



(11)

EP 4 826 044 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
21.10.2026 Bulletin 2026/43

(21) Application number: **24903120.4**

(22) Date of filing: **30.12.2024**

(51) International Patent Classification (IPC):
C22C 38/04 ^(2006.01) **C22C 38/02** ^(2006.01)
C22C 38/06 ^(2006.01) **C22C 38/00** ^(2006.01)
C21D 8/02 ^(2026.01) **C21D 9/46** ^(2006.01)
C23G 1/08 ^(2006.01) **C23C 2/08** ^(2006.01)

(52) Cooperative Patent Classification (CPC):
C21D 8/02; C21D 9/46; C22C 38/00; C22C 38/02;
C22C 38/04; C22C 38/06; C23C 2/08; C23G 1/08

(86) International application number:
PCT/IB2024/063303

(87) International publication number:
WO 2025/126188 (19.06.2025 Gazette 2025/25)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **15.12.2023 KR 20230182697**

(71) Applicant: **POSCO Co., Ltd**
Gyeongsangbuk-do 37859 (KR)

(72) Inventors:
• **KIM, Jae Hyung**
Pohang-si, Gyeongsangbuk-do 37859 (KR)
• **HONG, Youngkwang**
Pohang-si, Gyeongsangbuk-do 37859 (KR)

(74) Representative: **Meissner Bolte Partnerschaft**
mbB
Patentanwälte Rechtsanwälte
Postfach 86 06 24
81633 München (DE)

Remarks:

The filing date of the international application is within two months from the date of expiration of the priority period (R. 26bis.3 PCT)

(54) **COLD-ROLLED STEEL SHEET FOR CANS AND MANUFACTURING METHOD THEREFOR**

(57) A cold-rolled steel sheet for cans according to an embodiment of the present invention comprises, by weight%, carbon (C): 0.0005 to 0.004%, manganese (Mn): 0.4 to 0.8%, silicon (Si): 0.05% or less, phosphorus (P): 0.030% or less, sulfur (S): 0.030% or less, aluminum (Al): 0.01 to 0.07%, nitrogen (N): 0.0005 to

0.004%, and the balance of iron (Fe) and other inevitable impurities; and comprises 95% or more of deformed ferrite by area %, wherein a ratio of an average grain diameter in a rolling direction to an average grain diameter in a thickness direction of the deformed ferrite is 1.1 or more and less than 1.5.

EP 4 826 044 A1

Description**[Technical Field]**

5 **[0001]** An embodiment of the present invention relates to a cold-rolled steel sheet for cans and a method for manufacturing the same. Specifically, an embodiment of the present invention relates to a cold-rolled steel sheet for a safety dome of a portable butane gas can and a method for manufacturing the same.

[Background Art]

10 **[0002]** Black plate, which is a steel material used for cans, generally has a thin material thickness, and thus the material is classified by a temper grade expressed as HR30T, which is a Rockwell superficial hardness scale. In order to manufacture a can for storing contents using black plate, tin or the like is plated on the surface of the black plate to impart corrosion resistance, and after cutting the plate to a predetermined size, it is processed into a circular or
15 rectangular shape. Methods for processing the container are divided into a method of processing without welding, such as a 2-piece can in which the container consists of two parts, a lid and a body, and a method of fastening the body by welding or bonding, such as a 3-piece can in which the can consists of three parts: a body, a top lid, and a bottom lid.

20 **[0003]** Among black plates (SR-BP, single reduced black plates) manufactured by a single reduction process, the main use of soft black plates with a temper grade of T3 or less is for parts where workability is required, whereas hard black plates with temper grades of T4 to T6 are widely used for parts where a property that may withstand internal pressure caused by contents is required rather than workability, such as can bodies and lids.

25 **[0004]** A secondary rolled steel sheet refers to a steel sheet in which the strength of the material is increased by applying a relatively high reduction ratio in a temper rolling process to a material that has undergone hot rolling, primary cold rolling, and annealing. A secondary rolled tin-plated substrate (DR-BP, double reduced black plate), which is a representative application for secondary rolling materials, is classified into grades according to the strength and hardness of the material, and in the case of most materials for secondary rolling, there is a problem that the strength increases due to work hardening, but ductility rapidly decreases as a consequence thereof.

30 **[0005]** In particular, in the case where continuous annealing is performed using low-carbon steel as a black plate for secondary rolling, an aging phenomenon occurs due to elements dissolved in the steel during a tin-melting step for alloying a tin layer in a tin plating process or a baking step for drying organic substances such as lacquer in a can manufacturing process. Due to this, when processing a can, there is not only a problem of causing processing defects such as fluting, which involves bending into an angular shape, or stretcher strain that causes stripe-shaped defects on the surface of the steel sheet, but also strain aging occurs after secondary rolling, acting as a factor that further
35 reduces the ductility of the material.

