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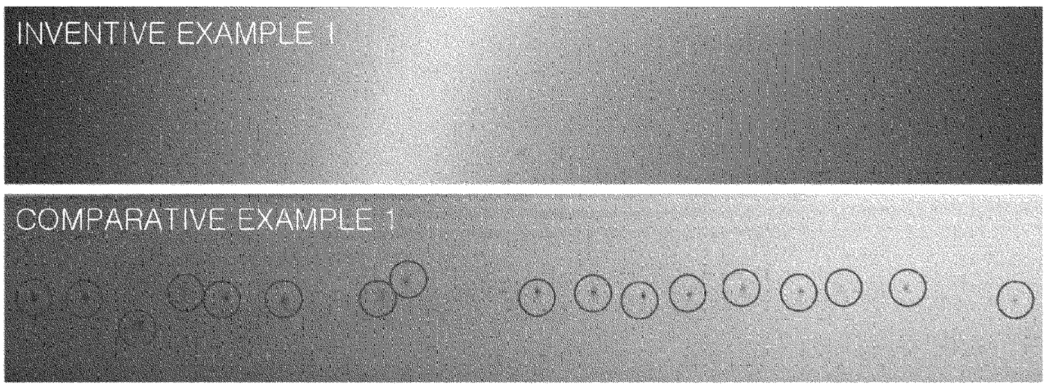
(54) HIGH STRENGTH COLD ROLLED STEEL SHEET HAVING EXCELLENT SURFACE QUALITY AND LOW MECHANICAL PROPERTY DEVIATION AND MANUFACTURING METHOD OF SAME

(57) The present invention relates to: a high-strength cold-rolled steel sheet having excellent surface quality and low mechanical property deviation; and a manufacturing method thereof and, more particularly, to: a high-strength cold-rolled steel sheet that can be suitably used for automotive parts by ensuring high strength and elongation with little surface defects and low mechanical property deviation; and a manufacturing method thereof.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a high-strength cold-rolled steel sheet used in structural members with a large amount of forming, such as pillars, seat rails, members, and the like, of a vehicle body and a method for manufacturing the same, and more specifically to a high-strength cold-rolled steel sheet that has excellent surface quality and low material deviation and can be suitably used for automotive parts and method for a manufacturing the same.

Background Art

[0002] In recent years, as safety and environmental regulations are being strengthened in the automobile industry, the use of high-strength steel with a tensile strength of 780 MPa or more is increasing when manufacturing vehicle bodies to improve vehicle fuel efficiency and protect passengers.

[0003] High-strength steel used in conventional vehicle bodies includes a dual phase (DP) steel, comprising dual phases, which are a soft ferrite matrix and hard martensite phase, a transformation induced plasticity (TRIP) steel using transformation-induced plasticity of retained austenite, a complex phase (CP) steel, comprising a complex structure of ferrite and hard bainite or martensite, and the like.

[0004] However, in high-strength steel, when a large amount of Si, Al, Mn, or the like are added, there may be a problem in that weldability is poor and surface defects of the steel sheet occur due to dents in a furnace during annealing. In addition, when a large amount of hardenable elements such as Mn, Cr, Mo, or the like are added, there may be a problem in that material deviation of a hot-rolled coil occurs, so that thickness quality may deteriorate during cold rolling. In this case, the surface defects due to dents of the steel sheet in a furnace refer to surface defects of the steel sheet formed when metal-based oxides on a surface of the steel sheet are adsorbed and accumulated on rolls of an annealing furnace, and by contact between the steel sheet and the rolls during rolling.

[0005] The contents of the prior art related to manufacturing technology of high-strength cold-rolled steel sheets and hot-dip galvanized steel sheets to solve the above-described problems are briefly described as follows.

[0006] Among the prior art, Patent Document 1 discloses a high-strength cold-rolled steel sheet and a manufacturing method thereof, through a process of cold rolling a hot-rolled steel sheet including a low-temperature transformation phase of 60% or more, by volume, at a cold rolling reduction rate of more than 60% and less than 80%, and a process of continuously annealing a steel sheet after cold rolling in a ferrite and austenite dual-phase zone. However, the cold-rolled steel sheet obtained from Patent Document 1 had a strength as low as 370 to 590 MPa, causing a problem in that it is difficult to be applied to vehicle impact-resistant members and limited to use only for interior and exterior panels.

[0007] In addition, Patent Document 2 discloses a method of manufacturing a cold-rolled steel sheet simultaneously obtaining high strength and high ductility by utilizing a tempered martensite phase, and having an excellent plate shape after continuous annealing. However, the technology of Patent Document 2 had a problem of poor weldability due to a high carbon content in steel, which is 0.2% or more, and a problem of the occurrence of surface defects due to dents in the furnace due to a large amount of Si contained therein.

(Patent Document 1) Korean Patent Publication No. 2004-0066935

(Patent Document 2) Japanese Patent Publication No. 2010-090432

Summary of Invention

Technical Problem

[0008] An aspect of the present disclosure is to provide a high-strength cold-rolled steel sheet having excellent surface quality and low material deviation and a method for manufacturing thereof.

[0009] An object of the present disclosure is not limited to the above description. The object of the present disclosure will be understood from the entire content of the present specification, and a person skilled in the art to which the present disclosure pertains will understand an additional object of the present disclosure without difficulty.

Solution to Problem

[0010] According to an aspect of the present disclosure, provided is a high-strength cold-rolled steel sheet,

the high-strength cold-rolled steel sheet including: by weight%, C: 0.05 to 0.3%, Si: 0.01 to 2.0%, Mn: 1.5 to 3.0%,

Al: 0.01 to 0.1%, P: 0.001 to 0.015%, S: 0.001 to 0.01%, N: 0.001 to 0.01%, with a remainder of Fe, and other unavoidable impurities,
wherein a value defined by Relational Expression 1 satisfies 0.6 or more and less than 0.9,
as a microstructure, by area%, ferrite: 50% or more, and a remainder including bainite and martensite,
wherein an average number of surface defects satisfying one or more conditions of a depth of 100 um or more and a short side length of 1 mm or more, is less than $10/m^2$.

[Relational Expression 1] $C + (1.3\times Si+Mn)/6 + (Cr+1.2\times Mo)/5 + 100\times_B$

[0011] In Relational Expression 1, C, Si, Mn, Cr, Mo, and B represent an average weight percentage for each element. when each of the above-described elements is not added, 0 is substituted.

[0012] According to another aspect of the present disclosure, provided is a method for manufacturing a high-strength cold-rolled steel sheet,

the method, including reheating a steel slab including, by weight%: C: 0.05 to 0.3%, Si: 0.01 to 2.0%, Mn: 1.5 to 3.0%, Al: 0.01 to 0.1%, P: 0.001 to 0.015%, S: 0.001 to 0.01%, N: 0.001 to 0.01%, with a remainder of Fe, and other unavoidable impurities, wherein a value defined by Relational Expression 1 satisfies 0.6 or more and less than 0.9, to a temperature within a range of 1100 to 1350°C;
hot rolling the reheated steel slab at a temperature within a range of 850 to 1150°C;
cooling the hot-rolled steel sheet to a temperature within a range of 450 to 700°C at an average cooling rate of 10 to 70°C/s;
coiling the cooled steel sheet at a temperature within a range of 450 to 700°C;
cold rolling the wound steel sheet at a reduction rate of 40 to 70%; and
continuously annealing the cold-rolled steel sheet at a temperature within a range of 740 to 900°C,
wherein in the coiling, based on an entire width of the steel sheet, a surface temperature (Te) of both end portions in the width direction is controlled to satisfy 601 to 700°C, and a surface temperature (Tc) of a center portion is controlled to satisfy 450 to 600°C.

[Relational Expression 1] $C + (1.3\times Si+Mn)/6 + (Cr+1.2\times Mo)/5 + 100\times B$

[0013] In Relational Expression 1, C, Si, Mn, Cr, Mo and B represent an average weight percentage of each element. In addition, if each of the above-described elements is not added, 0 is substituted.

