



(11)

EP 4 826 103 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: **24904431.4**

(22) Date of filing: **13.12.2024**

(51) International Patent Classification (IPC):
C22C 38/58 ^(2006.01) **C22C 38/42** ^(2006.01)
C22C 38/06 ^(2006.01) **C22C 38/00** ^(2006.01)
C22C 38/44 ^(2006.01) **C22C 38/48** ^(2006.01)
C22C 38/54 ^(2006.01) **C23C 2/06** ^(2006.01)
C21D 8/02 ^(2026.01)

(52) Cooperative Patent Classification (CPC):
C21D 8/02; C22C 38/00; C22C 38/06; C22C 38/42;
C22C 38/44; C22C 38/48; C22C 38/54;
C22C 38/58; C23C 2/06

(86) International application number:
PCT/KR2024/096929

(87) International publication number:
WO 2025/127866 (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 20230183878**

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

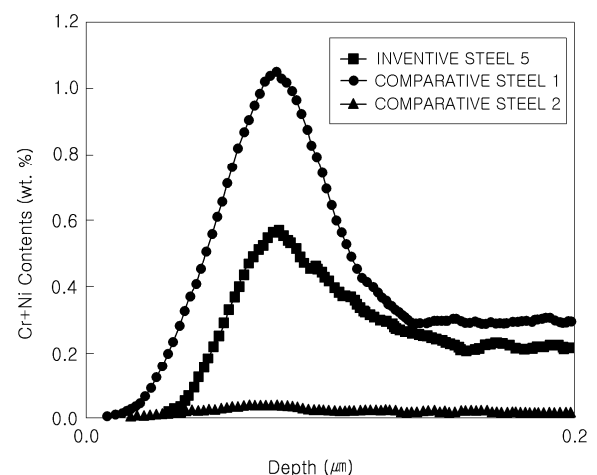
(72) Inventors:
• **NA, Hyun-Taek**
Gwangyang-si, Jeollanam-do 57807 (KR)
• **SEONG, Hwan-Goo**
Gwangyang-si, Jeollanam-do 57807 (KR)
• **LEE, Jae-Hoon**
Gwangyang-si, Jeollanam-do 57807 (KR)
• **KIM, Jae-Joong**
Gwangyang-si, Jeollanam-do 57807 (KR)

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

(54) **STEEL SHEET AND METHOD FOR MANUFACTURING SAME**

(57) The present invention relates to a steel sheet suitable as a material for a vehicle structural member, a reinforcing material and the like, and, more specifically, to a steel sheet with excellent hole expandability and surface layer hardness, and a method for manufacturing same.

[FIG. 1]



Description

Technical Field

[0001] The present disclosure relates to a steel sheet suitable as a material for structural members, reinforcing members, and the like, of automobiles, and more particularly, to a steel sheet having an excellent hole expansion ratio and excellent hardness of a surface layer portion, and a method for manufacturing the same.

Background Art

[0002] Recently, with the aim of reducing global greenhouse gases, power systems of automobiles have been changing from internal combustion engines to electric motors, and in the electric vehicle market, competition for reducing automobile weight to increase driving distance per charge has been intensifying. As part of this trend, in order to minimize the weight of battery pack housing components, aluminum alloys having a lower density than steel materials have been actively adopted.

[0003] Meanwhile, automobile manufacturers and parts manufacturers are expanding the adoption of steel materials, which have relatively low material costs due to a decrease in battery prices, have low carbon emissions in terms of life cycle assessment, and have excellent responsiveness to thermal runaway, along with mass production for popularization of electric automobiles.

[0004] Examples of the related art include the following documents.

[0005] Patent Document 1 is an example in which a steel material is applied to a lower plate of a battery housing for protecting battery cells. In this technology, from the viewpoint of crashworthiness, ultra-high-strength steel having a tensile strength of 980 to 1,800 MPa is adopted in order to protect battery cells from impacts occurring at a lower portion of an automobile body during driving. Such ultra-high-strength steel not only provides crashworthiness but also has the effect of supporting a heavy battery pack. However, in order to achieve high strength, use of a large amount of ferroalloys is essential, and manufacturing costs are also relatively high due to a complicated heat treatment process.

[0006] Patent Document 2 discloses a steel sheet for structural members or reinforcing members of an automobile body, the steel sheet having a tensile strength of 490 MPa or more, a relationship between tensile strength and elongation ($TS \times EI$) of 15,000 MPa% or more, and excellent plating properties. In this technology, by adding Sb as an alloying element, a uniform enriched layer is formed in the outermost surface layer portion of a steel sheet, and formation of oxidative inclusions in the surface layer portion is suppressed, thereby ensuring plating properties. However, the range of the Sb content proposed for forming an Sb-enriched layer in the surface layer of the steel sheet has limitations in ensuring impact resistance against external factors such as stone chipping that may occur during driving of an automobile. That is, in order to ensure the above-described impact resistance and the like, the hardness of the surface layer portion of the steel sheet should be uniform; however, solid-solution strengthening and transformation strengthening effects required to implement this may be insufficient. In addition, addition of a large amount of Sb may not only act as a factor that deteriorates plating adhesion, but may also be economically disadvantageous because Sb is an expensive element and increases manufacturing costs.

[0007] Meanwhile, Patent Document 3 discloses a technology for manufacturing a hot-dip plated steel sheet or an alloyed hot-dip plated steel sheet having a tensile strength of 590 MPa and excellent fatigue properties and impact resistance. In this technology, in order to suppress softening of a surface layer portion that may generally occur during a steel sheet manufacturing process, temper rolling is performed after hot rolling to increase precipitation formation sites in the structure of the surface layer portion, thereby additionally realizing a precipitation strengthening effect and ensuring the hardness of the surface layer portion. However, in order to obtain the precipitation strengthening effect, addition of expensive alloying elements such as Nb, Ti, Mo, and V is essential, and when these elements are non-uniformly distributed in the surface layer portion, there is a problem of deterioration in plating properties, such as occurrence of unplated portions. In addition, when the hardness of the surface layer portion of the steel sheet depends only on the precipitation strengthening effect, defects such as transverse cracks may be caused during component processing.

(Patent Document 1) Korean Patent Laid-Open Publication No. 2023-0032302

(Patent Document 2) Korean Patent No. 10-0711358

(Patent Document 3) Korean Patent No. 10-1313957

Summary of Invention

Technical Problem

[0008] An aspect of the present disclosure is to provide a steel sheet suitable as a material for structural members, reinforcing members, and the like of automobiles, the steel sheet having uniform hardness of a surface layer portion and an excellent hole expansion ratio in order to improve resistance to impacts and the like that may be caused during use of an automobile, and a method for manufacturing the same.

[0009] The object of the present disclosure is not limited to the above description. The object of the present disclosure may be understood from the overall content of the present specification, and those skilled in the art to which the present disclosure pertains will have no difficulty in understanding additional objects of the present disclosure.

