



(11)

EP 4 826 079 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: **24904323.3**
- (22) Date of filing: **16.12.2024**

- (51) International Patent Classification (IPC):
C22C 38/38 ^(2006.01) **C22C 38/22** ^(2006.01)
C22C 38/32 ^(2006.01) **C22C 38/28** ^(2006.01)
C22C 38/26 ^(2006.01) **C22C 38/06** ^(2006.01)
C22C 38/00 ^(2006.01) **C22C 38/34** ^(2006.01)
C21D 8/02 ^(2026.01)
- (52) Cooperative Patent Classification (CPC):
C21D 8/02; C22C 38/00; C22C 38/06; C22C 38/22;
C22C 38/26; C22C 38/28; C22C 38/32;
C22C 38/34; C22C 38/38
- (86) International application number:
PCT/KR2024/020424
- (87) International publication number:
WO 2025/127758 (19.06.2025 Gazette 2025/25)

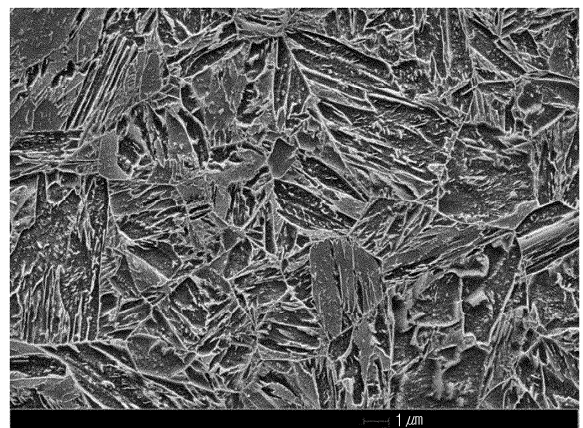
- (84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN
- (30) Priority: **15.12.2023 KR 20230182937**
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(54) **COLD ROLLED STEEL SHEET AND METHOD OF MANUFACTURING SAME**

(57) The purpose of one aspect of the present invention is to provide a cold rolled steel sheet and a method of manufacturing same. The purpose of a preferred aspect of the present invention is to provide an ultra-high strength cold rolled steel sheet having excellent formability due to high elongation and hole expandability, and a method of manufacturing same.

[FIG. 1]



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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 cold-rolled steel sheet and a method for manufacturing the same that can be preferably applied to automobile collision and structural members.

Background Art

10 **[0002]** Recently, steel sheets for automobiles are required to have higher strength for improving fuel efficiency or durability due to various environmental regulations and energy use regulations. In particular, as impact stability regulations for automobiles have recently spread, high-strength steel with excellent yield strength has been adopted for structural members such as a member, a seat rail, and a pillar to improve the impact resistance of a vehicle body.
 15 The higher the yield strength of the structural member compared to the tensile strength, that is, the higher the yield ratio (yield strength/tensile strength), the more advantageous it is in terms of impact energy absorption capability. However, in general, as the strength of the steel sheet increases, the elongation decreases, causing a problem of deterioration in formability, and thus the development of a material that can compensate for this is required.

[0003] Typically, methods for strengthening steel include solid-solution strengthening, precipitation strengthening, strengthening by grain refinement, and transformation strengthening. However, among these methods, strengthening by solid-solution strengthening and grain refinement has a disadvantage in that it is very difficult to manufacture high-strength steel with a tensile strength of 490 MPa or more.

20 **[0004]** Precipitation-strengthened high-strength steel is a technology that secures strength by adding carbide- and nitride-forming elements such as Cu, Nb, Ti, and V to precipitate carbides and nitrides to strengthen the steel sheet, or by refining grains through the suppression of grain growth by fine precipitates. This technology has the advantage of easily obtaining high strength at a low manufacturing cost, but it has a disadvantage in that high-temperature annealing must be performed to secure ductility by causing sufficient recrystallization, as the recrystallization temperature sharply increases due to fine precipitates. In addition, there is a problem in that it is difficult to obtain high-strength steel of 600 MPa or higher with precipitation-strengthened steel that strengthens a ferrite matrix by precipitating carbides and nitrides.

30 **[0005]** Various types of transformation-strengthened high-strength steels have been developed, such as Dual Phase (DP) steel with a ferrite-martensite dual-phase structure including hard martensite in a ferrite matrix, Transformation Induced Plasticity (TRIP) steel using the transformation-induced plasticity of retained austenite, or Complex Phase (CP) steel composed of ferrite and a hard bainite or martensite structure. However, in such Advanced High Strength Steel (AHSS), the elongation is limited to about 8% when the achievable tensile strength is 1500 MPa. Furthermore, for application as structural members to ensure crash safety, Hot Press Forming (HPF) steel, which secures final strength by quenching through direct contact with a die that is water-cooled after forming at high temperature, is gaining attention, but its application is not widespread due to excessive facility investment costs and high heat treatment and process costs.

40 **[0006]** Recently, to further improve passenger safety during a collision, high-strengthening and weight reduction of vehicle seat components are being pursued simultaneously. These components are manufactured by two methods: roll forming and press forming. As a component connecting the passenger and the vehicle body, the seat component must provide support with high stress to prevent the passenger from being ejected outward during a collision. For this, high yield strength and a high yield ratio are necessary. In addition, since most of the processed components require stretch-flangeability, the application of a steel material with excellent hole expandability is required.

45 **[0007]** Meanwhile, Patent Document 1 discloses a high-tensile-strength cold-rolled steel sheet with a tensile strength of 880-1170 MPa, controlled to have a martensite single-phase structure by optimizing the alloy composition and heat treatment conditions. Patent Document 2 discloses a method for manufacturing a high-tensile-strength steel sheet, wherein a steel sheet in which the volume fraction of a low-temperature transformation phase composed of martensite and retained austenite accounts for 90% or more of the entire metal structure is held by heating in a two-phase region, thereby controlling it to a structure of fine ferrite and austenite including laths of the low-temperature transformation phase, and then by subsequent cooling, finally obtaining a metal structure in which ferrite and the low-temperature transformation phase are finely dispersed in a lath-like form.

50 **[0008]** However, although Patent Documents 1 and 2 claim that high yield strength can be obtained without a water-cooling treatment, there are disadvantages such as very low ductility or low stretch-flangeability due to the massive generation of austenite in the steel.

55 **[0009]** Therefore, there is a need for the development of an ultra-high-strength cold-rolled steel sheet with excellent formability due to high elongation and hole expandability.

[Prior Art Documents]

[0010]

(Patent Document 1) Japanese Patent Publication No. 3729108

(Patent Document 2) Japanese Unexamined Patent Application Publication No. 2005-272954

Disclosure of Invention

Technical Problem

[0011] An aspect of the present disclosure is to provide a cold-rolled steel sheet and a method for manufacturing the same.**[0012]** A preferred aspect of the present disclosure is to provide an ultra-high-strength cold-rolled steel sheet with excellent formability due to high elongation and hole expandability, and a method for manufacturing the same.

Solution to Problem

[0013] An embodiment of the present disclosure provides a cold-rolled steel sheet comprising, by weight %: C: 0.050-0.40%, Mn: 1.0-3.0%, Cr: 0.010-1.20%, P: 0.0010-0.10%, S: 0.010% or less (excluding 0%), Si+Sol.Al: 0.10-3.0%, Mo: 0.020-0.20%, and B: 0.0010-0.0050%, with the balance being Fe and other unavoidable impurities; satisfying the following Relational Expression 1; and having a microstructure comprising, by area %: 70-95% of one or more of bainite and tempered martensite, 3-15% of retained austenite, and a remainder structure, wherein the bainite and the tempered martensite have an average grain size of 3 μm or less.

$$2.40 \leq X = 7C + (1.3\text{Si} + \text{Mn})/6 + (\text{Cr} + 1.2\text{Mo})/5 + 100B \leq 3.0 \quad [\text{Relational Expression 1}]$$

(wherein, the content of each alloying element in Relational Expression 1 signifies weight %.)