Advantageous Effects of Invention

[0014] According to an aspect of the present disclosure, a high-strength cold-rolled steel sheet having excellent surface quality and low material deviation and a manufacturing method thereof may be provided.

[0015] Various and beneficial advantages and effects of the present disclosure 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 the Drawings

[0016]

FIG. 1 illustrates an image captured with a general low-magnification camera of surface defects of each cold-rolled steel sheet obtained from Inventive Example 1 and Comparative Example 1 of the present disclosure.
FIG. 2 illustrates an image captured with a high-magnification scanning cell microscope (SEM) of the surface defects defined in the present disclosure.

Best Mode for Invention

[0017] Hereinafter, preferred embodiments of the present disclosure will be described. However, the embodiments of the present disclosure can be modified into various other forms, and the scope of the present disclosure is not limited to the embodiments described below. In addition, the embodiments of the present disclosure are provided to more completely explain the present disclosure to those with average knowledge in the related technical literature.

[0018] Meanwhile, the terms used herein are intended to describe the present disclosure and are not intended to limit the present disclosure. For example, the singular forms used herein include the plural forms unless the related definition clearly dictates the contrary. In addition, the meaning of "comprising" as used in the specification specifies a component, and does not exclude the presence or addition of other components.

[0019] In the prior art, a technology has not been developed, the technology for satisfying advanced demands for a cold-rolled steel sheet having high strength having a tensile strength (TS) of 780 MPa or more and excellent formability and that can be applied structural members with a large amount of forming, and having excellent surface quality and low material deviation.

[0020] Accordingly, the present inventors conducted in-depth studies to provide a cold-rolled steel sheet satisfying all of the above-described characteristics, while solving the problems in the prior art, and as a result thereof, the present inventors have confirmed that the above-described object could be achieved by optimizing the composition and manufacturing conditions of the steel sheet, and thus the present disclosure was provided.

[0021] That is, according to the present disclosure, it is possible to provide a high-strength cold-rolled steel sheet having a high strength of 780 MPa or more, a product of tensile strength and elongation of 12,000 MPa% or more, and that can be suitably applied to structural member parts such as pillars, or the like, requiring a stable strength-elongation balance and impact absorption, among parts forming the vehicle body.

[0022] Hereinafter, a high-strength steel sheet having excellent surface quality and low material deviation according to an aspect of the present disclosure will be described in detail.

[0023] According to an aspect of the present disclosure, a high-strength cold-rolled steel sheet includes, by weight%: C: 0.05 to 0.3%, Si: 0.01 to 2.0%, Mn: 1.5 to 3.0%, Al: 0.01 to 0.1%, P: 0.001 to 0.015%, S: 0.001 to 0.01%, N: 0.001 to 0.01%, with a remainder of Fe, and other unavoidable impurities.

[0024] Hereinafter, the reason for which the components of the cold-rolled steel sheet are added and the content thereof provided in the present disclosure is limited will be described in detail. Unless otherwise particularly stated in the present disclosure, the content of each element is by weight%.

Carbon (C): 0.05 to 0.3%

[0025] Carbon (C) is a very important element in securing a martensite structure, effective in strengthening steel. When an amount of C added increases, a fraction of a martensite phase and bainite phase increases, resulting in an increase in tensile strength. Therefore, to ensure high strength, a lower limit of the C content is controlled to be 0.05%. However, when the C content increases, an austenite region expands during dual-phase zone annealing, so the fraction of the martensite phase and bainite phase, which are hard phases, increases, and a fraction of a ferrite phase, which is a soft phase, decreases, resulting in inferior formability and weldability. Therefore, an upper limit of the C content is controlled to be 0.3%. Meanwhile, in terms of further improving the above-described effect, more preferably, the lower limit of the C content may be 0.06%, or the upper limit of the C content may be 0.12%.

Silicon (Si): 0.01 to 2.0%

[0026] Silicon (Si) is an element, deoxidizing molten steel and having a solid-solution strengthening effect, which is advantageous for improving formability by delaying formation of coarse carbides. However, when the Si content is less than 0.01%, the above-described effect is low, making it difficult to improve formability. On the other hand, when the Si content exceeds 2.0%, red scales due to Si is severely formed on a surface of the steel sheet during hot rolling. As a result, surface defects occur, or surface thickening occurs during an annealing process, so that non-plating occurs. In addition, there is a problem in that plating adhesion becomes poor due to the formation of surface oxide, and the surface quality becomes very poor. Therefore, in the present disclosure, a Si content is controlled to be 0.01 to 2.0%. Meanwhile, in terms of further improving the above-described effect, more preferably, a lower limit of the Si content may be 0.4%, or an upper limit of the Si content may be 1.2%.

Manganese (Mn): 1.5 to 3.0%

[0027] Manganese (Mn), like Si, is an element, which is effective in solid-solution strengthening steel, and is an element greatly increasing hardenability. However, when a Mn content is less than 1.5%, the above-described effects due to addition cannot be obtained, and when the Mn content exceeds 3.0%, the strengthening effect greatly increases and ductility decreases. In addition, during slab casting in a continuous casting process, a segregated portion develops significantly in a thickness center portion, and during cooling after hot rolling, a microstructure thereof in a thickness direction becomes non-uniform and MnS is formed, resulting in poor formability such as stretch flangeability, or the like. Therefore, in the present disclosure, the Mn content is controlled to 1.5 to 3.0%. Meanwhile, in terms of further improving the above-described effect, more preferably, a lower limit of the Mn content may be 1.8%, or an upper limit of the Mn content may be 2.6%.

Aluminum (Al): 0.01 to 0.1%

[0028] Aluminum (Al) is a component, mainly added for deoxidation. When the Al content is less than 0.01%, an addition effect thereof is insufficient. On the other hand, when the Al content exceeds 0.1%, AlN is formed in combination with nitrogen, so it is likely to cause corner cracks in the slab during continuous casting, and it is likely to cause defects due to inclusion formation. Therefore, in the present disclosure, the Al content is controlled to 0.01 to 0.1%. Meanwhile, in terms of further improving the above-described effect, more preferably, a lower limit of the Al content may be 0.015%, or an upper limit of the Al content may be 0.06%.

Phosphorus (P): 0.001 to 0.015%

[0029] Phosphorus (P) is an alloy element having a significant solid-solution strengthening effect and may have a characteristic of achieving a significant solid-solution strengthening effect even with a small content thereof. However, P is added excessively, brittleness may occur due to grain boundary segregation, microcracks are likely to occur during forming, and ductility and impact resistance are greatly deteriorated. In addition, there may be a problem of causing defects on a surface thereof during plating. Therefore, an upper limit of a P content is controlled to be 0.015%. Meanwhile, if the P content is less than 0.001%, excessive manufacturing costs may be required to satisfy this value, which is not only economically disadvantageous, but also secured strength is insufficient, so a lower limit of the P content is controlled to be 0.001% or more. Therefore, in the present disclosure, it is preferable to control the P content to be 0.001 to 0.015%. Meanwhile, in terms of further improving the above-described effect, more preferably, a lower limit of the P content may be 0.003%, or an upper limit of the P content may be 0.012%.

Sulfur (S): 0.001 to 0.01%

[0030] Sulfur (S) is an impurity present in steel. When a S content exceeds 0.01%, S combines with Mn to form non-metallic inclusions, and as a result, there is a problem in that fine cracks are likely to occur during cutting and processing of steel, and extension flangeability and impact resistance are greatly reduced. In addition, in order to form the S content to be less than 0.001%, there is a problem in that a large amount of time is required during steelmaking operation, which reduces productivity. Therefore, in the present disclosure, it is preferable to control the S content to 0.001 to 0.01%. Meanwhile, in terms of further improving the above-described effect, more preferably, a lower limit of the S content may be 0.002%, or an upper limit of the S content may be 0.007%.

