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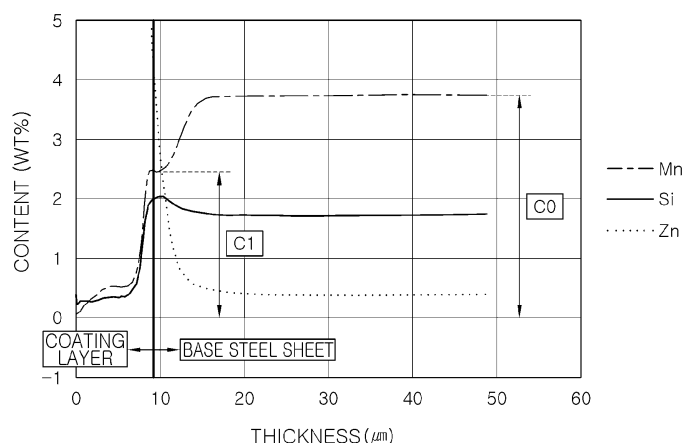
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(54) **COLD ROLLED STEEL SHEET AND METHOD OF MANUFACTURING SAME**

(57) One aspect of the present invention provides a cold rolled steel sheet and a method of manufacturing same. One preferred aspect of the present invention

provides a cold rolled steel sheet having excellent formability, strength, and LME resistance, and a method of manufacturing same.

[FIG. 1]



Description

Technical Field

5 **[0001]** The present disclosure relates to a cold rolled steel sheet and a method of manufacturing the same, and more particularly, to a cold rolled steel sheet preferably applicable to automobile collision members, structural members, etc., and a method of manufacturing the same.

Background Art

10 **[0002]** Recently, due to various environmental and energy consumption regulations, there has been increasing demand for higher-strength steel sheets for automotive applications in order to improve fuel efficiency and durability. In particular, with the recent expansion of regulations on automotive crash safety, high-strength steels having excellent yield strength are being adopted for structural members such as members, seat rails, and pillars to enhance impact resistance of a vehicle body. The structural members exhibit improved impact energy absorption capacity as the yield strength relative to the tensile strength, that is, the yield ratio (yield strength divided by tensile strength), increases. However, in general, as the strength of steel sheets increases, elongation decreases, thereby leading to deterioration in formability. Therefore, there is a need to develop materials capable of compensating for this issue.

20 **[0003]** Typically, a method of strengthening steel includes solid solution strengthening, precipitation strengthening, strengthening by grain refinement, transformation strengthening, or the like. However, among the above-described methods, solid solution strengthening and strengthening by grain refinement have a disadvantage in that it is very difficult to manufacture high-strength steel having a tensile strength of 490 MPa or more.

25 **[0004]** Meanwhile, precipitation-strengthened high-strength steel is a technology in which strength is obtained by adding carbonitride-forming elements such as Cu, Nb, Ti, and V to precipitate carbonitrides, thereby strengthening a steel sheet or refining grains through the suppression of grain growth by fine precipitates. While this technology has the advantage of readily attaining high strength at relatively low manufacturing cost, it has a drawback in that the recrystallization temperature increases significantly due to fine precipitates, and therefore high-temperature annealing should be performed to ensure sufficient recrystallization and adequate ductility. In addition, the precipitation-strengthened steels in which carbonitrides are precipitated in a ferrite matrix have a limitation in that it is difficult to obtain high-strength steels having a strength of 600 MPa or more.

30 **[0005]** Meanwhile, transformation-strengthened high-strength steels have been developed, including dual phase steel (DP steel) having a ferrite-martensite dual phase microstructure in which hard martensite is formed in a ferrite matrix, transformation induced plasticity steel (TRIP steel) utilizing the transformation-induced plasticity of retained austenite, and complex phase steel (CP steel) composed of ferrite and hard bainite or martensite phases. Furthermore, for structural members requiring collision safety, hot press forming steel, which achieves final strength through rapid cooling by direct contact with a water-cooled die after high-temperature forming, has attracted attention. However, due to excessive equipment investment costs and high heat treatment and processing costs, its application has not been significantly expanded.

40 **[0006]** In particular, although the demand for TRIP steel to replace a hot press forming steel has been gradually increasing in recent years, the application of galvanized steel sheets containing 1 wt% or more of Si is hindered due to liquid metal embrittlement (LME) occurring during spot welding.

45 **[0007]** A representative manufacturing method for ensuring LME resistance in TRIP steel involves suppressing LME by forming a softened layer by performing decarburization treatment on a surface layer of the steel sheet during annealing or galvanizing heat treatment, for example by controlling a dew point of an annealing furnace. However, when decarburization is performed during annealing or galvanizing heat treatment, a dew point transition range of the annealing furnace is essential. Accordingly, there is a drawback in that a reduction in manufacturing yield is unavoidable due to insufficient decarburization in the transition section required to secure a desired decarburization region, and the transition section involves a processing time of at least 30 minutes to several hours.

