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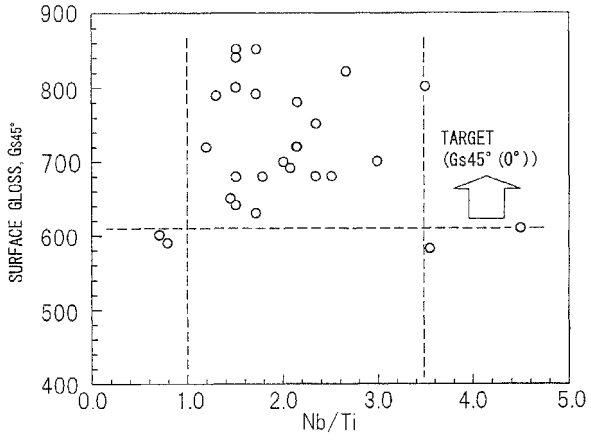
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(54) FERRITIC STAINLESS STEEL SHEET SUPERIOR IN SURFACE GLOSSINESS AND CORROSION RESISTANCE AND METHOD FOR PRODUCING SAME

(57) The stainless steel sheet according to the present invention is a ferritic stainless steel which is comprised of, by mass%, C: 0.001 to 0.03%, Si: 0.01 to 1.0%, Mn: 0.01 to 1.5%, P: 0.005 to 0.05%, S: 0.0001 to 0.01%, Cr: 12 to 16%, N: 0.001 to 0.03%, Nb: 0.05 to 0.3%, Ti: 0.03 to 0.15%, Al: 0.005 to 0.5%, Sn: 0.01 to 1.0%, and has the remainder of Fe and unavoidable impurities and satisfies the relationship of $1 \leq Nb/Ti \leq 3.5$. The method comprises heating a slab of stainless steel which contains the above steel ingredients, setting the extraction temperature 1080 to 1190°C, and setting the coiling temperature after the end of hot rolling 500 to 700°C. After hot rolling, the method comprises annealing the hot rolled sheet, which can be omitted, cold rolling once or cold rolling twice or more which includes processing annealing, and finish annealing the steel sheet at 850 to 980°C.

Fig.1



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Description

Technical Field

[0001] The present invention relates to an alloy-saving type ferritic stainless steel sheet which is excellent in surface glossiness and corrosion resistance and a method for producing the same.

Background Art

[0002] A ferritic stainless steel sheet is extensively used in household electrical appliances, kitchen equipments, and other fields in which corrosion resistance and surface quality in an indoor environment are demanded. As examples of such a ferritic stainless steel sheet, SUS430LX and SUS430J1L in the JIS standard may be mentioned. Further, NPLT 1 describes representative examples SUS430LX and SUS430J1L which are excellent in corrosion resistance. Such a ferritic stainless steel reduces the C and N, contains Cr: 16 to 20%, Nb: 0.3 to 0.6%, and Ti and trace amounts of Cu and Mo added compositely to prevent deterioration of the surface properties due to pitting or rusting.

[0003] In the past, the above-mentioned ferritic stainless steel sheet to which Nb, Ti, etc. have been added, has had the defect of being inferior in surface glossiness compared with other ferritic stainless steel sheet (SUS430) in the No. 3D finished or No. 2B finished products prescribed in JIS G 4305 and G 4307. PLT 1 discloses the method of production of cold rolled steel strip which is excellent in surface glossiness by the control of the amount of oxide scale formation in annealing a ferritic stainless steel to which Ti, Nb, etc. are added. Further, PLT 2 discloses the method of descaling cold rolled steel strip and the method of production of stainless cold rolled steel strip which is excellent in glossiness and corrosion resistance which prescribes the step of neutral salt electrolysis-nitrate electrolysis. While PLT 3 discloses the method of production of high glossiness stainless steel strip which controls the roughness of the work roll and lubrication conditions in cold rolling.

[0004] The above-mentioned ferritic stainless steel sheet is excellent economically to an austenitic stainless steel sheet which contains a large amount of Ni - which has remarkably risen in price in recent years. However, due to the price fluctuations in the component element Cr of stainless steel and the rising price of the rare element Nb, it is difficult to say that SUS430LX and SUS430J1L will also have economically sufficient in the future.

[0005] As a solution to the above problem, the method of improving the corrosion resistance by utilizing trace elements may be considered. PLT 4 and PLT 5 disclose a ferritic stainless steel which proactively adds P so as to improve the weather resistance, corrosion resistance, and crevice corrosion resistance. PLT 4 is a high Cr and P ferritic stainless steel which contains Cr: over 20% to 40% and P: over 0.06% to 0.2%. PLT 5 is a P ferritic stainless steel which contains Cr: 11% to less than 20% and P: over 0.04% to 0.2%. However, P becomes a factor inhibiting manufacturability, workability, and weldability.

[0006] The inventors have disclosed a ferritic stainless steel which is improved in corrosion resistance by utilizing trace elements - without relying on alloying of Cr or Mo from the viewpoint of economy. PLT 6 is a ferritic stainless steel which contains Cr: 13 to 22% and Sn: 0.001 to 1%, reduces the C, N, Si, Mn, and P, and adds Ti: 0.08 to 0.35% as a stabilizing element. However, these literatures do not study the effects on the surface glossiness at all, as explained above.

