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(54) **HIGH STRENGTH NON-ORIENTED ELECTRIC STEEL HAVING HIGHER MAGNETIC FLUX DENSITY AND MANUFACTURE METHOD THEREOF**

(57) A non-oriented electrical steel having relative high magnetic induction and high intensity and a manufacturing method thereof, comprising steps as follows: 1) smelting and pouring, the weight percentage of the compositions of the electrical steel are as follows: C≤0.0040%, Si is 2.50% to 4.00%, Al is 0.20% to 0.80%, Cr is 1.0 to 8.0%, Ni is 0.5 to 5.0%, Mn≤0.50%, P≤0.30%, S≤0.0020%, N≤0.0030%, Ti≤0.0030%, Nb≤0.010%, V≤0.010%, C+S+N+Ti≤0.010%, and a balance substantially being Fe and inevitable impurities, carrying out smelting, RH vacuum process and pouring; 2) hot rolling; 3) normalizing, temperature is 850 to 950°C, time is 0.5

to 3 min, then being cooled to 650 to 750 °C slowly at 5 to 15°C/s, further being cooled to no higher than 100 °C fast at 20 to 70°C/s; 4) acid pickling and cold rolling, total screw-down rate is no less than 70%; 5) annealing, temperature is 800 to 1000 °C, holding 5 to 60s, then being cooled to 650 to 750°C slowly at 3 to 10°C/s, further being cooled to no higher than 100°C fast at 20 to 70°C/s. The present invention can manufacture a non-oriented electrical steel having high intensity and high magnetic induction without increasing manufacturing difficulty.

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Description**Technical Field**

5 **[0001]** The present invention relates to manufacturing of an electrical steel field, especially to a non-oriented electrical steel having relative high magnetic induction and high intensity and a manufacturing method thereof, which is applied in devices requiring high starting torque and impact resistant performance, such as electric automobile motor and running-up electric machine, wherein by adding solid molten strengthening elements such as Ni, Cr and the like, as well as controlling elements that damage magnetic property such as C, N, S, Ti and the like, the magnetic property of the
10 electrical steel may be ensured so as to improve the yield strength of the electric steel, at the same time by carrying out a proper normalizing annealing process to a hot rolled plate so as to improve the magnetic induction of the product.

Background Art

15 **[0002]** With the exhaustion of nonrenewable resources such as oil and coal and the like day by day, the harmfulness of environmental greenhouse effect becomes severe day by day, electric automobile and hybrid power automobile, as a low pollutant and high environment-protective vehicle, is got more and more attention, which will be applied widely without doubt. Stator cores and rotor cores of traction motor of electric automobile and hybrid power automobile are made of non-oriented electric steel, when automobile starts up and accelerates, the traction motor needs high torque,
20 so that it is necessary for electric steel plate to possess a high magnetic induction. Also, rotor cores of motor endures extreme strain due to centrifugal force in a high speed, and is subjected to strong impact momentarily when automobile starts up, so it is required for core material to possess high intensity and toughness.

25 **[0003]** In current non-oriented silicon steel product, as the content of Si improves, the intensity of product improves, the yield intension of a part of top level high steel grade product reaches up to 450MPa, the iron loss of product is relatively low as well, which satisfies application in normal industrial electric machinery and electric generating set. But toughness and plasticity of this kind of products is bad, being prone to creak, and magnetic induction is relatively low as well, which is not applied in the use of running-up electric machine such as electric automobile motor, so it is necessary to develop a non-oriented electrical steel having high intensity and high magnetic induction.

30 **[0004]** "High Intensity electromagnetic steel plate and processing component thereof and manufacturing method thereof" is disclosed in Chinese Patent Application CN 1863934, wherein strengthening elements such as Mn, Cu and the like, are added in its composition, so as to improve yield intension and tensile intension of electromagnetic steel plate, the short of which is that when product is manufactured in accordance with this method, cold rolling is difficult, magnetic property of electromagnetic steel plate is affected as well, so the magnetic induction of the manufactured electromagnetic steel plate is relatively low. In order to improve the intensity of the product, it is necessary to cool from high temperature
35 to intermediate temperature at a high cooling speed after the cold rolling plate is annealed, but in this treatment, a larger stress will be produced in the inner of the strip which has a bad influence on the shape of the strip, and affects the magnetic property and fatigue resistance of the product. Also, in this patent application, it is necessary to hold a long time at intermediate temperature zone to carry out hardening treatment in annealing and cooling for cold rolling, which is adverse to achieve in a normal industrial annealing machine set. Another aspect of this application is to manufacture
40 an electromagnetic steel plate, wherein the material thereof is relatively soft before being punched, the manufactured component is thermo-hardened to achieve the object of intensity improvement and abrasion resistance, which makes several thermal treatment processes added in customer use.

45 **[0005]** In the application WO 2009/128428 A1, it is necessary to cool at more than 50°C/s of cooling speed in a temperature interval from 900°C to 500°C, after the product is finally annealed. But in this method, intense stress will be produced in strip, having a strong influence on the shape of the strip and the magnetic property, which is adverse to be applied in actual industrial production.

