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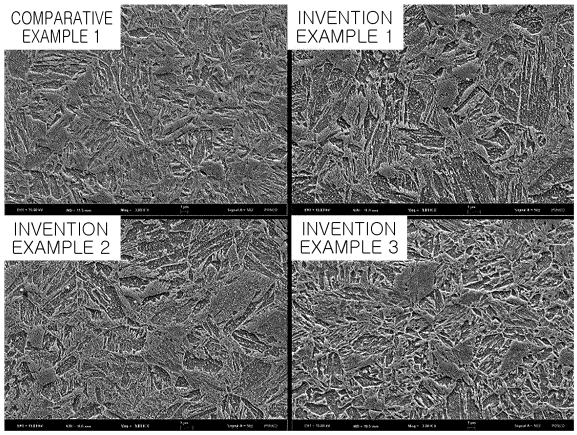
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(54) ULTRAHIGH-STRENGTH STEEL SHEET WITH EXCELLENT BENDABILITY AND STRETCH FLANGEABILITY, AND MANUFACTURING METHOD THEREFOR

(57) The present invention relates to an ultra-high-strength steel sheet with excellent bendability and stretch flangeability, and a manufacturing method therefor and, more specifically, to: a steel sheet having excellent bendability and stretch flangeability by using rapid low-temperature tempering, and having a high yield ratio and ultrahigh strength; and a manufacturing method therefor.

FIG. 1



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Description

Technical Field

[0001] The present disclosure relates to an ultra-high strength steel sheet with excellent bendability and stretch flangeability and a manufacturing method therefor, and more specifically, to a steel sheet with excellent bendability and stretch flangeability by using rapid low-temperature tempering, and having a high yield ratio and ultra-high strength, and a manufacturing method therefor.

Background Art

[0002] In order to satisfy contradictory goals of reducing weight and ensuring collision safety, as a steel sheet for automobiles, various types of steel sheets for automobiles such as dual phase steel (hereinafter, referred to as 'DP steel'), transformation induced plasticity steel (hereinafter, referred to as 'TRIP steel'), complex phase steel (hereinafter, referred to as 'CP steel'), or the like, are being developed.

[0003] In such advanced high-strength steels, strength may be increased by increasing a carbon amount, but when considering practical aspects such as spot weldability, or the like, a tensile strength that can be implemented is limited to about 1200 MPa. In application to structural members to ensure collision safety, a method of securing final strength by rapid cooling through direct contact with a die that is formed at a high temperature and then water cooled is receiving attention. But due to excessive facility investment costs and high heat treatment and processing costs, the expansion of application is not significant.

[0004] As an alternative to a rapid cooling method through water cooling, a slow cooling method is generally used. However, in continuous annealing furnaces and continuous annealing hot-dip plating lines with a slow cooling section, martensitic steel with a microstructure fraction of 90% or more after an annealing heat treatment has a disadvantage of poor yield strength as a ratio of yield strength to tensile strength is less than 0.75.

[0005] In order to increase resistance in the event of a car collision, it is desirable to further increase the yield strength, and improvement measures therefor are required. Tempering of martensitic steel is commonly performed to improve insufficient ductility and toughness of martensitic steel, but a method is required to increase yield strength while suppressing a decrease in tensile strength as much as possible.

[0006] In addition, in order to process martensitic steel through roll forming, press forming, or the like, excellent bendability and stretch flangeability are essential. However, because ordinary martensitic steel often does not secure sufficient bendability and stretch flangeability for forming due to the extremely high strength, research to increase the same is also required.

[0007] In Patent Document 1 (Japanese Patent Publication No. 2528387), since a steel sheet is required to be rapidly cooled to room temperature after annealing, there is a problem that the steel sheet cannot be manufactured unless there is a line with special equipment that can rapidly cool the steel sheet between an annealing furnace and an over-aging furnace.

[0008] In addition, in Patent Document 2 (Korean Patent Publication No. 10-2010-0116608), martensite transformation may be caused in a steel sheet that has reached an Ms point, that is, a martensite transformation start temperature, and at the same time, high strength may be obtained through an autotempering treatment, tempering martensite after transformation, but there may be a problem with manufacturing stability, because strict control of heat treatment conditions at a temperature directly below Ms is required.

[0009] In addition, Patent Document 3 (Korean Patent Publication No. 10-2014-0030970) proposes performing an additional heat treatment to achieve target physical properties, but there is a problem that too much time is consumed and productivity is excessively reduced, or it is difficult to set efficient conditions to achieve the target physical properties.

(Patent Document 1) Japanese Patent Publication No. 2528387
(Patent Document 2) Korean Patent Publication No. 10-2010-0116608
(Patent Document 3) Korean Patent Publication No. 10-2014-0030970

Summary of Invention

Technical Problem

[0010] An aspect of the present disclosure is to provide an ultra-high strength steel sheet with excellent bendability and stretch flangeability and a method for manufacturing the same.

[0011] The object of the present disclosure is not limited to the above. A person skilled in the art would have no difficulty in understanding the further subject matter of the present invention from the general content of this specification.

Solution to Problem

[0012] According to an aspect of the present disclosure, provided is an ultra-high strength steel sheet,

the steel sheet comprising by weight: carbon (C) : 0.12 to 0.4%, silicon (Si): 0.5% or less (excluding 0%), manganese (Mn): 2.5 to 4.0%, phosphorous (P): 0.03% or less (excluding 0%), sulfur (S): 0.012% or less (excluding 0%), aluminum (Al): 0.1% or less (excluding 0%), chromium (Cr): 1% or less (excluding 0%), titanium (Ti): 48/14×[N]~0.1%, niobium (Nb): 0.1% or less (excluding 0%), boron (B): 0.005% or less (excluding 0%), nitrogen (N): 0.01% or less (excluding 0%), with a balance of Fe and other impurities,
wherein the steel sheet comprises, as a microstructure, by area, martensite: 90% or more, and a sum of ferrite and bainite: 10% or less,
wherein a value of M defined by Relational expression 1 below satisfies a range of 100 to 500.

[Relational expression 1]

$$M = P_{size} \times P_{number} \times [C]^{0.5} \times [Mn]^{2} \times [S]$$

[0013] In the above Relational expression 1, P_{size} is an average diameter of inclusions having a diameter of 1 um or more, and P_{number} is an average number of inclusions having a diameter of 1 μm or more. [C] and [Mn] are average weight % contents of elements in parentheses in the steel sheet, respectively, and [S] is an average ppm content of element in parentheses in the steel sheet.

[0014] According to another aspect of the present disclosure, provided is a manufacturing method for an ultra-high strength steel sheet,

the method comprising operations of: preparing a steel sheet, which comprises, by weight: carbon (C): 0.12 to 0.4%, silicon (Si): 0.5% or less (excluding 0%), manganese (Mn): 2.5 to 4.0%, phosphorous (P): 0.03% or less (excluding 0%), sulfur (S): 0.012% or less (excluding 0%), aluminum (Al): 0.1% or less (excluding 0%), chromium (Cr): 1% or less (excluding 0%), titanium (Ti): 48/14×[N]~0.1%, niobium (Nb): 0.1% or less (excluding 0%), boron (B): 0.005% or less (excluding 0%), nitrogen (N): 0.01% or less (excluding 0%), with a balance of Fe and other impurities, and consists of a microstructure comprising, by area, martensite: 90% or more, and a sum of ferrite and bainite: 10% or less; and
performing tempering on the steel sheet,
wherein a value of P defined by Relational expression 2 below satisfies a range of 1.5 to 77.0.