[0006] To suppress such strain aging, a method using a batch annealed material has been proposed; however, even in the case of the batch-annealed material, there are fundamental problems such as decreased productivity due to the long time required for annealing, non-uniform material properties, and deteriorated workability caused by frequent surface defects of the secondary rolled steel sheet.

40 **[0007]** In order to solve such problems, measures to manufacture a secondary-rolled tin-plated substrate through a continuous annealing method, which features low production costs, uniform material properties, and excellent flatness and surface characteristics, have recently been actively considered.

45 **[0008]** In addition, since the secondary rolling method for securing material properties through work hardening involves manufacturing a steel sheet through processes such as hot rolling, primary cold rolling, annealing, temper rolling, and secondary cold rolling after tapping steel, additional processes are required compared to a conventional process in which a product is manufactured through annealing and temper rolling, thereby leading to increased manufacturing costs, and thus countermeasures for this are also being actively considered.

[Disclosure]**[Technical Problem]**

50 **[0009]** An embodiment of the present invention provides a cold-rolled steel sheet for cans and a method for manufacturing the same. Specifically, an embodiment of the present invention provides a cold-rolled steel sheet for a safety dome of a portable butane gas can and a method for manufacturing the same.
55

[Technical Solution]

[0010] A cold-rolled steel sheet for cans according to an embodiment of the present invention comprises, by weight%, carbon (C): 0.0005 to 0.004%, manganese (Mn): 0.4 to 0.8%, silicon (Si): 0.05% or less, phosphorus (P): 0.030% or less, sulfur (S): 0.030% or less, aluminum (Al): 0.01 to 0.07%, nitrogen (N): 0.0005 to 0.004%, and the balance of iron (Fe) and other inevitable impurities; and comprises 95% or more of deformed ferrite by area %, wherein a ratio of an average grain diameter in a rolling direction to an average grain diameter in a thickness direction of the deformed ferrite is 1.1 or more and less than 1.5.

[0011] The dislocation density of the deformed ferrite is from $1 \times 10^{15}/\text{m}^2$ to $5 \times 10^{15}/\text{m}^2$.

[0012] A cold-rolled steel sheet for cans according to an embodiment of the present invention has a tensile strength of 300 to 450 MPa, an elongation of 20% or more, and a yield ratio of 0.85 or more and 1 or less.

[0013] The cold rolled steel sheet for cans according to an embodiment of the present invention may further comprise a tin plating layer located on the surface of the steel sheet.

[0014] A method for manufacturing a cold-rolled steel sheet for cans according to an embodiment of the present invention comprises: manufacturing a hot-rolled steel sheet by hot rolling a slab comprising, in weight%, carbon (C): 0.0005 to 0.004%, manganese (Mn): 0.4 to 0.8%, silicon (Si): 0.05% or less, phosphorus (P): 0.030% or less, sulfur (S): 0.030% or less, aluminum (Al): 0.01 to 0.07%, nitrogen (N): 0.0005 to 0.004%, and a balance of iron (Fe) and other inevitable impurities; a primary cold rolling step of manufacturing a cold-rolled steel sheet by primary cold rolling the hot-rolled steel sheet; an annealing step of annealing the cold-rolled steel sheet; and a secondary cold rolling step of secondary cold rolling the annealed steel sheet at a reduction ratio of 5% or more and less than 9%.

[0015] The method for manufacturing a cold-rolled steel sheet for cans according to an embodiment of the present invention may satisfy Equation 1 below.

[Equation 1]

$$[\text{FDT}] \times [\text{CT}] \times [\text{RR1}] \times [\text{AT}] / 10^{10} \geq 3.2$$

[0016] (In Equation 1, [FDT] represents the finish rolling temperature (°C) in the step of manufacturing the hot-rolled steel sheet, [CT] represents the coiling temperature (°C) in the step of manufacturing the hot-rolled steel sheet, [RR1] represents the reduction ratio (%) in the primary cold rolling step, and [AT] represents the annealing temperature (°C) in the cold-rolled sheet annealing step.)

[0017] The slab may be heated to 1100 to 1300°C before the step of manufacturing the hot-rolled steel sheet.

[0018] A step of pickling the steel sheet before the primary cold rolling step may be further included.

[0019] A step of tin plating the steel sheet after secondary cold rolling may be further included.

[Advantageous Effects]

[0020] A cold rolled steel sheet for cans according to an embodiment of the present invention exhibits excellent strength, elongation, and load value simultaneously, and thus may be used for a safety dome for portable butane gas cans.

