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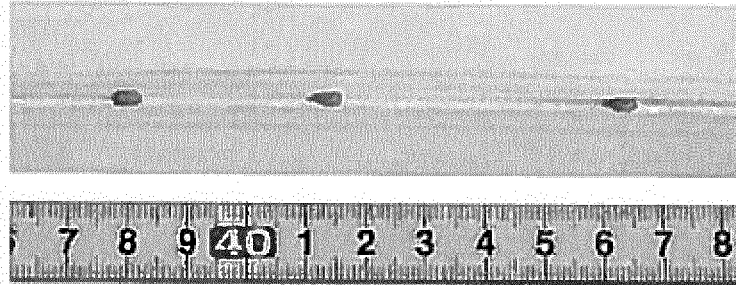
(54) **FERRITIC STAINLESS STEEL SHEET**

(57) Provided is a ferritic stainless steel sheet that has low susceptibility to exfoliation of black spots on a weld bead (in a TIG weld zone, in particular) during bending.

The ferritic stainless steel includes, in mass%, C: 0.020% or less, Si: 0.05 to 0.50%, Mn: 0.05 to 0.50%, P: 0.040% or less, S: 0.030% or less, Al: 0.001 to 0.150%, Cr: 18.0 to 25.0%, Ti: 0.01 to 0.50%, Ca: 0.0001 to 0.0015%, O (oxygen): 0.0015 to 0.0040%, and N: 0.025% or less, with the balance being Fe and incidental

impurities. The ferritic stainless steel sheet further satisfies formula (1), below: $0.5 \leq \text{PBI} \leq 20.0 \dots (1)$ (where $\text{PBI} = (7\text{Al} + 2\text{Ti} + \text{Si} + 10\text{Zr} + 130\text{Ca}) \times \text{O (oxygen)} \times 1000$, and Al, Ti, Si, Zr, Ca, and O (oxygen) in the formula each represent a content [mass%] of a corresponding element in the ferritic stainless steel sheet, and the content of an element not included in the ferritic stainless steel sheet is 0).

FIG. 1



Description

Technical Field

5 **[0001]** The present invention relates to a ferritic stainless steel sheet. In particular, the present invention relates to a ferritic stainless steel sheet that has excellent weld penetration characteristics and which has low susceptibility to exfoliation of black spots on the weld bead during bending.

Background Art

10 **[0002]** Ferritic stainless steel sheets are less costly and have better price stability than austenitic stainless steel sheets, which contain a high amount of Ni. Furthermore, ferritic stainless steel sheets have excellent corrosion resistance and are thus used in a variety of applications, such as building materials, transport equipment, home appliances, and kitchen equipment.

15 **[0003]** Among ferritic stainless steel sheets there is a Ti-stabilized ferritic stainless steel sheet, which includes Ti, a stabilizing element. Containing Ti results in formation of Ti carbonitride in the steel, which reduces dissolved C and dissolved N, and also promotes development of a {111} recrystallization texture. As a result, the steel sheet has excellent workability. When a Ti-stabilized ferritic stainless steel sheet is subjected to TIG welding (Tungsten Inert Gas welding), however, oxides called black spots tend to form on the weld bead even when sufficient gas shielding is provided.

20 **[0004]** Techniques for reducing the formation of black spots on the weld bead are disclosed in Patent Literature 1 and 2.

[0005] Patent Literature 1 discloses a ferritic stainless steel that achieves a reduced formation of black spots. The ferritic stainless steel satisfies a BI value ($3\text{Al} + \text{Ti} + 0.5\text{Si} + 200\text{Ca}$) expressed by the steel composition being 0.8 or less.

[0006] Patent Literature 2 discloses a ferritic stainless steel that achieves a reduced formation of black spots. The ferritic stainless steel satisfies the above described BI value by the steel composition being 0.8 or less.

25 **[0007]**

Citation List

Patent Literature

30 **[0007]**

PTL 1: Japanese Unexamined Patent Application Publication No. 2010-202973

PTL 2: Japanese Unexamined Patent Application Publication No. 2012-36444

35 Summary of Invention

Technical Problem

40 **[0008]** When large and thick black spots form, one problem is as follows. In the case that the steel sheet including the weld bead is subjected to bending, black spots may exfoliate and the sites after such black spots have exfoliated may act as initiation sites for crevice corrosion, which may result in deterioration of corrosion resistance. Neither of the technologies disclosed in Patent Literature 1 and 2 sufficiently inhibits exfoliation, during bending, of black spots of Ti-stabilized ferritic stainless steel sheets. Furthermore, since the upper limits of the contents of Si, Al, Ti, and Ca, which have a deoxidizing effect, are strictly limited, the oxygen concentration in the ferritic stainless steel tends to increase.

45 Thus, oxides tend to form in the steel and, in the process of steel sheet production, scabs and surface defects tend to form. The technologies disclosed in Patent Literature 1 and 2 pose such problems.

[0009] Currently, Ti-stabilized ferritic stainless steel sheets, described above, are widely used in household appliances in order to reduce product costs. On the other hand, structures of such home appliances are increasingly complex, and accordingly, there are cases in which a Ti-stabilized ferritic stainless steel sheet is applied to a portion that is to be exposed to a severe corrosive environment after its weld zone is processed by bending. Thus, there is a need for a Ti-stabilized stainless steel sheet that has low susceptibility to crevice corrosion attack which is caused by exfoliation of black spots even in the case that the weld bead is processed by bending.

50 **[0010]** The present invention is directed toward providing a ferritic stainless steel sheet that has low susceptibility to exfoliation of black spots in a TIG weld zone during bending.

55 **[0011]**

Solution to Problem

[0011] To address the problems described above, the present inventors conducted extensive research to inhibit ex-

foliation of black spots during bending. As a result, the following was found. The steel composition may be defined to have an O (oxygen) content of not greater than a specific value and have a PBI value, expressed by " $(7Al + 2Ti + Si + 10Zr + 130Ca) \times O \text{ (oxygen)} \times 1000$ ", of not greater than a specific value. This composition reduces the occurrence of exfoliation of black spots during bending regardless of the ratio of the total lengths of black spots in the bead direction to the full length of the weld bead (black spot formation length ratio).

[0012] Also, it was found that, in the case that the O (oxygen) content or the PBI value is extremely small, the weld bead has less tendency to penetrate in the sheet thickness direction and thus the weld penetration characteristics are degraded. Accordingly, the present inventors discovered that, by formulating defining the steel composition to have an O (oxygen) content within a specific range and have a PBI value within a specific range, good weld penetration characteristics and good inhibition of black spot exfoliation can both be achieved. The mechanism is believed to be as follows.

[0013] During TIG welding, the black spot moves on the weld bead as if the black spot were dragged by the electrode with increasing in size, and after being increased to a certain size or larger, the black spot is fixed to the edge of the weld bead. In a ferritic stainless steel sheet, when the content of an element having a high affinity for oxygen or the content of oxygen is low, the surface tension of the molten pool that forms during TIG welding decreases as the temperature increases. As a result, a strong flow forms on the surface of the molten pool, in a direction from the center of the weld bead, where the temperature is high, to the edge of the weld bead, where the temperature is low. With this strong flow, outward Marangoni convection becomes active. As a result, the black spot, in a state of being relatively small, is fixed to the bead edge. Thus, the individual black spots are thin and small, which results in a reduced occurrence of exfoliation during bending.

[0014] If the content of an element having a high affinity for oxygen or the content of oxygen is excessively low in a ferritic stainless steel sheet, outward Marangoni convection becomes extremely active and thus the "depth to width" ratio of the molten pool becomes extremely small. Consequently, characteristics of weld bead penetration in the sheet thickness direction are degraded.

[0015] Further studies were conducted based on the above findings, and the present invention was made. The gist of the invention is as follows.

