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

(57) The present invention pertains to a cold rolled steel sheet and a method for manufacturing same. One aspect of the present invention provides: a cold rolled steel sheet having excellent weldability, strength, and formability; and a method for manufacturing same.

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Description

Technical Field

5 **[0001]** The present disclosure relates to a cold rolled steel sheet having excellent weldability, strength and formability and a method of manufacturing the same.

Background Art

10 **[0002]** Recently, in order reduce the weight of automobiles and enhance safety thereof, a technology for manufacturing a steel sheet having high strength is being promoted, and in particular, demand for a high-strength steel material having a tensile strength of 980 MPa or higher is increasing. However, when simply improving strength, since it is a common phenomenon that ductility and formability decrease, a high-strength steel sheet for cold forming overcoming this to have formability are highly utilized in terms of improving fuel efficiency through weight reduction, improving manufacturing parts/forming productivity, and ensuring safety of final parts.

15 **[0003]** In order to improve the formability of a steel material, a method of using a Transformation Induced Plasticity (TRIP) phenomenon by introducing retained austenite as in Patent Document 1 is widely used as a method to increase elongation. However, in the case of such a TRIP steel sheet, it is necessary to add a large amount of Si and Al to introduce retained austenite, which causes Liquid Metal Embrittlement (LME) to occur during spot welding of the steel sheet, thereby limiting the use of a plated steel sheet and a cold-rolled steel sheet welded with a plating material. In addition, as the strength of the steel sheet increases, a problem of hydrogen embrittlement, in which assembled parts suddenly fracture during use, may occur, so it is necessary to ensure that the steel sheet does not corrode severely, even when exposed to a corrosive environment.

25 [Prior art document]

[0004] (Patent Document 1) Korean Patent Publication No. 2017-7015003

Summary of Invention

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Technical Problem

[0005] An aspect of the present disclosure is to provide a cold-rolled steel sheet having excellent weldability, strength, and formability, and a method of manufacturing the same.

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Solution to Problem

40 **[0006]** According to an aspect of the present disclosure, provided is a cold-rolled steel sheet having excellent weldability, strength, and formability, the cold-rolled steel sheet including by weight: C: 0.14 to 0.16%, Si: 0.3 to 0.6%, Al: 0.01 to 0.3%, Mn: 2.6 to 3.0%, Cr: 0.01 to 0.25%, Mo: 0.15 to 0.4%, B: 0.0001 to 0.005%, Nb: 0.001 to 0.05%, Ti: 0.001 to 0.05%, P: 0.04% or less (excluding 0%), S: 0.01% or less (excluding 0%), N: 0.01% or less (excluding 0%), with a remainder of Fe and other unavoidable impurities, wherein the following Relational Expressions 1 and 2 are satisfied, wherein a microstructure consists of retained austenite: more than 1% and 5% or less, fresh martensite: 10% or more and less than 25%, bainite: less than 20% (excluding 0%), tempered martensite: 55% or more and less than 80%, and ferrite: 5% or less (including 0%).

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$$234 \times [C] - 29 \times [Si] - 128 \times [Al] + 29 \times [Mn] + 10 \times [Cr] - 17 \times [Mo] - 37 \times [Nb] - 49 \times [Ti] + 100 \times [B] \geq 80$$

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$$5 \times [C] + [Si] + 0.5 \times [Al] \leq 1.5$$

where a content of each element in the above Relational Expressions 1 and 2 refers to % by weight.

55 **[0007]** According to another aspect of the present disclosure, provided is a method of manufacturing a cold-rolled steel sheet having excellent weldability, strength, and formability, the method including: heating a slab including by weight: C: 0.14 to 0.16%, Si: 0.3 to 0.6%, Al: 0.01 to 0.3%, Mn: 2.6 to 3.0%, Cr: 0.01 to 0.25%, Mo: 0.15 to 0.4%, B: 0.0001 to 0.005%, Nb: 0.001 to 0.05%, Ti: 0.001 to 0.05%, P: 0.04% or less (excluding 0%), S: 0.01% or less (excluding 0%), N: 0.01% or less (excluding 0%), with a remainder of Fe and other unavoidable impurities, wherein the following

Relational Expressions 1 and 2 are satisfied; finish hot rolling the heated slab at a temperature within a range of 830 to 980°C to obtain a hot-rolled steel sheet; coiling the hot-rolled steel sheet at a temperature within a range of 450 to 700°C; cold rolling the coiled hot-rolled steel sheet to obtain a cold-rolled steel sheet; continuously annealing the cold-rolled steel sheet at a temperature within a range of 800 to 840°C; primarily cooling the continuously annealed steel sheet at an average cooling rate of less than 10°C/s to a primary cooling end temperature of 550 to 650°C; secondarily cooling the primarily cooled steel sheet at an average cooling rate of 10°C/s or more to a secondary cooling end temperature of 320 to 360°C; and reheating the secondarily cooled steel sheet to a temperature within a range of 380 to 480°C.

$$234 \times [C] - 29 \times [Si] - 128 \times [Al] + 29 \times [Mn] + 10 \times [Cr] - 17 \times [Mo] - 37 \times [Nb] - 49 \times [Ti] + 100 \times [B] \geq 80$$

$$5 \times [C] + [Si] + 0.5 \times [Al] \leq 1.5$$

where a content of each element in the above Relational Expressions 1 and 2 refers to % by weight.

Advantageous Effects of Invention

[0008] As set forth above, according to an aspect of the present disclosure, a cold-rolled steel sheet having excellent weldability, strength, and formability and a method of manufacturing the same may be provided.

Best Mode for Invention

[0009] Hereinafter, a cold-rolled steel sheet having excellent weldability, strength, and formability according to an embodiment of the present disclosure will be described.

[0010] First, an alloy composition of the present disclosure will be described. A content of the alloy composition described below refers to % by weight.

Carbon (C): 0.14 to 0.16%

[0011] Carbon (C) is an element to secure strength of a steel material, through solid solution strengthening and precipitation strengthening. When the C content is less than 0.14%, it is difficult to secure a tensile strength (TS) of 1180 MPa. On the other hand, when the C content is more than 0.16%, arc weldability and laser weldability deteriorate, and a risk of occurrence of LME cracks increases. Therefore, the C content is preferably in a range of 0.14 to 0.16%. A lower limit of the C content is more preferably 0.145%. An upper limit of the C content is more preferably 0.155%.