Citations List

Patent Literature

[0007]

PLT 1: Japanese Unexamined Patent Publication No. 61-288021 A1
PLT 2: Japanese Unexamined Patent Publication No. 4-232297 A1
PLT 3: Japanese Unexamined Patent Publication No. 8-243603 A1
PLT 4: Japanese Unexamined Patent Publication No. 6-172935 A1
PLT 5: Japanese Unexamined Patent Publication No. 7-34205 A1
PLT 6: Japanese Unexamined Patent Publication No. 2009-174036 A1

Non Patent Literature

[0008] NPLT 1: Stainless Steel Handbook, 3rd Edition, P532

Summary of Invention

Technical Problem

[0009] As explained above, SUS430LX and SUS430J1L, which contain 16% or more of Cr and have Nb or other stabilizing elements added to them, have economical problems in the future. On the other hand, the ferritic stainless steel which utilizes trace elements to improve the corrosion resistance, has problems from the viewpoint of manufacturability and surface glossiness. In recent years, in the stainless steel sheet which is used for household electrical appliances, kitchen equipments, etc. a demand of the improvement in surface glossiness increases.
Therefore, the present invention has as its theme to obtain a corrosion resistance which is not different from SUS430LX or SUS430J1L by an amount of Cr of less than 16% and strikingly improve the surface glossiness in alloy-saving type ferritic stainless steel sheet and has as its object the provision of alloy-saving type ferritic stainless steel sheet and a method for producing the same which realize this.

Solution to Problem

[0010] The inventors engaged in in-depth studies to solve the above problem. As a result, the inventors obtained the following new findings which are the effect of improvement of corrosion resistance due to the addition of Sn and, in addition, and the relationship between the addition of the stabilizing elements Nb and Ti and the surface glossiness in ferritic stainless steel with an amount of Cr of less than 16%, and thereby completed the present invention.

[0011]

(a) To realize the effect of improvement of the corrosion resistance due to addition of a trace amount of Sn, 12% or more of an amount of Cr is required. In addition, to maintain the soundness of the passivation film comprised of Cr and a trace amount of Sn, it is effective to reduce the C, N, Si, Mn, P, and S and add Nb and Ti which are stabilizing elements.

[0012]

(b) Nb is a stabilizing element which is effective for appearing an action in improving the corrosion resistance and surface glossiness. In steel to which a trace amount of Sn is added, that action is appeared from 0.05%. However, if adding Nb 0.3% or more, the rise in the hot rolling heating temperature and annealing temperature of the steel material leads to a decrease in the surface gloss due to the oxide scale.

[0013]

(c) Ti has an action as a stabilizing element which immobilizes C and N and, in addition, forms Ti-based carbosulfides (for example, $Ti_4C_2S_2$) at the time of heating for hot rolling and suppresses the formation of MnS or CaS which form starting points of rust. In steel to which a trace amount of Sn is added, that action is appeared from 0.03%. However, if adding Ti 0.15% or more, scabs due to inclusions and concentration of Ti in the oxide film cause a decrease in surface glossiness.

[0014]

(d) It was discovered that the effects of addition of Nb and Ti in the above steel to which a trace amount of Sn is added, remarkably appear in composite addition in the range of $1 \leq Nb/Ti \leq 3.5$. That is, to improve the corrosion resistance and surface glossiness of steel to which a trace amount of Sn is added, it was found that it is effective to add mainly Nb, which has a large action in improving the surface glossiness, and compositely add a trace amount of Ti so as to suppress the formation of starting points of rust and maintain the soundness of the passivation film.

[0015]

(e) The action of improvement of the surface glossiness due to the addition of Nb is still unclear in many points, but the cause of the decrease in the surface glossiness, that is, the internal oxidation and grain boundary oxidation in heating for hot rolling and annealing, are more suppressed due to the presence of solute Sn and solute Nb. Therefore, the effect of improvement of the glossiness due to the addition of Nb is believed to be obtained due to the superposition with solute Sn.

[0016]

(f) The extraction temperature after heating for hot rolling, from the viewpoint of improvement of the glossiness, is a temperature for securing the amount of scale formation for removing inclusions at the cast slab surface layer which induce scabs and for forming Ti-based carbon sulfides (for example, $Ti_4C_2S_2$) to suppress the formation of MnS or CaS which forms rust. In a steel with an amount of Cr of less than 16% and to which a trace amount of Sn is added, setting the temperature 1080 to 1190°C is effective.

[0017]

(g) Coiling after hot rolling, from the viewpoint of improvement of the surface glossiness, suppresses surface defects at the time of coiling and suppresses internal oxides and grain boundary oxidation which decrease in glossiness. In a steel with an amount of Cr of less than 16% and to which a trace amount of Sn is added, setting the temperature 500 to 700°C is effective. Further, it is effective to set the annealing temperature 980°C or less from the viewpoint of securing glossiness.

[0018] The gist of the present invention, obtained based on the above findings (a) to (g), is as follows:

[0019]

(1) A ferritic stainless steel sheet which is excellent in surface glossiness and corrosion resistance comprising: by mass%,

C: 0.001 to 0.03%,
Si: 0.01 to 1.0%,
Mn: 0.01 to 1.5%,
P: 0.005 to 0.05%,
S: 0.0001 to 0.01%,
Cr: 12 to 16%,
N: 0.001 to 0.03%,
Nb: 0.05 to 0.3%,
Ti: 0.03 to 0.15%,
Al: 0.005 to 0.5%, and
Sn: 0.01 to 1.0%; and
the steel sheet having the remainder being Fe and
unavoidable impurities, and satisfying the relationship of $1 \leq Nb/Ti \leq 3.5$.

[0020]

(2) The ferritic stainless steel sheet which is excellent in surface glossiness and corrosion resistance as set forth in (1), wherein the stainless steel sheet further contains, by mass%, one element or more of

Ni: 0.01 to 0.5%,
Cu: 0.01 to 0.5%,
Mo: 0.01 to 0.5%,
V: 0.01 to 0.5%,
Zr: 0.01 to 0.5%,
Co: 0.01 to 0.5%,
Mg: 0.0001 to 0.005%,
B: 0.0003 to 0.005%, and
Ca: 0.0003 to 0.005%.