[Mode for Invention]

[0021] Terms such as first, second and third are used to describe various parts, components, regions, layers and/or sections, but are not limited thereto. These terms are only used to distinguish one part, component, region, layer or section from another part, component, region, layer or section. Accordingly, a first part, component, region, layer or section described below may be referred to as a second part, component, region, layer or section without departing from the scope of the present invention.

[0022] The terminology used herein is for the purpose of referring to specific embodiments only and is not intended to limit the present invention. As used herein, the singular forms include the plural forms as well unless the context clearly indicates otherwise. The meaning of "comprising" as used in the specification specifies a specific characteristic, region, integer, step, operation, element and/or component, and does not exclude the presence or addition of another characteristic, region, integer, step, operation, element and/or component.

[0023] In addition, unless otherwise specified, % refers to weight percent, and 1 ppm is 0.0001 weight percent.

[0024] In an embodiment of the present invention, 'further comprising an additional element' means including the additional element by replacing the balance of iron (Fe) by an amount corresponding to the added amount of the additional element.

[0025] Unless otherwise defined, all terms including technical and scientific terms used herein have the same meaning as generally understood by a person of ordinary skill in the art to which the present invention belongs. Terms defined in commonly used dictionaries shall be further interpreted as having meanings consistent with the relevant technical literature and the present disclosure, and shall not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0026] Hereinafter, embodiments of the present invention will be described in detail so that a person of ordinary skill in the art to which the present invention pertains may easily practice the same. However, the present invention may be implemented in various different forms and should not be construed as being limited to the embodiments described herein.

[0027] In an embodiment of the present invention, high tensile strength and high yield ratio characteristics were simultaneously secured by controlling the addition amounts of C, Mn, and the like in an alloy composition, particularly in a steel composition based on ultra-low carbon steel, and by optimizing the microstructure.

[0028] Through this, ultra-thin steel sheets used for food/beverage cans, gas containers, and particularly safety domes for portable butane gas cans may be manufactured, and a process shortening effect, in which strip passability is easily secured in the process and heat treatment efficiency is excellent, may also be obtained.

[0029] A cold rolled steel sheet for cans according to an embodiment of the present invention comprises, in weight%, carbon (C): 0.0005 to 0.004%, manganese (Mn): 0.4 to 0.8%, silicon (Si): 0.05% or less, phosphorus (P): 0.030% or less, sulfur (S): 0.030% or less, aluminum (Al): 0.01 to 0.07%, nitrogen (N): 0.0005 to 0.004%, and the balance of iron (Fe) and other inevitable impurities.

[0030] Hereinafter, each component will be described in detail.

Carbon (C): 0.0005 to 0.0040 weight%

[0031] Carbon (C) is an element generally added for the strength improvement of a steel sheet, and is a representative element that may cause aging when it exists in steel as a solid-solution element. If the carbon content is too high, the material hardens, which not only lowers cold rollability but may also adversely affect ductility. On the other hand, if the carbon (C) content is too low, it may be difficult to secure hardness and strength due to coarsening of the structure, etc., and thus it may be difficult to secure target material properties. More specifically, the carbon may be included in an amount of 0.0010 to 0.0030 weight%.

Manganese (Mn): 0.40 to 0.80 weight%

[0032] Manganese (Mn) is a solid-solution strengthening element that increases the strength of steel and improves hot workability, but it is an element that may impair the ductility and workability of steel if excessive manganese-sulfide (MnS) precipitates are formed. Therefore, if Manganese (Mn) is excessively added, ductility is lowered and it may become a factor in increasing costs and causing center segregation due to the addition of a large amount of alloying elements. However, if the Manganese (Mn) content is too low, while workability is improved, it becomes a cause of red shortness and it may be difficult to secure a target temper grade. More specifically, Mn may be included in an amount of 0.45 to 0.60 weight%.

Silicon (Si): 0.050 weight% or less

[0033] Silicon (Si) combines with oxygen or the like to form an oxide layer on a surface of a steel sheet, acting as a factor that worsens tin plateability and lowers corrosion resistance, and thus the addition amount thereof may be limited. However, a case where the Si content is 0 weight% may be excluded in consideration of unavoidable inclusion in the steel. More specifically, Si may be included in an amount of 0.001 to 0.040 weight%.

Phosphorus (P): 0.0300 weight% or less

[0034] Phosphorus (P) is an element that exists as a solute element in steel and causes solid solution strengthening to improve the strength and hardness of the steel. If the P content is too high, there is a concern that center segregation may occur during casting and workability may decrease. However, 0% may be excluded in consideration of unavoidable inclusion in the steel. More specifically, P may be included in an amount of 0.0001 to 0.0100 weight%. More specifically, P may be included in an amount of 0.0005 to 0.0050 weight%.