Solution to Problem

[0010] According to an aspect of the present disclosure, a steel sheet contains, by wt%, 0.050 to 0.150% of carbon (C), 0.010 to 1.000% of silicon (Si), 1.000 to 3.000% of manganese (Mn), 0.01 to 0.10% of aluminum (Sol.Al), 0.001 to 0.050% of phosphorus (P), 0.001 to 0.020% of sulfur (S), 0.0010 to 0.0100% of nitrogen (N), 0.020 to 0.300% of chromium (Cr), 0.010 to 0.100% of nickel (Ni), 0.010 to 0.400% of copper (Cu), and the balance of Fe and other inevitable impurities.

[0011] In the steel sheet according to an embodiment in the present disclosure, Si, Cr, and Ni in the alloy composition may satisfy the following Relational Expression 1.

[Relational Expression 1]

$$2.000 \leq 17(\text{Cr} + \text{Ni}) / \text{Si} \leq 4.000$$

[0012] (In Relational Expression 1, Cr, Ni, and Si represent the weight contents of the respective elements.)

[0013] As such, the steel sheet according to an embodiment in the present disclosure that satisfies the alloy composition and Relational Expression 1 representing the content relationship of specific elements may control enrichment behavior of Cr and Ni in a surface layer portion. In particular, a relationship between the contents of Cr and Ni and the enrichment values of Cr and Ni in the surface layer portion may satisfy the following Relational Expression 2.

[Relational Expression 2]

$$0.150 \leq \Delta(\text{Cr} + \text{Ni}) \leq 0.500$$

$$\Delta(\text{Cr} + \text{Ni}) = [\text{Cr}_{(0.5 \mu\text{m})} + \text{Ni}_{(0.5 \mu\text{m})}] - [\text{Cr}_{(1/4t)} + \text{Ni}_{(1/4t)}]$$

[0014] (In Relational Expression 2, $\text{Cr}_{(0.5 \mu\text{m})}$ and $\text{Ni}_{(0.5 \mu\text{m})}$ represent the maximum enrichment values (wt%) of Cr and Ni, respectively, in a surface layer region from a surface of the steel sheet to a depth of 500 nm in a thickness direction, and $\text{Cr}_{(1/4t)}$ and $\text{Ni}_{(1/4t)}$ represent the weight average contents of Cr and Ni, respectively, at a $t/4$ point in the thickness direction of the steel sheet (where t represents the thickness (mm) of the steel sheet).)

[0015] In an embodiment in the present disclosure, the steel sheet may further contain one or more selected from molybdenum (Mo), niobium (Nb), and antimony (Sb) in a total content of 1.0% or less, and may further contain 0.0030% or less of boron (B).

[0016] In an embodiment in the present disclosure, the steel sheet may include, as a microstructure, ferrite having an area fraction of 90% or more, and, as the balance, one or more of bainite, martensite, and retained austenite.

[0017] The steel sheet according to an embodiment in the present disclosure may have high strength and an excellent hole expansion ratio, and may ensure uniform surface hardness.

[0018] As an example, the steel sheet may have a tensile strength (TS) of 590 MPa or more, and a relationship between the tensile strength (TS) and hole expansion ratio (HER) may satisfy the following Relational Expression 3. In addition, the steel sheet may have a surface hardness (Vickers hardness) of 170 or more.

[0019] In an embodiment in the present disclosure, the steel sheet may include a zinc-based plating layer formed on at least one surface.

[0020] According to another aspect of the present disclosure, a method for manufacturing a steel sheet includes: preparing a steel slab; heating the steel slab in a temperature range of 1,000 to 1,350°C; obtaining a hot-rolled steel sheet by finish hot-rolling the heated steel slab in a temperature range of 800 to 1000°C; coiling the hot-rolled steel sheet in a temperature range of 400 to 650°C; obtaining a cold-rolled steel sheet by cold-rolling the coiled hot-rolled

steel sheet at a reduction ratio of 30% or more; annealing the cold-rolled steel sheet by heating the cold-rolled steel sheet to a temperature of Ac1 or higher and holding the cold-rolled steel sheet at the temperature; and cooling the annealed cold-rolled steel sheet to a temperature range of 450 to 650°C at a cooling rate of 35°C/s or less.

[0021] In an embodiment in the present disclosure, the steel slab may have the above-described alloy composition and may also satisfy Relational Expression 1.

[0022] When the steel slab satisfying the alloy composition and Relational Expression 1 according to an embodiment in the present disclosure is used, the steel sheet to be manufactured may satisfy Relational Expression 2.

[0023] In an embodiment in the present disclosure, the method may further include obtaining a hot-dip galvanized steel sheet by subjecting the cooled cold-rolled steel sheet to hot-dip galvanizing in a temperature range of 440 to 480°C, and may optionally further include subjecting the hot-dip galvanized steel sheet to alloying heat treatment.

Advantageous Effects of Invention

[0024] According to the present disclosure, it is possible to provide a steel sheet having excellent hardness uniformity in a surface layer compared to a high-strength steel sheet using a conventional transformed structure, and having an improved hole expansion ratio.

[0025] The steel sheet of the present disclosure may also be easily formed into components, and thus may be suitably applied to structural members, reinforcing members, and the like of automobiles.

Brief Description of Drawings

[0026] FIG. 1 shows part of the results obtained by measuring Cr and Ni enrichment values from a surface to a depth of 1 μm in a thickness direction of a steel sheet according to an embodiment in the present disclosure, using a glow discharge analysis technique (GDS, Glow Discharge Spectrometer).

Best Mode for Invention

[0027] The inventors of the present disclosure recognized problems of existing ultra-high-strength steel used as a material for structural members, reinforcing members, and the like of automobiles. Accordingly, the inventors of the present disclosure conducted intensive research on measures for ensuring resistance to impacts continuously applied in an automobile use environment and for improving a hole expansion ratio of a steel sheet so that the steel sheet may be easily formed into components and the like.

[0028] As a result, while optimizing the alloy composition and manufacturing conditions of the steel sheet, the inventors of the present disclosure confirmed that the content relationship between specific elements affects the surface layer hardness of the steel sheet, thereby completing the present disclosure.

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

[0030] According to an aspect of the present disclosure, a steel sheet may contain, by wt%, 0.050 to 0.150% of carbon (C), 0.010 to 1.000% of silicon (Si), 1.000 to 3.000% of manganese (Mn), 0.01 to 0.10% of aluminum (Sol.Al), 0.001 to 0.050% of phosphorus (P), 0.001 to 0.020% of sulfur (S), 0.0010 to 0.0100% of nitrogen (N), 0.020 to 0.300% of chromium (Cr), 0.010 to 0.100% of nickel (Ni), and 0.010 to 0.400% of copper (Cu).

[0031] Hereinafter, reasons for limiting the alloy composition of the steel sheet according to an aspect of the present disclosure will be described in detail. Meanwhile, unless otherwise specifically stated, the content of each element is based on weight, and a fraction of a structure is based on area.

Carbon (C): 0.050 to 0.150%

[0032] Carbon (C) is the most economical and effective element for strengthening steel, and as a content thereof increases, a fraction of hard phases (martensite, bainite, and the like) in a structure constituting the steel increases, thereby increasing tensile strength.

[0033] In an embodiment in the present disclosure, when the content of C is less than 0.050%, the fraction of hard phases in the steel structure becomes insufficient, such that a target level of strength cannot be ensured. On the other hand, when the content thereof exceeds 0.150%, formation of coarse carbides or pearlite in the steel is facilitated, such that formability deteriorates and weldability also deteriorates.

