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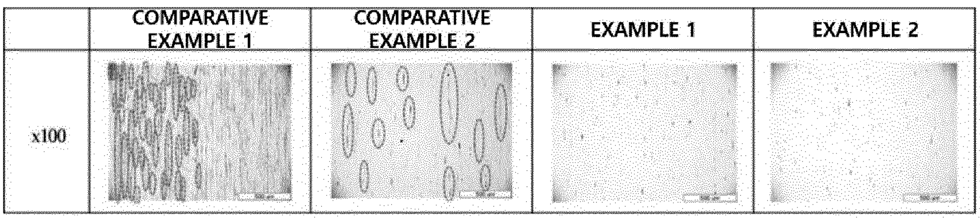
(54) **FERRITE-BASED STAINLESS STEEL HAVING IMPROVED SURFACE CHARACTERISTICS AND METHOD FOR MANUFACTURING SAME**

(57) Disclosed are a ferrite-based stainless steel having improved surface characteristics and a method for manufacturing same. The ferrite-based stainless steel according to the present invention includes, in percent by weight (wt%), 0.001 to 0.05% of C, 0.001 to 0.05% of N, 0.1 to 1.0% of Si, 0.1 to 1.0% of Mn, 12.0 to 22.0% of Cr, 0.01 to 1.0% of Ti, 0.01 to 1.0% of Nb, and the remainder of Fe and unavoidable impurities, wherein micro flaws having a length of 100 μm or more are distributed at a density of 5 pieces/mm^2 or less.

FIG. 1



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Description

[Technical Field]

[0001] The present disclosure relates to a ferrite-based stainless steel having improved surface characteristics and a method for manufacturing the same, more specifically, to a ferrite-based stainless steel having excellent gloss and distinctness of reflected image and a method for manufacturing the same.

[Background Art]

[0002] In general, stainless steels are classified according to chemical compounds or metal structures. According to the metal structure, stainless steels may be classified into austenitic, ferritic, martensitic, and dual phase stainless steels.

[0003] Because ferrite-based stainless steels have excellent corrosion resistance even using small amounts of expensive alloying elements, price competitiveness thereof is higher than that of austenitic stainless steels, and thus ferrite-based stainless steels are a steel type applied to various fields.

[0004] Meanwhile, materials for home appliances and exterior trims of vehicles need to have excellent surface characteristics. Specifically, required surface characteristics include a gloss (GS 20°C) of 1,050 or more and a distinctness of reflected image of 90 or more.

[0005] Gloss refers to an amount of light reflected by the surface of an object at a specular angle, as a measure that quantifies the degree of gloss of the surface of the object as a percentage with respect to a gloss of a standard sample having a constant refractive index.

[0006] Distinctness of reflected image (DOI) refers to a ratio of a difference between an amount of light reflected by the surface of an object at a specular angle and an amount of light reflected by the surface at an angle deviating by ±0.3° from the specular angle. DOI is also referred to as resolution and indicates clearness of an object. Objects having the same gloss may have different DOI values according to surface shapes of the objects and distribution and shapes of micro flaws.

[0007] In general, cold-rolled ferrite-based stainless steels for door trims of vehicles are manufactured by skin pass rolling bright-annealed steel sheets. However, there is a problem that a desired distinctness of reflected image cannot be obtained according to conventional manufacturing methods due to micro flaws remaining on the surface in the case of visual observation although a gloss of 1,050 or more is obtained.

[0008] It has been found that such micro flaws that deteriorate surface characteristics are caused by a lubricant remaining in concave grooves of the surface of a ferrite-based stainless steel during cold rolling. Also, it has been known that micro flaws are caused in the case of performing cold rolling on a rough surface after hot rolling or performing cold rolling in a state where shot ball marks formed by shot blasting during hot annealing and pickling processes remains.

[0009] Therefore, it is essential to reduce micro flaws on the surface of a ferrite-based stainless steel before final cold rolling in order to improve surface characteristics of the ferrite-based stainless steel.

[Disclosure]

[Technical Problem]

[0010] Provided are a ferrite-based stainless steel having a uniform deviation of distinctness of reflected image in a rolling direction (L) and in a direction (C) perpendicular to the rolling direction by controlling distribution of micro flaws on the surface by introducing a surface treatment process and controlling cold rolling conditions and a method for manufacturing the same.

[Technical Solution]

[0011] In accordance with an aspect of the present disclosure, a ferrite-based stainless steel having improved surface characteristics according to an embodiment of the present disclosure includes, in percent by weight (wt%), 0.001 to 0.05% of C, 0.001 to 0.05% of N, 0.1 to 1.0% of Si, 0.1 to 1.0% of Mn, 12.0 to 22.0% of Cr, 0.01 to 1.0% of Ti, 0.01 to 1.0% of Nb, and the remainder of Fe and unavoidable impurities, wherein micro flaws having a length of 100 μm or more are distributed at a density of 5 pieces/mm^2 or less.

[0012] In addition, according to an embodiment of the present disclosure, the ferrite-based stainless steel may further include at least one of 0.01 to 2.0% of Mo, 0.10% or less (excluding 0) of Al, 1.0% or less (excluding 0) of Cu, 0.01 to 0.3% of V, 0.01 to 0.3% of Zr, and 0.0010 to 0.0100% of B.

[0013] In addition, according to an embodiment of the present disclosure, an area rate of oil pit may be 2% or less.

[0014] In addition, according to an embodiment of the present disclosure, an area rate of micro flaws may be 1.6% or less, and micro flaws having a length of 100 μm or more may be distributed at a density of 2 pieces/mm^2 or less.

[0015] In addition, according to an embodiment of the present disclosure, a distinctness of reflected image may be 90 or more in a rolling direction (L direction) and a direction (C direction) perpendicular to the rolling direction, respectively.

[0016] In addition, according to an embodiment of the present disclosure, a deviation of distinctness of reflected image between the L direction and the C direction may be 5 or less.