[0014] The cold-rolled steel sheet may further include one or more of N: 0.0010-0.010%, Ti: 0.010-0.120%, and Nb: 0.0010-0.050%.**[0015]** The content of Si may be 2.50% or less (excluding 0%), and the content of Sol.Al may be 0.010-0.10%.**[0016]** The remainder structure may include one or more of fresh martensite: 10% or less (including 0%) and ferrite: 5% or less (including 0%).**[0017]** The cold-rolled steel sheet may have a yield strength (YS) of 1100 MPa or more, a tensile strength (TS) of 1450 MPa or more, an elongation (EI) of 9% or more, and a hole expansion ratio (HER) of 30% or more.**[0018]** The cold-rolled steel sheet may have a product of tensile strength (TS) and elongation (EI) of 13050 MPa% or more.

[0019] Another embodiment of the present disclosure provides a method for manufacturing a cold-rolled steel sheet, comprising: a step of heating a slab comprising, by weight %: C: 0.050-0.40%, Mn: 1.0-3.0%, Cr: 0.010-1.20%, P: 0.0010-0.10%, S: 0.010% or less (excluding 0%), Si+Sol.Al: 0.10-3.0%, Mo: 0.020-0.20%, and B: 0.0010-0.0050%, with the balance being Fe and other unavoidable impurities, and satisfying the following Relational Expression 1; a step of finish hot rolling the heated slab to obtain a hot-rolled steel sheet; a step of coiling the hot-rolled steel sheet; a step of cold rolling the coiled hot-rolled steel sheet to obtain a cold-rolled steel sheet; a step of continuously annealing the cold-rolled steel sheet at a continuous annealing temperature (SS) of 750-900°C; a step of first cooling the continuously annealed cold-rolled steel sheet; a step of second cooling the first-cooled cold-rolled steel sheet to a second cooling end temperature (Tq) of 150-350°C; and a step of reheating the second-cooled cold-rolled steel sheet at a reheating temperature (Tp) of 200-450°C; wherein the method satisfies the following Relational Expression 2.

$$2.40 \leq X = 7C + (1.3\text{Si} + \text{Mn})/6 + (\text{Cr} + 1.2\text{Mo})/5 + 100B \leq 3.0 \quad [\text{Relational Expression 1}]$$

$$175 \leq Y = 0.3(\text{SS} - \text{A1}) + 0.85(\text{Ms} - \text{Tq}) - 1.22(\text{Tp} - \text{Tq}) + 52X \leq 216 \quad [\text{Relational Expression 2}]$$

$$[\text{Equation 2}] \quad \text{A1} (^\circ\text{C}) = 723 - 10.7\text{Mn} - 16.9\text{Ni} + 29.1\text{Si} + 16.9\text{Cr}$$

$$[\text{Equation 3}] \text{ Ms } (^{\circ}\text{C}) = 539 - 423\text{C} - 30.4\text{Mn} - 12.1\text{Cr} - 7.5\text{Mo}$$

(wherein, in Relational Expression 1, the content of each alloying element is in weight %, and in Relational Expression 2, SS denotes the continuous annealing temperature, A1 denotes the eutectoid transformation temperature, Ms denotes the martensite transformation start temperature, Tq denotes the second cooling end temperature, and Tp denotes the reheating temperature, where A1 is expressed by Equation 2, Ms is expressed by Equation 3, and X denotes $7\text{C} + (1.3\text{Si} + \text{Mn})/6 + (\text{Cr} + 1.2\text{Mo})/5 + 100\text{B}$.)

[0020] The slab heating may be performed at 1000-1350°C.

[0021] The finish hot rolling may be performed at Ar3-1000°C.

[0022] The coiling may be performed at 450-750°C.

[0023] The cold rolling may be performed at a cold reduction ratio of 20-90%.

[0024] The first cooling may be performed to a first cooling end temperature of 550-750°C.

[0025] The first cooling may be performed at a first cooling rate of 1-10°C/s.

[0026] The second cooling may be performed at a second cooling rate of 5-60°C/s.

[0027] After the reheating, a step of temper rolling the cold-rolled steel sheet at an elongation of 0.010-1.0% may be further included.

Advantageous Effects of Invention

[0028] According to an aspect of the present disclosure, a cold-rolled steel sheet and a method for manufacturing the same can be provided.

[0029] According to a preferred aspect of the present disclosure, an ultra-high-strength cold-rolled steel sheet with excellent formability due to high elongation and hole expandability, and a method for manufacturing the same, can be provided.

Brief Description of Drawings

[0030] FIG. 1 is a photograph of Inventive Example 1 according to an embodiment of the present disclosure, observed using a scanning electron microscope (SEM).

Best Mode for the Invention

[0031] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the term "comprises" when used in this specification, specifies the presence of stated features, integers, steps, operations, elements, and/or components, but does not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0032] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure, and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0033] Hereinafter, a cold-rolled steel sheet according to an embodiment of the present disclosure will be described. First, the alloy composition of the present disclosure will be described. However, the content of the alloy composition described below signifies weight % unless otherwise specified.

C: 0.050-0.40%

[0034] Carbon (C) is a very important element added to strengthen the transformation structure. C promotes high strength and facilitates the formation of martensite in transformation-structured steel. As the C content increases, the amount of martensite in the steel increases. However, if the C content exceeds 0.40%, the strength of martensite increases, but the strength difference with ferrite, which has a low carbon concentration, becomes large, and this strength difference easily causes fracture at the interphase interface when stress is applied, thereby deteriorating stretch-flangeability. In addition, weldability deteriorates, causing welding defects during component processing by customers. On the other hand, if the C content is less than 0.050%, it is very difficult to secure the strength of martensite desired in the present disclosure. Therefore, it is preferable that the C content is in the range of

0.050-0.40%.

[0035] More preferably, the lower limit of the C content is 0.080%, and even more preferably 0.10%. More preferably, the upper limit of the C content is 0.350%, and even more preferably 0.30%.

[0036] Mn: 1.0-3.0% Manganese (Mn) is an element that refines grains without impairing ductility and strengthens steel by completely precipitating sulfur in the steel as MnS, thereby preventing hot shortness due to the formation of FeS. In addition, it serves to lower the critical cooling rate at which the martensite phase is obtained, thereby allowing martensite to be formed more easily. If the Mn content is less than 1.0%, it may be difficult to sufficiently secure the aforementioned effects. If the Mn content exceeds 3.0%, problems such as weldability and hot-rollability are likely to occur. Therefore, it is preferable that the Mn content is in the range of 1.0-3.0%.

[0037] More preferably, the lower limit of the Mn content is 1.20%, even more preferably 1.50%, and most preferably 1.70%. More preferably, the upper limit of the Mn content is 2.90%, even more preferably 2.70%, and most preferably 2.50%.

