



(11)

EP 4 826 063 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
21.10.2026 Bulletin 2026/43

(21) Application number: **24904314.2**

(22) Date of filing: **16.12.2024**

(51) International Patent Classification (IPC):
C22C 38/04 ^(2006.01) **C22C 38/02** ^(2006.01)
C22C 38/06 ^(2006.01) **C22C 38/00** ^(2006.01)
C22C 38/58 ^(2006.01) **C22C 38/42** ^(2006.01)
C22C 38/12 ^(2006.01) **C22C 38/14** ^(2006.01)
C22C 38/44 ^(2006.01) **C23C 2/06** ^(2006.01)

(52) Cooperative Patent Classification (CPC):
C22C 38/00; C22C 38/02; C22C 38/04;
C22C 38/06; C22C 38/12; C22C 38/14;
C22C 38/42; C22C 38/44; C22C 38/58; C23C 2/06;
C23C 2/28

(86) International application number:
PCT/KR2024/020395

(87) International publication number:
WO 2025/127749 (19.06.2025 Gazette 2025/25)

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

(30) Priority: **15.12.2023 KR 20230183766**

(71) Applicant: **POSCO Co., Ltd**
Gyeongsangbuk-do 37859 (KR)

(72) Inventors:
• **JUNG, Ki-Taek**
Gwangyang-si, Jeollanam-do 57807 (KR)

- **CHO, Hang-Sik**
Gwangyang-si, Jeollanam-do 57807 (KR)
- **CHO, Won-Tae**
Gwangyang-si, Jeollanam-do 57807 (KR)
- **SEO, Chang-Hyo**
Gwangyang-si, Jeollanam-do 57807 (KR)
- **PARK, Man-Young**
Gwangyang-si, Jeollanam-do 57807 (KR)

(74) Representative: **Meissner Bolte Partnerschaft**
mbB
Patentanwälte Rechtsanwälte
Postfach 86 06 24
81633 München (DE)

(54) **COLD-ROLLED STEEL SHEET AND METHOD FOR MANUFACTURING SAME**

(57) The present invention relates to a cold-rolled steel sheet and a method for manufacturing same and, more specifically, to a high-strength cold-rolled steel

sheet having excellent moldability and a method for manufacturing same.

EP 4 826 063 A1

Description

Technical Field

5 **[0001]** The present disclosure relates to a cold-rolled steel sheet and a method for manufacturing the same, and more particularly, to a high-strength cold-rolled steel sheet with excellent formability and a method for manufacturing the same.

Background Art

10 **[0002]** In the automotive industry, there has been a recent focus on reducing vehicle body weight and securing crash safety to improve fuel efficiency and stability, in conjunction with regulations on greenhouse gas emissions due to global warming. Accordingly, the demand for securing manufacturing technology for high-strength steel sheets is increasing.

15 **[0003]** Among them, high-strength steel sheets for cold forming, which also have formability, are excellent in terms of economic efficiency as they can increase productivity, and are also more advantageous in terms of the safety of the final parts. Accordingly, automotive parts to which high-strength steel sheets are applied require not only strength but also excellent usability properties such as formability and weldability for part forming, including excellent elongation and resistance to Liquid Metal Embrittlement (LME).

20 **[0004]** To improve the formability of steel sheets, a method of utilizing the Transformation Induced Plasticity (TRIP) phenomenon by introducing retained austenite has been widely used as a way to increase elongation.

[0005] However, in the case of such TRIP steel sheets, it is common to add large amounts of elements such as C, Si, Mn, and Al into the steel to introduce retained austenite. If the content of the added elements is excessive or insufficient compared to the properties of the target steel grade, the material properties may be excessive or insuffi-
25 cient. Furthermore, steel sheets containing these elements may form oxides on the steel sheet surface during the annealing heat treatment process, which can deteriorate the plating property when the steel sheet is immersed in a molten zinc plating bath.

[0006] Therefore, to satisfy the target material properties, appropriate control of additive elements such as C, Si, Mn, and Al is essential.

30

Disclosure of Invention

Technical Problem

35 **[0007]** An embodiment of the present disclosure is to provide a cold-rolled steel sheet and a method for manufacturing the same.

[0008] An embodiment of the present disclosure is to provide a high-strength cold-rolled steel sheet with excellent formability and a method for manufacturing the same.

[0009] The object of the present disclosure is not limited to the above-mentioned contents. A person of ordinary skill
40 in the art would understand additional objects of the present disclosure from the overall contents of this specification without any difficulty.

Solution to Problem

45 **[0010]** According to an embodiment of the present disclosure, a cold-rolled steel sheet may comprise, by weight%, C: 0.050-0.250%, Si: 0.10-3.00%, Al: 0.005-3.000%, Mn: 1.00-3.00%, P: 0.0400% or less, S: 0.0100% or less, N: 0.0100% or less, with the remainder being Fe and other unavoidable impurities,

50 wherein a value R1 defined by the following Relational Expression 1 is 0.35 or more,
a value R2 defined by the following Relational Expression 2 is 0.59 or less,
and a microstructure comprises, by area%, 50.0-85.0% of ferrite, 0.5-10.0% of retained austenite, 3.0-30.0% of bainite, and 30.0% or less of fresh martensite.

55 [Relational Expression 1]

$$R1 = [C] + 0.15 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

[Relational Expression 2]

$$R2 = [C] + 0.2333 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

[0011] The cold-rolled steel sheet may further include, by weight%, one or more selected from Cu: 0.1% or less, Ni: 0.1% or less, Mo: 0.300% or less, and Cr: 0.200% or less.

[0012] The cold-rolled steel sheet may further include, by weight%, one or more selected from Nb, Ti, and V in a total amount of 0.100% or less.

[0013] The cold-rolled steel sheet may have a tensile strength of 690 MPa or more and an elongation of 25% or more.

[0014] The cold-rolled steel sheet may further include a zinc coating layer on at least one surface.