50 **[0008]** Therefore, there is a need for a technology capable of ensuring LME resistance by forming a softened layer on a surface layer without performing decarburization during annealing or galvanizing heat treatment.

Summary of Invention

Technical Problem

55 **[0009]** An aspect of the present disclosure is to provide a cold rolled steel sheet and a method of manufacturing the same.

[0010] Another aspect of the present disclosure is to provide a cold rolled steel sheet having excellent formability,

strength, and LME resistance, and a method of manufacturing the same.

Solution to Problem

- 5 **[0011]** According to an aspect of the present disclosure, a cold rolled steel sheet includes: by wt%, C: greater than 0.150% and 0.30% or less, Si: 3.0% or less (excluding 0%), Mn: 0.90 to 5.0%, Al: 3.0% or less (excluding 0%), P: 0.150% or less (excluding 0%), S: 0.030% or less (excluding 0%), and N: 0.030% or less (excluding 0%), and a balance of Fe and unavoidable impurities; and satisfying the following Relational Equations 1 to 3.

10
$$[\text{Relational Equation 1}] \quad 0.15 \leq A1 \leq 0.8$$

$$[\text{Relational Equation 2}] \quad 0.15 \leq A2 \leq 0.8$$

15
$$[\text{Relational Equation 3}] \quad 0.6 \leq B \leq 1.5$$

(However, in the above Relational Equations 1 to 3, A refers to $(C0-C1)/C0$, C0 refers to an average Mn content of the steel sheet, C1 refers to an average Mn content at a position 1 μm in a thickness direction from a surface of the steel sheet, A1 refers to an A value at an edge portion of the steel sheet in a width direction, A2 refers to the A value at a central portion of the steel sheet in a width direction, and B refers to $A1/A2$.)

- 20 **[0012]** The cold rolled steel sheet may have ferrite, fresh martensite, tempered martensite, and a microstructure including bainite and retained austenite.

[0013] The cold rolled steel sheet may have a tensile strength of 980 MPa or more.

[0014] The cold rolled steel sheet may have an elongation of 15% or more.

- 25 **[0015]** The cold rolled steel sheet may not exhibit B-type LME cracks during spot welding.

[0016] The cold rolled steel sheet may have a hot-dip galvanized layer or an alloyed hot-dip galvanized layer formed on at least one surface thereof.

- [0017]** According to another aspect of the present disclosure, a method of manufacturing a cold rolled steel sheet includes: heating a slab including, by wt%, C: greater than 0.150% and 0.30% or less, Si: 3.0% or less (excluding 0%), Mn: 0.90 to 5.0%, Al: 3.0% or less (excluding 0%), P: 0.150% or less (excluding 0%), S: 0.030% or less (excluding 0%), and N: 0.030% or less (excluding 0%), and a balance of Fe and unavoidable impurities; obtaining a hot rolled steel sheet by finish hot rolling the heated slab; coiling the hot rolled steel sheet at 500 to 680°C to obtain a coiled coil; heat-treating the coiled coil at 500 to 750°C for 5 to 48 hours; cooling the heat-treated coiled coil at a cooling rate of 0.005°C/s or more; and cold-rolling the cooled coiled coil to obtain a cold rolled steel sheet.

- 35 **[0018]** The heating of the slab may be performed at 1000 to 1350°C.

[0019] The heating of the slab may be performed for 60 to 1000 minutes.

[0020] The finish hot rolling may be performed at 800 to 1000°C.

[0021] The method may further include: after the cold rolling, performing continuous annealing at 730 to 900°C.

- 40 **[0022]** The method may further include: after the continuous annealing, obtaining a hot-dip galvanized steel sheet by hot-dip galvanizing the continuously annealed cold rolled steel sheet at 450 to 490°C.

[0023] The method may further include: after the hot-dip galvanizing, temper rolling the hot-dip galvanized steel sheet with a reduction ratio of 0.01 to 0.5%.

[0024] The method may further include: after the hot-dip galvanizing, obtaining an alloyed hot-dip galvanized steel sheet by alloying heat-treating the hot-dip galvanized steel sheet at 450 to 580°C.

- 45 **[0025]** The method may further include: after the alloying heat-treating, temper rolling the alloyed hot-dip galvanized steel sheet with a reduction ratio of 0.01 to 0.5%.

Advantageous Effects of Invention

- 50 **[0026]** According to an aspect of the present disclosure, it is possible to provide a cold rolled steel sheet and a method of manufacturing the same.

[0027] According to another aspect of the present disclosure, it is possible to provide a cold rolled steel sheet having excellent formability, strength, and LME resistance, and a method of manufacturing the same.

55 Brief Description of Drawings

[0028] FIG. 1 is an example of a graph measured using a glow discharge spectrometer (GDS) analysis method.

Best Mode for Invention

[0029] Hereinafter, a cold rolled steel sheet according to an example embodiment of the present disclosure will be described. First, the alloy composition will be described. The alloy composition described below refers to wt% unless otherwise specified.

