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(54) **Stainless steel sheet product good of delayed fracture-strength and manufacturing method thereof**

(57) A semi-stable austenite stainless steel sheet containing 12.0-18.0 mass % Cr and 4.0-10.0 mass % Ni is solution-annealed, cold-rolled at a reduction ratio of 35-65% and then optionally aged or nitride-aged at 300-650°C. The stainless steel sheet product comprises a matrix of strain-induced martensite, wherein residual austenite grains are dispersed at a rate of 20 vol. % or more. Residual austenite grains and prior austenite

grains are elongated with an aspect ratio of 3 or more. A surface layer of the stainless steel sheet product is hardened more than HV450 in the state that a half-value width of (200) α' X-ray diffraction peak is 0.30 degrees or broader. The product is good of delayed fracture strength due to the specified structure and the modified surface layer.

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Description

[0001] The present invention relates to a stainless steel sheet product, which is useful as a member or part driven under environmental conditions with a fear of delayed fracture derived from penetration of hydrogen due to its excellent properties such as corrosion-resistance, surface hardness, toughness and fatigue strength, and also relates to a manufacturing method thereof.

[0002] 18%Ni maraging steel, which is a representative steel material with hardness of HV450 or more, has a single phase of martensite in a quenched state. It is hardened by aging. Good wear-resistance and fatigue strength are applied to the steel by nitriding to harden a surface layer.

[0003] Although 18%Ni maraging steel is very hard, it is poor of toughness and ductility due to a single phase of martensite. Due to poor toughness and ductility, fatigue strength is insufficient, and delayed fracture originated in interstitial hydrogen often occurs in presence of inclusions. In order to overcome these disadvantages, severe selection of raw materials and also special processes involving high-vacuum melting and secondary refining are necessary for reduction of impurities to a possible lowest level. As a result, 18%Ni maraging steel has been prepared with lower productivity at a higher cost, as compared with conventional steel.

[0004] The element **Ti** is often added as an aging promoter to 18%Ni maraging steel, but increases inclusions of titanium compound unfavorable for fatigue strength of 18%Ni maraging steel.

[0005] The present invention aims at provision of a high-strength and tough stainless steel product having surface hardness of HV450 or more and being improved in delayed fracture strength by combination of a specified alloying design and manufacturing conditions.

[0006] The present invention proposes a new stainless steel product suitable for this purpose. The proposed stainless steel product contains 12.0-18.0 mass % **Cr** and 4.0-10.0 mass % **Ni**. Its metallurgical structure comprises a matrix of strain-induced martensite, in which residual austenite grains are dispersed at a rate of 20 vol. % or more. The residual austenite grains as well as prior austenite grains are elongated with an aspect ratio of 3 at least. The stainless steel product has a surface layer hardened to HV450 or more in the state that a half-value width of (200) α' X-ray diffraction peak is 0.30 degrees at least.

[0007] The stainless steel sheet product is manufactured by solution-annealing the semi-stable austenitic stainless steel sheet, cold-rolling the annealed stainless steel sheet at a reduction ratio of 35-65%, and then optionally aging or nitride-aging the rolled steel sheet at 300-650°C. Nitride-aging is performed by a gas-nitriding process or a salt bath process. According to the gas-nitriding process, a stainless steel sheet is heated at 300-650°C in a nitrogen atmosphere. According to the salt bath process, a stainless steel sheet is immersed in a salt bath, which contains one or more of **NaCN**, **KCN**, **NaCNO** and **KCNO** as basic components, and held at 300-650°C.

[0008] When a solution-annealed stainless steel sheet is welded to a ring shape and then cold-rolled by a ring rolling mill, a steel belt good of fatigue strength suitable for a continuously variable transmission is manufactured.

[0009] The inventors have continued various researches and experiments for development of a stainless steel sheet endurable under severe conditions with a fear of interstitial hydrogen, and discovered that a semi-stable austenitic stainless steel sheet having a dual phase structure of strain-induced martensite and austenite is suitable for the purpose instead of conventional martensite steel sheet having a single phase of martensite. The stainless steel sheet is further improved in resistance to hydrogen embrittlement and delayed fracture by conditioning it to the metallurgical structure, wherein residual austenite grains are dispersed in a matrix of strain-induced martensite at a rate of 20 vol. % at least, and modifying its surface layer to a hardened state of HV450 or more. The residual austenite grains as well as prior austenite grains are preferably elongated with an aspect ratio of 3 at least by cold-rolling. A surface layer of the stainless steel sheet product is preferably modified to the state that a half-value width of (200) α' X-ray diffraction peak is 0.30 degrees or broader.