[0015] According to an embodiment of the present disclosure, a method for manufacturing a cold-rolled steel sheet may include: heating a steel slab including, by weight%, C: 0.050-0.250%, Si: 0.10-3.00%, Al: 0.005-3.000%, Mn: 1.00-3.00%, P: 0.0400% or less, S: 0.0100% or less, N: 0.0100% or less, with the remainder being Fe and other unavoidable impurities, wherein a value R1 defined by Relational Expression 1 is 0.35 or more, and a value R2 defined by Relational Expression 2 is 0.59 or less;

finish hot-rolling the heated steel slab;

coiling the finish hot-rolled steel sheet;

cold-rolling the coiled steel sheet;

continuously annealing the cold-rolled steel sheet in a temperature range of 800-900°C;

first cooling the continuously annealed steel sheet to a temperature range of 550-720°C at an average cooling rate of 1.0°C/s or more;

second cooling the first-cooled steel sheet to a temperature range of 150-480°C at an average cooling rate of 10.0°C/s or more;

and reheating the second-cooled steel sheet to a temperature range of 350-480°C.

[Relational Expression 1]

$$R1 = [C] + 0.15 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

[Relational Expression 2]

$$R2 = [C] + 0.2333 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

[0016] The steel slab may further include, by weight%, one or more selected from Cu: 0.1% or less, Ni: 0.1% or less, Mo: 0.300% or less, and Cr: 0.200% or less.

[0017] The steel slab may further include, by weight%, one or more selected from Nb, Ti, and V in a total amount of 0.100% or less.

[0018] The heating step may be performed in a temperature range of 1150-1250°C,

the finish hot-rolling step may be performed in a temperature range of 830-980°C,

the coiling step may be performed by cooling at an average cooling rate of 10-100°C/s to a temperature range of 450-700°C,

and the cold-rolling step may be performed with a cold reduction ratio of 30-60%.

[0019] The method may further include: plating the reheated steel sheet in a zinc plating bath at 450-470°C; and performing an alloying heat treatment on the plated steel sheet in a temperature range of 470-550°C.

[0020] The continuous annealing step may be performed in a dew point temperature atmosphere of -15.0 to 30.0°C.

Advantageous Effects of Invention

[0021] According to an embodiment of the present disclosure, a cold-rolled steel sheet and a method for manufacturing the same can be provided.

[0022] According to an embodiment of the present disclosure, a high-strength cold-rolled steel sheet with excellent formability and a method for manufacturing the same can be provided.

[0023] According to an embodiment of the present disclosure, a cold-rolled steel sheet and a method for manufacturing the same, which can be applied to zinc-coated steel sheets used in the automotive industry due to excellent strength and ductility, can be provided.

[0024] According to an embodiment of the present disclosure, a cold-rolled steel sheet and a method for manufacturing the same, which has excellent strength and ductility and excellent coating adhesion after plating, can be provided.

[0025] The various and beneficial advantages and effects of the present disclosure are not limited to the above-mentioned contents, and can be more easily understood in the process of describing specific embodiments of the present disclosure.

Best Mode for the Invention

[0026] Although not essential, it should be noted that the technical solution according to each aspect of the present disclosure can be usefully employed in technical solutions of other aspects. In addition, the composition and various useful parameters according to each aspect of the present disclosure can be appropriately combined with other aspects to obtain advantageous effects.

[0027] Hereinafter, preferred embodiments of the present disclosure will be described. The embodiments of the present disclosure may be modified into various other forms, and the scope of the present disclosure should not be construed as being limited to the embodiments described below. The embodiments of the present disclosure are provided to explain the present disclosure in more detail to those of ordinary skill in the art to which the present disclosure belongs.

[0028] Hereinafter, the present disclosure will be described in detail.

[0029] Hereinafter, the steel composition of the present disclosure will be described in detail.

[0030] Unless otherwise specified in the present disclosure, the % indicating the content of each element is based on weight.

[0031] The cold-rolled steel sheet according to an embodiment of the present disclosure may include, by weight%, C: 0.050-0.250%, Si: 0.10-3.00%, Al: 0.005-3.000%, Mn: 1.00-3.00%, P: 0.0400% or less, S: 0.0100% or less, and N: 0.0100% or less.

Carbon (C): 0.050-0.250%

[0032] Carbon (C) is an element that secures the strength of the steel material through solid solution strengthening and precipitation strengthening, and is an effective element for securing high elongation by stabilizing retained austenite. If the content of carbon (C) is less than 0.050%, it may not be possible to secure the desired level of tensile strength. According to an embodiment of the present disclosure, it may be 0.060% or more. According to an embodiment of the present disclosure, it may be 0.070% or more. On the other hand, if its content exceeds 0.250%, it may exceed the desired range of tensile strength or weldability may deteriorate due to the increase in carbon (C) content. According to an embodiment of the present disclosure, it may be 0.230% or less. According to an embodiment of the present disclosure, it may be 0.220% or less.

Silicon (Si): 0.10-3.00%

[0033] Silicon (Si) is a useful element for increasing the strength of the steel sheet by solid solution strengthening and precipitation hardening. Because it suppresses the formation of cementite, it has the effect of promoting C concentration into austenite, and it is an essential element for increasing the strength and elongation of the steel by generating retained austenite after annealing. If the silicon (Si) content is less than 0.10%, retained austenite may not be formed, making it difficult to obtain uniform elongation. According to an embodiment of the present disclosure, it may be 0.30% or more. According to an embodiment of the present disclosure, it may be 0.50% or more. On the other hand, if the content of silicon (Si) exceeds 3.00%, the properties of the welded zone may deteriorate due to LME cracking, and the surface properties and plating properties of the steel material may worsen. According to an embodiment of the present disclosure, it may be 2.50% or less. According to an embodiment of the present disclosure, it may be 2.00% or less.

Aluminum (Al): 0.005-3.000%

[0034] Aluminum (Al) is an element that has a deoxidizing effect on molten steel, and similarly to Si, it has the effect of increasing elongation by improving the stability of austenite. If the content of aluminum (Al) is less than 0.005%, deoxidation of the steel material may not be sufficiently achieved, and the cleanliness of the steel material may be impaired. According to an embodiment of the present disclosure, it may be 0.015% or more. According to an embodiment of the present disclosure, it may be 0.020% or more. On the other hand, if the aluminum (Al) content is excessive, the transformation temperature increases significantly and the fraction of ferrite increases, which may pose a problem in achieving ultra-high strength. Therefore, in the present disclosure, the upper limit of the aluminum (Al) content may be limited to 3.000%. According to an embodiment of the present disclosure, it may be 2.500% or less. According to an embodiment of the present disclosure, it may be 2.000% or less.