[0017] In accordance with another aspect of the present disclosure, a method for manufacturing a ferrite-based stainless steel having improved surface characteristics may include: hot rolling a slab including, in percent by weight (wt%), 0.001 to 0.05% of C, 0.001 to 0.05% of N, 0.1 to 1.0% of Si, 0.1 to 1.0% of Mn, 12.0 to 22.0% of Cr, 0.01 to 1.0% of Ti, 0.01 to 1.0% of Nb, and the remainder of Fe and unavoidable impurities and hot annealing the hot-rolled steel sheet; cold rolling the hot-rolled, annealed steel sheet twice or more by controlling a roll diameter to 70 mm or less and cold annealing the cold-rolled steel sheet; bright annealing the cold-rolled, annealed steel sheet; and skin pass rolling the bright-annealed steel sheet, wherein surface polishing treatment is introduced after hot annealing or after primary cold rolling.

[0018] In addition, according to an embodiment of the present disclosure, the ferrite-based stainless steel may further include at least one of 0.01 to 2.0% of Mo, 0.10% or less (excluding 0) of Al, 1.0% or less (excluding 0) of Cu, 0.01 to 0.3% of V, 0.01 to 0.3% of Zr, and 0.0010 to 0.0100% of B.

[0019] In addition, according to an embodiment of the present disclosure, the cold rolling may include primary cold rolling performed at a reduction ratio of 40% or more, and secondary cold rolling performed at a reduction ratio of 40% or more, wherein a total reduction ratio is 80% or more.

[0020] In addition, according to an embodiment of the present disclosure, the cold rolling may further include tertiary cold rolling performed at a reduction ratio of 40% or more.

[0021] In addition, according to an embodiment of the present disclosure, a re-heating temperature may be from 1050 to 1280°C, and a final rolling temperature may be from 800 to 950°C during the hot rolling.

[0022] In addition, according to an embodiment of the present disclosure, the surface polishing treatment may be performed by removing the surface layer by 7 μm or more using a polishing belt having a roughness of #70 mesh or more.

[0023] In addition, according to an embodiment of the present disclosure, the surface polishing treatment may be performed once or twice.

[0024] In addition, according to an embodiment of the present disclosure, the cold annealing may be performed at a temperature of 850 to 1,100°C.

[0025] In addition, according to an embodiment of the present disclosure, the bright annealing may be performed at a temperature of 850 to 1,100°C.

[0026] In addition, according to an embodiment of the present disclosure, the skin pass rolling may be performed using a work roll having an average roughness of #600 or more.

[0027] In addition, according to an embodiment of the present disclosure, the skin pass rolling may be performed twice to five times.

[0028] In addition, according to an embodiment of the present disclosure, micro flaws having a length of 100 μm or more may be distributed at a density of 5 pieces/mm^2 or less.

[0029] In addition, according to an embodiment of the present disclosure, a distinctness of reflected image may be 90 or more in a rolling direction (L direction) and a direction (C direction) perpendicular to the rolling direction, respectively.

[0030] In addition, according to an embodiment of the present disclosure, a deviation of distinctness of reflected image between the L direction and the C direction may be 5 or less.

[Advantageous Effects]

[0031] According to the present disclosure, provided are a ferrite-based stainless steel having a high gloss and a uniform deviation of distinctness of reflected image in the rolling direction (L) and the direction (C) perpendicular to the rolling direction by controlling a distribution density of surface micro flaws, and a method for manufacturing the same.

[Description of Drawings]

[0032]

FIG. 1 is an optical microscopic image showing surfaces of ferrite-based stainless steels according to examples of the present disclosure and comparative examples.

FIG. 2 is a graph showing area rates of surface micro flaws (%) of examples of the present disclosure and comparative examples.

FIG. 3 is a graph showing distribution densities of micro flaws of examples of the present disclosure and comparative examples.

FIG. 4 is a graph showing distinctness of reflected image in a rolling direction (L direction) and a direction (C direction) perpendicular to the rolling direction in examples of the present disclosure and comparative examples.

FIG. 5 is a graph showing deviations of distinctness of reflected image in a rolling direction (L direction) and a direction (C direction) perpendicular to the rolling direction in examples of the present disclosure and comparative examples.

[Best Mode]

[0033] A ferrite-based stainless steel having improved surface characteristics according to an embodiment of the present disclosure includes, in percent by weight (wt%), 0.001 to 0.05% of C, 0.001 to 0.05% of N, 0.1 to 1.0% of Si, 0.1 to 1.0% of Mn, 12.0 to 22.0% of Cr, 0.01 to 1.0% of Ti, 0.01 to 1.0% of Nb, and the remainder of Fe and unavoidable impurities, wherein micro flaws having a length of 100 μm or more are distributed at a density of 5 pieces/mm^2 or less.

[Modes of the Invention]

[0034] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. The following embodiments are provided to fully convey the spirit of the present disclosure to a person having ordinary skill in the art to which the present disclosure belongs. The present disclosure is not limited to the embodiments shown herein but may be embodied in other forms. In the drawings, parts unrelated to the descriptions are omitted for clear description of the disclosure and sizes of elements may be exaggerated for clarity.

[0035] Throughout the specification, the term "include" an element does not preclude other elements but may further include another element, unless otherwise stated.

[0036] As used herein, the singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0037] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. First, a ferrite-based stainless steel will be described, and then a method for manufacturing the ferrite-based stainless steel will be described.

[0038] In the present disclosure, micro flaws refer to flaws formed on the surface of a ferrite-based stainless steel and having a length of 100 μm or more. Micro flaws are formed during hot rolling/annealing, pickling and cold rolling processes from a steel-making process due to various factors and observed in various forms such as steel-making inclusions, hot rolling defects, and oil pits and white stripes formed by non-uniform texture during cold rolling.

[0039] Specifically, micro flaws are caused as a lubricant remains in concave grooves on the surface of a ferrite-based stainless steel during cold rolling. Or, micro flaws are caused by cold rolling performed on a rough surface after hot rolling or by cold rolling performed in a state where shot ball marks formed by shot blasting during hot annealing and pickling processes remains.

[0040] In this case, there is a problem in that surface characteristics and distinctness of reflected image of a ferrite-based stainless steel cannot be examined by visual observation. As a result of intensive efforts to obtain a uniform distinctness of reflected image in a rolling direction (L) and a direction (C) perpendicular to the rolling direction by reducing micro flaws on the surface thereof together with gloss of the ferrite-based stainless steel, the present inventors have found those described below.

