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(54) **COLD-ROLLED STEEL SHEET, ZN-PLATED STEEL SHEET AND METHODS FOR MANUFACTURING SAME**

(57) The present invention relates to steels that are suitable as automobile exterior materials and, more specifically, to a cold-rolled steel sheet, a ZN-plated

steel sheet obtained by galvanizing the cold-rolled steel sheet, and methods for manufacturing same

EP 4 826 049 A1

Description

Technical Field

5 **[0001]** The present disclosure relates to a steel appropriate as an automotive exterior material, and more particularly, to a cold-rolled steel sheet, a zinc-plated steel sheet obtained by galvanizing the cold-rolled steel sheet, and a method for manufacturing the same.

Background Art

10 **[0002]** Automotive exterior materials, in particular, exterior panel materials, are required to have a baking hardening characteristic at or above a certain level, and a baking hardening phenomenon refers to increasing yield strength, a phenomenon in which yield strength is increased by fixation of carbon and nitrogen in a solid solution state which are activated when painting and baking on dislocation produced during steel pressing. Since a steel having an excellent
 15 baking hardening characteristic is easily formed before plating baking and has a characteristics of improved dent resistance in a final product, it is ideal as an automotive exterior panel material. Also, the automotive exterior panel material is required to have a certain level of room temperature aging resistance so that aging is guaranteed for a certain period of time or longer (Patent Document 1).

[0003] Meanwhile, manufacturers who produce parts for automotive exterior panels such as hoods and doors are applying strict requirements to such parts. One of the requirements relates to painted appearance of the parts to which paint is applied. Exterior panels having significantly good painted appearance are highly evaluated when the panels have a mirror-like surface on which the panels reflect light without distortion, leading to clear reflected images.

[0004] The painted appearance is influenced by the surface of the coated substrate, as well as paint quality, and the surface is formed of in-plane structures having various sizes and scale. When the surface structures are small, they
 25 may be identified as surface roughness, but large structures may be identified as so called surface waviness. Thereamong, it is well known that large surface structures are conducted by passing through painted layers. Thus, the waviness of the coated substrate surface still exist to a certain part on the surface of the exterior paint layer.

[0005] Recently, since automobile manufacturers aim for energy and cost reduction through middle omission during a painting process, the surface waviness of automobiles is becoming increasingly important.

30 **[0006]** That is, the surface waviness may be measured after compression or forming is applied, the surface waviness in a formed part is important, and since a middle process is being omitted as described above, the importance of the surface characteristic of a substrate before coating, that is, a base steel sheet is increasing. That is to say, a manufacturing technology to allow the surface of a base steel sheet which is an initial substrate for manufacturing parts having a painted appearance to have a uniform and fine microstructure is required.

35 **[0007]** (Patent Document 1) Korean Patent Laid-Open Publication No. 10-2017-0012865

Summary of Invention

Technical Problem

40 **[0008]** An aspect of the present disclosure is to provide a zinc-plated steel sheet having excellent distinctness of image as well as a baking hardening characteristic and aging resistance which are generally required physical properties, in providing a steel appropriate as an automotive exterior material, and a method for manufacturing the same.

[0009] Another aspect of the present disclosure is to provide a cold-rolled steel sheet which is a base steel sheet for
 45 obtaining the zinc-plated steel sheet, and a method for manufacturing the same.

[0010] Meanwhile, the object of the present disclosure is not limited to the above description. The object of the present disclosure will be understood from the entire content of the present specification, and a person skilled in the art to which the present disclosure pertains will understand an additional object of the present disclosure without difficulty.

50 **[0011]** According to an aspect of the present disclosure, a cold-rolled steel sheet includes, by weight: 0.0010 to 0.0050% of carbon (C), 0.050% or less (excluding 0%) of silicon (Si), 0.10 to 0.25% of manganese (Mn), 0.010 to 0.035% of phosphorus (P), 0.0100% or less of sulfur (S), 0.0050% or less of nitrogen (N), 0.100% or less (excluding 0%) of aluminum (Al), 0.0010 to 0.0100% of niobium (Nb), 0.0100% or less (excluding 0%) of copper (Cu), a reminder of Fe, and unavoidable impurities.

[0012] In an example embodiment of the present disclosure, the cold-rolled steel sheet may satisfy the following

Relation 1:

[Relation 1]

$$\text{Nb} (12/93) + \text{S} (63/32) + \text{Cu} (32/63) + d/2 \leq 11$$

wherein d is an average crystal grain size (μm) of ferrite in an extreme surface part, and the extreme surface part is an ND surface (rolled surface) at a point within 100 μm in a thickness direction from a surface of the cold-rolled steel sheet.

[0013] In an example embodiment of the present disclosure, a microstructure of the base steel sheet may be ferrite at an area fraction of 95% or more.

[0014] In an example embodiment of the present disclosure, the ferrite may have an average crystal grain size of 20 μm or less.

[0015] According to the present disclosure, there is an effect of providing a base steel sheet (cold-rolled steel sheet) for providing a zinc-plated steel sheet having improved baking hardening characteristic and distinctness of image so as to be appropriate as an automotive exterior material, by limiting an alloy composition and optimizing a relationship between the alloy composition and the microstructure.

[0016] According to another aspect of the present disclosure, a method for manufacturing a cold-rolled steel sheet includes: preparing a steel slab; heating the steel slab to a temperature in a range of 1100 to 1300°C; finish hot rolling the heated steel slab at or above an Ar3 temperature to obtain a hot-rolled steel sheet; winding the hot-rolled steel sheet at a temperature in a range of 600 to 650°C; pickling the wound hot-rolled steel sheet and then cold rolling the steel sheet at a reduction rate of 70 to 83% to obtain a cold-rolled steel sheet; and annealing the cold-rolled steel sheet at a temperature in a range of 760 to 820°C.

[0017] In an example embodiment of the present disclosure, the steel slab may have the alloy composition described above, and the manufactured cold-rolled steel sheet may satisfy Relation 1.

[0018] According to another aspect of the present disclosure, a zinc-plated steel sheet includes: a base steel sheet; and a zinc-based plating layer provided on at least one surface of the base steel sheet.