[Relational expression 2]

$$P = \frac{\exp\left(\frac{T+273.15}{40}\right)}{10000} X \left[\log\left(t_{eff}\right) - 0.25\right]$$

[0015] In the above Relational expression 2, T is a maximum temperature of tempering, and a unit thereof is °C. In addition, t_{eff} is an effective heat treatment time, and a unit thereof is seconds.

Advantageous Effects of Invention

[0016] As set forth above, according to an aspect of the present disclosure, an ultra-high strength steel sheet having excellent bendability and stretch flangeability and a manufacturing method therefor may be provided.

[0017] Alternatively, according to an aspect of the present disclosure, a yield strength of martensitic steel having a martensite fraction of 90% or more may be improved, or one or more characteristics of bendability and stretch flangeability may be improved through additional heat treatment on a steel sheet having a low yield strength manufactured in a continuous annealing furnace or a continuous annealing hot dip plating line with a slow cooling section.

[0018] The various and beneficial advantages and effects of the present invention are not limited to the above-described content, and may be more easily understood through description of specific embodiments of the present disclosure.

Brief description of drawings

[0019] FIG. 1 is a photograph captured with a scanning electron microscope (SEM) of a microstructure of a cross-sectional specimen cut in a thickness direction of the steel sheet obtained from Comparative Example 2 and Invention examples 1 to 3 of the present disclosure.

Best Mode for Invention

[0020] Hereinafter, preferred embodiments of the present disclosure will be described. Embodiments of the present disclosure may be modified in various forms, and the scope of the present disclosure should not be construed as being limited to the embodiments described below. The present embodiments are provided to those skilled in the art to further elaborate the present disclosure.

[0021] Meanwhile, the terms used in this specification are for describing specific embodiments and are not intended to limit the present disclosure. For example, as used herein, singular forms comprise plural forms unless the relevant definition clearly indicates the contrary. In addition, the meaning of "comprising" used in the specification is to specify a configuration and not to exclude the presence or addition of another configuration.

[0022] Conventionally, when using a slow cooling method without a rapid cooling facility, in slow cooling conditions for a continuous annealing furnace or continuous annealing-type hot dip plating line with a slow cooling section, cooling is generally performed to 650°C or 460°C, which is a hot dip plating bath immersion temperature at a cooling rate of 3°C/s after annealing. A steel sheet having a composition system of the present disclosure manufactured under the above-described conditions has a martensite fraction of 90% or more as a microstructure, the steel sheet having an initial yield strength of 1000 to 1250 MPa, an initial tensile strength of 1200 to 1700 MPa, and a yield ratio of less than 0.75, which has a disadvantage of poor yield strength.

[0023] However, not only it is necessary to improve the yield strength to increase resistance in the event of a car collision, it is also necessary to improve bendability and stretch flangeability in order to undertake roll forming or press forming processes.

[0024] Accordingly, the purpose of the present disclosure is to improve the yield strength of ultra-high strength steel sheets having such a low yield strength while suppressing a decrease in tensile strength as much as possible.

[0025] As a result of conducting intensive studies to obtain a steel sheet that not only improves bendability and stretch flangeability, and the like, but also satisfies the above-described characteristics, the present inventors have confirmed that effective properties of inclusions in steel were controlled, while controlling a content of components such as C, Mn and S in the steel was controlled to a limited range, thereby completing the present disclosure.

[0026] Hereinafter, an ultra-high strength steel sheet having excellent bendability and stretch flangeability according to the present disclosure will be described in detail.

[0027] According to the present disclosure, the high strength steel sheet comprises, by weight: carbon (C): 0.12 to 0.4%, silicon (Si): 0.5% or less (excluding 0%), manganese (Mn): 2.5 to 4.0%, phosphorous (P): 0.03% or less (excluding 0%), sulfur (S): 0.012% or less (excluding 0%), aluminum (Al): 0.1% or less (excluding 0%), chromium (Cr): 1% or less (excluding 0%), titanium (Ti): 48/14×[N]~0.1% (where [N] is a weight % content of nitrogen (N) in steel), niobium (Nb): 0.1% or less (excluding 0%), boron (B): 0.005% or less (excluding 0%), nitrogen (N): 0.01% or less (excluding 0%), with a balance of Fe and other impurities.

[0028] Hereinafter, the reason for adding components to the steel sheet and the reason for limiting the content in the present disclosure will be explained in detail. In this case, when indicating the content of each element in this specification, unless otherwise specified, contents are indicated in weight %.

Carbon (C): 0.12 to 0.4%

[0029] Carbon (C) is an essential element to secure martensite strength, and C should be added in an amount of 0.12% or more. However, if a C content exceeds 0.4%, weldability deteriorates, so an upper limit thereof is limited to 0.4%. Meanwhile, in terms of further improving the above-described effect, a lower limit of the C content may be 0.15%, or an upper limit of the C content may be 0.30%.

Silicon (Si): 0.5% or less (excluding 0%)

[0030] Silicon (Si) is an element added to stabilize ferrite, and needs to be present in an amount exceeding 0% for the above-described effect. However, Si has a disadvantage of deteriorating strength by promoting ferrite formation during slow cooling after annealing in a typical continuous annealing-type hot dip plating heat treatment furnace with a slow cooling section. In addition, when a large amount of Mn is added to suppress phase transformation as in the present disclosure, there is a concern for deterioration of hot-dip plating characteristics due to formation of surface oxides by Si

during annealing, surface concentration of Si, and dent defects due to oxidation, so an upper limit of a Si content is limited to 0.5%. Meanwhile, in terms of further improving the above-described effect, a lower limit of the Si content may be 0.1%, or an upper limit of the Si content may be 0.45%.

Manganese (Mn): 2.5 to 4.0%

[0031] Manganese (Mn) is an element suppressing ferrite formation in steel and facilitating austenite formation, and 2.5% or more of Mn is added to secure the above-described effects. If an Mn content in steel is less than 2.5%, there is a problem that ferrite is easily formed during slow cooling in the case of a continuous annealing-type hot dip plating heat treatment furnace. In addition, when the Mn content exceeds 4.0%, band formation due to segregation caused in a slab and hot rolling process becomes excessive, and a problem of increased iron alloy cost due to excessive alloy input during a conversion operation occurs. Therefore, in the present disclosure, the Mn content is limited to 2.5 to 4.0%, and in terms of further improving the above-described effect, a lower limit of the Mn content may be 2.7%, or an upper limit of the Mn content may be 3.8%.

Phosphorus (P): 0.03% or less (excluding 0%)

[0032] Phosphorus (P) is an impurity element that is inevitably comprised in steel, and is present in excess of 0%. However, if a P content exceeds 0.03%, weldability decreases, a risk of steel brittleness increases, and a possibility of causing dent defects increases, so an upper limit of the P content is limited to 0.03%. Meanwhile, in terms of further improving the above-described effect, the upper limit of the P content may be 0.012%, or a lower limit of the P content may be 0.0005%.