[0034] Therefore, in an embodiment in the present disclosure, C may be contained in an amount of 0.050 to 0.150%. According to another embodiment in the present disclosure, C may be contained in an amount of 0.060% or more or 0.070% or more. According to still another embodiment in the present disclosure, C may be 0.145% or less or 0.140% or less.

Silicon (Si): 0.010 to 1.000%

[0035] Silicon (Si) is an element added for deoxidation of molten steel and may exhibit a solid-solution strengthening effect.

[0036] In an embodiment in the present disclosure, when a content of Si is less than 0.010%, the above-described effects cannot be sufficiently obtained. On the other hand, when the content thereof exceeds 1.000%, oxides are formed on a surface of the steel, thereby inhibiting plating properties.

[0037] Therefore, in an embodiment in the present disclosure, Si may be contained in an amount of 0.010 to 1.000%. According to another embodiment in the present disclosure, Si may be contained in an amount of 0.020% or more or 0.030% or more. According to still another embodiment in the present disclosure, Si may be 0.900% or less or 0.850% or less.

Manganese (Mn): 1.000 to 3.000%

[0038] Manganese (Mn) may be added for a solid-solution strengthening effect, similarly to Si. In addition, Mn increases hardenability of steel, thereby facilitating formation of hard phases in the structure of the steel.

[0039] In an embodiment in the present disclosure, when the content of Mn is less than 1.000%, the above-described effects cannot be sufficiently obtained. On the other hand, when the content thereof exceeds 3.000%, hardenability of the steel greatly increases, and the fraction of hard phases becomes excessively high, such that it may be difficult to ensure intended ductility.

[0040] Therefore, in an embodiment in the present disclosure, Mn may be contained in an amount of 1.000 to 3.000%. According to another embodiment in the present disclosure, Mn may be contained in an amount of 1.100% or more or 1.200% or more. According to still another embodiment in the present disclosure, Mn may be 2.900% or less or 2.850% or less.

Aluminum (Sol.Al): 0.01 to 0.10%

[0041] Aluminum (Sol.Al) is an element added for deoxidation of molten steel.

[0042] In an embodiment in the present disclosure, when a content of Sol.Al is less than 0.01%, the effect of adding Sol.Al is insufficient. On the other hand, when the content thereof exceeds 0.10%, Sol.Al combines with nitrogen (N) to form AlN, thereby easily causing corner cracks in a slab during continuous casting. In addition, defects may occur due to formation of Al-based inclusions.

[0043] Therefore, in an embodiment in the present disclosure, Sol.Al may be contained in an amount of 0.01 to 0.10%.

Phosphorus (P): 0.001 to 0.050%

[0044] Phosphorus (P) is an element inevitably introduced into steel, and when a content thereof is excessive, weldability of the steel may be inhibited, and a risk of embrittlement may increase. Meanwhile, in order to control P to an extremely small amount, refining costs sharply increase.

[0045] Accordingly, in an embodiment in the present disclosure, the content of P may be limited to 0.001 to 0.050%.

Sulfur (S): 0.001 to 0.020%

[0046] Sulfur (S) is an element inevitably introduced into steel, and when a content thereof is excessive, weldability of the steel may be inhibited, and ductility of the steel may deteriorate. Meanwhile, in order to control S to an extremely small amount, refining costs sharply increase.

[0047] Accordingly, in an embodiment in the present disclosure, the content of S may be limited to 0.001 to 0.020%.

Nitrogen (N): 0.0010 to 0.0100%

[0048] Nitrogen (N) is an element inevitably introduced into steel, and when a content thereof is excessive, a risk of embrittlement of the steel increases. In addition, there is a problem in that continuous casting quality deteriorates due to excessive precipitation of AlN caused by reaction with Al. Meanwhile, in order to control N to an extremely small amount, refining costs sharply increase.

[0049] Accordingly, in an embodiment in the present disclosure, the content of N may be limited to 0.0010 to 0.0100%.

Chromium (Cr): 0.020 to 0.300%

[0050] Chromium (Cr) is an element that delays formation of ferrite and promotes formation of hard phases during a cooling process in a steel manufacturing process.

[0051] In an embodiment in the present disclosure, when a content of Cr is less than 0.020%, hard phases are not sufficiently formed, such that a target level of strength cannot be ensured. On the other hand, when the content thereof exceeds 0.300%, a martensite phase is excessively formed in the structure of the steel, resulting in deterioration of ductility.

[0052] Therefore, in an embodiment in the present disclosure, Cr may be contained in an amount of 0.020 to 0.300%. According to another embodiment in the present disclosure, Cr may be contained in an amount of 0.025% or more or 0.030% or more. According to still another embodiment in the present disclosure, Cr may be 0.295% or less or 0.290% or less.

Nickel (Ni): 0.010 to 0.100%

[0053] Nickel (Ni), similarly to Cr, is an element that delays formation of ferrite and promotes formation of hard phases during a cooling process in a steel manufacturing process.

[0054] In an embodiment in the present disclosure, when a content of Ni is less than 0.010%, hard phases are not sufficiently formed, such that a target level of strength cannot be ensured. On the other hand, when the content thereof exceeds 0.100%, a martensite phase is excessively formed in the structure of the steel, resulting in deterioration of ductility.

[0055] Therefore, in an embodiment in the present disclosure, Ni may be contained in an amount of 0.010 to 0.100%. According to another embodiment in the present disclosure, Ni may be contained in an amount of 0.015% or more or 0.020% or more. According to still another embodiment in the present disclosure, Ni may be 0.098% or less.

Copper (Cu): 0.010 to 0.400%

[0056] Copper (Cu) is an element useful for ensuring weather resistance of steel and preventing hydrogen embrittlement.

[0057] In an embodiment in the present disclosure, when a content of Cu is less than 0.010%, the above-described effects cannot be sufficiently obtained. On the other hand, when the content thereof exceeds 0.400%, a large number of scab (dent) defects due to intergranular liquation may occur on a surface of a slab.

[0058] Therefore, in an embodiment in the present disclosure, Cu may be contained in an amount of 0.010 to 0.400%. According to another embodiment in the present disclosure, Cu may be contained in an amount of 0.012% or more. According to still another embodiment in the present disclosure, Cu may be 0.380% or less.

[0059] In addition to the above-described alloy composition, the steel sheet according to an embodiment in the present disclosure may further contain one or more selected from molybdenum (Mo), niobium (Nb), and antimony (Sb), and/or 0.0030% or less of boron (B).

[0060] Molybdenum (Mo), niobium (Nb), and boron (B) are elements that improve hardenability of steel and contribute to formation of hard phases in the structure of the steel. Antimony (Sb) is an element advantageous for ensuring plating properties by forming a uniform enriched layer in the surface layer of the steel sheet.

[0061] In an embodiment in the present disclosure, when one or more of Mo, Nb, and Sb are added, if a content thereof exceeds 1.0%, manufacturing costs sharply increase. In particular, in the case of Sb, plating adhesion may instead deteriorate due to excessive surface enrichment.