[0038] Cr: 0.010-1.20% Chromium (Cr) is a component added to improve the hardenability of steel and secure high strength, and is an effective element for forming martensite, a low-temperature transformation phase. If the Cr content is less than 0.010%, it is difficult to sufficiently obtain the aforementioned effects. If the Cr content exceeds 1.20%, not only are the effects saturated, but cold-rollability may also deteriorate as the strength of the hot-rolled steel sheet excessively increases. Therefore, it is preferable that the Cr content is in the range of 0.010-1.20%.

[0039] More preferably, the lower limit of the Cr content is 0.050%, even more preferably 0.10%, and most preferably 0.30%. More preferably, the upper limit of the Cr content is 1.0%, even more preferably 0.80%, and most preferably 0.70%.

[0040] P: 0.0010-0.10% Phosphorus (P), as a substitutional alloying element with the greatest solid-solution strengthening effect, serves to improve in-plane anisotropy and enhance strength. If the P content is less than 0.0010%, it may be difficult to sufficiently secure this effect, and it may also cause a problem of increased manufacturing costs. If the P content exceeds 0.10%, press formability deteriorates and brittleness of the steel may occur. Therefore, it is preferable that the P content is in the range of 0.0010-0.10%.

[0041] More preferably, the lower limit of the P content is 0.0050%, even more preferably 0.0080%, and most preferably 0.010%. More preferably, the upper limit of the P content is 0.080%, even more preferably 0.060%, and most preferably 0.040%.

[0042] S: 0.010% or less (excluding 0%) Sulfur (S) is an impurity element in steel that impairs the ductility and weldability of the steel sheet. If the S content exceeds 0.010%, it is highly likely to impair the ductility and weldability of the steel sheet, so in the present disclosure, it is preferable to limit the S content to 0.010% or less. More preferably, the S content is 0.0050% or less, even more preferably 0.0010% or less, and most preferably 0.0009% or less.

Si+Sol.Al: 0.10-3.0%

[0043] If the content of Si+Sol.Al is less than 0.10%, elongation may be reduced. If the content of Si+Sol.Al exceeds 3.0%, weldability may be deteriorated. Therefore, it is preferable that the content of Si+Sol.Al is in the range of 0.10-3.0%. More preferably, the lower limit of the Si+Sol.Al content is 0.50%, even more preferably 0.80%, and most preferably 1.0%. More preferably, the upper limit of the Si+Sol.Al content is 2.80%, even more preferably 2.60%, and most preferably 2.50%.

[0044] The content of Si may be 2.50% or less (excluding 0%). Silicon (Si) promotes ferrite transformation and increases the carbon content in untransformed austenite, forming a composite structure of ferrite and martensite, which hinders the increase in martensite strength. In addition, in relation to surface properties, it is desirable to limit its addition as much as possible because it not only causes surface scale defects but also deteriorates phosphatability. Accordingly, in the present disclosure, the Si content can be controlled to 2.50% or less. More preferably, the Si content is 2.30% or less, even more preferably 2.10% or less, and most preferably 2.0% or less.

[0045] The content of Sol.Al may be 0.010-0.10%. Soluble aluminum (Sol.Al) is an effective element not only for deoxidation by combining with oxygen in the steel, but also for improving the hardenability of martensite by partitioning carbon in ferrite to austenite. If the content of Sol.Al is less than 0.010%, it may be difficult to sufficiently secure this effect. If the content of Sol.Al exceeds 0.10%, the effect is saturated and manufacturing costs may increase. Therefore, the content of Sol.Al may be in the range of 0.010-0.10%. More preferably, the lower limit of the Sol.Al content is 0.0150%, and even more preferably 0.020%. More preferably, the upper limit of the Sol.Al content is 0.090%, even more preferably 0.080%, and most preferably 0.070%.

Mo: 0.020-0.20%

[0046] Molybdenum (Mo) is an element advantageous for securing strength through improvement of hardenability and formation of Mo-based precipitates. If the Mo content is less than 0.020%, it may be difficult to sufficiently secure

this effect. If the Mo content exceeds 0.20%, coarse carbides may form, which can be a disadvantage in that elongation deteriorates. Therefore, it is preferable that the Mo content is in the range of 0.020-0.20%. More preferably, the lower limit of the Mo content is 0.030%, even more preferably 0.040%, and most preferably 0.050%. More preferably, the upper limit of the Mo content is 0.190%, even more preferably 0.180%, and most preferably 0.170%.

B: 0.0010-0.0050%

[0047] Boron (B) is an element that delays the transformation of austenite to pearlite during the cooling process after annealing, and is an element that suppresses ferrite formation and promotes martensite formation. If the B content is less than 0.0010%, it may be difficult to sufficiently secure this effect. If the B content exceeds 0.0050%, there may be a disadvantage of increased manufacturing costs due to an excess of ferroalloy. Therefore, it is preferable that the B content is in the range of 0.0010-0.0050%. More preferably, the lower limit of the B content is 0.00120%, even more preferably 0.00140%, and most preferably 0.00150%. More preferably, the upper limit of the B content is 0.00450%, even more preferably 0.0040%, and most preferably 0.00350%.

[0048] The remaining component is iron (Fe). However, in a normal manufacturing process, unintended impurities may be inevitably incorporated from raw materials or the surrounding environment, so these cannot be excluded. Since these impurities are known to any person skilled in the art of the normal manufacturing process, all of their details are not specifically mentioned in this specification.

[0049] The cold-rolled steel sheet of the present disclosure may further include one or more of N: 0.0010-0.010%, Ti: 0.010-0.120%, and Nb: 0.0010-0.050%.

N: 0.0010-0.010%

[0050] Nitrogen (N) is a component that has an effective action of stabilizing austenite. If the N content is less than 0.0010%, it is difficult to sufficiently obtain the aforementioned effect. If the N content exceeds 0.010%, the risk of cracking during continuous casting increases significantly due to the formation of AlN and the like. Therefore, it is preferable that the N content is in the range of 0.0010-0.010%. More preferably, the lower limit of the N content is 0.0020%, and even more preferably 0.0030%. More preferably, the upper limit of the N content is 0.0090%, even more preferably 0.0080%, and most preferably 0.0070%.

Ti: 0.010-0.120%

[0051] Titanium (Ti) is an element effective for grain refinement by precipitating nano-precipitates through an increase in the strength of the steel sheet and bonding with carbon. These nano-precipitates also serve to strengthen the matrix structure, thereby reducing the hardness difference between phases. If the Ti content is less than 0.010%, it may be difficult to sufficiently secure this effect. If the Ti content exceeds 0.120%, ductility may be deteriorated due to the formation of coarse precipitates. Therefore, it is preferable that the Ti content is in the range of 0.010-0.120%. More preferably, the lower limit of the Ti content is 0.020%, and even more preferably 0.030%. More preferably, the upper limit of the Ti content is 0.110%, and even more preferably 0.10%.

Nb: 0.0010-0.050%

[0052] Niobium (Nb) is an element effective for grain refinement by precipitating nano-precipitates through an increase in the strength of the steel sheet and bonding with carbon. These nano-precipitates also serve to strengthen the matrix structure, thereby reducing the hardness difference between phases. If the Nb content is less than 0.0010%, it may be difficult to sufficiently secure this effect. If the Nb content exceeds 0.050%, ductility may be deteriorated due to the formation of coarse precipitates. Therefore, it is preferable that the Nb content is in the range of 0.0010-0.050%. More preferably, the lower limit of the Nb content is 0.00150%, and even more preferably 0.0020%. More preferably, the upper limit of the Nb content is 0.0450%, and even more preferably 0.040%.