Nitrogen (N): 0.001 to 0.01%

[0031] Nitrogen (N) is a representative solid-solution strengthening element along with C, and contributes to forming coarse precipitates along with Ti and Al. In addition, a solid-solution strengthening effect of N is better than that of carbon, but there is a problem in that toughness decreases significantly as an amount of N in steel increases. In addition, in order to manufacture a N content to be less than 0.001%, there is a problem that productivity is reduced because a large amount of time is required during steelmaking operation. Therefore, in the present disclosure, it is preferable to control the N content to be 0.001 to 0.01%. Meanwhile, in terms of further improving the above-described effect, more preferably, a lower limit of the N content may be 0.002%, and an upper limit of the N content may be 0.006%.

[0032] Meanwhile, according to an aspect of the present disclosure, although not particularly limited, optionally, the cold-rolled steel sheet may include, by weight%: one or more elements selected from Cr: 1.0% or less (including 0%), Mo: 0.2% or less (including 0%), and B: 0.005% or less (including 0%). Hereinafter, the reason for which the selected element are added and the content thereof provided in the present disclosure is limited will be described in detail.

Chromium (Cr): 1.0% or less (excluding 0%)

[0033] Chromium (Cr) is a component added to improve hardenability of steel and ensure high strength, and is an element that plays a very important role in formation of martensite, which is also advantageous for manufacturing composite steel with high ductility by minimizing a decrease in elongation compared to an increase in strength. Therefore, Cr may be selectively added for the above-described effect. However, if the Cr content exceeds 1.0%, not only are the above-described effects saturated, but there is a problem in that cold rolling properties are deteriorated due to an excessive increase in hot rolling strength. In addition, since there is a problem that a fraction of martensite increases significantly after annealing, resulting in a decrease in elongation, an upper limit of the Cr content is controlled to be 1.0% or less. Meanwhile, in terms of further improving the above-described effect, more preferably, a lower limit of the

Cr content may be 0.01%, or an upper limit of the Cr content may be 0.8%.

Molybdenum (Mo): 0.2% or less (including 0%)

[0034] Molybdenum (Mo) is an element that suppresses pearlite formation and increases hardenability. Therefore, in order to secure the above-described effects, Mo may be selectively added in the present disclosure. However, if a Mo content exceeds 0.2%, an effect of improving strength does not increase significantly, but ductility deteriorates, which may be economically disadvantageous. Therefore, it is preferable to control the Mo content to be 0.2% or less. Meanwhile, in terms of further improving the above-described effect, more preferably, a lower limit of the Mo content may be 0.01%, or an upper limit of the Mo content may be 0.1%.

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

[0035] When boron (B) exists in a solid state in steel, B has an effect of improving brittleness of steel in a low-temperature range by stabilizing grain boundaries, and greatly increases hardenability of steel. Therefore, B can be selectively added for the above-described effect. However, if an upper limit of the B content exceeds 0.005%, recrystallization is delayed during annealing and oxides are formed on a surface thereof, resulting in poor plating properties. Therefore, it is preferable to control the B content to be 0.005% or less. Meanwhile, in terms of further improving the above-mentioned effect, more preferably, a lower limit of the B content may be 0.0003%, or an upper limit of the B content may be 0.0025%.

[0036] 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 steelmaking manufacturing process, the entire contents thereof are not particularly mentioned in the present specification.

[0037] According to an aspect of the present disclosure, the high-strength cold-rolled steel sheet may have a value defined by Relational Expression 1 of 0.6 or more and less than 0.9, and by satisfying this value, a desired material may be secured by minimizing the material deviation of the cold-rolled steel sheet and suppressing the occurrence of surface defects.

[Relational Expression 1]

$$C + (1.3\times Si+Mn)/6 + (Cr+1.2\times Mo)/5 + 100\times B$$

[0038] In Relational Expression 1, C, Si, Mn, Cr, Mo and B represent an average weight percentage for each element. In this case, when each of the above-described elements is not added, 0 is substituted.

[0039] In the present disclosure, Relational Expression 1 is an expression representing hardenability of a steel material according to the composition of the present disclosure, and a coefficient in front of each element quantitatively represents a scale by which the element contributes to hardenability. If the hardenability of the steel material is high, it is advantageous to secure hard low-temperature transformation phases such as bainite phase and martensite phase, which contributes to improving strength. The lower the hardenability is, ferrite transformation is promoted, which is disadvantageous in securing strength.

[0040] In particular, in order to secure high strength of 780 MPa or more, which is a target tensile strength (TS) in the present invention, a value defined from Relational Expression 1 should satisfy 0.6 or more. On the other hand, if the value defined from Relational Expression 1 is 0.9 or more, the strength becomes too high, so there is a problem in that an elongation rate deteriorates. In addition, if the value defined by Relational Expression 1 is 0.9 or more, phase transformation of ferrite is significantly delayed in an operation of cooling a hot-rolled steel sheet, immediately after hot rolling, to a temperature within a range of 450 to 700°C at an average cooling rate of 10 to 70°C/s. Accordingly, in a subsequent coiling, among bainite phases in the hot-rolled steel sheet, a lower bainite phase having high hardness and a martensite phase are excessively formed, causing material deviation depending on a position thereof in a width direction to worsen and a shape thereof to deteriorate. Therefore, in the present disclosure, it is preferable to control the value defined by Relational Expression 1 to satisfy 0.6 or more and less than 0.9. Meanwhile, in terms of maximizing the above-described effect, a lower limit of the value defined from Relational Expression 1 may be 0.62, or an upper limit of the value defined from Relational Expression 1 may be 0.84.

[0041] Meanwhile, according to an aspect of the present disclosure, the high-strength cold-rolled steel sheet includes: by area, as a microstructure, ferrite: 50% or more, and a remainder: bainite and martensite. In the microstructure, if ferrite is less than 50%, there is a problem of poor formability due to insufficient elongation. In addition, the remainder, which is bainite and martensite, may be 50% or less. If the sum of bainite and martensite exceeds 50%, there is a problem of excessively high strength and insufficient elongation.

[0042] Alternatively, according to an aspect of the present disclosure, although not particularly limited thereto, in terms of improving elongation and formability, the microstructure of the high-strength cold-rolled steel sheet may include, by area: ferrite: 50 to 85% and bainite and martensite, and a sum of bainite and martensite: 15 to 50%.

[0043] Among the high-strength cold-rolled steel sheets, if ferrite exceeds 85%, a target strength may not be achieved, and if the sum of bainite and martensite is less than 15%, the target strength may not be achieved. Meanwhile, in terms of further improving the above-described effect, the microstructure of the high-strength cold-rolled steel sheet may more preferably include, by area: ferrite: 66 to 75%.

[0044] In addition, according to an aspect of the present disclosure, although not particularly limited thereto, the microstructure of the high-strength cold-rolled steel sheet, may include, by area: bainite: 3 to 7% and/or martensite: 19 to 31%. Among the high-strength cold-rolled steel sheets, if bainite is less than 3%, a target strength may not be achieved, and if bainite exceeds 7%, there may be a problem in that the strength is high but the elongation is low.

[0045] According to an aspect of the present disclosure, the high-strength cold-rolled steel sheet has an average number of surface defects satisfying one or more conditions of a depth of 100 um or more and a short side length of 1 mm or more of less than 10/m^2 (including 0/m^2). In measuring the average number of surface defects, the conditions that the 'depth is 100 um or more' or 'short side length is 1mm or more' are merely sufficient determination criteria as long as they are satisfiedto measure the average number of surface defects. Therefore, in this specification, an upper limit value for each of the depth and short side length described above is not particularly limited.

[0046] In the present disclosure, a surface defect refers to a defect having a groove shape, and specifically, a defect in a form of a dent in a thickness direction, which is a defect that can be confirmed when observing the surface of the steel sheet with a naked eye. In addition, the depth of the surface defect may mean a 'maximum depth' in the thickness direction for the defect having the groove shape, based on a cross-section of the cold-rolled steel sheet in the thickness direction (i.e., a direction perpendicular to a rolling direction, based on the cross-section). In addition, the short side length of the surface defect may mean a shortest length passing through a point of the maximum depth, based on the surface of the cold-rolled steel sheet. Meanwhile, in order to observe surface defect having the groove shape existing on the surface of the above-described steel sheet and confirm the depth and short side length of each surface defect, an image captured using a high-magnification scanning electron microscope (SEM) is shown in FIG. 2.