Sulfur (S): 0.012% or less (excluding 0%)

[0033] Sulfur (S), like P, is an impurity element that is inevitably comprised in steel, and is present in excess of 0%. However, since S is an element impairing ductility and weldability of a steel sheet, and when a S content exceeds 0.012%, there is high possibility to impair the ductility and weldability of the steel sheet, so it is preferable to limit an upper limit of the S content to 0.012%. Meanwhile, in terms of further improving the above-described effect, an upper limit of the S content may be 0.009%, or a lower limit of the S content may be 0.0001%.

Aluminum (Al): 0.1% or less (excluding 0%)

[0034] Aluminum (Al) is an alloy element expanding a ferrite region. Al has a disadvantage of promoting ferrite formation when using a continuous annealing-type hot dip plating heat treatment process with slow cooling as in the present disclosure, and high temperature hot rolling properties due to AlN formation may be reduced, so an upper limit of an Al content is limited to 0.1%. Meanwhile, in terms of further improving the above-described effect, a lower limit of the Al content may be 0.01%, or an upper limit of the Al content may be 0.08%.

Chromium (Cr): 1% or less (excluding 0%)

[0035] Chromium (Cr) is an alloy element facilitating securing a low-temperature transformation structure by suppressing ferrite transformation, and is comprised in an amount exceeding 0% for the above-described effect. Cr has an advantage of suppressing ferrite formation when using a continuous annealing-type hot dip plating heat treatment process with slow cooling as in the present disclosure, but if it exceeds 1%, there is a problem that a cost of iron alloy increases due to excessive alloy input, so an upper limit of a Cr content is limited to 1%. Meanwhile, in terms of further improving the above-described effect, a lower limit of the Cr content may be 0.01%, or an upper limit of the Cr content may be 0.5%.

Ti: 48/14×[N]~0.1% (where [N] is a weight % content of nitrogen (N) in steel)

[0036] Titanium (Ti) is a nitride forming element and scavenging is performed by precipitating N in the steel into TiN. In addition, if Ti is not added, there may be concern about the occurrence of cracks during continuous casting due to AlN formation, so it may be necessary to add more than 48/14 × [N]% of Ti by chemical equivalent for the above-described effect. However, if a Ti content exceeds 0.1%, martensite strength is reduced by additional carbide precipitation in addition to the removal of dissolved nitrogen (N), so an upper limit of the Ti content is limited to 0.1%. Meanwhile, in terms of further improving the above-described effect, a lower limit of the Ti content may be 0.01%, or an upper limit of the Ti content may be 0.08%.

Niobium (Nb): 0.1% or less (excluding 0%)

[0037] Niobium (Nb) is an element that segregates at austenite grain boundaries and suppresses coarsening of austenite grains during annealing heat treatment, so Nb is required to be added in excess of 0%. However, if a Nb content exceeds 0.1%, there may be a problem that a cost of iron alloy increases due to excessive alloy input, so an upper limit of the Nb content is limited to 0.1%. Meanwhile, in terms of further improving the above-described effect, a lower limit of the Nb content may be 0.01%, or an upper limit of the Nb content may be 0.06%.

Boron (B): 0.005% or less (excluding 0%)

[0038] Boron (B) is an element that suppresses ferrite formation, and has an advantage of suppressing the ferrite formation, and in particular, it has an advantage of suppressing the ferrite formation during cooling after annealing, so B is comprised in an amount exceeding 0%. However, if a B content exceeds 0.005%, rather, a problem of promoting ferrite formation due to precipitation of $Fe_{23}(C, B)_6$ occurs, so an upper limit of the B content is limited to 0.005%. Meanwhile, in terms of further improving the above-described effect, the upper limit of the B content may be 0.003%, or a lower limit of the B content may be 0.0005%.

Nitrogen (N): 0.01% or less (excluding 0%)

[0039] Nitrogen (N) is an impurity element that is inevitably comprised in steel and is present in excess of 0%. However, if the N content exceeds 0.01%, a risk of cracks occurring during continuous casting through AlN formation, or the like increases significantly. Therefore, in the present invention, it is preferable to limit an upper limit of the N content to 0.01%. Meanwhile, in terms of further improving the above-described effect, the upper limit of the N content may be 0.008%, or a lower limit of the N content may be 0.0005%.

[0040] The remaining component of the present disclosure is iron (Fe). However, since in the common manufacturing process, unintended impurities may be inevitably incorporated from raw materials or the surrounding environment, the component may not be excluded. Since these impurities are known to any person skilled in the common manufacturing process, the entire contents thereof are not particularly mentioned in the present specification.

[0041] An ultra-high strength steel sheet according to the present disclosure comprises, as a microstructure, by area: martensite: 90% or more, and a sum of ferrite and bainite: 10% or less. Since it is not easy to measure the microstructure by volume fraction, which is a three-dimensional concept, a microstructure is measured by area fraction through observation of a cross-section cut in a thickness direction, which is a method used when observing a conventional microstructure. Meanwhile, it is necessary to note that the microstructure of the ultra-high strength steel sheet has the same microstructure before and after heat treatment (tempering), to be described later.

[0042] As components of the microstructure, it is advantageous to secure ultra-high strength by having martensite, a hard phase, as a main phase, so in the present disclosure, 90% or more of martensite is comprised. In other words, if martensite is less than 90% in the microstructure of the ultra-strength steel sheet, there may be a problem in which a target strength may not be secured. In terms of maximizing the above-described effect, a lower limit of the martensite area fraction in the microstructure may be 94%.

[0043] Meanwhile, in terms of securing ultra-high strength, the higher a fraction of martensite, which is a hard phase, the more advantageous it is for securing strength, so an upper limit of the martensite area fraction is not particularly limited. However, as an example of the present disclosure, the upper limit of the martensite area fraction may be 99%.

[0044] In addition, if the sum of ferrite and bainite in the microstructure of the ultra-strength steel sheet exceeds 10%, a problem may occur in which the target strength cannot be secured. In terms of further maximizing the above-described effect, in the microstructure, a lower limit of the total area fraction of the ferrite and bainite may be 1%, or 2%, or an upper limit of the total area fraction of the ferrite and bainite may be 6%.

[0045] Alternatively, although not particularly limited, according to an aspect of the present disclosure, as a microstructure of the ultra-strength steel sheet, by area, ferrite: 1 to 5% and bainite: 1% or less (including 0%) may be further comprised.

[0046] In the ultra-high strength steel sheet according to the present disclosure, a value of M, defined from the following Relational expression 1 satisfies 100 to 500. If the value of M below is less than 100, there may be a problem of not securing the target strength. On the other hand, if the value of M below exceeds 500, a problem in which impact properties and bendability of the steel material deteriorate may occur. Here, since Relational expression 1 below is a value obtained empirically, a unit may not be defined separately, and it is sufficient to satisfy only the unit of each variable defined below.

[0047]

[Relational expression 1]

$$M = P_{size} \times P_{number} \times [C]^{0.5} \times [Mn]^{2} \times [S]$$

[0048] In the above Relational expression 1, P_{size} is an average diameter of inclusions with a diameter of 1 μm or more, and P_{number} is an average number of inclusions with a diameter of 1 um or more. [C] and [Mn] are average weight % contents of elements in parentheses in the steel sheet, and [S] is an average ppm content of the element in parentheses in the steel sheet.