[0053] The cold-rolled steel sheet of the present disclosure can satisfy the aforementioned alloy composition and, at the same time, satisfy the following Relational Expression 1. Relational Expression 1 is for securing high strength, which is the object of the present disclosure, while also securing hole expansion ratio (HER) and elongation. If the X value is less than 2.40, the target tensile strength of the present disclosure cannot be obtained. If the X value exceeds 3.0, not only the target tensile strength but also the elongation of the present disclosure cannot be obtained. Therefore, it is advantageous for the X value to be in the range of 2.40-3.0. More preferably, the lower limit of the X value is 2.420, even more preferably 2.440, and most preferably 2.460. More preferably, the upper limit of the X value is 2.90, even more preferably 2.80, and most preferably 2.70.

$$2.40 \leq X = 7C + (1.3Si + Mn)/6 + (Cr + 1.2Mo)/5 + 100B \leq 3.0$$

[Relational Expression 1]

(wherein, the content of each alloying element in Relational Expression 1 signifies weight %.)

[0054] The microstructure of the cold-rolled steel sheet of the present disclosure may comprise, by area %: 70-95% of one or more of bainite and tempered martensite, 3-15% of retained austenite, and a remainder structure. The bainite and tempered martensite are structures advantageous for securing tensile strength. If the fraction of one or more of bainite and tempered martensite is less than 70%, the target tensile strength of the present disclosure cannot be obtained. If the fraction of one or more of bainite and tempered martensite exceeds 95%, the target elongation of the present disclosure cannot be obtained. The retained austenite is a structure advantageous for securing elongation. If the fraction of retained austenite is less than 3%, the target elongation of the present disclosure cannot be obtained. If the fraction of retained austenite exceeds 15%, the target tensile strength of the present disclosure cannot be obtained. The remainder structure is an impurity structure that may be unavoidably formed during the manufacturing process. The remainder structure may include one or more of fresh martensite: 10% or less (including 0%) and ferrite: 5% or less (including 0%). The fresh martensite is a structure disadvantageous for securing formability. If the fraction of fresh martensite exceeds 10%, it may be difficult to secure the target formability of the present disclosure. The ferrite is a structure disadvantageous for securing formability. If the fraction of ferrite exceeds 5%, the hardness difference between phases may increase, thereby reducing hole expandability.

[0055] The bainite and tempered martensite may have an average grain size of 3 μm or less. If the average grain size of the bainite and tempered martensite exceeds 3 μm , it may be disadvantageous for securing formability. Meanwhile, as an example, the average grain size of the bainite and tempered martensite can be measured using electron backscatter diffraction (EBSD) analysis.

[0056] The cold-rolled steel sheet may have a yield strength (YS) of 1100 MPa or more, a tensile strength (TS) of 1450 MPa or more, an elongation (El) of 9% or more, and a hole expansion ratio (HER) of 30% or more. More preferably, the tensile strength (TS) is 1470 MPa or more, and the elongation (El) is 10% or more. Meanwhile, in the present disclosure, the upper limits of the yield strength, tensile strength, elongation, and hole expandability are not particularly limited, but for example, the upper limit of the yield strength may be 1470 MPa, the upper limit of the tensile strength may be 1700 MPa, the upper limit of the elongation may be 20%, and the upper limit of the hole expandability may be 40%. In addition, the cold-rolled steel sheet according to an embodiment of the present disclosure may have a product of tensile strength (TS) and elongation (El) of 13050 MPa% or more. More preferably, the product of tensile strength (TS) and elongation (El) is 14700 MPa% or more. In the present disclosure, the upper limit of the product of tensile strength (TS) and elongation (El) is not particularly limited, but for example, the upper limit of the product of tensile strength (TS) and elongation (El) may be 34000 MPa%.

[0057] Hereinafter, a method for manufacturing a cold-rolled steel sheet according to an embodiment of the present disclosure will be described.

[0058] First, a slab satisfying the aforementioned alloy composition and Relational Expression 1 is heated. The slab heating may be performed at 1000-1350°C. If the heating temperature of the slab is less than 1000°C, there is a possibility that it will be hot-rolled in a region below the finish hot rolling temperature range. If the heating temperature of the slab exceeds 1350°C, there is a possibility that it will melt by reaching the melting point of the steel. Therefore, the slab heating may be performed at 1000-1350°C. More preferably, the lower limit of the heating temperature of the slab is 1100°C, even more preferably 1130°C, and most preferably 1150°C. More preferably, the upper limit of the heating temperature of the slab is 1280°C, even more preferably 1260°C, and most preferably 1250°C.

[0059] Thereafter, the heated slab is finish hot rolled to obtain a hot-rolled steel sheet. The finish hot rolling may be performed at Ar3-1000°C. If the finish hot rolling temperature is less than Ar3, the hot deformation resistance is likely to increase sharply, and problems may occur in the manufacturing process. If the finish hot rolling temperature exceeds 1000°C, not only may excessively thick oxide scale be generated, but the microstructure of the steel sheet is also likely to become coarse. Therefore, the finish hot rolling may be performed at Ar3-1000°C. More preferably, the lower limit of the finish hot rolling temperature is 800°C, even more preferably 850°C, and most preferably 870°C. More preferably, the upper limit of the exit-side temperature of the finishing mill during finish hot rolling is 980°C, even more preferably 970°C, and most preferably 960°C. Meanwhile, the Ar3 can be obtained through the following [Equation 1].

$$\text{Ar3}(\text{°C}) = 910 - 203\sqrt{C} - 30Mn + 44.7Si - 11Cr + 31.5Mo - 15.2Ni$$

[Equation 1]

[0060] Thereafter, the hot-rolled steel sheet is coiled. The coiling may be performed at 450-750°C. If the coiling temperature is less than 450°C, excessive martensite or bainite may be generated, causing an excessive increase in the strength of the hot-rolled steel sheet, which may lead to problems such as poor shape due to the load during cold rolling. If the coiling temperature exceeds 750°C, pickling properties may deteriorate due to an increase in surface

scale. Therefore, it is advantageous for the coiling temperature to be in the range of 450-750°C. More preferably, the lower limit of the coiling temperature is 465°C, even more preferably 480°C, and most preferably 495°C. More preferably, the upper limit of the coiling temperature is 700°C, even more preferably 650°C, and most preferably 600°C.

[0061] Thereafter, the coiled hot-rolled steel sheet is cold-rolled to obtain a cold-rolled steel sheet. In the present disclosure, the cold rolling conditions are not particularly limited, and any conditions used in the art can be used. However, as an example, the cold rolling may be performed at a cold reduction ratio of 20-90%. If the cold reduction ratio is less than 20%, it is difficult to secure the target thickness precision, and it may be difficult to correct the shape of the steel sheet. If the cold reduction ratio exceeds 90%, cracks may occur at the edge of the steel sheet, and the cold rolling load may become excessively large in terms of productivity. Therefore, the cold reduction ratio may be 20-90%. More preferably, the lower limit of the cold reduction ratio is 23%, even more preferably 25%, and most preferably 30%. More preferably, the upper limit of the cold reduction ratio is 80%, even more preferably 70%, and most preferably 50%.

[0062] Thereafter, the cold-rolled steel sheet is continuously annealed at a continuous annealing temperature (SS) of 750-900°C. If the continuous annealing temperature is less than 750°C, a large amount of ferrite is generated, making it difficult to secure the target yield strength and tensile strength of the present disclosure. If the continuous annealing temperature exceeds 900°C, the grain size of austenite increases, which may increase the packet size of martensite formed during cooling. Therefore, it is advantageous for the continuous annealing temperature to be in the range of 750-900°C. More preferably, the lower limit of the continuous annealing temperature is 760°C, even more preferably 770°C, and most preferably 780°C. More preferably, the upper limit of the continuous annealing temperature is 890°C, even more preferably 880°C, and most preferably 870°C.