[1] A ferritic stainless steel sheet including, in mass%, C: 0.020% or less, Si: 0.05 to 0.50%, Mn: 0.05 to 0.50%, P: 0.040% or less, S: 0.030% or less, Al: 0.001 to 0.150%, Cr: 18.0 to 25.0%, Ti: 0.01 to 0.50%, Ca: 0.0001 to 0.0015%, O (oxygen): 0.0015 to 0.0040%, and N: 0.025% or less, with the balance being Fe and incidental impurities, the ferritic stainless steel sheet further satisfying formula (1), below.

$$0.5 \leq PBI \leq 20.0 \dots (1)$$

(Here, $PBI = (7Al + 2Ti + Si + 10Zr + 130Ca) \times O \text{ (oxygen)} \times 1000$, and Al, Ti, Si, Zr, Ca, and O (oxygen) in the formula each represent a content [mass%] of a corresponding element in the ferritic stainless steel sheet, and the content of an element not contained in the ferritic stainless steel sheet is 0).

[2] The ferritic stainless steel sheet according to [1], further including, in mass%, at least one selected from Zr: 0.01 to 0.80%, Nb: 0.01% or greater and less than 0.40%, and V: 0.01 to 0.50%.

[3] The ferritic stainless steel sheet according to [1] or [2], further including, in mass%, at least one selected from Cu: 0.30 to 0.80%, Ni: 0.01 to 2.50%, Co: 0.01 to 0.50%, Mo: 0.01 to 2.00%, and W: 0.01 to 0.50%.

[4] The ferritic stainless steel sheet according to any one of [1] to [3], further including, in mass%, at least one selected from B: 0.0003 to 0.0030%, Mg: 0.0005 to 0.0100%, Y: 0.001 to 0.20%, REM (rare earth metal): 0.001 to 0.10%, Sn: 0.01 to 0.50%, and Sb: 0.01 to 0.50%.

[5] The ferritic stainless steel sheet according to any one of [1] to [4], wherein the ferritic stainless steel sheet has low susceptibility to exfoliation of black spots in a weld zone during bending.

Advantageous Effects of Invention

[0016] The present invention provides a ferritic stainless steel sheet that has low susceptibility to exfoliation of black spots in a TIG weld zone during bending. Furthermore, the ferritic stainless steel sheet of the present invention has excellent characteristics of weld bead penetration and also exhibits excellent corrosion resistance even at its bent portion.

Brief Description of Drawings

[0017] Fig. 1 is a diagram illustrating the appearance of black spots that formed in Example No. 3, of Table 1, which will be described later.

Description of Embodiments

[0018] Embodiments of the present invention, including the best mode, will be described below.

[0019] The ferritic stainless steel sheet of the present invention satisfies the following formula (1).

$$0.5 \leq \text{PBI} \leq 20.0 \dots (1)$$

Here, $\text{PBI} = (7\text{Al} + 2\text{Ti} + \text{Si} + 10\text{Zr} + 130\text{Ca}) \times \text{O (oxygen)} \times 1000$

(In formula (1), Al, Ti, Si, Zr, Ca, and O (oxygen) each represent the content [mass%] of the corresponding element in the ferritic stainless steel sheet, and the content of an element not contained in the ferritic stainless steel sheet is 0).

[0020] Al, Ti, Si, Zr, and Ca are elements having a particularly high affinity for oxygen and tend to form oxides. When the product of the value of the contents of these elements and the value of the oxygen content is large, black spots tend to exfoliate during bending. In equation (1), the coefficients of Al, Ti, Si, Zr, and Ca are determined based on the magnitude of the influence on the characteristics of weld bead penetration and on the magnitude of the influence that causes exfoliation of black spots during bending.

[0021] In the case that the PBI value is greater than 20.0, black spots exfoliate during bending. To inhibit such exfoliation, the PBI value is not greater than 20.0. In the case that the PBI value is not greater than 5.0, the exfoliation of black spots during bending can be further inhibited effectively.

[0022] In the case that the PBI value is less than 0.5, the characteristics of weld bead penetration in the sheet thickness direction is deteriorated. Accordingly, the PBI value is not less than 0.5 in the present invention. In the case that the PBI value is 1.5 or greater, the characteristics of weld bead penetration are excellent.

[0023] Furthermore, in the case that the PBI value is 1.5 or greater, good inhibition of exfoliation of black spots during bending is achieved compared with the case in which the PBI value is less than 1.5. This is believed to be due to the fact that, as described above, the weld penetration characteristics are better in the case that the PBI value is 1.5 or greater than in the case that the PBI value is less than 1.5. Thus, in the present invention, it is further preferable that the PBI value be 1.5 or greater and 5.0 or less.

[0024] Next, reasons for limiting the chemical composition to the aforementioned ranges in the present invention will be described. The percentages indicating the chemical composition of the steel are mass percentages unless otherwise specified.

C: 0.020% or less

[0025] C is an effective element for increasing the strength of steel. Thus, it is preferable that the C content not be less than 0.001%. On the other hand, if the C content is greater than 0.020%, corrosion resistance and workability deteriorate significantly. Thus, the C content is not greater than 0.020 %. The C content is preferably not greater than 0.015% and more preferably not greater than 0.010%.

Si: 0.05 to 0.50%

[0026] Si is an element which is useful as a deoxidizer. This effect is obtained when the Si content is 0.05% or greater. It is preferable that the Si content not be less than 0.08%. If the Si content is greater than 0.50%, the steel hardens and workability is deteriorated. In addition, even when the composition satisfies formula (1), black spots formed in TIG welding of a ferritic stainless steel sheet tend to exfoliate during bending, and the sites after such exfoliation may act as initiation sites for crevice corrosion. Thus, the Si content is not greater than 0.50%. The Si content is preferably not greater than 0.30% and more preferably not greater than 0.15%.

Mn: 0.05 to 0.50%

[0027] Mn acts as a deoxidizer. This effect is obtained when the Mn content is 0.05% or greater. The Mn content is preferably not less than 0.10%, more preferably not less than 0.15%, and even more preferably not less than 0.17%. If the Mn content is greater than 0.50%, precipitation and coarsening of MnS is promoted, which causes deterioration of corrosion resistance. Thus, the Mn content is not greater than 0.50%. The Mn content is preferably less than 0.30% and more preferably not greater than 0.20%.

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P: 0.040% or less

[0028] P is an element that deteriorates corrosion resistance. In addition, P deteriorates hot workability due to segregation at grain boundaries. For this reason, the P content is desirably as low as possible and is thus not greater than 0.040%. It is preferable that the P content not be greater than 0.030%. The lower limit of the P content is not particularly specified.

S: 0.030% or less

[0029] S, together with Mn, forms precipitated MnS. Such MnS deteriorates corrosion resistance due to acting as corrosion initiation sites. Thus, the S content is desirably low and is thus not greater than 0.030%. It is preferable that the S content not be greater than 0.020%. The S content is more preferably not greater than 0.010% and even more preferably not greater than 0.005%. The lower limit of the S content is not particularly specified.

Al: 0.001 to 0.150%

[0030] Al is an effective element for deoxidation. This effect is obtained when the Al content is 0.001% or greater. The Al content is preferably not less than 0.005% and more preferably not less than 0.010%. If the Al content is greater than 0.150%, formation of scales on the slab upper surface, which produce a lubricating effect in hot rolling, is reduced and thus surface defects tend to form, which deteriorates productivity. In addition, if the Al content is greater than 0.150%, black spots formed in TIG welding of steel sheets tend to exfoliate during bending even when the composition satisfies formula (1), and the sites after such exfoliation may act as initiation sites for crevice corrosion. Thus, the Al content is not greater than 0.150%. The Al content is preferably not greater than 0.100% and more preferably not greater than 0.050%.

Cr: 18.0 to 25.0%

[0031] Cr is an element that enhances corrosion resistance by forming a passivation film on the surface. If the Cr content is less than 18.0%, sufficient corrosion resistance is not achieved. Thus, the Cr content is not less than 18.0, preferably not less than 20.0%, and more preferably not less than 20.5%. If the Cr content is greater than 25.0%, toughness tends to be deteriorated because of the influence of the σ phase or 475°C embrittlement. Thus, the Cr content is not greater than 25.0%. The Cr content is preferably not greater than 23.0% and more preferably not greater than 21.5%.