Sulfur (S): 0.030 weight% or less

[0035] Sulfur (S) combines with Mn in steel to form non-metallic inclusions that serve as corrosion initiation points

and cause red shortness, so it is desirable to reduce the content thereof as much as possible. Also, since sulfur combines with manganese in the steel to form manganese-sulfide precipitates, if the sulfur content is too high, the size of these precipitates may coarsen, making it difficult to secure a target temper grade. However, 0% may be excluded in consideration of unavoidable inclusion in the steel. More specifically, S may be included in an amount of 0.001 to 0.025 weight%. More specifically, S may be included in an amount of 0.005 to 0.020 weight%.

Aluminum (Al): 0.010 to 0.070 weight%

[0036] Aluminum (Al) is an element added in aluminum-killed steel as a deoxidizer and for the purpose of preventing material degradation due to aging. To obtain the above-described effects, Al may be included in an appropriate amount or more. However, if Aluminum (Al) is excessively added, the deoxidation effect may be saturated, and surface inclusions such as aluminum oxide (Al_2O_3) may rapidly increase, which may deteriorate the surface characteristics of the hot-rolled material and decrease workability. More specifically, Al may be included in an amount of 0.015 to 0.050 weight%.

Nitrogen (N): 0.0005 to 0.0040 weight%

[0037] Nitrogen (N) is an element effective for strengthening a material while existing in a solid solution state within steel, and may be included in an amount of 0.0005% or more in order to secure a target temper grade. On the other hand, if the content thereof exceeds 0.004%, not only do aging properties rapidly deteriorate, but also the burden due to denitrification in a steel manufacturing stage increases, which may deteriorate steelmaking workability.

[0038] In addition to the alloy composition described above, the balance includes Fe and unavoidable impurities. However, the addition of other components is not excluded in an embodiment of the present invention. The unavoidable impurities may be unintentionally mixed in from raw materials or the surrounding environment in a conventional steel manufacturing process, and may not be excluded. The unavoidable impurities may be understood by a person skilled in the art of conventional steel manufacturing. For example, one or more selected from the group consisting of Ti: 0.01 weight% or less, Mo: 0.01 weight% or less, V: 0.01 weight% or less, Ni: 0.1 weight% or less, Cr: 0.1 weight% or less, and Cu: 0.1 weight% or less may be further included.

[0039] A cold rolled steel sheet for cans according to an embodiment of the present invention comprises 95% or more of deformed ferrite in area %.

[0040] The term 'deformed ferrite' refers to deformed ferrite. That is, the deformed ferrite of the present invention is deformed to have a dislocation density of $1 \times 10^{15}/\text{m}^2$ or more, and may be distinguished from other ferrites by the difference in dislocation density. In the present invention, the microstructure may be identified by observing with an optical or electron microscope and measuring the dislocation density by XRD.

[0041] When an area fraction of deformed ferrite with high dislocation density (Deformed ferrite) is 90% or more, a fluctuation range of material properties is small, and the strength may reach a target level. More specifically, the deformed ferrite may be included in an amount of 95% or more. More specifically, the deformed ferrite may be included in an amount of 97 to 100%.

[0042] A ratio of an average grain diameter in the rolling direction to an average grain diameter in the thickness direction (hereinafter, also referred to as an aspect ratio) of the deformed ferrite is 1.1 or more and less than 1.5. The aspect ratio may be measured through optical microscope observation for a steel sheet cross-section including the thickness direction and the rolling direction.

[0043] If the aspect ratio of the deformed ferrite is too small, there may be a problem in securing the strength level intended in the present invention, and if the aspect ratio is too large, it may cause a deviation in material properties for each direction of the product. More specifically, the aspect ratio of the deformed ferrite may be from 1.2 to 1.4.

[0044] The dislocation density of the deformed ferrite may be $1.0 \times 10^{15}/\text{m}^2$ to $5.0 \times 10^{15}/\text{m}^2$. In an embodiment of the present invention, the dislocation density may be measured through XRD.

[0045] If the dislocation density of the deformed ferrite is too low, the target level of strength may not be secured, whereas if the dislocation density of the deformed ferrite is too high, brittleness may occur and ductility and formability may be inferior. More specifically, the dislocation density of the deformed ferrite may be from $2.0 \times 10^{15}/\text{m}^2$ to $4.5 \times 10^{15}/\text{m}^2$.

[0046] A cold rolled steel sheet for cans according to an embodiment of the present invention has a tensile strength of 300 to 450 MPa, an elongation of 20% or more, and a yield ratio of 0.85 to 1.00, so that excellent strength characteristics may be secured.