Manganese (Mn): 1.00-3.00%

[0035] Manganese (Mn) is an element added to secure strength. If the content of manganese (Mn) is less than 1.00%, it may be difficult to secure strength. According to an embodiment of the present disclosure, it may be 1.10% or more. According to an embodiment of the present disclosure, it may be 1.20% or more. On the other hand, if its content exceeds 3.00%, the bainite transformation speed may slow down, leading to the formation of an excessive amount of fresh martensite, making it difficult to obtain high elongation. In addition, a band structure may be formed due to the segregation of manganese (Mn), which may impair the material uniformity and formability of the material. According to an embodiment of the present disclosure, it may be 2.70% or less. According to an embodiment of the present disclosure, it may be 2.50% or less.

Phosphorus (P): 0.0400% or less

[0036] Phosphorus (P) is an impurity that is contained and segregates at grain boundaries, deteriorating toughness. Therefore, it is advantageous to control its content as low as possible. If phosphorus (P) is excessively added, the toughness of the steel material deteriorates, so its upper limit may be limited to 0.0400%. According to an embodiment of the present disclosure, it may be 0.0300% or less. On the other hand, the lower limit of the phosphorus (P) content is not particularly limited, but it may be 0.0020%.

Sulfur (S): 0.0100% or less

[0037] Sulfur (S) is contained as an impurity in the steel, similar to P. Since sulfur (S) combines with Mn to form inclusions, which can reduce hole expandability and also reduce weldability and hot rollability, it is advantageous to control it as low as possible. In an embodiment of the present disclosure, the upper limit of the sulfur (S) content may be limited to 0.0100%, considering the case where it is unavoidably included. According to an embodiment of the present disclosure, it may be 0.0021% or less. On the other hand, the lower limit of the sulfur (S) content is not particularly limited, but it may be 0.0009%.

Nitrogen (N): 0.0100% or less

[0038] Nitrogen (N) is an impurity contained in the steel, and it is advantageous to control its content as low as possible. In an embodiment of the present disclosure, the upper limit of the nitrogen (N) content may be limited to 0.0100%, considering the case where it is unavoidably included.

[0039] The steel of the present disclosure may include the remaining iron (Fe) and unavoidable impurities in addition to the above-mentioned composition. Unavoidable impurities may be unintentionally incorporated in a conventional manufacturing process, and therefore cannot be excluded. Since these impurities are known to anyone skilled in the conventional steel manufacturing field, all of their contents are not particularly mentioned in this specification.

[0040] The cold-rolled steel sheet according to an embodiment of the present disclosure may further include one or more of Cu: 0.1% or less, Ni: 0.1% or less, Mo: 0.300% or less, and Cr: 0.200% or less by weight%.

One or more of Copper (Cu): 0.1% or less, Nickel (Ni): 0.1% or less, Molybdenum (Mo): 0.300% or less, and Chromium (Cr): 0.200% or less

[0041] Copper (Cu), nickel (Ni), molybdenum (Mo), and chromium (Cr) are elements that increase the strength of the steel. These elements increase the strength and hardenability of the steel. However, if an excessive amount is added, the target strength grade may be exceeded, and since they are expensive elements, their upper limits may be limited

to 0.1%, 0.1%, 0.300%, and 0.200%, respectively, from an economic point of view. On the other hand, since copper (Cu), nickel (Ni), molybdenum (Mo), and chromium (Cr) act as solid solution strengthening elements, if one or more of copper (Cu), nickel (Ni), molybdenum (Mo), and chromium (Cr) are added in an amount of less than 0.03%, the solid solution strengthening effect may be insignificant. Therefore, when added, each may be added in an amount of 0.03% or more.

[0042] The cold-rolled steel sheet according to an embodiment of the present disclosure may further include, by weight%, one or more of Nb, Ti, and V in a total amount of 0.100% or less.

Total content of one or more of Niobium (Nb), Titanium (Ti), and Vanadium (V): 0.100% or less

[0043] Niobium (Nb), titanium (Ti), and vanadium (V) are elements that increase the strength of the steel. However, if the content of these elements is excessive, there is a concern that recrystallization may be delayed due to local grain pinning, which may impair the uniformity of the structure. Therefore, the total content of these elements may be limited to 0.100% or less. If one or more of niobium (Nb), titanium (Ti), and vanadium (V) are added in an amount of less than 0.030%, the strength-enhancing effect may be insignificant. Therefore, when added, their total content may be 0.030% or more.

[0044] The cold-rolled steel sheet according to an embodiment of the present disclosure may have a value of R1, defined by the following Relational Expression 1, of 0.35 or more.

[Relational Expression 1]

$$R1 = [C] + 0.15 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

[0045] According to an embodiment of the present disclosure, by controlling the content relationship between C and Mn through Relational Expression 1, both strength and ductility can be secured.

[0046] If the value of R1 defined by the above Relational Expression 1 is less than 0.35, there may be a problem that the target tensile strength (TS) cannot be sufficiently secured. According to an embodiment of the present disclosure, it may be 0.36 or more. On the other hand, the upper limit of the R1 value is not particularly limited, but according to an embodiment of the present disclosure, it may be 0.45.

[0047] The cold-rolled steel sheet according to an embodiment of the present disclosure may have a value of R2, defined by the following Relational Expression 2, of 0.59 or less.

[Relational Expression 2]

$$R2 = [C] + 0.2333 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

[0048] In the present disclosure, by additionally controlling the content relationship between C and Mn through Relational Expression 2, both strength and ductility can be secured.

[0049] If the value of R2 defined by Relational Expression 2 exceeds 0.59, it may exceed the target range of tensile strength, and there may be a problem that it is difficult to secure the desired elongation. According to an embodiment of the present disclosure, it may be 0.57 or less. On the other hand, the lower limit of the R2 value is not particularly limited, but according to an embodiment of the present disclosure, it may be 0.40. According to an embodiment of the present disclosure, it may be 0.45 or more.

[0050] Hereinafter, the microstructure of the steel of the present disclosure will be described in detail.

[0051] Unless otherwise specified in the present disclosure, the % indicating the fraction of the microstructure is based on area.

[0052] The microstructure of the cold-rolled steel sheet according to an embodiment of the present disclosure may include, by area%, 50.0-85.0% of ferrite, 0.5-10.0% of retained austenite, 3.0-30.0% of bainite, and 30.0% or less of fresh martensite.

[0053] If the ferrite fraction is less than 50.0%, it is difficult to secure elongation because the fraction of soft ferrite is insufficient, and the fraction of bainite, retained austenite, and fresh martensite increases, which may lead to an excessive increase in strength. On the other hand, if its fraction exceeds 85.0%, it may be difficult to sufficiently secure the desired strength.