C: greater than 0.150% and 0.30% or less

[0030] C is an element that is advantageous for securing strength and stabilizing retained austenite, thereby increasing the ductility of the steel sheet. When the C content is 0.150% or less, it may be difficult to secure the desired tensile strength. When the C content exceeds 0.30%, cold rolling may be difficult during the manufacture of the steel sheet. Therefore, the C content is preferably greater than 0.150% and 0.30% or less. The lower limit of the C content is more preferably 0.160%, and even more preferably 0.170%. The upper limit of the C content is more preferably 0.280%, still more preferably 0.270%, and even more preferably 0.250%.

Si: 3.0% or less (excluding 0%)

[0031] Si is an element that has a strength-enhancing effect through solid solution strengthening, and plays a role in strengthening ferrite, thereby homogenizing the microstructure and improving workability. In addition, Si may contribute to the formation of retained austenite by suppressing the precipitation of cementite. When the Si content exceeds 3.0%, coating defects such as incomplete coating may occur during the coating process when manufacturing steel sheets, or the weldability of the steel sheet may be reduced. Therefore, the Si content is preferably 3.0% or less (excluding 0%). The Si content is more preferably 2.70% or less, and even more preferably 2.30% or less. Meanwhile, in the present disclosure, the lower limit of the Si content is not specifically limited, but as an example, the lower limit of the Si content may be 0.50%. The lower limit of the Si content is more preferably 0.70%, and even more preferably 1.0%.

Mn: 0.90 to 5.0%

[0032] Mn is an element that helps improve both strength and ductility. When the Mn content is less than 0.90%, it may be difficult to sufficiently secure above-described effects. When the Mn content exceeds 5.0%, it may be difficult to sufficiently secure retained austenite because the C enrichment in the austenite is insufficient due to the increase in the bainite transformation time. Therefore, the Mn content preferably ranges from 0.90 to 5.0%. The lower limit of the Mn content is more preferably 1.0%, and even more preferably 1.50%. The upper limit of the Mn content is more preferably 4.0%, and even more preferably 3.0%.

Al: 3.0% or less (excluding 0%)

[0033] Al binds to oxygen in steel to perform deoxidation. In addition, Al helps stabilize retained austenite by suppressing cementite precipitation. When the Al content exceeds 3.0%, the workability of the steel sheet deteriorates and inclusions may increase. Therefore, the Al content is preferably 3.0% or less (excluding 0%). The Al content is more preferably 2.0% or less, and even more preferably 1.0% or less. Meanwhile, in the present disclosure, the lower limit of the Al content is not specifically limited, but as an example, the lower limit of the Al content may be 0.0150%. The lower limit of the Al content is more preferably 0.020%, and even more preferably 0.050%.

P: 0.150% or less (excluding 0%)

[0034] P is an impurity inevitably included during the manufacturing process, and when the P content exceeds 0.150%, impact toughness may be degraded. Therefore, the P content preferably has the range of 0.150% or less (excluding 0%). The P content is more preferably 0.10% or less, and even more preferably 0.080% or less. Meanwhile, in the present disclosure, the lower limit of the P content is not specifically limited, but as an example, the lower limit of the P content may be 0.00010%. The lower limit of the P content is more preferably 0.00030%, and even more preferably 0.00050%.

S: 0.030% or less (excluding 0%)

[0035] S is an impurity inevitably included during the manufacturing process, and when the S content exceeds 0.030%, MnS may be formed in the steel sheet and degrade ductility. Therefore, the S content preferably has the

range of 0.030% or less (excluding 0%). The S content is more preferably 0.010% or less, and even more preferably 0.0080% or less. Meanwhile, in the present disclosure, the lower limit of the S content is not specifically limited, but as an example, the lower limit of the S content may be 0.0010%. The lower limit of the S content is more preferably 0.0020%, and even more preferably 0.0030%.

N: 0.030% or less (excluding 0%)

[0036] N is an impurity inevitably included in the manufacturing process, and when the N content exceeds 0.030%, nitrides may be formed during continuous casting, which may cause cracking in the slab. Therefore, the N content is preferably in the range of 0.030% or less (excluding 0%). The N content is more preferably 0.010% or less, and even more preferably 0.0080% or less. Meanwhile, in the present disclosure, the lower limit of the N content is not specifically limited, but as an example, the lower limit of the N content may be 0.0010%. The lower limit of the N content is more preferably 0.0020%, and even more preferably 0.0030%.

[0037] The remaining component is iron (Fe). However, since unintended impurities from raw materials or the surrounding environment may inevitably be mixed in a normal manufacturing process, the unintended impurities may not be excluded. Since these impurities are known to those skilled in the ordinary manufacturing process, not all thereof are specifically mentioned in this specification.