[0047] The present inventors have repeatedly conducted extensive research to solve the problems in the prior art, and to provide a cold-rolled steel sheet that can minimize surface defects and material deviation while securing a desired level of strength and formability.

[0048] As a result thereof, the present inventors have found that the above-described effects may be secured, by controlling that an average number of surface defects satisfying one or more of the above-described depth is 100 um or more and short side length of 1mm or more to be less than 10/m^2. That is, in the present disclosure, if the average number of surface defects is 10/m^2 or more, a problem of surface dents may occur. Meanwhile, in terms of further improving the above-described effect, preferably, the average number of surface defects described above may be 8/m^2 or less.

[0049] Meanwhile, according to an aspect of the present disclosure, the present inventors have repeatedly conducted additional research to provide a cold-rolled steel sheet that can simultaneously secure a desired level of strength and formability without affecting material deviation, or the like, even if there are surface defects in the surface of the steel sheet. As a result thereof, in the present disclosure, the present inventors have additionally found that surface defect characteristics at a level, without affecting material deviation, or the like, even if surface defects exist. Specifically, although not particularly limited in the present disclosure, a maximum depth of the surface defects may be 500 um or less. In this case, the maximum depth of the surface defects may be a maximum value of the depth for each surface defect existing on the surface of the steel sheet.

[0050] Meanwhile, according to an aspect of the present disclosure, a difference in yield strength (YS) between both end portions and a center portion in a width direction of the cold-rolled steel sheet may be 100 MPa or less. By satisfying the difference in the yield strength between both end portions and the center portion to be 100 MPa or less, a steel sheet having reduced material deviation in the width direction may be provided, and a material thereof may be uniform in the width direction. In this case, the 'both end portions' may refer to sections, corresponding 30% (corresponding to a sum of: 60%) from both ends based on a total width (referred to as 100%) of the cold-rolled steel sheet in a width direction thereof, and the 'center portion' may refer to a section, corresponding to 40% excluding the both end portions, based on the total width of the cold-rolled steel sheet in the width direction thereof.

[0051] Meanwhile, according to an aspect of the present disclosure, the cold-rolled steel sheet may have a tensile strength (TS) of 780 MPa or more, preferably 780 MPa or more and less than 1180 MPa, and more preferably 800 MPa or more and 1100 MPa or less. If the tensile strength of the cold-rolled steel sheet is less than 780 MPa, there may be a problem in that the target strength required for parts applied thereto, may not be achieved, and if the tensile strength of the cold-rolled steel sheet exceeds 1100 MPa, there may be a problem in that cracks occur during molding parts, or impact resistant of the parts is significantly reduced.

[0052] In addition, according to an aspect of the present disclosure, the cold-rolled steel sheet may have a yield strength (YS) of 380MPa or more, and more preferably 390 MPa or more and 650 MPa or less. If the yield strength of the cold-rolled steel sheet is less than 380 MPa, there may be a problem in that impact resistance of the parts deteriorates, and if the yield strength of the cold-rolled steel sheet exceeds 650 MPa, there may be a problem in that formability deteriorates.

[0053] In addition, according to an aspect of the present disclosure, the cold-rolled steel sheet has a product of tensile strength and elongation of 12,000 MPa% or more (more preferably, 12,000 MPa% or more and 16,500 MPa% or less, most preferably 12,000 MPa% or more and 16,200 MPa% or less). By satisfying the above-described physical properties, it is possible to secure an effect that can be suitably applied to structural member parts such as a filler, or the like, requiring a stable strength-elongation balance and impact absorption among the parts constituting the vehicle body.

[0054] Although not particularly limited thereto, the cold-rolled steel sheet may optionally further include a plating layer formed on the surface. In this case, the plating layer may be formed through a plating process described later. In addition, since the composition of the plating layer can be applied differently depending on the purpose thereof, it is not particularly limited in this specification, and an example of the plating layer includes a zinc-based plating layer.

[0055] Hereinafter, a manufacturing method of a high-strength cold-rolled steel sheet according to an aspect of the present disclosure will be described in detail. However, the manufacturing method of the cold-rolled steel sheet according to the present disclosure does not necessarily mean that it should be manufactured by the following manufacturing method.

Steel slab reheating

[0056] A steel slab satisfying the above-described composition is reheated to a temperature of 1100 to 1350°C. The composition of the steel slab is the same as that of the cold-rolled steel sheet described above, and in this case, the description for the above-described cold-rolled steel sheet is equally applied to a reason for adding each component and limiting a content thereof in the steel slab. Meanwhile, when a reheating temperature of the steel slab is less than 1100°C, segregated alloy elements in a center portion of the slab remain, and an initiation temperature of hot rolling is too low, causing a problem in increased rolling load. On the other hand, when the reheating temperature of the steel slab exceeds 1350°C, there is a problem in that strength is reduced due to coarsening of austenite grains. Therefore, in the present disclosure, the reheating temperature of the steel slab is preferably controlled to 1100 to 1350°C.

Hot rolling

[0057] The reheated steel slab is hot rolled at a temperature of 850 to 1150°C. When the temperature of hot rolling exceeds 1150°C, a temperature of a hot-rolled steel sheet increases, so a size of grains becomes coarse, surface quality of the hot-rolled steel sheet deteriorates. When the temperature of hot rolling is less than 850°C, due to development of stretched grains due to excessive recrystallization delay, a load during rolling increases and a temperature at both ends decreases significantly, so an uneven microstructure during cooling is formed, thereby increasing material deviation and deteriorating formability.

Cooling, after hot rolling

[0058] The hot-rolled steel sheet is cooled to a temperature of 450 to 700°C at an average cooling rate of 10 to 70°C/s (more preferably, to a temperature of 20 to 50°C/s). When a cooling temperature of the hot-rolled steel sheet is less than 450°C, there is a problem in that material deviation deteriorates, and when the cooling temperature exceeds 700°C, there is a problem in that not only does material deviation occur, but also internal oxidation of the hot-rolled steel sheet occurs, causing surface defects. In addition, when the average cooling rate is less than 10°C/s, there is a problem in that crystal grains of a matrix structure become coarse, and a microstructure becomes non-uniform. In addition, when the average cooling rate exceeds 70°C/s, there is a problem in that bainite and martensite phases are easily to be formed, causing increased load during cold rolling.

Coiling

[0059] The cooled steel sheet is wound at a temperature of 450 to 700°C. when a coiling temperature is less than 450°C and the steel sheet is cooled and wound, bainite and martensite phases are formed unnecessarily in steel, resulting in non-uniform shapes and a significant increase in rolling load during cold rolling. when the coiling temperature exceeds 700°C, ferrite crystal grains becomes larger and a coarse pearlite phase is easily formed, resulting in forming non-uniform microstructure during annealing, resulting in a problem of poor formability of steel. In addition, hot-rolled oxides increase and are adsorbed on a roll during annealing, causing oxides to accumulate in the roll. When the steel sheet is rolled, there is a problem causing surface defects such as dent defects on a surface of the steel sheet due to friction between the steel sheet and the roll. In addition, when hot-rolled oxides remain on the steel sheet, plating quality and plating adhesion are deteriorated during plating of the steel sheet.

[0060] Typically, after the coiling, cooling proceeds rapidly in both end portions in a width direction of the wound steel sheet (coil) due to exposure to surrounding atmosphere, and cooling proceeds slowly in a center portion in the width direction thereof. As a result, cooling deviation occurs in the width direction of the steel sheet from the coiling, which causes a difference in microstructure in each position of the wound steel sheet, ultimately resulting in material deviation for the hot- rolled steel sheet. In a hot-rolled steel sheet having such high material deviations, in a process of perform cold rolling, not only does the material deviation of the hot-rolled steel sheet become worse, but surface defects having a form of grooves, which were not observed with a naked eye in hot-rolled steel sheet become worse after performing cold rolling, resulting in a problem of large surface defects occurring. In other words, the hot-rolled steel sheet having high material deviation not only has inferior shapes during cold rolling, but also causes material deviation in each position in a width direction in a final annealed material. Therefore, the present inventors conducted intensive research to solve the above-described problem. As a result thereof, a manufacturing method, is provided to control the temperatures in both end portions and in the center portion, differently during the coiling.