[0010] Increase of residual austenite grains in a matrix of strain-induced martensite promotes dissolution of hydrogen in the austenite grains, and diffusion speed of hydrogen is lower in an austenite phase than a martensite phase. Dissolution of hydrogen means decrease of active hydrogen effecting on fracture and also retards motion of hydrogen atoms in the steel matrix. An effect of the austenite phase on delayed fracture derived from interstitial hydrogen is apparently recognized by lowering a rate of the strain-induced martensite below 80 vol. %.

[0011] Diffusion of an element generally occurs at grain boundaries with ease rather than inside grains, and hydrogen is also diffused along grain boundaries. Diffusion of hydrogen from one grain to an adjacent grain along grain boundaries is drastically retarded in the case where an aspect ratio of the grains is 3 or more. The effect of the aspect ratio on diffusion of hydrogen will be explained as follows:

[0012] Dislocation density is basically high at grain boundaries, and strains are predominantly accumulated at the grain boundaries as increase of the aspect ratio. The high dislocation density and accumulation of strains extremely delays diffusion of hydrogen and enhances resistance to delayed fracture originated in interstitial hydrogen.

[0013] Transgranular dislocations are also effective for trapping hydrogen atoms diffused into a steel matrix. Trapping of hydrogen atoms is intensified as increase of transgranular dislocations, so as to suppress delayed fracture. A degree

of dislocations accumulated in grains can be quantitatively represented as a half-value width of (200) diffraction peak by analyzing a steel sheet product with α' X-ray.

[0014] The other features of the present invention as well as alloying elements and manufacturing conditions will be understood from the following explanation:

Alloying Design

C up to 0.20 mass %

[0015] **C** is an austenite former, which suppresses generation of δ -ferrite in a high-temperature region and also strengthens a martensite phase induced by cold-rolling. Solubility limit of **C** is lowered as increase of **Si** content in the inventive alloy system. Excessive inclusion of **C** promotes precipitation of coarse chromium carbide particles, which put harmful influences on intergranular corrosion resistance and fatigue strength, during aging. In this sense, **C** content is preferably controlled to 0.20 mass % at most.

1.0-5.0 mass % of **Si**

[0016] **Si** is an alloying element useful as a deoxidizing agent at a steelmaking stage, and **Si** content derived from the deoxidizing agent has been controlled to 1.0 mass % at most as noted in such work-hardened stainless steel as **SUS301** or **SUS304**. Increase of **Si** content on the contrary is favorable in the inventive stainless steel, so as to promote generation of strain-induced martensite during cold-rolling. The element **Si** also hardens the strain-induced martensite. Moreover, residual austenite grains are hardened by dissolution of **Si**. Consequently, the stainless steel sheet is substantially strengthened by cold-rolling. The element **Si** is also effective in combination with **Cu** for promotion of age-hardening. These effects are typically noted by addition of **Si** at a ratio of 1.0 mass % or more. However, excessive addition of **Si** above 5.0 mass % causes high-temperature cracking and brings out various troubles in a manufacturing process. In this sense, **Si** content is preferably controlled within a range of 1.0-5.0 mass %.

Mn up to 5.0 mass %

[0017] **Mn** is an alloying element, which raises stability of an austenite phase. **Mn** content is determined to a ratio in balance with the other alloying elements. However, excessive addition of **Mn** above 5.0 mass % unfavorably suppresses generation of strain-induced martensite during cold-rolling.

4.0-10.0 mass % of **Ni**

[0018] Although **Ni** is an alloying element necessary for maintenance of an austenite phase at high and low temperatures in general, the inventive stainless steel is based on the alloying design that an austenite phase semi-stable at a room temperature is partially transformed to strain-induced martensite by cold-rolling. **Ni** content is determined within a range of 4.0-10.0 mass % from such the alloying design. Shortage of **Ni** means excessive generation of δ -ferrite in a high-temperature region and transformation to martensite in a cooling step. As a result, an austenite phase cannot be maintained in a stainless steel sheet cooled down to a room temperature. Surplus of **Ni** on the contrary stabilizes an austenite phase to an extent unfavorable for generation of strain-induced martensite.