[0049] As a result of conducting extensive research to provide an ultra-high strength steel material improving yield strength while controlling a decrease in tensile strength as much as possible, and the same time, improving stretch flangeability and bendability, the present inventors have found that it is important to minimize inclusions in the steel to the extent possible while setting the content of components such as C, Mn, and S in the steel type to a limited range.

[0050] Specifically, in order to manufacture an ultra-high strength steel sheet according to the present disclosure, first, it is necessary to combine contents of components such as C, Mn, and S in the heat-treated steel sheet in an optimized form. Therefore, in relational expression 1, [C] is an average weight % content of carbon (C) in a steel sheet, and [Mn] is an average weight % content of manganese (Mn) in the steel sheet. Meanwhile, [S] is an average ppm content of sulfur (S) in the steel sheet. However, when the value of [S] is less than 30ppm (0.003wt%), an effect by sulfur (S) is similar to the case of 30ppm, so when calculating the value of M, the value of [S] is defined as 30.

[0051] Meanwhile, the above-described elements are all elements that generate inclusions in steel, examples thereof comprise sulfides such as MnS and carbides such as (Nb, Ti)C. Inclusions are a higher concept comprising both sulfides and carbides mentioned in order to explain an optimal tempering effect in the present invention. In order to suppress the generation of such inclusions, the components of the described elements should be optimally combined, and the size and number of the inclusions generated should be managed to satisfy the above relational expression 1. Inclusions generated in the steel becomes a starting point of crack occurrence, and as a result, the generation of inclusions reduces impact properties of the steel type and causes a decrease in bendability. Therefore, as illustrated in relational expression 1, by controlling the content of the above-described components and characteristics of the inclusions, not only can the strength of the steel sheet and stretch flangeability of the steel sheet be secured, but also the bendability can also be improved.

[0052] In this specification, the inclusions mean sulfides and carbides such as MnS and (Nb,Ti)C. Commonly known types of inclusions comprise nitrides, but in the present disclosure, those that have a significant impact on strength and bendability are inclusions formed from Mn, C, and S. So inclusions in the present specification comprise only sulfides, carbides (comprising carbonitrides), but do not comprise nitrides.

[0053] In addition, among the inclusions, an average diameter [μm] of inclusions having a diameter of 1μm or more is defined as P_{size}. In this case, the above-described inclusions may be composed of various forms such as MnS, carbide, and the like. When a shape thereof is spherical, the inclusion having a diameter of 1μm or more is determined to be a major inclusion. When the shape is not spherical, a diameter thereof is measured assuming it as a sphere having the same area, and when the value is 1μm or more, the inclusion is determined to be a valid inclusion. Meanwhile, a method of measuring thereof is not specifically limited, but in order to accurately determine, it is preferable to measure using a high-performance microscope with magnification of 3000 times or more.

[0054] In addition, among the inclusions, an average number [ea] of inclusions with a diameter of 1 um or more is defined as P_{number}. Although not particularly limited on the method of measuring an average number of inclusions, but as in the embodiments of the present disclosure, it is preferable to measure using a high-performance microscope with a magnification of 3000 times or more. As an example, the average number of inclusions may refer to an average number of inclusions with a diameter of 1 um or more present in a range of 100 to 600 μm^2 per unit area. Meanwhile, in the present specification, if the average number of inclusions with a diameter of 1 um or more described above is less than 1, the value of Relational expression 1 is defined as 1. In order to increase statistical accuracy of the number of inclusions present per unit area, an average value of at least three measurements can be used.

[0055] Meanwhile, although not particularly limited, according to an aspect of the present disclosure, in terms of further improving the above-described effect, a lower limit of the value of M may be 103, or an upper limit of the value of M may be 441.

[0056] According to an embodiment of the present disclosure, although not particularly limited, the ultra-high strength steel sheet may have a yield strength (YS) of 1140 to 1500 MPa and a tensile strength (TS) of 1470 to 1700 MPa. This is because, due to the characteristics of the steel sheet applied to a collision member, having the strength of the corresponding value is appropriate, considering strength, weight reduction, formability, and productivity. Meanwhile, although not particularly limited, more preferably, in the ultra-high strength steel sheet, a lower limit of the yield strength may be 1250 MPa, or an upper limit of the yield strength may be 1350 MPa. In addition, in the ultra-high strength steel sheet, a lower limit of the tensile strength may be 1480 MPa, or an upper limit of the tensile strength may be 1600 MPa.

[0057] In addition, according to an aspect of the present disclosure, although not particularly limited, the ultra-high strength steel sheet may have a yield ratio of 0.8 or more. This is because, due to the characteristics of the steel sheet applied to a collision member, it is advantageous to have a high yield strength compared to a tensile strength. Meanwhile, although not particularly limited, in terms of further improving the above-described effect, preferably, in the ultra-high strength steel sheet, a lower limit of the yield ratio may be 0.84, or an upper limit of the yield ratio may be 0.90.

[0058] In addition, according to an aspect of the present disclosure, although not particularly limited, the ultra-high strength steel sheet may have stretch flangeability (HER) of 25% or more. This is because it is preferable to have excellent stretch flangeability in order to process ultra-high strength steel sheets through roll forming or press forming. Meanwhile, although not particularly limited, in terms of further improving the above-described effect, preferably, in the ultra-high strength steel sheet, a lower limit of the stretch flangeability (HER) may be 28%, or an upper limit of the stretch flangeability (HER) may be 40%.

[0059] In addition, according to an aspect of the present disclosure, although not particularly limited, the ultra-high strength steel sheet may have bendability R/t of 4 or less. This is because it is preferable to have excellent bending properties in order to process an ultra-high strength steel sheet through roll forming or press forming. Meanwhile, although not particularly limited, in terms of further improving the above-described effect, preferably, in the ultra-high strength steel sheet, a lower limit of the bendability (R/t) may be 2.6, or an upper limit of the bendability (R/t) may be 3.8.

[0060] In addition, according to an aspect of the present disclosure, although not particularly limited, the ultra-high strength steel sheet may have an elongation (El) in the range of 3 to 13%. If the elongation is less than 3%, a problem in which formability is insufficient may occur, and if the elongation exceeds 13%, a large amount of soft phases excluding martensite may be formed in steel, which may cause a problem in operability to secure a stable target strength.

[0061] Next, a [manufacturing method of an ultra-high strength steel sheet] according to another aspect of the present disclosure will be described in detail below. However, this does not mean that the ultra-high strength steel sheet of the present disclosure should be manufactured by the following manufacturing method.

[0062] First, a steel sheet, which comprises, by weight: carbon (C): 0.12 to 0.4%, silicon (Si): 0.5% or less (excluding 0%), manganese (Mn) : 2.5 to 4.0%, phosphorous (P) : 0.03% or less (excluding 0%), sulfur (S): 0.012% or less (excluding 0%), aluminum (Al): 0.1% or less (excluding 0%), chromium (Cr): 1% or less (excluding 0%), titanium (Ti): 48/14×[N]~0.1%, niobium (Nb): 0.1% or less (excluding 0%), boron (B): 0.005% or less (excluding 0%), nitrogen (N): 0.01% or less (excluding 0%), with a balance of Fe and other impurities, and consists of a microstructure comprising, by area, martensite: 90% or more, and a sum of ferrite and bainite: 10% or less, is prepared. In this case, the above description may be equally applied to an alloy composition and microstructure of the steel sheet.