Silicon (Si): 0.3 to 0.6%

[0012] Silicon (Si) is a key element in Transformation Induced Plasticity (TRIP) steel increasing a fraction and elongation of retained austenite by inhibiting precipitation of cementite. When the Si content is less than 0.3%, almost no retained austenite remains, resulting in excessively low elongation. On the other hand, when the Si content is more than 0.6%, it is impossible to prevent deterioration of properties of a weld zone due to the formation of LME cracks, and surface properties and plating properties of a steel material deteriorate. Therefore, the Si content is preferably in a range of 0.3 to 0.6%. A lower limit of the Si content is more preferably 0.35%. An upper limit of the Si content is more preferably 0.55%, even more preferably 0.5%, and most preferably 0.45%.

Aluminum (Al): 0.01 to 0.3%

[0013] Aluminum (Al) is not only an element included for deoxidation of a steel material, but also an element which is effective in stabilizing retained austenite by suppressing precipitation of cementite. When the Al content is less than 0.01%, the deoxidation of the steel material is not sufficiently achieved, and cleanliness of the steel material is impaired. On the other hand, when the Al content is more than 0.3%, a temperature required for single-phase region heating during annealing increases, and castability of the steel material is impaired. Therefore, the Al content is preferably in a range of 0.01 to 0.3%. A lower limit of the Al content is more preferably 0.02%. An upper limit of the Al content is more preferably 0.25%, and even more preferably 0.2%.

Manganese (Mn): 2.6 to 3.0%

[0014] Manganese (Mn) is an element added to secure strength. When the Mn content is less than 2.6%, it is difficult to secure strength therewith. On the other hand, when the Mn content is more than 3.0%, a bainite transformation rate is slowed and too much fresh martensite is formed, making it difficult to obtain high hole expandability. In addition, a band structure may be formed due to segregation of Mn, which impairs the material uniformity and formability of the material. Therefore, the Mn content is preferably in a range of 2.6 to 3.0%. A lower limit of the Mn content is more preferably 2.7%. An upper limit of the Mn content is more preferably 2.9%.

Chromium (Cr): 0.01 to 0.25%

[0015] Chromium (Cr) is an element added to secure strength and hardenability. When Mn is added alone, a very large amount of Mn should be added, exceeding the range of the Mn content of the present disclosure. This problem can be solved by adding 0.01% or more of Cr. On the other hand, when the Cr content is more than 0.25%, local corrosion properties may deteriorate, hydrogen embrittlement cracks may occur, and oxides may be formed on the surface, impairing phosphate treatment properties. Therefore, the Cr content is preferably in a range of 0.01 to 0.25%. A lower limit of the Cr content is more preferably 0.05%, and even more preferably 0.1%. An upper limit of the Cr content is more preferably 0.2%, and even more preferably 0.15%.

Molybdenum (Mo): 0.15 to 0.4%

[0016] Molybdenum (Mo) is an element added to secure strength and hardenability. When the Mo content is less than 0.15%, it is difficult to secure strength and hardenability. On the other hand, when the Mo content is more than 0.4%, phase transformation is suppressed, making it difficult to obtain a bainite structure, and as an expensive element, economic feasibility in manufacturing a steel sheet deteriorates. Therefore, the Mo content is preferably in a range of 0.15 to 0.4%. A lower limit of the Mo content is more preferably 0.17%. An upper limit of the Mo content is more preferably 0.3%, and even more preferably 0.23%.

Boron (B): 0.0001 to 0.005%

[0017] Boron (B) is an element added to secure hardenability. When Mn is added alone, a very large amount of Mn should be added exceeding the range of the Mn content of the present disclosure, but this problem can be solved by adding 0.0001% or more of B. However, when the B content is more than 0.005%, B is excessively accumulated on the surface, impairing plating adhesion of a plating material. Therefore, the B content is preferably in a range of 0.0001 to 0.005%. A lower limit of the B content is more preferably 0.0005%. An upper limit of the B content is more preferably 0.002%, and even more preferably 0.0015%.

Niobium (Nb): 0.001 to 0.05%

[0018] Niobium (Nb) is an element added to secure strength of a steel sheet and refine a microstructure thereof. When Nb is added in an amount of less than 0.001%, it is difficult to obtain an effect of improving the strength and refining the microstructure. On the other hand, when the Nb content is more than 0.05%, recrystallization is delayed due to local grain fixation, thereby impairing the uniformity of the microstructure. Therefore, the Nb content is preferably in a range of 0.001 to 0.05%. A lower limit of the Nb content is more preferably 0.02%, and even more preferably 0.025%. An upper limit of the Nb content is more preferably 0.04%, and even more preferably 0.035%.

Titanium (Ti): 0.001 to 0.05%

[0019] Titanium (Ti) is an element added to secure strength of a steel sheet and refine a microstructure thereof. When Ti is added in an amount of less than 0.001%, it is difficult to obtain an effect of improving the strength and refining the microstructure. On the other hand, when the Ti content is more than 0.05%, castability is impaired due to excessive formation of TiN, and recrystallization is delayed due to local grain fixation, thereby impairing the uniformity of the microstructure. Therefore, the Ti content is preferably in a range of 0.001 to 0.05%. A lower limit of the Ti content is more preferably 0.01%, and even more preferably 0.015%. An upper limit of the Ti content is more preferably 0.03%, and even more preferably 0.02%.

Phosphorus (P): 0.04% or less (excluding 0%)

[0020] Phosphorus (P) exists as an impurity in steel, which is advantageous to control the P content as low as possible. However, considering the case in which P is inevitably included, 0% is excluded (i.e., more than 0%). Meanwhile, P may be intentionally added to increase the strength of a steel material, but when P is added excessively, toughness of the steel material deteriorates. Therefore, in the present disclosure, an upper limit of the P content is preferably limited to 0.04% to prevent this. The P content is more preferably 0.02% or less, and even more preferably 0.01% or less.