[0021]

(3) A method of production of a ferritic stainless steel sheet which is excellent in surface glossiness and corrosion resistance, comprising of: heating a slab of stainless steel which contains the steel ingredients described in the above (1) or (2), taking out the slab from the heating furnace at an extraction temperature of 1080 to 1190°C, and hot rolling and coiling the steel sheet at a temperature of 500 to 700°C.

[0022]

(4) The method of production of ferritic stainless steel sheet which is excellent in surface glossiness and corrosion resistance as set forth in (3), comprising of: coiling the steel sheet in hot rolling, cold rolling and finish annealing the steel sheet at 850 to 980°C.

[0023]

(5) The method of production of the ferritic stainless steel sheet which is excellent in surface glossiness and corrosion resistance as set forth in (3), comprising of: coiling the steel sheet in hot rolling, cold rolling twice or more which includes processing annealing, and finish annealing the steel sheet at 850 to 980°C.

[0024]

(6) The method of production of the ferritic stainless steel sheet which is excellent in surface glossiness and corrosion resistance as set forth in (4) or (5), comprising of: coiling the steel sheet in hot rolling, and annealing the hot rolled sheet at an annealing temperature of in the range of the recrystallization temperature to 1050°C before cold rolling.

Advantageous Effects of Invention

[0025] According to the present invention, the remarkable effect is exhibited of obtaining an alloy saving type ferritic stainless steel sheet which is excellent in surface glossiness and corrosion resistance which does not rise in alloy cost or manufacturing cost and therefore is excellent in economy. The steel sheet has a corrosion resistance no different from SUS430LX and SUS430J1L, and remarkably improves the surface glossiness.

Brief Description of Drawings

[0026]

FIG. 1 shows the relationship between the Nb/Ti amount and surface glossiness Ga45° (0°). FIG. 2 shows the relationship between the Nb/Ti amount and surface glossiness Ga45° (90°).

Description of Embodiments

[0027] The requirements of the present invention will be explained in detail. Note that the "%" of content of the elements means "mass%".

[0028]

[1] The reasons limitation of the ingredients will be explained below.

Because C degrades the corrosion resistance, the upper limit of its content is 0.03%. From the viewpoint of the corrosion resistance, the less the content of C is, the better characteristics are presented. The upper limit is preferably 0.02%, more preferably 0.01%, still more preferably 0.005%. Further, excessive reduction leads to an increase in the refining cost, so the lower limit of the content is 0.001%. Considering the corrosion resistance or manufacturing cost, the lower limit is preferably 0.002%.

[0029] Si is sometimes added as a deoxidizing element. However, Si is a solution strengthening element. From the viewpoint of the suppression of the decrease in the workability, the upper limit is 1.0%. From the viewpoint of the workability, the less the content of Si is, the better characteristics are presented. The upper limit is preferably 0.6%, more preferably 0.3%, still more preferably 0.2%. Further, because an excessive reduction leads to an increase in the refining cost, the lower limit of the Si content is 0.01%. If considering the workability and manufacturing cost, the lower limit is preferably 0.05%.

[0030] Since Mn is an element which forms MnS, the starting point of rust, and inhibits the corrosion resistance, so content should be as little as possible. From the viewpoint of suppression of the decrease in the corrosion resistance, the upper limit of the content is 1.5%. From the viewpoint of the corrosion resistance, the less the content of Mn is, the better characteristics are presented. The upper limit is preferably 1.0%, more preferably 0.3%, still more preferably 0.2%. Further, excessive reduction leads to an increase in the refining cost, so the lower limit of the content of Mn is 0.01%. Preferably, considering the corrosion resistance and the manufacturing cost, the lower limit should be 0.05%.

[0031] Because P is an element which inhibits manufacturability and weldability, the less the content of P is, the better

characteristics are presented. From the viewpoint of suppression of the decrease in manufacturability and weldability, the upper limit of the content is 0.05%. From the viewpoint of the manufacturability and weldability, the less the content of P is, the better characteristics are presented. The upper limit is preferably 0.04%, more preferably 0.03%. Further, an excessive reduction leads to an increase in the refining costs, so the lower limit of the content of P is 0.005%. More preferably, considering the manufacturing cost, it should be 0.01%.

[0032] S is an impurity element. It inhibits corrosion resistance and hot workability. The less the content of S is, the better characteristics are presented. To secure the corrosion resistance and hot workability, the upper limit of the content of S is 0.01%. From the viewpoint of the corrosion resistance or hot workability, the less the content of S is, the better characteristics are presented. The upper limit is preferably 0.005%, more preferably 0.003%, still more preferably 0.002%. Further, since an excessive reduction leads to an increase in the refining cost, preferably the lower limit of the content is 0.0001%. More preferably, considering the corrosion resistance and manufacturing cost, the lower limit should be 0.0002%.

[0033] Cr is an element of ferritic stainless steel. It is also an essential element for securing the corrosion resistance. To secure the corrosion resistance of the present invention, the lower limit is 12%. The upper limit is 16% from the viewpoint of economy compared with SUS430LX. Considering the corrosion resistance and the amount of addition of Sn, it is preferably 13 to 15%.

[0034] N, as well as C, degrades the corrosion resistance, so the smaller the content, the better, therefore the upper limit is 0.03%. From the viewpoint of the corrosion resistance, the less the content of N, the better characteristics are presented. The upper limit is preferably 0.02%, more preferably 0.012%. Further, excessive reduction leads to an increase in the refining cost, so preferably the lower limit is 0.001%. More preferably, considering the corrosion resistance and manufacturing cost, the content should be 0.005%.