[0038] It is preferable that the cold rolled steel sheet of the present disclosure satisfies the following Relational Equations 1 to 3. FIG. 1 is an example of a graph measured using a glow discharge spectrometer (GDS) analysis method. Referring to FIG. 1, in the following Relational Equations 1 to 3, A refers to $(C0-C1)/C0$, C0 refers to an average Mn content of the steel sheet, C1 refers to an average Mn content at a position 1 μm in a thickness direction from a surface of the steel sheet, A1 refers to an A value at an edge portion of the steel sheet in a width direction, A2 refers to the A value at a central portion of the steel sheet in a width direction, and B refers to $A1/A2$. Meanwhile, the edge portion may, as an example, be a position 10 mm away from an end portion of the steel sheet in the width direction.

$$[\text{Relational Equation 1}] \quad 0.15 \leq A1 \leq 0.8$$

$$[\text{Relational Equation 2}] \quad 0.15 \leq A2 \leq 0.8$$

[0039] The above Relational Equations 1 and 2 are intended to suppress LME resistance by controlling an Mn deficiency rate in a surface layer portion. When the A1 and A2 values are less than 0.15, the LME may occur during welding. When the A1 and A2 values exceed 0.8, excessive Mn deficiency may reduce the strength in the surface layer portion, thereby reducing durability such as fatigue characteristics. Therefore, the A1 and A2 values preferably range from 0.15 to 0.8. The lower limit of the A1 and A2 values is more preferably 0.16, even more 0.17, and most preferably 0.18. The upper limit of the A1 and A2 values is more preferably 0.7, even more 0.6, and most preferably 0.5.

$$[\text{Relational Equation 3}] \quad 0.6 \leq B \leq 1.5$$

[0040] When a Mn-depleted layer is extensively formed on the surface of the steel sheet prior to coating, during the alloying heat treatment for manufacturing a GA steel sheet, diffusion between the Zn coating layer and Fe is promoted, thereby increasing the degree of alloying of the coating layer and improving coating adhesion. The above Relational Equation 3 is an index representing the homogeneity of the Mn depletion rate, which is used to prevent color variation on the surface of the coating layer caused by an alloying deviation, a coating weight, or the like during the manufacturing of a GA steel sheet. When the B value is less than 0.6, the coating weight in the central portion of the steel sheet in the width direction may become excessive compared to the edge portion, or the excessive alloying may occur. When the B value exceeds 1.5, the coating weight in the edge portion of the steel sheet in the width direction may become excessive compared to the central portion, or the excessive alloying may occur. Therefore, the B value preferably ranges from 0.6 to 1.5. The lower limit of the B value is more preferably 0.65, even more 0.68, and most preferably 0.7. The upper limit of the B value is more preferably 1.4, even more 1.35, and most preferably 1.3.

[0041] The cold rolled steel sheet may have ferrite, fresh martensite, tempered martensite, and a microstructure including bainite and retained austenite. By having such a microstructure, the desired mechanical properties such as tensile strength and elongation may be easily secured.

[0042] The cold rolled steel sheet of the present disclosure provided as described above may have a tensile strength of 980 MPa or more. In addition, the elongation may be 15% or more. Furthermore, B-type LME cracks may not occur during spot welding.

[0043] Meanwhile, 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.

[0044] Hereafter, a method of manufacturing a cold rolled steel sheet according to an example embodiment of the present disclosure will be described.

[0045] First, the slab satisfying the above-described alloy composition is heated. In the present disclosure, the heating conditions for the slab are not specifically limited, and the conventional conditions used in the relevant technical field may be applied. However, as an example, the heating of the slab may be performed at 1000 to 1350°C.

[0046] Subsequently, the heated slab is finish hot-rolled to obtain a hot rolled steel sheet. In the present disclosure, the finish hot rolling conditions are not specifically limited, and the conventional conditions used in the relevant technical field may be applied. However, as an example, the finish hot rolling may be performed at 800 to 1000°C.

[0047] Generally, since the central portion of the coiled coil in the width direction remains at a high temperature for a longer period compared to the edge portion, a larger Mn-deficient layer is formed in the central portion compared to the edge portion. Meanwhile, during the heat treatment, since the heat source is supplied from the outside of the coiled coil, the edge portion of the coiled coil remains at a high temperature for a longer period compared to the central portion, so a larger Mn-deficient layer is formed in the edge portion compared to the central portion. That is, in the present disclosure, the Mn-deficient layer is uniformly formed on the surface layer portion by appropriately controlling the following coiling and heat treatment processes.

[0048] Subsequently, the hot rolled steel sheet is coiled at 500 to 680°C to obtain the coiled coil. When the coiling temperature is below 500°C, the coiling process may not be easily performed, and the Mn-deficient layer may not be sufficiently formed on the surface layer portion, or the Mn-deficient layer may be formed unevenly. When the coiling temperature exceeds 680°C, the scale generated on the surface of the hot rolled steel sheet extends to the inside of the steel sheet, which may make the pickling process difficult. Therefore, the coiling temperature preferably ranges from 500 to 680°C. The lower limit of the coiling temperature is more preferably 510°C, even more preferably 520°C, and most preferably 530°C. The upper limit of the coiling temperature is more preferably 670°C, even more preferably 660°C, and most preferably 650°C.