Sulfur (S): 0.01% or less (excluding 0%)

[0021] Sulfur (S), like P, exists as an impurity in steel, and it is advantageous to control the S content as low as possible. In addition, since S deteriorates ductility and impact properties of steel, an upper limit of the S content is preferably limited to 0.01%. The S content is more preferably 0.003% or less, and even more preferably 0.001% or less. However, considering the case in which S is inevitably included, 0% is excluded (i.e., more than 0%).

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

[0022] Nitrogen (N) is an impurity element, which is included in a steel material, and when a large amount of N is contained, there is a risk that a large amount of nitrides such as TiN and AlN, so it is advantageous that the N content be as low as possible. Therefore, an upper limit of the N content is preferably limited to 0.01%. The N content is more preferably 0.05% or less, and even more preferably 0.03% or less. However, considering the case in which N is inevitably included, 0% is excluded (i.e., more than 0%).

[0023] 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.

[0024] Meanwhile, the cold-rolled steel sheet of the present disclosure may further include one or two of Cu: 0.1% or less (excluding 0%) and Ni: 0.1% or less (excluding 0%).

Copper (Cu): 0.1% or less (excluding 0%) and Nickel (Ni): 0.1% or less (excluding 0%)

[0025] Copper (Cu) and nickel (Ni) are elements increasing strength of a steel material. The above-described elements are elements of increasing the strength and hardenability of the steel material. However, when an excessive amount of copper (Cu) and nickel (Ni) are added, a target strength grade may be exceeded, and since copper (Cu) and nickel (Ni) are expensive elements, which is disadvantageous from an economic perspective, an upper limit of each of the contents of copper (Cu) and nickel (Ni) is preferably 0.1% or less. Meanwhile, in order to obtain better solid solution strengthening, a lower limit of each of the contents of Cu and Ni may be 0.03%.

[0026] In addition, the cold-rolled steel sheet of the present disclosure may optionally further include V: 0.05% or less (excluding 0%).

Vanadium (V): 0.05% or less (excluding 0%)

[0027] Vanadium (V) may increase strength of a steel material even with addition of a small amount thereof, but the action thereof on improving elongation is not significant, so the V content is preferably to be controlled to be 0.05% or less.

[0028] In addition, the cold-rolled steel sheet of the present disclosure is preferably to satisfy the alloy composition described above, and at the same time, to satisfy the Relational Expressions 1 and 2 below.

$$234 \times [C] - 29 \times [Si] - 128 \times [Al] + 29 \times [Mn] + 10 \times [Cr] - 17 [Mo] - 37 \times [Nb] - 49 \times [Ti] + 100 [B] \geq 80 \quad [\text{Relational Expression 1}]$$

[0029] When the above-described Relational Expression 1 is not satisfied, a fraction of ferrite desired by the present disclosure is formed excessively during annealing conditions, deteriorating not only yield strength but also hole expandability. In the above Relational Expression 1, a value of a left side is more preferably 90 or more, and even more preferably, 100 or more.

$$5 \times [C] + [Si] + 0.5 \times [Al] \leq 1.5 \quad [\text{Relational Expression 2}]$$

[0030] Meanwhile, according to an embodiment of the present disclosure, when a large amount of alloying elements such as C, Si, and Al are added, spot weldability deteriorates, and in particular, when spot welding is performed on a galvanized steel sheet, Liquid Metal Embrittlement (LME) is caused. In general, spot welding of a steel material is performed below a minimum current value at which expulsion occurs, and a minimum current value at which expulsion occurs may be seen as the condition that can provide the highest amount of heat input when performing actual spot welding. When LME resistance is high, LME may not occur even at a welding current value above the minimum current value at which expulsion occurs, and in this case, an AE value defined as a difference obtained by subtracting the minimum current value at which expulsion occurs from the minimum current value minimum current at which LME occurs has a positive value. That is, welding is performed below the minimum current value at which expulsion occurs during actual spot welding, and at this time, if LME does not occur, it can be determined that the AE value is 0 or more. Meanwhile, the AE value has a unit of kA.

[0031] Relational Expression 2 is a component Relational Expression which derives a condition for excellent LME resistance, that is, the AE value is 0 or more. When the Relational Expression 2 is not satisfied, there is a problem that the LME resistance is reduced. In the above Relational Expression 2, the value of the left side is more preferably 1.25 or less, and even more preferably 1.05 or less.

[0032] The microstructure of the cold-rolled steel sheet according to an embodiment of the present disclosure preferably consists of: retained austenite: more than 1% and 5% or less, fresh martensite: 10% or more and less than 25% (excluding 0%), bainite: less than 20%, tempered martensite: 55% or more and less than 80%, and ferrite: 5% or less (including 0%). A fraction of the microstructure described below refers to % by area.

Retained austenite: more than 1% and less than 5%

[0033] Retained austenite is a structure increasing elongation of a steel material through a TRIP effect. The higher the fraction, the higher the elongation may be obtained. In the present disclosure, in order to obtain the required level of elongation, it is preferable that the fraction is more than 1%. However, to obtain more than 5% of austenite, a large amount of C and Si should be added, and in this case, spot welding LME resistance deteriorates.

Fresh martensite: 10% or more and less than 25%

[0034] Fresh martensite is a structure advantageous for securing strength. When the fraction of fresh martensite is less than 10%, tensile strength of a steel material may be insufficient, but yield strength may be excessively high. When the fraction of fresh martensite is 25% or more, the strength may be excessively high and hole expandability may be low.

Bainite: less than 20% (excluding 0%)

[0035] Bainite is a structure having lower strength than martensite, but which is advantageous for stabilizing retained austenite. However, when the bainite fraction is 20% or more, the martensite fraction may be relatively low, which may cause a problem of insufficient overall strength.

Tempered martensite: 55% or more and less than 80%

[0036] Tempered martensite is a structure advantageous for securing strength and hole expandability. Tempered martensite is formed when the steel sheet is cooled below a martensite transformation start point (M_s) during secondary cooling after annealing and then subjected to a tempering heat treatment in the process of being reheated. When a fraction of tempered martensite is less than 55%, which means that there is too much fresh martensite formed during final cooling, and thus the strength becomes excessively high and hole expandability becomes poor. In addition, when the fraction of tempered martensite is 80% or more, a fraction of fresh martensite decreases and strength cannot be obtained.