[0019] In an example embodiment of the present disclosure, the base steel sheet may include, by weight: 0.0010 to 0.0050% of carbon (C), 0.050% or less (excluding 0%) of silicon (Si), 0.10 to 0.25% of manganese (Mn), 0.010 to 0.035% of phosphorus (P), 0.0100% or less of sulfur (S), 0.0050% or less of nitrogen (N), 0.100% or less (excluding 0%) of aluminum (Al), 0.0010 to 0.0100% of niobium (Nb), 0.0100% or less (excluding 0%) of copper (Cu), a reminder of Fe, and unavoidable impurities.

[0020] In an example embodiment of the present disclosure, the base steel sheet may satisfy Relation 1:

[Relation 1]

$$\text{Nb} (12/93) + \text{S} (63/32) + \text{Cu} (32/63) + d/2 \leq 11$$

wherein d is an average crystal grain size (μm) in an extreme surface part, and the extreme surface part is an ND surface (rolled surface) at a point within 100 μm in a thickness direction of the base steel sheet from an interface between the base steel sheet and the zinc-based plating layer.

[0021] According to the present disclosure, there is an effect of providing a zinc-plated steel sheet having improved distinctness of image so as to be appropriate as an automotive exterior material by optimizing an alloy component system. According to an example embodiment of the present disclosure, the zinc-plated steel sheet may have ΔW_{sa} defined by the following Relation 2 of 0.15 μm or less:

ΔW_{sa} = surface waviness of steel sheet after 5% deformation - surface waviness of steel sheet before deformation [Relation 2]

[0022] In an example embodiment of the present disclosure, the zinc-plated steel sheet may have a baking hardening amount of 30 MPa or more in a tensile test after a heat treatment at 170°C for 20 minutes.

[0023] In an example embodiment of the present disclosure, the base steel sheet may be the cold-rolled steel sheet described above.

[0024] In an example embodiment of the present disclosure, the zinc-plated steel sheet may have physical properties of a yield strength of 180 MPa or more, a tensile strength of 300 MPa or more, and an elongation rate of 33% or more.

[0025] According to still another aspect of the present disclosure, a method for manufacturing a zinc-plated steel sheet includes: preparing a steel slab; heating the steel slab to a temperature in a range of 1100 to 1300°C; finish hot rolling the heated steel slab at or above a Ar3 temperature to obtain a hot-rolled steel sheet; winding the hot-rolled steel sheet at a temperature in a range of 600 to 650°C; pickling the wound hot-rolled steel sheet and then cold rolling the steel sheet at a reduction rate of 70 to 83% to obtain a cold-rolled steel sheet; annealing the cold-rolled steel sheet at a temperature in a range of 760 to 820°C; hot galvanizing the annealed cold-rolled steel sheet to obtain a zinc-plated steel sheet; and temper rolling the zinc-plated steel sheet.

[0026] In an example embodiment of the present disclosure, the steel slab may have the same alloy composition as the base steel sheet and also may satisfy Relation 1 described above.

[0027] In an example embodiment of the present disclosure, the temper rolling treatment may be performed with a rolling force of 0.6 to 1.8% using a roll having a roughness (Ra) of 1.0 to 2.2 μm .

[0028] In an example embodiment of the present disclosure, the hot galvanizing may be performed in a zinc-based plating bath at 440 to 480°C.

[0029] In an example embodiment of the present disclosure, the temper rolling treatment may be performed by one or more methods selected from electro discharge texturing (EDT), shot blasting (SBT), and Topocrom Texturing (TCT) working.

Advantageous Effects of Invention

[0030] According to the present disclosure, a zinc-plated steel sheet having excellent baking hardenability and aging resistance which are physical properties required as an automotive exterior material, and a cold-rolled steel sheet appropriate for obtaining the zinc-plated steel sheet may be provided.

[0031] Furthermore, according to the present disclosure, the zinc-plated steel sheet has improved distinctness of image and may be appropriately applied to the parts of an automotive exterior material having a painted appearance.

Best Mode for Invention

[0032] Since uniformity of a substrate (base steel sheet) surface becomes gradually important, in improving baking hardening characteristic and aging resistance of a steel applied as an automotive exterior material, while manufacturing parts having a painted appearance using the steel, the present inventors conducted an in-depth study on a method for achieving the surface uniformity.

[0033] As a result, they recognized that it is important to secure uniform and fine crystal grains on a surface part of the substrate (base steel sheet), and thus, intended to optimize the contents of certain elements of the alloy composition. In particular, according to an aspect of the present disclosure, it was confirmed that a steel having improved distinctness of image so as to be appropriate as an automotive exterior material may be provided, by controlling precipitate formation elements, while having an ultra-low carbon steel as a basic component in order to secure the baking hardening characteristic and the aging resistance, thereby completing the present disclosure.

[0034] Hereinafter, the present disclosure will be described in detail.

[0035] The cold-rolled steel sheet according to an aspect of the present disclosure may include, by weight: 0.0010 to 0.0050% of carbon (C), 0.050% or less (excluding 0%) of silicon (Si), 0.10 to 0.25% of manganese (Mn), 0.010 to 0.035% of phosphorus (P), 0.0100% or less of sulfur (S), 0.0050% or less of nitrogen (N), 0.100% or less (excluding 0%) of aluminum (Al), 0.0010 to 0.0100% of niobium (Nb), and 0.0100% or less (excluding 0%) of copper (Cu).

[0036] Hereinafter, the reasons of limiting the alloy composition of the cold-rolled steel sheet according to an example embodiment of the present disclosure will be described in detail. Meanwhile, unless otherwise particularly stated, the content of each element is by weight and the ratios of the structure are by area.

Carbon (C): 0.0010 to 0.0050%

[0037] Carbon (C) is an intrusive solid solution element, and has a significant influence on formation of steel sheet texture in cold rolling and annealing processes. When a solid solution carbon amount in steel is increased, growth of crystal grains having {111} gamma (γ)-fiber textures favorable for drawing working is suppressed, and growth of crystal grains having {110} and {100} textures is promoted, thereby deteriorating the drawing characteristic of an annealed cold-rolled steel sheet. Thus, C may be included in an amount of 0.0050% or less, and when the content of C is more than 0.0050%, the aging resistance of a steel sheet may be deteriorated. Meanwhile, in terms of securing the baking hardenability of a steel sheet, C may be included in an amount of 0.0010% or more.