[0049] Subsequently, the coiled coil is heat-treated at 500 to 750°C for 5 to 48 hours. The heat treatment is intended to resolve the non-uniformity of the Mn-deficient layer of the steel sheet in the width direction and to reduce the cold rolling load. When the heat treatment temperature is less than 500°C, problems may arise in that the cold rolling load is not sufficiently reduced, the Mn-depleted layer is not sufficiently formed at the edge portion of the coiled coil in the width direction, or the Mn-depleted layer is formed unevenly. When the heat treatment temperature exceeds 750°C, the pickling process may become difficult because the scale is formed deep inside the steel sheet. Therefore, the heat treatment temperature preferably ranges from 500 to 750°C. The lower limit of the heat treatment temperature is more preferably 520°C, even more preferably 540°C, and most preferably 550°C. The upper limit of the heat treatment temperature is more preferably 720°C, even more preferably 700°C, and most preferably 680°C. When the heat treatment time is less than 5 hours, heat transfer to the central portion of the coiled coil is insufficient, which may result in insufficient reduction of the cold rolling load or insufficient formation of the Mn-deficient layer at the edge portion of the coiled coil in the width direction. When the heat treatment time exceeds 48 hours, the pickling process may become difficult because the scale is formed deep inside the steel sheet. Therefore, the heat treatment time preferably ranges from 5 to 48 hours. The lower limit of the heat treatment time is more preferably 6 hours, even more preferably 7 hours, and most preferably 8 hours. The upper limit of the heat treatment time is more preferably 40 hours, even more preferably 30 hours, and most preferably 24 hours.

[0050] Subsequently, the heat-treated coiled coil is cooled at a cooling rate of 0.005°C/s or higher. The cooling is intended to prevent the excessive formation of the Mn-deficient layer that may occur after the heat treatment of the coiled coil. When the cooling rate is less than 0.005°C/s, the Mn-deficient layer may be formed excessively or unevenly. Additionally, coarse carbides may form on the steel sheet, which may cause a problem of reduced toughness. Therefore, the cooling rate preferably has a range of 0.005°C/s or higher. The cooling rate is more preferably 0.006°C/s or higher, even more preferably 0.007°C/s or higher, and most preferably 0.008°C/s or higher. In the present disclosure, the upper limit of the cooling rate is not specifically limited, but as an example, the upper limit of the cooling rate may be 10°C/s. The upper limit of the cooling rate is more preferably 5°C/s, even more preferably 3°C/s, and most preferably 1°C/s. Various cooling methods, such as fan cooling, mist cooling, and water cooling, may be applied for the cooling. Meanwhile, the cooling rate may be measured at a midpoint between an outermost winding portion and an innermost winding portion of the edge portion of the coiled coil. Furthermore, since the present disclosure performs cooling on the coiled coil, in the case of general air cooling, the cooling rate may be less than 0.005°C/s.

[0051] Subsequently, the cooled coiled coil is cold-rolled to obtain the cold rolled steel sheet. In the present disclosure, the cold rolling conditions are not specifically limited, and the conventional conditions used in the relevant technical field may be applied.

[0052] After the cold rolling, the method may further include continuous annealing. In the present disclosure, the continuous annealing conditions are not specifically limited, and the conventional conditions used in the relevant

technical field may be applied. However, as an example, the continuous annealing may be performed at 730 to 900°C. Meanwhile, after the continuous annealing, cooling may be performed to a temperature of 250 to 500°C.

[0053] After the continuous annealing, the method may further include obtaining the hot-dip galvanized steel sheet by hot-dip galvanizing the continuously annealed cold rolled steel sheet. In the present disclosure, the hot-dip galvanizing conditions are not specifically limited, and the conventional conditions used in the relevant technical field may be applied. However, as an example, the hot-dip galvanizing may be performed at 450 to 490°C.

[0054] After the hot-dip galvanizing, the method may further include obtaining an alloyed hot-dip galvanized steel sheet by alloying heat-treating the hot-dip galvanized steel sheet. In the present disclosure, the alloying heat treatment conditions are not specifically limited, and the conventional conditions used in the relevant technical field may be applied. However, as an example, the alloying heat treatment may be performed at 450 to 580°C.

[0055] After the hot-dip galvanizing or the alloying heat treatment, the method may further include temper rolling the hot-dip galvanized steel sheet or the alloyed hot-dip galvanized steel sheet. In the present disclosure, the temper rolling conditions are not specifically limited, and the conventional conditions used in the relevant technical field may be applied. However, as an example, the temper rolling may be performed with a reduction ratio of 0.01 to 0.5%.

Mode for Invention

[0056] Hereinafter, the present disclosure will be described in more detail with reference to examples. However, the following examples are only examples for describing the present disclosure in more detail, and do not limit the scope of the present disclosure.