[0041] In the present disclosure, as a result of conducting intensive studies on factors of reducing the deviation in distinctness of reflected image of the surface of a ferrite-based stainless steel, the inventors have found that surface characteristics of a cold-rolled ferrite-based stainless steel sheet may be improved by controlling a distribution density of micro flaws having a length of 100 μm or more. These results may be achieved by controlling a roll diameter to 70 mm or less during cold rolling as well as adjusting contents of alloying elements and adjusting the size and distribution density of micro flaws.

[0042] A ferrite-based stainless steel having improved surface characteristics according to an embodiment of the present disclosure includes, in percent by weight (wt%), 0.001 to 0.05% of C, 0.001 to 0.05% of N, 0.1 to 1.0% of Si, 0.1 to 1.0% of Mn, 12.0 to 22.0% of Cr, 0.01 to 1.0% of Ti, 0.01 to 1.0% of Nb, and the remainder of Fe and unavoidable impurities.

[0043] Hereinafter, reasons for numerical limitations on the contents of alloying elements in the embodiment of the present disclosure will be described. Hereinafter, the unit is wt% unless otherwise stated.

[0044] The content of C is from 0.001 to 0.05%.

[0045] Carbon (C), as an interstitial solid solution strengthening element, improves strength of a ferrite-based stainless steel and may be added in an amount of 0.001% or more. However, when the C content is excessive, impact toughness, corrosion resistance, and workability deteriorate, and thus an upper limit thereof may be set to 0.05%.

[0046] The content of N is from 0.001 to 0.05%.

[0047] Nitrogen (N), also as an interstitial solid solution strengthening element like C, enhances strength of a ferrite-based stainless steel, and thus may be added in an amount of 0.001% or more. However, when the N content is excessive, N binds to aluminum or titanium to form a nitride, deteriorates ductility of a steel, and causes stretcher strain of a cold-rolled product, and thus an upper limit thereof may be set to 0.05%.

[0048] The content of Si is from 0.1 to 1.0%.

[0049] Silicon (Si) is an element serving as a deoxidizer during a steel-making process and stabilizing a ferrite phase. In the present disclosure, in order to obtain strength and corrosion resistance of a ferrite-based stainless steel, it is preferable to add Si in an amount of 0.1% or more. However, when the Si content is excessive, there may be a problem of deteriorating ductility and formability, and thus an upper limit thereof may be set to 1.0%.

[0050] The content of Mn is from 0.1 to 1.0%.

[0051] Manganese (Mn), as an austenite-stabilizing element, may be added in an amount of 0.1% or more. However, an excess of Mn may cause a problem of deteriorating corrosion resistance, and thus an upper limit thereof may be set to 1.0%.

[0052] The content of Cr is from 12.0 to 22.0%.

[0053] Chromium (Cr) stabilizes ferrite, as a basic element contained in stainless steels in the largest amount among the elements used to improve corrosion resistance. In the present disclosure, Cr may be added in an amount of 12.0% or more to obtain corrosion resistance by forming a passivated layer inhibiting oxidation. However, an excess of Cr may increase manufacturing costs and deteriorate formability, and thus an upper limit thereof may be set to 22.0%.

[0054] The content of Ti is from 0.01 to 1.0%.

[0055] Titanium (Ti) is an element effective on obtaining corrosion resistance of steels by preferentially binding to interstitial elements such as carbon (C) and nitrogen (N) to form precipitates (carbonitrides) to reduce amounts of solute C and solute N in the steels and inhibit formation of a Cr depletion region. In the present disclosure, Ti may be added in an amount of 0.01% or more. However, when the Ti content is excessive, Ti-based inclusions are formed causing a problem in a manufacturing process and surface defects such as scabs may be caused, and thus an upper limit thereof may be set to 1.0%.

[0056] The content of Nb is from 0.01 to 1.0%.

[0057] Niobium (Nb) is an element improving corrosion resistance by preferentially binding to interstitial elements such as carbon (C) and nitrogen (N) to form carbonitrides to reduce an amount of solute C and may be added in an amount of 0.01% or more in the present disclosure. However, an excess of Nb may increase manufacturing costs and form Laves precipitates, thereby causing problems of deteriorating formability, causing brittle fracture, and deteriorating toughness, and thus an upper limit thereof may be set to 1.0%.

[0058] In addition, according to an embodiment of the present disclosure, the ferrite-based stainless steel may further include at least one of 0.01 to 2.0% of Mo, 0.10% or less (excluding 0) of Al, 1.0% or less (excluding 0) of Cu, 0.01 to 0.3% of V, 0.01 to 0.3% of Zr, and 0.0010 to 0.0100% of B.

[0059] The content of Mo is from 0.01 to 2.0%.

[0060] Molybdenum (Mo) is an element effective on obtaining corrosion resistance, particularly pitting corrosion resistance, of steels and may be added in an amount of 0.01% or more in the present disclosure. However, an excess of Mo may increase manufacturing costs and deteriorate impact characteristics, thereby increasing the risk of breakage during processing, and thus an upper limit thereof may be set to 2.0%.

[0061] The content of Al is from 0.1% or less.

[0062] Aluminum (Al) is a strong deoxidizer and serves to lower the content of oxygen in a molten steel. However, when the Al content is excessive, sleeve defects of a cold-rolled strip occur due to an increase in nonmetallic inclusions, and thus an upper limit thereof may be set to 0.1%.

[0063] The content of Cu is 1.0% or less.

[0064] Copper (Cu) may be additionally added to improve corrosion resistance. An excess of Cu may cause a problem of deteriorating workability, and thus an upper limit thereof may be set to 1.0%.

[0065] The contents of V and Zr are from 0.01 to 0.3%, respectively.

[0066] Vanadium (V) and zirconium (Zr) are elements reacting with carbon (C) and nitrogen (N) to form carbonitrides and may be added in an amount of 0.01% or more in the present disclosure to improve corrosion resistance and high-temperature strength. However, when the V content and Zr content are excessive, a problem of increasing manufacturing costs may occur, and thus an upper limit thereof may be set to 0.3%.

[0067] The content of B is from 0.001 to 0.01%.

[0068] Boron (B), as an element effective on obtaining satisfactory surface quality by inhibiting occurrence of cracks during a casting process, may be added in an amount of 0.001% or more. However, an excess of B may form a nitride (BN) on the surface of a product during an annealing/acid pickling process, thereby deteriorating the surface quality, and thus an upper limit thereof may be set to 0.01%.