[0063] Thereafter, the continuously annealed cold-rolled steel sheet is first-cooled. The first cooling is intended to transform most of the austenite into martensite during the second cooling by suppressing ferrite transformation. The first cooling may be performed to a first cooling end temperature of 550-750°C. If the first cooling end temperature is less than 550°C or exceeds 700°C, productivity may be reduced. Therefore, it is advantageous for the first cooling end temperature to be in the range of 550-700°C. More preferably, the lower limit of the first cooling end temperature is 575°C, and even more preferably 600°C. More preferably, the upper limit of the first cooling end temperature is 690°C, and even more preferably 680°C. In addition, the first cooling may be performed at a first cooling rate of 1-10°C/s. If the first cooling rate is less than 1°C/s, a ferrite phase is formed during cooling, making it difficult to secure high strength. If the first cooling rate exceeds 10°C/s, the cooling amount in the second cooling increases, which may lead to an increase in the final temperature deviation and material deviation. Therefore, it is advantageous for the first cooling rate to be in the range of 1-10°C/s. More preferably, the lower limit of the first cooling rate is 2°C/s, even more preferably 3°C/s, and most preferably 4°C/s. More preferably, the upper limit of the first cooling rate is 8°C/s, even more preferably 7°C/s, and most preferably 6°C/s.

[0064] Thereafter, the first-cooled cold-rolled steel sheet is second-cooled to a second cooling end temperature (Tq) of 150-350°C. The second cooling is for securing the shape in the width and length directions of the coil, as well as for securing a high yield ratio and hole expandability. If the second cooling end temperature is less than 150°C, the yield strength and tensile strength may increase simultaneously and the ductility may be severely deteriorated due to an excessive increase in martensite during over-aging heat treatment. In particular, shape deterioration due to rapid cooling is expected, leading to workability deterioration during the processing of automobile parts. If the second cooling end temperature exceeds 350°C, the austenite generated during annealing may not transform into martensite, and high-temperature transformation phases such as bainite and granular bainite may be generated, causing a sharp drop in yield strength. The generation of such a structure can cause a decrease in the yield ratio as well as a decrease in hole expandability. Therefore, it is advantageous for the second cooling end temperature to be in the range of 150-350°C. More preferably, the lower limit of the second cooling end temperature is 170°C, even more preferably 190°C, and most preferably 200°C. More preferably, the upper limit of the second cooling end temperature is 340°C, even more preferably 330°C, and most preferably 320°C. In addition, the second cooling may be performed at a second cooling rate of 5-60°C/s. If the second cooling rate is less than 5°C/s, high-temperature phases such as upper bainite are mixed in during cooling, making it impossible to obtain the target tempered martensite fraction and high strength. If the second cooling rate exceeds 60°C/s, there may be a disadvantage that the shape of the product is thermally damaged. Therefore, it is advantageous for the second cooling rate to be in the range of 5-60°C/s. More preferably, the lower limit of the second cooling rate is 6°C/s, even more preferably 7°C/s, and most preferably 10°C/s. More preferably, the upper limit of the second cooling rate is 50°C/s, even more preferably 40°C/s, and most preferably 30°C/s.

[0065] Thereafter, the second-cooled cold-rolled steel sheet is reheated at a reheating temperature (Tp) of 200-450°C. The reheating is for interphase carbon partitioning necessary for stabilizing retained austenite and for additional bainite phase transformation. If the reheating temperature is less than 200°C, there may be a disadvantage that the strength becomes excessively high and the formability deteriorates. If the reheating temperature exceeds

450°C, it is difficult to obtain the strength desired in the present disclosure. Therefore, it is advantageous for the reheating temperature to be in the range of 200-450°C. More preferably, the lower limit of the reheating temperature is 210°C, even more preferably 230°C, and most preferably 250°C. More preferably, the upper limit of the reheating temperature is 440°C, even more preferably 430°C, and most preferably 420°C.

[0066] The method for manufacturing a cold-rolled steel sheet of the present disclosure can satisfy the following Relational Expression 2. Relational Expression 2 is for simultaneously securing strength, elongation, and hole expandability. If the Y value is less than 175, the target tensile strength cannot be obtained. If the Y value exceeds 216, the target elongation cannot be obtained. Therefore, it is advantageous for the Y value to be in the range of 175-216. More preferably, the lower limit of the Y value is 181, even more preferably 183, and most preferably 185. More preferably, the upper limit of the Y value is 215, even more preferably 210, and most preferably 208.

$$175 \leq Y = 0.3(SS-A1) + 0.85(Ms-Tq) - 1.22(Tp-Tq) + 52X \leq 216$$

[Relational Expression 1]

$$[Equation 2] A1(^{\circ}C) = 723 - 10.7Mn - 16.9Ni + 29.1Si + 16.9Cr$$

$$[Equation 3] Ms(^{\circ}C) = 539 - 423C - 30.4Mn - 12.1Cr - 7.5Mo$$

(wherein, in Relational Expression 2, SS denotes the continuous annealing temperature, A1 denotes the eutectoid transformation temperature, Ms denotes the martensite transformation start temperature, Tq denotes the second cooling end temperature, and Tp denotes the reheating temperature, where A1 is expressed by Equation 2, Ms is expressed by Equation 3, and X denotes $7C + (1.3Si + Mn)/6 + (Cr + 1.2Mo)/5 + 100B$.)

[0067] Meanwhile, after reheating, a step of temper rolling the cold-rolled steel sheet at an elongation of 0.010-1.0% may be further included. Typically, when temper rolling transformation-structured steel, the yield strength increases by 50 MPa or more with almost no increase in tensile strength. If the elongation is less than 0.010%, it can be very difficult to control the shape in an ultra-high-strength steel like that of the present disclosure. If the elongation exceeds 1.0%, the operability may become very unstable due to the high-elongation work.

Mode for the Invention

[0068] Hereinafter, the present disclosure will be described in more detail through examples. However, it should be noted that the following examples are merely for illustrating 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 described in the claims and matters reasonably inferred therefrom.

(Example)

[0069] A slab having the alloy composition shown in Table 1 below was heated at 1200°C for 1 hour, and then hot rolling, coiling, cold rolling, first cooling, second cooling, and reheating were performed using the conditions shown in Table 2 below to manufacture a cold-rolled steel sheet. At this time, the reduction ratio during cold rolling was 40%. Thereafter, the cold-rolled steel sheet was temper-rolled at an elongation of 0.2%.

[0070] The microstructure and mechanical properties of the cold-rolled steel sheet manufactured as described above were measured, and the results are shown in Tables 3 and 4 below, respectively.

[0071] The type and fraction of the microstructure were measured by the Point Counting method from photographs observed using a scanning electron microscope (SEM).

[0072] The average grain size of bainite and tempered martensite was measured using electron backscatter diffraction (EBSD) analysis.

[0073] Yield strength (YS), tensile strength (TS), and elongation (EI) were measured by preparing a JIS No. 5 tensile test specimen and then performing a tensile test.

[0074] The hole expansion ratio (HER) was measured by press-expanding a 10 mmØ punched hole (die inner diameter 10.3 mm, clearance 12.5%) with a conical punch having a vertex angle of 60° at a rate of 20 mm/min in a direction such that the burr of the punched hole faces outward.

$$\text{Hole Expansion Ratio (HER) (\%)} = \{(D - D_0)/D_0\} \times 100$$

(wherein, D denotes the hole diameter (mm) when a crack penetrates the steel sheet, and D0 denotes the initial hole

diameter (mm.)