[0061] Specifically, in the present disclosure, as a method for reducing material deviation of the steel sheet in the width direction, and suppressing surface defects, during the coiling, based on an entire width of the steel sheet, a surface temperature (Te) of both end portions in the width direction is controlled to satisfy 601 to 700°C, and a surface temperature (Tc) of a center portion is controlled to satisfy 450 to 600°C. In this case, the 'width direction of the steel sheet' refers to a direction perpendicular to a transport direction of the steel sheet based on a surface of the steel sheet. In addition, the above-description is equally applied to the both end portions and the center portion.

[0062] In this case, if Te is less than 601°C, there is a problem in that material deviation is worsened due to overcooling at both ends, and if Te exceeds 700°C, there is a problem in that material deviation and surface defects are worsened due to deterioration of the center portion. In addition, if Tc is less than 450 °C, a difference in the temperatures between the center portion and both end portions increases, causing a problem in that the material deviation worsens, and if Tc exceeds 600°C, the temperature in the center portion is too high, causing a problem of material deviation and surface defects.

[0063] As described above, in the above-described coiling, in order to differently control a surface temperature in both end portions and a surface temperature in a center portion of the steel sheet in a width direction thereof, various methods can be applied, so this is not particularly limited. For example, during the coiling, in order to control the temperatures in both end portions and in the center portion of the steel sheet differently, in the cooling before coiling, a coolant provided onto both ends may be blocked before reaching the steel sheet, an amount of coolant provided thereonto may be controlled differently, and the two methods described above, may be used in parallel. As an example, according to an aspect of the present disclosure, in the cooling before the coiling, based on a total width of the steel sheet, an amount of coolant provided into the center portion excluding the both end portions may be controlled to be greater than an amount of coolant provided onto the both end portions in the width direction.

[0064] In addition, according to an aspect of the present disclosure, although not particularly limited thereto, in terms of further improving the effect of further reducing material deviation and suppressing surface defects, in the coiling, a difference (Te-Tc) between the surface temperature of both end portions and the surface temperature (Tc) of the center portion may be 150°C or less. In this case, if the value of Te-Tc exceeds 150°C, a problem of worsening material deviation in the width direction may occur. However, the lower the temperature deviation calculated from Te-Tc, the more desirable it is, so a lower limit thereof may not be specifically limited, and may be preferably 0°C. Meanwhile, more preferably, the lower limit of the Te-Tc value may be 50°C, and an upper limit of the Te-Tc value may be 90°C.

Maintaining within heat retaining cover

[0065] After the above-described coiling operation, optionally, a steel sheet may be moved into a heat retaining cover and maintained at a temperature of 400 to 500°C for more than 6 hours. After the coiling operation, by being maintained in the heat retaining cover for a long period of time, if the steel sheet is maintained for a long period of time at a temperature in a range of 601 to 700°C and 450 to 600°C in both end portions and in a center portion of the steel sheet, respectively, a large amount of bainite structure is formed uniformly in both end portions and in the center portion due to an overall length of a coil, so that it is possible to manufacture a cold-rolled steel sheet having excellent shape quality and low rolling load and uniform thickness during cold rolling.

[0066] During the maintenance operation within heat retaining cover, a surface temperature of the steel sheet can be adjusted to a temperature within a range of 450 to 500°C. In this case, in the maintenance operation within the heat retaining cover, if the surface temperature of the steel plate is less than 400°C, the above-described effect cannot be secured, and if the surface temperature of the steel plate exceeds 500°C, coarse carbides are formed locally and hot-rolled oxides increase, which may deteriorate the formability and surface quality of steel.

[0067] In addition, if a holding time within the heat retaining cover is less than 6 hours, a problem of material deviation may occur. An upper limit of the holding time within the heat retaining cover is not particularly limited, but may be 8 hours or less as an example.

[0068] Additionally, in terms of further improving the above-described effect, the wound steel sheet can be stored in the heat retaining cover within 90 minutes, immediately after being wound. if a time before being stored in the heat retaining cover exceeds 90 minutes, due to excessive air cooling, overcooling may occur in the center portion in the width direction, making it impossible to meet the temperature range of 450 to 600°C. Alternatively, after the maintenance operation within the heat retaining cover, air cooling or water cooling may be further performed to room temperature.

Cold rolling

[0069] Cold rolling is performed on the wound steel sheet at a cold rolling reduction rate of 40 to 70%. If the cold rolling reduction rate is less than 40%, not only is it difficult to secure a target thickness but it is also difficult to correct a shape of the steel sheet. On the other hand, if the cold rolling reduction rate exceeds 70%, there is a high possibility of cracks occurring in an end portion of the steel sheet, and there is a problem of cold rolling load. Therefore, in the present disclosure, it is preferable to limit the cold rolling reduction rate to 40 to 70%.

Annealing

[0070] The cold-rolled steel sheet is continuously annealed at a temperature of 740 to 900°C. If the annealing temperature is less than 740°C, non-recrystallization may occur, resulting in insufficient strength and elongation. If the annealing temperature exceeds 900°C, there may be a problem in that surface oxides occur. Meanwhile, in terms of further improving the above-described effect, the annealing temperature may be more preferably 750 to 850°C.

[0071] In addition, although not particularly limited thereto, according to an aspect of the present disclosure, after the continuous annealing operation, optionally, an operation of primary cooling to 650 to 700°C at a cooling rate of 1 to 10°C/sec; and after the primary cooling operation, and an operation of secondary cooling from Ms-100°C to Ms+100°C at a cooling rate of 11 to 20°C/sec may be further included. In addition, after the secondary cooling operation, optionally, an operation of overaging may be further included while keeping a temperature constant. By satisfying the conditions of the primary cooling operation; the secondary cooling operation, and the overaging operation, strength and elongation may be further improved. In this case, Ms may mean a starting temperature at which martensite is generated when the steel sheet is cooled after annealing, and may be obtained from Relational Expression 2.

[Relational Expression 2]

$$Ms = 539-423\times C-30.4\times Mn-12.1\times Cr-17.7\times Ni-7.5\times Mo$$

[0072] In Relational Expression 2, C, Mn, Cr, Ni, and Mo represent an average weight percentage for each element. In this case, when each of the above-described elements is not added, 0 is substituted.

[0073] In addition, according to an aspect of the present disclosure, optionally, an operation of plating (preferably, hot-dip galvanizing) the cold-rolled steel sheet may be further included, and a plated steel sheet can be obtained by performing the plating.

Mode for Invention

[0074] 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 in detail by illustration, and are 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.

(Example)

[0075] A steel slab satisfying the composition in Table 1 below were reheated at a temperature of 1200°C, hot rolled at a temperature of 900°C, and cooled to a temperature of 450 to 700°C at a cooling rate of 20 to 50°C/s and then wound. In this case, during the coiling, based on a total width in a width direction of a steel sheet, an amount of coolant provided onto a center portion excluding the both end portions was controlled to be greater than an amount of coolant provided onto the both end portions of the steel sheet in the width direction, so that a surface temperature (Te) of the steel sheet in both end portions of sections, corresponding to 30% from both ends and a surface temperature (Tc) in a center portion of remaining sections, corresponding 40% from both ends satisfy the hot rolling conditions shown in Table 2 below. In addition, the wound hot-rolled steel sheet was moved into a heat retaining cover and as heat retaining cover conditions shown in Table 2 below, the wound hot-rolled steel sheet was controlled to satisfy an average temperature and holding time before and after being charged into a cover. Subsequently, the hot-rolled steel sheet was cold rolled at a cold rolling reduction rate of 50%, subjected to continuous cooling at a temperature of 800°C, primarily cooled to a temperature of 670°C at an average cooling rate of 8°C/s, and then secondarily cooled to a temperature of Ms+100°C at an average cooling rate 12°C/s, to obtain a cold-rolled steel sheet.