Ferrite: 5% or less (including 0%)

[0037] Ferrite is a structure that has an adverse effect on yield strength and hole expandability, and theoretically, a fraction of ferrite is preferably 0%. However, ferrite may inevitably be formed during the manufacturing process, and when the fraction of ferrite is more than 5%, the yield strength may be lowered and the hole expandability may also be poor, so in the present disclosure, an upper limit of the fraction of ferrite is limited to be 5%.

[0038] The cold-rolled steel sheet of the present disclosure provided as described above may have a tensile strength of 1180 to 1350 MPa, a yield strength of 740 to 980 MPa, an elongation of 8% or more, a hole expandability of 20% or more, and an AE value of 0 kA or more, and thus excellent strength, ductility, hole expandability, and weldability may

be secured at the same time.

[0039] In addition, the cold-rolled steel sheet of the present disclosure may have a hot-dip galvanized layer or an alloyed hot-dip galvanized layer formed on at least one surface thereof. In the present disclosure, there is no particular limitation on the composition of the hot-dip galvanized layer, and any hot-dip galvanized layer commonly applied in the technical field may be preferably applied to the present disclosure. In addition, the hot-dip galvanized layer may be an alloyed hot-dip galvanized layer alloyed with some alloy components of the steel sheet.

[0040] Hereinafter, a method of manufacturing a cold-rolled steel sheet having excellent weldability, strength, and formability according to an embodiment of the present disclosure will be described.

[0041] First, a slab satisfying the above-described alloy composition and Relational Expressions 1 and 2 is heated. Although not particularly limited, a heating temperature when heating the slab may be 1150 to 1250°C. When the slab heating temperature is lower than 1150°C, it may not be possible to perform hot rolling, a subsequent operation. On the other hand, when the slab heating temperature is more than 1250°C, a lot of energy is unnecessarily consumed to increase the slab temperature. Therefore, it is preferable that the slab heating temperature has a range from 1150 to 1250°C. A lower limit of the slab heating temperature is more preferably 1170°C, and even more preferably 1180°C. An upper limit of the slab heating temperature is more preferably 1230°C, and even more preferably 1220°C.

[0042] Thereafter, the heated slab is subjected to finish hot rolling at a temperature within a range of 830 to 980°C to obtain a hot-rolled steel sheet. When the finishing hot rolling temperature (hereinafter also referred to as 'FDT') is lower than 830°C, a rolling load is increased and shape defects increase, thereby deteriorating productivity. On the other hand, when the finishing hot rolling temperature is more than 980°C, surface quality deteriorates due to an increase in oxides due to excessively high temperature work. Therefore, it is preferable that the finish hot rolling temperature has a range from 830 to 980°C. A lower limit of the finish hot rolling temperature is more preferably 850°C, and even more preferably 880°C. An upper limit of the finish hot rolling temperature is more preferably 950°C, and even more preferably 930°C.

[0043] Thereafter, the hot-rolled steel sheet is coiled at a temperature within a range of 450 to 700°C. When the coiling temperature (hereinafter also referred to as 'CT') is more than 700°C, coarse internal oxidation in hot rolling occurs, which may cause a disadvantage of deteriorating surface properties. On the other hand, when the coiling temperature is lower than 450°C, it corresponds to a transition boiling region, which may cause a disadvantage of deteriorating controllability of the coiling temperature and deteriorating the shape of the steel sheet. Therefore, it is preferable that the coiling temperature has a range of 450 to 700°C. A lower limit of the coiling temperature is 500°C. An upper limit of the coiling temperature is more preferably 650°C, and even more preferably 620°C.

[0044] Meanwhile, although not particularly limited, after the finish hot rolling, cooling may be performed at an average cooling rate of 10 to 110°C/s to the coiling temperature. When the average cooling rate is less than 10°C/s, there is a disadvantage in that hot rolling productivity is low and a cooling medium with low cooling capacity should be deliberately adopted during actual production. When the average cooling rate is more than 100°C/s, there is a disadvantage in that the temperature deviation inside the steel sheet becomes uneven, causing the shape to deteriorate and the strength of the steel sheet to become excessively high.

[0045] Thereafter, the coiled hot-rolled steel sheet is cold rolled to obtain a cold-rolled steel sheet. During the cold rolling, a cold rolling reduction rate may be 30 to 60%. When the cold rolling reduction rate is less than 30%, it may be difficult to secure target thickness accuracy and correction of the shape of the steel plate may become difficult. On the other hand, when the cold rolling reduction rate is more than 60%, the possibility of cracks occurring at an edge of the steel sheet increases, and a cold rolling load may become excessively large.

[0046] Thereafter, the cold-rolled steel sheet is continuously annealed at a temperature within a range of 800 to 840°C. The continuous annealing is performed to heat a steel sheet to an austenite single phase region to form austenite close to 100% and be used for subsequent phase transformation. If the continuous annealing temperature (hereinafter also referred to as 'SS') is lower than 800°C, sufficient recrystallization and austenite transformation may not occur and ferrite at a level which is more than 5 % by area may be generated. On the other hand, if the continuous annealing temperature is higher than 840°C, productivity may decrease, coarse austenite may be formed and the material may deteriorate, and surface quality such as peeling of a plating material may deteriorate. Meanwhile, the continuous annealing may be performed in a continuous alloying hot dip plating furnace.

[0047] Meanwhile, although not particularly limited, during the continuous annealing, an atmosphere in a continuous annealing furnace may be controlled with a gas comprising, by volume, 95% or more of nitrogen and a remainder of hydrogen. When the nitrogen fraction is less than 95% and a ratio of hydrogen is not increased accordingly, an oxidizing atmosphere is formed in the furnace and oxides are formed on a surface of the steel sheet, deteriorating the surface quality. When the ratio of hydrogen increases, process difficulties such as explosion prevention increase.