[0062] In an embodiment in the present disclosure, when the content of B exceeds 0.003%, ductility of the steel may deteriorate.

[0063] The remaining component of the steel sheet in the present disclosure is iron (Fe). However, in a typical manufacturing process, unintended impurities may inevitably be introduced from raw materials or the surrounding environment, and thus such impurities cannot be excluded. Since these impurities are readily understandable to those skilled in the typical manufacturing process, details thereof are not specifically mentioned in the present specification.

[0064] In an embodiment in the present disclosure, in order to ensure uniform surface hardness of the steel sheet and ensure ductility, contents of Cr and Ni, which are hardenability elements, may be limited in relation to Si. Specifically, Cr, Ni, and Si may satisfy the following Relational Expression 1.

[Relational Expression 1]

$$2.000 \leq 17(\text{Cr} + \text{Ni}) / \text{Si} \leq 4.000$$

[0065] (In Relational Expression 1, Cr, Ni, and Si represent the weight contents of the respective elements.)

[0066] Si present in steel is an element that readily forms oxides on a surface of the steel. According to an embodiment in the present disclosure, by increasing the contents of Cr and Ni relative to Si, enrichment amounts of Cr and Ni on the surface of the steel may be increased, instead of forming oxides caused by Si.

[0067] In particular, according to an embodiment in the present disclosure, as described above, by optimizing the relationship in the alloy composition and, at the same time, controlling manufacturing conditions of the steel sheet, which will be described in detail below, enrichment values of Cr and Ni in a surface layer portion of the steel may be ensured as follows.

[Relational Expression 2]

$$0.150 \leq \Delta(\text{Cr}+\text{Ni}) \leq 0.500$$

$$\Delta(\text{Cr}+\text{Ni}) = [\text{Cr}_{(0.5 \mu\text{m})} + \text{Ni}_{(0.5 \mu\text{m})}] - [\text{Cr}_{(1/4t)} + \text{Ni}_{(1/4t)}]$$

[0068] (In Relational Expression 2, $\text{Cr}_{(0.5 \mu\text{m})}$ and $\text{Ni}_{(0.5 \mu\text{m})}$ represent the maximum enrichment values (wt%) of Cr and Ni, respectively, in a surface layer region from a surface of the steel sheet to a depth of 500 nm in a thickness direction, and $\text{Cr}_{(1/4t)}$ and $\text{Ni}_{(1/4t)}$ represent the weight average contents of Cr and Ni, respectively, at a t/4 point in the thickness direction of the steel sheet (where t represents the thickness (mm) of the steel sheet).)

[0069] That is, in the steel sheet according to an embodiment in the present disclosure, Cr and Ni, which are each added in a certain amount, may be mainly enriched on the surface side of the steel sheet rather than in the interior thereof, more specifically, immediately below a scale layer formed on the surface of the steel sheet. By enriching these hardenability elements on the surface side of the steel sheet (immediately below the scale layer), solid-solution strengthening and transformation strengthening effects may be introduced on the surface side of the steel sheet. As a result, an effect of preventing a decrease in hardness in the surface layer portion of the steel sheet may be obtained.

[0070] Accordingly, when the steel sheet according to an embodiment in the present disclosure is applied to structural members, reinforcing members, and the like of automobiles, there is an advantage in that resistance to continuous impacts occurring in an actual use environment may be enhanced.

[0071] Meanwhile, it should be noted that, in Relational Expression 2, Cr and Ni measured at the t/4 point in the thickness direction of the steel sheet represent the steel composition of the respective elements added to the steel sheet, and the contents measured at the t/4 point are used as representative values thereof. In other words, $\text{Cr}_{(1/4t)}$ and $\text{Ni}_{(1/4t)}$ in Relational Expression 2 represent the contents of Cr and Ni in the base steel sheet, respectively, and values measured at the t/4 point in the thickness direction are set as representative values thereof.

[0072] The steel sheet according to an embodiment in the present disclosure may include ferrite as a main phase in a microstructure, and may include one or more of bainite, martensite, and retained austenite as the remaining structure. Here, the remaining structure is referred to as a second phase.

[0073] In an embodiment in the present disclosure, ferrite formed as a main phase may be included in an area fraction of 90% or more. When the fraction of ferrite is less than 90%, ductility of the steel sheet may decrease.

[0074] Meanwhile, the steel sheet according to an embodiment in the present disclosure may ensure a target strength by including a bainite (B) phase and a martensite (M) phase, which are hard phases, as the second phase. As an example, the hard phases (B+M) may be included in an area fraction of 3% or more, and may not exceed 10% at maximum.

[0075] In addition, a retained austenite phase may be included as the second phase, and the retained austenite phase is a structure remaining after the above-described ferrite and hard phases are formed, and may be included in an amount of 0%. However, the retained austenite phase does not exceed 2% at maximum.

[0076] Meanwhile, inclusion of an extremely small amount of a pearlite (P) phase as the second phase is not excluded, and the second phase may be configured to include a retained austenite phase and pearlite in addition to hard phases.

[0077] The steel sheet according to an embodiment in the present disclosure may have properties suitable as a material for automobiles, particularly as a material for structural members, reinforcing members, and the like. As an example, the steel sheet according to an embodiment in the present disclosure may have a tensile strength of 590 MPa or more.

[0078] In addition, the steel sheet according to an embodiment in the present disclosure may have uniform surface hardness and an excellent hole expansion ratio.

[0079] As an example, the steel sheet may have a relationship between tensile strength (TS) and hole expansion ratio (HER) satisfying the following Relational Expression 3, and may have a surface hardness (Vickers hardness) of 170 or more. Here, the surface hardness is based on a hardness value measured from the surface of the steel sheet to

a depth of 2 μm in the thickness direction.

[Relational Expression 3]

$$TS \times HER \geq 30,000 \text{ MPa}\%$$

[0080] The steel sheet according to an embodiment in the present disclosure refers to a cold-rolled steel sheet, but may also include a plated steel sheet including a plating layer formed on at least one surface of the cold-rolled steel sheet.

[0081] In this case, the plating layer may be a zinc-based plating layer containing zinc (Zn) as a main component, and it should be noted that addition of Mg, Al, Si, and the like in addition to zinc is not excluded. That is, the plating layer may be a pure zinc plating layer or may be an alloy plating layer.

[0082] Hereinafter, a method for manufacturing a steel sheet according to another aspect of the present disclosure will be described in detail. It is noted that the manufacturing method described below corresponds to one example for manufacturing a steel sheet according to an embodiment in the present disclosure, particularly a cold-rolled steel sheet and a plated steel sheet using the cold-rolled steel sheet.

[0083] The steel sheet according to an embodiment in the present disclosure may be manufactured by subjecting a prepared steel slab to processes of [heating - hot rolling - coiling - cold rolling - annealing - cooling], and each process step will be described in detail below.

[Heating of steel slab]

[0084] First, a steel slab is prepared. In an embodiment in the present disclosure, the steel slab may be manufactured using a converter method or an electric furnace method. Thereafter, the prepared steel slab may be heated. The heating process of the steel slab is a process for smoothly performing a hot rolling process described below and sufficiently obtaining target properties of the steel sheet.