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[Table 1]

Steel No .	Alloy Composition (unit: weight%)													
	C	Si+S ol .Al	Si	Mn	Cr	Ti	Nb	Mo	B	Sol. Al	P	S	N	X
1	0.24 5	0.63 1	0.61	2.48	0.32	0.04	0.02	0.04 8	0.00 14	0.02 1	0.00 9	0.00 3	0.00 4	2.48
2	0.22 2	1.14 1	1.12	2.68	0.63	0.10	0.01	0.09 0	0.00 21	0.02 1	0.01 1	0.00 4	0.00 5	2.60
3	0.25 2	1.49 8	1.48	2.40	0.05	0.05	0.04	0.10 0	0.00 18	0.01 8	0.01 1	0.00 4	0.00 5	2.70
4	0.33 1	0.40 5	0.38	2.69	0.53	0.02	0.01	0.12 0	0.00 22	0.02 5	0.01 1	0.00 3	0.00 5	3.20
5	0.18 0	0.67 5	0.65	2.45	0.21	0.03	0.02	0.07 0	0.00 17	0.02 5	0.01 2	0.00 3	0.00 5	2.04
X = 7C + (1.3Si+Mn)/6 + (Cr+1.2Mo)/5 + 100B														

[Table 2]

Category	Steel No .	Ar3(°C)	Finish Rolling Temp. (°C)	Coiling Temp. (°C)	Cont. Annealing Temp. (SS) (°C)	1st Cooling End Temp. (°C)	1st Cooling Rate (/s)	2nd Cooling End Temp. (Tq) (°C)	2nd Cooling Rate (/s)	Reheating Temp. (Tp) (°C)	A1 (°C)	M s (°C)	Y
Inv. Ex. 1	1	760	912	512	851	612	3	202	32	279	720	356	205
Inv. Ex. 2	1	760	899	523	849	632	3	201	32	302	720	356	176
Com p. Ex. 1	1	760	918	505	852	711	2	212	39	358	720	356	113
Com p. Ex. 2	1	760	902	521	853	692	2	198	32	413	720	356	41
Inv. Ex. 3	1	760	923	503	846	682	2	247	34	302	720	356	192
Com p. Ex. 3	1	760	915	506	850	693	2	250	34	358	720	356	126
Com p. Ex. 4	1	760	897	506	853	642	3	156	38	253	720	356	220
Com p. Ex. 5	1	760	912	512	853	662	3	149	39	349	720	356	100
Inv. Ex. 4	2	780	913	523	851	632	3	204	33	299	738	355	182
Com p. Ex. 6	2	780	915	505	848	672	3	201	37	348	738	355	120
Inv. Ex. 5	2	780	916	521	853	612	3	244	29	305	738	355	190
Com p. Ex. 7	2	780	918	503	895	690	3.2	249	34	353	738	355	145
Com p. Ex. 8	2	780	906	506	852	670	3	148	39	302	738	355	158
Inv. Ex. 6	3	805	915	506	851	693	2	200	38	300	741	358	186
Inv. Ex. 7	3	805	897	543	850	642	3	250	30	300	741	358	204
Inv. Ex. 8	3	805	912	532	847	662	3	248	32	315	741	358	184
Comp. Ex. 9	3	805	913	521	843	632	3	249	30	350	741	358	140
Comp. Ex. 10	3	805	915	526	856	672	3	247	31	411	741	358	69
Comp. Ex. 11	3	805	897	562	853	612	3	150	36	300	741	358	168
Comp. Ex. 12	4	727	912	532	845	682	2	200	37	300	714	310	177
Comp. Ex. 13	4	727	913	514	857	693	2	200	38	350	714	310	120
Comp. Ex. 14	4	727	915	542	847	672	3	250	33	300	714	310	196
Comp. Ex. 15	4	727	916	516	852	612	3	150	36	300	714	310	161

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(continued)

Category	Steel No .	Ar3 (°C)	Finish Rolling Temp. (°C)	Coiling Temp. (°C)	Cont. Annealing Temp. (SS) (°C)	1st Cooling End Temp. (°C)	1st Cooling Rate (/s)	2nd Cooling End Temp. (Tq) (°C)	2nd Cooling Rate (/s)	Reheating Temp. (Tp) (°C)	A1 (°C)	Ms (°C)	Y
Comp. Ex. 16	5	779	905	853	853	603	3	195	36	307	719	307	171
Comp. Ex. 17	3	805	915	506	811	693	1.8	200	38	300	741	358	173
$Y = 0.3(SS-A1) + 0.85(Ms-Tq) - 1.22(Tp-Tq) + 52X$ $Ar3(^{\circ}C) = 910 - 203 \backslash C - 30Mn + 44.7Si - 11Cr + 31.5Mo - 15.2Ni$ $A1(^{\circ}C) = 723 - 10.7Mn - 16.9Ni + 29.1Si + 16.9Cr$ $Ms(^{\circ}C) = 539 - 423C - 30.4Mn - 12.1Cr - 7.5Mo$ $X = 7C + (1.3Si + Mn)/6 + (Cr + 1.2Mo)/5 + 100B$													

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[Table 3]

Category	TM + B (one or more) (area%)	Retained Y (area%)	FM (area%)	F (area%)	B avg. grain size (μm)	TM avg. grain size (μm)
Inv. Ex. 1	91	6	2	1	2.2	1.2
Inv. Ex. 2	90	7	1.6	1.4	2.4	1.6
Comp. Ex. 1	85	11	3	1	2.3	1.5
Comp. Ex. 2	87	10	3	0	2.1	1.6
Inv. Ex. 3	88	9	3	0	1.9	1.8
Comp. Ex. 3	86	11	3	0	2.3	1.4
Comp. Ex. 4	96	2	2	0	2.8	1.7
Comp. Ex. 5	96	2	2	0	2.4	1.6
Inv. Ex. 4	88	8	3	1	2.3	1.7
Comp. Ex. 6	88	9	2	1	2.3	1.5
Inv. Ex. 5	88	7	3	2	2.2	1.6
Comp. Ex. 7	85	9	4	2	3.5	3.2
Comp. Ex. 8	96	2	1	1	2.6	1.8
Inv. Ex. 6	91	7.8	1.2	0	2.3	1.6
Inv. Ex. 7	86	9.8	3.3	0.9	2.4	1.5
Inv. Ex. 8	86	11.8	1.4	0.8	1.9	1.1
Comp. Ex. 9	88	11.1	0.9	0	1.8	1.1
Comp. Ex. 10	86	12.1	0.9	1	1.8	1.0
Comp. Ex. 11	96	2	1	1	2.3	1.3
Comp. Ex. 12	90	6	3	1	2.5	1.4
Comp. Ex. 13	89	8	2	1	2.7	1.5
Comp. Ex. 14	86	10	3	1	2.6	1.6
Comp. Ex. 15	96	3	1	0	2.8	1.8
Comp. Ex. 16	89	8	2	1	2.9	1.7
Comp. Ex. 17	69	8	9.4	13.6	2.6	2.1
B: Bainite TM: Tempered Martensite γ: Austenite FM: Fresh Martensite F: Ferrite						

[Table 4]

