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(54) **COLD-ROLLED STEEL SHEET FOR CAN AND METHOD FOR MANUFACTURING SAME**

(57) 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): 0.2 to 0.6%, 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%, the remainder being iron (Fe) and other unavoidable impurities, wherein the cold-rolled steel sheet contains 95% or more of deformed ferrite in area %, and 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 1.5 to 2.0.

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Description**[Technical Field]**

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

[Background Art]

10 **[0002]** Black plate, which is a steel material used for manufacturing cans, typically has a thin thickness; therefore, the material is classified by a temper grade expressed as HR30T, which is Rockwell superficial hardness. In order to manufacture cans for storing contents using the black plate, corrosion resistance is imparted by plating tin or the like onto the surface of the black plate, and the black plate is cut to a predetermined size and then processed into a circular or rectangular shape. Methods for manufacturing a container are divided into a method for 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 for fastening the body by welding or bonding, such as a 3-piece can in which the can consists of three parts, a body, an upper lid, and a lower lid.

15 **[0003]** Among black plates (SR-BP, single reduced black plates) manufactured by a single reduction method, soft black plates of temper grade T3 or lower are mainly used for parts requiring formability, whereas hard black plates of temper grade T4 to T6 are widely used for parts where properties capable of withstanding internal pressure from contents are required rather than formability, such as bodies and lids of cans.

20 **[0004]** A double reduced steel sheet refers to a steel sheet whose strength has been increased by applying a relatively high reduction ratio in a temper rolling process to a material that has undergone hot rolling, first cold rolling, and annealing. Double reduced tin plate (DR-BP, double reduced black plate), which is a representative application of a material for secondary rolling, is classified into grades according to the strength and hardness of the material; for most materials for secondary rolling, strength increases due to work hardening, but there is a problem in that ductility rapidly decreases as a consequence.

25 **[0005]** In particular, when continuous annealing is performed using a 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 during a baking step for drying organic substances such as lacquer in a can manufacturing process. This causes a problem of inducing processing defects such as fluting, where the material is bent into a rectangular shape during the processing of a can, or stretcher strain, which causes stripe-shaped defects on the surface of the steel sheet; furthermore, strain aging occurs even after secondary rolling, which acts as a factor that further reduces the ductility of the material.

30 **[0006]** Although a method using a batch annealed material has been proposed to suppress such strain aging, even in the case of the batch-annealed material, there are fundamental problems such as reduced productivity as it takes a long time for annealing, non-uniform material properties of the product, and reduced workability due to frequent surface defects on the double reduced steel sheet.

35 **[0007]** In order to solve such problems, recently, a method of manufacturing a double reduced tin plate through a continuous annealing method, which enables low production costs, uniform material properties, and excellent flatness and surface characteristics, is being actively reviewed.

40 **[0008]** In addition, since the secondary rolling method, which secures material properties by work hardening, manufactures a steel sheet through processes including hot rolling, first cold rolling, annealing, temper rolling, and second cold rolling after tapping the steel, it has a problem in that it causes an increase in manufacturing costs due to the addition of processes compared to a conventional process in which a product is manufactured by annealing and temper rolling; therefore, countermeasures for this are also being actively reviewed.

[Disclosure]**[Technical Problem]**

45 **[0009]** In an embodiment of the present invention, a cold-rolled steel sheet for cans and a manufacturing method thereof are provided. Specifically, in an embodiment of the present invention, a cold-rolled steel sheet for safety domes of portable butane gas cans and a manufacturing method thereof are provided.

[Technical Solution]

[0010] 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): 0.2 to 0.6%, 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%, the remainder being iron (Fe) and other unavoidable impurities, wherein the cold-rolled steel sheet contains 95% or more of deformed ferrite in area %, and 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 1.5 to 2.0.

[0011] The dislocation density of the deformed ferrite is in the range of $3 \times 10^{15}/\text{m}^2$ to $6 \times 10^{15}/\text{m}^2$.

[0012] A cold-rolled steel sheet for cans according to an embodiment of the present invention has a tensile strength of 350 to 450 MPa, an elongation of 15% or more, a yield ratio of 0.7 to 1.0, and a load value of 110 to 150 MPa×mm.

[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 a 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: a step of hot rolling a slab comprising, in weight%, carbon (C): 0.0005 to 0.004%, manganese (Mn): 0.2 to 0.6%, 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%, the remainder being iron (Fe) and other unavoidable impurities, to manufacture a hot-rolled steel sheet; a first cold rolling step of cold rolling the hot-rolled steel sheet to manufacture a cold-rolled steel sheet; a step of annealing the cold-rolled steel sheet; and a secondary cold rolling step of cold rolling the annealed steel sheet at a reduction ratio of 9 to 14%.