[0085] As an example, the steel slab may have the same alloy composition and alloy component relational expression (Relational Expression 1) as the steel sheet according to an embodiment in the present disclosure, and the descriptions of each alloying element and the component relational expression are as described above.

[0086] In an embodiment in the present disclosure, the steel slab may be heated in a temperature range of 1,000 to 1,350°C. When the heating temperature is lower than 1,000°C, a scale layer is not readily formed by selective oxidation of Fe, such that Cr and Ni cannot be sufficiently enriched immediately below the scale layer. On the other hand, when the temperature exceeds 1,350°C, scale is generated excessively.

[Hot rolling]

[0087] The heated steel slab may be hot-rolled to obtain a hot-rolled steel sheet.

[0088] In an embodiment in the present disclosure, the hot-rolled steel sheet may be manufactured by performing finish hot rolling in a temperature range of 800 to 1,000°C during the hot rolling. In an embodiment in the present disclosure, when the temperature during the finish hot rolling is lower than 800°C, a rolling load greatly increases. On the other hand, when the temperature exceeds 1,000°C, thermal fatigue of rolling rolls greatly increases.

[Coiling]

[0089] The manufactured hot-rolled steel sheet may be coiled.

[0090] In an embodiment in the present disclosure, the coiling process may be performed in a temperature range of 400 to 650°C. When the coiling temperature is lower than 400°C, bainite and martensite are excessively formed in the hot-rolled steel sheet, such that a rolling load increases during subsequent cold rolling. On the other hand, when the temperature exceeds 650°C, scale may be excessively formed on a surface of the hot-rolled steel sheet, which inhibits plating properties.

[Cold rolling]

[0091] The coiled hot-rolled steel sheet may be cold-rolled to manufacture a cold-rolled steel sheet. The cold rolling is a process performed to control the shape and thickness of the steel sheet.

[0092] In an embodiment in the present disclosure, a reduction ratio during cold rolling is not particularly limited. However, cold rolling may be performed at a reduction ratio of 30% or more in order to suppress formation of coarse ferrite during recrystallization in subsequent annealing. In addition, an upper limit of the reduction ratio is also not

particularly limited, and it is noted that those skilled in the art may appropriately select the upper limit depending on the target thickness.

[0093] Meanwhile, before performing the cold rolling, the hot-rolled steel sheet may be pickled to remove an oxide layer formed on the surface. In this case, the pickling may be performed under ordinary conditions, and the conditions thereof are not particularly limited.

[Annealing and cooling]

[0094] The manufactured cold-rolled steel sheet may be annealed and then cooled.

[0095] In an embodiment in the present disclosure, the annealing may be performed by heating the cold-rolled steel sheet to Ac1 or higher. When the temperature during the annealing is lower than Ac1, an austenite phase is not sufficiently formed during the annealing, such that a final microstructure may not be formed as intended, strength may deteriorate, and anisotropy of properties may become severe.

[0096] In an embodiment in the present disclosure, after the cold-rolled steel sheet is heated, the cold-rolled steel sheet may be held for a certain period of time. In this case, the holding process may be performed for 10 seconds or longer in order to induce sufficient recrystallization.

[0097] After the annealing and holding process is performed, the cold-rolled steel sheet may be cooled. In an embodiment in the present disclosure, the cooling may be performed to a temperature range of 450 to 650°C at a cooling rate of 35°C/s or less (excluding 0°C/s).

[0098] When the cooling rate during the cooling exceeds 35°C/s, non-uniformity in ferrite transformation behavior increases, such that shape defects such as a wave phenomenon may occur in the steel sheet, and strip breakage due to strip deviation may occur. In addition, when a cooling end temperature during the cooling is lower than 450°C, bainite and martensite phases are excessively formed, such that the hole expansion ratio of the steel sheet may decrease. On the other hand, when the temperature exceeds 650°C, pearlite is excessively formed, such that the hole expansion ratio of the steel sheet may also decrease. Meanwhile, a lower limit of the cooling rate during the cooling is not particularly limited, but the cooling may be performed at 3°C/s or more from the viewpoint of ensuring an intended microstructure, properties, and the like.

[0099] Meanwhile, when the annealing and cooling are performed as described above, a conveying speed of the steel sheet, that is, a line speed (mpm), may be 80 to 200 mpm. As an example, the annealing of the cold-rolled steel sheet obtained by cold rolling may be performed by charging the cold-rolled steel sheet into an annealing furnace. At this time, when the time during which the cold-rolled steel sheet passes through the furnace becomes excessive, oxides may be excessively formed on a surface of the steel sheet during annealing, and in consideration thereof, the line speed may be set to 80 mpm or more. However, when the speed exceeds 200 mpm, recrystallization may not sufficiently occur during annealing. In another embodiment in the present disclosure, the line speed of the steel sheet during annealing may be 100 mpm or more, and may also be 180 mpm or less.

[0100] According to an embodiment in the present disclosure, by controlling the alloy composition system and manufacturing conditions, a steel sheet (cold-rolled steel sheet) having soft ferrite and a predetermined fraction of hard phases may be obtained. In particular, by increasing enrichment amounts of Cr and Ni on the surface side of the steel sheet, uniform surface hardness may be ensured, and an excellent hole expansion ratio may be achieved.

[0101] In an embodiment in the present disclosure, the cold-rolled steel sheet may be plated to obtain a plated steel sheet, and, as an example, hot-dip galvanizing may be performed on the cold-rolled steel sheet.

[Hot-dip galvanizing]

[0102] The cold-rolled steel sheet according to an embodiment in the present disclosure may be immersed in a hot-dip zinc-based plating bath to manufacture a hot-dip zinc-based plated steel sheet.

[0103] In an embodiment in the present disclosure, the hot-dip galvanizing process may be performed under ordinary conditions, and as an example, may be performed in a temperature range of 440 to 480°C. In addition, the composition of the hot-dip zinc-based plating bath during the hot-dip galvanizing is not particularly limited, and may be a pure zinc plating bath or a zinc-based alloy plating bath containing Si, Al, Mg, and the like.

[Alloying heat treatment]

[0104] In addition, if necessary, an alloyed hot-dip zinc-based plated steel sheet may be obtained by subjecting the hot-dip zinc-based plated steel sheet manufactured by hot-dip galvanizing according to an embodiment in the present disclosure to alloying heat treatment.

[0105] In an embodiment in the present disclosure, conditions of the alloying heat treatment process are not particularly limited, and may be ordinary conditions. As an example, the alloying heat treatment process may be

performed in a temperature range of 480 to 600°C.

Mode for Invention

[0106] Hereinafter, the present disclosure will be described in more detail with reference to Examples. However, it should be noted that the following Examples are intended only to illustrate the present disclosure in more detail and are not intended to limit the scope of the present disclosure. This is because the scope of the present disclosure is determined by the matters recited in the claims and matters reasonably inferred therefrom.

(Examples)

[0107] After steel slabs having the alloy compositions shown in Table 1 were prepared, each steel slab was heated in a temperature range of 1,000 to 1,350°C. Thereafter, cold-rolled steel sheets were manufactured through a series of processes under the conditions shown in Table 2.

[0108] The microstructure and mechanical properties of each manufactured cold-rolled steel sheet were measured. The results are shown in Table 3.