[0047] A cold-rolled steel sheet for cans according to an embodiment of the present invention is a high-strength material. In applications such as internal pressure tubes or can dome parts using ultra-thin materials, the tensile strength of the steel sheet is set to 300 MPa or more so that deformation resulting from the internal pressure of the can occurs at a specific pressure or higher, and thus the lower limit of the tensile strength may be limited to 350 MPa.

On the other hand, if the tensile strength exceeds 450 MPa, it may be advantageous in terms of internal pressure characteristics of the can, but usability may decrease due to deterioration in rollability caused by the increase in strength, and the legal standards for safety dome operating pressure may not be satisfied because a very high pressure is required for dome deformation. More specifically, the tensile strength may be 375 to 425 MPa.

[0048] If the total elongation is less than 20%, the flange workability of the can may become inferior, which may cause a problem of processing cracks. More specifically, the elongation may be 23 to 35%.

[0049] Meanwhile, the yield ratio, which represents the ratio of the yield strength to the tensile strength of a material, is a factor closely related to the strength of the material and is defined as [yield strength/tensile strength]. To satisfy legal standards for the operating pressure of a safety dome, a high-strength material is required, and for this purpose, the yield ratio may be 0.85 to 1.00. More specifically, the yield ratio may be 0.87 to 0.95.

[0050] The cold-rolled steel sheet for cans according to an embodiment of the present invention may further comprise a tin plating layer located on the surface of the steel sheet. The tin plating layer is not particularly limited, and tin plating may be performed under common conditions that may be applied in the relevant technical field. Through tin plating, the steel sheet according to an embodiment of the present invention may comprise a tin plating layer on the surface.

[0051] A method for manufacturing a cold-rolled steel sheet for cans according to an embodiment of the present invention comprises: a step of manufacturing a hot-rolled steel sheet by hot rolling a slab comprising, in weight%, carbon (C): 0.0005 to 0.004%, manganese (Mn): 0.4 to 0.8%, silicon (Si): 0.05% or less, phosphorus (P): 0.030% or less, sulfur (S): 0.030% or less, aluminum (Al): 0.01 to 0.07%, nitrogen (N): 0.0005 to 0.004%, and a balance of iron (Fe) and other inevitable impurities; a primary cold rolling step of manufacturing a cold-rolled steel sheet by primary cold rolling the hot-rolled steel sheet; an annealing step of annealing the cold-rolled steel sheet; and a secondary cold rolling step of secondary cold rolling the annealed steel sheet at a reduction ratio of 5% or more and less than 9%.

[0052] Hereinafter, each step will be described in detail.

[0053] First, a hot-rolled steel sheet is manufactured by hot rolling a slab.

[0054] Since the alloy composition of the slab has been described in the section for the above-described cold-rolled steel sheet for cans, a redundant description thereof will be omitted. Since alloying elements do not substantially change during the manufacturing process of the cold-rolled steel sheet for cans, the alloy composition of the cold-rolled steel sheet for cans and the alloy composition of the slab are substantially the same.

[0055] The method may further include a step of heating a slab to 1100 to 1300°C before the step of manufacturing a hot-rolled steel sheet. Slab heating may be performed in order to smoothly perform a subsequent rolling process and to sufficiently obtain target physical properties of the steel sheet. The present invention is not particularly limited to such reheating conditions, and any common reheating conditions may be applied. More specifically, the slab may be heated to 1150 to 1250°C.

[0056] The heated slab may be hot finish rolled at a finish rolling temperature of 900 to 950°C. If the finish rolling temperature is too low, as hot rolling is finished in a low-temperature region, formation of mixed grains proceeds rapidly, which may lead to a decrease in rollability and workability. On the other hand, if the finish rolling temperature is too high, uniform hot rolling is not performed throughout the thickness, so grain refinement becomes insufficient, and a decrease in impact toughness due to grain coarsening may appear. More specifically, hot rolling may be performed at a finish rolling temperature of 905 to 935°C.

[0057] The hot-rolled steel sheet may be coiled at a coiling temperature of 550 to 700°C. The hot-rolled steel sheet may be coiled after cooling in a run-out table (ROT) step. If the coiling temperature is too low, during cooling and holding, the formation behavior of low-temperature precipitates shows a difference due to temperature non-uniformity in the width direction, causing material deviation, which may adversely affect workability. On the other hand, if the coiling temperature is too high, problems such as material softening and a decrease in corrosion resistance may occur as the structure of the final product becomes coarse. More specifically, the hot-rolled steel sheet may be coiled at a coiling temperature of 580 to 650°C.