(Example)

[0057] A slab having an alloy composition shown in Table 1 below was heated at 1200°C for 1 hour and finish hot-rolled at 900°C to obtain a hot rolled steel sheet. Thereafter, the hot rolled steel sheet was coiled under the conditions listed in Table 2 below to obtain a coiled coil. Subsequently, the coiled coil was heat-treated and cooled under the conditions listed in Table 2 below, followed by cold rolling, thereby manufacturing the cold rolled steel sheet. In this case, during cooling, the cooling rate was determined as an average cooling rate while the steel sheet was cooled to 400°C by measuring the temperature at a position corresponding to a midpoint between an inner winding portion and an outer winding portion on a side surface of the coil. For the cold rolled steel sheets manufactured in this manner, after A1 and A2, tensile strength, elongation, LME resistance, and GA alloying deviation were measured, the results were shown in Table 3 below. Meanwhile, for Comparative Examples 1 and 3, the heat treatment of the coiled coil was not performed.

[0058] The A1 and A2 were measured using a glow discharge spectrometry (GDS) analysis method. In this case, the A refers to (C0-C1)/C0, the C0 refers to the average Mn content of the steel sheet, and the C1 refers to an average Mn content at a position 1 μm from the surface of the steel sheet in the thickness direction. In addition, A1 refers to the A value at an edge portion (a position 10 mm from the end portion) in the width direction of the steel sheet, and A2 refers to an A value at a center portion of the steel sheet in a width direction. Further, B shown in Table 3 below refers to A1/A2.

[0059] Tensile strength and elongation were measured by taking JIS No. 5 tensile specimens from the cold rolled steel sheet and performing a tensile test thereon.

[0060] The LME resistance was evaluated by spot-welding the cold rolled steel sheet in accordance with SEP 1220-2 and determining whether B-type LME cracks occurred. In this case, the occurrence of the B-type LME cracks was evaluated at the edge portion and center portion of the steel sheet in the width direction. The edge portion was a point located 10 mm away from an end portion of the steel sheet, and the central portion was a 1/2 point of the steel sheet.

[0061] The GA alloying deviation was determined by continuously annealing and cooling the cold rolled steel sheet under the conditions listed in Table 2 below, hot-dip galvanizing the cold rolled steel sheet at 460°C, temper rolling the galvanized cold rolled steel sheet at a reduction ratio of 0.2%, and alloying heat-treating the steel sheet at 520°C to manufacture an alloyed hot-dip galvanized steel sheet. Thereafter, the alloying degree (Fe content, wt%) of the coating layer of the alloyed hot-dip galvanized steel sheet was measured by XRF analysis, and then the deviation between the center portion and the edge portion was calculated. In this case, the alloying deviation was evaluated as good when it was 3 or less, and as poor when it exceeded 3.

EP 4 826 055 A1

[Table 1]

Steel grade No.	Alloy Composition (wt%)							
	C	Si	Mn	B	Al	P	S	N
1	0.20	1.45	2.25	0.0014	0.021	0.009	0.003	0.00
2	0.17	1.71	2.54	0.0024	0.031	0.011	0.004	0.005
3	0.25	1.30	1.81	0.0018	0.300	0.011	0.004	0.005
4	0.21	1.55	1.92	0.0022	0.020	0.011	0.003	0.005
5	0.18	1.50	2.60	0.0017	0.025	0.012	0.003	0.005
6	0.21	1.55	1.92	0.0022	0.020	0.011	0.003	0.005
7	0.18	1.50	2.60	0.0017	0.025	0.012	0.003	0.005
8	0.17	1.71	2.54	0.0024	0.031	0.011	0.004	0.005

[Table 2]

Division	Steel grade No.	Coiling Temperature (°C)	Heat Treatment Temperature (°C)	Heat Treatment Time (Time)	Cooling Rate (°C/s)	Continuous Annealing Temperature (°C)	Cooling End Temperature (°C)
Inventive Example 1	1	575	640	9	0.012	811	421
Inventive Example 2	2	635	530	15	0.018	872	409
Inventive Example 3	3	600	580	11	0.008	835	448
Comparative Example 1	4	520	-	-	0.005	825	410
Comparative Example 2	5	490	450	12	0.011	821	403
Comparative Example 3	6	665	-	-	0.005	825	410
Comparative Example 4	7	452	510	8	0.01	820	401
Comparative Example 5	7	680	420	10	0.003	818	405
Comparative Example 6	8	480	700	12	0.011	835	413
Comparative Example 7	8	635	530	10	0.002	863	411

[Table 3]

Division	A1	A2	B	Tensile Strength (MPa)	Elongation (%)	Occurrence of LME Crack at Edge Portion	Occurrence of LME Crack at Central Portion	GA Alloying Deviation
Inventive Example 1	0.364	0.245	1.5	1021	23	No Occurrence	No Occurrence	Good

(continued)