[0054] If the retained austenite fraction is less than 0.5%, it may be difficult to secure elongation. According to an embodiment of the present disclosure, the retained austenite fraction is 1.0% or more. On the other hand, if its fraction

exceeds 10.0%, there is a problem that elongation cannot be obtained due to a lack of ferrite fraction.

[0055] If the bainite fraction is less than 3.0%, there is a concern that the desired strength and elongation may not be properly secured. On the other hand, if its fraction exceeds 30.0%, the bainite transformation from the initial austenite becomes excessive, and the tensile strength may be lowered due to a lack of fresh martensite transformation.

[0056] If the fresh martensite fraction exceeds 30.0%, the hard martensite becomes excessive, which may exceed the desired level of tensile strength. According to an embodiment of the present disclosure, the lower limit of the fresh martensite fraction may be 4.5%.

[0057] The cold-rolled steel sheet according to an embodiment of the present disclosure has a tensile strength of 690 MPa or more and an elongation of 25% or more.

[0058] According to an embodiment of the present disclosure, the tensile strength may be 780 MPa or less.

[0059] According to an embodiment of the present disclosure, the cold-rolled steel sheet may include a coating layer on at least one surface. In the present disclosure, the type of coating layer is not particularly limited, but it may be a zinc coating layer. According to an embodiment of the present disclosure, the zinc coating layer may be a hot-dip zinc coating layer. In addition, according to an embodiment of the present disclosure, it may be a galvanized coating layer.

[0060] Hereinafter, the method for manufacturing the steel of the present disclosure will be described in detail.

[0061] The cold-rolled steel sheet according to an embodiment of the present disclosure can be manufactured by heating, hot rolling, coiling, cold rolling, continuous annealing, first cooling, second cooling, and reheating a steel slab that satisfies the above-mentioned alloy composition.

Heating

[0062] The steel slab satisfying the alloy composition according to an embodiment of the present disclosure can be heated in a temperature range of 1150-1250°C.

[0063] The manufacturing method of the steel slab is not particularly limited, and a continuous casting slab can be used, and a slab manufactured by a thin slab caster or the like can be used. In addition, hot rolling, which is a subsequent process, can be performed immediately after continuous casting.

[0064] When heating the steel slab, if the temperature is less than 1150°C, the finish hot rolling temperature is likely to be excessively lowered, and there is a concern that the rolling load will increase. On the other hand, from the viewpoint of manufacturing cost, the upper limit of the heating temperature may be limited to 1250°C or less.

Finish Hot Rolling

[0065] The heated steel slab can be finish hot-rolled in a temperature range of 830-980°C.

[0066] During the finish hot rolling, if the temperature is less than 830°C, the rolling load is large and the shape becomes poor, which may worsen the productivity. According to an embodiment of the present disclosure, it may be 880°C or more. On the other hand, if the finish hot rolling temperature exceeds 980°C, there is a concern that the surface quality may deteriorate due to an increase in oxides due to excessive high-temperature work. According to an embodiment of the present disclosure, it may be 950°C or less. According to an embodiment of the present disclosure, it may be 930°C or less.

Coiling

[0067] The finish hot-rolled steel sheet is cooled at an average cooling rate of 10-100°C/s and can be coiled in a temperature range of 450-700°C.

[0068] During coiling, if the temperature exceeds 700°C, thick hot-rolled internal oxides are formed on the surface of the steel sheet, and the pickling property may be deteriorated. According to an embodiment of the present disclosure, it may be 670°C or less. According to an embodiment of the present disclosure, it may be 640°C or less. On the other hand, to improve toughness by refining the effective grain size, the lower limit of the coiling temperature may be limited to 450°C. According to an embodiment of the present disclosure, it may be 480°C or more. According to an embodiment of the present disclosure, it may be 500°C or more.

[0069] When cooling to the coiling temperature after hot rolling, if the average cooling rate is less than 10°C/s, the productivity of hot rolling decreases, and in actual production, there may be a problem of having to adopt a cooling medium with a low cooling capacity. On the other hand, if the average cooling rate exceeds 100°C/s, the temperature deviation inside the steel sheet does not become uniform, resulting in poor shape, and there is a concern that the strength of the steel sheet will be excessively high.

Cold Rolling

[0070] The coiled steel sheet can be cold-rolled with a cold reduction ratio of 30-60%.

[0071] During cold rolling, if the cold reduction ratio is less than 30%, it is difficult to secure the target thickness precision, and it may be difficult to correct the shape of the steel sheet. On the other hand, if the reduction ratio exceeds 60%, the possibility of cracks occurring at the edge of the steel sheet increases, and the load during cold rolling may be excessively large.

Continuous Annealing

[0072] The cold-rolled steel sheet can be continuously annealed in a temperature range of 800-900°C.

[0073] During continuous annealing, if the temperature is less than 800°C, sufficient recrystallization and austenite transformation do not occur, which may make it difficult to secure the target martensite and bainite fractions after annealing. On the other hand, if the continuous annealing temperature exceeds 900°C, productivity is lowered, coarse austenite is formed, and the material may deteriorate, and surface quality such as peeling of the coating material may deteriorate.

[0074] According to an embodiment of the present disclosure, the continuous annealing may be performed in a dew point temperature atmosphere of -15.0 to 30.0°C.

[0075] During continuous annealing, by controlling the dew point temperature, internal oxidation of the steel sheet can be promoted. Through the internal oxidation, the plating property and LME resistance can be secured.

[0076] If the dew point temperature is less than -15.0°C, the amount of oxygen flowing into the steel decreases, which intensifies only surface oxidation and does not cause internal oxidation. Therefore, a large amount of oxides exists on the surface, and there is a concern that the above-mentioned beneficial effects cannot be obtained. According to an embodiment of the present disclosure, the dew point temperature may be -10.0°C or more. On the other hand, if the dew point temperature exceeds 30.0°C, internal oxidation increases and the effect of suppressing surface oxidation by suppressing the diffusion of alloy elements increases, but the amount of water vapor supply increases rapidly, which poses a problem that the capacity of the humidification facility must be unnecessarily increased. In addition, condensed water vapor may be applied for a long period of time in continuous annealing, which may cause facility problems. According to an embodiment of the present disclosure, it may be 20.0°C or less.

[0077] According to an embodiment of the present disclosure, if the dew point temperature deviates from the proposed range, the target material can be satisfied during the manufacture of the cold-rolled steel sheet, but there may be a problem of coating peeling after plating.