[0048] Thereafter, the continuously annealed steel sheet is primarily cooled at an average cooling rate of less than 10°C/s to a primary cooling end temperature of 550 to 650°C (hereinafter referred to as 'SCS'). The primary cooling end temperature may be defined as a point in time at which secondary cooling (rapid cooling) is initiated by additionally applying a quenching equipment that was not applied in primary cooling. When the cooling process is divided into primary and secondary cooling and performed in stages, a temperature distribution of the steel sheet may be made uniform in

a slow cooling stage, a final temperature and material deviation may be reduced, and a necessary phase composition may be obtained. When the primary cooling end temperature is higher than 650°C, a cooling amount of cooling to the secondary cooling end temperature may increase and the shape of the steel sheet may deteriorate, and when the primary cooling end temperature is lower than 550°C, a load of a slow cooling process increases. When the primary cooling rate is 10°C/s or more, the amount of cooling in the secondary cooling increases, resulting in an increase in the final temperature deviation and material deviation. Meanwhile, when the primary cooling rate is less than 1°C/s, a large amount of ferrite phases are formed during cooling, so that it may be difficult to obtain the target microstructure and material. A lower limit of the primary cooling end temperature is more preferably 570°C. An upper limit of the primary cooling end temperature is more preferably 630°C. The primary cooling rate is even more preferably in the range of 1°C/s or more and less than 10°C/s.

[0049] Thereafter, the primarily cooled steel sheet is secondarily cooled at an average cooling rate of 10°C/s or more to a secondary cooling end temperature of 320 to 360°C (hereinafter referred to as 'RCS'). The secondary cooling end temperature is set to be a Ms temperature of the steel sheet or lower, so that martensite transformation occurs during cooling, and this martensite ultimately becomes tempered martensite through a reheating operation, which is a post-process. Since the Ms temperature of 1180MPa of a high-elongated steel sheet is mostly 400°C or lower, in the present disclosure, the secondary cooling end temperature was controlled to be in a range of 320 to 360°C. When the secondary cooling end temperature is lower than 320°C, an amount of initial martensite transformation increases too much and the yield strength increases, resulting in poor formability. On the other hand, when the secondary cooling end temperature is more than 360°C, tempered martensite is not generated and a fraction of vulnerable fresh martensite increases, resulting in poor yield strength and hole expandability. When the secondary cooling rate is less than 10°C/s, even if the target secondary cooling end temperature is reached, high-temperature phase transformation occurs during cooling, so that it may not obtain the target martensite fraction and high strength. A lower limit of the second cooling stop temperature is more preferably 330°C. An upper limit of the secondary cooling stop temperature is more preferably 350°C.

[0050] Meanwhile, as mentioned above, the secondary cooling may be performed by additionally using a quenching equipment which was not applied in the primary cooling, and in the present disclosure, the type of the quenching equipment is not particularly limited, but a hydrogen quenching equipment may be used as a preferred example. More specifically, the hydrogen quenching equipment may use a gas consisting of 5 to 80% hydrogen and a remainder of nitrogen by volume. When the hydrogen fraction is more than 80%, there may be a disadvantage in that it becomes difficult to manage equipment such as explosion control of the equipment, and when the hydrogen fraction is less than 5%, there may be a disadvantage in that it becomes difficult to utilize the efficient heat transfer characteristics of hydrogen, which is a light element.

[0051] Thereafter, the secondarily cooled steel sheet is reheated to a temperature range of 380 to 480°C. Through the above-described process, carbon distribution between phases and additional bainite phase transformation required for stabilization of retained austenite are obtained. In the present disclosure, an end point temperature of the heating section is referred to as a reheating temperature (hereinafter also referred to as 'RHS') for convenience. When the reheating temperature is lower than 380°C, the strength becomes excessively high and the elongation deteriorates. On the other hand, when the reheating temperature is more than 480°C, an austenite phase remains untransformed and a rate of fresh martensite, which is transformed during final cooling, increases, thereby impairing hole expandability and elongation. Meanwhile, a temperature at which bainite transformation is performed most actively, the so-called nose temperature, is about 400 to 420°C. In consideration thereof, it is more preferable to maintain the reheating temperature in a range of 400 to 420°C.

[0052] Meanwhile, although not particularly limited, during the reheating, an average temperature increase rate may be 0.5 to 2.5°C/s. When the average temperature increase rate is less than 0.5°C/s, an overall process time may become too long, which may cause a problem of an excessive heat treatment, and when the average temperature increase rate is more than 2.5°C/s, it may be difficult to secure the target physical properties in the present disclosure.

[0053] According to an embodiment of the present disclosure, after the reheating operation, if necessary, the cold-rolled steel sheet may be additionally subjected to a hot-dip galvanizing, alloyed hot-dip galvanizing, or temper rolling process.

[0054] Specifically, an operation of hot dip galvanizing the reheated cold-rolled steel sheet in a plating bath at a temperature within a range of 450 to 470°C may be further included. In addition, if necessary, an operation of performing an alloying heat treatment of the hot-dip galvanized cold-rolled steel sheet may be further included bath at a temperature within a range of 470 to 550°C. The alloying heat treatment is performed to obtain an appropriate alloying level, the temperature may be determined by a surface condition of the steel sheet. By controlling the surface condition of a steel material, an alloying heat treatment temperature should not exceed 550°C to prevent softening of the steel sheet and loss of retained austenite due to excessive temperature. Meanwhile, in order to quickly proceed with alloying, the alloying heat treatment temperature is preferably higher than the hot-dip galvanizing temperature, so the lower limit may be controlled to a temperature of 470°C. In addition, after performing the alloying heat treatment, in order to correct the shape of the steel sheet and adjust the yield strength, an operation in which the alloyed heat treated cold-rolled steel

sheet is cooled to room temperature and then temper rolled at a reduction rate of less than 1% may be further included.

Mode for Invention

[0055] 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.

(Example)

[0056] A slab having the alloy composition shown in Table 1 below was prepared and then reheated at a temperature within a range of 1180 to 1220°C, and was subjected to hot rolling, coiling, primary cooling, secondary cooling, and reheating processes under the conditions shown in Table 2 below to manufacture a cold-rolled steel sheet. In this case, after finishing hot rolling, the cooling rate was 30 to 50°C/s, the cold rolling reduction rate was 33 to 55%, and the gas used during continuous annealing was 95% N by volume to 5% H by volume, and the gas used during secondary cooling was 75% H by volume to 25% N by volume.