Ti: 0.01 to 0.50%

[0032] Ti is an effective element for deoxidation. Also, Ti is an effective element to improve corrosion resistance, because it suppresses formation of Cr carbonitrides and Cr-depleted zones by stabilizing C and N. Furthermore, Ti improves workability by promoting development of a {111} recrystallization texture. These effects are obtained when the Ti content is 0.01% or greater. The Ti content is preferably not less than 0.05% and more preferably not less than 0.20%. If the Ti content is greater than 0.50%, the ferritic stainless steel sheet hardens and thus bendability is deteriorated. Further, TiN acts as corrosion initiation sites, which deteriorates corrosion. In addition, if the Ti content is greater than 0.50%, black spots formed in TIG welding of a steel sheet tend to exfoliate during bending even when the composition satisfies formula (1), and the sites after such exfoliation may act as initiation sites for crevice corrosion. For the above reasons, the Ti content is not greater than 0.50%. The Ti content is preferably not greater than 0.40% and more preferably not greater than 0.30%.

Ca: 0.0001 to 0.0015%

[0033] Ca is an effective element for deoxidation. This effect is obtained when the Ca content is 0.0001% or greater. The Ca content is preferably not less than 0.0002% and more preferably not less than 0.0003%. If Ca is contained in an amount of greater than 0.0015%, black spots formed in TIG welding of a steel sheet tend to exfoliate during bending even when the composition satisfies formula (1), and the sites after such exfoliation may act as initiation sites for crevice corrosion. Thus, the Ca content is not greater than 0.0015%. The Ca content is preferably not greater than 0.0010% and more preferably not greater than 0.0005%.

O (oxygen): 0.0015 to 0.0040%

[0034] O (oxygen) is an element that improves characteristics of weld bead penetration in the sheet thickness direction

in TIG welding. This effect is obtained when the O (oxygen) content is 0.0015% or greater. The O (oxygen) content is preferably not less than 0.0020% and more preferably not less than 0.0025%. If O (oxygen) is contained in an amount of greater than 0.0040%, black spots formed in TIG welding of a steel sheet tend to exfoliate during bending even when the composition satisfies formula (1), and the sites after such exfoliation may act as initiation sites for crevice corrosion. Thus, the O (oxygen) content is not greater than 0.0040%. The O (oxygen) is preferably not greater than 0.0035% and more preferably not greater than 0.0030%.

N: 0.025% or less

[0035] If N is contained in an amount of greater than 0.025%, corrosion resistance and workability significantly is deteriorated. Thus, the N content is not greater than 0.025%. It is desirable that N be reduced as much as possible. The N content is preferably not greater than 0.020% and more preferably not greater than 0.015%. The lower limit of the N content is not particularly specified.

[0036] While basic components have been described above, other elements, described below, can be contained in the present invention.

Zr: 0.01 to 0.80%

[0037] Similarly to Ti, Zr is an effective element for deoxidation. In addition, Zr is an element that improves corrosion resistance, since it suppresses formation of Cr carbonitrides and Cr-depleted zones and prevent sensitization by stabilizing C and N. In order to obtain these effects, it is preferable that the Zr content not be less than 0.01%. The Zr content is more preferably not less than 0.02% and even more preferably not less than 0.03%. On the other hand, if the Zr content is greater than 0.80%, the ferritic stainless steel sheet hardens and thus bendability may be deteriorated. In addition, if the Zr content is greater than 0.80%, black spots formed in TIG welding of a steel sheet tend to exfoliate during bending even when the composition satisfies formula (1), and this may result in initiation sites for crevice corrosion. Thus, the Zr content is not greater than 0.80%. The Zr content is more preferably not greater than 0.30% and even more preferably not greater than 0.10%.

Nb: 0.01% or greater and less than 0.40%

[0038] Similarly to Ti, Nb is an element that improves corrosion resistance, since it suppresses formation of Cr carbonitrides and Cr-depleted zones and prevent sensitization by stabilizing C and N. In order to obtain this effect, it is preferable that the Nb content not be less than 0.01%. The Nb content is more preferably not less than 0.03% and even more preferably not less than 0.05%. If the Nb content is 0.40% or greater, the ferritic stainless steel sheet hardens and may thus have deteriorated bendability, and in addition, the recrystallization temperature increases, which deteriorates productivity. Thus, it is preferable that the Nb content be less than 0.40%. The Nb content is more preferably not greater than 0.30% and even more preferably not greater than 0.15%.

V: 0.01 to 0.50%

[0039] V is an element that improves the crevice corrosion resistance of the ferritic stainless steel sheet. In order to obtain this effect, it is preferable that the V content not be less than 0.01%. The V content is more preferably not less than 0.03% and even more preferably not less than 0.05%. If the V content is greater than 0.50%, workability may be deteriorated. Thus, it is preferable that the V content not be greater than 0.50%. The V content is more preferably not greater than 0.30% and even more preferably not greater than 0.10%.

Cu: 0.30 to 0.80%

[0040] Cu is an element that improves corrosion resistance by strengthening the passivation film. If Cu is contained in excessive amounts, ϵ -Cu tends to precipitate, which may deteriorate corrosion resistance. Thus, it is preferable that the Cu content be from 0.30 to 0.80%. The lower limit of the Cu content is more preferably not less than 0.35% and even more preferably not less than 0.40%. The upper limit of the Cu content is more preferably not greater than 0.50% and even more preferably not greater than 0.45%.

Ni: 0.01 to 2.50%

[0041] Ni is an element that suppresses acid-induced anode reaction and thus makes it possible to maintain a passive state even at a lower pH. That is, Ni is highly effective in improving crevice corrosion resistance and noticeably suppresses

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the progress of corrosion in a state of active dissolution, and thus improves corrosion resistance. In order to obtain this effect, it is preferable that the Ni content not be less than 0.01%. The Ni content is more preferably not less than 0.05% and even more preferably not less than 0.10%. If the Ni content is greater than 2.50%, hydrogen embrittlement cracking tends to occur at worked portions. Thus, it is preferable that the Ni content not be greater than 2.50%. The Ni content is more preferably not greater than 0.80% and even more preferably not greater than 0.25%.

Co: 0.01 to 0.50%

[0042] Co is an element that improves the crevice corrosion resistance of the ferritic stainless steel. In order to obtain this effect, it is preferable that the Co content not be less than 0.01%. It is more preferable that the Co content not be less than 0.10%. If the Co content is greater than 0.50%, workability may be deteriorated. Thus, it is preferable that the Co content not be greater than 0.50%. The Co content is more preferably not greater than 0.30% and even more preferably not greater than 0.15%.

Mo: 0.01 to 2.00%

[0043] Mo has the effect of improving the crevice corrosion resistance of the ferritic stainless steel sheet. In order to obtain this effect, it is preferable that the Mo content not be less than 0.01%. The Mo content is more preferably not less than 0.10 and even more preferably not less than 0.30%. If the Mo content is greater than 2.00%, coarse intermetallic compounds may form, which may deteriorate toughness. Thus, it is preferable that the Mo content not be greater than 2.00%. The Mo content is more preferably not greater than 1.00% and even more preferably not greater than 0.60%.

W: 0.01 to 0.50%

[0044] W is an element that improves the crevice corrosion resistance of the ferritic stainless steel sheet. In order to obtain this effect, it is preferable that the W content not be less than 0.01%. It is more preferable that the W content not be less than 0.10%. If the W content is greater than 0.50%, workability may be deteriorated. Thus, it is preferable that the W content not be greater than 0.50%. It is more preferable that the W content not be greater than 0.30%.

B: 0.0003 to 0.0030%

[0045] B is an element that improves hot workability and secondary workability. It is known that addition of B to a Ti-containing steel is effective. In order to obtain this effect, it is preferable that the B content not be less than 0.0003%. It is more preferable that the B content not be less than 0.0010%. If the B content is greater than 0.0030%, toughness may be deteriorated. Thus, it is preferable that the B content not be greater than 0.0030%. It is more preferable that the B content not be greater than 0.0025%.

Mg: 0.0005 to 0.0100%

[0046] Mg acts as deoxidizer by forming a Mg oxide together with Al in molten steel. In order to obtain this effect, it is preferable that the Mg content not be less than 0.0005%. It is more preferable that the Mg content not be less than 0.0010%. If the Mg content is greater than 0.0100%, the toughness of the steel is deteriorated, which may reduce productivity. Thus, it is preferable that the Mg content not be greater than 0.0100%. The Mg content is more preferably not greater than 0.0050% and even more preferably not greater than 0.0030%.