12.0-18.0 mass % of **Cr**

[0019] **Cr** is an alloying element effective for corrosion resistance, and **Cr** content of 12.0 mass % at least is necessary for corrosion resistance suitable for the purpose. However, excessive addition of **Cr** above 18.0 mass % causes excessive generation of δ -ferrite in a high-temperature region, since **Cr** is a ferrite former. Although generation of δ -ferrite can be suppressed by addition of austenite formers such as **C**, **N**, **Ni**, **Mn** and **Cu**, addition of austenite formers means stabilization of an austenite phase at a room temperature and suppresses generation of strain-induced martensite during cold-rolling. Excessive addition of austenite formers also puts harmful influences on increase of strength during aging. In this sense, **Cr** content is determined within a range of 12.0-18.0 mass %.

Cu up to 3.5 mass %

[0020] **Cu** is an optional element effective for promotion of age-hardening in combination with **Si**. But, excessive addition of **Cu** above 3.5 mass % worsens hot-workability of a stainless steel sheet and also causes occurrence of cracks.

Mo up to 5.0 mass %

[0021] Mo is an optional element for improvement of corrosion resistance and also promotes dispersion of fine carbonitride particles during aging. Abrupt release of strains is favorably suppressed by Mo during high-temperature aging treatment, which is a processing step suitable for releasing surplus of strains induced by cold-rolling but harmful on fatigue strength. Since the fine carbonitride particles precipitated by aging favorably increase strength of a stainless steel sheet, the stainless steel sheet can be aged at a relatively higher temperature without decrease of strength. However, excessive addition of Mo causes generation of δ -ferrite in a high-temperature region, and deformation resistance (in other words, hot-workability) at a high-temperature region becomes bigger as increase of **Mo** content. In this sense, **Mo** content is preferably determined at a ratio up to 5.0 mass %.

N up to 0.15 mass %

[0022] **N** is an austenite former effective for hardening austenite and martensite phases, but excessive inclusion of **N** causes occurrence of blow holes in a casting step. In this sense, **N** content is preferably determined at a ratio up to 0.15 mass %.

Metallurgical Structure of Cold-Rolled Stainless Steel Sheet Rates of strain-induced martensite and residual austenite

[0023] An amount of hydrogen dissolved in a steel matrix becomes bigger as decrease of strain-induced martensite (in other words, increase of residual austenite), since diffusion of hydrogen is slower in austenite grains than martensite grains. As a result, an absolute amount of active hydrogen harmful on fracture strength is reduced, and motion of the active hydrogen is also restricted, so as to suppress delayed fracture. Such an effect of decrease of strain-induced martensite on delayed fracture property is apparently noted, when a rate of strain-induced martensite is reduced to 80 vol. % or less in a cold-rolled stainless steel sheet.

Aspect ratio of austenite grains

[0024] In general, density of dislocations is high at grain boundaries, and predominant accumulation of strains is more intensified as a bigger aspect ratio of grains. Such grain boundaries and the bigger aspect ratio are effective for retarding diffusion of hydrogen and inhibiting delayed fracture originated in interstitial hydrogen. These effects on delayed fracture are typically noted at an aspect ratio of 3 at least in the inventive alloy system. Density of dislocations in grains.

[0025] Transgranular dislocations trap hydrogen atoms and favorably suppress delayed fracture. Density of transgranular dislocations can be evaluated as a half-value width of (200) α' X-ray diffraction peak, since the width becomes broader as increase of dislocations accumulated in grains at a surface layer of a stainless steel sheet product. The effect of transgranular dislocations on delayed fracture is clearly noted, when the width is of 0.30 degrees at least.

Manufacturing Conditions

Cold-rolling

[0026] A stainless steel sheet, which is cold-rolled with a too-small reduction ratio, is poor of surface hardness with insufficient accumulation of dislocations evaluated as a half-value width of (200) α' X-ray diffraction peak. A reduction ratio of 35 % at least is necessary for raising the half-value width to an effective level for delayed fracture strength. A surface layer of the stainless steel sheet is also hardened to HV450 or more by the cold-rolling, resulting in improvement of fatigue strength. In this sense, a reduction ratio is preferably determined within a range of 35-65% in the cold-rolling step. A too-high reduction ratio above 65 % leads to excessive generation of strain-induced martensite and worsens various properties of a stainless steel sheet product.