Category	Yield Strength (YS) (MPa)	Tensile Strength (TS) (MPa)	Elongation (EI) (%)	Hole Expansion Ratio (HER) (%)	TS×EI (MPa%)
Inv. Ex. 1	1141	1531	10.3	32	15769
Inv. Ex. 2	1192	1493	10.6	35	15826
Comp. Ex. 1	1221	1421	9.7	38	13784
Comp. Ex. 2	1221	1348	12.3	34	16580
Inv. Ex. 3	1151	1510	10.7	34	16157

(continued)

	Category	Yield Strength (YS) (MPa)	Tensile Strength (TS) (MPa)	Elongation (El) (%)	Hole Expansion Ratio (HER) (%)	TS×EI (MPa%)
5	Comp. Ex. 3	1211	1434	10.6	29	15200
	Comp. Ex. 4	1224	1524	8	26	12192
	Comp. Ex. 5	1283	1435	8.2	36	11767
	Inv. Ex. 4	1182	1511	10.4	31	15714
10	Comp. Ex. 6	1221	1432	9.8	29	14034
	Inv. Ex. 5	1142	1493	10.6	34	15826
	Comp. Ex. 7	1235	1421	8.9	29	12647
15	Comp. Ex. 8	1301	1525	8.1	21	12353
	Inv. Ex. 6	1186	1506	11.2	36	16867
	Inv. Ex. 7	1127	1523	11.8	32	17971
	Inv. Ex. 8	1154	1501	11.1	31	16661
20	Comp. Ex. 9	1242	1426	9.5	38	13547
	Comp. Ex. 10	1185	1389	12.5	36	17363
	Comp. Ex. 11	1285	1578	8.1	29	12782
25	Comp. Ex. 12	1241	1532	8.9	23	13635
	Comp. Ex. 13	1282	1455	9.5	32	13823
	Comp. Ex. 14	1185	1532	9.6	28	14707
	Comp. Ex. 15	1221	1511	9.5	21	14355
30	Comp. Ex. 16	1052	1435	11.2	36	16072
	Comp. Ex. 17	912	1582	12.4	21	19612

35 **[0075]** As can be seen from Tables 1 to 4, in the case of Inventive Examples 1 to 8 that satisfy the alloy composition and manufacturing conditions proposed by the present disclosure, it can be seen that the yield strength, tensile strength, elongation, hole expansion ratio, and TS×EI are excellent as the microstructure and the average grain size of bainite and tempered martensite desired by the present disclosure are secured.

[0076] In the case of Comparative Example 1, which does not satisfy the Y value, the average grain size of bainite of the present disclosure was not secured, and the tensile strength, elongation, and TS×EI were found to be insufficient.

40 **[0077]** In the case of Comparative Example 2, which does not satisfy the Y value, the average grain size of bainite of the present disclosure was not secured, and the tensile strength was found to be insufficient.

[0078] In the case of Comparative Example 3, which does not satisfy the Y value, the average grain size of bainite of the present disclosure was not secured, and the tensile strength and hole expansion ratio were found to be insufficient.

45 **[0079]** In the case of Comparative Example 4, which does not satisfy the Y value, the microstructure of the present disclosure was not secured, and the elongation, hole expansion ratio, and TS×EI were found to be insufficient.

[0080] In the case of Comparative Example 5, which does not satisfy the second cooling end temperature and the Y value, the microstructure of the present disclosure was not secured, and the tensile strength, elongation, and TS×EI were found to be insufficient.

50 **[0081]** In the case of Comparative Example 6, which does not satisfy the Y value, the average grain size of bainite of the present disclosure was not secured, and the tensile strength, elongation, hole expansion ratio, and TS×EI were found to be insufficient.

[0082] In the case of Comparative Example 7, which does not satisfy the Y value, the average grain size of bainite and tempered martensite of the present disclosure was not secured, and the tensile strength, elongation, hole expansion ratio, and TS×EI were found to be insufficient.

55 **[0083]** In the case of Comparative Example 8, which does not satisfy the second cooling end temperature and the Y value, the microstructure of the present disclosure was not secured, and the elongation, hole expansion ratio, and TS×EI were found to be insufficient.

[0084] In the case of Comparative Example 9, which does not satisfy the Y value, the average grain size of bainite of

the present disclosure was not secured, and the tensile strength, elongation, and TS×EI were found to be insufficient.

[0085] In the case of Comparative Example 10, which does not satisfy the Y value, the average grain size of bainite of the present disclosure was not secured, and the tensile strength was found to be insufficient.

[0086] In the case of Comparative Example 11, which does not satisfy the Y value, the microstructure of the present disclosure was not secured, and the elongation, hole expansion ratio, and TS×EI were found to be insufficient.

[0087] In the case of Comparative Example 12, which does not satisfy the X value, the elongation, hole expansion ratio, and TS×EI were found to be insufficient.

[0088] In the case of Comparative Example 13, which does not satisfy the X and Y values, the tensile strength, elongation, and TS×EI were found to be insufficient.

[0089] In the case of Comparative Example 14, which does not satisfy the X value, the elongation and hole expansion ratio were found to be insufficient.

[0090] In the case of Comparative Example 15, which does not satisfy the X and Y values, the microstructure of the present disclosure was not secured, and the elongation, hole expansion ratio, and TS×EI were found to be insufficient.

[0091] In the case of Comparative Example 16, which does not satisfy the X and Y values, the tensile strength and elongation were found to be insufficient.

[0092] In the case of Comparative Example 17, which does not satisfy the Y value, the microstructure of the present disclosure was not secured, and the yield strength and hole expansion ratio were found to be insufficient.

[0093] FIG. 1 is a photograph of Inventive Example 1 of the present disclosure observed using a scanning electron microscope (SEM). As can be seen from FIG. 1, Inventive Example 1 mainly includes bainite and tempered martensite, which are the objects of the present disclosure, includes an appropriate fraction of retained austenite, and it can be seen that small amounts of fresh martensite and ferrite are formed.