[0076] For each cold-rolled steel sheet obtained in this manner, a microstructure, mechanical properties, an average number of surface defects per unit area (number/m^2) observed on a surface of the steel sheet, in Inventive Example and Comparative Example, were measured and shown in Tables 3 to 5 below. In this case, YS, TS, and El mean 0.2% off-set yield strength, tensile strength, and elongation at break, respectively, which illustrates that test results obtained by collecting JIS No. 5 standard test specimens from the center portion and both end portions in a direction, respectively, in a direction perpendicular to a rolling direction. In addition, the above-described microstructure was measured using a scanning electron microscope (FE-SEM), and the microstructure was measured using a photograph observed at 3,000 to 5,000 times magnification, by area %. In addition, the average number of surface defects was measured by observing a surface of the manufactured steel sheet with a naked eye and satisfying one or more conditions of a depth of 100 um or more and a short side length of 1 mm or more. In particular, a maximum depth for the surface defects was measured in the same manner as described herein. In addition, for samples taken from the center portion and both ends of the cold-rolled steel sheet in a width direction, the yield strength was measured in the same manner as described above, and the material deviation for these samples in the width direction was measured and shown in Tables 4 and 5 below.

[Table 1]

Classifi cation	COMPOSITION [WEIGHT %] (REMAINDER OF FE AND IMPURITIES)										RELATIO NAL EXPRESS ION 1
	C	Si	Mn	Cr	Mo	B	Al	P	S	N	
INVENTIV E STEEL 1	0.1	0.4	2.5	0.1	0	0	0.0 3	0.0 10	0.0 02	0.0 04	0.62
INVENTIV E STEEL 2	0.0 6	0.9	2.4	0.1	0.0 2	0.0 007	0.0 25	0.0 08	0.0 03	0.0 05	0.75
INVENTIV E STEEL 3	0.1 2	1.2	2.6	0	0.1	0	0.0 35	0.0 09	0.0 04	0.0 02	0.84
COMPARAT IVE STEEL 1	0.1 8	2.1	2.2	0	0	0	0.0 4	0.0 09	0.0 05	0.0 04	1.00
COMPARAT IVE STEEL 2	0.0 9	0.9	1.7	0	0	0	0.1	0.0 Oil	0.0 07	0.0 03	0.57

[Table 2]

Classification		COILING CONDITION			HEAT RETAINING COVER CONDITION	
		Te (°C)	Tc (°C)	Te-Tc (°C)	TEMPERATURE (°C)	TIME (hr)
INVENTIVE STEEL 1	INVENTIVE EXAMPLE 1	650	580	70	480	8
	INVENTIVE EXAMPLE 2	680	590	90	450	7
	COMPARATIVE EXAMPLE 1	720	650	70	490	7
	COMPARATIVE EXAMPLE 2	580	400	180	420	8
	COMPARATIVE EXAMPLE 3	610	490	120	NOT APPLIED	
	COMPARATIVE EXAMPLE 4	650	590	60	570	10

(continued)

Classification		COILING CONDITION			HEAT RETAINING COVER CONDITION	
		Te (°C)	Tc (°C)	Te-Tc (°C)	TEMPERATURE (°C)	TIME (hr)
INVENTIVE STEEL 2	INVENTIVE EXAMPLE 3	640	570	75	490	8
	INVENTIVE EXAMPLE 4	680	590	90	450	7
	COMPARATIVE EXAMPLE 5	720	650	70	490	7
	COMPARATIVE EXAMPLE 6	580	400	180	420	8
	COMPARATIVE EXAMPLE 7	610	490	120	NOT APPLIED	
	COMPARATIVE EXAMPLE 8	650	590	60	570	10
INVENTIVE STEEL 3	INVENTIVE EXAMPLE 5	640	570	75	490	8
	INVENTIVE EXAMPLE 6	680	590	90	450	7
	COMPARATIVE EXAMPLE 9	720	650	70	490	7
	COMPARATIVE EXAMPLE 10	580	400	180	420	8
	COMPARATIVE EXAMPLE 11	610	490	120	NOT APPLIED	
	COMPARATIVE EXAMPLE 12	650	590	60	570	10
COMPARATIVE STEEL 1	COMPARATIVE EXAMPLE 13	650	580	70	480	8
	COMPARATIVE EXAMPLE 14	680	590	90	450	7
COMPARATIVE STEEL 2	COMPARATIVE EXAMPLE 15	650	580	70	480	8
	COMPARATIVE EXAMPLE 16	680	590	90	450	7

[Table 3]

Classification		MICROSTRUCTURE [AREA %]		
		FERRITE	BAINITE	MARTENSIT E
INVENTIVE STEEL 1	INVENTIVE EXAMPLE 1	75	5	20
	INVENTIVE EXAMPLE 2	74	7	19
	COMPARATIVE EXAMPLE 1	73	6	21
	COMPARATIVE EXAMPLE 2	77	4	19
	COMPARATIVE EXAMPLE 3	79	2	19
	COMPARATIVE EXAMPLE 4	77	6	17

(continued)

Classification		MICROSTRUCTURE [AREA %]		
		FERRITE	BAINITE	MARTENSIT E
INVENTIVE STEEL 2	INVENTIVE EXAMPLE 3	75	6	19
	INVENTIVE EXAMPLE 4	74	7	19
	COMPARATIVE EXAMPLE 5	73	6	21
	COMPARATIVE EXAMPLE 6	77	4	19
	COMPARATIVE EXAMPLE 7	79	2	19
	COMPARATIVE EXAMPLE 8	77	6	17
INVENTIVE STEEL 3	INVENTIVE EXAMPLE 5	66	3	31
	INVENTIVE EXAMPLE 6	66	4	30
	COMPARATIVE EXAMPLE 9	66	5	29
	COMPARATIVE EXAMPLE 10	64	3	33
	COMPARATIVE EXAMPLE 11	67	6	27
	COMPARATIVE EXAMPLE 12	64	6	30
COMPARATIVE STEEL 1	COMPARATIVE EXAMPLE 13	59	5	36
	COMPARATIVE EXAMPLE 14	56	7	37
COMPARATIVE STEEL 2	COMPARATIVE EXAMPLE 15	85	2	13
	COMPARATIVE EXAMPLE 16	83	1	16

[Table 4]

Classification		WIDTH IN CENTER PORTION				SURFACE DEFECT
		YS (MPa)	TS (MPa)	El (%)	TS*El (MPa%)	AVERAGE NUMBER (number/m ^{2})
INVENTIVE STEEL 1	INVENTIVE EXAMPLE 1	440	812	19	15428	1
	INVENTIVE EXAMPLE 2	465	807	20	16140	1
	COMPARATIV E EXAMPLE 1	423	819	19	15561	15
	COMPARATIV E EXAMPLE 2	415	829	19	15751	3
	COMPARATIV E EXAMPLE 3	390	831	20	16620	2
	COMPARATIV E EXAMPLE 4	397	817	21	17157	18

(continued)

Classification		WIDTH IN CENTER PORTION				SURFACE DEFECT
		YS (MPa)	TS (MPa)	El (%)	TS*El (MPa%)	AVERAGE NUMBER (number/m 2)
INVENTIVE STEEL 2	INVENTIVE EXAMPLE 3	412	825	19	15675	0
	INVENTIVE EXAMPLE 4	399	844	19	16036	0
	COMPARATIV E EXAMPLE 5	445	835	20	16700	18
	COMPARATIV E EXAMPLE 6	427	799	21	16779	1
	COMPARATIV E EXAMPLE 7	399	824	21	17304	2
	COMPARATIV E EXAMPLE 8	408	809	21	16989	22
INVENTIVE STEEL 3	INVENTIVE EXAMPLE 5	605	1028	15	15420	1
	INVENTIVE EXAMPLE 6	635	1054	15	15810	1
	COMPARATIV E EXAMPLE 9	645	1038	16	16608	14
	COMPARATIV E EXAMPLE 10	607	1019	16	16304	1
	COMPARATIV E EXAMPLE 11	616	1038	14	14532	1
	COMPARATIV E EXAMPLE 12	635	1041	15	15615	22
COMPARATIV E STEEL 1	COMPARATIV E EXAMPLE 13	689	1097	17	18649	16
	COMPARATIV E EXAMPLE 14	678	1087	18	19566	22
COMPARATIV E STEEL 2	COMPARATIV E EXAMPLE 15	345	658	26	17108	1
	COMPARATIV E EXAMPLE 16	332	628	27	16956	1