[0038] Therefore, according to an example embodiment of the present disclosure, C may be included in an amount of 0.0010 to 0.0050%. According to another example embodiment of the present disclosure, C may be included in an amount of 0.0011% or more or 0.0012% or more, and according to another example embodiment, C may be included in an amount of 0.0045% or less.

Silicon (Si): 0.050% or less

[0039] Silicon (Si) is an element contributing to strength increase by solid solution strengthening, but in the present disclosure, even when Si is not intentionally added, there is no difficulty in securing physical properties. However, 0% may be excluded, considering the inevitably added level during a steel sheet manufacturing process.

[0040] According to an example embodiment of the present disclosure, when the content of Si is more than 0.050%, scale defects are caused on the surface of a steel sheet to deteriorate plating surface characteristics, and thus, the content may be limited to 0.050% or less.

[0041] Therefore, according to an example embodiment of the present disclosure, Si may be included in an amount of 0.050% or less, excluding 0%, and according to another example embodiment, it may be included in an amount of 0.040% or less.

Manganese (Mn): 0.10 to 0.25%

[0042] Manganese (Mn), which is a solid solution strengthening element, contributes to an increase in steel strength, and also has an effect of precipitating S present in steel as MnS to suppress brittleness occurrence caused by S.

[0043] In an example embodiment of the present disclosure, when the content of Mn is less than 0.10%, intended strength may not be secured, but when the content is more than 0.25%, surface defects may occur by an oxide.

[0044] Therefore, in an example embodiment of the present disclosure, Mn may be included in an amount of 0.10 to 0.25%, and according to another example embodiment, it may be included in an amount of 0.11% or more or 0.13% or more. According to another example embodiment, Mn may be included in an amount of 0.23% or less or 0.21% or less.

Phosphorus (P): 0.010 to 0.035%

[0045] Phosphorus (P) has the best solid solution effect and is effective for securing strength without greatly impairing a drawing characteristic of steel.

[0046] In an example embodiment of the present disclosure, when the content of P is less than 0.010%, the effect described above may not be sufficiently obtained, but when the content is more than 0.035%, strength is excessively increased, or secondary brittleness and surface striped defects may occur due to P segregation.

[0047] Therefore, in an example embodiment of the present disclosure, the P may be included in an amount of 0.010 to 0.035%. According to another example embodiment of the present disclosure, P may be included in an amount of 0.015% or more, and according to another example embodiment, P may be included in an amount of 0.030% or less.

Sulfur (S): 0.0100% or less and nitrogen (N): 0.0050% or less

[0048] Sulfur (S) and nitrogen (N) are impurities present in steel and elements which are unavoidably added in a steel manufacturing process. In terms of securing the welding characteristic of steel, it is favorable to control the content of the elements as low as possible.

[0049] In an example embodiment of the present disclosure, S may be 0.0100% or less, and N may be 0.0050% or less. However, considering the unavoidably added level during the steel manufacturing process, the contents of S and N may be more than 0%.

Aluminum (Al): 0.100% or less (excluding 0%)

[0050] Aluminum (Al) is bonded to N present in steel and precipitated as AlN, and the precipitate contributes to improvement of the drawing characteristic and ductility of steel.

[0051] In an example embodiment of the present disclosure, when the content of Al is more than 0.100%, an Al inclusion is excessively formed during a steelmaking operation, thereby causing internal defects in a steel sheet.

[0052] Therefore, in an example embodiment of the present disclosure, Al may be included in an amount of 0.100% or less, excluding 0%. According to another example embodiment of the present disclosure, Al may be included in an amount of 0.080% or less. According to another example embodiment of the present disclosure, Al may be included in an amount of 0.005% or more.

Niobium (Nb): 0.0010 to 0.0100%

[0053] Niobium (Nb) is an element which is the most effective for forming very fine crystal grains in rolling and cooling processes, when an austenite unrecrystallization temperature range due to a solute drag and precipitate pinning effect during hot rolling expands to a high temperature.

[0054] In an example embodiment of the present disclosure, when the content of Nb is less than 0.0010%, the austenite unrecrystallization temperature range narrows, and the crystal grain refinement effect may not be expressed. However, when the content is more than 0.0100%, baking hardenability is deteriorated due to scavenging of C.

[0055] Therefore, in an example embodiment of the present disclosure, Nb may be included in an amount of 0.0010 to 0.0100%. According to another example embodiment of the present disclosure, Nb may be included in an amount of 0.0020% or more or 0.0030% or more. According to another example embodiment, Nb may be included in an amount of 0.0090% or less or 0.0085% or less.

Copper (Cu): 0.0100% or less (including 0%)

[0056] Copper (Cu) is an element which is difficult to control when adjusting the composition of steel in a steelmaking process, and in an example embodiment of the present disclosure, when the content of Cu is more than 0.0100%, a Cu_2S precipitate is formed to cause non-uniformity of a crystal grain size and occurrence of grain boundary embrittlement.

[0057] Therefore, in an example embodiment of the present disclosure, Cu may be included in an amount of 0.0100% or less, and according to another example embodiment, it may be included in an amount of 0.0095% or less, and according to still another example embodiment, it may be included in an amount of 0.0090% or less.

[0058] In an example embodiment of the present disclosure, Cu may be included in an amount of more than 0%, and as an example, at 0.0010% or more, considering that it is not easy to remove Cu in a steelmaking process.

[0059] The remaining component of the present disclosure is iron (Fe). However, since in a common manufacturing process, unintended impurities may be unavoidably incorporated from raw materials or the surrounding environment, it may not be excluded. Since these impurities are known to any person skilled in the common manufacturing process, the entire contents thereof are not particularly mentioned in the present specification.

[0060] In an example embodiment of the present disclosure, the cold-rolled steel sheet may have the alloy composition described above and may include 0.0050% or less of carbon in the alloy composition. Thus, in an example embodiment of the present disclosure, the microstructure of the cold-rolled steel sheet may be mainly formed of a ferrite phase. As an example, the ferrite phase may be included in an amount of an area fraction of 95% or more. As another example, the microstructure of the cold-rolled steel sheet may be formed of a ferrite single phase structure.

[0061] In an example embodiment of the present disclosure, the cold-rolled steel sheet may include 5% or less of unavoidably produced other structures, and as an example, may include 5% or less of pearlite.