[0063] In this case, as a steel sheet before heat treatment (tempering) to be described later, a cold-rolled steel sheet, a hot-dip galvanized steel sheet, a galvaannealed steel sheet, an electro-galvanized steel sheet, and the like, may be used. And during heat treatment or after heat treatment, properties of the hot-dip galvanized steel sheet, the galvaannealed steel sheet, the electro-galvanized steel sheet may be maintained as it is, or changed into a new type of steel sheet.

[0064] Subsequently, tempering (or rapid tempering) is performed on the steel sheet using an induction heater or the like. In this case, the tempering is controlled so that a value of P, defined by Relational expression 2 below, satisfies a range of 1.5 to 77.0.

[Relational expression 2]

$$P = \frac{\exp\left(\frac{T+273.15}{40}\right)}{10000} X \left[\log\left(t_{eff}\right) - 0.25\right]$$

[0065] In Relational expression 2, T is a maximum temperature of tempering, and a unit thereof is °C. In addition, t_{eff} is an effective heat treatment time, and a unit thereof is seconds.

[0066] An ultra-high-strength steel sheets having a yield ratio of less than 0.75 manufactured through a continuous annealing furnace with a slow cooling section or a continuous annealing alloy plating furnace have dissolved carbon fixed to dislocations introduced during martensite formation. In this case, the fixed carbon may be made to freely diffuse through rapid low-temperature tempering heat treatment using an induction heater, thereby increasing a ratio of yield strength and tensile strength. When the fixed carbon diffuses freely, deformation of the material is suppressed by fixing dislocations, resulting in an increase in yield strength. Freeing the fixed carbon is a function of temperature and time, like normal diffusion behavior. The higher the temperature and the longer the time, the more freely it can diffuse, but when the temperature is too high and the time is too long, the yield strength and tensile strength decrease due to formation of carbides.

[0067] In addition, the increase in yield strength has a result of improving stretch flangeability of a material. In general, as the yield strength increases for the same grade of tensile strength, toughness increases, so the stretch flangeability

tends to increase. In addition, it tends to increase as a difference in interphase strength between microstructures within the material decreases, and the difference in interphase strength due to differences in cooling at each location within the material may be reduced through tempering heat treatment.

[0068] However, if the tempering temperature is high or the time is too long, the generated carbides are excessively coarsened and cracks are generated at the corresponding location, which has an adverse effect of reducing the stretch flangeability. As the yield strength increases for the same grade of tensile strength, the toughness of the material increases, so the bending properties also tend to increase.

[0069] Therefore, it is possible to increase the bending properties through tempering heat treatment under appropriate conditions suggested by the present invention. However, when the heat treatment temperature is high, or the heat treatment time is long, the generated carbides become excessively coarse and becomes a starting point of crack occurrence during bending tests, which tends to deteriorate bending characteristics.

[0070] Therefore, as a result of repeatedly conducting intensive studies to provide an ultra-high strength steel material improving yield strength while controlling a decrease in tensile strength as much as possible, and at the same time, improving stretch flangeability and bendability, it was confirmed that the above-described purpose may be achieved by controlling tempering conditions so that a value of P defined by Relational expression 2 satisfies a range of 1.5 to 77.0.

[0071] Meanwhile, although not particularly limited, in terms of further improving the above-described effect, a lower limit of the value of P defined by Relational expression 2 may be 15.8, or an upper limit of the value of P defined by relational expression 2 may be 54.7.

[0072] In the present specification, t_{eff} is an effective heat treatment time and is a residence time [sec] in a section in which 90% or more of a maximum temperature of the tempering described above has been reached. In this case, whether 90% or more of the maximum temperature of the tempering has been reached is determined based on an absolute temperature [K].

[0073] In addition, according to an embodiment of the present disclosure, although not particularly limited, the T (maximum temperature of tempering) may satisfy a range of 100 to 300°C. If the T is less than 100°C, it may be difficult to induce the diffusion behavior of carbon described above, and if the T exceeds 300°C, the carbides may become excessively coarse, making it difficult to achieve the target physical properties. Meanwhile, although not particularly limited, in terms of further improving the above-described effect, preferably, a lower limit of the T may be 200°C, or an upper limit of the T may be 250°C.

[0074] In addition, according to an embodiment of the present disclosure, although not particularly limited, the t_{eff} may satisfy a range of 1 to 120 seconds. If the t_{eff} is less than 1 second, there may be a problem of not stably securing the target strength due to an excessively short effective heat treatment time. In addition, if the t_{eff} exceeds 120 seconds, the heat treatment time may be prolonged, which may cause problems with productivity, and the carbides may become coarse, thereby reducing bendability.

[0075] In addition, according to an embodiment of the present disclosure, although not particularly limited, the tempering may be performed to satisfy the following relational expression 3.

[0076]

[Relational expression 3]

$$5 \leq t_{total} \leq 120$$

[0077] In the above Relational expression 3, t_{total} is a total heat treatment time of tempering, and a unit thereof is seconds.

[0078] In other words, if the total heat treatment time (t_{total}) of tempering is less than 5 seconds, it may be difficult to secure sufficient time to induce carbon diffusion behavior, and facility limitations may occur even in reaching a target heat treatment temperature. On the other hand, controlling an upper limit of the total heat treatment time (t_{total}) of tempering to 120 seconds or less is one of the key control conditions of the invention, wherein if the total heat treatment time (t_{total}) of tempering exceeds 120 seconds, carbides become coarse so that it is difficult to achieve target physical properties, and in particular, an adverse effect on bending properties is very significant. In addition, as the heat treatment time increases, productivity may decrease significantly, and separate additional processes may be required. Meanwhile, although not limited thereto, in terms of further improving the above-described effect, a lower limit of the total heat treatment time (t_{total}) of the tempering may be 10 seconds, or an upper limit of the total heat treatment time (t_{total}) of the tempering may be 30 seconds.

[0079] In addition, according to an embodiment of the present disclosure, although not particularly limited, the tempering may be performed to satisfy the following relational expression 4.

[0080]

[Relational expression 4]

$$1 \leq t_{heat} \leq 119$$

[0081] In the above Relational expression 4, t_{heat} is a heating time of tempering, and a unit thereof is seconds.

[0082] According to an embodiment of the present disclosure, if the heating time (t_{heat}) of the tempering is less than 1 second, an overload problem in a heating equipment may occur due to an excessively short heating time, or a problem may occur in which the steel material is not heated evenly. In addition, if the heating time (t_{heat}) of the tempering exceeds 119 seconds, there may be a problem in which productivity may decrease and it may become difficult to secure a sufficient holding time. Meanwhile, although not particularly limited, in terms of further improving the above-described effect, a lower limit of the heating time (t_{heat}) of the tempering may be 30 seconds, or an upper limit of the heating time (t_{heat}) of the tempering may be 50 seconds.