[0078] In addition, according to an embodiment of the present disclosure, to obtain a significant effect during internal oxidation, the hydrogen concentration in the atmosphere gas during annealing may be included at 1% or more by volume%.

[0079] If the hydrogen concentration is less than 1%, the trace amount of oxygen unavoidably included in the H₂ and N₂ gases is not effectively removed by oxidation, and the oxygen partial pressure increases, which may cause surface oxidation of the steel sheet. On the other hand, if the hydrogen concentration exceeds 70%, there is a risk of explosion during gas leakage, and the cost associated with high-hydrogen operation increases. Therefore, the hydrogen concentration may be limited to 70% or less. Except for the hydrogen, the impurity gas unavoidably included may be substantially nitrogen.

[0080] According to an embodiment of the present disclosure, the continuous annealing may be performed in a continuous galvannealing line.

First Cooling

[0081] The continuously annealed steel sheet can be first cooled to a temperature range of 550-720°C at an average cooling rate of 1.0°C/s or more.

[0082] During the first cooling, the cooling end temperature can be defined as the point at which the second cooling is initiated by the additional application of a rapid cooling facility that was not applied in the first cooling.

[0083] According to an embodiment of the present disclosure, when the cooling process is performed in stages by dividing it into first and second cooling, the temperature distribution of the steel sheet can be made uniform in the slow cooling stage, thereby reducing the final temperature and material deviation, and securing the desired microstructure.

[0084] During the first cooling, if the end temperature is less than 550°C, the bainite fraction may be excessively high, and it may be difficult to cool to a temperature range of less than 550°C at the desired cooling rate under actual facility conditions. On the other hand, if the first cooling end temperature exceeds 720°C, the amount of cooling to the second cooling end temperature increases, which may cause the shape of the steel sheet to be poor, and there is a concern that the bainite fraction will be lower than the target level.

[0085] During the first cooling, if the average cooling rate is less than 1.0°C/s, the ferrite fraction transformed during the first cooling increases, and it may be difficult to secure the desired strength and work hardening ability due to a lack of martensite and retained austenite fractions that affect the strength and work hardening ability. On the other hand, the upper limit of the average cooling rate is not particularly limited, but it may be limited to 100.0°C/s or less for operability. According to an embodiment of the present disclosure, it may be limited to 10.0°C/s or less.

Second Cooling

[0086] The first-cooled steel sheet can be second cooled to a temperature range of 150-480°C at an average cooling rate of 10.0°C/s or more.

[0087] As mentioned above, according to an embodiment of the present disclosure, the second cooling may be additionally applied with a rapid cooling facility that was not applied in the first cooling. In the present disclosure, the type of the rapid cooling facility is not particularly limited, but according to an embodiment, a hydrogen rapid cooling facility can be used. According to an embodiment of the present disclosure, the hydrogen rapid cooling facility may use a gas composed of 50-80% hydrogen and the balance nitrogen by volume%. If the hydrogen volume fraction exceeds 80%, there may be a disadvantage that management such as explosion control of the facility becomes difficult. On the other hand, if the volume fraction is less than 50%, there may be a disadvantage that it is difficult to utilize the efficient heat transfer characteristics of hydrogen, which is a light element.

[0088] During the second cooling, if the end temperature is less than 150°C, the initial martensite transformation amount is excessive, the yield strength and tensile strength are excessively high, and the formability may be poor. According to an embodiment of the present disclosure, during the second cooling, the end temperature is set to be equal to or higher than the Ms temperature to limit the martensite transformation during cooling. According to an embodiment of the present disclosure, during the second cooling, the end temperature may be 200°C or more. According to an embodiment of the present disclosure, it may be 250°C or more. On the other hand, if the second cooling end temperature exceeds 450°C, sufficient bainite may not be generated because it is higher than the bainite transformation start point during cooling, and there is a high probability that a large amount of fresh martensite will be generated in the final stage, which may exceed the appropriate tensile strength range.

[0089] During the second cooling, if the average cooling rate is less than 10.0°C/s, there may be a problem of poor operability. According to an embodiment of the present disclosure, it may be 20.0°C/s or more. On the other hand, the upper limit of the average cooling rate during the second cooling is not particularly limited, but according to an embodiment of the present disclosure, it may be 60.0°C/s.

Reheating

[0090] The second-cooled steel sheet can be reheated to a temperature range of 350-480°C.

[0091] According to an embodiment of the present disclosure, the bainite phase transformation can be obtained through the reheating process. According to an embodiment of the present disclosure, the end point temperature during the reheating may be referred to as the reheating temperature for convenience.

[0092] During reheating, if the temperature is less than 350°C, the strength may be excessively high and the elongation may be poor. On the other hand, if the temperature exceeds 450°C, the austenite that could not be transformed and remained may become fresh martensite during the final cooling, which may adversely affect the elongation. Meanwhile, the so-called nose temperature at which the bainite transformation is most active is about 400-450°C. According to an embodiment of the present disclosure, the lower limit of the temperature during reheating may be 400°C. According to an embodiment of the present disclosure, the upper limit of the reheating temperature may be 450°C.

Plating

[0093] The reheated steel sheet can be plated in a zinc plating bath at 450-470°C.

[0094] According to an embodiment of the present disclosure, the reheated steel sheet can be zinc-plated as needed. In addition, temper rolling can be additionally performed.

[0095] According to an embodiment of the present disclosure, the temperature of the zinc plating bath is not particularly limited, and may be a conventional condition applicable in the same technical field.

Alloying Heat Treatment

[0096] The plated steel sheet can be subjected to an alloying heat treatment in a temperature range of 470-550°C.

[0097] According to an embodiment of the present disclosure, the zinc-plated steel sheet can be subjected to an

alloying heat treatment as needed. The alloying heat treatment can be performed to obtain an appropriate alloying level, and the temperature can be determined according to the surface state of the steel sheet. By controlling the surface state of the steel material, the upper limit of the alloying heat treatment temperature can be limited to 550°C to prevent softening of the steel sheet and disappearance of retained austenite due to excessive tempering. On the other hand, to proceed with alloying quickly, the alloying heat treatment temperature may be higher than the molten zinc plating temperature, and its lower limit may be limited to 470°C.

[0098] According to an embodiment of the present disclosure, after the alloying heat treatment, the shape of the steel sheet is corrected and the yield strength is adjusted, and the alloyed heat-treated steel sheet may be additionally subjected to temper rolling with a reduction ratio of 1% or less after being cooled to room temperature.