[0062] In an example embodiment of the present disclosure, ferrite may have an average crystal grain size of 20 μm or less. When the average crystal grain size of the ferrite is more than 20 μm , the surface of the steel sheet becomes non-uniform during formation of a zinc-plated steel sheet obtained by galvanizing the cold-rolled steel sheet, and it may be difficult to secure distinctness of image. Herein, the average crystal grain size of the ferrite refers to an average value of a ferrite crystal grain size to the total thickness cross section of the cold-rolled steel sheet. That is to say, the average crystal grain size of ferrite is distinguished from an extreme surface part average crystal grain size (d) in the following Relation 1.

[0063] The cold-rolled steel sheet according to an example embodiment of the present disclosure may satisfy the following Relation 1 showing a relationship between the alloy composition and the microstructure (crystal grain size):

[Relation 1]

$$\text{Nb}(12/93) + \text{S}(63/32) + \text{Cu}(32/63) + d/2 \leq 11$$

wherein d is an average crystal grain size (μm) of ferrite in an extreme surface part, and the extreme surface part is an ND surface (rolled surface) at a point within 100 μm in a thickness direction from a surface of the cold-rolled steel sheet.

[0064] The inventors of the present disclosure found that it is important to control precipitation-type elements which affect texture recrystallization in an annealing process during a process of manufacturing the cold-rolled steel sheet, in securing uniform and fine crystal grains on the surface part of the cold-rolled steel sheet, and thus, derived Relation 1.

[0065] In an example embodiment of the present disclosure, the content of Nb constituting Relation 1 is excessive,

Nb is bonded to C to deteriorate the baking hardenability of the cold-rolled steel sheet, and S and Cu form a Cu_2S precipitate in an annealing process during a steel manufacturing process to cause non-uniformity of structure. Thus, according to an example embodiment of the present disclosure, the relationship between the contents of Nb, S, and Cu and the average crystal grain size of ferrite in the extreme surface part may be controlled as Relation 1, thereby improving the baking hardenability of the cold-rolled steel sheet. Furthermore, the distinctness of image of the zinc-plated steel sheet obtained by galvanizing the cold-rolled steel sheet having an improved baking hardening characteristic may be improved.

[0066] In an example embodiment of the present disclosure, the meaning that the value of Relation 1, that is, the relationship between the contents of Nb, S, and Cu and the average crystal grain size of the extreme surface part of the cold-rolled steel sheet is more than 11, is non-uniformly formed surface of the cold-rolled steel sheet. Thus, the baking hardenability of the cold-rolled steel sheet may not be secured, and the distinctness of image of the zinc-plated steel sheet may not be secured.

[0067] In an example embodiment of the present disclosure, since the average crystal grain size (d) in the extreme surface part of Relation 1 is distinguished from the average crystal grain size of ferrite mentioned above, it is acceptable for the value of d to be outside of the average crystal grain size range of ferrite described above.

[0068] The average crystal grain size mentioned in the present disclosure refers to the size of the circle equivalent diameter of each crystal grain, and the average value of these diameter.

[0069] Hereinafter, the method for manufacturing a cold-rolled steel sheet according to another aspect of the present disclosure will be described in detail. The following manufacturing method corresponds to an example for manufacturing the cold-rolled steel sheet according to an example embodiment of the present disclosure.

[0070] According to an example embodiment of the present disclosure, the cold-rolled steel sheet may be manufactured through processes of [hot rolling - cold rolling - annealing] of a heated steel slab, and each process step will be described in detail below.

[Steel slab heating]

[0071] After preparing a steel slab according to an example embodiment of the present disclosure, the steel slab may be heated. The heating process of the steel slab is a process for performing the hot rolling process described later well. As an example, since the steel slab may have the same alloy composition as the cold-rolled steel sheet according to an example embodiment of the present disclosure, the description of the alloy element is replaced with the above description.

[0072] In an example embodiment of the present disclosure, the heating of the steel slab may be performed at a temperature in a range of 1100 to 1300°C. When the heating temperature is lower than 1100°C, a rolling load may occur in the subsequent hot rolling process, but when the temperature is higher than 1300°C, surface scale defects may occur.

[Hot rolling]

[0073] The heated steel slab may be hot rolled to obtain a hot-rolled steel sheet.

[0074] In an example embodiment of the present disclosure, finish hot rolling may be performed at or above Ar_3 during the hot rolling, and when the temperature is lower than Ar_3 , two-phase region rolling may be performed to cause texture non-uniformity.

[0075] In an example embodiment of the present disclosure, in terms of securing fine crystal grains on the surface of a steel sheet in finish hot rolling, the finish hot rolling may be performed at a temperature in a range of 880 to 950°C.

[Winding]

[0076] The hot-rolled steel sheet obtained by the hot rolling may be wound.

[0077] In an example embodiment of the present disclosure, the winding may be performed at a temperature in a range of 600 to 650°C. When the temperature during winding is lower than 600°C, a large amount of solid solubilized Nb and the like are present in steel to adversely affect the recrystallization and particle growth suppression in the subsequent annealing process, but when the temperature is higher than 650°C, secondary scale may be produced to deteriorate the surface of the steel sheet.

[Cold rolling]

[0078] The wound hot-rolled steel sheet may be cold rolled with uncoiling to obtain a cold-rolled steel sheet. Herein, the rolling reduction rate may be controlled so that an intended thickness may be obtained.

[0079] In an example embodiment of the present disclosure, the cold rolling may be controlled to 70 to 83% based on a cumulative rolling reduction rate. When the reduction rate during the cold rolling is less than 70%, {111} texture does not sufficiently grow to deteriorate formability, but when it is more than 83%, the load of a rolling roll becomes severe to deteriorate the shape.

[0080] According to another example embodiment of the present disclosure, the cold rolling may be performed at a cumulative rolling reduction rate of 74% or more, and according to still another example embodiment, it may be performed at a cumulative rolling reduction rate of 80% or less.

[0081] In an example embodiment of the present disclosure, before performing the cold rolling, a pickling process may be further performed in order to remove surface scale of the wound hot-rolled steel sheet. Since the pickling process depends on common conditions, the conditions are not particularly defined.

[Annealing]

[0082] The cold-rolled steel sheet obtained by the cold rolling may be annealed.

[0083] In an example embodiment of the present disclosure, in order to remove deformation caused by the rolling in the annealing treatment and perform softening to promote improvement of processability, annealing may be performed at a recrystallization temperature or higher.