[0083] In addition, according to an embodiment of the present disclosure, although not particularly limited, the tempering may be performed to satisfy the following relational expression 5. In other words, when a tempering holding time (t_{hold}) is less than 1 second, target strength may not be secured and there may be a problem in which the same physical properties may not be secured at all locations of the steel material. In addition, if the tempering holding time (t_{hold}) exceeds 119 seconds, not only productivity may decrease, but there may be a problem in which a carbide may coarsen and bendability may decrease. Meanwhile, although not illustrated, in terms of further improving the above-described effect, preferably, a lower limit of the tempering holding time (t_{hold}) may be 15 seconds, or an upper limit of the tempering holding time (t_{hold}) may be 30 seconds.

[0084]

[Relational expression 5]

$$1 \leq t_{hold} \leq 119$$

[0085] In the above Relational expression 5, t_{hold} is a holding time of tempering, and a unit thereof is seconds.

[0086] Meanwhile, in the present specification, the above relational expressions 4 and 5 refer to conditions that are satisfied when tempering is performed in a form of general heating - holding - cooling. Therefore, when the heat treatment process of the steel material is not performed in the form of heating - holding - cooling, it is sufficient not to satisfy the conditions of relational expressions 4 and 5, and in this case, it is sufficient to satisfy only the above-described Relational expression 3. Meanwhile, examples of a case in which the heat treatment process of the steel material described above is not performed in the form of heating - holding - cooling comprise a case in which heating - holding - cooling process is repeated several times during heat treatment, the holding or cooling step is omitted, or the like.

Mode for Invention

(Example)

[0087] Hereinafter, the present disclosure will be specifically described through the following Examples. However, it should be noted that the following examples are only for describing the present disclosure by illustration, and not intended to limit the right scope of the present disclosure. The reason is that the right scope of the present disclosure is determined by the matters described in the claims and reasonably inferred therefrom.

[0088] After preparing a steel sheet having the composition illustrated in Table 1 and the microstructure illustrated in Table 2, rapid tempering was performed on the steel sheet to meet the conditions illustrated in Table 3 below.

[0089]

[Table 1]

[wt%]	C	Mn	S*	Si	P	Al	Cr	Ti	Nb	B	N
Inventio n steel A	0.18	3.6	36	0.11	0.012	0.022	0.05	0.02	0.039	0.0016	0.004
Inventio n steel B	0.16	3.5	90	0.11	0.012	0.022	0.05	0.02	0.039	0.0016	0.004
Inventio n steel C	0.22	2.7	5	0.11	0.012	0.022	0.05	0.02	0.039	0.0016	0.004
Inventio n steel D	0.22	2.7	5	0.11	0.012	0.022	0.05	0.02	0.039	0.0016	0.004

(continued)

[wt%]	C	Mn	S*	Si	P	Al	Cr	Ti	Nb	B	N
Inventio n steel E	0.29	3.7	90	0.11	0.012	0.022	0.05	0.02	0.039	0.0016	0.004
Inventio n steel F	0.15	2.6	10	0.11	0.012	0.022	0.05	0.02	0.039	0.0016	0.004
Inventio n steel G	0.26	3.2	95	0.11	0.012	0.022	0.05	0.02	0.039	0.0016	0.004
Comparat ive steel H	0.11	2.5	40	0.11	0.012	0.022	0.05	0.02	0.039	0.0016	0.004
Comparat ive steel I	0.27	3	250	0.11	0.012	0.022	0.05	0.02	0.039	0.0016	0.004
Comparat ive steel J	0.26	4.5	65	0.11	0.012	0.022	0.05	0.02	0.039	0.0016	0.004

[0090] However, S*: a unit of S content is ppm

[Table 2]

	Steel type	Martensite [area %]	Ferrite [area %]	Bainite [area %]
Invention example 1	Invention steel A	96	4	0
Invention example 2	Invention steel B	94	5	1
Invention example 3	Invention steel C	98	2	0
Invention example 4	Invention steel D	98	2	0
Comparati ve example 1	Invention steel E	99	1	0
Comparati ve example 2	Invention steel F	90	8	2
Comparati ve example 3	Invention steel G	97	3	0
Comparati ve example 4	Invention steel A	96	4	0
Comparati ve example 5	Comparati ve steel H	80	5	15
Comparati ve example 6	Comparati ve steel I	95	1	4
Comparati ve example 7	Comparati ve steel J	97	0	3

[Table 3]

	T*	t_{eff}*	t_{heat}*	t_{hold}*	t_{total}*	Tempering index, P
Inventio n example 1	200	25.4	20	20	40	15.8
Inventio n example 2	200	25.4	20	20	40	15.8
Inventio n example 3	200	25.4	20	20	40	15.8
Inventio n example 4	250	24.7	20	20	40	54.7
Comparat ive example 1	250	139.5	600	600	1200	90.7
Comparat ive example 2	100	30.0	20	20	40	1.4
Comparat ive example 3	250	139.5	600	600	1200	90.7
Comparat ive example 4	300	24.2	20	20	40	189.4
Comparat ive example 5	100	30.0	20	20	40	1.4
Comparat ive example 6	200	25.4	20	20	40	15.8

(continued)

	T*	t_{eff}*	t_{heat}*	t_{hold}*	t_{total}*	Tempering index, P
Comparat ive example 7	200	25.4	20	20	40	15.8

T* = Maximum temperature of tempering
t_{eff}* = Residence time in a section in which 90% or more of a maximum temperature of tempering has been reached [sec]
t_{heat}* = Heating time of tempering [sec]
t_{hold}* = Holding time of tempering [sec]
t_{total}* = Total heat treatment time

$$P = \frac{\exp(\frac{T+273.15}{40})}{10000} X\ [\log(t_{eff}) - 0.25]$$

[0091] After manufacturing a cross-sectional specimen by cutting a steel sheet obtained from each of the invention examples and comparative examples in Table 3 in a thickness direction, an average diameter (P_{size}) of inclusions having a diameter of 1 um or more, and average number (P_{number}) of inclusions having a diameter of 1 um or more was measured in the same manner as described above in the specification based on a unit area of 400μm^2 and was illustrated in Table 4 below. However, when there are no inclusions having a diameter of 1 um or more, the P_{size} and P_{number} were expressed as '1', respectively.

[0092] In addition, through a room temperature tensile experiment, a yield strength (YS), a tensile strength (TS), and a yield ratio (yield strength/tensile strength; YR) were calculated according to ISO-6892 standards and were shown in Table 5 below.

[0093] In addition, for each of the comparative examples and invention examples below, after measuring the yield strength (YS) and tensile strength (TS) values for each specimen before tempering heat treatment were measured, based on the above-described measured values, a change in yield strength (ΔYS) and a change in tensile strength (ΔTS) for each specimen after tempering heat treatment were measured and were illustrated in Table 5 below.

[0094] In addition, elongation (El) was measured according to ISO-6892 standards, and stretch flangeability (HER) was measured by drilling a 10 mm hole in a steel material and expanding the hole at a constant speed. In addition, bendability (R/t) was measured by pressing the steel material with an indenter having a constant R value, which was illustrated in Table 5 below.