Mode for the Invention

[0099] Hereinafter, the present disclosure will be described in more detail through examples. However, it should be noted that the following examples are for illustrating the present disclosure in more detail, and are not intended to limit the scope of rights of the present disclosure.

(Example)

[0100] After preparing a steel slab having the alloy composition shown in Table 1 below, a steel sheet was manufactured under the conditions shown in Table 2 below. At this time, hot rolling was performed in a temperature range of 880-930°C, and coiling was performed in a temperature range of 480-640°C after cooling at an average cooling rate of 10°C/s or more after hot rolling.

[Table 1]

teel Type	Alloy Composition (weight%)											Relational Expression 1		Relational Expression 2
	C	Si	Mn	P	S	Al	Ti	Nb	N	Cr	Mo	R1	R2	
A	0.080	1.50	1.30	0.0070	0.0020	0.030	-	-	0.0040	0.019	0.005	0.28	0.38	
B	0.110	1.50	1.30	0.0070	0.0020	0.030	-	-	0.0040	0.020	0.003	0.31	0.41	
C	0.080	1.50	1.45	0.0070	0.0020	0.005	-	-	0.0090	0.015	0.003	0.30	0.42	
D	0.080	1.50	1.60	0.0070	0.0020	0.005	-	-	0.0090	0.017	0.005	0.32	0.45	
E	0.080	1.50	1.70	0.0070	0.0020	0.080	-	-	0.0040	0.013	0.007	0.34	0.48	
F	0.120	1.50	1.60	0.0100	0.0020	0.030	-	-	0.0060	0.005	0.009	0.36	0.49	
G	0.110	1.40	1.60	0.0070	0.0020	0.080	0.015	0.02	0.0040	0.012	0.005	0.35	0.48	
H	0.200	1.50	1.60	0.0100	0.0020	0.030	-	-	0.0060	0.018	0.006	0.44	0.57	
I	0.200	1.47	1.51	-	-	0.028	-	-	0.0050	0.022	0.002	0.43	0.55	
J	0.200	1.47	1.51	-	-	0.028	-	-	0.0070	0.011	0.004	0.43	0.55	
K	0.100	1.50	2.00	0.0100	0.0020	0.030	-	-	0.0060	0.030	0.005	0.40	0.57	
L	0.217	1.51	1.53	-	-	0.048	-	-	0.0050	0.026	0.006	0.45	0.57	
M	0.220	1.50	1.53	-	-	0.048	-	-	0.0060	0.011	0.005	0.45	0.58	
N	0.100	1.50	2.00	0.0100	0.0020	0.030	-	-	0.0060	0.040	0.008	0.40	0.57	
O	0.110	1.40	1.90	0.0070	0.0020	0.080	0.015	0.02	0.0040	0.009	0.002	0.40	0.55	
P	0.100	1.49	2.10	0.0062	0.0024	0.084	-	-	0.0017	0.015	0.009	0.42	0.59	
Q	0.230	1.05	2.00	-	-	0.990	-	-	0.0060	0.021	0.002	0.53	0.70	
R	0.219	1.50	1.72	-	-	0.047	-	-	0.0060	0.025	0.005	0.48	0.62	
S	0.239	1.53	1.71	-	-	0.030	-	-	-	0.021	0.005	0.50	0.64	
T	0.090	1.45	2.10	0.0070	0.0020	0.080			0.0060	0.015	0.002	0.41	0.58	

$$[\text{Relational Expression 1}] \quad R1 = [C] + 0.15 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

$$[\text{Relational Expression 2}]$$

$$R2 = [C] + 0.2333 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

[Table 2]

Specimen No.	Steel Type	Steel Type		1st Cooling		2nd Cooling		Reheating
		Temp (°C)	Dew Point (°C)	Temp (°C)	Avg. Rate (°C/s)	Temp (°C)	Avg. Rate (°C/s)	Temp (°C)
1	A	780	15.6	640	4.4	400	17.5	440
2	B	800	14.4	640	5.0	400	17.5	440
3	C	780	14.8	640	4.4	400	17.5	440
4	D	800	14.6	640	5.0	400	17.5	440
5	E	800	15.9	640	5.0	400	17.5	440
6	F	800	-40.3	650	5.0	400	18.2	430
7	G	820	15.1	640	5.7	400	17.5	440
8	H	800	15.8	650	4.7	400	18.2	370
9	I	830	-45.2	650	5.7	400	18.2	400
10	J	830	15.6	750	5.7	400	18.2	400
11	K	840	14.8	650	6.0	400	18.2	430
12	L	800	15.5	650	4.7	400	18.2	400
13	M	800	15.7	650	4.7	400	18.2	400
14	N	780	14.9	650	4.4	485	18.2	485
15	O	820	15.2	640	5.7	400	17.5	440
16	P	810	15.0	640	5.4	440	14.6	440
17	Q	890	15.7	700	6.0	400	19.7	400
18	R	830	15.1	650	5.7	300	25.5	400
19	S	800	14.9	650	4.7	300	25.5	400
20	T	850	-45.9	640	5.3	300	10.5	300

[0101] The microstructure and properties of the manufactured steel sheets were measured and are shown in Table 3 below.

[0102] The microstructure was calculated by observing the Phase map using the Electron Backscatter Diffraction (EBSD) method at a 1/4 position from the surface of the steel sheet in the thickness center direction, and the retained austenite fraction was measured through the X-ray diffraction (XRD) method.

[0103] In addition, the yield strength (YS), tensile strength (TS), and elongation (T-EI) were measured and shown through a tensile test in the direction perpendicular to the rolling direction. At this time, the gauge length was 50 mm, and the tensile specimen width was 25 mm according to the specimen standard.

[0104] In addition, after plating the manufactured steel sheet, the plating property was visually evaluated and shown in Table 3 below. To evaluate the plating property, a sealer for automotive structures was applied to a thickness of about 5 mm after hot-dip galvanizing and cured at a temperature of 150-170°C. Thereafter, the plated steel sheet cooled to room temperature was bent by 90° and the sealer was peeled off. If the entire interface between the zinc coating and the base steel sheet was peeled off, it was judged that the coating adhesion was poor. After the plating

property evaluation, if no peeling occurred, it was indicated as 'O', and if peeling occurred and the coating adhesion was poor, it was indicated as 'x'.