Summary of the Invention

50 **[0006]** The object of the present invention is to provide a non-oriented electrical steel having relative high magnetic induction and high intensity and a manufacturing method thereof, which can be manufactured from existing devices without increasing manufacturing difficulty, so as to stably manufacture a non-oriented electrical steel having high intensity, abrasion resistance as well as high magnetic property.

55 **[0007]** In order to obtain the above-described object, the technical solution of the present invention is that

[0008] A non-oriented electrical steel having relative high magnetic induction and high intensity, wherein the weight percentage of the chemical composition are :

C: $\leq 0.0040\%$

Si: 2.50%~4.00%
 Al: 0.20%~0.80%
 Cr: 1.0~8.0%
 Ni: 0.5~5.0%
 Mn: <0.50%
 P: ≤0.30%
 S: ≤0.0020%
 N: ≤0.0030%
 Ti: ≤0.0030%
 Nb: ≤0.010%
 V: ≤0.010%
 C+S+N+Ti: ≤0.010%

and a balance substantially being Fe and inevitable impurities.

[0009] Further, the non-oriented electrical steel of the present invention comprises $Cu \leq 3\%$, as represented by weight percentage.

[0010] Also, the non-oriented electrical steel of the present invention comprises Sb and/or Sn, having a total content of no more than 0.5%, as represented by weight percentage.

[0011] Preferably, in the non-oriented electrical steel of the present invention, $C \leq 0.002\%$ or $C \leq 0.0015\%$; the content of Si is 2.8 to 3.3%; the content of Al is 0.4% to 0.6%; the content of Cr is 2.5% to 6%; the content of Ni is 1.0% to 3.5%; the content of P is no more than 0.1%, the content of S is no more than 0.0015%; the content of N is no more than 0.002%; the content of Ti is no more than 0.0015%, as represented by weight percentage.

[0012] A method for manufacturing a non-oriented electrical steel having relative high magnetic induction and high intensity in accordance with the present invention, comprising steps as follows:

1) smelting and pouring

the weight percentage of the chemical compositions of the non-oriented electrical steel are as follows: $C \leq 0.0040\%$, Si is 2.50%~4.00%, Al is 0.20%~0.80%, Cr is 1.0~8.0%, Ni is 0.5~5.0%, $Mn \leq 0.50\%$, $P \leq 0.30\%$, $S \leq 0.0020\%$, $N \leq 0.0030\%$, $Ti \leq 0.0030\%$, $Nb \leq 0.010\%$, $V \leq 0.010\%$, $C+S+N+Ti \leq 0.010\%$, and a balance substantially being Fe and inevitable impurities, carrying out smelting, RH vacuum process and being poured to a slab in accordance with the above compositions;

2) hot rolling

heating temperature of the slab is 1050 °C to 1200 °C, holding time is no less than 30min, incipient rolling temperature in planishing process is controlled to 940 °C to 1000°C, end-rolling temperature is no less than 850°C, final stand screw-down rate is controlled to 10 to 15%, the coiling temperature is controlled to 500 to 700 °C, the thickness of rolled plate is 2.0 to 2.6mm;

3) hot rolled plate normalizing

the normalizing temperature is 850 to 950°C, holding time is 0.5 to 3min, then being cooled to 650 to 750°C slowly at a cooling speed of 5 to 15°C/s, further being cooled to no higher than 100°C fast at a cooling speed of 20 to 70°C/s;

4) acid pickling and cold rolling

being cold rolled by means of single cold rolled process, total screw-down rate is no less than 70%;

5) annealing with continuous furnace

carrying out annealing treatment with continuous furnace, annealing temperature is 800 to 1000 °C, holding it 5 to 60s, then being cooled to 650 to 750 °C slowly at a cooling speed of 3 to 10°C/s, further being cooled to no higher than 100°C fast at a cooling speed of 20 to 70°C/s.

[0013] Further, the non-oriented electrical steel of the present invention comprises $Cu \leq 3\%$, as represented by weight percentage.

[0014] Also, the non-oriented electrical steel of the present invention comprises Sb and/or Sn, having a total content of no more than 0.5%, as represented by weight percentage.

[0015] In the composition designs of the present invention,

[0016] C can improve the intensity of the steel plate, but fine carbonization will strongly deteriorate magnetic property, when the content of C is larger, magnetic aging will occur in electrical steel, so the percentage of C is no more than 0.004% in the present invention, if the content of C is 0.002% or lower, the inhibiting effect on magnetic aging is prominent, in order to improve intensity without producing non-metallic deposition such as carbonization etc., more preferred being ≤0.0015%.

[0017] Si can improve electric resistance of steel and reduce iron loss, if improving the content of Si, iron loss may be reduced while intensity may be improved, so the content of Si can be improved as high as possible, requiring no less

than 2.5%, but when the content of Si is improved to a certain extent, product become brittle while magnetic induction decreases, therefore, it is required that the content of Si is no more than 4.0%, further preferably being 2.8 to 3.3%.