[0015] The method for manufacturing 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 a finish rolling temperature (°C) in the step of manufacturing the hot-rolled steel sheet, [CT] represents a coiling temperature (°C) in the step of manufacturing the hot-rolled steel sheet, [RR1] represents a reduction ratio (%) in the first cold rolling step, and [AT] represents an annealing temperature (°C) in the annealing step of the cold-rolled sheet.)

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

[0018] The method may further comprise a pickling step of pickling the steel sheet before the step of first cold rolling.

[0019] The method may further comprise a step of tin plating the steel sheet after the second cold rolling.

[Advantageous Effects]

[0020] A cold-rolled steel sheet for cans according to an embodiment of the present invention has excellent strength, elongation, and load value simultaneously and 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 used only 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] Technical terms used herein are only for mentioning a particular embodiment and are not intended to limit the present invention. Singular forms used herein include plural forms as well unless the phrases clearly indicate the opposite meaning. 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, % means weight%, and 1 ppm is 0.0001 weight%.

[0024] In an embodiment of the present invention, the term 'further comprising an additional element' means that the additional element is included in an amount that replaces an equivalent amount of the balance of iron (Fe).

[0025] Unless otherwise defined, all terms, including technical and scientific terms, used herein have the same meaning as commonly understood by a person of ordinary skill in the art to which the present invention belongs.

Terms defined in commonly used dictionaries shall be interpreted as having meanings consistent with the related technical literature and the content of the present disclosure, and shall not be interpreted in an ideal or overly formal sense unless expressly 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 belongs may easily implement the same. However, the present invention may be implemented in many different forms and is not limited to the embodiments described herein.

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

[0028] Through this, an ultra thin steel sheet used for food/beverage cans, gas containers, particularly a safety dome for portable butane gas cans, and the like may be manufactured, and a process shortening effect, in which threading property is easily secured in a process and the efficiency of heat treatment is excellent, may also be obtained at the same time.

[0029] According to an embodiment of the present invention, the composition, in weight%, comprises carbon (C): 0.0005 to 0.004%, manganese (Mn): 0.2 to 0.6%, 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 remainder of iron (Fe) and other unavoidable 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 to improve the strength of a steel sheet, and it is a representative element that may cause aging when present in steel as a solid solution element. If the carbon content is too high, the material is hardened, which may not only lower cold rollability but also adversely affect ductility. On the other hand, if the carbon (C) content is too low, it may be difficult to obtain the target material properties because it is difficult to secure sufficient hardness and strength due to coarsening of the structure and the like. More specifically, the steel may contain carbon in an amount of 0.0010 to 0.0030 weight%.

Manganese (Mn): 0.20 to 0.60 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 inhibit the ductility and formability of steel if excessive manganese-sulfide (MnS) precipitates are formed. Therefore, if manganese (Mn) is added excessively, ductility is reduced, and it may be a cause of cost increase due to the addition of a large amount of alloying elements and the occurrence of center segregation. However, if the manganese (Mn) content is too low, formability is improved, but 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 0.25 to 0.55 weight%.

Silicon (Si): 0.050 weight% or less

[0033] Silicon (Si) combines with oxygen or the like to form an oxidation layer on the surface of the steel sheet, thereby acting as a factor that worsens tin platability and lowers corrosion resistance, and thus the addition amount thereof may be limited. However, 0 weight% may be excluded in consideration of unavoidable inclusion in the steel. More specifically, it 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 improves the strength and hardness of steel by causing solid solution strengthening while existing as a solid solution element in the steel. If the content is too high, center segregation may occur during casting and formability may be lowered. However, 0% may be excluded in consideration of unavoidable inclusion in the steel. More specifically, the steel may comprise P in an amount of 0.0001 to 0.0100 weight%. More specifically, the steel may comprise P 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 act as corrosion initiation points and is a cause of red shortness, so it is preferable to reduce its content as much as possible. In addition, since it combines