Y: 0.001 to 0.20%

[0047] Y is an element that prevents a decrease in viscosity of molten steel and improves the cleanliness of the molten steel. In order to obtain this effect, it is preferable that the Y content not be less than 0.001%. If the Y content is greater than 0.20%, workability may be deteriorated. Thus, it is preferable that the Y content not be greater than 0.20%. It is more preferable that the Y content not be greater than 0.10%.

REM (rare earth metal): 0.001 to 0.10%

[0048] REMs (rare earth metals: elements having atomic numbers from 57 to 71, e.g., La, Ce, and Nd) are elements that improve high-temperature oxidation resistance. In order to obtain this effect, it is preferable that the REM content not be less than 0.001%. It is more preferable that the REM content not be less than 0.005%. If the REM content is greater than 0.10%, surface defects may form during hot rolling. Thus, it is preferable that the REM content not be greater

than 0.10%. It is more preferable that the REM content not be greater than 0.05%.

Sn: 0.01 to 0.50%

[0049] Sn is effective in reducing the formation of work-induced surface roughness composed of a deformation zone which is inevitably induced during rolling.

In order to obtain this effect, it is preferable that the Sn content not be less than 0.01%. It is more preferable that the Sn content not be less than 0.03%. If the Sn content is greater than 0.50%, workability may be deteriorated. Thus, it is preferable that the Sn content not be greater than 0.50%. It is more preferable that the Sn content not be greater than 0.20%.

Sb: 0.01 to 0.50%

[0050] Similarly to Sn, Sb is effective in reducing the formation of work-induced surface roughness composed of a deformation zone which is inevitably induced during rolling. In order to obtain this effect, it is preferable that the Sb content not be less than 0.01%. It is more preferable that the Sb content not be less than 0.03%. If the Sb content is greater than 0.50%, workability may be deteriorated. Thus, it is preferable that the Sb content not be greater than 0.50%. It is more preferable that the Sb content not be greater than 0.20%.

[0051] The balance, other than the elements described above, is Fe and incidental impurities.

[0052] Next, a suitable method for producing the ferritic stainless steel sheet of the present invention will be described. Steelmaking is performed by a known method using, for example, a converter, an electric furnace, or a vacuum melting furnace to obtain a steel having the chemical composition described above. Next, secondary refining is performed by, for example, VOD (vacuum oxygen decarburization) to control the oxygen concentration. Thereafter, a continuous casting process or an ingot casting-slabbing process is performed to produce a steel material (slab). The steel material is heated to a temperature of 1000°C to 1200°C and is thereafter hot-rolled to a sheet thickness of 2.0 mm to 5.0 mm under conditions including a finishing temperature of 700°C to 1000°C. The hot-rolled sheet, produced in this manner, is annealed at a temperature of 850°C to 1100°C and pickled and is next cold-rolled and then subjected to cold-rolled-sheet annealing at a temperature of 800°C to 1000°C. After cold-rolled-sheet annealing, pickling is performed for descaling. The descaled cold-rolled sheet may be subjected to skin pass rolling.

[0053] The ferritic stainless steel sheet of the present invention is effectively used not only as a cold-rolled sheet product as described above, but also as a hot-rolled sheet product. In addition, the ferritic stainless steel sheet of the present invention is suitable for bending. Furthermore, the ferritic stainless steel sheet of the present invention is suitable for applications in which the weld zone is processed by bending. Such a weld zone may be formed by any welding method. Preferably, such a weld zone is formed by TIG welding.

EXAMPLE

[0054] Examples of the present invention will be described below. The scope of the present invention is not limited to the examples described below.

[0055] Steelmaking was performed to produce 100-kg ingots of ferritic stainless steels having chemical compositions shown in Tables 1 to 5 (the balance being Fe and incidental impurities). Thereafter, heating to a temperature of 1200°C was performed and hot rolling was performed to obtain a hot-rolled sheet of 3.0 mm sheet thickness. Subsequently, annealing was performed at 1050°C and pickling was performed by a common method. Thereafter, cold rolling was performed to a sheet thickness of 1.0 mm, and further, annealing was performed at 900°C and pickling was performed by a common method.

[0056] Pieces of 35 mm × 200 mm were cut from the obtained cold-rolled and annealed sheet, and both sides of flat surface were dry-polished with #600 emery paper. Thereafter, the edge surface was scraped to obtain test pieces. I-shaped groove TIG welding was performed on the obtained test pieces to prepare welded members. The TIG welding conditions included a welding current of 70 A, a welding voltage of 11 V, and a welding speed of 40 cm/min. The shielding gas used was argon, with a flow rate of 15 L/min for the torch side and 10 L/min for the back side.

<Black spot exfoliation during bending>

[0057] To evaluate black spot exfoliation during bending, bending test pieces of 30 mm × 200 mm, including the weld bead, were cut from the obtained welded members. The test pieces were subjected to 180° tight bending such that the black spot formation area was the center of bending. Only a region including the front edge, in the bend, was cut and the front edge of the bend was observed with an optical microscope and a scanning electron microscope at a magnification of 120x and 3000x, respectively. Test pieces that had no exfoliation observed through either of the optical microscopes

or the scanning electron microscope were given a rating of "O" (pass: excellent), test pieces that had no exfoliation observed through the optical microscope but had exfoliation observed through the scanning electron microscope were given a rating of "□" (pass), and test pieces that had exfoliation observed through both microscopes were given a rating of "▲" (fail). The evaluation results are shown in the column "Exfoliation during bending" in Tables 1 to 5.

<Corrosion resistance of bent portion with black spots>

[0058] To evaluate the corrosion resistance of the bent portion with black spots, a compound cycle corrosion test was conducted on the aforementioned bending test pieces processed by bending. The end portions of the test piece were covered by vinyl tape, and thereafter the test piece was placed in a testing apparatus, with the front edge of the bent portion oriented upward in the vertical direction. The test environment was in accordance with JASO M609-91. One cycle was as follows: salt spray (5% NaCl), 2 h → drying (60°C), 4 h → exposure to humidity (50°C), 2h. Test pieces that had no outflow rust observed after 10 cycles of the test were given a rating of "O" (pass: excellent), test pieces that had no outflow rust observed at the time when 5 cycles of the test were completed but had outflow rust observed after 10 cycles of the test were given a rating of "□" (pass), and test pieces that had outflow rust observed at the time when 5 cycles of the test were completed were given a rating of "▲" (fail). The evaluation results are shown in the column "Corrosion resistance" in Tables 1 to 5.

<Weld Penetration Characteristics>

[0059] To evaluate the characteristics of weld bead penetration in the sheet thickness direction, the bead widths of the front bead and the back bead of the aforementioned welded member were measured. Then, the bead width of the front bead was divided by the bead width of the back bead to obtain a value (bead width of front bead/bead width of back bead value) for evaluation. Test pieces having a value of 2 or less were given a rating of "O" (pass: excellent), test pieces having a value of greater than 2 and not greater than 3 were given a rating of "□" (pass), and test pieces having a value of greater than 3 were given a rating of "▲" (fail). The evaluation results are shown in the column "Weldability" in Tables 1 to 5.