5	Division	A1	A2	B	Tensile Strength (MPa)	Elongation (%)	Occurrence of LME Crack at Edge Portion	Occurrence of LME Crack at Central Portion	GA Alloying Deviation
	Inventive Example 2	0.196	0.301	0.7	1290	16	No Occurrence	No Occurrence	Good
10	Inventive Example 3	0.287	0.266	1.1	991	27	No Occurrence	No Occurrence	Good
	Comparative Example 1	0.035	0.056	0.6	1001	25	Occurrence	Occurrence	Good
15	Comparative Example 2	0.091	0.014	6.5	1152	18	Occurrence	Occurrence	Poor
	Comparative Example 3	0.042	0.287	0.1	1020	24	Occurrence	No Occurrence	Poor
20	Comparative Example 4	0.154	0.028	5.5	1131	19	No Occurrence	Occurrence	Poor
	Comparative Example 5	0.175	0.448	0.4	1102	20	No Occurrence	No Occurrence	Poor
25	Comparative Example 6	0.406	0.168	2.4	1267	15	No Occurrence	No Occurrence	Poor
	Comparative Example 7	0.187	0.351	0.5	1286	15	No Occurrence	No Occurrence	Poor

30 **[0062]** As can be seen from Tables 1 to 3, in the case of Inventive Examples 1 to 3 satisfying the conditions proposed by the present disclosure, it can be confirmed that not only good formability and strength but also excellent LME resistance and favorable GA alloying deviation are obtained.

35 **[0063]** On the other hand, in the case of Comparative Examples 1 to 7 not satisfying the conditions proposed by the present disclosure, it can be confirmed that the formability and strength are excellent, but the LME resistance or GA alloying deviation is poor.

Claims

40 **1.** A cold rolled steel sheet, comprising:

by wt%, C: greater than 0.150% and 0.30% or less, Si: 3.0% or less (excluding 0%), Mn: 0.90 to 5.0%, Al: 3.0% or less (excluding 0%), P: 0.150% or less (excluding 0%), S: 0.030% or less (excluding 0%), and N: 0.030% or less (excluding 0%), and a balance of Fe and unavoidable impurities, and
45 satisfying the following Relational Equations 1 to 3.

$$[\text{Relational Equation 1}] \quad 0.15 \leq A1 \leq 0.8$$

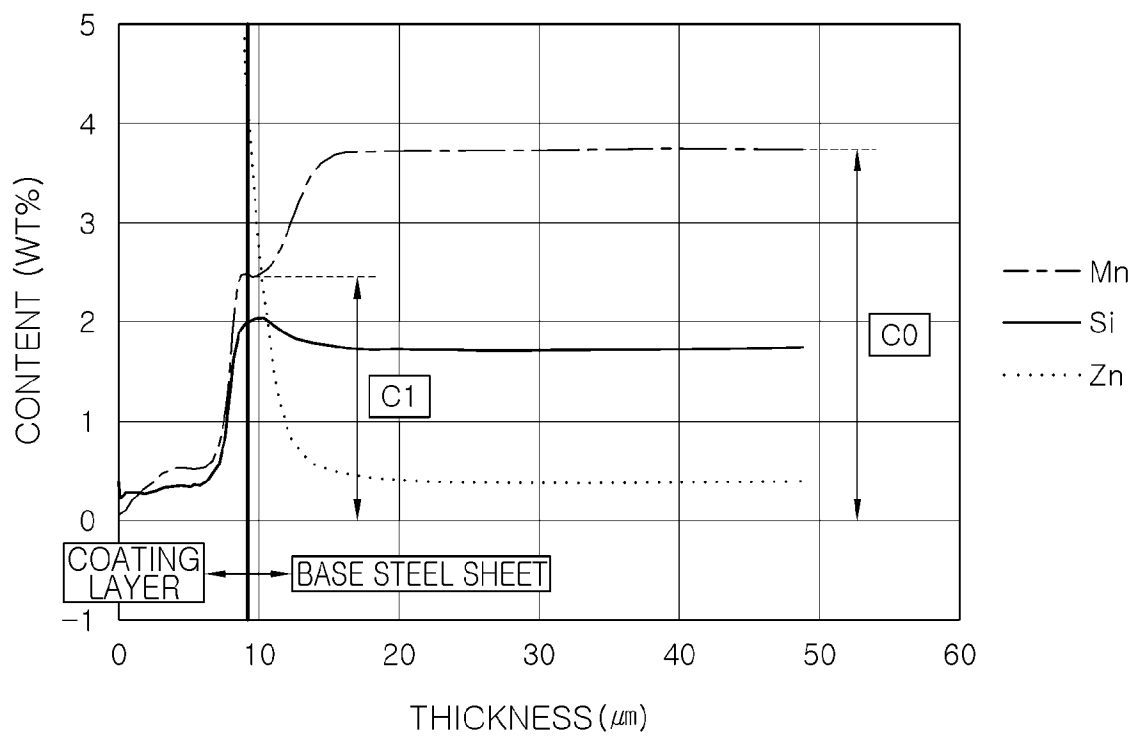
50 $[\text{Relational Equation 2}] \quad 0.15 \leq A2 \leq 0.8$

$$[\text{Relational Equation 3}] \quad 0.6 \leq B \leq 1.5$$

55 (However, in the above Relational Equations 1 to 3, A refers to $(C0-C1)/C0$, C0 refers to an average Mn content of the steel sheet, C1 refers to an average Mn content at a position 1 μm in a thickness direction from a surface of the steel sheet, A1 refers to an A value at an edge portion of the steel sheet in a width direction, A2 refers to the A value at a central portion of the steel sheet in a width direction, and B refers to $A1/A2$.)