[0095] In addition, after cutting the steel material to a size of 1000 mm or more in length, the steel material was placed on a flat place and a wave height was measured, and flatness of the steel material was evaluated based on a maximum value of the wave height. In this case, when the maximum value of wave height is less than 10 mm, a shape thereof was evaluated as 'good', and when the maximum value of wave height was 10 mm or more, a shape thereof was evaluated 'bad' and was illustrated in Table 5 below.

[Table 4]

Reference	P_{size} [μm]	P_{number} [ea]	M*
Invention example 1	1	1	198
Invention example 2	1	1	441
Invention example 3	1	1	103
Invention example 4	1.4	2	287
Comparativ e example 1	1	1	664
Comparativ e example 2	1	1	26
Comparativ e example 3	1.2	3	1786
Comparativ e example 4	1.5	4	1188
Comparativ e example 5	1	1	83
Comparative example 6	1.4	8	13094

(continued)

Reference	P_{size} [μm]	P_{number} [ea]	M*
Comparative example 7	2.1	5	7047
$M^* = P_{size} \times P_{number} \times [C]^{0.5} \times [Mn]^2 \times [S]$			

[Table 5]

Reference	YS [MPa]	TS [MPa]	YR	El [%]	HER [%]	R/t	Flatness
Invention example 1	1311	1540	0.85	8.7	38	2.6	Good
Invention example 2	1284	1498	0.86	9.1	40	2.8	Good
Invention example 3	1271	1511	0.84	8.5	37	3.3	Good
Invention example 4	1291	1484	0.87	8.3	28	3.8	Good
Comparative example 1	1387	1611	0.86	6.2	20	4.5	Bad
Comparative example 2	1071	1443	0.74	8.2	32	2.5	Good
Comparative example 3	1411	1615	0.87	6.5	21	4.5	Bad
Comparative example 4	1208	1425	0.85	10.5	24	5.3	Good
Comparative example 5	917	1221	0.75	13.1	28	2.8	Bad
Comparative example 6	1377	1594	0.86	6.1	18	5.7	Bad
Comparative example 7	1421	1657	0.86	5.4	17	5.8	Bad

[0096] As can be seen from the experimental results in Table 5, in the case of Invention examples 1 to 4, which satisfies an alloy composition and manufacturing conditions of the present disclosure, and in which a value of M defined from Relational expression 1 satisfies a range of 100 to 500, it was confirmed that a yield ratio, bendability, and stretch flangeability were excellent, and at the same time, flatness was also excellent, while securing a high yield strength and tensile strength.

[0097] On the other hand, in the case of Comparative Examples 1 to 4, which satisfies the alloy composition of the present disclosure, but a value of P defined from Relational expression 2 is less than 1.5 or exceeds 77.0, it was confirmed that one or more of the characteristics of strength, yield ratio, bendability, stretch flangeability, and flatness were inferior due to inappropriate tempering conditions.

[0098] On the other hand, in the case of Comparative Examples 5 to 7, which do not satisfy the alloy composition of the present disclosure, strength, bendability, stretch flangeability, and flatness were all inferior.

[0099] Specifically, Comparative Example 5 illustrates a steel type that does not meet the alloy composition of the present disclosure, and specifically, a carbon content is insufficient. Carbon, an interstitial reinforcing element, is an element that greatly contributes to increasing a strength of the steel type, and due to a lack of carbon, a tensile strength and yield strength fell short of values targeted in the present disclosure. In addition, in Comparative Example 5, a sufficient time and temperature were not secured in a tempering process, so that a P value of expression (2) was less than the value targeted in the present disclosure. Due to this, a sufficient increase in yield strength was not secured during the tempering process, and the yield strength was insufficient after the tempering process.

[0100] Comparative Example 6 is a case in which a steel type having an excess sulfur content, compared to an alloy composition targeted in the present disclosure was used. When a concentration of sulfur in steel is high, sulfur reacts with manganese to generate inclusions such as manganese sulfide, or the like, and these inclusions greatly reduces bending properties and stretch flangeability of the steel. Therefore, in Comparative Example 6, an M value of Relational expression (1), which was quantified considering these factors, exceeded the target value in the present disclosure. Due thereto, R/t, which is an indicator of the bending properties of Comparative Example 6, and HER, which is an indicator of the stretch flangeability, do not satisfy the target values of the present disclosure.

[0101] Comparative Example 7 illustrates a steel type of which a manganese content is excessive compared to an alloy composition targeted in the present disclosure. When a concentration of manganese in steel is high, manganese reacts with sulfur to generate inclusions such as manganese sulfide, or the like, and these inclusions greatly reduce bending properties and stretch flangeability of the steel. Therefore, in Comparative Example 7, an M value of expression

(1) quantified in consideration of the above-described factors exceeded a target value in the present disclosure. As a result, it was confirmed that R/t, an indicator of the bending characteristics of Comparative Example 7, and HER, an indicator of the stretch flangeability, did not satisfy the target values of the present disclosure. In addition, when a concentration of manganese in steel is high, manganese forms a band structure in the steel. These structural characteristics caused by manganese cause deterioration of the bending and shape characteristics of the steel type. In addition, an increase in the content of manganese improves hardenability of the steel type, thereby increasing a tensile strength, and if the tensile strength exceeds the target value in the present disclosure, the shape of the steel becomes deteriorated during production of steel, and it becomes difficult to correct the deteriorated shape, which causes a problem of the shape of the steel being deteriorated. As a result, in Comparative Example 7, all the tensile strength, HER, bendability, and flatness of the steel did not meet the target values of the present invention.

Claims

1. An ultrahigh strength steel sheet comprising, by weight: carbon (C): 0.12 to 0.4%, silicon (Si): 0.5% or less (excluding 0%), manganese (Mn): 2.5 to 4.0%, phosphorous (P) : 0.03% or less (excluding 0%), sulfur (S): 0.012% or less (excluding 0%), aluminum (Al): 0.1% or less (excluding 0%), chromium (Cr): 1% or less (excluding 0%), titanium (Ti): 48/14×[N]~0.1%, niobium (Nb): 0.1% or less (excluding 0%), boron (B): 0.005% or less (excluding 0%), nitrogen (N): 0.01% or less (excluding 0%), with a balance of Fe and other impurities,

   wherein the steel sheet comprises, as a microstructure, by area, martensite: 90% or more, and a sum of ferrite and bainite: 10% or less,
   wherein a value of M defined by Relational expression 1 below satisfies a range of 100 to 500.

$$[\text{Relational expression 1}]$$

$$M = P_{size} \times P_{number} \times [C]^{0.5} \times [Mn]^{2} \times [S]$$

   In the above Relational expression 1, P_{size} is an average diameter of inclusions having a diameter of 1 um or more, and P_{number} is an average number of inclusions having a diameter of 1 um or more. [C] and [Mn] are average weight % contents of elements in parentheses in the steel sheet, respectively, and [S] is an average ppm content of element in parentheses in the steel sheet.

2. The ultrahigh strength steel sheet of claim 1, wherein a yield strength is 1140 to 1500MPa, and a tensile strength is 1470 to 1700MPa.

3. The ultrahigh strength steel sheet of claim 2, wherein a yield ratio is 0.8 or more.

4. The ultrahigh strength steel sheet of claim 1, wherein stretch flangeability HER is 25% or more, and bendability R/t is 4 or less.