[0069] The remaining component of the composition of the present disclosure is iron (Fe). However, the composition may include unintended impurities inevitably incorporated from raw materials or surrounding environments, and thus addition of other alloy components is not excluded. These impurities are known to any person skilled in the art of manufacturing and details thereof are not specifically mentioned in the present disclosure.

[0070] Meanwhile, a ferrite-based stainless steel having improved surface characteristics according to an embodiment of the present disclosure includes micro flaws having a length of 100 μm or more and distributed at a density of 5 pieces/mm^2 or less. Preferably, a distribution density of micro flaws may be 2 pieces/mm^2.

[0071] As described above, in order to improve surface characteristics of a ferrite-based stainless steel, micro flaws occurring on the surface thereof need to be reduced.

[0072] Specifically, in order to obtain a distinctness of reflected image (DOI) of 90 or more in a rolling direction (L) of the ferrite-based stainless steel satisfying the above-described composition of the alloying elements and in a direction (C) perpendicular to the rolling direction respectively and to obtain a DOI deviation of 5 or less therebetween, an area rate of micro flaws having a length of 100 μm or more needs to be controlled to 2% or less, preferably, 1.6% or less.

[0073] Hereinafter, a method for manufacturing a ferrite-based stainless steel having improved surface characteristics according to another embodiment of the present disclosure will be described.

[0074] The method for manufacturing the ferrite-based stainless steel having improved surface characteristics according to an embodiment of the present disclosure includes: hot rolling and hot annealing a slab including the above-described composition of alloying elements; cold rolling the hot-rolled, annealed steel sheet twice or more by controlling a roll diameter to 70 mm or less; and bright annealing the cold-rolled steel sheet; and skin pass rolling the bright-annealed steel sheet, wherein surface polishing is introduced after the hot annealing or primary cold rolling.

[0075] The slab including the above-described composition may be processed using a series of hot rolling and hot annealing, cold rolling and cold annealing, bright annealing, and skin pass rolling to produce a final product.

[0076] In order to improve both of gloss and distinctness of reflected image of a ferrite-based stainless steel, surface micro flaws should be reduced. In the present disclosure, attempts have been made to minimize occurrence of surface micro flaws of a ferrite-based stainless steel by removing surface scales and micro flaws by introducing a surface treatment process and by controlling the roll diameter during cold rolling.

[0077] First, the slab is re-heated in a temperature range of 1,050 to 1,280°C.

[0078] With respect to the conditions for hot rolling, as a re-heating temperature for the slab and a final rolling temperature increase, recrystallization occurs more efficiently during a hot rolling process. However, at a too high temperature, a coarse band structure is formed so that recrystallization does not smoothly proceed even after cold rolling and annealing resulting in deterioration of elongation and anisotropy, and a structure is non-uniformly recrystallized and has a non-uniform thickness during a subsequent cold rolling process so that oil introduced into concave grooves causes occurrence of micro flaws in large quantity. Therefore, upper limits of the re-heating temperature of the slab and the final rolling temperature during hot rolling may be set to 1,280°C and 950°C, respectively.

[0079] On the contrary, as the re-heating temperature and the final rolling temperature decrease, stored deformation energy increases during hot rolling to improve recrystallization and anisotropy during annealing. However, at too low re-heating temperature and final rolling temperature, sticking defects in which a material sticks to a rolling mill easily occur. Therefore, lower limits of the re-heating temperature and the final rolling temperature during the hot rolling may be set to 1,100°C and 800°C, respectively.

[0080] Subsequently, the prepared hot-rolled steel sheet may be pickled and cold-rolled to manufacture a thin plate. According to the embodiment, the cold rolling may be performed twice or more by primary cold rolling and secondary cold rolling while controlling the roll diameter to 70 mm or less.

[0081] In order to decrease the length of micro flaws formed on a surface, a diameter of a cold rolling roll needs to be reduced. As the roll diameter increases, the length of micro flaws increases in the rolling direction and the distinctness of reflected image decreases in the C direction perpendicular to the rolling direction, and thus the roll diameter acts as a factor causing a deviation between the L direction and the C direction.

[0082] In the present disclosure, attempts have been made to minimize micro flaws such that the number of micro flaws having a length of 100 μm or more is controlled to 5 pieces/mm^2 or less by controlling the roll diameter to 70 mm or less. Preferably, the roll diameter is controlled within the range of 40 to 70 mm during cold rolling.

[0083] For example, the primary cold rolling may be performed at a reduction ratio of 40% or more. Subsequently, the primarily cold-rolled steel sheet may be annealed at a temperature of 850 to 1,050°C.

[0084] Subsequently, the secondary cold rolling may be performed at a reduction ratio of 40% or more. Then, the secondarily cold-rolled steel sheet may be annealed at a temperature of 850 to 1,050°C. Thus, a total reduction ratio of the secondarily cold-rolled steel sheet may be 80% or more.

[0085] If required, the secondarily cold-rolled and annealed steel sheet may be subjected to third cold rolling at a reduction ratio of 40% or more.

[0086] The cold annealing may be performed at a temperature of 850 to 1,100°C. In the present disclosure, the cold annealing temperature may be controlled to 1,100°C or below to prevent formation of a non-uniformly recrystallized structure with a non-uniform thickness during a subsequent cold rolling caused by formation of a coarse band structure. However, in the case where the cold annealing is performed at a too low temperature, a sufficient recrystallization effect cannot be obtained, and thus the temperature range of the cold annealing is controlled to 850°C or higher.

[0087] Meanwhile, in order to remove non-uniform surface scales and micro flaws formed after annealing, surface polishing is introduced after hot annealing or primary cold rolling according to the present disclosure.

[0088] For example, surface polishing may be performed after the primary cold rolling before the secondary cold rolling using a polishing belt having a roughness of #70 mesh or more to remove the surface layer by 7 μm or more. Such a surface polishing process may be performed once or twice in consideration of costs and productivity according to a processing load.

[0089] After conducting cold annealing twice or more, a bright annealing process is performed to obtain intrinsic gloss without forming oxide scales on the surface of the cold-rolled, annealed steel sheet. In this case, the bright annealing may be performed under a reducing atmosphere containing hydrogen or nitrogen in a temperature range of 850 to 1,100°C.