[Table 1]

Test No.	Chemical composition (mass%)													PBI	Exfoliation during bending	Corrosion resistance	Weldability	Remarks	
	C	Si	Mn	P	S	Al	Cr	Ti	Ca	O	N	Other elements (1)	Other elements (2)						Other elements (3)
1	0.008	0.14	0.15	0.022	0.003	0.046	18.1	0.28	0.0004	0.0026	0.011				2.8	○	○	○	Invention Example
2	0.010	0.11	0.21	0.022	0.003	0.039	19.5	0.29	0.0005	0.0027	0.007				2.8	○	○	○	Invention Example
3	0.013	0.09	0.19	0.024	0.002	0.027	21.1	0.22	0.0003	0.0028	0.012				2.1	○	○	○	Invention Example
4	0.007	0.09	0.17	0.023	0.003	0.028	22.8	0.25	0.0004	0.0028	0.011				2.3	○	○	○	Invention Example
5	0.009	0.12	0.22	0.020	0.002	0.032	24.7	0.26	0.0004	0.0030	0.011				2.7	○	○	○	Invention Example
6	0.010	0.15	0.15	0.029	0.003	0.001	21.0	0.25	0.0003	0.0027	0.008				1.9	○	○	○	Invention Example
7	0.011	0.10	0.23	0.024	0.001	0.012	21.2	0.29	0.0004	0.0029	0.009				2.4	○	○	○	Invention Example
8	0.007	0.12	0.25	0.022	0.003	0.094	20.7	0.26	0.0005	0.0028	0.008				3.8	○	○	○	Invention Example
9	0.009	0.13	0.21	0.027	0.001	0.147	21.3	0.30	0.0004	0.0027	0.009				4.9	○	○	○	Invention Example
10	0.013	0.14	0.19	0.028	0.001	0.042	21.8	0.02	0.0004	0.0028	0.012				1.5	○	○	○	Invention Example
11	0.009	0.12	0.16	0.027	0.003	0.024	21.1	0.08	0.0004	0.0029	0.011				1.5	○	○	○	Invention Example
12	0.012	0.11	0.31	0.025	0.001	0.022	21.3	0.27	0.0005	0.0027	0.011				2.3	○	○	○	Invention Example
13	0.008	0.09	0.17	0.024	0.003	0.035	21.1	0.49	0.0005	0.0027	0.011				3.7	○	○	○	Invention Example
14	0.008	0.06	0.19	0.028	0.002	0.022	20.7	0.21	0.0004	0.0026	0.008				1.8	○	○	○	Invention Example
15	0.010	0.08	0.16	0.027	0.002	0.030	20.5	0.24	0.0001	0.0028	0.009				2.2	○	○	○	Invention Example
16	0.012	0.14	0.19	0.028	0.003	0.021	21.2	0.28	0.0005	0.0028	0.008				2.6	○	○	○	Invention Example
17	0.013	0.45	0.24	0.022	0.001	0.030	21.3	0.26	0.0003	0.0029	0.010				3.5	○	○	○	Invention Example
18	0.008	0.11	0.16	0.020	0.001	0.028	20.9	0.24	0.0001	0.0027	0.008				2.2	○	○	○	Invention Example
19	0.013	0.09	0.21	0.022	0.003	0.027	21.2	0.25	0.0002	0.0026	0.011				2.1	○	○	○	Invention Example
20	0.007	0.11	0.17	0.024	0.001	0.026	21.3	0.27	0.0009	0.0026	0.008				2.5	○	○	○	Invention Example
21	0.008	0.09	0.18	0.029	0.003	0.022	21.2	0.23	0.0015	0.0026	0.012				2.3	○	○	○	Invention Example
22	0.008	0.11	0.21	0.023	0.003	0.038	21.5	0.27	0.0003	0.0016	0.011				1.5	○	○	○	Invention Example
23	0.009	0.12	0.24	0.022	0.002	0.030	20.5	0.29	0.0003	0.0022	0.010				2.1	○	○	○	Invention Example
24	0.008	0.08	0.21	0.021	0.002	0.033	21.3	0.21	0.0001	0.0034	0.009				2.5	○	○	○	Invention Example
25	0.011	0.09	0.15	0.028	0.001	0.023	21.5	0.30	0.0002	0.0038	0.012				3.3	○	○	○	Invention Example
26	0.008	0.33	0.16	0.022	0.002	0.044	20.7	0.38	0.0008	0.0035	0.013				5.3	□	○	○	Invention Example
27	0.011	0.45	0.22	0.027	0.001	0.098	21.3	0.25	0.0013	0.0038	0.012				6.9	□	○	○	Invention Example
28	0.010	0.43	0.20	0.027	0.001	0.136	20.9	0.46	0.0014	0.0034	0.012				8.4	○	□	○	Invention Example
29	0.011	0.47	0.20	0.029	0.001	0.147	21.1	0.48	0.0013	0.0039	0.010				10.2	□	□	○	Invention Example
30	0.012	0.08	0.17	0.026	0.002	0.030	21.2	0.12	0.0002	0.0026	0.009				1.4	○	○	□	Invention Example
31	0.008	0.09	0.18	0.030	0.002	0.026	21.5	0.11	0.0005	0.0022	0.008				1.2	□	○	□	Invention Example
32	0.007	0.10	0.16	0.023	0.001	0.024	20.7	0.12	0.0002	0.0018	0.008				1.0	○	○	□	Invention Example
33	0.012	0.09	0.15	0.027	0.002	0.022	21.4	0.16	0.0002	0.0015	0.013				0.9	□	○	□	Invention Example
34	0.008	0.08	0.17	0.027	0.002	0.021	20.7	0.03	0.0003	0.0026	0.012				0.8	○	□	□	Invention Example
35	0.008	0.06	0.25	0.022	0.002	0.002	21.0	0.11	0.0001	0.0018	0.010				0.6	○	□	□	Invention Example

[Table 2]

Test No.	Chemical composition (mass%)													PBI	Exfoliation during bending	Corrosion resistance	Weldability	Remarks
	C	Si	Mn	P	S	Al	Cr	Ti	Ca	O	N	Other elements (1)	Other elements (2)	Other elements (3)				
36	0.009	0.11	0.16	0.023	0.001	0.021	20.9	0.30	0.0004	0.0029	0.009	Zr:0.01			2.9	○	○	Invention Example
37	0.011	0.11	0.16	0.022	0.002	0.033	21.0	0.28	0.0002	0.0026	0.012	Zr:0.02			2.9	○	○	Invention Example
38	0.009	0.10	0.23	0.022	0.003	0.025	21.3	0.28	0.0003	0.0027	0.008	Zr:0.03			3.2	○	○	Invention Example
39	0.008	0.09	0.45	0.029	0.002	0.031	21.3	0.24	0.0004	0.0025	0.013	Zr:0.05			3.3	○	○	Invention Example
40	0.011	0.11	0.16	0.028	0.003	0.029	21.0	0.28	0.0003	0.0027	0.007	Zr:0.09			4.9	○	○	Invention Example
41	0.010	0.10	0.23	0.020	0.003	0.023	20.8	0.27	0.0002	0.0026	0.010	Zr:0.15			6.1	□	○	Invention Example
42	0.008	0.11	0.24	0.023	0.003	0.037	20.7	0.20	0.0001	0.0027	0.011	Zr:0.28			9.7	○	□	Invention Example
43	0.008	0.11	0.18	0.029	0.001	0.032	20.7	0.27	0.0003	0.0028	0.012	Zr:0.49			16.3	□	□	Invention Example
44	0.008	0.05	0.25	0.024	0.003	0.001	20.9	0.20	0.0001	0.0025	0.010	Zr:0.75			19.9	□	□	Invention Example
45	0.011	0.15	0.24	0.026	0.002	0.098	20.7	0.38	0.0014	0.0028	0.009	Zr:0.16			9.5	□	○	Invention Example
46	0.012	0.38	0.19	0.022	0.003	0.073	21.4	0.22	0.0012	0.0035	0.007	Zr:0.22			12.9	□	□	Invention Example
47	0.008	0.36	0.21	0.030	0.002	0.135	21.5	0.48	0.0005	0.0036	0.011	Zr:0.25			17.4	□	□	Invention Example
48	0.012	0.29	0.19	0.028	0.001	0.042	20.6	0.38	0.0003	0.0038	0.013	Zr:0.38			19.7	□	□	Invention Example
49	0.011	0.05	0.22	0.028	0.002	0.011	20.5	0.11	0.0002	0.0028	0.012	Zr:0.01			1.3	□	○	Invention Example
50	0.003	0.06	0.25	0.022	0.001	0.014	21.0	0.02	0.0003	0.0016	0.002	Zr:0.02			0.7	□	○	Invention Example
51	0.010	0.08	0.18	0.023	0.002	0.031	21.1	0.30	0.0001	0.0027	0.012	Nb:0.12			2.5	○	○	Invention Example
52	0.008	0.11	0.19	0.028	0.002	0.039	20.8	0.23	0.0005	0.0029	0.008	Nb:0.05			2.6	○	○	Invention Example
53	0.010	0.09	0.19	0.026	0.002	0.022	20.6	0.24	0.0003	0.0030	0.012	V:0.08			2.3	○	○	Invention Example
54	0.010	0.10	0.24	0.028	0.001	0.035	20.7	0.21	0.0005	0.0028	0.012	V:0.03			2.3	○	○	Invention Example
55	0.013	0.09	0.22	0.026	0.003	0.021	21.1	0.21	0.0004	0.0030	0.009	Zr:0.06, Nb:0.08			3.9	○	○	Invention Example
56	0.010	0.09	0.17	0.027	0.002	0.021	20.7	0.28	0.0002	0.0025	0.009	Zr:0.09, Nb:0.03			4.3	○	○	Invention Example
57	0.007	0.12	0.23	0.020	0.002	0.032	21.4	0.26	0.0004	0.0028	0.012	Zr:0.04, V:0.09			3.7	○	○	Invention Example
58	0.012	0.11	0.16	0.029	0.002	0.036	20.6	0.27	0.0005	0.0027	0.010	Zr:0.07, V:0.14			4.5	○	○	Invention Example
59	0.013	0.11	0.17	0.027	0.001	0.020	20.5	0.21	0.0003	0.0028	0.008	Zr:0.03, Nb:0.06, V:0.05			2.8	○	○	Invention Example
60	0.012	0.11	0.23	0.029	0.001	0.037	21.3	0.30	0.0002	0.0028	0.010	Zr:0.06, Nb:0.13, V:0.03			4.5	○	○	Invention Example
61	0.012	0.09	0.23	0.023	0.001	0.021	21.4	0.22	0.0004	0.0028	0.012	Cu:0.40			2.0	○	○	Invention Example
62	0.011	0.12	0.24	0.021	0.002	0.025	21.1	0.27	0.0002	0.0027	0.010	Ni:0.25			2.3	○	○	Invention Example
63	0.008	0.10	0.19	0.020	0.002	0.039	21.1	0.26	0.0002	0.0028	0.012	Co:0.14, Mo:0.31, W:0.18			2.6	○	○	Invention Example
64	0.009	0.08	0.20	0.028	0.001	0.027	21.4	0.23	0.0003	0.0030	0.007		B:0.0013		2.3	○	○	Invention Example
65	0.010	0.09	0.20	0.023	0.003	0.033	20.7	0.20	0.0004	0.0026	0.012		Mg:0.0022		2.0	○	○	Invention Example
66	0.007	0.11	0.16	0.025	0.001	0.030	20.6	0.20	0.0001	0.0026	0.012		Sn:0.01		1.9	○	○	Invention Example
67	0.011	0.11	0.24	0.023	0.003	0.026	20.7	0.25	0.0004	0.0029	0.012		Y:0.02, La:0.03, Sb:0.01		2.4	○	○	Invention Example