[Table 5]

Classification		MATERIAL IN BOTH END PORTIONS	YS DEVIATION IN WIDTH DIRECTION (MPa)
		YS (MPa)	
INVENTIVE STEEL 1	INVENTIVE EXAMPLE 1	480	40
	INVENTIVE EXAMPLE 2	475	10
	COMPARATIVE EXAMPLE 1	441	18
	COMPARATIVE EXAMPLE 2	523	108
	COMPARATIVE EXAMPLE 3	502	112
	COMPARATIVE EXAMPLE 4	412	15
INVENTIVE STEEL 2	INVENTIVE EXAMPLE 3	479	67
	INVENTIVE EXAMPLE 4	465	66
	COMPARATIVE EXAMPLE 5	448	3
	COMPARATIVE EXAMPLE 6	533	106
	COMPARATIVE EXAMPLE 7	517	118
	COMPARATIVE EXAMPLE 8	432	24
INVENTIVE STEEL 3	INVENTIVE EXAMPLE 5	623	18
	INVENTIVE EXAMPLE 6	669	34
	COMPARATIVE EXAMPLE 9	650	5
	COMPARATIVE EXAMPLE 10	726	119
	COMPARATIVE EXAMPLE 11	729	113
	COMPARATIVE EXAMPLE 12	669	34
COMPARATIVE STEEL 1	COMPARATIVE EXAMPLE 13	725	36
	COMPARATIVE EXAMPLE 14	700	22

(continued)

Classification		MATERIAL IN BOTH END PORTIONS	YS DEVIATION IN WIDTH DIRECTION (MPa)
		YS (MPa)	
COMPARATIVE STEEL 2	COMPARATIVE EXAMPLE 15	355	10
	COMPARATIVE EXAMPLE 16	339	7

[0077] As can be seen from the experimental results in Tables 1 to 5, in the case of Invention Examples 1 to 6 satisfying the composition and manufacturing conditions of the present disclosure, it was possible to obtain a cold-rolled steel sheet for securing a tensile strength (TS) of 780 MPa or more while suppressing material deviation and surface defects. In this case, it was confirmed that a maximum depth of surface defects measured in the cold-rolled steel sheets obtained from Invention Examples 1 to 6 of the present application satisfied 500 um or less.

[0078] On the other hand, in the case of Comparative Examples 1 to 16, not satisfying one or more of the composition and manufacturing conditions of the present disclosure, material deviation was inferior, surface defects occurred, and/or it was difficult to secure the physical properties desired in the present disclosure.

[0079] In particular, Comparative Steel 1 had a Si addition amount exceeding 2.0% and did not satisfy Relational Expression 1. Therefore, in the case of Comparative Examples 13 and 14 using Comparative Steel 1, although the manufacturing conditions presented in the present disclosure were satisfied so the material deviation was good, there was a problem in that a dent problem occurred due to Si oxide accumulation in an annealing furnace, so that an average number of surface defects of a product exceeded a target value.

[0080] In addition, Comparative Steel 2 did not satisfy Relational Expression 1 due to a small amount of alloy added. Therefore, in the case of Comparative Examples 15 and 16 using Comparative Steel 2, although the manufacturing conditions presented in the present disclosure were satisfied and surface defects and material deviation were good, the tensile strength was less than 780 MPa and did not satisfy a target material.

[0081] In addition, Comparative Examples 1, 5, and 9 illustrate an example in which temperatures in both end portions and a center portion in a width direction are higher than the temperature presented in the present disclosure, and Comparative Examples 4, 8, and 12 illustrate an example in which a temperature of a heat retaining cover exceeded a reference temperature. Accordingly, in Comparative Examples, hot-rolled oxides were excessively generated, and a large number of surface defects of the final steel sheet occurred due to the oxides.

[0082] In addition, in the case of Comparative Examples 2, 6, and 10, temperatures in both end portions and a center portion in a width direction were lower than the temperature suggested in the present disclosure, and Comparative Examples 2, 6, and 10 illustrate an example in which a difference (Te-Tc) between a surface temperature in both end portions and a surface temperature in the center portion exceeded 150°C, and Comparative Examples 3, 7, and 11, illustrates an example in which a heat retaining cover is not applied. Accordingly, in the above Comparative Examples, a target material of an annealed steel sheet could be secured and an average number of surface defects was good, but there was a problem in that deviation of the yield strength of the annealed steel sheet in the width direction exceeded the target value of 100 MPa.

Claims

1. A high-strength cold-rolled steel sheet comprising:

by weight%, C: 0.05 to 0.3%, Si: 0.01 to 2.0%, Mn: 1.5 to 3.0%, Al: 0.01 to 0.1%, P: 0.001 to 0.015%, S: 0.001 to 0.01%, N: 0.001 to 0.01%, with a remainder of Fe, and other unavoidable impurities,
wherein a value defined by Relational Expression 1 satisfies 0.6 or more and less than 0.9,
as a microstructure, by area%, ferrite: 50% or more, a remainder: bainite and martensite,
wherein an average number of surface defects satisfying one or more conditions of a depth of 100 um or more and a short side length of 1 um or more, is less than $10/m^2$.

[Relational Expression 1]

$$C + (1.3\times Si+Mn)/6 + (Cr+1.2\times Mo)/5 + 100\times B$$

In Relational Expression 1, C, Si, Mn, Cr, Mo, and B represent an average weight percentage for each element. when each of the above-described elements is not added, 0 is substituted.

2. The high-strength cold-rolled steel sheet of claim 1, wherein the microstructure comprises, by area%, ferrite: 50 to 85% and a sum of bainite and martensite: 15 to 50%.

3. The high-strength cold-rolled steel sheet of claim 1, wherein the microstructure comprises, by area%, ferrite: 66 to 75%.

4. The high-strength cold-rolled steel sheet of claim 3, wherein the microstructure comprises, by area%, bainite: 3 to 7%.

5. The high-strength cold-rolled steel sheet of claim 3, wherein the microstructure comprises, by area%, martensite: 19 to 31%.

6. The high-strength cold-rolled steel sheet of claim 1, further comprising one or more selected elements from, by weight%, Cr: 1.0% or less (including 0%), Mo: 0.2% or less (including 0%), and B: 0.005% or less (including 0%).

7. The high-strength cold-rolled steel sheet of claim 1, wherein a tensile strength is 780MPa or more and a yield strength is 380MPa or more.

8. The high-strength cold-rolled steel sheet of claim 1, wherein a product of the tensile strength and elongation is 12,000MPa% or more.

9. The high-strength cold-rolled steel sheet of claim 1, wherein a difference in yield strength between both end portions and a center portion is 100MPa or less, in a width direction of the cold-rolled steel sheet.

10. A method for manufacturing a high-strength cold-rolled steel sheet, the method comprising:

reheating a steel slab including, by weight%, C: 0.05 to 0.3%, Si: 0.01 to 2.0%, Mn: 1.5 to 3.0%, Al: 0.01 to 0.1%, P: 0.001 to 0.015%, S: 0.001 to 0.01%, N: 0.001 to 0.01%, with a remainder of Fe, and other unavoidable impurities, wherein a value defined by Relational Expression 1 satisfies 0.6 or more and less than 0.9, to a temperature of 1100 to 1350°C;
hot rolling the reheated steel slab at a temperature within a range of 850 to 1150°C;
cooling the hot-rolled steel sheet to a temperature within a range of 450 to 700°C at an average cooling rate of 10 to 70°C/s;
coiling the cooled steel sheet at a temperature within a range of 450 to 700°C;
cold rolling the wound steel sheet at a reduction rate of 40 to 70%; and
continuously annealing the cold-rolled steel sheet at a temperature within a range of 740 to 900°C,
wherein in the coiling, based on an entire width of the steel sheet, a surface temperature (Te) of both end portions in a width direction is controlled to satisfy 601 to 700°C, and a surface temperature (Tc) of a center portion is controlled to satisfy 450 to 600°C.