[0090] In the present disclosure, the bright annealing temperature may be controlled to 1,100°C or below in order to prevent a structure from being non-uniformly formed and having a non-uniform thickness during a subsequent cold rolling process due to a coarse band structure formed at a too high temperature. However, in the case of performing the cold annealing at a too low temperature, sufficient processibility may not be obtained due to insufficient recrystallization, and thus the temperature range of the bright annealing is controlled to 850°C or higher.

[0091] Subsequently, skin pass rolling is conducted to improve surface gloss of the ferrite-based stainless steel.

[0092] The skin pass rolling may be conducted using a work roller having an average roughness of #600 or more. In the case of using a work roller having an average roughness less than #600, surface gloss may decrease due to the too rough work roll, failing to obtain a desired level of gloss.

[0093] The skin pass rolling may be conducted twice to 5 times. Sufficient gloss cannot be obtained in the case of conducting skin pass rolling only once and costs may increase and productivity cannot be obtained due to a processing load in the case of conducting skin pass rolling 6 times or more.

[0094] The final cold-rolled steel sheet that has gone through the skin pass rolling may have micro flaws having a length of 100 μm or more and distributed at a density of 5 pieces/mm^2 or less, and an area rate of the micro flaws may be 2% or less, preferably, 1.6% or less.

[0095] As such, non-uniform surface scales and micro flaws may be removed by surface polishing after hot annealing or primary cold rolling, and the length of the micro flaws formed on the surface may be reduced by controlling the roll diameter to 70 mm or less during cold rolling.

[0096] Accordingly, in a final ferrite-based stainless steel product, the distinctness of reflected image (DOI) may be 90 or more in the rolling direction (L) and the direction (C) perpendicular to the rolling direction and the DOI deviation may be 5 or less.

[0097] Hereinafter, the embodiments of the present disclosure will be described in more detail with reference to the following examples.

Examples

[0098] Alloying elements including, in percent by weight (wt%), 0.02% of C, 0.02% of N, 0.4% of Si, 0.3% of Mn, 18% of Cr, 0.4% of Nb, 1.0% of Mo, and the remainder of Fe and unavoidable impurities, were melted by ingot melting to prepare a slab, and the slab was heated at 1,100°C for 2 hours and hot-rolled. After the hot rolling, the hot-rolled steel sheet was hot-annealed at 1,000°C for 90 seconds. Subsequently, the hot-annealed steel sheet was subjected to primary cold rolling at a reduction ratio of 40% using a roll having a diameter of 50 mm and then primary cold annealing at 1,000°C for 90 seconds. Then, the surface of the cold-rolled, annealed steel sheet was polished once by 7 μm or more under the conditions shown in Table 1 below using a polishing belt having a roughness of #80 mesh. Subsequently, the steel sheet was subjected to secondary cold rolling at a reduction ratio of 40% using a roll having a diameter of 50 mm, bright annealing in a 100% hydrogen atmosphere at 1,000°C for 60 seconds, and skin pass rolling using a work roll having an average roughness of #600 or more, thereby manufacturing a final steel sheet.

[0099] In Comparative Examples land 2, final steel sheets were manufactured in the same manner as in the examples, except that the roll diameter during cold rolling and surface polishing conditions were changed as shown in Table 1 below.

[0100] The skin pass-rolled steel sheet was observed using an optical microscope with a maximized light source and a magnification of 50 times and area rates of micro flaws were measured using an image analyzer and shown in Table 1 below.

[0101] Specifically, the area rate of micro flaws was an area rate of oil pits and roll marks formed on the surface of the steel sheet. The oil pit refers to a defect in a concave form formed due to an inflow of a rolling oil during cold rolling, and the roll mark (RM) refers to a defect in a linear form remaining on the surface due to a transferred roughness of the roll during cold rolling.

Table 1

	Example 1	Example 2	Comparative Example 1	Comparative Example 2
Manufacturing conditions (roll diameter/no. of polishing)	50 mm /once	50 mm /twice	140 mm/ 0 times	140 mm/ once
Area rate of micro flaws (%)	1.61	0.55	8.12	0.55
	1.30	0.56	6.90	0.74
	1.40	0.52	9.16	0.62
Average (%)	1.44	0.54	8.06	0.64
Distribution density of micro flaws (pieces/mm^2)	1.28	0	35.4	4.7
	1.70	0	32.0	6.4
	0.85	0	41.0	5.1
Average (pieces/mm^2)	1.27	0	36.1	5.4

[0102] Gloss and distinctness of reflected image of each steel sheet in the rolling direction (L direction) and the direction (C direction) perpendicular to the rolling direction, and deviation therebetween were measured. Specifically, the gloss was measured using a glossmeter with respect to GS20° and the distinctness of reflected image was measured using a DOI measuring device (DorigonII), and the results are shown in Table 2 below.

Table 2

		Example 1	Example 2	Comparative Example 1	Comparative Example 2
Distinctness of reflected image	L direction	95.26	96.98	75.45	95.28
		95.35	96.65	75.30	95.70
		95.40	96.48	75.41	95.30
	Average (%)	95.34	96.70	75.39	95.43
	C direction	94.80	95.73	66.66	89.17
		94.79	95.75	63.12	90.22
		94.66	95.65	63.54	90.13
	Average (%)	94.75	95.71	64.44	89.84
	Deviation of L and C directions |L-C|	0.59	0.99	10.95	5.59

(continued)

		Example 1	Example 2	Comparative Example 1	Comparative Example 2
Gloss	L direction	1078	1091	820	1070
		1080	1090	816	1036
		1081	1088	815	1005
		1081	1089	813	1014
		1081	1090	815	1028
	Average in L direction	1080	1090	816	1031
	C direction	1081	1078	743	1005
		1082	1075	745	968
		1086	1059	742	956
		1082	1064	746	976
		1082	1085	739	1035
	Average in C direction	1083	1072	743	902
	Deviation of L and C directions |L-C|	3	18	73	129

[0103] FIG. 1 is an optical microscopic image showing surfaces of ferrite-based stainless steels according to examples of the present disclosure and comparative examples. Referring to FIG. 1, excellent gloss and clear surfaces were observed by visual observation in Examples 1 and 2 in which the roll diameter was controlled to 70 mm or less during cold rolling and surface polishing treatment was performed after hot annealing or after primary cold rolling. On the contrary, long surface defects formed in the longitudinal direction were observed in Comparative Examples 1 and 2.