[0035] Nb is an essential element for improving the corrosion resistance and, in addition, improving the surface gloss in the trace Sn steel of the present invention. The above effect is expressed from 0.05% or more. However, excessive addition raises the recrystallization temperature of the steel and conversely causes a decrease in the surface glossiness. Therefore, the upper limit is 0.3%. Preferably, considering the corrosion resistance, surface glossiness, and manufacturability, the content is 0.1 to 0.2%.

[0036] Ti functions as a stabilizing element which immobilizes the C and N and also is an essential element for improvement of the corrosion resistance. The above effect is expressed from 0.03%. However, excessive addition leads to a decrease in the surface glossiness due to scabs caused by inclusions and concentration of Ti in the oxide film. Therefore, the upper limit is 0.15%. Preferably, considering the corrosion resistance, surface gloss, and manufacturability, the content is 0.05 to 0.1%.

[0037] Because Al is an element which is effective as a deoxidizing element, the lower limit of the content is 0.005%. However, since excessive addition causes deterioration of the workability or toughness and weldability, the upper limit of the content of Al is 0.5%. From the viewpoint of the workability, toughness, and weldability, the less the content of Al is, the better characteristics are presented. The upper limit is preferably 0.1%, more preferably 0.05%, still more preferably 0.03%. Further, considering the refining cost, the lower limit of the content is more preferably 0.01%.

[0038] Sn is an essential element for securing the corrosion resistance which is targeted by the present invention without relying on alloying of Cr and Mo and addition of the rare elements Ni, Co, etc. To obtain the corrosion resistance which is targeted by the present invention, the lower limit of the content of Sn is 0.01%. To secure the better corrosion resistance, the content is preferably 0.05% or more, more preferably 0.1% or more. However, excessive addition leads to a decrease in the surface gloss or manufacturability. The effect of improvement of the corrosion resistance also becomes saturated. For this reason, the upper limit is 1.0%. Considering the corrosion resistance and the surface glossiness, the upper limit of the content is 0.5% or less, more preferably 0.3%, still more preferably 0.2%.

[0039] Nb and Ti are added in the above ranges. The amounts of addition should satisfy $1 \leq Nb/Ti \leq 3.5$ to obtain the corrosion resistance and the surface glossiness which are targeted by the present invention. When $Nb/Ti < 1$, surface gloss due to the Ti-based inclusions or Ti-based oxides decreases. On the other hand, when $3.5 < Nb/Ti$, surface gloss due to the internal oxidation or grain boundary oxidation caused by the rise of the hot rolling heating temperature and annealing temperature decreases. The more preferable range is $1.5 \leq Nb/Ti \leq 3$ considering the corrosion resistance and surface glossiness which are targeted by the present invention.

[0040] Ni, Cu, Mo, V, Zr, and Co are elements which improve the corrosion resistance due to a synergistic effect with Sn and may be added in accordance with need. When added, the contents are the 0.01% or more where this effect is exhibited, preferably 0.02% or more. More preferably, the contents are 0.05% where the effect is more remarkable. However, if over 0.5%, a rise in the material cost or a decrease in the surface glossiness occurs, so the upper limits of the contents are 0.5%. Since these elements are rare, in case of adding these elements, the preferable ranges of Ni and Cu are 0.1 to 0.4%, while the preferable range of Mo is 0.1 to 0.3%. The preferable ranges of V, Zr, and Co are 0.02 to 0.3%.

[0041] Mg forms Mg oxides in the molten steel together with Al and acts as a deoxidant and also acts as nuclei for precipitation of TiN. TiN forms the nuclei for solidification of the ferrite phase in the solidification process. By promoting

the crystallization of TiN, it is possible to cause the fine formation of the ferrite phase at the time of solidification. By refining the solidified structure, it is possible to prevent surface defects due to ridging or roping or other coarse solidified structures of the product. In addition, it causes improvement of the workability. Therefore, it may be added as needed. When added, the content is 0.0001% or more for realizing these effects. However, if over 0.005%, the manufacturability deteriorates, so the upper limit is 0.005%. Preferably, considering the manufacturability, the content is 0.0003 to 0.002%.

[0042] B is an element which improves the hot workability and the secondary workability. Addition to ferritic stainless steel is effective, so it may be added as needed. When added, the content is 0.0003% or more for realizing these effects. However, excessive addition leads to a decrease in the elongation, so the upper limit is 0.005%. Preferably, considering the material cost and workability, the content is 0.0005 to 0.002%.

[0043] Ca is an element which improves the hot workability and the cleanliness of the steel and may be added as needed. When added, the content is 0.0003% or more for realizing these effects. However, excessive addition leads to a decrease in the manufacturability or a decrease in the corrosion resistance due to CaS and other water soluble inclusions, so the upper limit is 0.005%. Preferably, considering the manufacturability and corrosion resistance, the content is 0.0003 to 0.0015%.

[II] The reasons for limitation of the production method will be explained below.

[0044] One example of the production method which is required for obtaining sheets which have the ingredients shown in the above section [I] and which have the same corrosion resistances as SUS430LX and SUS430J1L and surface gloss superior to SUS430LX and SUS430J1L, will be shown.

[0045] A slab of steel which has the ingredients which are shown in the above section [I] was inserted in a hot rolling heating furnace and heated. The extraction temperature of the slab from the hot rolling heating furnace was 1080°C or more so as to secure an amount of scale formation for removing inclusions at the surface layer of the cast slab which would lead to scabs. The amount of scale formation should be, converted to scale thickness, 0.2 mm or more. Further, the upper limit of the extraction temperature was 1190°C to suppress the formation of MnS or CaS which form starting points of rust and stabilize Ti-based carbon sulfides (for example $Ti_4C_2S_2$). If considering securing the corrosion resistance and the surface gloss which are targeted by the present invention, the extraction temperature is preferably 1140 to 1180°C.