with manganese in steel to form manganese-sulfide-based precipitates, if the sulfur content is excessive, the size of these precipitates becomes coarse, making it difficult to secure a target temper grade. However, 0% may be excluded in consideration of unavoidable inclusion in steel. More specifically, S may be included in an amount of 0.001 to 0.025 weight%. Even 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 to aluminum-killed steel for the purpose of acting as a deoxidizer and preventing material degradation due to aging. In order to obtain the above-described effect, it may be included in an amount of an appropriate level or more. However, if aluminum (Al) is added excessively, the deoxidation effect becomes saturated and surface inclusions, such as aluminum oxide (Al_2O_3), rapidly increase, which may worsen the surface characteristics of a hot-rolled material and lower formability. 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 materials while existing in a solid solution state inside steel, and may be included in an amount of 0.0005% or more to secure a target temper grade. On the other hand, if the content exceeds 0.004%, not only does the aging property rapidly worsen, but steelmaking workability may also be deteriorated by increasing the burden associated with denitrogenation in the steel manufacturing step.

[0038] In addition to the above described alloy composition, the balance consists of Fe and inevitable impurities. However, in an embodiment of the present invention, the addition of other compositions is not excluded. The inevitable impurities may be unintentionally introduced from raw materials or the surrounding environment during a common steel manufacturing process, and cannot be excluded. The inevitable impurities may be understood by a person skilled in the art of the common steel manufacturing field. For example, the composition may further comprise one or more 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.

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

[0040] The term 'deformed ferrite' refers to ferrite that has been deformed. 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, a microstructure may be identified by observation using an optical or electron microscope and by measuring the dislocation density using XRD.

[0041] When the area fraction of deformed ferrite having a high dislocation density is 90% or more, the variation in 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 1.5 to 2.0. The aspect ratio may be measured through optical microscope observation on a cross section of the steel sheet including a thickness direction and a rolling direction.

[0043] If the aspect ratio of the deformed ferrite is too small, there is a problem in securing a strength level intended in the present invention, and if the aspect ratio is too large, material property deviation for each direction of a product may be caused. More specifically, the aspect ratio of the deformed ferrite may be 1.5 to 1.7.

[0044] The dislocation density of the deformed ferrite may be $3.0 \times 10^{15}/\text{m}^2$ to $6.0 \times 10^{15}/\text{m}^2$. 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, a strength at a desired level 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 $3.1 \times 10^{15}/\text{m}^2$ to $5.0 \times 10^{15}/\text{m}^2$.

[0046] A cold-rolled steel sheet for cans according to an embodiment of the present invention has a tensile strength of 350 to 450 MPa, an elongation of 15% or more, and a yield ratio of 0.7 to 1.0, and thus characteristics of excellent strength may be secured.

[0047] The cold-rolled steel sheet for cans according to an embodiment of the present invention is a high strength material. In fields using ultra thin materials, such as for internal pressure pipes or can dome parts, the tensile strength of the steel sheet is 350 MPa or more so that deformation caused by the internal pressure of a can occurs at a specific pressure or higher; thus, a lower limit of the tensile strength may be limited to 350 MPa. Meanwhile, if the tensile strength exceeds 450 MPa, it may be advantageous in terms of the internal pressure characteristics of the can;

however, usability may decrease due to a reduction in rollability caused by an increase in strength, and regarding dome deformation, a very high pressure is required, so a legal standard for the safety dome operating pressure may not be satisfied. More specifically, the tensile strength may be 375 to 425 MPa.

[0048] If total elongation is less than 15%, flange processability of a can may be inferior, which may cause a problem of processing cracks occurring. More specifically, elongation may be 20 to 35%.

[0049] Meanwhile, the yield ratio, representing a ratio of the yield strength to the tensile strength of a material, is a factor having a close relationship with the strength of the material and is defined as [yield strength/tensile strength]. A high strength material is required to satisfy a legal standard for safety dome operating pressure, and for this, the yield ratio may be in a range of 0.70 to 1.00. More specifically, the yield ratio may be in a range of 0.80 to 0.95.

[0050] A load value, calculated as a product of tensile strength and thickness of a steel sheet, is an index having a very high correlation with an operating pressure at which a dome is lifted when an internal pressure of a butane gas can increases. A cold-rolled steel sheet for cans according to an embodiment of the present invention may have a load value of 110.0 to 150.0 MPa×mm. If the load value is too small, a dome may be lifted even at a low internal pressure, and thus a legal safety standard may not be satisfied. If the load value is too high, a dome may operate only when a very high internal pressure is applied, so a risk of explosion may increase, and at the same time, a legal safety standard may not be satisfied. Even if the tensile strength of the steel sheet is satisfied, if the thickness of the steel sheet is thin, a proper operating pressure may not be satisfied, so a legal safety standard for a butane gas can safety dome may be satisfied when a combination of the tensile strength and thickness of the steel sheet corresponds to a specific level. More specifically, the load value may be 130.0 to 145.0 MPa×mm.