[Table 3]

Test No.	Chemical composition (mass%)													PBI	Exfoliation during bending	Corrosion resistance	Weldability	Remarks
	C	Si	Mn	P	S	Al	Cr	Ti	Ca	O	N	Other elements (1)	Other elements (2)	Other elements (3)				
68	0.013	0.12	0.23	0.021	0.002	0.040	21.2	0.28	0.0003	0.0029	0.009	Zr:0.05	Co:0.10		4.3	○	○	Invention Example
69	0.011	0.11	0.24	0.022	0.002	0.035	20.6	0.20	0.0003	0.0026	0.008	Zr:0.10	Cu:0.43		4.7	○	○	Invention Example
70	0.008	0.09	0.16	0.030	0.002	0.033	21.0	0.24	0.0004	0.0026	0.012	Zr:0.09	Cu:0.31, Mo:0.52		4.6	○	○	Invention Example
71	0.011	0.10	0.23	0.025	0.003	0.027	21.5	0.23	0.0003	0.0025	0.011	Nb:0.14	W:0.19		2.0	○	○	Invention Example
72	0.010	0.08	0.21	0.026	0.001	0.023	20.8	0.22	0.0002	0.0028	0.007	Nb:0.10	Cu:0.45		2.0	○	○	Invention Example
73	0.012	0.11	0.25	0.021	0.002	0.039	21.3	0.27	0.0003	0.0027	0.011	Nb:0.33	Ni:0.12, Co:0.45		2.6	○	○	Invention Example
74	0.011	0.11	0.20	0.021	0.002	0.028	20.8	0.29	0.0005	0.0025	0.011	V:0.08	Ni:0.22		2.4	○	○	Invention Example
75	0.012	0.10	0.19	0.021	0.001	0.039	20.9	0.21	0.0004	0.0029	0.008	V:0.09	Cu:0.80		2.5	○	○	Invention Example
76	0.012	0.09	0.23	0.027	0.002	0.033	20.8	0.24	0.0002	0.0026	0.012	V:0.25	Cu:0.44, Ni:0.15, W:0.28		2.2	○	○	Invention Example
77	0.010	0.08	0.16	0.028	0.003	0.027	21.4	0.25	0.0002	0.0027	0.009	Zr:0.04, Nb:0.14	Mo:0.52		3.2	○	○	Invention Example
78	0.011	0.09	0.24	0.026	0.002	0.020	20.9	0.27	0.0004	0.0025	0.009	Zr:0.06, Nb:0.11	Cu:0.40		3.6	○	○	Invention Example
79	0.011	0.08	0.17	0.024	0.003	0.024	20.9	0.29	0.0002	0.0027	0.013	Zr:0.07, Nb:0.11	Co:0.14, Mo:0.48		4.2	○	○	Invention Example
80	0.008	0.12	0.16	0.025	0.001	0.036	20.7	0.21	0.0004	0.0027	0.007	Zr:0.03, V:0.08	Cu:0.42		3.1	○	○	Invention Example
81	0.013	0.08	0.17	0.026	0.002	0.033	21.3	0.21	0.0001	0.0030	0.008	Zr:0.05, V:0.06	Cu:0.40, W:0.11		3.7	○	○	Invention Example
82	0.010	0.09	0.24	0.024	0.002	0.020	21.2	0.20	0.0003	0.0030	0.011	Zr:0.09, Nb:0.07, V:0.07	Ni:0.23		4.7	○	○	Invention Example
83	0.009	0.10	0.19	0.029	0.003	0.032	20.9	0.24	0.0002	0.0030	0.008	Zr:0.03, Nb:0.13, V:0.06	Cu:0.71		3.4	○	○	Invention Example
84	0.011	0.08	0.20	0.027	0.002	0.030	20.8	0.27	0.0002	0.0025	0.012	Zr:0.07, Nb:0.08, V:0.09	Cu:0.45, Ni:0.12		3.9	○	○	Invention Example
85	0.012	0.12	0.24	0.029	0.002	0.032	21.3	0.22	0.0003	0.0030	0.012	Zr:0.04		B:0.0017	3.7	○	○	Invention Example
86	0.008	0.11	0.24	0.020	0.002	0.021	20.7	0.21	0.0002	0.0027	0.009	Zr:0.09		Y:0.046, La:0.020	4.3	○	○	Invention Example
87	0.012	0.12	0.23	0.020	0.003	0.034	20.5	0.26	0.0001	0.0027	0.008	Nb:0.12		Mg:0.0016	2.4	○	○	Invention Example
88	0.010	0.10	0.22	0.025	0.001	0.024	21.0	0.27	0.0003	0.0027	0.010	Nb:0.13		Sn:0.19, Sb:0.12	2.3	○	○	Invention Example
89	0.013	0.10	0.25	0.020	0.003	0.028	21.3	0.23	0.0002	0.0029	0.007	V:0.07		Y:0.028	2.3	○	○	Invention Example
90	0.009	0.11	0.22	0.030	0.001	0.027	21.0	0.20	0.0002	0.0028	0.013	V:0.08		Mg:0.0015, La:0.035	2.0	○	○	Invention Example
91	0.011	0.12	0.19	0.021	0.002	0.034	20.5	0.22	0.0003	0.0028	0.009	Zr:0.06, Nb:0.08		Ce:0.027	4.0	○	○	Invention Example
92	0.011	0.09	0.23	0.024	0.001	0.029	21.4	0.28	0.0002	0.0025	0.010	Zr:0.10, Nb:0.11		B:0.0010, Y:0.048	4.7	○	○	Invention Example
93	0.010	0.08	0.16	0.024	0.003	0.025	21.1	0.26	0.0002	0.0028	0.009	Zr:0.08, V:0.05		Sn:0.19	4.2	○	○	Invention Example
94	0.008	0.10	0.23	0.021	0.003	0.027	21.1	0.24	0.0004	0.0027	0.009	Zr:0.10, V:0.06		B:0.0023, Mg:0.0012	4.9	○	○	Invention Example
95	0.008	0.10	0.16	0.021	0.003	0.022	21.1	0.30	0.0004	0.0028	0.011	Zr:0.08, Nb:0.11, V:0.07		Sb:0.04	4.8	○	○	Invention Example
96	0.010	0.09	0.21	0.022	0.002	0.020	20.5	0.30	0.0001	0.0028	0.010	Zr:0.07, Nb:0.13, V:0.05		Mg:0.0030, Sn:0.09	4.3	○	○	Invention Example