[0046] The coiling temperature after hot rolling is 500°C or more so as to suppress surface defects during coiling. If the coiling temperature is less than 500°C, the spraying of water after hot rolling causes shape defects in the hot rolled steel strip and induces surface defects at the time of uncoiling or running operations. The coiling temperature is 700°C or less so as to suppress the growth of internal oxides or grain boundary oxidation which leads to a decrease in gloss. Over 700°C, precipitates which contain Ti or P easily form and are liable to lead to a decrease in corrosion resistance. If considering securing the surface gloss and corrosion resistance which are targeted by the present invention, the coiling temperature is preferably 550 to 650°C.

[0047] After coiling in hot rolling, the sheet is cold rolled. At this time, before the cold rolling, the hot rolled sheet may also be annealed. Further, the cold rolling may be performed once, or twice or more. However, when cold rolling twice or more, process annealing is performed between the cold rolling operations. When annealing the hot rolled sheet, to suppress the growth of internal oxides or grain boundary oxidation which is caused to a decrease in gloss, the annealing temperature is preferably 1050°C or less. Further, the lower limit of the annealing temperature is preferably the recrystallization temperature of the steel (850°C or so). Here, the "recrystallization temperature" means the temperature where new strain-free crystal grains are formed from the rolled worked structure. In the case of performing process annealing between the cold rolling operations, it is preferable to use a similar temperature range.

[0048] The conditions of the cold rolling are not particularly limited. The finish annealing after the cold rolling is preferably performed at 980°C or less by considering the surface gloss. As explained above, the lower the annealing temperature, the more the internal oxidation and grain boundary oxidation are suppressed. It is advantageous for improvement of the surface gloss. Therefore, the lower limit is preferably the recrystallization temperature of 850°C. The pickling method is not particularly limited. There is no problem even if performed by a method which is commonly used industrially. For example, there are dipping in an alkali salt bath + electrolytic pickling + dipping in nitrofluoric acid and dipping in an alkali salt bath + electrolytic pickling. The electrolytic pickling may be performed by neutral salt electrolysis, nitric acid electrolysis, etc.

[Examples]

[0049] Examples of the present invention will be explained as follows.

[0050] A ferritic stainless steel which has the ingredients of Table 1 was smelted, hot rolled by an extraction temperature of 1150 to 1220°C, and coiled by a coiling temperature of 480 to 750°C to obtain hot rolled steel sheet of a thickness of 4.0 to 6.0 mm. The hot rolled steel sheet was annealed, or not, and was cold rolled once or twice interspaced by process annealing to produce 0.4 to 1.0 mm thick cold rolled steel sheet. The obtained cold rolled steel sheet was treated by

finish annealing at a temperature of completion of recrystallization of 870 to 1020°C and was treated by ordinary pickling to obtain the No. 2B product in surface specifications prescribed in JIS G 4307. For the ordinary pickling, for example, dipping in an alkali salt bath (430°C), then treatment by neutral salt electrolysis (50°C, Na_2SO_4) may be used. For the ingredients of the steel, both of the ranges prescribed by the present invention and other ranges were used. For the manufacturing conditions, both of the conditions prescribed by the present invention and other conditions were used. For the comparative steel, SUS430LX (17%Cr-0.3%Ti) was used.

[0051] The surface gloss was evaluated by measuring the gloss 45° Gloss value (Gs45°) in the rolling direction of the steel sheet (0°) and in the direction perpendicular to the rolling (90°) prescribed in JIS Z 8741. The corrosion resistance was evaluated by preparing samples of steel sheets (thickness x 100 mm square) of No. 2B surfaces and #600 polished surfaces and running tests dipping them in a 80°C, 0.5% NaCl aqueous solution for 168 hr and salt spray tests based on JIS Z 2371 (168 hr continuous spray test). The extent of rusting was evaluated compared with SUS430LX as "Very good" in the case of a good level with no stains or spot rusting, as "Good" in the cause of an equivalent level and no difference, and as "Poor" in the case of rust streaks or other inferior level. Table 2 shows the test results.

[0052]