[0109] First, Cr and Ni enrichment values from a surface of each cold-rolled steel sheet to a depth of 1 μm in a thickness direction were measured using a glow discharge analysis technique (GDS, Glow Discharge Spectrometer), and, among the resulting values, a (Cr+Ni) content at a point 500 nm deep from the surface was derived. In addition, a (Cr+Ni) content at a t/4 point in the thickness direction of each cold-rolled steel sheet (where t represents the thickness (mm) of the cold-rolled steel sheet) was determined by measuring the (Cr+Ni) content at 50 locations at the corresponding point using an SEM-EDS technique and then deriving an average value. From these values, a $\Delta(\text{Cr+Ni})$ value was calculated. The results are shown in Table 3.

[0110] The type and fraction of the microstructure of each cold-rolled steel sheet were measured by etching the steel sheet using a Nital etching method and then observing the etched steel sheet at a magnification of 1,000 to 5,000 using a scanning electron microscope (SEM) and an image analyzer.

[0111] Among the mechanical properties of each cold-rolled steel sheet, tensile strength (TS) and elongation at fracture (EI) were measured after ASTM standard specimens were taken in a direction parallel to a rolling direction. In addition, hardness was measured at the surface using a Micro-Vickers tester. At this time, a load of 500 g was applied, and in a state in which an analysis area was set to 20 mm $\times$ 10 mm (width $\times$ length), a total of 50 locations were measured at intervals of 2 mm, and the hardness was represented as the minimum hardness value.

[0112] In addition, the hole expansion ratio (HER) of each cold-rolled steel sheet was measured in accordance with the JSF T1001-1996 standard using a 90 mm $\times$ 120 mm (width $\times$ length) specimen.

[Table 1]

Classification	Alloy composition system (wt%)										
	C	Si	Mn	Sol.Al	P	S	N	Cr	Ni	Cu	Relational Expression 1
Inventive Steel 1	0.085	0.370	1.750	0.03	0.011	0.002	0.0026	0.039	0.025	0.060	2.941
Inventive Steel 2	0.086	0.381	1.731	0.03	0.011	0.006	0.0034	0.031	0.025	0.080	2.499
Inventive Steel 3	0.071	0.920	2.300	0.05	0.010	0.006	0.0030	0.052	0.082	0.370	2.476
Inventive Steel 4	0.071	0.920	2.300	0.06	0.010	0.006	0.0030	0.112	0.033	0.220	2.679
Inventive Steel 5	0.071	0.920	2.300	0.05	0.010	0.006	0.0030	0.112	0.097	0.115	3.862
Comparative Steel 1	0.085	0.360	1.710	0.06	0.012	0.007	0.0034	0.172	0.131	0.085	14.308
Comparative Steel 2	0.087	0.350	1.710	0.03	0.010	0.011	0.0031	0.001	0.002	0.283	0.146

EP 4 826 103 A1

(continued)

Classification	Alloy composition system (wt%)										
	C	Si	Mn	Sol.Al	P	S	N	Cr	Ni	Cu	Relational Expression 1
Comparative Steel 3	0.086	0.381	1.731	0.04	0.011	0.006	0.0034	0.041	0.023	0.085	2.856
Comparative Steel 4	0.086	0.381	1.731	0.06	0.011	0.006	0.0034	0.041	0.025	0.110	2.945
In Table 1, Comparative Steel 3 and Comparative Steel 4 are classified as Comparative Steels because the manufacturing conditions shown in Table 2 fall outside the scope of an embodiment in the present disclosure.											

[Table 2]

Classifica tion	Finish hot rolling temperature (°C)	Coiling temperature (°C)	Cold rolling reduction ratio (%)	Annealing					Plating		Thickness (mm)
				Line speed (m/min)	Ac 1	Annealing temperature (°C)	Cooling rate (°C/s)	Cooling temperature (°C)	Hot-dip galvanizing (°C)	Alloying heat treatment (°C)	
Inventive Steel 1	890	580	50	130	71 5	800	6	550	-	-	1.2
Inventive Steel 2	980	580	50	120	71 6	805	5	550	-	-	1.2
Inventive Steel 3	980	580	55	120	72 5	805	4	500	450	-	1.3
Inventive Steel 4	905	600	50	150	72 6	815	10	550	-	-	1.7
Inventive Steel 5	905	580	45	150	72 5	815	5	480	450	500	1.4
Comparative Steel 1	898	560	50	130	71 6	805	4	490	-	-	1.2
Comparative Steel 2	905	590	50	150	71 5	815	6	550	-	-	1.2
Comparative Steel 3	900	570	50	130	71 6	800	9	400	-	-	1.2
Comparative Steel 4	900	570	50	130	71 6	800	-	700	-	-	1.2
Comparative Steel 4 is a case in which, after annealing, a separate cooling process was not applied, and was left as it was after being annealed up to 700°C.											

[Table 3]

Classification	Relational Expression 2	Microstructure (area fraction)		Mechanical properties				
		F	Second phase (B+M+RA)	TS (MPa)	EI (%)	HER (%)	TS×HER (MPa%)	Surface hardness
Inventive Steel 1	0.206	95	5	653	26	59	38527	189
Inventive Steel 2	0.192	94	6	618	28	66	40788	172
Inventive Steel 3	0.206	94	6	785	21	51	40035	223
Inventive Steel 4	0.327	96	4	779	21	55	42845	232
Inventive Steel 5	0.362	93	7	793	20	40	31720	236
Comparative Steel 1	0.749	85	15	722	17	35	25270	211
Comparative Steel 2	0.037	95	5	599	30	70	41930	147
Comparative Steel 3	0.264	70	30	734	18	31	22754	194
Comparative Steel 4	0.242	85	15	668	19	27	18036	159
F represents ferrite, B represents bainite, M represents martensite, and RA represents a retained austenite phase. With respect to the remaining structure (second phase) other than F in the microstructure, inclusion of a small amount of a pearlite (P) phase is not excluded, and therefore the fraction of (B+M+RA) representing the remaining structure is a fraction that includes the P phase.								

[0113] As shown in Tables 1 to 3, in Inventive Steels 1 to 5, which satisfied the alloy composition system and manufacturing conditions according to an embodiment in the present disclosure, the microstructure was mainly formed of ferrite, and hard phases were appropriately formed. As a result, an excellent hole expansion ratio was achieved while high strength was obtained. In addition, by controlling enrichment behavior of Cr and Ni on the surface of the steel sheet, an excellent surface hardness value of 170 or more was obtained.

[0114] On the other hand, in Comparative Steels 1 to 4, which did not satisfy at least one of the alloy composition system and manufacturing conditions according to an embodiment in the present disclosure, intended properties could not be obtained.

[0115] Among them, in Comparative Steel 1, the enrichment amounts of Cr and Ni in the surface layer were excessive, and thus Relational Expression 2 was not satisfied. As a result, a ferrite phase was not sufficiently formed, and a remaining structure was excessively formed, such that the hole expansion ratio was poor. In Comparative Steel 2, the enrichment amounts of Cr and Ni in the surface layer were insufficient, such that the surface hardness was significantly low. Comparative Steels 3 and 4 are cases in which the annealing conditions among the manufacturing conditions were not satisfied. In Comparative Steel 3, the end temperature in the rapid cooling zone was controlled to be too low, such that the fraction of hard phases was excessive and the hole expansion ratio was poor. In Comparative Steel 4, the end temperature in the rapid cooling zone was controlled to be excessively high, such that the fraction of pearlite in the structure became excessive, the hole expansion ratio was poor, and the surface hardness was also low.