[0058] Next, a cold-rolled steel sheet is manufactured by subjecting the hot-rolled steel sheet to primary cold rolling. In this case, the reduction ratio during the primary cold rolling may be 80 to 94%. The reduction ratio may be obtained as $\{(\text{thickness of the steel sheet before rolling}) - (\text{thickness of the steel sheet after rolling})\} / (\text{thickness of the steel sheet before rolling}) \times 100$. If the cold reduction ratio is too low, the thickness of the hot-rolled steel sheet must be decreased to manufacture a target ultra-thin material, which not only significantly degrades hot rolling workability but also makes it difficult to ensure crystal grains for securing material properties of a final product due to the low reduction ratio. On the other hand, if the cold reduction ratio is too high, the material is hardened, which may cause a problem of significantly degrading cold workability due to the load of a rolling mill. More specifically, the reduction ratio during the primary cold rolling may be 85 to 93%.

[0059] In an embodiment of the present invention, a step of pickling the steel sheet after coiling and before cold rolling may be further included. Pickling treatment conditions are not particularly limited, but the pickling may be performed under common conditions applied in the same technical field.

[0060] Next, the cold-rolled steel sheet is subjected to cold-rolled sheet annealing. In this case, the annealing temperature may be 600 to 800°C. The annealing process may lower the strength, which has been increased by the strain introduced in cold rolling, to a target strength by performing annealing. In this aspect, if the annealing temperature is too low, the strain is not sufficiently released, so that the strength is high but the workability may be significantly reduced. On the other hand, if the annealing temperature is too high, recrystallization occurs rapidly during the annealing process, such that the fraction of deformed ferrite decreases and the material is softened, and thus the target strength may not be obtained. In addition, there is a concern that equipment operation failure may occur due to material defects such as sheet breakage in a continuous facility. More specifically, the annealing temperature may be 650 to 780°C.

[0061] The method for manufacturing a cold-rolled steel sheet for cans according to an embodiment of the present invention may satisfy Equation 1 below.

[Equation 1]

$$[FDT] \times [CT] \times [RR1] \times [AT] / 10^{10} \geq 3.2$$

[0062] (In Equation 1, [FDT] represents the finish rolling temperature (°C) in the step of manufacturing the hot-rolled steel sheet, [CT] represents the coiling temperature (°C) in the step of manufacturing the hot-rolled steel sheet, [RR1] represents the reduction ratio (%) in the primary cold rolling step, and [AT] represents the annealing temperature (°C) in the cold-rolled sheet annealing step.)

[0063] Equation 1 combines temperature conditions and reduction ratio conditions in each step. In an embodiment of the present invention, desired strength and material characteristics are obtained by setting all of the finish rolling temperature, the coiling temperature, the primary cold rolling reduction ratio, and the annealing temperature relatively high. If any one of these values is low, the value of Equation 1 decreases, making it difficult to obtain the desired strength and material characteristics. More specifically, the value of the left side of Equation 1 may be 3.50 to 4.00. More specifically, the value of the left side of Equation 1 may be 3.55 to 3.80.

[0064] Next, the annealed steel sheet is subjected to secondary cold rolling at a reduction ratio of 5% or more and less than 9%. Secondary cold rolling may be performed for sheet shape control after annealing, imparting roughness, and finally, for obtaining a target material level. If the reduction ratio is too low, it may be difficult to secure a desired level of material by secondary rolling. If the reduction ratio is too high, work hardening proceeds rapidly, and thus there may be difficulty in securing target elongation and tensile strength. More specifically, the secondary cold rolling reduction ratio may be 6 to 8%.

[0065] Next, a step of tin plating the secondary cold-rolled steel sheet may be further included. In this case, the tin plating may be performed in a temperature range of 250 to 350°C, and the tin-plated steel sheet may be cooled to room temperature. Tin plating conditions are not particularly limited, and the tin plating may be performed under common conditions that may be applied in the same technical field.

[0066] Hereinafter, the present invention will be described in more detail through examples. However, these examples are only for illustrating the present invention, and the present invention is not limited thereto.

Example 1

[0067] Slabs having the compositions shown in Table 1 below were manufactured, and after heating the slabs to 1,250°C, cold-rolled steel sheets for cans having a thickness of 0.35 mm were manufactured by hot rolling, pickling, primary cold rolling, annealing, and secondary cold rolling according to the processes summarized in Table 2 below.

[0068] The microstructure of each specimen was observed using an optical microscope after nital etching, the dislocation density was measured through XRD, and the area fraction of deformed ferrite and the dislocation density of the microstructure are shown. The grain aspect ratio of the deformed ferrite represents the ratio of the average grain diameter in the rolling direction to the average grain diameter in the thickness direction, and may be measured through optical microscope observation.

[0069] Yield strength and elongation were measured through a tensile test at room temperature, and tensile specimens were manufactured by machining into standard specimens according to ASTM standards (ASTM E-8 standard). The yield strength (YS) and elongation (EI) of the tensile specimens were measured using a tensile testing machine (INSTRON, Model 6025). The yield ratio was calculated by dividing the yield strength by the tensile strength.