[0084] In an example embodiment of the present disclosure, the annealing may be performed at a temperature in a range of 760 to 820°C. During the annealing treatment, when the temperature is lower than 760°C, a sufficient recrystallization driving force may not be secured, but when the temperature is higher than 820°C, crystal grains may be coarsened.

[0085] Hereinafter, the zinc-plated steel sheet according to another aspect of the present disclosure will be described in detail.

[0086] According to an example embodiment of the present disclosure, the zinc-plated steel sheet may include a base steel sheet; and a plating layer provided on at least one surface of the base steel sheet.

[0087] In an example embodiment of the present disclosure, the plating layer may be a zinc-based plating layer including zinc as a main component, and the constituents of the plating layer commonly applied in the art may be identically applied to the zinc-based plating layer.

[0088] In an example embodiment of the present disclosure, the base steel sheet for providing the plating layer may be the cold-rolled steel sheet according to an example embodiment of the present disclosure. As described above, the cold-rolled steel sheet according to an example embodiment of the present disclosure secures surface uniformity as well as baking hardenability by optimizing a relationship between an alloy composition and microstructure, as well as controlling the alloy composition and the microstructure.

[0089] The zinc-plated steel sheet according to an example embodiment of the present disclosure providing the plating layer, as an example, the zinc-based plating layer on at least one surface of the cold-rolled steel sheet may have excellent distinctness of image.

[0090] In an example embodiment of the present disclosure, the zinc-plated steel sheet may have a characteristic of ΔW_{sa} defined by the following Relation 2 of 0.15 μm or less. That is, since the zinc-plated steel sheet according to an example embodiment of the present disclosure is obtained by using the cold-rolled steel sheet having improved surface uniformity as the base steel sheet, the surface change amount after deformation may be minimized. In an example embodiment of the present disclosure, the ΔW_{sa} value according to Relation 2 being more than 0.15 μm means that the change amount after deformation is relatively large, which is unfavorable for securing distinctness of image.

ΔW_{sa} = surface waviness of steel sheet after 5% deformation - surface waviness of steel sheet before deformation [Relation 2]

[0091] In Relation 2 according to an example embodiment of the present disclosure, ΔW_{sa} , which is a W_{sa} measurement value of a plated steel sheet, represents a difference between a W_{sa} value before working (deformation) and a W_{sa} value after working (deformation) of the plated steel sheet. As an example of the working (deformation) may be imparted through machine forming, but is not limited thereto.

[0092] In an example embodiment of the present disclosure, the zinc-plated steel sheet may have an excellent baking hardening characteristic, and specifically, a baking hardening amount (L-BH, tensile test after a heat treatment at 170°C for 20 minutes) of 30 MPa or more.

[0093] In addition, in an example embodiment of the present disclosure, since the zinc-plated steel sheet may have the physical properties of a yield strength of 180 MPa or more, a tensile strength of 300 MPa or more, and an elongation rate of 33% or more, it may be appropriately applied as an automotive exterior material.

[0094] Hereinafter, a method for manufacturing a zinc-plated steel sheet according to another aspect of the present disclosure will be described in detail. The following manufacturing method corresponds to an example for manufacturing the zinc-plated steel sheet according to an example embodiment of the present disclosure.

[0095] According to an example embodiment of the present disclosure, the zinc-plated steel sheet may be manufactured by preparing a base steel sheet; hot galvanizing the base steel sheet to obtain a zinc-plated steel sheet having a zinc-based plating layer on at least one surface of the base steel sheet; and temper rolling the zinc-plated steel sheet. Each process step will be described in detail in the following.

[Preparation of base steel sheet]

[0096] First, a base steel sheet for performing the zinc plating process according to an example embodiment of the present disclosure. In an example embodiment of the present disclosure, the base steel sheet may be a cold-rolled steel sheet, and the cold-rolled steel sheet may be the cold-rolled steel sheet according to an example embodiment of the present disclosure. That is, since it may be the cold-rolled steel sheet as described above, the description of the base steel sheet will be replaced with the above description of the cold-rolled steel sheet.

[Hot-dip galvanization]

[0097] The prepared base steel sheet, that is, the cold-rolled steel sheet is hot-dip galvanized in a continuous hot-dip galvanizing line, thereby obtaining a zinc-plated steel sheet having a zinc-based plating layer formed on at least one surface of the cold-rolled steel sheet.

[0098] In an example embodiment of the present disclosure, the hot galvanizing may be performed by dipping the base steel sheet in a plating bath including zinc as the main component, and the component in the plating bath is not particularly limited. That is to say, it may depend on common conditions which are applied to manufacture of the zinc-plated steel sheet by the hot galvanizing process.

[0099] In an example embodiment of the present disclosure, the hot galvanizing may be performed at a temperature in a range of 440 to 480°C. The temperature range refers to the temperature of the plating bath.

[Temper rolling]

[0100] The zinc-plated steel sheet may be temper rolled.

[0101] In an example embodiment of the present disclosure, the temper rolling may be performed with a rolling force of 0.6 to 1.8% using a roll having a roughness (Ra) of 1.0 to 2.2 μm .

[0102] In an example embodiment of the present disclosure, when the roughness (Ra) of the roll during the temper rolling is less than 1.0 μm , the targeted surface may not be secured due to low roughness working, but when it is more than 2.2 μm , a subsequent forming process, for example, a press process may not be performed well.

[0103] In an example embodiment of the present disclosure, when temper rolling is performed using a roll having a controlled surface roughness, the rolling force is less than 0.6%, baking hardenability may be deteriorated, but when the rolling force is more than 1.8%, yield strength may be excessively increased.

[0104] In an example embodiment of the present disclosure, the temper rolling treatment may be performed by one or more methods selected from electro discharge texturing (EDT), shot blasting (SBT), and Topocrom Texturing (TCT) working. As an example, the Topocrom texturing (TCT) working is a method of forming unevenness on a chromium coating layer itself by adjusting the temperature of a coating solution and current density in a chromium (Cr) coating process, without a process of mechanically and physically working roughness

[0105] The zinc-plated steel sheet manufactured according to an example embodiment of the present disclosure may have an excellent baking hardening characteristic and aging resistance, and also excellent distinctness of image by uniformly securing surface crystal grains.