[0057] A microstructure and mechanical properties of the cold-rolled steel sheet prepared as described above were measured, and the results thereof were shown in Table 3 below.

[0058] The microstructure was measured using a Point Counting method from a photograph using a scanning electron microscope (SEM), and a fraction of retained austenite was measured using XRD.

[0059] Among the mechanical properties, yield strength YS, tensile strength TS, and elongation EL were measured through a tensile test in a direction perpendicular to rolling. A test specimen having a gauge length of 50 mm and a width of a tensile specimen of 25 mm was used.

[0060] Among the mechanical properties, hole expandability (HER) was measured according to ISO 16330 standards, and a hole was sheared with a clearance of 12% using a 10mm diameter punch.

[0061] Meanwhile, hot-dip galvanizing (GI) was performed on the cold-rolled steel sheet under the conditions shown in Table 2 below, an alloying heat treatment (GA) was performed on some steel types, and spot welding was performed to measure an AE value, and the results thereof were shown in Table 3 below. The AE value refers to a value obtained by subtracting a minimum current value at which expulsion occurs from a minimum current value at which LME occurs. In the spot welding test, a current was increased in a unit of 0.5 kA from a low current value, but a short cooling time was given between each current value to prevent excessive heat input to the material. As the current value is increased in this manner, a minimum current value at which a nugget in a weld zone expulsions was measured, and at the same time, a minimum current value at which LME occurs is measured from observation of a surface and cross-section of the weld zone, and then the results thereof were shown in Table 3 below. Regarding whether LME occurs, when the surface of the weld zone was observed at 10x magnification and the cross-section thereof was observed at 100x magnification, a case in which no cracks due to LME were observed were evaluated as pass, and a case in which cracks were observed were evaluated as fail.

[0062] In addition, a hole with a diameter of 10 mm was drilled in the cold-rolled steel sheet using a punch with a clearance of 12%, immersed in a hydrochloric acid solution of 0.1 normal concentration and corroded for 100 hours, and then whether hydrogen embrittlement cracks occur in the punched region was evaluated.

[Table 1]

Steel type No.	Alloy composition(weight %)													
	C	Si	Al	Mn	Cr	Mo	B	Nb	Ti	P	S	N	Relat ion 1	Relati on2
A	0.149	0.41	0.085	2.85	0.18	0.21	0.0018	0.031	0.018	0.0066	0.0008	0.0041	91.1	1.20
B	0.1	0.57	0.09	2.62	0.03	0.12	0.001	0.022	0.021	0.0095	0.0015	0.0034	67.8	1.12
C	0.12	0.42	0.315	2.42	0.41	0.05	0.0002	0.015	0.017	0.0072	0.0024	0.0045	47.6	1.18

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(continued)

Steel type No.	Alloy composition(weight %)													
	C	Si	Al	Mn	Cr	Mo	B	Nb	Ti	P	S	N	Relation 1	Relation 2
D	0.18	0.72	0.034	2.57	0.67	0.19	0.0012	0.033	0.012	0.0053	0.0019	0.0042	93.2	1.64
E	0.19	1.0	0.0	2.0	0.0	0.0	0.00	0.0	0.01	0.00	0.00	0.00	83.6	2.17
	9	21	23	63	52	15	04	26	7	58	21	57		
F	0.155	0.39	0.033	2.72	0.21	0.26	0.0008	0.029	0.021	0.0082	0.0014	0.0033	95.3	1.18
G	0.154	0.51	0.052	2.61	0.24	0.22	0.0002	0.042	0.0023	0.0074	0.0012	0.0043	87.3	1.31
[Relation 1] $234 \times [C] - 29 \times [Si] - 128 \times [Al] + 29 \times [Mn] + 10 \times [Cr] - 17 \times [Mo] - 37 \times [Nb] - 49 \times [Ti] + 100 \times [B] \geq 80$ [Relation 2] $5 \times [C] + [Si] + 0.5 \times [Al] \leq 1.5$														

[Table 2]

Division	Steel type	Thickness of hot-rolled material (mm)	FD T (°C)	CT (°C)	Thickness of cold-rolled material (mm)	SS (°C)	Primary average cooling rate (°C/s)	SC S (°C)	Secondary average cooling rate (°C/s)	RC S (°C)	RH S (°C)	GI PO T (°C)	GA (°C)
Comparative Example 1	A	2.7	93 8	58 2	1.6	83 2	4.1	60 5	13.9	31 2	44 3	45 8	51 7
Inventive Example 1	A	2.1	92 5	59 3	1.2	83 3	4.0	59 2	11.6	33 2	44 0	46 0	50 9
Inventive Example 2	A	2.4	94 1	60 5	1.4	82 9	3.6	61 2	11.7	34 9	43 3	46 3	51 1
Comparative Example 2	A	2.6	91 2	59 6	1.6	83 2	4.4	58 8	10.4	36 8	43 2	46 0	-
Comparative Example 3	B	2.4	92 1	63 2	1.2	81 1	4.1	58 2	12.3	32 2	43 3	46 2	-
Comparative Example 4	C	2.4	89 9	56 5	1.2	82 5	3.3	63 3	14.0	32 6	45 1	45 8	51 9
Comparative Example 5	D	2.5	91 6	61 7	1.3	82 1	4.3	57 2	11.4	32 3	44 8	46 3	-
Comparative Example 6	E	2.2	88 2	66 4	1.1	81 2	3.6	62 2	15.2	32 1	43 5	46 1	50 4

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(continued)

Division	Steel type	Thickness of hot-rolled material (mm)	FD T (° C)	CT (° C)	Thickness of cold-rolled material (mm)	SS (° C)	Primary average cooling rate (°C/s)	SC S (° C)	Secondary average cooling rate (°C/s)	RC S (° C)	RH S (° C)	GI POT (° C)	GA (° C)
Inventive Example 3	F	2.7	88 7	55 4	1.6	83 3	3.9	59 3	11.3	32 8	42 1	45 9	-
Inventive Example 4	G	2.1	91 1	61 1	1.1	82 7	4.1	60 4	13.2	33 6	43 6	46 1	51 1