EP 4 826 044 A1

[Table 1]

Steel Class(wt%)	C	Mn	Si	P	S	Al	N
A	0.0020	0.55	0.025	0.0015	0.015	0.025	0.0010
B	0.0025	0.55	0.025	0.0015	0.015	0.025	0.0010
C	0.0100	0.55	0.025	0.0015	0.015	0.025	0.0015
D	0.0100	1.00	0.025	0.0015	0.015	0.025	0.0015
E	0.0100	0.25	0.025	0.0015	0.015	0.025	0.0060

[Table 2]

No.	Steel Class	Hot rolling finishing temperature (°C)	Coiling temperature (°C)	Primary cold rolling reduction ratio (%)	Annealing temperature (°C)	Value of Equation 1	Secondary cold rolling reduction ratio (%)
1	A	910	600	89	740	3.60	8
2	B	910	610	89	740	3.66	8
3	A	750	610	89	740	3.01	8
4	A	920	450	90	740	2.76	8
5	B	930	620	64	740	2.73	8
6	A	910	610	89	550	2.72	8
7	B	920	610	88	740	3.65	16
8	C	910	600	89	740	3.60	8
9	D	910	600	88	740	3.56	8
10	E	910	600	89	740	3.60	8
11	C	750	610	88	740	2.98	8
12	D	910	610	88	550	2.69	8
13	E	920	610	89	740	3.70	3

[Table 3]

No.	Deformed ferrite (area %)	Aspect ratio	Dislocation density (10 ¹⁵ /m ²)	Tensile strength (MPa)	Elongation (%)	Yield ratio	Classification
1	99	1.3	3.4	380	31	0.92	Example 1
2	99	1.4	3.3	400	25	0.91	Example 2
3	98	2.1	6.2	480	12	0.93	Comparative Example 1
4	98	1.4	6.1	475	14	0.90	Comparative Example 2
5	99	1.6	0.5	280	33	0.80	Comparative Example 3
6	98	1.4	7.5	465	13	0.92	Comparative Example 4
7	99	2.2	8.5	490	8	0.95	Comparative Example 5
8	98	1.4	6.2	460	11	0.90	Comparative Example 6
9	99	1.6	6.5	475	10	0.89	Comparative Example 7
10	97	1.5	7.2	480	9	0.89	Comparative Example 8
11	97	1.5	6.3	460	14	0.90	Comparative Example 9
12	96	2.5	7.8	500	5	0.96	Comparative Example 10

(continued)

No.	Deformed ferrite (area %)	Aspect ratio	Dislocation density ($10^{15}/\text{m}^2$)	Tensile strength (MPa)	Elongation (%)	Yield ratio	Classification
13	98	1.4	6.2	470	10	0.90	Comparative Example 11

[0070] As shown in Tables 1 to 3, it may be confirmed that Inventive Examples 1 and 2 satisfy both the steel composition and the manufacturing conditions, the aspect ratio of deformed ferrite is appropriately formed, and the tensile strength, elongation, and yield ratio are all excellent, thereby satisfying the requirements for a safety dome.

[0071] On the other hand, if the steel composition is not satisfied or the manufacturing conditions are not met, it may be confirmed that deformed ferrite is not appropriately formed, or dislocation density is not appropriately formed, and tensile strength, elongation, or yield ratio is partially inferior, thereby failing to satisfy the requirements for a safety dome.

[0072] The present invention is not limited to the embodiments but may be embodied in various different forms, and it will be understood by a person of ordinary skill in the art to which the present invention pertains that the present invention may be implemented in other specific forms without departing from the technical spirit or essential characteristics of the present invention. Therefore, it should be understood that the embodiments described above are illustrative in all respects and not restrictive.

Claims

1. A cold-rolled steel sheet for cans comprising, by weight%, carbon (C): 0.0005 to 0.004%, manganese (Mn): 0.4 to 0.8%, silicon (Si): 0.05% or less, phosphorus (P): 0.030% or less, sulfur (S): 0.030% or less, aluminum (Al): 0.01 to 0.07%, nitrogen (N): 0.0005 to 0.004%, and the balance of iron (Fe) and other inevitable impurities, and

comprising 95% or more of deformed ferrite in area %,

wherein a ratio of an average grain diameter in the rolling direction to an average grain diameter in the thickness direction of the deformed ferrite is 1.1 or more and less than 1.5.

2. The cold-rolled steel sheet for cans of claim 1, wherein dislocation density of the deformed ferrite is from $1 \times 10^{15}/\text{m}^2$ to $5 \times 10^{15}/\text{m}^2$.