[0104] FIGS. 2 and 3 are graphs showing area rates of micro flaws (%) and distribution densities of micro flaws of examples and comparative examples, respectively.

[0105] Referring to Tables 1 and 2 and FIGS. 1 and 2, it was confirmed that the area rates of micro flaws were 2% or less, and the distribution density of micro flaws having a length of 100 μm or more was 5 pieces/mm^2 or less in the ferrite-based stainless steels according to Examples 1 and 2, in which surface polishing was performed after primary cold rolling and cold rolling was performed using a roll with a diameter of 70 mm or less.

[0106] On the contrary, in the case of Comparative Example 1 in which a roll having a relatively great diameter was used during cold rolling and surface polishing was not performed, the area rate of micro flaws was 8% or more, and the distribution density of micro flaws having a length of 100 μm or more exceeded 35 pieces/mm^2, and blurred surfaces were visually observed.

[0107] FIGS. 4 and 5 are graphs showing distinctness of reflected image and deviation of distinctness of reflected image in a rolling direction (L direction) and a direction (C direction) perpendicular to the rolling direction in examples of the present disclosure and comparative examples.

[0108] Referring to Table 2 and FIG. 4, in the ferrite-based stainless steels according to Examples 1 and 2, in which surface polishing was performed after primary cold rolling and cold rolling was performed using a roll with a diameter of 70 mm or less, surface gloss (GS 20°C) was 1,050 or more in the rolling direction (L) and the direction (C) perpendicular to the rolling direction and the distinctness of reflected image was over 90 respectively which is higher than requirements for vehicle door trims.

[0109] Also, referring to FIG. 5, in the case of Examples 1 and 2, the deviation of distinctness of reflected image between the rolling direction (L) and the direction (C) perpendicular to the rolling direction was below 5. Particularly, in the case of Example 1, it was confirmed that although the area rate of micro flaws was 1.44%, which was higher than that of Comparative Example 2, a clearer surface was visually observed because the deviation of distinctness of reflected image between the L direction and the C direction was uniform.

[0110] Based thereon, it was confirmed that micro flaws having a great length decreased distinctness of reflected image in the C direction perpendicular to the rolling direction acting as a factor inducing deviation between the L direction and the C direction.

[0111] According to the above-described embodiment, a ferrite-based stainless steel having improved surface characteristics may be manufactured by removing micro flaws by primarily introducing surface polishing to reduce the deviation of surface distinctness of reflected image, and by controlling the size of micro flaws using a small-diameter rolling roll.

[0112] While the present disclosure has been particularly described with reference to exemplary embodiments, it should be understood by those of skilled in the art that various changes in form and details may be made without departing from the spirit and scope of the present disclosure.

[Industrial Applicability]

[0113] The ferrite-based stainless steel according to the present disclosure may be applied to home appliances or exterior trims of vehicles by uniformly obtaining gloss and deviation of distinctness of reflected image.

Claims

1. A ferrite-based stainless steel having improved surface characteristics comprising, in percent by weight (wt%), 0.001 to 0.05% of C, 0.001 to 0.05% of N, 0.1 to 1.0% of Si, 0.1 to 1.0% of Mn, 12.0 to 22.0% of Cr, 0.01 to 1.0% of Ti, 0.01 to 1.0% of Nb, and the remainder of Fe and unavoidable impurities,
wherein micro flaws having a length of 100 μm or more are distributed at a density of 5 pieces/mm^2 or less.

2. The ferrite-based stainless steel according to claim 1, further comprising at least one of 0.01 to 2.0% of Mo, 0.10% or less (excluding 0) of Al, 1.0% or less (excluding 0) of Cu, 0.01 to 0.3% of V, 0.01 to 0.3% of Zr, and 0.0010 to 0.0100% of B.

3. The ferrite-based stainless steel according to claim 1, wherein an area rate of micro flaws is 2% or less.

4. The ferrite-based stainless steel according to claim 1, wherein an area rate of micro flaws is 1.6% or less, and micro flaws having a length of 100 μm or more are distributed at a density of 2 pieces/mm^2 or less.

5. The ferrite-based stainless steel according to claim 1, wherein a distinctness of reflected image is 90 or more in a rolling direction (L direction) and a direction (C direction) perpendicular to the rolling direction, respectively.

6. The ferrite-based stainless steel according to claim 5, wherein a deviation of distinctness of reflected image between the L direction and the C direction is 5 or less.

7. A method for manufacturing a ferrite-based stainless steel having improved surface characteristics, the method comprising:

    hot rolling a slab comprising, in percent by weight (wt%), 0.001 to 0.05% of C, 0.001 to 0.05% of N, 0.1 to 1.0% of Si, 0.1 to 1.0% of Mn, 12.0 to 22.0% of Cr, 0.01 to 1.0% of Ti, 0.01 to 1.0% of Nb, and the remainder of Fe and unavoidable impurities and hot annealing the hot-rolled steel sheet;
    cold rolling and cold annealing the hot-rolled, annealed steel sheet twice or more by controlling a roll diameter to 70 mm or less;
    bright annealing the cold-rolled, annealed steel sheet; and
    skin pass rolling the bright-annealed steel sheet,
    wherein surface polishing treatment is introduced after hot annealing or after primary cold rolling.

8. The method according to claim 7, wherein the ferrite-based stainless steel further comprises at least one of 0.01 to 2.0% of Mo, 0.10% or less (excluding 0) of Al, 1.0% or less (excluding 0) of Cu, 0.01 to 0.3% of V, 0.01 to 0.3% of Zr, and 0.0010 to 0.0100% of B.

9. The method according to claim 7, wherein the cold rolling comprises:

    primary cold rolling performed at a reduction ratio of 40% or more; and
    secondary cold rolling performed at a reduction ratio of 40% or more,
    wherein a total reduction ratio is 80% or more.

10. The method according to claim 9, wherein the cold rolling further comprising tertiary cold rolling performed at a reduction ratio of 40% or more.

11. The method according to claim 7, wherein a re-heating temperature is from 1050 to 1280°C, and a final rolling temperature is from 800 to 950°C during the hot rolling.

12. The method according to claim 7, wherein the surface polishing treatment is performed by removing the surface layer by 7 μm or more using a polishing belt having a roughness of #70 mesh or more.