[Relational Expression 1]

$$C + (1.3\times Si+Mn)/6 + (Cr+1.2\times Mo)/5 + 100\times B$$

In Relational Expression 1, C, Si, Mn, Cr, Mo and B represent an average weight percentage of each element. In addition, if each of the above-described elements is not added, 0 is substituted.

11. The method of claim 10, further comprising:
after the coiling, moving the wound steel sheet into a heat retaining cover and maintaining at a temperature within a range of 400 to 500°C for more than 6 hours.

12. The method of claim 10, wherein in the coiling, a difference (Te-Tc) between the surface temperature of both end portions and the surface temperature (Tc) of the center portion is controlled to satisfy a temperature of 150°C or less.

13. The method of claim 10, wherein in the cooling, based on an entire width of the steel sheet, an amount of coolant provided onto a center portion excluding the both end portions is controlled to be greater than an amount of coolant provided onto the both end portions in a width direction.

FIG. 1

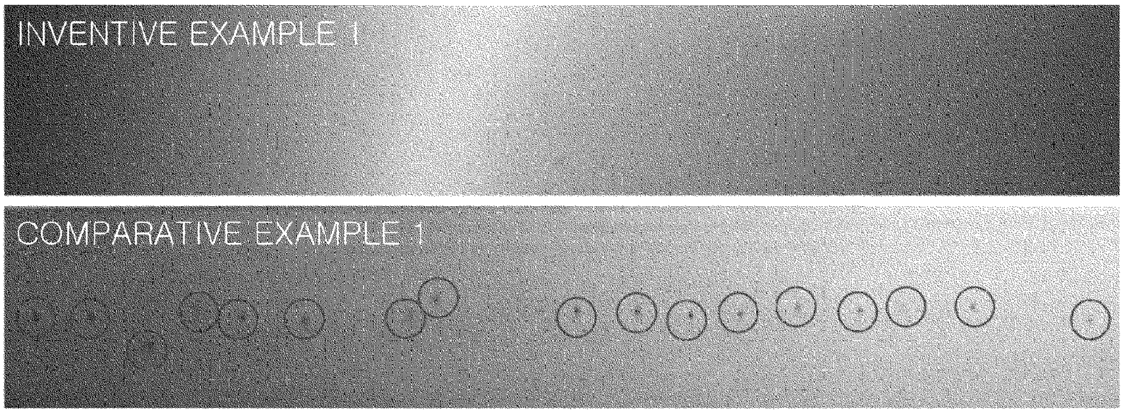
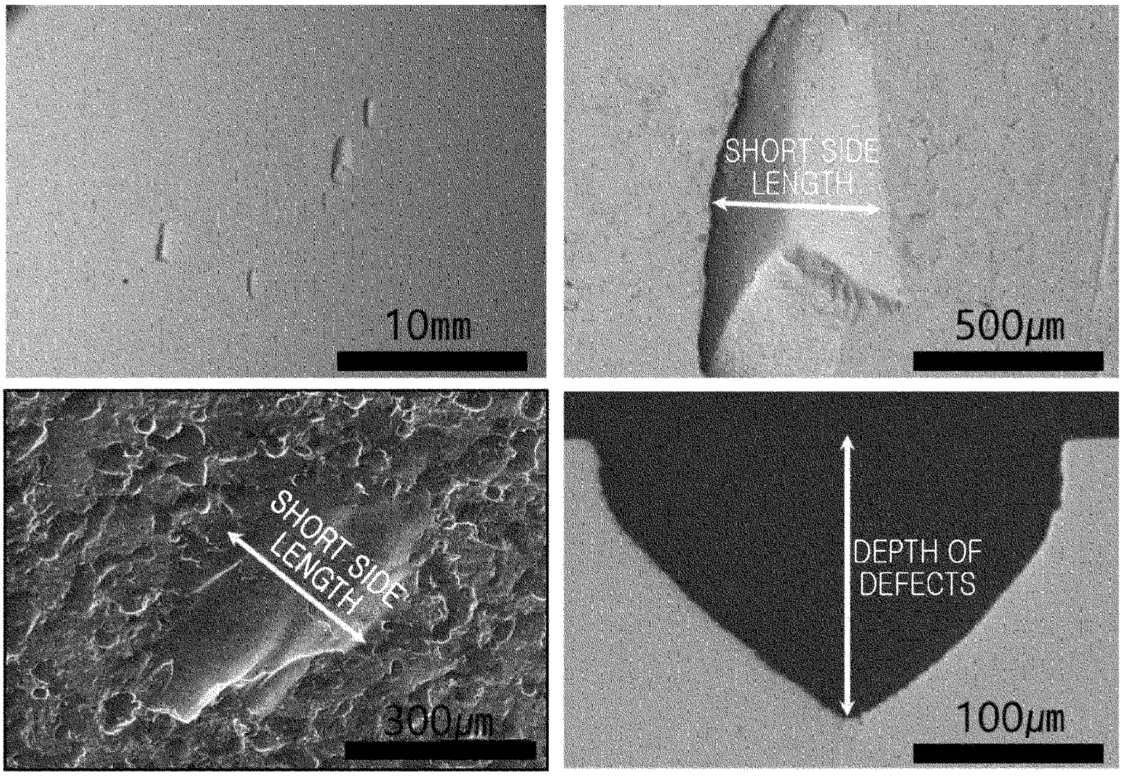

INVENTIVE EXAMPLE 1
COMPARATIVE EXAMPLE 1

FIG. 2


10mm
SHORT SIDE LENGTH
500μm
SHORT SIDE LENGTH
300μm
DEPTH OF DEFECTS
100μm

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2022/014012

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/02(2006.01)i; **C22C 38/04**(2006.01)i; **C22C 38/06**(2006.01)i; **C22C 38/00**(2006.01)i; **C21D 8/02**(2006.01)i; **B21C 47/02**(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 38/02(2006.01); B21B 1/16(2006.01); C21D 8/02(2006.01); C21D 8/06(2006.01); C21D 9/46(2006.01); C22C 38/00(2006.01); C22C 38/04(2006.01); C22C 38/06(2006.01); C22C 38/58(2006.01)

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

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

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

eKOMPASS (KIPO internal) & keywords: 냉연(cold rolled), 권취(coiling), 냉각(cooling), 중앙(center), 편차(variation), 페라이트(ferrite), 베이나이트(bainite), 마르텐사이트(martensite)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2020-0101980 A (JFE STEEL CORPORATION) 28 August 2020 (2020-08-28) See paragraphs [0065], [0094] and [0123], claims 1-2 and 7 and table 5.	1-13
A	WO 2020-203159 A1 (NIPPON STEEL CORPORATION) 08 October 2020 (2020-10-08) See paragraph [0076] and claims 1-3.	1-13
A	KR 10-2021-0080044 A (POSCO) 30 June 2021 (2021-06-30) See paragraph [0057] and figure 1.	1-13
A	JP 2021-063253 A (JFE STEEL CORP.) 22 April 2021 (2021-04-22) See paragraph [0059] and claims 1-4.	1-13
A	KR 10-2014-0102309 A (NIPPON STEEL & SUMITOMO METAL CORPORATION) 21 August 2014 (2014-08-21) See paragraph [0088] and claim 1.	1-13

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 December 2022	**22 December 2022**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2022/014012

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		EP 3705592 A1	09 September 2020
		JP 6597938 B1	30 October 2019
		JP WO2019-151017 A1	08 August 2019
		KR 10-2433938 B1	19 August 2022
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		KR 10-2021-0116563 A	27 September 2021
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		WO 2013-105632 A1	18 July 2013

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- JP 2010090432 A **[0007]**