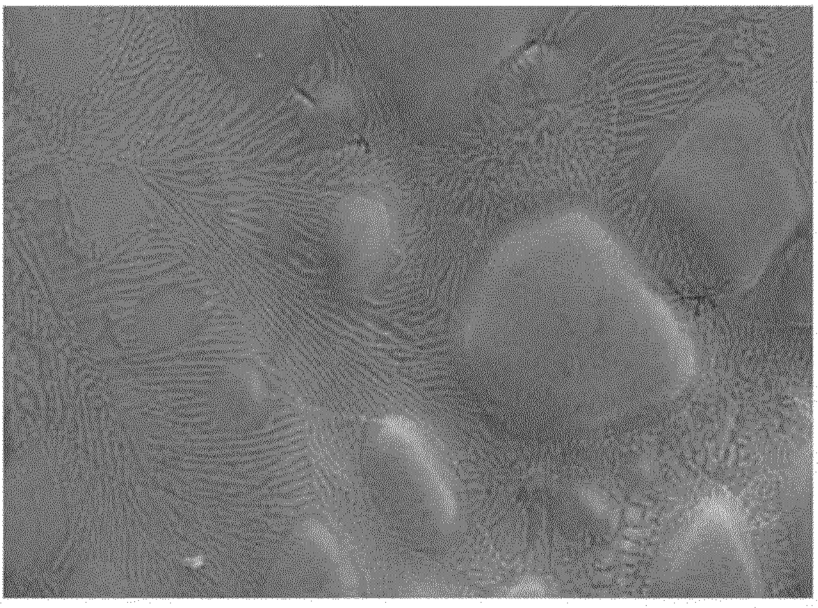


FIG. 1

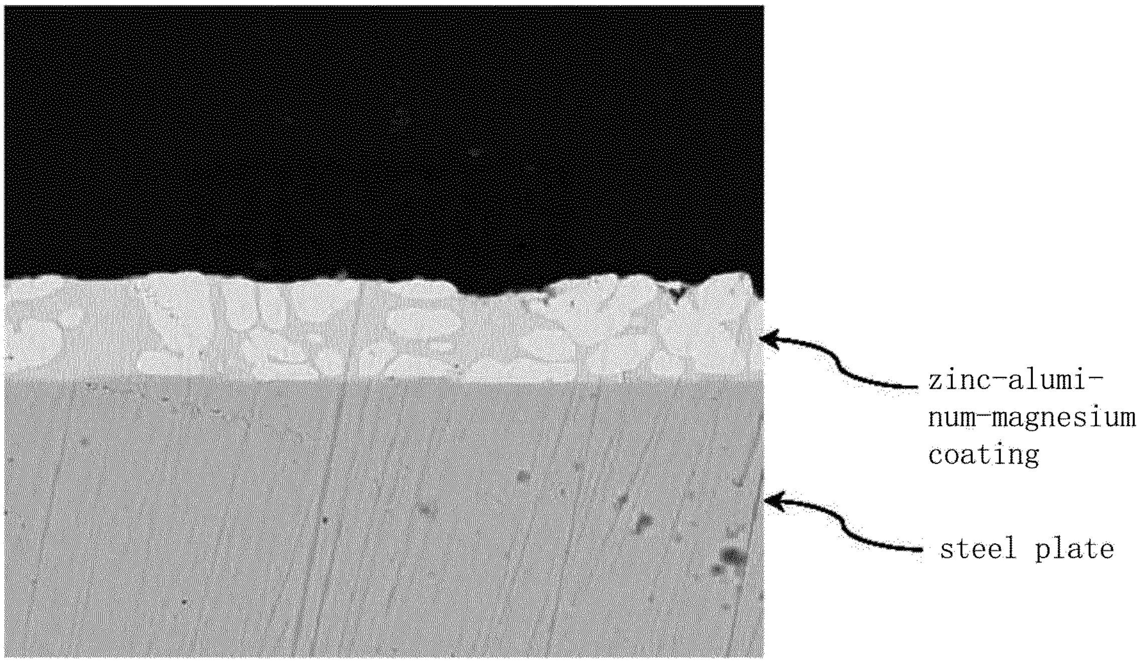


FIG. 2

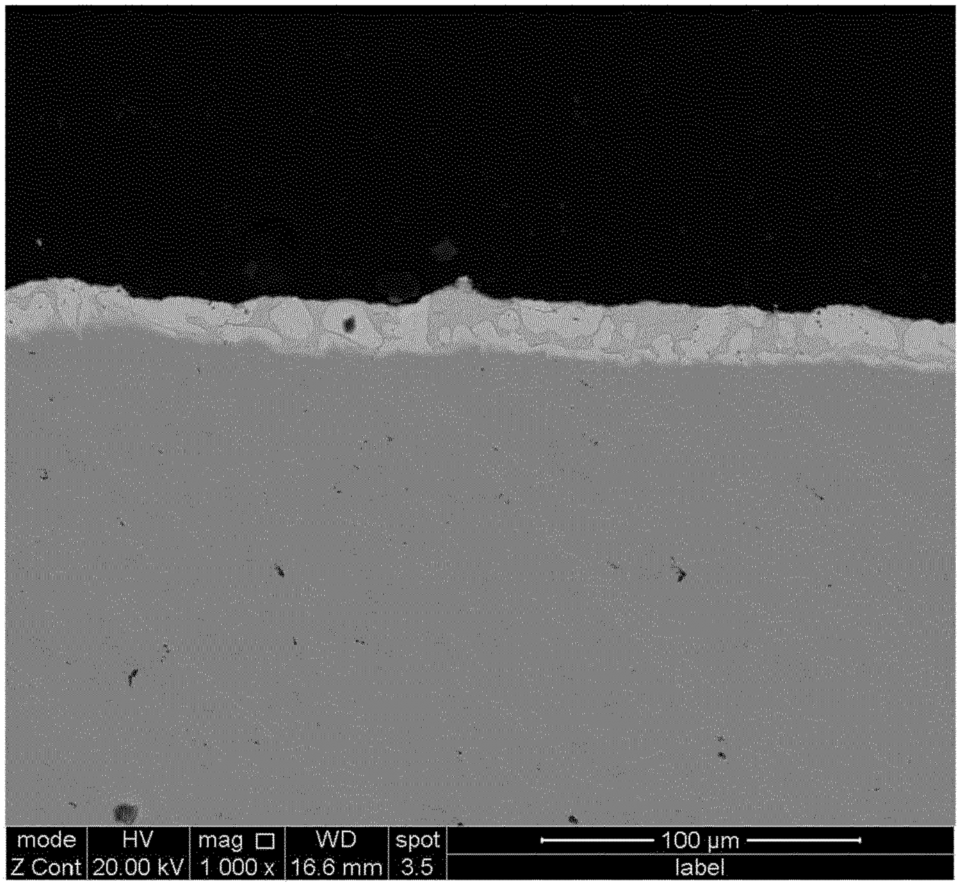


FIG. 3

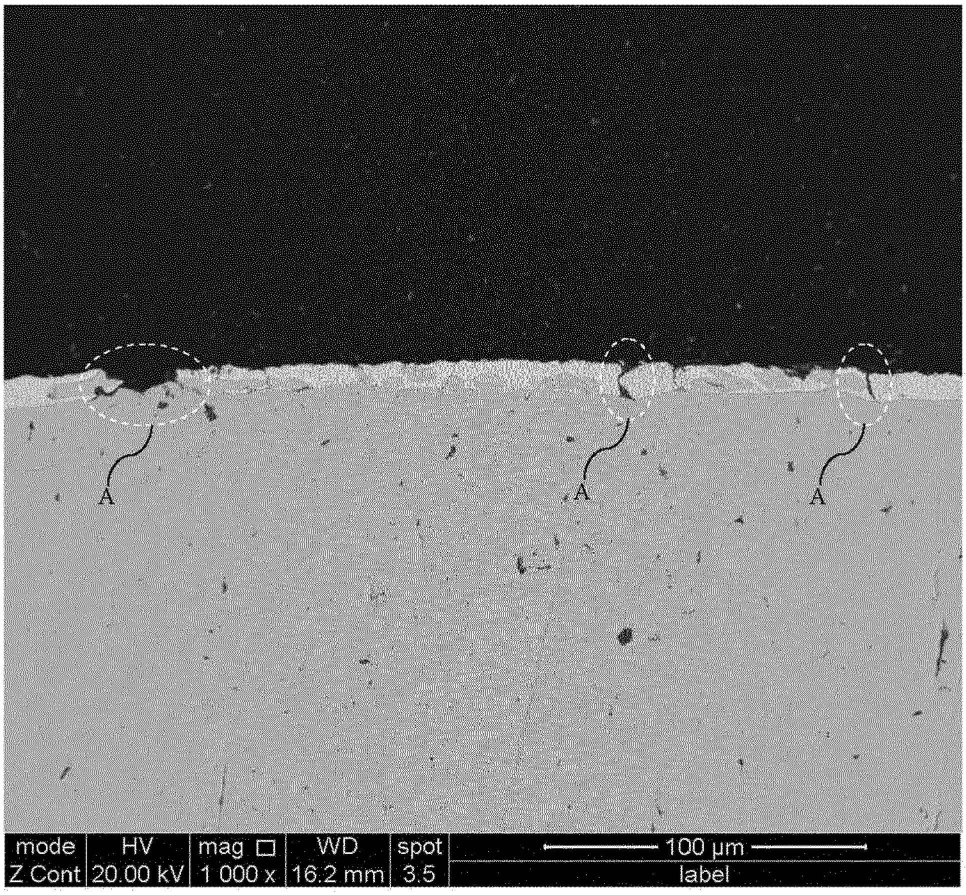

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FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2019/130630

A. CLASSIFICATION OF SUBJECT MATTER

C23C 2/06(2006.01)i; C23C 2/40(2006.01)i; C23C 2/02(2006.01)i; C23C 2/20(2006.01)i; C22C 18/04(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C23C2; C22C18

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI, EPODOC, DWPI, SIPOABS: 镀, 锌, 铝, 镁, 稀土, 镧, 铈, Zn, Al, Mg, RE, La, Ce, plat+, zinc , aluminum , magnesium, rare-earth, lanthanum, cerium

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 109536864 A (HBIS COMPANY LIMITED) 29 March 2019 (2019-03-29) description, paragraphs 0015-0020, table 1, embodiments 1-3	1-10
A	CN 103834890 A (STATE GRID CORPORATION OF CHINA et al.) 04 June 2014 (2014-06-04) entire document	1-10
A	CN 104419867 A (ANGANG STELL CO., LTD.) 18 March 2015 (2015-03-18) entire document	1-10
A	KR 101376381 B1 (DONGBU STEEL CO., LTD.) 20 March 2014 (2014-03-20) entire document	1-10
A	WO 2015028738 A1 (AIR LIQUIDE et al.) 05 March 2015 (2015-03-05) entire document	1-10

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

* Special categories of cited documents:	
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"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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Information on patent family members

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