[0051] The cold-rolled steel sheet for cans according to an embodiment of the present invention may further comprise a tin plating layer located on a surface of the steel sheet. The tin plating layer is not particularly limited, and tin plating may be performed under common conditions applicable in the same technical field. Through tin plating, a steel sheet according to an embodiment of the present invention may comprise a tin plating layer on a surface thereof.

[0052] A method for manufacturing a cold-rolled steel sheet for cans according to an embodiment of the present invention comprises: a step of hot rolling a slab comprising, in weight%, carbon (C): 0.0005 to 0.004%, manganese (Mn): 0.2 to 0.6%, 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%, the balance being iron (Fe) and other unavoidable impurities, to manufacture a hot-rolled steel sheet; a first cold rolling step of cold rolling the hot-rolled steel sheet to manufacture a cold-rolled steel sheet; a step of annealing the cold-rolled steel sheet; and a secondary cold rolling step of cold rolling the annealed steel sheet at a reduction ratio of 9 to 14%.

[0053] Hereinafter, each step will be described in detail.

[0054] First, a slab is hot rolled to manufacture a hot-rolled steel sheet.

[0055] Since the alloy composition of the slab has been described regarding the aforementioned cold-rolled steel sheet for cans, a redundant description will be omitted. Since alloy components do not substantially change during a 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.

[0056] Before the step of manufacturing the hot-rolled steel sheet, the method may further comprise a heating step of heating the slab to 1100 to 1300°C. Slab heating may be performed 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 used. More specifically, the slab may be heated to 1150 to 1250°C.

[0057] 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, formation of mixed grains proceeds rapidly as hot rolling is finished in a low temperature region, which may result in a decrease in rollability and formability. 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 coarsening of grains may appear. More specifically, hot rolling may be performed at a finish rolling temperature of 905 to 935°C.

[0058] The hot-rolled steel sheet may be coiled at a coiling temperature of 550 to 700 °C. The hot-rolled steel sheet may be cooled in a run-out table (ROT) step and then coiled. If the coiling temperature is too low, the formation behavior of low-temperature precipitates shows a difference due to temperature non-uniformity in a width direction during cooling and holding, thereby causing material property deviation, which may adversely affect formability. On the other hand, if the coiling temperature is too high, problems of material softening and a decrease in corrosion resistance may occur as a structure of a final product becomes coarse. More specifically, the steel sheet may be coiled at a coiling temperature of 580 to 650 °C.

[0059] Next, a cold-rolled steel sheet is manufactured by first cold rolling the hot-rolled steel sheet. In this case, a reduction ratio during the first cold rolling may be 80 to 94%. The reduction ratio may be calculated by (steel sheet thickness before rolling - steel sheet thickness after rolling) / (steel sheet thickness before rolling) × 100. If the cold reduction ratio is too low, the hot-rolled steel sheet thickness must be lowered to manufacture a target ultra-thin

material, which not only significantly lowers hot rolling workability, but it may also be difficult to secure grains for securing material properties of a final product as the reduction ratio is low. On the other hand, if the cold reduction ratio is too high, the material is hardened, but there may be a problem of significantly lowering cold workability due to a load on a rolling mill. More specifically, the reduction ratio during the first cold rolling may be 85 to 93%.

[0060] In an embodiment of the present invention, the method may further comprise a step of pickling the steel sheet after coiling and before cold rolling. Pickling treatment conditions are not particularly limited, but may be performed under common conditions applied in the same technical field.

[0061] Next, the cold-rolled steel sheet is subjected to annealing. In this case, an annealing temperature may be 600 to 800°C. In the annealing process, the strength, which is increased due to strain introduced during cold rolling, may be reduced to a target strength by performing the annealing.

[0062] In this aspect, if the annealing temperature is too low, strain is not sufficiently released, which may lead to high strength but significantly lowered formability. On the other hand, if the annealing temperature is too high, a recrystallization phenomenon proceeds rapidly during the annealing process, so the area fraction of deformed ferrite decreases and the material softens, so the target strength may not be obtained. In addition, there is a risk of facility operation failure due to material defects such as sheet breakage in a continuous facility. More specifically, the annealing temperature may be in the range of 650 to 780°C.

[0063] A method for manufacturing cold-rolled steel sheet for cans according to an embodiment of the present invention may satisfy Equation 1 below.