Table 1

	C	Si	Mn	P	S	Cr	N	Nb	Ti	Al	Sn	Nb/Ti	Others	Remarks
A	0.003	0.11	0.09	0.021	0.001	12.2	0.012	0.21	0.09	0.028	0.31	2.3		Inv. steel
B	0.003	0.09	0.1	0.014	0.001	15.7	0.011	0.15	0.07	0.035	0.05	2.1		Inv. steel
C	0.009	0.07	0.08	0.02	0.001	13.8	0.008	0.14	0.04	0.04	0.18	3.5	Ca: 0.003, B: 0.003	Inv. steel
D	0.002	0.05	0.28	0.022	8E-04	14.6	0.009	0.15	0.07	0.02	0.12	2.1		Inv. steel
E	0.003	0.05	0.05	0.015	0.002	15.2	0.009	0.16	0.06	0.032	0.13	2.7		Inv. steel
F	0.003	0.11	0.12	0.022	0.002	14.8	0.017	0.12	0.07	0.022	0.15	1.7		Inv. steel
G	0.004	0.11	0.09	0.012	0.001	12.5	0.016	0.27	0.13	0.03	0.25	2.1		Inv. steel
H	0.004	0.09	0.11	0.021	9E-04	14.6	0.009	0.06	0.05	0.016	0.15	1.2	Ni: 0.1, Cu: 0.1	Inv. steel
I	0.005	0.11	0.08	0.015	8E-04	14.4	0.008	0.12	0.08	0.035	0.11	1.5	Mo: 0.2, Mg: 0.005	Inv. steel
J	0.018	0.05	0.28	0.022	8E-04	14.1	0.009	0.17	0.08	0.02	0.12	2.1	V: 0.2	Inv. steel
K	0.001	0.8	0.03	0.022	7E-04	14.8	0.006	0.16	0.09	0.02.	0.13	1.8	Co: 0.05, Zr: 0.05	Inv. steel
L	0.002	0.01	0.8	0.022	5E-04	14.5	0.005	0.13	0.09	0.02	0.12	1.4	V: 0.02, Co: 0.015, Zr: 0.015	Inv. steel
M	0.002	0.12	0.15	0.022	0.001	14.4	0.011	0.12	0.08	0.085	0.11	1.5		Inv. steel
N	0.005	0.08	0.08	0.02	0.001	14.2	0.009	0.13	0.1	0.042	0.11	1.30	B: 7 ppm, Ca: 3 ppm	Inv. steel
O	0.034	0.09	0.12	0.022	0.002	13.2	0.012	0.14	0.06	0.04	0.09	2.3		Comp. steel
P	0.003	0.11	1.55	0.023	0.002	13.3	0.013	0.15	0.05	0.045	0.11	3.0		Comp. steel
Q	0.007	0.12	0.13	0.023	0.011	13.1	0.012	0.15	0.06	0.042	0.12	2.5		Comp. steel
R	0.005	0.11	0.11	0.021	0.001	11.7	0.013	0.14	0.07	0.045	0.11	2.0		Comp. steel
S	0.006	0.11	0.12	0.023	0.001	13.3	0.011	0.32	0.09	0.05	0.11	3.6		Comp. steel
T	0.004	0.11	0.11	0.021	9E-04	13.3	0.012	0.04	0.05	0.05	0.09	0.8		Comp. steel
U	0.004	0.11	0.09	0.023	0.002	13.2	0.011	0.12	0.17	0.05	0.11	0.7		Comp. steel
V	0.003	0.11	0.11	0.023	0.002	13.2	0.011	0.09	0.02	0.05	0.11	4.5		Comp. steel

[0053]

Table 2

	No.	Steel	Gloss Gs45°		Corrosion resistance		Hot rolling (°C)		Annealing after hot rolling	Times of cold rolling	Final annealing (°C)	Remarks
			0°	90°	Dipping in 0.5%NaCl	Spraying of 3.5% NaCl	Extraction	Coiling				
Inv.ing.	1	A	680	620	Good	Good	1140	580	Yes	1	870	Inv. ex.
	2	B	720	680	Very good	Very good	1180	600	Yes	1	950	Inv. ex.
	3	C	800	750	Good	Good	1160	590	Yes	1	940	Inv. ex.
	4	D	780	730	Very good	Very good	1180	610	Yes	1	930	Inv. ex.
	5	E	820	780	Very good	Very good	1180	680	Yes	1	945	Inv. ex.
	6	F	790	730	Very good	Good	1180	550	Yes	1	950	Inv. ex.
	7		850	800	Very good	Very good	1160	600	No	2	950	Inv. ex.
	8		630	550	Good	Good	1050	480	No	1	950	Inv. ex.
	9		630	550	Good	Good	1180	620	Yes	1	1020	Inv. ex.
	10	G	690	630	Good	Good	1150	600	Yes	1	880	Inv. ex.
	11	H	720	670	Good	Very good.	1160	600	Yes	1	930	Inv. ex.
	12	I	800	750	Very good	Very good	1180	680	Yes	1	940	Inv. ex.
	13		850	820	Very good	Very good	1160	550	Yes	2	930	Inv. ex.
	14		840	810	Very good	Very good	1160	650	No	2	940	Inv. ex.
	15		640	550	Good	Good	1220	750	Yes	1	960	Inv. ex.
	16		680	600	Good	Good	1160	650	Yes	1	990	Inv. ex.
	17	J	720	650	Good	Good	1180	650	Yes	1	940	Inv. ex.
	18	K	680	630	Good	Good	1180	550	Yes	1	950	Inv. ex.
	19	L	650	620	Good	Good	1180	650	Yes	1	950	Inv. ex.
	20	M	640	620	Good	Good	1180	550	Yes	1	960	Inv. ex.
	21	N	790	760	Good	Good	1150	580	Yes	1	910	Inv. ex.

(continued)

	No.	Steel	Gloss Gs45°		Corrosion resistance		Hot rolling (°C)		Annealing after hot rolling	Times of cold rolling	Final annealing (°C)	Remarks
			0°	90°	Dipping in 0.5%NaCl	Spraying of 3.5% NaCl	Extraction	Coiling				
Comp.ing.	22	O	750	700	Poor	Good	1180	600	Yes	1	930	Comp. ex.
	23	P	700	650	Poor	Poor	1180	600	Yes	1	930	Comp. ex.
	24	Q	680	650	Poor	Poor	1180	620	Yes	1	930	Comp. ex.
	25	R	700	650	Poor	Poor	1160	600	Yes	1	890	Comp. ex.
	26	s	580	550	Good	Good	1180	620	Yes	1	1000	Comp. ex.
	27	T	590	500	Good	Good	1180	630	Yes	1	870	Comp. ex.
	28	U	600	510	Good	Good	1180	600	Yes	1	940	Comp. ex.
	29	V	610	520	Poor	Poor	1180	600	Yes	1	870	Comp. ex.
		SUS430LX	610	520	Reference (stains)	Reference (sp ot rusting)	1200	650	Yes	1	920	Conv. ex.
(Note 1) Evaluation of corrosion resistance/Compared with SUS430LX, Very good: Excellent (no stains or spot rusting) Good: No difference (equal) Poor: Inferior (streaks of rust)												

[0054] From Table 2, Test No. 1 to 21 are ferritic stainless steel which satisfies all of the ingredients which are limited in the present invention. It was found that these steel sheets have higher surface gloss compared with SUS430LX (gloss of SUS430LX at Ga45° (0°) = 610 or more and gloss at Ga45° (90°) = 520 or more) and have corrosion resistance which is higher than or the same quality as SUS430LX.