[Table 3]

Division n	Microstructure (area)					Mechanical properties					LME properties				Whether hydrogen embrittlement cracks occur
	RA	FM	B	TM	F	YS (MPa)	TS (MPa)	EL (%)	HER (%)	AE value (kA)	Minimum current value at which expulsion occurs (kA)	Minimum current value at which LME occurs (kA)	Whether LME occurs		
Comparative Example 1	3	8	10	77	2	1011	1198	11	40	1.5	10.5	12	Pass	Not occur	
Inventive Example 1	3	14	10	71	2	868	1260	10	33	1	11	12	Pass	Not occur	
Inventive Example 2	2	21	12	62	3	843	1323	9	26	1.5	10.5	12	Pass	Not occur	
Comparative Example 2	3	33	25	36	3	912	1372	8	18	1	10.5	11.5	Pass	Not occur	
Comparative Example 3	3	15	21	36	25	721	1123	13	12	1.5	10	11.5	Pass	Not occur	
Comparative Example 4	3	14	11	38	34	689	1107	12	13	1.5	10	11.5	Pass	Occur	
Comparative Example 5	4	15	11	68	2	878	1195	11	28	- 0.5	11.5	11	Fail	Occur	

(continued)

Division	Microstructure (area)					Mechanical properties				LME properties				Whether hydrogen embrittlement cracks occur
	RA	FM	B	TM	F	YS (MPa)	TS (MPa)	EL (%)	HER (%)	AE value (kA)	Minimum current value at which expulsion occurs (kA)	Minimum current value at which LME occurs (kA)	Whether LME occurs	
Comparative Example 6	7	12	13	65	3	923	1227	13	35	-1	12	11	Fail	Occur
Inventive Example 3	2	17	11	68	2	921	1233	10	31	1	10.5	11.5	Pass	Not occur
Inventive Example 4	3	19	12	64	2	888	1225	9	29	0.5	11	11.5	Pass	Not occur
RA: Retained Austenite, FM: Fresh Martensite, B: Bainite, TM: Tempered Martensite, F: Ferrite														

[0063] As can be seen from Tables 1 to 3, in Inventive Examples 1 to 4 satisfying the alloy composition, Relational Expressions 1 and 2, and manufacturing conditions, proposed by the present disclosure, it can be seen that the cold-rolled steel sheet not only has a tensile strength of 1180 to 1350MPa, a yield strength of 740 to 980MPa, an elongation of 8% or more, and hole expandability of 20% or more, but also has excellent LME properties.

[0064] On the other hand, in Comparative Examples 1 and 2 in which the alloy composition and Relational Expressions 1 and 2 of the present disclosure were satisfied, but a secondary cooling end temperature was outside the range of the present disclosure, it can be seen that the microstructure desired by the present disclosure was not secured, and the yield strength was too high or the hole expandability was lowered to less than 20%, resulting in poor formability.

[0065] In Comparative Examples 3 and 4, the manufacturing conditions of the present disclosure were satisfied, but the alloy composition and Relational Expression 1 of the present disclosure were not satisfied, so it can be seen that the microstructure desired by the present disclosure cannot be secured and the mechanical properties are inferior.

[0066] In Comparative Examples 5 and 6, the manufacturing conditions of the present disclosure were satisfied, but the alloy composition and Relational Expression 2 of the present disclosure were not satisfied, so it can be seen that the LME properties were inferior.

[0067] In particular, in Comparative Examples 4, 5, and 6, it can be seen that hydrogen embrittlement cracks occurred due to excessive addition of Cr.

Claims

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

C: 0.14 to 0.16%, Si: 0.3 to 0.6%, Al: 0.01 to 0.3%, Mn: 2.6 to 3.0%, Cr: 0.01 to 0.25%, Mo: 0.15 to 0.4%, B: 0.0001 to 0.005%, Nb: 0.001 to 0.05%, Ti: 0.001 to 0.05%, P: 0.04% or less (excluding 0%), S: 0.01% or less (excluding 0%), N: 0.01% or less (excluding 0%), with a remainder of Fe and other unavoidable impurities, wherein the following Relational Expressions 1 and 2 are satisfied, wherein a microstructure consists of retained austenite: more than 1% and 5% or less, fresh martensite: 10% or more and less than 25%, bainite: less than 20% (excluding 0%), tempered martensite: 55% or more and less than 80%, and ferrite: 5% or less (including 0%),

$$234 \times [C] - 29 \times [Si] - 128 \times [Al] + 29 \times [Mn] + 10 \times [Cr] - 17 [Mo] - 37 \times [Nb] - 49 \times [Ti] + 100 [B] \geq 80 \quad [\text{Relational Expression 1}]$$

$$5 \times [C] + [Si] + 0.5 \times [Al] \leq 1.5 \quad [\text{Relational Expression 2}]$$

where a content of each element in the above Relational Expressions 1 and 2 refers to % by weight.

2. The cold-rolled steel sheet of claim 1, wherein the cold-rolled steel sheet further comprises one or two of Cu: 0.1% or less (excluding 0%) and Ni: 0.1% or less (excluding 0%).

3. The cold-rolled steel sheet of claim 1, wherein the cold-rolled steel sheet further comprises V: 0.05% or less (excluding 0%).

4. The cold-rolled steel sheet of claim 1, wherein the cold-rolled steel sheet has a tensile strength of 1180 to 1350 MPa, a yield strength of 740 to 980 MPa, an elongation of 8% or more, hole expandability of 20% or more, and an AE value of 0 kA or more,

where the AE value refers to a difference obtained by subtracting a minimum current value at which expulsion occurs from a minimum current value at which LME occurs.

5. The cold-rolled steel sheet of claim 1, wherein the cold-rolled steel sheet has a hot-dip galvanized layer or alloyed hot-dip galvanized layer formed on at least one surface of the cold-rolled steel sheet.