[0027] After a semi-stable austenite stainless steel sheet is cold-rolled under the conditions to generate strain-induced martensite at a controlled ratio and to accumulate strains in crystal grains with a proper aspect ratio, it is aged or nitride-aged for improvement of surface hardness and fatigue strength. Aging or nitride-aging is preferably performed at 300-650°C in 20 minutes. If the stainless steel sheet is heated at a temperature lower than 300°C, an effect of aging or nitride-aging on strength is insufficient. But, a higher temperature above 650°C leads to partial inversion of strain-induced martensite to austenite, resulting in lowering of strength and retard of nitriding reaction.

[0028] Nitride-aging may be performed by a conventional process, which has been applied to steel material. For instance, gas nitriding, gas soft-nitriding, gas nitrosulphurizing, plasma nitriding, salt-bath nitriding, ion-nitriding, salt-bath carbonitriding, salt-bath nitrosulphurizing, etc.

[0029] In the gas nitriding process, sole ammonia gas or mixed gas based on ammonia is used as a nitriding gas. The mixed gas based on ammonia may be prepared by mixing ammonia gas with **RX** gas (endothermic modified gas: **CO+H₂+N₂**), **NX** gas (modified gas produced by complete combustion of butane and based on nitrogen), propane, butane or mixture of (**CO₂+CO**). The salt-bath nitriding process uses a molten salt prepared by adding one or both of **Na₂CO₃** and **K₂CO₃** to one or more of basic components selected from **NaCN**, **KCN**, **NaCNO** and **KCNO**.

EXAMPLE

[0030] Several semi-stable austenite stainless steels having compositions shown in **Table 1** were melted in a vacuum furnace. Each stainless steel was cast to a slab, forged, hot-rolled, annealed and then cold-rolled. Steels **A**, **B** and **C** belong to semi-stable austenite stainless steel defined by the present invention, while steel **D** corresponds to 18%Ni maraging steel for comparison.

[0031] After each cold-rolled steel sheet was solution-annealed 1 minute at 1050°C and quenched in water, it was cold-rolled to thickness of 0.18 mm with various reduction ratios by a ring-rolling mill. Thereafter, the steel sheets were processed by barreling, shot-peening, shot-blasting or combination thereof. Some steel sheets were finally aged or nitride-aged. Nitride-aging was performed in a nitrogen atmosphere of 50 vol. % **NH₃** and 50 vol. % **NX** gas or in a salt bath consisting of 40 mass % **NaCN**, 40 mass % **Na₂CO₃** and the balance being (**NaK**)₄**Fe(CN)O₆**.

Table 1:

Steel Kind	Chemical Composition Of Austenite Stainless Steels									
	Alloying Elements (mass %)									
	C	Si	Mn	Ni	Cr	Cu	Mo	Ti	Co	N
A	0.077	2.23	0.45	7.54	16.22	0.24	1.25	0.01	0.01	0.074
B	0.082	2.68	0.28	8.25	13.56	0.16	2.25	0.01	0.00	0.080
C	0.040	1.35	1.43	5.34	14.25	1.89	0.98	0.01	0.01	0.087
D	0.005	0.02	0.03	18.24	0.05	0.02	5.02	0.44	9.08	0.002

[0032] A test piece of 20 mm in length and 20 mm in width sampled from each steel sheet was electrolytically polished and then subjected to X-ray analysis to detect a half-value width of (200) α' X-ray diffraction peak. The X-ray analysis was performed with a scanning speed of 0.2 degrees/minute under accelerating voltage of 40kV and an electric current of 120A.

[0033] Surface hardness of each test piece in a finish-annealed state was measured by Vickers hardness meter with a load of 300g.

[0034] A rate of residual austenite grains in each test piece was measured by a magnetic method using an oscillating magnetometer.

[0035] An aspect ratio of prior austenite grains was calculated as follows: 100 grains were sampled at random from elongated austenite grains, which were observed on a cross section of a test piece cut off along a rolling direction. A major axis **D₁** and a minor axis **D₂** of each elongated austenite grain along the rolling direction and a vertical direction, respectively, were measured. Quotient **D₁/D₂** was calculated per every sampled austenite grains. A mean value of the quotients **D₁/D₂** was regarded as an aspect ratio of prior austenite grains.