[Table 3]

Specimen No.	Steel Type	Microstructure (area%)				Properties				Division
		F	RA	B	FM	YS (MPa)	TS (MPa)	T-EI (%)	Plating	
1	A	90.3	1.9	2.6	5.2	450	589	32.5	○	Comp. Ex.1
2	B	87.1	3.2	3.4	6.3	440	615	31.5	○	Comp. Ex.2
3	C	89.3	1.7	5.7	3.3	404	618	36.0	○	Comp. Ex.3
4	D	85.6	2.4	4.8	7.2	414	628	34.4	○	Comp. Ex. 4
5	E	86.5	2.9	3.5	7.1	404	641	32.7	○	Comp. Ex. 5
6	F	75	6.4	3.7	14.9	405	695	29.8	×	Inv. Ex.1
7	G	73.2	5.5	6	15.3	474	698	31.2	○	Inv. Ex.2
8	H	74.1	4.7	5.1	16.1	435	725	25.6	○	Inv. Ex.3
9	I	71.9	6.2	8	13.9	486	729	33.1	×	Inv. Ex.4
10	J	47.6	1.7	19.4	31.3	490	763	22.5	○	Comp. Ex. 6
11	K	68.2	2.4	12.2	17.2	410	734	30.4	○	Inv. Ex. 5
12	L	75.3	2.5	6.5	15.7	402	740	26.4	○	Inv. Ex.6
13	M	78.7	3.5	6.3	11.5	402	740	26.4	○	Inv. Ex.7
14	N	64.1	1.7	9.8	31.4	390	796	21.8	○	Comp. Ex. 7
15	O	77.3	5.4	3	14.3	482	745	31.3	○	Inv. Ex. 8
16	P	78.7	6.2	10.3	4.8	326	748	25.2	○	Inv. Ex.9
17	Q	43.9	4.2	17.3	34.6	438	863	23.4	○	Comp. Ex. 8
18	R	71.4	0.4	4.8	23.4	495	810	23.8	○	Comp. Ex. 9
19	S	68.9	11.5	5.7	13.9	476	901	21.2	○	Comp. Ex.10
20	T	69.1	2.3	2.7	25.9	425	775	23.1	×	Comp. Ex.11

[0105] * F: Ferrite, RA: Retained Austenite, B: Bainite, FM: Fresh Martensite As shown in Table 3 above, in the case of the invention examples that satisfy the alloy composition and manufacturing conditions of the present disclosure, the microstructure characteristics proposed in the present disclosure were satisfied, and the target properties in the present disclosure were also secured.

[0106] On the other hand, Invention Examples 1 and 4 achieved the properties of the cold-rolled steel sheet proposed in the present disclosure, but are examples in which peeling occurred after plating because the dew point temperature during continuous annealing was out of the range of the present disclosure. When the dew point temperature during continuous annealing deviates from the range proposed in the present disclosure, it can be confirmed that the coating adhesion of the plated steel sheet after plating is deteriorated.

[0107] On the other hand, Comparative Examples 1 to 5 are examples that do not satisfy Relational Expression 1 proposed in the present disclosure. As a result, ferrite was excessively formed, and the desired level of strength was not secured.

[0108] In Comparative Example 6, the end temperature during the first cooling exceeded the proposed range. As a result, the ferrite fraction was insufficient, and the elongation was deteriorated.

[0109] In Comparative Example 7, the end temperature during the second cooling exceeded the proposed range, and the temperature during reheating was also exceeded. As a result, fresh martensite was excessively formed in the final microstructure, and as a result, the elongation was deteriorated.

[0110] Comparative Examples 8 to 10 are examples that do not satisfy Relational Expression 2 proposed in the present disclosure. As a result, the proposed microstructure fraction was not properly secured, and the desired level of elongation was not secured.

[0111] In Comparative Example 11, the temperature during reheating was below the proposed range, and bainite

was not sufficiently formed. As a result, the elongation was lowered.

[0112] Although the present disclosure has been described in detail through the examples above, other forms of embodiments are also possible. Therefore, the technical spirit and scope of the claims described below are not limited to the embodiments.

Claims

1. A cold-rolled steel sheet, comprising, by weight%:

C: 0.050-0.250%,
Si: 0.10-3.00%,
Al: 0.005-3.000%,
Mn: 1.00-3.00%,
P: 0.0400% or less,
S: 0.0100% or less,
N: 0.0100% or less,
with the remainder being Fe and other unavoidable impurities,
wherein a value R1 defined by the following Relational Expression 1 is 0.35 or more,
a value R2 defined by the following Relational Expression 2 is 0.59 or less, and
a microstructure comprises, by area%:

50.0-85.0% of ferrite,
0.5-10.0% of retained austenite,
3.0-30.0% of bainite, and
30.0% or less of fresh martensite.

[Relational Expression 1]

$$R1 = [C] + 0.15 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

[Relational Expression 2]

$$R2 = [C] + 0.2333 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

2. The cold-rolled steel sheet of claim 1,
wherein the cold-rolled steel sheet further comprises, by weight%, one or more selected from the group consisting of Cu: 0.1% or less, Ni: 0.1% or less, Mo: 0.300% or less, and Cr: 0.200% or less.

3. The cold-rolled steel sheet of claim 1,
wherein the cold-rolled steel sheet further comprises, by weight%, one or more selected from the group consisting of Nb, Ti, and V in a total amount of 0.100% or less.

4. The cold-rolled steel sheet of claim 1,
wherein the cold-rolled steel sheet has a tensile strength of 690 MPa or more and an elongation of 25% or more.

5. The cold-rolled steel sheet of claim 1,
wherein the cold-rolled steel sheet further comprises a zinc coating layer on at least one surface thereof.

6. A method for manufacturing a cold-rolled steel sheet, the method comprising:
heating a steel slab comprising, by weight%:

C: 0.050-0.250%,

Si: 0.10-3.00%,
 Al: 0.005-3.000%,
 Mn: 1.00-3.00%,
 P: 0.0400% or less,
 S: 0.0100% or less,
 N: 0.0100% or less,
 with the remainder being Fe and other unavoidable impurities,
 wherein a value R1 defined by the following Relational Expression 1 is 0.35 or more, and a value R2 defined
 by the following Relational Expression 2 is 0.59 or less;
 finish hot-rolling the heated steel slab;
 coiling the finish hot-rolled steel sheet;
 cold-rolling the coiled steel sheet;
 continuously annealing the cold-rolled steel sheet in a temperature range of 800-900°C;
 first cooling the continuously annealed steel sheet to a temperature range of 550-720°C at an average cooling
 rate of 1.0°C/s or more;
 second cooling the first-cooled steel sheet to a temperature range of 150-480°C at an average cooling rate of
 10.0°C/s or more; and
 reheating the second-cooled steel sheet to a temperature range of 350-480°C.