[0106] Hereinafter, the present disclosure will be specifically described through the following examples. However, it should be noted that the following examples are only for describing the present disclosure by illustration, and not intended to limit the scope of right of the present disclosure. The reason is that the rights scope of the present disclosure is determined by the matters described in the claims and reasonably inferred therefrom.

Mode for Invention

(Examples)

[0107] A steel slab having the alloy composition shown in the following Table 1 and a thickness of 250 mm was prepared, heated at 1300°C or lower, and then hot rolled, wound, cold rolled, and annealed under the conditions

shown in the following Table 2 to manufacture a cold-rolled steel sheet. Each cold-rolled steel sheet was dipped into a hot galvanizing bath at $455 \pm 5^\circ\text{C}$ to perform plating, thereby obtaining a zinc-plated steel sheet. Thereafter, each zinc-plated steel sheet was temper rolled using a roll according to the conditions of the following Table 2.

[0108] The mechanical properties, the baking hardening characteristic, and deep drawing workability of the zinc-plated steel sheet manufactured according to the above were evaluated, and the results are shown in the following Table 3.

[0109] The tensile physical properties of yield strength (YS), tensile strength (TS), and elongation rate (T-El) were measured using a universal tensile tester in accordance with the standard of ISO6892, after collecting a specimen in accordance with the standard of JIS 5.

[0110] The same specimen as the specimen for evaluating the tensile physical properties was baked at 170°C for 20 minutes after 2% pre-strain, and then lower yield stress (L-BH) was measured to evaluate a baking hardening characteristic. At this time, only when the L-BH value was 30 MPa or more, it was determined as a pass.

[0111] In order to measure a r value which is an indicator of the deep drawing working, JIS 5 tensile specimens in a total of 3 direction of a parallel direction, a 45° direction, and a perpendicular direction to the rolling direction were collected on each zinc-plated steel sheet, and the r value of each specimen was measured. The r value was derived by measuring a change value of a sheet thickness and a change value of a sheet width when a tensile deformation of about 15% was performed in the previously performed tensile test, and determining a ratio of the change value of the sheet width to the sheet thickness. At this time, when the r value in the direction parallel to the rolling direction was r_0 , the r value in the 45° direction was r_{45} , and the r value in the perpendicular direction was r_{90} , each value was substituted into the following (equation) to determine a final r value, and when the value is 1.0 or more, it was determined as a pass.

$$(\text{Equation}) \quad r \text{ value} = r_0 + (2 \times r_{45}) + (r_{90}/4)$$

[0112] Meanwhile, in order to confirm the crystal grain distribution in the extreme surface part of the cold-rolled steel sheet which is the base steel sheet of the zinc-plated steel sheet, the average crystal grain size of the annealed cold-rolled steel sheet was measured using an Orientation imaging microscopy (OIM) analysis software available from TeXSEM Laboratories (TSL) through electron backscattered diffraction (EBSD) analysis. In addition, as a result of confirming the microstructure of each cold-rolled steel sheet with an optical microscope, ferrite at an area fraction of 95% or more was observed in all steel types (Inventive Steels 1 to 9 and Comparative Steels 1 to 6). At this time, residual structure other than ferrite was a pearlite phase.

[0113] Further, in order to measure the surface waviness of the zinc-plated steel sheet, a blank of 225 mm×225 mm was manufactured, and then the blank was compressed in a compressor having the force of a hollow punch having a diameter of 75 mm and a blank holder so that movement of any material of the blank was completely suppressed between the blank holder and the die, thereby manufacturing a cup. At this time, deformation of the cup was performed at a punch pull depth of about 17 to 18 mm so that a thickness strain of the bottom was about $5\% \pm 0.2\%$. Thereafter, the surface waviness before deformation and the surface waviness after deformation of the blank were measured, and a difference between the values (ΔW_{sa}) was calculated.

[Table 1]

Steel type	Alloy composition (wt%)								
	C	Si	Mn	P	S	Al	Nb	Cu	N
Inventive Steel 1	0.0016	0.025	0.13	0.020	0.0060	0.034	0.0030	0.0010	0.0015
Inventive Steel 2	0.0017	0.021	0.18	0.019	0.0046	0.035	0.0039	0.0080	0.0021
Inventive Steel 3	0.0021	0.035	0.19	0.022	0.0080	0.033	0.0030	0.0050	0.0018
Inventive Steel 4	0.0018	0.032	0.15	0.021	0.0043	0.035	0.0030	0.0080	0.0022
Inventive Steel 5	0.0023	0.018	0.15	0.020	0.0062	0.032	0.0048	0.0065	0.0019
Inventive Steel 6	0.0018	0.022	0.18	0.025	0.0054	0.035	0.0030	0.0024	0.0018
Inventive Steel 7	0.0019	0.024	0.15	0.020	0.0087	0.031	0.0050	0.0021	0.0025
Inventive Steel 8	0.0015	0.028	0.17	0.024	0.010	0.029	0.0030	0.0080	0.0023
Inventive Steel 9	0.0017	0.020	0.20	0.018	0.010	0.032	0.0035	0.0100	0.0015
Comparative Steel 1	0.0018	0.026	0.18	0.022	0.0088	0.035	0.0032	0.0050	0.0013

(continued)

Steel type	Alloy composition (wt%)								
	C	Si	Mn	P	S	Al	Nb	Cu	N
Comparative Steel 2	0.0018	0.030	0.14	0.023	0.0092	0.040	0.0054	0.1300	0.0022
Comparative Steel 3	0.0018	0.024	0.18	0.021	0.0090	0.039	0.0080	0.1500	0.0018
Comparative Steel 4	0.0018	0.028	0.15	0.020	0.0110	0.031	0.0011	0.1200	0.0016
Comparative Steel 5	0.0016	0.025	0.13	0.020	0.0060	0.034	0.0030	0.0010	0.0027
Comparative Steel 6	0.0017	0.021	0.18	0.019	0.0046	0.035	0.0120	0.0080	0.0024
In table 1, Inventive Steels 1 and 5 satisfied the present disclosure, but were indicated as comparative steels, since their process conditions of the following Table 2 were out of the scope of the present disclosure.									