[Equation 1]

$$[FDT] \times [CT] \times [RR1] \times [AT] / 10^{10} \geq 3.20$$

[0064] (In Equation 1, [FDT] represents a finish rolling temperature (°C) in the step of manufacturing the hot-rolled steel sheet, [CT] represents a coiling temperature (°C) in the step of manufacturing the hot-rolled steel sheet, [RR1] represents a reduction ratio (%) in the first cold rolling step, and [AT] represents an annealing temperature (°C) in the annealing step of the cold-rolled sheet.)

[0065] In Equation 1, temperature conditions and reduction ratio conditions in each step are combined. In an embodiment of the present invention, target strength and material properties are obtained by setting the finish rolling temperature, the coiling temperature, the first cold rolling reduction ratio, and the annealing temperature all to be relatively high. If any one of these values is small, the value of Equation 1 decreases, and it becomes difficult to obtain the target strength and material properties. More specifically, the value of the left side of Equation 1 may be from 3.50 to 4.00. More specifically, the value of the left side of Equation 1 may be from 3.55 to 3.80.

[0066] Next, the annealed steel sheet is subjected to second cold rolling at a reduction ratio of 9 to 14%. The second cold rolling may be performed for sheet shape control, roughness provision after annealing, and finally, for obtaining a target material level. If the reduction ratio is too low, it may be difficult to secure material properties at a desired level by secondary rolling. If the reduction ratio is too high, work hardening proceeds rapidly, which may make it difficult to secure target elongation and tensile strength. More specifically, the second cold rolling reduction ratio may be 10 to 13%.

[0067] Next, the method may further comprise a step of tin plating the second cold-rolled steel sheet. 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 applicable in the same technical field.

[0068] 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

[0069] Slabs having compositions shown in Table 1 below were manufactured, and after heating the slabs to 1250°C, hot rolling, pickling, first cold rolling, annealing, and second cold rolling were performed according to processes summarized in Table 2 below to manufacture cold-rolled steel sheets for cans having thicknesses summarized in Table 3 below.

[0070] The microstructure was observed using an optical microscope after nital etching for each specimen, and the dislocation density was measured via XRD. The area fraction of deformed ferrite and the dislocation density of the microstructure were determined. The grain aspect ratio of the deformed ferrite represents a ratio of an average grain diameter in the rolling direction to an average grain diameter in the thickness direction, and may be measured through optical microscope observation.

[0071] The yield strength and elongation were measured through a tensile test at room temperature, and the tensile specimens were manufactured by processing them into standard specimens according to ASTM standards (ASTM E-8 standard). Yield strength (YS) and elongation (EI) of the tensile specimens were measured using a tensile tester (INSTRON, Model 6025). The yield ratio was calculated by dividing the yield strength by the tensile strength. The load value was obtained by multiplying the tensile strength by the thickness.

[Table 1]

Steel grade (weight %)	C	Mn	Si	P	S	Al	N
A	0.0020	0.25	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	0.25	0.025	0.0015	0.015	0.025	0.0015
D	0.0100	0.75	0.025	0.0015	0.015	0.025	0.0015
E	0.0100	0.25	0.025	0.0015	0.015	0.025	0.0055

[Table 2]

No.	Steel grade	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	10
2	B	910	610	89	740	3.66	10
3	A	750	610	89	740	3.01	10
4	A	920	450	90	740	2.76	10
5	B	930	620	64	740	2.73	10
6	A	910	610	89	550	2.72	10
7	B	920	610	88	740	3.65	16
8	C	910	600	89	740	3.60	10
9	D	910	600	88	740	3.56	10
10	E	910	600	89	740	3.60	10
11	C	750	610	88	740	2.98	10
12	D	910	610	88	550	2.69	10
13	E	920	610	89	740	3.70	5

[Table 3]

No.	Thickness (mm)	Deformed ferrite (area %)	Aspect ratio	Dislocation density ($10^{15}/m^2$)
1	0.355	99	1.5	3.4
2	0.355	99	1.6	3.3
3	0.220	98	2.2	6.2
4	0.210	98	1.5	6.1
5	0.210	99	1.7	1.5
6	0.210	98	1.5	7.5
7	0.450	99	2.3	8.5
8	0.210	98	1.4	6.2
9	0.355	99	1.7	6.5

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(continued)

No.	Thickness (mm)	Deformed ferrite (area %)	Aspect ratio	Dislocation density ($10^{15}/\text{m}^2$)
10	0.355	97	1.6	7.2
11	0.230	97	1.6	6.3
12	0.420	96	2.5	7.8
13	0.350	98	1.6	6.2