[0036] Ring-shaped test pieces of 350 mm in length and 15 mm in width were sampled from each steel sheet. A lubricant was applied to test pieces, and two test pieces were overlapped together and examined by such a rotary fatigue test as follows:

[0037] The overlapped test pieces were hung on a driven pulley of 40.0 mm in diameter and fixed to a belt, which was stretched between the driven pulley and a drive pulley, at both ends. The driven pulley was rotated at 800 rpm in the state that the test pieces were stretched by the belt. Fatigue strength of the test piece was evaluated as a cycle number until fracture of the test pieces. Test pieces, which were not fractured even after 1000×10⁴ cycles, were regarded as material good of fracture strength.

[0038] Test results of cold-rolled steel sheets are shown in **Table 2**, while those of aged or nitride-aged steel sheets are shown in **Table 3**.

Table 2: Effects Of Reduction Ratio And Residual Austenite On Surface Hardness And Fatigue Strength

(Cold-Rolled Steel Sheets)							
Sample No.	Steel Kind	Reduction ratio (%)	Half-value width*1 (degrees)	Residual austenite (vol. %)	Surface hardness HV0.3	Aspect ratio of prior austenite grains	Cycle number ($\times 10^4$) until fatigue
Inventive examples							
1	A	60	0.45	48	466	5.2	500
2	A	50	0.42	52	456	4.8	543
3	B	44	0.41	46	453	3.9	478
4	B	50	0.46	32	465	4.4	421
5	C	50	0.48	25	498	4.2	612
6	C	45	0.46	37	492	3.8	523
7	C	40	0.44	52	462	3.2	453
Comparative							
8	A	15	<u>0.25</u>	88	<u>333</u>	<u>1.9</u>	124
9	B	30	<u>0.27</u>	76	<u>359</u>	<u>2.7</u>	213
10	C	20	<u>0.28</u>	75	<u>392</u>	<u>2.4</u>	154
11	C	70	0.49	<u>11</u>	530	6.2	98
12	D	40	<u>0.28</u>	0	<u>358</u>	3.1	189

*1) a half-value width of (200) α' X-ray diffraction peak

The underlined figures are out of ranges defined by the present invention.

Table 3: Effects Of Reduction Rate And Residual Austenite On Surface Hardness And Fatigue Strength
(Steel Sheets Aged or Nitride-Aged at 520°C for 30 minutes)

Sample No.	Steel Kind	Reduction ratio (%)	Nitriding	Half-value width*1 (degrees)	Residual austenite (vol%)	Surface hardness HV0.3	Aspect ratio of prior austenite grains	Cycle number ($\times 10^4$) until fatigue	NOTE
13	A	60	—	0.36	48	568	5.2	≥ 1000	Inventive examples
14	A	50	Gas	0.33	52	967	4.8	≥ 1000	
15	B	44	—	0.32	46	565	3.9	890	
16	B	50	Salt bath	0.35	32	1023	4.4	≥ 1000	
17	C	50	—	0.38	25	602	4.2	≥ 1000	
18	C	45	Gas	0.37	37	945	3.8	943	
19	C	40	Gas	0.34	52	921	3.2	≥ 1000	
20	A	15	Gas	<u>0.22</u>	88	543	<u>1.9</u>	342	
21	B	30	—	<u>0.24</u>	76	467	<u>2.7</u>	245	
22	C	20	Salt bath	<u>0.26</u>	75	502	<u>2.4</u>	76	Comparative
23	C	70	Salt bath	0.37	<u>11</u>	1156	6.2	123	
24	D	40	—	<u>0.24</u>	<u>0</u>	610	3.1	65	
25	D	40	Gas	<u>0.24</u>	<u>0</u>	856	3.1	113	

*1) a half-value width of (200) α' X-ray diffraction peak

The underlined figures are out of ranges defined by the present invention.

[0039] Results in **Tables 2** and **3** prove that the inventive stainless steel sheets are good of fatigue strength, i.e. $\geq 400 \times 10^4$ cycles by the rotary fracture test.

[0040] On the other hand, **Sample Nos. 8-10** were poor of fatigue strength, since density of strains accumulated at grain boundaries were insufficient due to small reduction ratios in addition to small aspect ratios. **Sample Nos. 11** and **13** were also poor of fatigue strength, since strain-induced martensite grains were excessively generated due to a high reduction ratio of 70%.

[0041] When **Sample Nos. 8-10** (cold-rolled steel sheets) were observed by a microscope, cracks originated in poor strength were detected in grains at fracture planes. **Sample No. 11** (a cold-rolled steel sheet) and **Sample Nos. 20-25** (aged or nitride-aged steel sheets) were cracked at grain boundaries. Change from transgranular to intergranular cracking is probably explained by increase of strength due to aging or nitride-aging. Such intergranular cracking is a kind of typical delayed fracture caused by penetration of hydrogen into steel ring material from a lubricant between two overlapped steel rings.