[0055] Test No. 8, 9, 15, and 16 have the ingredients which are prescribed in the present invention, but deviate from the method of production according to the present invention (extraction temperature and coiling temperature). These steel sheets satisfy the corrosion resistance or gloss which is targeted by the present invention, but the gloss is inferior to other examples of the present invention.

[0056] Test No. 22 to 29 are the production method which is prescribed in the present invention, but using ingredients are deviated from that of the present invention. These steel sheets cannot give both the surface gloss and corrosion resistance which are targeted in the present invention.

[0057] FIG. 1 and FIG. 2 show the relationship between the amounts of Nb/Ti and the surface gloss in the examples. To obtain the surface gloss which is targeted by the present invention, that is, Gs45°(0°) of 610 or more and Gs45°(90°) of 520 or more corresponding to SUS430LX, it is important to obtain the ranges of ingredients according to the present invention being $1 \leq Nb/Ti \leq 3.5$.

Industrial Applicability

[0058] According to the present invention, it is possible to obtain an alloy-saving type ferritic stainless steel excellent in surface gloss and corrosion resistance, which is economically excellent without rising in alloy cost or manufacturing cost, has a corrosion resistance of SUS430LX or SUS430J1L, and is strikingly improved in surface gloss.

Claims

1. A ferritic stainless steel sheet which is excellent in surface gloss and corrosion resistance, comprising: by mass%,

C: 0.001 to 0.03%,
Si: 0.01 to 1.0%,
Mn: 0.01 to 1.5%,
P: 0.005 to 0.05%,
S: 0.0001 to 0.01%,
Cr: 12 to 16%,
N: 0.001 to 0.03%,
Nb: 0.05 to 0.3%,
Ti: 0.03 to 0.15%,
Al: 0.005 to 0.5%, and
Sn: 0.01 to 1.0%;
the steel sheet having the remainder being Fe and unavoidable impurities, and
satisfying the relationship of $1 \leq Nb/Ti \leq 3.5$.

2. The ferritic stainless steel sheet which is excellent in surface gloss and corrosion resistance as set forth in claim 1, wherein said stainless steel sheet further contains, by mass%, one element or more of

Ni: 0.01 to 0.5%,
Cu: 0.01 to 0.5%,
Mo: 0.01 to 0.5%,
V: 0.01 to 0.5%,
Zr: 0.01 to 0.5%,
Co: 0.01 to 0.5%,
Mg: 0.0001 to 0.005%,
B: 0.0003 to 0.005%, and
Ca: 0.0003 to 0.005%.

3. A method of production of a ferritic stainless steel sheet which is excellent in surface gloss and corrosion resistance, comprising of: heating a slab of stainless steel which contains the steel ingredients described in claims 1 or 2, taking out the slab from the heating furnace at an extraction temperature of 1080 to 1190°C, and hot rolling and coiling

the steel sheet at a temperature of 500 to 700°C.

4. The method of production of the ferritic stainless steel sheet which is excellent in surface gloss and corrosion resistance as set forth in claim 3, comprising of: coiling the steel sheet in hot rolling, cold rolling, and finish annealing the steel sheet at 850 to 980°C.

5. The method of production of the ferritic stainless steel sheet which is excellent in surface gloss and corrosion resistance as set forth in claim 3, comprising of: coiling the steel sheet in hot rolling, cold rolling twice or more which includes processing annealing, and finish annealing the steel sheet at 850 to 980°C.

6. The method of production of the ferritic stainless steel sheet which is excellent in surface gloss and corrosion resistance as set forth in claims 4 or 5, comprising of: coiling the steel sheet in hot rolling, and annealing the hot rolled sheet at an annealing temperature of in the range of the recrystallization temperature to 1050°C before cold rolling.