[Table 4]

Test No.	Chemical composition (mass%)													PBI	Exfoliation during bending	Corrosion resistance	Weldability	Remarks
	C	Si	Mn	P	S	Al	Cr	Ti	Ca	O	N	Other elements (1)	Other elements (2)	Other elements (3)				
97	0.009	0.12	0.21	0.021	0.003	0.029	21.4	0.27	0.0002	0.0029	0.011		Cu:0.40	B:0.0014	2.6	○	○	Invention Example
98	0.012	0.08	0.22	0.024	0.003	0.027	20.6	0.28	0.0001	0.0028	0.009		Ni:0.18, W:0.30	Mg:0.0025, Y:0.052	2.4	○	○	Invention Example
99	0.009	0.08	0.21	0.026	0.001	0.039	20.7	0.23	0.0005	0.0027	0.011	Zr:0.07	Co:0.13	Mg:0.0021	4.3	○	○	Invention Example
100	0.009	0.09	0.16	0.022	0.001	0.021	20.5	0.20	0.0004	0.0026	0.008	Zr:0.10	Cu:0.42	Sb:0.13	4.4	○	○	Invention Example
101	0.007	0.08	0.20	0.021	0.003	0.034	21.5	0.27	0.0005	0.0026	0.010	Zr:0.10	Ni:0.22, Mo:0.48	B:0.0028, Ce:0.027, Sn:0.14	5.0	○	○	Invention Example
102	0.012	0.10	0.16	0.022	0.001	0.024	21.0	0.20	0.0004	0.0025	0.008	Nb:0.12	Mo:0.34	Y:0.062	1.8	○	○	Invention Example
103	0.007	0.10	0.19	0.027	0.003	0.039	21.2	0.20	0.0001	0.0027	0.009	Nb:0.13	Cu:0.65	Mg:0.0020	2.1	○	○	Invention Example
104	0.012	0.11	0.18	0.020	0.002	0.038	20.8	0.29	0.0003	0.0030	0.010	Nb:0.06	Cu:0.43, Co:0.11, W:0.27	B:0.0018, Sn:0.01	3.0	○	○	Invention Example
105	0.012	0.12	0.16	0.026	0.002	0.030	20.9	0.29	0.0002	0.0025	0.008	V:0.06	W:0.16	Nd:0.012	2.3	○	○	Invention Example
106	0.008	0.10	0.24	0.028	0.001	0.029	21.5	0.28	0.0003	0.0027	0.008	V:0.10	Cu:0.43	Sn:0.12	2.4	○	○	Invention Example
107	0.008	0.08	0.15	0.021	0.002	0.022	20.8	0.23	0.0004	0.0030	0.011	V:0.09	Ni:0.16, Co:0.14, Mo:0.39	B:0.0016, Mg:0.0018, Y:0.072	2.2	○	○	Invention Example
108	0.009	0.12	0.21	0.029	0.001	0.026	21.3	0.22	0.0005	0.0027	0.010	Zr:0.04, Nb:0.14	Cu:0.44	Sn:0.16	3.3	○	○	Invention Example
109	0.009	0.11	0.22	0.029	0.003	0.025	21.1	0.29	0.0002	0.0028	0.009	Zr:0.08, Nb:0.07	Co:0.11, W:0.28	Mg:0.0022, Y:0.048, La:0.023	4.7	○	○	Invention Example
110	0.008	0.10	0.18	0.030	0.001	0.033	20.5	0.26	0.0004	0.0025	0.008	Zr:0.09, V:0.07	Ni:0.17	Sb:0.02	4.5	○	○	Invention Example
111	0.012	0.12	0.18	0.028	0.001	0.028	21.5	0.20	0.0004	0.0029	0.008	Zr:0.07, V:0.09	Cu:0.48	B:0.0024	4.3	○	○	Invention Example
112	0.012	0.09	0.23	0.028	0.002	0.024	21.1	0.30	0.0005	0.0027	0.010	Zr:0.04, V:0.06	Cu:0.41, Mo:0.34	Y:0.026, Sn:0.13	3.6	○	○	Invention Example
113	0.009	0.09	0.25	0.022	0.002	0.034	20.6	0.26	0.0004	0.0027	0.013	Zr:0.04, Nb:0.10, V:0.07	Mo:0.57	Mg:0.0023	3.5	○	○	Invention Example
114	0.009	0.10	0.18	0.027	0.001	0.030	21.2	0.22	0.0003	0.0029	0.008	Zr:0.04, Nb:0.11, V:0.08	Cu:0.30	B:0.0014	3.4	○	○	Invention Example
115	0.010	0.09	0.17	0.025	0.002	0.028	20.7	0.21	0.0002	0.0027	0.012	Zr:0.06, Nb:0.05, V:0.07	Cu:0.44, Ni:0.22, Co:0.15	Y:0.088, Sn:0.15, Sb:0.21	3.6	○	○	Invention Example

[Table 5]

Test No.	Chemical composition (mass%)															PBI	Exfoliation during bending	Corrosion resistance	Weldability	Remarks
	C	Si	Mn	P	S	Al	Cr	Ti	Ca	O	N	Other elements (1)	Other elements (2)	Other elements (3)						
116	0.010	0.11	0.24	0.020	0.003	<u>0.155</u>	21.1	0.24	0.0001	0.0026	0.011				4.4	▲	▲	○	Comparative Example	
117	0.009	0.12	0.19	0.025	0.002	0.029	<u>16.5</u>	0.25	0.0003	0.0026	0.009				2.2	○	▲	○	Comparative Example	
118	0.011	0.11	0.18	0.020	0.002	0.022	20.8	<u>0.53</u>	0.0002	0.0030	0.010	Zr:0.01			4.4	▲	▲	○	Comparative Example	
119	0.008	0.22	0.18	0.020	0.002	0.038	21.1	-	0.0004	0.0029	0.007				1.6	○	▲	○	Comparative Example	
120	0.013	<u>0.54</u>	0.22	0.030	0.002	0.033	20.5	0.13	0.0004	0.0028	0.009				3.0	▲	▲	○	Comparative Example	
121	0.012	0.11	0.18	0.028	0.002	0.035	21.1	0.29	<u>0.0018</u>	0.0029	0.008	Zr:0.01			3.7	▲	▲	○	Comparative Example	
122	0.011	0.14	0.18	0.020	0.001	0.098	18.8	0.20	0.0001	<u>0.0056</u>	0.009				6.9	▲	▲	○	Comparative Example	
123	0.008	0.14	0.20	0.021	0.003	0.026	21.1	0.11	0.0001	<u>0.0069</u>	0.007				3.8	▲	▲	○	Comparative Example	
124	0.009	0.06	0.18	0.029	0.002	0.011	21.4	0.16	0.0003	<u>0.0008</u>	0.012	Zr:0.04			0.7	□	○	▲	Comparative Example	
125	0.013	0.11	0.18	0.024	0.002	0.040	20.8	0.26	0.0010	<u>0.0014</u>	0.010				1.5	○	○	▲	Comparative Example	
126	0.010	0.15	0.21	0.024	0.002	0.047	21.5	0.17	0.0003	0.0028	<u>0.027</u>				2.4	○	▲	○	Comparative Example	
127	0.009	0.08	0.15	0.023	0.001	0.031	21.1	0.10	0.0005	0.0015	0.008	<u>Zr:0.82</u>			13.1	▲	▲	○	Comparative Example	
128	0.013	0.15	0.22	0.025	0.001	0.036	20.8	0.22	0.0010	0.0029	0.010	Zr:0.65			<u>21.7</u>	▲	▲	○	Comparative Example	
129	0.008	0.49	0.17	0.023	0.003	0.134	21.5	0.48	0.0012	0.0038	0.011	Zr:0.32			<u>21.8</u>	▲	▲	○	Comparative Example	
130	0.002	0.08	0.23	0.029	0.001	0.002	20.5	0.03	0.0001	0.0016	0.001				<u>0.3</u>	○	○	▲	Comparative Example	
131	0.012	0.06	0.25	0.026	0.001	0.005	21.4	0.08	0.0002	0.0015	0.010				<u>0.4</u>	□	○	▲	Comparative Example	
132	0.008	0.05	0.16	0.020	0.003	0.004	20.6	0.05	0.0004	0.0018	0.008				<u>0.4</u>	○	□	▲	Comparative Example	