6. A method for manufacturing a cold-rolled steel sheet, comprising:

heating a slab including by weight: C: 0.14 to 0.16%, Si: 0.3 to 0.6%, Al: 0.01 to 0.3%, Mn: 2.6 to 3.0%, Cr: 0.01

to 0.25%, Mo: 0.15 to 0.4%, B: 0.0001 to 0.005%, Nb: 0.001 to 0.05%, Ti: 0.001 to 0.05%, P: 0.04% or less (excluding 0%), S: 0.01% or less (excluding 0%), N: 0.01% or less (excluding 0%), with a remainder of Fe and other unavoidable impurities, wherein the following Relational Expressions 1 and 2 are satisfied;
 finish hot rolling the heated slab at a temperature within a range of 830 to 980°C to obtain a hot-rolled steel sheet;
 coiling the hot-rolled steel sheet at a temperature within a range of 450 to 700°C;
 cold rolling the coiled hot-rolled steel sheet to obtain a cold-rolled steel sheet;
 continuously annealing the cold-rolled steel sheet at a temperature within a range of 800 to 840°C;
 primarily cooling the continuously annealed steel sheet at an average cooling rate of less than 10°C/s to a primary cooling end temperature of 550 to 650°C;
 secondarily cooling the primarily cooled steel sheet at an average cooling rate of 10°C/s or more to a secondary cooling end temperature of 320 to 360°C; and
 reheating the secondarily cooled steel sheet to a temperature within a range of 380 to 480°C,

$$234 \times [\text{C}] - 29 \times [\text{Si}] - 128 \times [\text{Al}] + 29 \times [\text{Mn}] + 10 \times [\text{Cr}] - 17 [\text{Mo}] - 37 \times [\text{Nb}] - 49 \times [\text{Ti}] + 100 [\text{B}] \geq 80$$

$$5 \times [\text{C}] + [\text{Si}] + 0.5 \times [\text{Al}] \leq 1.5$$

[Relational Expression 2]

where a content of each element in the above Relational Expressions 1 and 2 refers to % by weight.

7. The method for manufacturing a cold-rolled steel sheet of claim 6, wherein the slab further comprises one or two of Cu: 0.1% or less (excluding 0%) and Ni: 0.1% or less (excluding 0%).
8. The method for manufacturing a cold-rolled steel sheet of claim 6, wherein the slab further comprises V: 0.05% or less (excluding 0%).
9. The method for manufacturing a cold-rolled steel sheet of claim 6, wherein when the slab is heated, a heating temperature is 1150 to 1250°C.
10. The method for manufacturing a cold-rolled steel sheet of claim 6, wherein after the finish hot rolling is performed, cooling is performed at an average cooling rate of 10 to 100°C/s to a coiling temperature.
11. The method for manufacturing a cold-rolled steel sheet of claim 6, wherein during the cold rolling, a cold rolling reduction rate is 30 to 60%.
12. The method for manufacturing a cold-rolled steel sheet of claim 6, wherein during the continuous annealing, an atmosphere in a continuous annealing furnace is controlled with a gas consisting of by volume, 95% or more of nitrogen and a remainder of hydrogen.
13. The method for manufacturing a cold-rolled steel sheet of claim 6, wherein during the secondary cooling, a gas consisting of by volume, 5 to 80% of hydrogen and a remainder of nitrogen is used.
14. The method for manufacturing a cold-rolled steel sheet of claim 6, wherein during the reheating, an average temperature increase rate is 0.5 to 2.5°C/s.
15. The method for manufacturing a cold-rolled steel sheet of claim 6, further comprising, after the reheating: hot-dip galvanizing the cold-rolled steel sheet in a plating bath at a temperature within a range of 450 to 470 °C.
16. The method for manufacturing a cold-rolled steel sheet of claim 15, further comprising, after the hot-dip galvanizing: performing an alloying heat treatment of the cold-rolled steel sheet at a temperature within a range of 470 to 550°C.
17. The method for manufacturing a cold-rolled steel sheet of claim 16, further comprising, after performing the alloying heat treatment:
 in which the cold-rolled steel sheet is cooled to room temperature, and then temper rolled at a reduction rate of less than 1%.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2022/019705

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/38(2006.01)i; C22C 38/06(2006.01)i; C22C 38/22(2006.01)i; C22C 38/32(2006.01)i; C22C 38/26(2006.01)i;
C22C 38/28(2006.01)i; C22C 38/00(2006.01)i; C22C 38/58(2006.01)i; C23C 2/06(2006.01)i; C21D 8/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C22C 38/38(2006.01); B32B 15/01(2006.01); C21D 6/00(2006.01); C21D 8/02(2006.01); C21D 9/46(2006.01);
C22C 38/00(2006.01); C22C 38/58(2006.01); C22C 38/60(2006.01)

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

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

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

eKOMPASS (KIPO internal) & keywords: 강판(steel sheet), 냉연(cold rolled), 마르텐사이트(martensite), 페라이트(ferrite),
베이나이트(bainite), 오스테나이트(austenite), 냉각(cooling), 템퍼드(tempered), 크롬(Cr), 몰리브덴(Mo), 보론(B), 니오븀
(Nb), 티타늄(Ti)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 2021-200578 A1 (JFE STEEL CORPORATION et al.) 07 October 2021 (2021-10-07) See claims 1-3 and 9.	1-17
A	JP 2017-053001 A (NIPPON STEEL & SUMITOMO METAL) 16 March 2017 (2017-03-16) See paragraphs [0057]-[0058] and claims 1-3.	1-17
A	KR 10-2016-0132926 A (KABUSHIKI KAISHA KOBE SEIKO SHO (KOBELCO STEEL, LTD.)) 21 November 2016 (2016-11-21) See paragraphs [0084]-[0088] and claims 1-5.	1-17

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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“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

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“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 08 March 2023	Date of mailing of the international search report 09 March 2023
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon Building 4, 189 Cheongsaro, Seo-gu, Daejeon 35208 Facsimile No. +82-42-481-8578	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2022/019705

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2021-123880 A1 (ARCELORMITTAL) 24 June 2021 (2021-06-24) See claims 1 and 10.	1-17

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2022/019705

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