2. The cold rolled steel sheet of claim 1, wherein the cold rolled steel sheet has ferrite, fresh martensite, tempered martensite, and a microstructure including bainite and retained austenite.
3. The cold rolled steel sheet of claim 1, wherein the cold rolled steel sheet has a tensile strength of 980 MPa or more.
4. The cold rolled steel sheet of claim 1, wherein the cold rolled steel sheet has an elongation of 15% or more.
5. The cold rolled steel sheet of claim 1, wherein the cold rolled steel sheet does not exhibit B-type LME cracks during spot welding.
6. The cold rolled steel sheet of claim 1, wherein the cold rolled steel sheet has a hot-dip galvanized layer or an alloyed hot-dip galvanized layer formed on at least one surface thereof.
7. A method of manufacturing a cold rolled steel sheet, comprising:
heating a slab including, by wt%, C: greater than 0.150% and 0.30% or less, Si: 3.0% or less (excluding 0%), Mn: 0.90 to 5.0%, Al: 3.0% or less (excluding 0%), P: 0.150% or less (excluding 0%), S: 0.030% or less (excluding 0%), and N: 0.030% or less (excluding 0%), and a balance of Fe and unavoidable impurities;
obtaining a hot rolled steel sheet by finish hot rolling the heated slab;
coiling the hot rolled steel sheet at 500 to 680°C to obtain a coiled coil;
heat-treating the coiled coil at 500 to 750°C for 5 to 48 hours;
cooling the heat-treated coiled coil at a cooling rate of 0.005°C/s or more; and
cold-rolling the cooled coiled coil to obtain a cold rolled steel sheet.
8. The method of claim 7, wherein the heating of the slab is performed at 1000 to 1350°C.
9. The method of claim 7, wherein the heating of the slab is performed for 60 to 1000 minutes.
10. The method of claim 7, wherein the finish hot rolling is performed at 800 to 1000°C.
11. The method of claim 7, further comprising:
after the cold rolling, performing continuous annealing at 730 to 900°C.
12. The method of claim 11, further comprising:
after the continuous annealing, obtaining a hot-dip galvanized steel sheet by hot-dip galvanizing the continuously annealed cold rolled steel sheet at 450 to 490°C.
13. The method of claim 12, further comprising:
after the hot-dip galvanizing, temper rolling the hot-dip galvanized steel sheet with a reduction ratio of 0.01 to 0.5%.
14. The method of claim 12, further comprising:
after the hot-dip galvanizing, obtaining an alloyed hot-dip galvanized steel sheet by alloying heat-treating the hot-dip galvanized steel sheet at 450 to 580°C.
15. The method of claim 14, further comprising:
after the alloying heat-treating, temper rolling the alloyed hot-dip galvanized steel sheet with a reduction ratio of 0.01 to 0.5%.

[FIG. 1]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2024/019578

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/04(2006.01)i; C22C 38/02(2006.01)i; C22C 38/06(2006.01)i; C22C 38/00(2006.01)i; C21D 8/02(2006.01)i;
C21D 9/46(2006.01)i; C23C 2/28(2006.01)i; C23C 2/06(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 38/04(2006.01); B21B 1/24(2006.01); C21D 8/02(2006.01); C21D 9/46(2006.01); C22C 38/00(2006.01);
C22C 38/06(2006.01); C22C 38/38(2006.01); C22C 38/54(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: 냉연강판(Cold Rolled Steel, CRS), 권취코일(Coiled Sheet), 권취온도
(Coiling Temperature), 냉각속도(Cooling Rate), LME(Liquid Metal Embrittlement), Mn결핍층(Manganese Depleted
Layer), 용융아연도금층(Hot-Dip Galvanized Layer, HDG)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2022-0086233 A (POSCO) 23 June 2022 (2022-06-23) See paragraphs [0094] and [0168]-[0175] and claims 1, 5-7 and 9.	1-15
Y	JP 2015-117406 A (NIPPON STEEL & SUMITOMO METAL) 25 June 2015 (2015-06-25) See claims 4-6.	1-15
Y	KR 10-2022-0081529 A (POSCO) 16 June 2022 (2022-06-16) See claim 6.	13
A	KR 10-1808430 B1 (HYUNDAI STEEL COMPANY) 13 December 2017 (2017-12-13) See paragraphs [0109]-[0122] and claim 1.	1-15
A	KR 10-2019-0133739 A (NIPPON STEEL CORPORATION) 03 December 2019 (2019-12-03) See paragraphs [0162]-[0194] and claim 1.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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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

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

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PCT/KR2024/019578

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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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2024/019578

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