[Table 4]

No.	Tensile strength (MPa)	Elongation (%)	Yield ratio	Load value (MPa×mm)	Safety dome operation pass or fail	Classification
1	380	31	0.92	134.9	Pass	Inventive Example 1
2	400	25	0.91	142.0	Pass	Inventive Example 2
3	480	10	0.93	105.6	Fail	Comparative Example 1
4	475	12	0.90	99.8	Fail	Comparative Example 2
5	340	33	0.80	71.4	Fail	Comparative Example 3
6	465	13	0.92	97.7	Fail	Comparative Example 4
7	490	8	0.95	220.5	Fail	Comparative Example 5
8	460	11	0.90	96.6	Fail	Comparative Example 6
9	475	10	0.89	168.6	Fail	Comparative Example 7
10	480	9	0.89	170.4	Fail	Comparative Example 8
11	460	14	0.90	105.8	Fail	Comparative Example 9
12	500	5	0.96	210.0	Fail	Comparative Example 10
13	470	10	0.90	164.5	Fail	Comparative Example 11

[0072] As shown in Tables 1 to 4, Inventive Examples 1 and 2 are cases in which both the steel composition and manufacturing conditions were satisfied, and it may be confirmed that the aspect ratio of deformed ferrite is appropriately formed, and the tensile strength, elongation, yield ratio, and load value are all excellent, satisfying the legal requirements for a safety dome.

[0073] On the other hand, it may be confirmed that in cases where the steel composition was not satisfied or the manufacturing conditions were not met, deformed ferrite is not appropriately formed, or dislocation density is not appropriately formed, and the tensile strength, elongation, yield ratio, or load value are partially inferior, so the legal requirements required for a safety dome are not satisfied.

[0074] The present invention is not limited to the embodiments, but may be manufactured in various different forms, and a person of ordinary skill in the art to which the present invention belongs will understand that the present invention may be implemented in other specific forms without changing the technical idea or essential features 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): 0.2 to 0.6%, silicon (Si): 0.05% or less (excluding 0%), phosphorus (P): 0.030% or less (excluding 0%), sulfur (S): 0.030% or less (excluding 0%), aluminum (Al): 0.01 to 0.07%, nitrogen (N): 0.0005 to 0.004%, the remainder being iron (Fe) and other unavoidable impurities,

wherein the cold-rolled steel sheet contains 95% or more of deformed ferrite in area %, and

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 1.5 to 2.0.

2. The cold-rolled steel sheet for cans of claim 1,
dislocation density of the deformed ferrite is in the range of $3 \times 10^{15}/\text{m}^2$ to $6 \times 10^{15}/\text{m}^2$.
3. The cold-rolled steel sheet for cans of claim 1,
the steel sheet has a tensile strength of 350 to 450 MPa, an elongation of 15% or more, a yield ratio of 0.7 to 1.0,
and a load value of 110 to 150 MPa $\times$ mm.
4. The cold-rolled steel sheet for cans of claim 1,
wherein the steel sheet further comprises a tin plating layer located on a surface of the steel sheet.
5. A method for manufacturing a cold-rolled steel sheet for cans, comprising the steps of:

a hot rolling step of hot rolling a slab comprising, in weight%, carbon (C): 0.0005 to 0.004%, manganese (Mn): 0.2 to 0.6%, silicon (Si): 0.05% or less (excluding 0%), phosphorus (P): 0.030% or less (excluding 0%), sulfur (S): 0.030% or less (excluding 0%), aluminum (Al): 0.01 to 0.07%, nitrogen (N): 0.0005 to 0.004%, the remainder being iron (Fe) and other unavoidable impurities, to manufacture a hot-rolled steel sheet;
a first cold rolling step of cold rolling the hot-rolled steel sheet to manufacture a cold-rolled steel sheet;
a step of annealing the cold-rolled steel sheet; and
a secondary cold rolling step of cold rolling the annealed steel sheet at a reduction ratio of 9 to 14%,
wherein Equation 1 below is satisfied:

[Equation 1]

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

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

6. The method for manufacturing a cold-rolled steel sheet for cans of Claim 5,
further comprising a heating 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 pickling step of pickling the steel sheet before the step of first cold rolling.
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 second cold rolling.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2024/063302

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

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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

“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 15 April 2025	Date of mailing of the international search report 15 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.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/IB2024/063302

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JP 10-237592 A	08 September 1998	JP 3845934 B2	15 November 2006

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