13. The method according to claim 12, wherein the surface polishing treatment is performed once or twice.

14. The method according to claim 7, wherein the cold annealing is performed at a temperature of 850 to 1,100°C.

15. The method according to claim 7, wherein the bright annealing is performed at a temperature of 850 to 1,100°C.

16. The method according to claim 7, wherein the skin pass rolling is performed using a work roll having an average roughness of #600 or more.

17. The method according to claim 16, wherein the skin pass rolling is performed twice to five times.

18. The method according to claim 16, wherein micro flaws having a length of 100 μm or more are distributed at a density of 5 pieces/mm^2 or less.

19. The method according to claim 7, wherein a distinctness of reflected image is 90 or more in a rolling direction (L direction) and a direction (C direction) perpendicular to the rolling direction, respectively.

20. The method according to claim 19, wherein a deviation of distinctness of reflected image between the L direction and the C direction is 5 or less.

FIG. 1

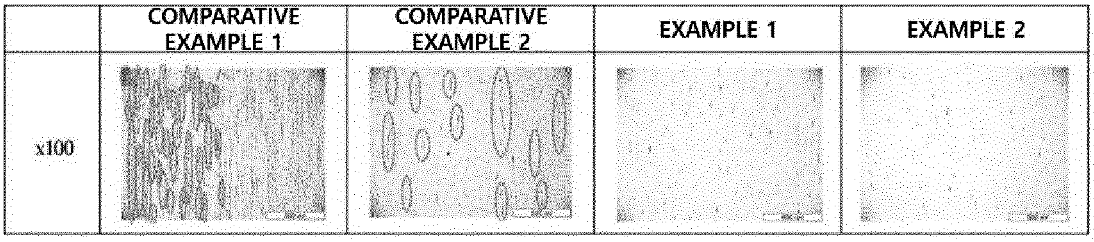


FIG. 2

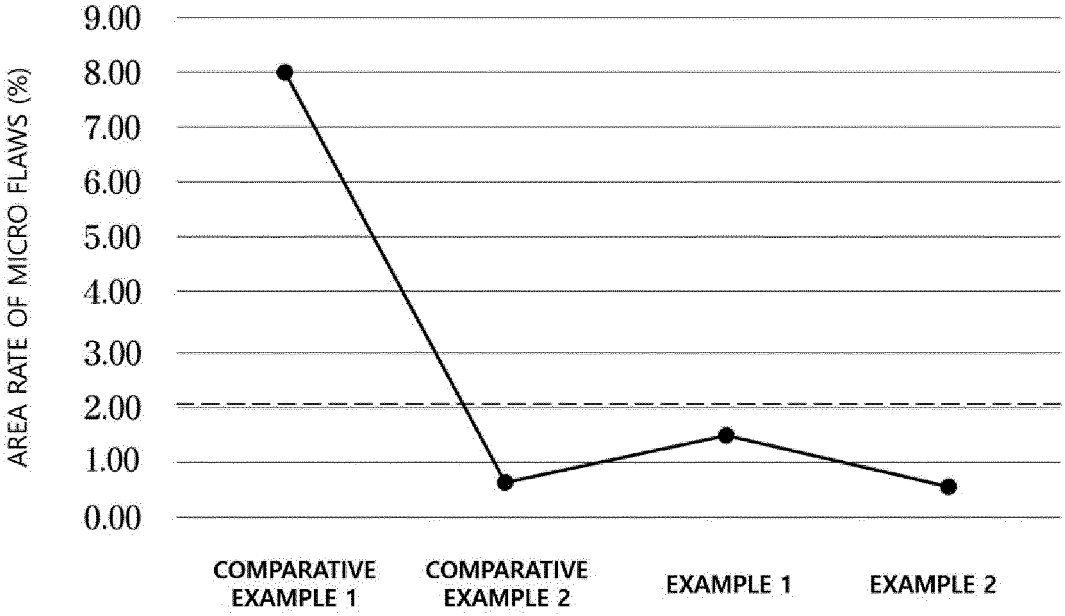


FIG. 3

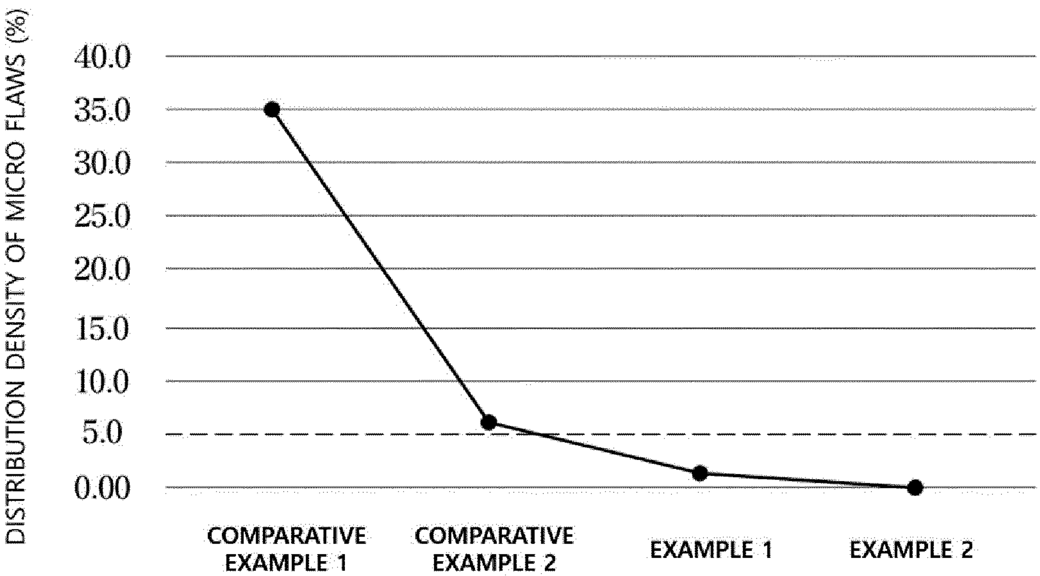


FIG. 4

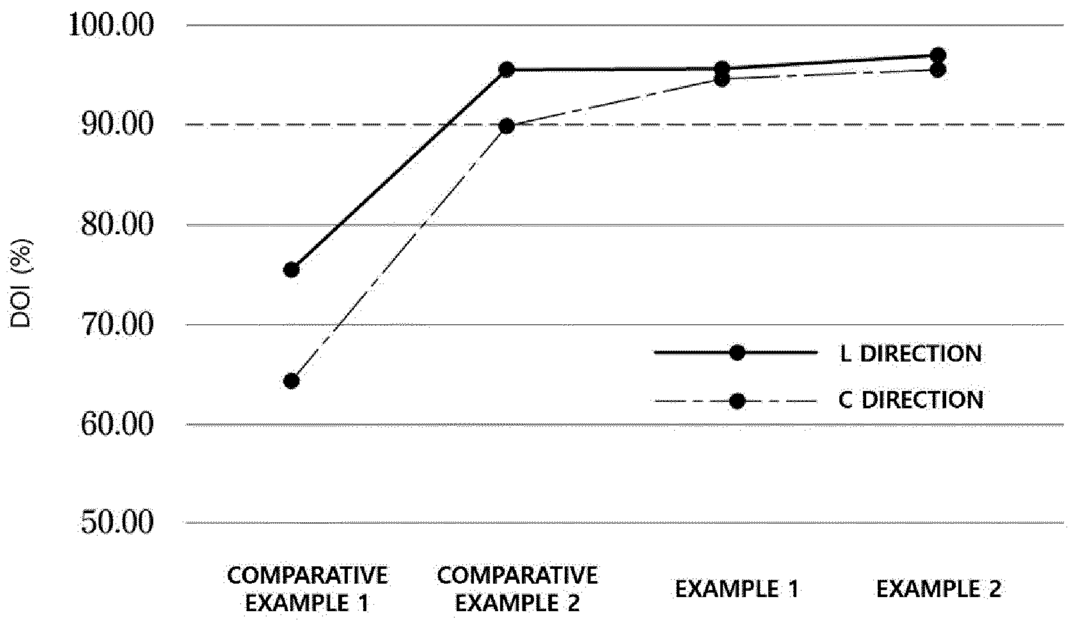
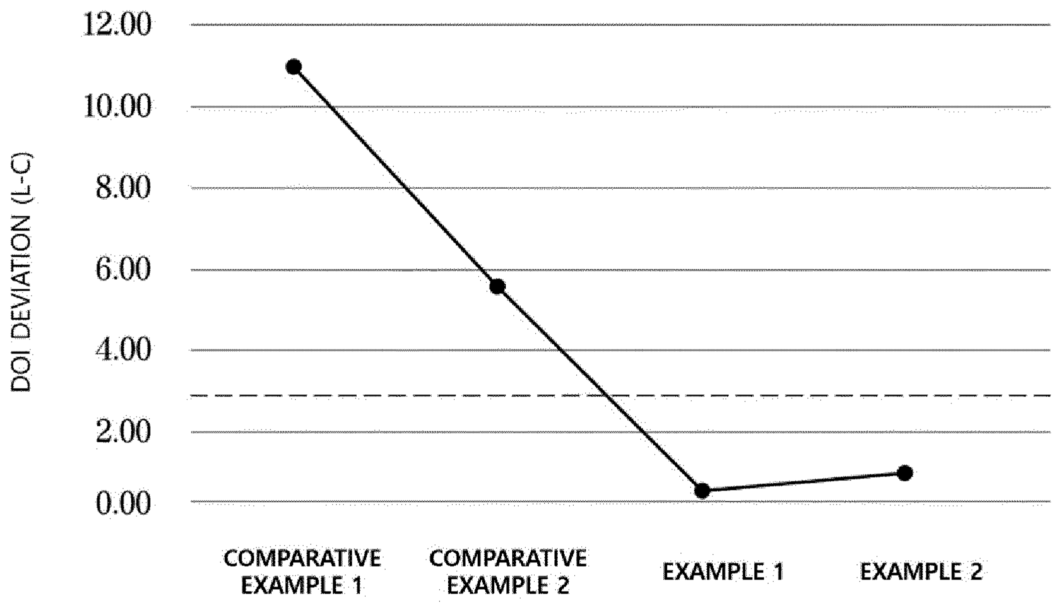

100.00
90.00
80.00
70.00
60.00
50.00
DOI (%)
L DIRECTION
C DIRECTION
COMPARATIVE EXAMPLE 1
COMPARATIVE EXAMPLE 2
EXAMPLE 1
EXAMPLE 2

FIG. 5


12.00
10.00
8.00
6.00
4.00
2.00
0.00
DOI DEVIATION (L-C)
COMPARATIVE EXAMPLE 1
COMPARATIVE EXAMPLE 2
EXAMPLE 1
EXAMPLE 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2020/014031