[0042] It is understood from these results that delayed fracture was suppressed by properly controlling an aspect ratio of prior austenite grains, surface hardness in a finish-annealed state and a rate of residual austenite as well as introduction of rolling strains. Although **Inventive Sample Nos. 15** and **18** were broken, fracture is transgranular with a ductile fracture plane.

[0043] According to the present invention as mentioned above, a semi-stable austenite stainless steel sheet is cold-rolled with a predetermined reduction ratio so as to promote transformation to strain-induced martensite. An aspect rate of prior austenite grains, a rate of residual austenite, surface hardness in a finish-annealed state and modification of a surface layer to a state appropriate for inhibiting diffusion of hydrogen are realized by the controlled cold-rolling, so that the cold-rolled steel sheet product is improved in strength and toughness as well as delayed fracture strength. The stainless steel sheet product manufactured in this way is useful as a member or part for various kinds of springs for automobiles, e.g. a metal gasket or a ring for a belt of a continuously variable transmission, a steel belt, a blade, a separator for a fuel cell, a leaf spring and so on.

Claims

1. A stainless steel sheet product excellent in strength, toughness and delayed fracture strength, which:

consists of 12.0-18.0 mass % **Cr**, 4.0-10.0 mass % **Ni**, 0.20 mass % or less **C**, 1.0~5.0 mass % **Si**, 5.0 mass % or less **Mn**, optionally one or more selected from **Cu** of up to 3.5 mass%, **Mo** of up to 5.0 mass%, **N** of up to 0.15 mass % and the balance being **Fe** except inevitable impurities;

comprises the metallurgical structure that residual austenite grains are present in a strain-induced martensite matrix at a rate of 20 vol. % or more, said austenite grains and also prior austenite grains being elongated with an aspect ratio of 3 or more; and

has a surface layer hardened above HV450 and modified to the state that a half-value width of (200) α' X-ray diffraction peak is 0.30 degrees at least.

2. A method of manufacturing a stainless steel sheet product excellent in strength, toughness and delayed fracture strength, which comprises the steps of:

providing a semi-stable austenitic stainless steel containing 12.0-18.0 mass % **Cr**, 4.0-10.0 mass % **Ni**, 0.20 mass % or less **C**, 1.0~5.0 mass % **Si**, 5.0 mass % or less **Mn**, optionally one or more selected from **Cu** of up to 3.5 mass %, **Mo** of up to 5.0 mass%, **N** of up to 0.15 mass% and the balance being **Fe** except inevitable impurities;

solution-annealing said stainless steel;

cold-rolling the solution-annealed stainless steel with a reduction ratio of 35-65% so as to promote transformation to strain-induced martensite; and

optionally processing said cold-rolled stainless steel by barreling, shot peening, shot blasting or combination thereof,

whereby the stainless steel is reformed to the metallurgical structure that residual austenite grains are present in a strain-induced martensite matrix at a rate of 20 vol. % or more, said austenite grains and also prior austenite grains being elongated with an aspect ratio of 3 or more, and a surface layer being hardened above HV450 and modified to the state that a half-value width of (200) α' X-ray diffraction peak is 0.30 degrees at least.

3. The manufacturing method as defined in Claim 2, wherein the stainless steel sheet is cold-rolled by a ring rolling mill.

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4. The manufacturing method as defined in Claim 2 or 3, wherein the stainless steel sheet is further aged or nitride-aged at 300-650°C after cold-rolling.
5. The manufacturing method as defined in Claim 4, wherein the stainless steel sheet is nitride-aged in a nitrogen atmosphere.
6. The manufacturing method as defined in claim 4, wherein the stainless steel sheet is nitride-aged in a salt bath based on one or more of **NaCN**, **KCN**, **NaCNO** and **KCNO**.



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 02 0480

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 05, 14 September 2000 (2000-09-14) -& JP 2000 063998 A (NISSHIN STEEL CO LTD), 29 February 2000 (2000-02-29) * abstract *	1-6	C22C38/34 C22C38/58 C22C38/42 C22C38/44 C21D8/02
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A	* abstract *	3,5,6	
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 6 November 2002	Examiner Vlassi, E
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03/92 (P04001)



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