5. A manufacturing method of an ultrahigh strength steel sheet, comprising operations of:

   preparing a steel sheet, which comprises, by weight: carbon (C): 0.12 to 0.4%, silicon (Si): 0.5% or less (excluding 0%), manganese (Mn) : 2.5 to 4.0%, phosphorous (P) : 0.03% or less (excluding 0%), sulfur (S): 0.012% or less (excluding 0%), aluminum (Al): 0.1% or less (excluding 0%), chromium (Cr): 1% or less (excluding 0%), titanium (Ti): 48/14x[N]~0.1%, niobium (Nb): 0.1% or less (excluding 0%), boron (B): 0.005% or less (excluding 0%), nitrogen (N): 0.01% or less (excluding 0%), with a balance of Fe and other impurities, and consists of a microstructure comprising, by area, martensite: 90% or more, and a sum of ferrite and bainite: 10% or less; and performing tempering on the steel sheet,
   wherein a value of P defined by relational expression 2 below satisfies a range of 1.5 to 77.0,

[Relational expression 2]

$$P = \frac{\exp\left(\frac{T+273.15}{40}\right)}{10000} X \left[\log\left(t_{eff}\right) - 0.25\right]$$

In the above Relational expression 2, T is a maximum temperature of tempering, and a unit thereof is °C. In addition, t_{eff} is an effective heat treatment time, and a unit thereof is seconds.

6. The manufacturing method of an ultrahigh strength steel sheet of claim 5, wherein the T satisfies a range of 100 to 300°C.

7. The manufacturing method of an ultrahigh strength steel sheet of claim 5, wherein the t_{eff} satisfies a range of 1 to 120 seconds.

8. The manufacturing method of an ultrahigh strength steel sheet of claim 5, wherein the following Relational expression 3 is satisfied,

[Relational expression 3]

$$5 \leq t_{total} \leq 120$$

In the above Relational expression 3, t_{total} is a total heat treatment time of tempering, and a unit thereof is seconds.

9. The manufacturing method of an ultrahigh strength steel sheet of claim 5, wherein the following Relational expression 4 is satisfied,

[Relational expression 4]

$$1 \leq t_{heat} \leq 119$$

In the above Relational expression 4, t_{heat} is a heating time of tempering, and a unit thereof is seconds.

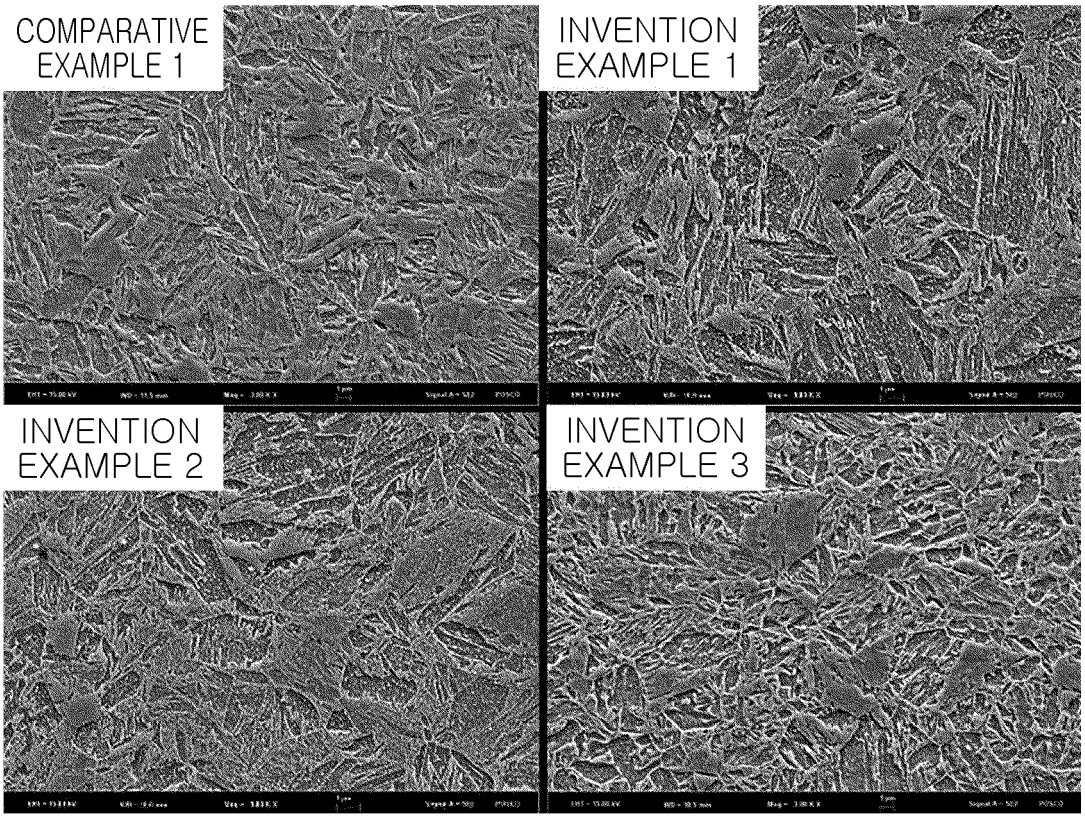
10. The manufacturing method of an ultrahigh strength steel sheet of claim 5, wherein the following Relational expression 5 is satisfied,

[Relational expression 5]

$$1 \leq t_{hold} \leq 119$$

In the above Relational expression 5, t_{hold} is a holding time of tempering, and a unit thereof is seconds.

FIG. 1


COMPARATIVE EXAMPLE 1
INVENTION EXAMPLE 1
INVENTION EXAMPLE 2
INVENTION EXAMPLE 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2022/016583

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/38(2006.01)i; **C22C 38/28**(2006.01)i; **C22C 38/26**(2006.01)i; **C22C 38/32**(2006.01)i; **C22C 38/00**(2006.01)i; **C21D 1/18**(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); C21D 9/46(2006.01); C22C 38/00(2006.01); C22C 38/02(2006.01); C22C 38/14(2006.01); C22C 38/28(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: 마르텐사이트(martensite), 베이나이트(bainite), 페라이트(ferrite), 크롬(Cr), 티타늄(Ti), 니오븀(Nb), 보론(B), 템퍼링(tempering), 강도(strength)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 6057027 B1 (JFE STEEL CORP.) 11 January 2017 (2017-01-11) See paragraphs [0034], [0065] and [0079], claims 1-3 and 5 and table 3.	1-10
A	CN 113122769 A (BAOSHAN IRON & STEEL CO., LTD.) 16 July 2021 (2021-07-16) See claims 1, 4-5 and 8.	1-10
A	US 2016-0312326 A1 (ARCELORMITTAL) 27 October 2016 (2016-10-27) See paragraph [0016] and claims 20 and 35.	1-10
A	JP 2011-153361 A (NISSHIN STEEL CO., LTD.) 11 August 2011 (2011-08-11) See paragraph [0030] and claims 1-2.	1-10
A	JP 2011-111670 A (NIPPON STEEL CORP.) 09 June 2011 (2011-06-09) See paragraph [0071] and claims 1-3 and 8.	1-10

☐ 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
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Information on patent family members

International application No.
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