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/28(2006.01)i; **C22C 38/26**(2006.01)i; **C21D 8/02**(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C22C 38/28(2006.01); B21B 1/22(2006.01); C21D 8/02(2006.01); C22C 38/00(2006.01); C22C 38/16(2006.01); C22C 38/18(2006.01); H01M 8/1018(2016.01)

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: 페라이트(ferrite), 스테인리스(stainless), 스틸(steel), 규소(silicon), 망간(manganese), 크롬(chrome), 티타늄(titanium)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	KR 10-1828282 B1 (POSCO) 14 February 2018 (2018-02-14) See paragraphs [0003], [0006], [0030] and [0050]-[0058], and claims 1-6 and 10-12.	1-10,12-14,16-20 11,15
Y	KR 10-2011-0075407 A (POSCO) 06 July 2011 (2011-07-06) See paragraphs [0063]-[0064].	11
Y	KR 10-2017-0063899 A (NIPPON STEEL & SUMITOMO METAL CORPORATION) 08 June 2017 (2017-06-08) See paragraph [0160].	15
X	KR 10-2016-0143900 A (POSCO) 15 December 2016 (2016-12-15) See paragraphs [0015] and [0042] and claims 1-11.	1-10,13-14,16-20

☑ 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	Date of mailing of the international search report
27 January 2021	**29 January 2021**
Name and mailing address of the ISA/KR **Korean Intellectual Property Office** **Government Complex-Daejeon Building 4, 189 Cheongsa-ro, Seo-gu, Daejeon 35208** Facsimile No. **+82-42-481-8578**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2020/014031

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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		WO 2016-158426 A1	06 October 2016

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