[Table 2]

Steel type	Finish hot rolling temperature (°C)	Winding temperature (°C)	Cold rolling reduction rate (%)	Annealing temperature (°C)	Temper rolling	
					Roll surface roughness (Ra, μm)	Rolling force (%)
Inventive Steel 1	910	611	78	788	1.8	1.52
Inventive Steel 2	915	620	79	790	2.0	1.62
Inventive Steel 3	905	613	80	810	2.1	1.3
Inventive Steel 4	921	618	78	820	2.1	1.31
Inventive Steel 5	899	625	80	791	2.0	1.51
Inventive Steel 6	912	610	81	800	1.9	0.8
Inventive Steel 7	916	605	79	795	2.1	1.27
Inventive Steel 8	925	619	80	816	2.0	1.4
Inventive Steel 9	890	624	80	811	2.0	1.31
Comparative Steel 1	911	621	80	839	2.0	1.54
Comparative Steel 2	905	613	80	810	1.9	1.3
Comparative Steel 3	899	625	80	791	2.1	1.51
Comparative Steel 4	912	610	81	800	2.1	1.6
Comparative Steel 5	910	620	60	790	2.0	1.52
Comparative Steel 6	908	615	80	835	2.0	1.4

[Table 3]

Steel type	d (μm)	Relation 1	YS (MPa)	TS (MPa)	El (%)	r value	L-BH (MPa)	ΔW_{sa} (μm)
Inventive Steel 1	17	8.5	208	316	42	1.5	66	0.07
Inventive Steel 2	18	9.0	199	311	45	1.5	40	0.06
Inventive Steel 3	20	10.0	194	323	46	1.4	38	0.08
Inventive Steel 4	19	9.5	192	308	41	1.8	50	0.13
Inventive Steel 5	18	9.0	200	324	43	1.6	32	0.05
Inventive Steel 6	21	10.5	212	317	42	1.5	45	0.08
Inventive Steel 7	15	7.5	211	309	40	1.5	55	0.09
Inventive Steel 8	20	9.0	193	313	46	1.8	47	0.11

(continued)

Steel type	d (μm)	Relation 1	YS (MPa)	TS (MPa)	El (%)	r value	L-BH (MPa)	ΔWsa (μm)
Inventive Steel 9	19	9.5	205	327	43	1.6	39	0.10
Comparative Steel 1	25	12.5	191	339	48	1.8	35	0.17
Comparative Steel 2	23	11.6	201	318	45	1.5	42	0.19
Comparative Steel 3	24	12.1	198	308	43	1.6	49	0.16
Comparative Steel 4	23	11.6	208	328	42	1.5	48	0.18
Comparative Steel 5	25	12.5	232	340	40	0.9	28	0.16
Comparative Steel 6	18	9.0	178	301	48	1.7	31	0.07
In Table 3, d is an average crystal grain size of ferrite in an extreme surface layer part of the annealed cold-rolled steel sheet and is an average size of crystal grains measured on an ND surface (rolled surface) at a point within 100 μm in the thickness direction from the surface of the cold-rolled steel sheet. Relation 1 represents a value derived from $[Nb(12/93) + S(63/32) + Cu(32/63) + d/2]$.								

[0114] As shown in Tables 1 to 3, Inventive Steels 1 to 9 which all satisfied the alloy compositions and the manufacturing conditions suggested in the present disclosure had the surface crystal grains of the base steel sheet (cold-rolled steel sheet) which were uniform and finely formed (satisfying Relation 1). As a result, since all of Inventive Steels 1 to 9 had excellent baking hardening characteristic and aging resistance, with L-BH which is the indicator of the baking hardenability of 30 MPa or more and the r value which is the indicator of deep drawing working of 1.0 or more, and secured the value of difference (ΔWsa) between the surface waviness before/after deformation as 0.15 μm or less, they were confirmed to have excellent distinctness of image.

[0115] However, Comparative Steels 1 to 6 which did not satisfy the alloy compositions or manufacturing conditions suggested in the present disclosure had the physical properties at least one of which was poor.

[0116] Comparative Steel 1 which satisfied the alloy composition of the present disclosure, but had an excessively high annealing temperature during the manufacturing conditions had a non-uniform surface crystal grains of the base steel sheet (cold-rolled steel sheet), did not satisfy Relation 1, and thus, had poor distinctness of image.

[0117] Comparative Steels 2 to 4 having an excessive Cu content in steel showed the results of a difference (ΔWsa) in surface waviness before/after deformation of more than 0.15 μm by having the value of Relation 1 of more than 11. That is, the distinctness of image was poor.

[0118] In addition, Comparative Steel 5 which satisfied the alloy composition of the present disclosure, but had an excessively low reduction rate during cold rolling was not able to uniformly secure the crystal grains on the surface part of the base steel sheet (cold-rolled steel sheet) so that Relation 1 was satisfied, and as a result, the distinctness of image was poor, and the workability and baking hardenability were also poor.

[0119] Meanwhile, Comparative Steel 6 satisfied Relation 1, but had an excessive Nb content in steel, and had poor yield strength by performing annealing at a high temperature.

[0120] Though not shown in Tables 1 to 3, since Inventive Steels 1 to 9 and Comparative Steels 1 to 6 contained carbon within a range of 0.001 to 0.005%, the ferrite phase was formed at 95% by area or more in the microstructure.

Claims

1. A cold-rolled steel sheet comprising, by weight: 0.0010 to 0.0050% of carbon (C), 0.050% or less (excluding 0%) of silicon (Si), 0.10 to 0.25% of manganese (Mn), 0.010 to 0.035% of phosphorus (P), 0.0100% or less of sulfur (S), 0.0050% or less of nitrogen (N), 0.100% or less (excluding 0%) of aluminum (Al), 0.0010 to 0.0100% of niobium (Nb), 0.0100% or less (excluding 0%) of copper (Cu), a remainder of Fe, and unavoidable impurities,

wherein the following Relation 1 is satisfied:

$$[\text{Relation 1}]$$

$$Nb(12/93) + S(63/32) + Cu(32/63) + d/2 \leq 11$$

wherein d is an average crystal grain size (μm) of ferrite in an extreme surface part, and the extreme surface

part is an ND surface (rolled surface) at a point within 100 μm in a thickness direction from a surface of the cold-rolled steel sheet.

2. The cold-rolled steel sheet of claim 1, wherein a microstructure of the cold-rolled steel sheet is formed of ferrite at an area fraction of 95% or more.