3. The cold-rolled steel sheet for cans of claim 1, wherein the cold-rolled steel sheet for cans has a tensile strength of 300 to 450 MPa, an elongation of 20% or more, and a yield ratio of 0.85 or more and 1 or less.

4. The cold-rolled steel sheet for cans of claim 1, further comprising a tin plating layer positioned on a surface of the steel sheet.

5. A method for manufacturing a cold-rolled steel sheet for cans comprising:

manufacturing a hot-rolled steel sheet by hot rolling a slab comprising, in weight%, carbon (C): 0.0005 to 0.004%, manganese (Mn): 0.4 to 0.8%, silicon (Si): 0.05% or less, phosphorus (P): 0.030% or less, sulfur (S): 0.030% or less, aluminum (Al): 0.01 to 0.07%, nitrogen (N): 0.0005 to 0.004%, and a balance of iron (Fe) and other inevitable impurities;

a primary cold rolling step of manufacturing a cold-rolled steel sheet by primary cold rolling the hot-rolled steel sheet;

an annealing step of annealing the cold-rolled steel sheet; and

a secondary cold rolling step of secondary cold rolling the annealed steel sheet at a reduction ratio of 5% or more and less than 9%, and

satisfying the following Equation 1 below.

[Equation 1]

$$[\text{FDT}] \times [\text{CT}] \times [\text{RR1}] \times [\text{AT}] / 10^{10} \geq 3.2$$

(In Equation 1, [FDT] represents the finish rolling temperature (°C) in the step of manufacturing the hot-rolled steel sheet, [CT] represents the coiling temperature (°C) in the step of manufacturing the hot-rolled steel sheet, [RR1] represents the reduction ratio (%) in the primary cold rolling step, and [AT] represents the annealing temperature (°C) in the cold-rolled sheet annealing step).

6. The method for manufacturing a cold-rolled steel sheet for cans of Claim 5, further comprising a step of heating the slab to 1100 to 1300°C before the step of manufacturing the hot-rolled steel sheet.
7. The method for manufacturing a cold-rolled steel sheet for cans of Claim 5, further comprising a step of pickling the steel sheet before the primary cold rolling step.
8. The method for manufacturing a cold-rolled steel sheet for cans of Claim 5, further comprising a step of tin-plating the steel sheet after the secondary cold rolling step.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2024/063303

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; C23G 1/08(2006.01)i; C23C 2/08(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 3/00(2006.01); C21D 8/04(2006.01); C21D 9/46(2006.01); C22C 38/00(2006.01);
C22C 38/06(2006.01); C22C 38/14(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 sheet), 페라이트(ferrite), 열간압연(hot rolled), 냉간압연(cold rolled), 소둔(anneal)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 6057023 B2 (NIPPON STEEL & SUMITOMO METAL) 11 January 2017 (2017-01-11) See paragraph [0047], claims 1, 5 and 7, and table 2.	1-8
Y	KR 10-2016-0052867 A (POSCO) 13 May 2016 (2016-05-13) See claims 5-10.	1-8
A	US 2016-0362761 A1 (JFE STEEL CORPORATION) 15 December 2016 (2016-12-15) See claims 1-3.	1-8
A	JP 05-059489 A (SUMITOMO METAL IND. LTD.) 09 March 1993 (1993-03-09) See claims 1-6.	1-8
A	JP 10-237592 A (KAWASAKI STEEL CORP.) 08 September 1998 (1998-09-08) See claims 1 and 3.	1-8

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

☒ See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“D” document cited by the applicant in the international application

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

14 April 2025

Date of mailing of the international search report

14 April 2025

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon Building 4, 189 Cheongsaro, Seo-gu, Daejeon 35208

Facsimile No. +82-42-481-8578

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/IB2024/063303

5

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 6057023 B2	11 January 2017	JP WO2016-104773 A1	27 April 2017
		TW 201631177 A	01 September 2016
		WO 2016-104773 A1	30 June 2016
KR 10-2016-0052867 A	13 May 2016	None	
US 2016-0362761 A1	15 December 2016	BR 112016019612 A2	23 October 2018
		CN 106029926 A	12 October 2016
		CN 106029926 B	02 October 2018
		JP 6195012 B2	13 September 2017
		JP WO2015-129191 A1	30 March 2017
		KR 10-1871735 B1	27 June 2018
		KR 10-2016-0126014 A	01 November 2016
		MY 174492 A	23 April 2020
		TW 201536930 A	01 October 2015
		TW I541363 B	11 July 2016
		WO 2015-129191 A1	03 September 2015
JP 05-059489 A	09 March 1993	JP 2661409 B2	08 October 1997
JP 10-237592 A	08 September 1998	JP 3845934 B2	15 November 2006

Form PCT/ISA/210 (patent family annex) (July 2022)