[Relational Expression 1]

$$R1 = [C] + 0.15 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

[Relational Expression 2]

$$R2 = [C] + 0.2333 \times [Mn]$$

(wherein, [C] and [Mn] are the weight% of each element.)

7. The method of claim 6,
 wherein the steel slab further comprises, by weight%, one or more selected from the group consisting of Cu: 0.1%
 or less, Ni: 0.1% or less, Mo: 0.300% or less, and Cr: 0.200% or less.

8. The method of claim 6,
 wherein the steel slab further comprises, by weight%, one or more selected from the group consisting of Nb, Ti,
 and V in a total amount of 0.100% or less.

9. The method of claim 6,
 wherein the heating is performed in a temperature range of 1150-1250°C,
 the finish hot-rolling is performed in a temperature range of 830-980°C,
 the coiling is performed by cooling at an average cooling rate of 10-100°C/s to a temperature range of
 450-700°C,
 and the cold-rolling is performed with a cold reduction ratio of 30-60%.

10. The method of claim 6,
 further comprising: plating the reheated steel sheet in a zinc plating bath at 450-470°C;
 and performing an alloying heat treatment on the plated steel sheet in a temperature range of 470-550°C.

11. The method of claim 6,
 wherein the continuous annealing is performed in a dew point temperature atmosphere of -15.0 to 30.0°C.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2024/020395

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/04(2006.01)i; C22C 38/02(2006.01)i; C22C 38/06(2006.01)i; C22C 38/00(2006.01)i; C22C 38/58(2006.01)i;
C22C 38/42(2006.01)i; C22C 38/12(2006.01)i; C22C 38/14(2006.01)i; C22C 38/44(2006.01)i; C23C 2/06(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); C21D 1/74(2006.01); C21D 8/02(2006.01); C21D 9/46(2006.01); C22C 38/00(2006.01);
C22C 38/38(2006.01); C22C 38/58(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: 이슬점(dew point), 연속소둔(continuous annealing), 페라이트(ferrite), 베이 나이트
(bainite), 냉각속도(cooling speed)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2022-0019395 A (POSCO) 17 February 2022 (2022-02-17) See paragraphs [0068]-[0078] and [0090] and claims 1-8.	1-10
Y		11
Y	KR 10-2203836 B1 (BAOSHAN IRON & STEEL CO., LTD.) 18 January 2021 (2021-01-18) See claim 7.	11
A	KR 10-2013-0032917 A (NIPPON STEEL & SUMITOMO METAL CORPORATION) 02 April 2013 (2013-04-02) See paragraphs [0064]-[0066] and claim 1.	1-11
A	JP 2012-117148 A (JFE STEEL CORP.) 21 June 2012 (2012-06-21) See claims 1 and 5.	1-11

☒ 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 19 March 2025	Date of mailing of the international search report 19 March 2025
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon Building 4, 189 Cheongsaro, Seo-gu, Daejeon 35208 Facsimile No. +82-42-481-8578	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2024/020395

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2018-0298462 A1 (NIPPON STEEL & SUMITOMO METAL CORPORATION) 18 October 2018 (2018-10-18) See claims 1 and 8.	1-11

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2024/020395

5	Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
	KR 10-2022-0019395 A	17 February 2022	KR 10-2490313 B1	19 January 2023
	KR 10-2203836 B1	18 January 2021	CN 106244923 A	21 December 2016
10			CN 106244923 B	06 July 2018
			EP 3508606 A1	10 July 2019
			EP 3508606 B1	25 August 2021
			JP 2019-531408 A	31 October 2019
			JP 6696047 B2	20 May 2020
15			KR 10-2019-0034596 A	02 April 2019
			US 11505844 B2	22 November 2022
			US 2019-0194774 A1	27 June 2019
			WO 2018-041089 A1	08 March 2018
	KR 10-2013-0032917 A	02 April 2013	BR 112013006143 A2	14 June 2016
20			BR 112013006143 B1	18 December 2018
			CA 2811189 A1	22 March 2012
			CA 2811189 C	22 April 2014
			CN 103097566 A	08 May 2013
			CN 103097566 B	18 February 2015
25			EP 2617849 A1	24 July 2013
			EP 2617849 B1	18 January 2017
			EP 3034644 A1	22 June 2016
			EP 3034644 B1	12 December 2018
			ES 2617477 T3	19 June 2017
30			ES 2711891 T3	08 May 2019
			JP 5021108 B2	05 September 2012
			JP WO2012-036269 A1	03 February 2014
			KR 10-1329840 B1	14 November 2013
			MX 2013002906 A	22 May 2013
35			MX 339219 B	17 May 2016
			PL 2617849 T3	31 July 2017
			PL 3034644 T3	30 April 2019
			US 2013-0167980 A1	04 July 2013
			US 9139885 B2	22 September 2015
40			WO 2012-036269 A1	22 March 2012
	JP 2012-117148 A	21 June 2012	CN 103210105 A	17 July 2013
			CN 103210105 B	12 August 2015
			EP 2634281 A1	04 September 2013
45			JP 5141811 B2	13 February 2013
			KR 10-1553757 B1	16 September 2015
			KR 10-2013-0086062 A	30 July 2013
			TW 201226581 A	01 July 2012
			TW I441928 B	21 June 2014
50			US 2013-0295410 A1	07 November 2013
			US 9028973 B2	12 May 2015
			WO 2012-063969 A1	18 May 2012
	US 2018-0298462 A1	18 October 2018	BR 112017025389 A2	07 August 2018
55			CN 107636184 A	26 January 2018
			CN 114990431 A	02 September 2022
			EP 3309273 A1	18 April 2018
			EP 3309273 B1	26 May 2021
			JP 6187710 B2	30 August 2017

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2024/020395

5

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
		JP WO2016-199922 A1	22 June 2017
		KR 10-2018-0016518 A	14 February 2018
		KR 10-2081361 B1	25 February 2020
		MX 2017015286 A	19 February 2018
		TW 201713778 A	16 April 2017
		TW I602927 B	21 October 2017
		US 10745775 B2	18 August 2020
		WO 2016-199922 A1	15 December 2016