[0116] FIG. 1 shows GDS profile measurement results of Inventive Steel 1 and Comparative Steels 1 and 2.

[0117] That is, as a result of measuring the (Cr+Ni) content in the thickness direction from the surface of the steel sheet, it was confirmed that, based on around a depth of 0.1 μm in the thickness direction, the (Cr+Ni) content was excessively high in Comparative Steel 1 and was significantly low in Comparative Steel 2, whereas Cr and Ni were present at appropriate levels in Inventive Steel 5.

Claims

1. A steel sheet comprising, by wt%, 0.050 to 0.150% of carbon (C), 0.010 to 1.000% of silicon (Si), 1.000 to 3.000% of manganese (Mn), 0.01 to 0.10% of aluminum (Sol.Al), 0.001 to 0.050% of phosphorus (P), 0.001 to 0.020% of sulfur (S), 0.0010 to 0.0100% of nitrogen (N), 0.020 to 0.300% of chromium (Cr), 0.010 to 0.100% of nickel (Ni), 0.010 to 0.400% of copper (Cu), and the balance of Fe and other inevitable impurities,

wherein Si, Cr, and Ni satisfy the following Relational Expression 1, and

a relationship between the contents of Cr and Ni and the enrichment values of Cr and Ni in a surface layer portion satisfies the following Relational Expression 2:

[Relational Expression 1]

$$2.000 \leq 17(\text{Cr} + \text{Ni}) / \text{Si} \leq 4.000$$

where Cr, Ni, and Si represent the weight contents of the respective elements,

[Relational Expression 2]

$$0.150 \leq \Delta(\text{Cr} + \text{Ni}) \leq 0.500$$

$$\Delta(\text{Cr} + \text{Ni}) = [\text{Cr}_{(0.5 \mu\text{m})} + \text{Ni}_{(0.5 \mu\text{m})}] - [\text{Cr}_{(1/4t)} + \text{Ni}_{(1/4t)}]$$

where $\text{Cr}_{(0.5 \mu\text{m})}$ and $\text{Ni}_{(0.5 \mu\text{m})}$ represent the maximum enrichment values (wt%) of Cr and Ni, respectively, in a surface layer region from a surface of the steel sheet to a depth of 500 nm in a thickness direction, and $\text{Cr}_{(1/4t)}$ and $\text{Ni}_{(1/4t)}$ represent the weight average contents of Cr and Ni, respectively, at a t/4 point in the thickness direction of the steel sheet, where t is the thickness (mm) of the steel sheet.

2. The steel sheet of claim 1, further comprising one or more selected from molybdenum (Mo), niobium (Nb), and antimony (Sb) in a total content of 1.0% or less.
3. The steel sheet of claim 1, further comprising 0.0030% or less of boron (B).
4. The steel sheet of claim 1, wherein the steel sheet includes, as a microstructure, ferrite having an area fraction of 90% or more, and, as the balance, one or more of bainite, martensite, and retained austenite.
5. The steel sheet of claim 1, wherein the steel sheet has a tensile strength (TS) of 590 MPa or more, and a relationship between the tensile strength (TS) and a hole expansion ratio (HER) satisfies the following Relational Expression 3:

[Relational Expression 3]

$$\text{TS} \times \text{HER} \geq 30,000 \text{ MPa}\%.$$

6. The steel sheet of claim 1, wherein the steel sheet has a surface hardness (Vickers hardness) of 170 or more (where the surface hardness refers to a hardness value measured from the surface of the steel sheet to a depth of 2 μm in the thickness direction).
7. The steel sheet of any one of claims 1 to 6, wherein the steel sheet includes a zinc-based plating layer formed on at least one surface.
8. A method for manufacturing a steel sheet, the method comprising:

preparing a steel slab containing, by wt%, 0.050 to 0.150% of carbon (C), 0.010 to 1.000% of silicon (Si), 1.000 to 3.000% of manganese (Mn), 0.01 to 0.10% of aluminum (Sol.Al), 0.001 to 0.050% of phosphorus (P), 0.001 to 0.020% of sulfur (S), 0.0010 to 0.0100% of nitrogen (N), 0.020 to 0.300% of chromium (Cr), 0.010 to 0.100% of nickel (Ni), 0.010 to 0.400% of copper (Cu), and the balance of Fe and other inevitable impurities, Si, Cr, and Ni satisfying the following Relational Expression 1;
 heating the steel slab in a temperature range of 1,000 to 1,350°C;
 obtaining a hot-rolled steel sheet by finish hot rolling the heated steel slab in a temperature range of 800 to 1,000°C;
 coiling the hot-rolled steel sheet in a temperature range of 400 to 650°C;
 obtaining a cold-rolled steel sheet by cold rolling the coiled hot-rolled steel sheet at a reduction ratio of 30% or more;

annealing the cold-rolled steel sheet by heating the cold-rolled steel sheet to a temperature of Ac1 or higher and holding the cold-rolled steel sheet at the temperature; and cooling the annealed cold-rolled steel sheet to a temperature range of 450 to 650°C at a cooling rate of 35°C/s or less,

[Relational Expression 1]

$$2.000 \leq 17(\text{Cr} + \text{Ni}) / \text{Si} \leq 4.000$$

in Relational Expression 1, Cr, Ni, and Si represent the weight contents of the respective elements.

9. The method of claim 8, wherein, in the steel sheet, a relationship between the contents of Cr and Ni and the enrichment values of Cr and Ni in a surface layer portion satisfies the following Relational Expression 2:

[Relational Expression 2]

$$0.150 \leq \Delta(\text{Cr} + \text{Ni}) \leq 0.500$$

$$\Delta(\text{Cr} + \text{Ni}) = [\text{Cr}_{(0.5 \mu\text{m})} + \text{Ni}_{(0.5 \mu\text{m})}] - [\text{Cr}_{(1/4t)} + \text{Ni}_{(1/4t)}]$$

in Relational Expression 2, $\text{Cr}_{(0.5 \mu\text{m})}$ and $\text{Ni}_{(0.5 \mu\text{m})}$ represent the maximum enrichment values (wt%) of Cr and Ni, respectively, in a surface layer region from a surface of the steel sheet to a depth of 500 nm in a thickness direction, and $\text{Cr}_{(1/4t)}$ and $\text{Ni}_{(1/4t)}$ represent the weight average contents of Cr and Ni, respectively, at a t/4 point in the thickness direction of the steel sheet (where t represents the thickness (mm) of the steel sheet).