[0060] The results obtained are shown in Tables 1 to 5. Invention Examples were evaluated as "pass" for all "Exfoliation during bending", "Corrosion resistance", and "Weldability". Furthermore, Invention Examples having a PBI value of 1.5 or greater and 5.0 or less, of all the Invention Examples, were excellent because the examples had a rating of "○" for all of the following: evaluation of black spot exfoliation during bending; corrosion resistance of the black spot formation area after bending; and characteristics of weld bead penetration in the sheet thickness direction. That is, it is seen that, in those examples, no black spots exfoliated during bending of the weld bead and thus corrosion resistance was excellent, and further the weld bead easily penetrated.

[0061] In Comparative Examples of Test Nos. 116, 118, 120 to 123 and 127, the contents of Al, Ti, Si, Ca, O, and Zr were each above the range in the present invention. As a result, black spots exfoliated during bending and the regions after such exfoliation had low corrosion resistance.

[0062] In Comparative Examples of Test Nos. 117 and 119, the contents of Cr and Ti were each below the range in the present invention. As a result, although no black spots exfoliated during bending, the regions including black spots had low corrosion resistance.

[0063] In Comparative Examples of Test Nos. 124 and 125, the content of O (oxygen) was below the range in the present invention. As a result, characteristics of weld bead penetration were poor.

[0064] In Comparative Example of Test No. 126, the content of N was above the range in the present invention. As a

result, although no black spots exfoliated during bending, the regions including black spots had low corrosion resistance.

[0065] In Comparative Examples of Test Nos. 128 and 129, the contents of the elements were within the ranges in the present invention respectively, but the PBI value of each was greater than 20.0. As a result, black spots exfoliated during bending and the regions after such exfoliation had low corrosion resistance.

[0066] In Comparative Examples of Test Nos. 130 to 132, the contents of the elements were within the ranges in the present invention respectively, but the PBI value of each was less than 0.5. As a result, characteristics of weld bead penetration were poor.

Industrial Applicability

[0067] The stainless steel sheet of the present invention has excellent characteristics of weld bead penetration, has low susceptibility to exfoliation, during bending, of black spots that form during welding, and has low susceptibility to occurrence of crevice corrosion due to exfoliation of black spots. Thus, the ferritic stainless steel sheet of the present invention is suitable for elevator inner panels, interiors, duct hoods, muffler cutters, lockers, home appliance parts, office equipment parts, automotive interior parts, automotive exhaust pipes, building materials, drain covers, marine transport containers, vessels, kitchen equipment, building interior and exterior materials, automotive parts, escalators, railway vehicles, and electrical device housing panels, for example.

Claims

1. A ferritic stainless steel sheet comprising, in mass%,

C: 0.020% or less,
Si: 0.05 to 0.50%,
Mn: 0.05 to 0.50%,
P: 0.040% or less,
S: 0.030% or less,
Al: 0.001 to 0.150%,
Cr: 18.0 to 25.0%,
Ti: 0.01 to 0.50%,
Ca: 0.0001 to 0.0015%,
O (oxygen): 0.0015 to 0.0040%, and
N: 0.025% or less, with the balance being Fe and incidental impurities,

the ferritic stainless steel sheet further satisfying formula (1), below:

$$0.5 \leq \text{PBI} \leq 20.0 \quad \dots (1)$$

(where $\text{PBI} = (7\text{Al} + 2\text{Ti} + \text{Si} + 10\text{Zr} + 130\text{Ca}) \times \text{O (oxygen)} \times 1000$, and Al, Ti, Si, Zr, Ca, and O (oxygen) in the formula each represent a content [mass%] of a corresponding element in the ferritic stainless steel sheet, and a content of an element not contained in the ferritic stainless steel sheet is 0).

2. The ferritic stainless steel sheet according to Claim 1, further comprising, in mass%, at least one selected from

Zr: 0.01 to 0.80%,
Nb: 0.01% or greater and less than 0.40%, and
V: 0.01 to 0.50%.

3. The ferritic stainless steel sheet according to Claim 1 or 2, further comprising, in mass%, at least one selected from

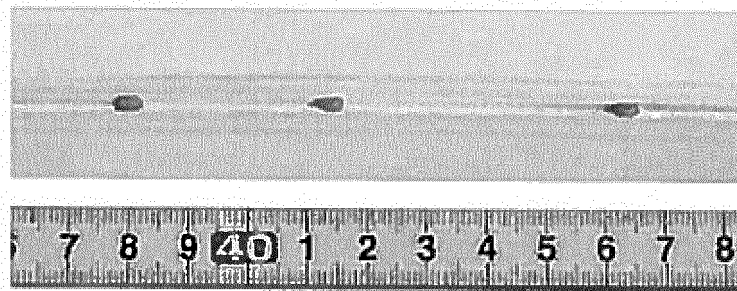
Cu: 0.30 to 0.80%,
Ni: 0.01 to 2.50%,
Co: 0.01 to 0.50%,
Mo: 0.01 to 2.00%, and
W: 0.01 to 0.50%.

4. The ferritic stainless steel sheet according to any one of Claims 1 to 3, further comprising, in mass%, at least one selected from

B: 0.0003 to 0.0030%,
Mg: 0.0005 to 0.0100%,
Y: 0.001 to 0.20%,
REM (rare earth metal): 0.001 to 0.10%,
Sn: 0.01 to 0.50%, and
Sb: 0.01 to 0.50%.

5. The ferritic stainless steel sheet according to any one of Claims 1 to 4, wherein the ferritic stainless steel sheet has low susceptibility to exfoliation of black spots in a weld zone during bending.

FIG. 1



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/006973

A. CLASSIFICATION OF SUBJECT MATTER

C22C38/00(2006.01)i, C22C38/28(2006.01)i, C22C38/60(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)

C22C38/00, C22C38/28, C22C38/60

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017

Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	WO 2016/017053 A1 (JFE Steel Corp.), 04 February 2016 (04.02.2016), table 1 & JP 5874864 B1 & KR 10-2017-0018457 A table 1 & TW 201610184 A	3-4 1-2, 5
X A	JP 2004-169150 A (JFE Steel Corp.), 17 June 2004 (17.06.2004), table 1 (Family: none)	4 1-3, 5

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
01 May 2017 (01.05.17)Date of mailing of the international search report
16 May 2017 (16.05.17)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/006973

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 2013-166989 A (Nippon Steel & Sumikin Stainless Steel Corp.), 29 August 2013 (29.08.2013), paragraph [0034] & WO 2013/122234 A1 & EP 2816133 A1 paragraph [0044]	1-5
A	JP 2013-209688 A (Nippon Steel & Sumikin Stainless Steel Corp.), 10 October 2013 (10.10.2013), paragraph [0034] (Family: none)	1-5
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A	JP 2000-144342 A (Sumitomo Metal Industries, Ltd.), 26 May 2000 (26.05.2000), (Family: none)	1-5

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- JP 2012036444 A [0007]