3. The cold-rolled steel sheet of claim 2, wherein the ferrite has an average crystal grain size of 20 μm or less.

4. A method for manufacturing a cold-rolled steel sheet, the method comprising:

preparing a steel slab including, by weight: 0.0010 to 0.0050% of carbon (C), 0.050% or less (excluding 0%) of silicon (Si), 0.10 to 0.25% of manganese, 0.010 to 0.035% of phosphorus, 0.0100% or less of sulfur (S), 0.0050% or less of nitrogen (N), 0.100% or less (excluding 0%) of aluminum, 0.0010 to 0.0100% of niobium (Nb), 0.0100% or less (excluding 0%) of copper (Cu), a reminder of Fe, and unavoidable impurities, heating the steel slab to a temperature in a range of 1100 to 1300°C; finish hot rolling the heated steel slab at or above a Ar3 temperature to obtain a hot-rolled steel sheet; winding the hot-rolled steel sheet at a temperature in a range of 600 to 650°C; pickling the wound hot-rolled steel sheet and then cold rolling the steel sheet at a reduction rate of 70 to 83% to obtain a cold-rolled steel sheet; and annealing the cold-rolled steel sheet at a temperature in a range of 760 to 820°C.

5. The method for manufacturing a cold-rolled steel sheet of claim 4, wherein the annealed cold-rolled steel sheet satisfies the following Relation 1:

[Relation 1]

$$\text{Nb} (12/93) + \text{S} (63/32) + \text{Cu} (32/63) + d/2 \leq 11$$

wherein d is an average crystal grain size (μm) of ferrite in an extreme surface part, and the extreme surface part is an ND surface (rolled surface) at a point within 100 μm in a thickness direction from a surface of the cold-rolled steel sheet.

6. A zinc-plated steel sheet comprising a base steel sheet; and a zinc-based plating layer provided on at least one surface of the base steel sheet, wherein ΔWsa defined by the following Relation 2 is 0.15 μm or less:

ΔWsa = surface waviness of steel sheet after 5% deformation - surface waviness of steel sheet before deformation. [Relation 2]

7. The zinc-plated steel sheet of claim 6, wherein the zinc-plated steel sheet has a baking hardening amount (L-BH, tensile test after a heat treatment at 170°C for 20 minutes) of 30 MPa or more.

8. The zinc-plated steel sheet of claim 6, wherein the base steel sheet is the cold-rolled steel sheet of any one of claims 1 to 3.

9. The zinc-plated steel sheet of claim 6, wherein the zinc-plated steel sheet has a yield strength of 180 MPa or more, a tensile strength of 300 MPa or more, and an elongation rate of 33% or more.

10. A method for manufacturing a zinc-plated steel sheet, the method comprising:

preparing a base steel sheet; hot galvanizing the base steel sheet to obtain a zinc-plated steel sheet having a zinc-based plating layer on at least one surface of the base steel sheet; and temper rolling the zinc-plated steel sheet, wherein the temper rolling is performed with a rolling force of 0.6 to 1.8% using a roll having a roughness (Ra) of 1.0 to 2.2 μm .

11. The method for manufacturing a zinc-plated steel sheet of claim 10, wherein the hot galvanizing is performed in a zinc-based plating bath at 440 to 480°C.
12. The method for manufacturing a zinc-plated steel sheet of claim 10, wherein the temper rolling is performed by one or more methods selected from electro discharge texturing (EDT), shot blasting (SBT), and Topocrom Texturing (TCT) working.
13. The method for manufacturing a zinc-plated steel sheet of claim 10, wherein the base steel sheet is the cold-rolled steel sheet of any one of claims 1 to 3.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2024/018812

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/04(2006.01)i; C22C 38/02(2006.01)i; C22C 38/00(2006.01)i; C22C 38/06(2006.01)i; C22C 38/12(2006.01)i;
C22C 38/16(2006.01)i; C21D 8/02(2006.01)i; C21D 9/46(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)

C22C 38/04(2006.01); B21B 27/00(2006.01); C21D 8/02(2006.01); C22C 38/00(2006.01); C22C 38/06(2006.01);
C22C 38/60(2006.01)

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

Korean utility models and applications for utility models: IPC as above

Japanese utility models and applications for utility models: IPC as above

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

eKOMPASS (KIPO internal) & keywords: 소부경화성(Bake Hardening, BH), 조질압연(Skin Pass Rolling, SPR), 선형성
(Linearity), 표면파상도(Surface Waviness), 자동차외판(Automotive Outer Panel), 냉연강판(Cold Rolled Steel,
CRS), 페라이트(Ferrite), 용융아연도금(Hot-Dip Galvanizing, HDG)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2011-246767 A (SUMITOMO METAL IND., LTD.) 08 December 2011 (2011-12-08) See paragraphs [0038]-[0048] and [0070]-[0075] and claims 1 and 11.	1-2,4-5
Y		3,8,13
X	KR 10-2022-0060883 A (POSCO) 12 May 2022 (2022-05-12) See paragraphs [0005], [0076]-[0078], [0093], [0107] and [0114], claims 1-4 and table 3.	6,9-11
Y		3,7-8,12-13
Y	KR 10-2022-0040594 A (POSCO) 31 March 2022 (2022-03-31) See claim 3.	7
Y	KR 10-1999-0055429 A (POHANG IRON & STEEL CO., LTD.) 15 July 1999 (1999-07-15) See claim 1.	12

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

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“D” document cited by the applicant in the international application

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“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

“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

“&” document member of the same patent family

Date of the actual completion of the international search

28 February 2025

Date of mailing of the international search report

28 February 2025

Name and mailing address of the ISA/KR

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Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2024/018812

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2019-534949 A (TATA STEEL IJMUIDEN B.V.) 05 December 2019 (2019-12-05) See claim 1.	1-13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2024/018812

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
The invention of group 1: claims 1-5 pertain to a cold rolled steel sheet that satisfies relation 1, and a manufacturing method therefor
The invention of group 2: claims 6-13 pertain to a galvanized steel sheet in which ΔW_{sa} defined by relation 2 is 0.15 μm or less, and a manufacturing method therefor.

- ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
- ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
- ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
- ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

- Remark on Protest**
- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
 - ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
 - ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2024/018812

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		US 2022-0064765 A1	03 March 2022
		WO 2018-073117 A1	26 April 2018

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 1020170012865 [0007]