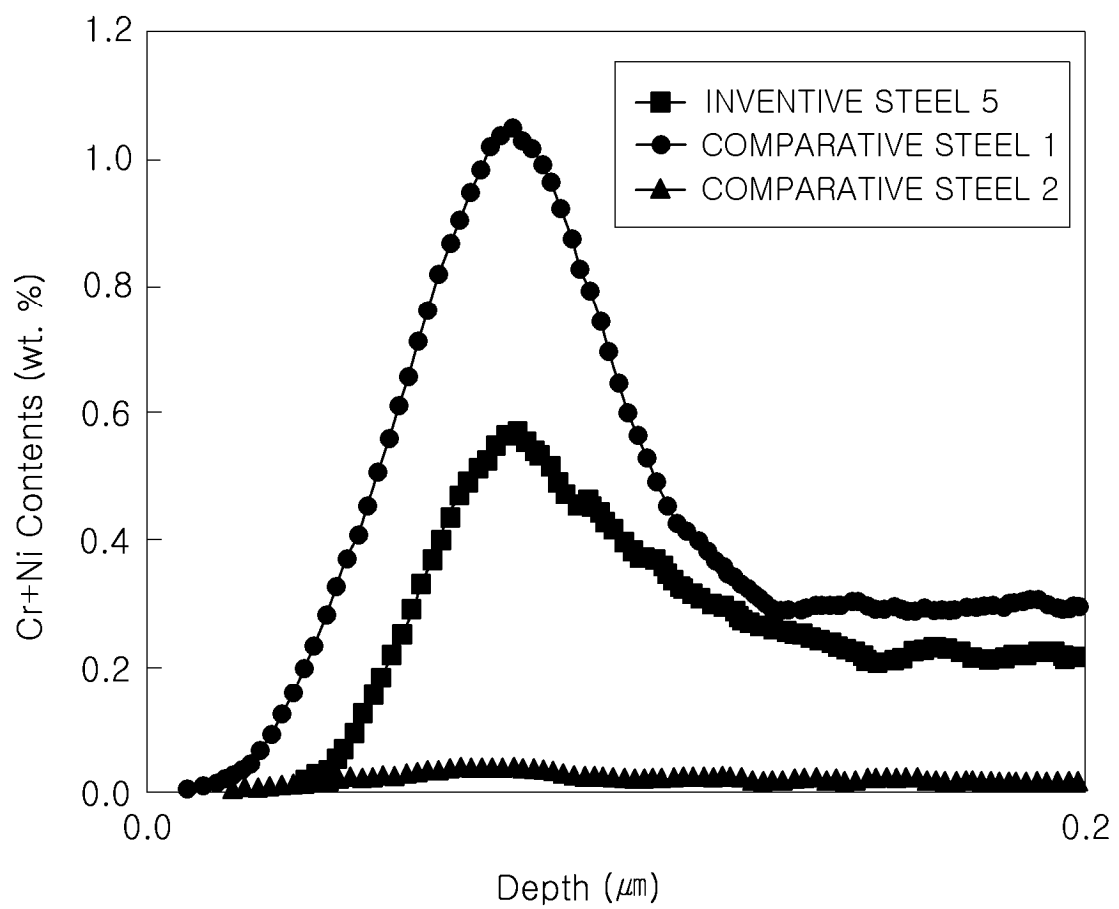
10. The method of claim 8, further comprising obtaining a hot-dip galvanized steel sheet by subjecting the cooled cold-rolled steel sheet to hot-dip galvanizing in a temperature range of 440 to 480°C.

11. The method of claim 10, further comprising subjecting the hot-dip galvanized steel sheet to alloying heat treatment.

12. The method of claim 8, wherein the steel slab further contains one or more selected from molybdenum (Mo), niobium (Nb), and antimony (Sb) in a total content of 1.0% or less.

13. The method of claim 8, wherein the steel slab further contains 0.0030% or less of boron (B).

[FIG. 1]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2024/096929

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/58(2006.01)i; C22C 38/42(2006.01)i; C22C 38/06(2006.01)i; C22C 38/00(2006.01)i; C22C 38/44(2006.01)i;
C22C 38/48(2006.01)i; C22C 38/54(2006.01)i; C23C 2/06(2006.01)i; C21D 8/02(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 38/58(2006.01); C21D 1/18(2006.01); C21D 1/22(2006.01); C21D 8/02(2006.01); C22C 38/00(2006.01);
C22C 38/04(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: 냉연강판(cold rolled steel sheet), 크롬(chromium), 니켈(nickel), 구리(copper), 페라이트(ferrite), 냉각(cooling), 열연(hot rolled), 소둔(annealing)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 6260750 B1 (JFE STEEL CORP.) 17 January 2018 (2018-01-17) See paragraphs [0054], [0056], [0063], [0069], [0082], [0101], [0105] and [0108], claims 1-6 and 8 and table 3.	1-13
A	JP 7173303 B2 (NIPPON STEEL CORPORATION) 08 December 2022 (2022-12-08) See paragraphs [0080]-[0081] and claim 1.	1-13
A	KR 10-2023-0098625 A (JFE STEEL CORPORATION) 04 July 2023 (2023-07-04) See paragraphs [0230]-[0236] and claims 1 and 7.	1-13
A	KR 10-2022-0079609 A (NIPPON STEEL CORPORATION) 13 June 2022 (2022-06-13) See paragraphs [0369]-[0373] and claims 1 and 7.	1-13
A	WO 2023-170245 A1 (TATA STEEL NEDERLAND TECHNOLOGY B.V.) 14 September 2023 (2023-09-14) See claim 1 and figure 1.	1-13

☐ 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	Date of mailing of the international search report
18 March 2025	18 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	Authorized officer
Facsimile No. +82-42-481-8578	Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2024/096929

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 6260750 B1	17 January 2018	JP WO2017-169941 A1	05 April 2018
		MX 2018011888 A	10 January 2019
		US 10920293 B2	16 February 2021
		US 2019-0085421 A1	21 March 2019
		WO 2017-169941 A1	05 October 2017
JP 7173303 B2	08 December 2022	CN 113597473 A	02 November 2021
		CN 113597473 B	01 November 2022
		JP WO2020-209276 A1	09 December 2021
		US 2022-0119909 A1	21 April 2022
		WO 2020-209276 A1	15 October 2020
KR 10-2023-0098625 A	04 July 2023	CN 116635541 A	22 August 2023
		EP 4261306 A1	18 October 2023
		EP 4261306 A4	31 July 2024
		JP 7111279 B1	02 August 2022
		JP WO2022-138395 A1	30 June 2022
		MX 2023007615 A	13 July 2023
		US 2024-0035105 A1	01 February 2024
		WO 2022-138395 A1	30 June 2022
KR 10-2022-0079609 A	13 June 2022	CN 114667360 A	24 June 2022
		CN 114667360 B	11 August 2023
		EP 4089192 A1	16 November 2022
		EP 4089192 A4	22 February 2023
		JP 7216933 B2	02 February 2023
		JP WO2021-141006 A1	15 July 2021
		KR 10-2742082 B1	16 December 2024
		MX 2022005496 A	02 June 2022
		US 2022-0389531 A1	08 December 2022
		WO 2021-141006 A1	15 July 2021
WO 2023-170245 A1	14 September 2023	EP 4490329 A1	15 January 2025
		KR 10-2024-0161095 A	12 November 2024

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- KR 20230032302 [0007]
- KR 100711358 [0007]
- KR 101313957 [0007]