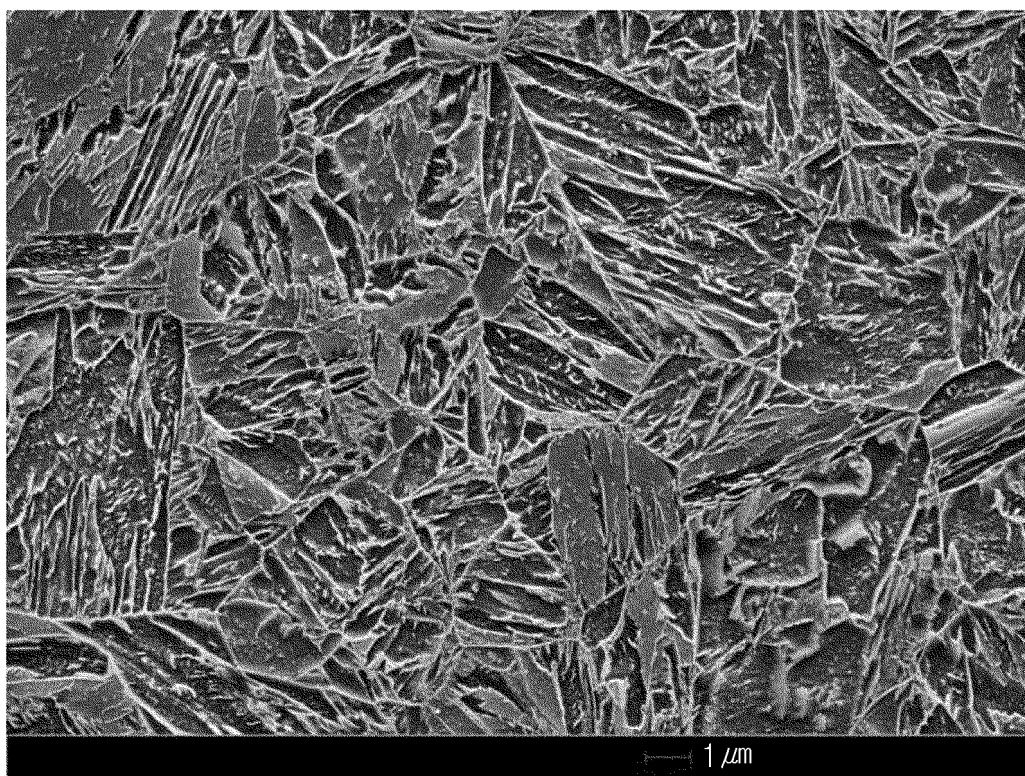
Claims

1. A cold-rolled steel sheet, comprising by weight %: C: 0.050-0.40%, Mn: 1.0-3.0%, Cr: 0.010-1.20%, P: 0.0010-0.10%, S: 0.010% or less (excluding 0%), Si+Sol.Al: 0.10-3.0%, Mo: 0.020-0.20%, and B: 0.0010-0.0050%, with the balance being Fe and other unavoidable impurities; satisfying Relational Expression 1; wherein a microstructure comprises, by area %: 70-95% of one or more of bainite and tempered martensite, 3-15% of retained austenite, and a remainder structure; and wherein the bainite and the tempered martensite have an average grain size of 3 μ m or less, [Relational Expression 1] $2.40 \leq X = 7C + (1.3Si+Mn)/6 + (Cr+1.2Mo)/5 + 100B \leq 3.0$ (wherein, the content of each alloying element in Relational Expression 1 signifies weight %).
2. The cold-rolled steel sheet of claim 1, wherein the cold-rolled steel sheet further comprises one or more of N: 0.0010-0.010%, Ti: 0.010-0.120%, and Nb: 0.0010-0.050%.
3. The cold-rolled steel sheet of claim 1, wherein a content of Si is 2.50% or less (excluding 0%), and a content of Sol.Al is 0.010-0.10%.
4. The cold-rolled steel sheet of claim 1, wherein the remainder structure comprises one or more of fresh martensite: 10% or less (including 0%) and ferrite: 5% or less (including 0%).
5. The cold-rolled steel sheet of claim 1, wherein the cold-rolled steel sheet has a yield strength (YS) of 1100 MPa or more, a tensile strength (TS) of 1450 MPa or more, an elongation (EI) of 9% or more, and a hole expansion ratio (HER) of 30% or more.
6. The cold-rolled steel sheet of claim 1, wherein the cold-rolled steel sheet has a product of tensile strength (TS) and elongation (EI) of 13050 MPa% or more.
7. A method for manufacturing a cold-rolled steel sheet, comprising: a step of heating a slab comprising, by weight %: C: 0.050-0.40%, Mn: 1.0-3.0%, Cr: 0.010-1.20%, P: 0.0010-0.10%, S: 0.010% or less (excluding 0%), Si+Sol.Al: 0.10-3.0%, Mo: 0.020-0.20%, and B: 0.0010-0.0050%, with the balance being Fe and other unavoidable impurities, and satisfying Relational Expression 1; a step of finish hot rolling the heated slab to obtain a hot-rolled steel sheet; a step of coiling the hot-rolled steel sheet; a step of cold rolling the coiled hot-rolled steel sheet to obtain a cold-rolled steel sheet; a step of continuously annealing the cold-rolled steel sheet at a continuous annealing temperature (SS) of 750-900°C; a step of first cooling the continuously annealed cold-rolled steel sheet;

a step of second cooling the first-cooled cold-rolled steel sheet to a second cooling end temperature (T_q) of 150-350°C; and a step of reheating the second-cooled cold-rolled steel sheet at a reheating temperature (T_p) of 200-450°C; and satisfying Relational Expression 2, [Relational Expression 1] $2.40 \leq X = 7C + (1.3Si+Mn)/6 + (Cr+1.2Mo)/5 + 100B \leq 3.0$ [Relational Expression 2] $175 \leq Y = 0.3(SS-A1) + 0.85(Ms-T_q) - 1.22(T_p-T_q) + 52X \leq 216$ [Equation 2] $A1(^{\circ}C) = 723-10.7Mn-16.9Ni+29.1Si+16.9Cr$ [Equation 3] $Ms(^{\circ}C) = 539-423C-30.4Mn-12.1Cr-7.5Mo$ (wherein, the content of each alloying element in Relational Expression 1 is in weight %, and in Relational Expression 2, SS denotes the continuous annealing temperature, A1 denotes the eutectoid transformation temperature, Ms denotes the martensite transformation start temperature, T_q denotes the second cooling end temperature, and T_p denotes the reheating temperature, where A1 is expressed by Equation 2, Ms is expressed by Equation 3, and X denotes $7C + (1.3Si+Mn)/6 + (Cr+1.2Mo)/5 + 100B$.)

8. The method of claim 5, wherein the slab heating is performed at 1000-1350°C.
9. The method of claim 5, wherein the finish hot rolling is performed at Ar_3 -1000°C.
10. The method of claim 5, wherein the coiling is performed at 450-750°C.
11. The method of claim 5, wherein the cold rolling is performed at a cold reduction ratio of 20-90%.
12. The method of claim 5, wherein the first cooling is performed to a first cooling end temperature of 550-750°C.
13. The method of claim 5, wherein the first cooling is performed at a first cooling rate of 1-10°C/s.
14. The method of claim 5, wherein the second cooling is performed at a second cooling rate of 5-60°C/s.
15. The method of claim 5, further comprising a step of temper rolling the cold-rolled steel sheet at an elongation of 0.010-1.0% after the reheating.

[FIG. 1]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2024/020424

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/38(2006.01)i; C22C 38/22(2006.01)i; C22C 38/32(2006.01)i; C22C 38/28(2006.01)i; C22C 38/26(2006.01)i;
C22C 38/06(2006.01)i; C22C 38/00(2006.01)i; C22C 38/34(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 38/38(2006.01); B21C 47/02(2006.01); C21D 1/18(2006.01); C22C 38/00(2006.01); C22C 38/04(2006.01);
C22C 38/06(2006.01); C22C 38/16(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: 템퍼드 마르텐사이트(tempered martensite), 베이나이트(bainite), 2차 냉각
(secondary cooling), 망간(Mn), 인장강도(tensile strength)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2023-0087773 A (POSCO) 19 June 2023 (2023-06-19) See paragraphs [0137]-[0149] and [0202], claims 1-6 and tables 2 and 3.	1-15
Y	KR 10-2023-0089785 A (POSCO) 21 June 2023 (2023-06-21) See claim 8 and table 2.	1-15
A	JP 2011-202195 A (JFE STEEL CORP.) 13 October 2011 (2011-10-13) See claims 1-8.	1-15
A	KR 10-1288701 B1 (JFE STEEL CORPORATION) 22 July 2013 (2013-07-22) See paragraphs [0063]-[0074] and claims 1 and 5.	1-15
A	JP 2018-035399 A (JFE STEEL CORP.) 08 March 2018 (2018-03-08) See claims 1-4.	1-15

☐ 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 25 March 2025	Date of mailing of the international search report 25 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.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2024/020424

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REFERENCES CITED IN THE DESCRIPTION

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