Fig.1

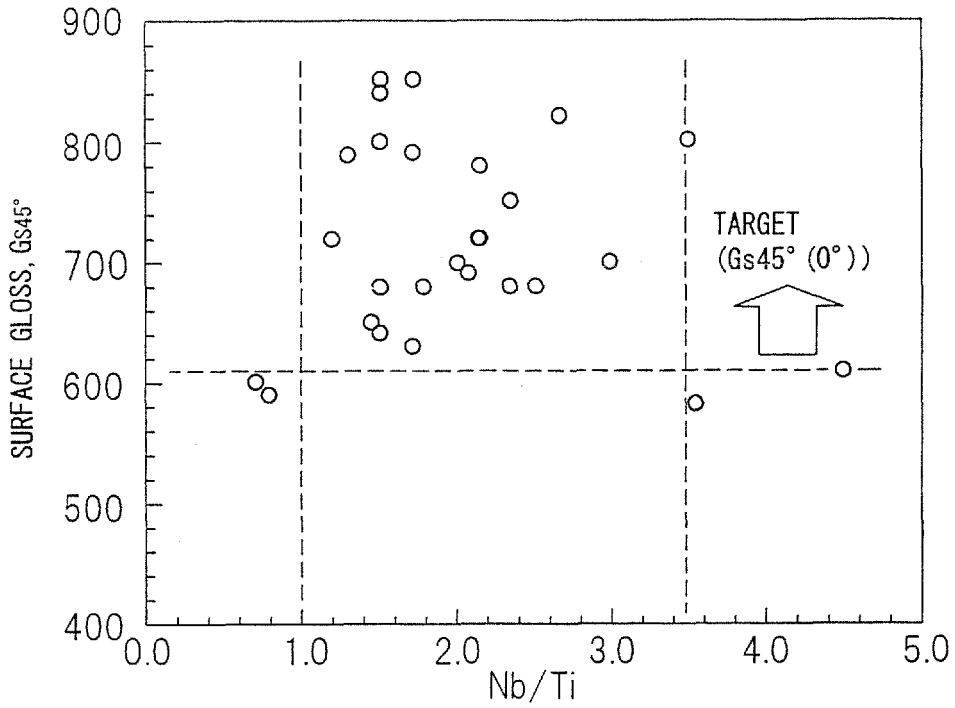
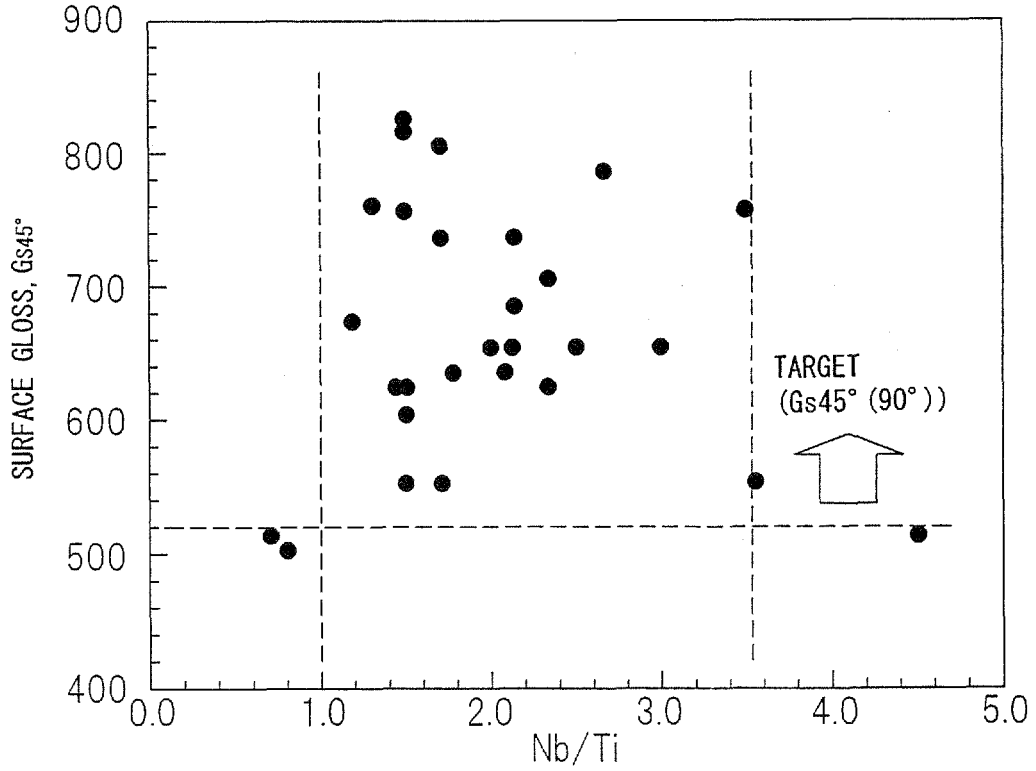

900
800
700
600
500
400
0.0
1.0
2.0
3.0
4.0
5.0
SURFACE GLOSS, Gs45°
Nb/Ti
TARGET
(Gs45° (0°))

Fig.2


900
800
700
600
500
400
0.0
1.0
2.0
3.0
4.0
5.0
SURFACE GLOSS, Gs45°
Nb/Ti
TARGET
(Gs45° (90°))

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/057512

A. CLASSIFICATION OF SUBJECT MATTER
C22C38/00(2006.01)i, *B21B3/02*(2006.01)i, *C21D8/02*(2006.01)i, *C21D9/46*(2006.01)i, *C22C38/28*(2006.01)i, *C22C38/54*(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, B21B3/02, C21D8/02, C21D9/46, C22C38/28, C22C38/54

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 1996-2011
Kokai Jitsuyo Shinan Koho 1971-2011 Toroku Jitsuyo Shinan Koho 1994-2011

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.
Y	JP 2004-060009 A (Nippon Steel Corp.), 26 February 2004 (26.02.2004), claims; paragraphs [0045] to [0047]; tables 1, 2 (Family: none)	1-6
Y	JP 2010-031315 A (Nippon Steel & Sumikin Stainless Steel Corp.), 12 February 2010 (12.02.2010), paragraphs [0036], [0039] (Family: none)	1-6
Y	JP 2001-288543 A (Nippon Steel Corp.), 19 October 2001 (19.10.2001), paragraphs [0024], [0031] (Family: none)	1-6

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

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Date of the actual completion of the international search	Date of mailing of the international search report
09 May, 2011 (09.05.11)	17 May, 2011 (17.05.11)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/057512

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 10-280035 A (Nippon Steel Corp.), 20 October 1998 (20.10.1998), claims; table 1 (Family: none)	1-2

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Patent documents cited in the description

- JP 61288021 A **[0007]**
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- JP 6172935 A **[0007]**
- JP 7034205 A **[0007]**
- JP 2009174036 A **[0007]**

Non-patent literature cited in the description

- Stainless Steel Handbook. 532 **[0008]**