[0018] The effect of Al is similar to that of Si, which may reduce iron loss, if the content of Al is improved, AlN may be coarsened, which facilitates the growth of structure crystal grain to improve magnetic property of steel, but with the increase of Al, viscosity of liquid steel increases, making steel-making more difficult, while magnetic induction decreases as well, so the content of Al is chosen to 0.2% to 0.8%, preferably to 0.4% to 0.6%.

[0019] Cr and Ni are essential elements in the present invention, added as strengthening elements, and metallic phase based on Cr and Ni is formed in steel plate, so that try for high intensity without deterioration in magnetic property. If the content of Cr is low, the effect of high intensity decreases, in order to improve the intensity of steel plate, technological requirement in subsequent process is high, degrees of freedom of adjustment in manufacture is low, but if the content of Cr is high, magnetic property will deteriorate, and crack is subjected to occur in hot rolling process, so it is required that the content of Cr is 1.0% to 8.0%, further preferably in 2.5% to 6%.

[0020] Ni can improve the intensity of steel plate and improve magnetic induction, having a little influence on iron loss, which is added as a beneficial element, but if Ni is added too more, crack is subjected to occur in hot rolling process, and the coating performance of the surface is worsened, and the cost of product is improved, so it is required in the present invention that the content of Ni is 0.5% to 5.0%, further preferably being 1.0% to 3.5%.

[0021] Mn can improve the intensity of steel, however, in the present invention, Mn is not added for that purpose, but is added for improving intrinsic resistance or coarsening sulfide to reduce iron loss, adding Mn too more will result in reduction of magnetic induction, so it is required that the content of Mn is no more than 0.5%.

[0022] P is an element for improving tension stress prominently, but P is subjected to segregate and accumulate in grain boundary, making steel plate brittle severely, so it is required that the content of P is no more than 0.3%, preferably being no more than 0.1%.

[0023] S is a element that damages magnetic property, the formed fine sulfide inhibits growth of crystal grain, making iron loss increasing, so it is required that the content of S is no more than 0.002%, preferably being no more than 0.0015%.

[0024] N, which is similar to S, will damage magnetic property, so it is required that the content of N is no more than 0.003%, preferably being no more than 0.002%.

[0025] Ti can improve the intensity of steel plate, but has a strong influence on magnetic property, its fine deposition such as TiC and TiN, will root in grain boundary, which inhibits growth of crystal grain, making iron loss increased and magnetic induction reduced, so it is required that the content of Ti is no more than 0.003%, further preferably being no more than 0.0015%.

[0026] In the present invention, the total content of C + N + S + Ti is controlled to within 0.01 %, so as to ensure the magnetic property of steel plate.

[0027] Nb and V, as elements that damage magnetic property, are required to be controlled no more than 0.01 %.

[0028] Cu is added selectively as an element for improving intensity, Sn and Sb are added selectively as an element for improving magnetic property.

[0029] Steel containing composition described above, as is similar to normal electrical steel, is manufactured by means of processes such as hot rolling, normalizing, acid pickling, cold rolling and final annealing and the like from a slab that is manufactured by using continuous casting process by means of smelting for decarburizing in converter, ladle refining for deoxidizing and alloying.

[0030] In the manufacturing method, in order to produce characterizing metallic phase in the steel plate, as well as ensure manufacturability and magnetic property, the cooling course in normalizing process and the final annealing process are controlled as follows.

[0031] Cooling is carried out in segment after hot rolled plate is normalized, slow cooling is employed in hot section, and fast cooling is employed in cold section, after strip comes from normalizing soaking section, the strip is cooled to 650 to 750 °C slowly at a cooling speed of 5 to 15°C/s, then is cooled to no higher than 100°C fast at a cooling speed of 20 to 70°C/s. Reducing cooling speed in hot section will make the structure of crystal grains recover sufficiently, which reduces stress in steel plate, improves the flatness of the shape of normalizing plate, and improves efficiency of cold rolling. Also, reducing cooling speed in hot section after being normalized, will make solid molten carbonization and nitride depositing sufficiently, forming gross impurities of carbonization and nitride, which avoids to form fine impurities that inhibits growth of crystal grain, and forms advantageous structure within finished steel plate, so that improving the magnetic property of steel plate.

[0032] Cooling is carried out in segment after strip is final annealed, the strip is cooled to 650 to 750 °C slowly at a cooling speed of 3 to 10°C/s at first, then is cooled to no higher than 100 °C fast at a cooling speed of 20 to 70°C/s. In high temperature slow cooling period, Cr and Ni metallic phases that is characterized in composition, size and number density, are formed efficiently, not solid molten body or sulfide whose strengthening ability is low, which worsens strongly magnetic property. Meanwhile, slow cooling in hot section also reduces internal stress in finished strip, improves magnetic property of finished product, and improves fatigue resistance of the product as well.

Advantageous Effects of Invention

[0033] In the non-oriented electrical steel having high magnetic induction and high intensity of the present invention, strengthening elements such as Ni and Cr and the like are added into the compositions, and elements that damage magnetic property such as C, N, S, Ti and the like, are controlled to a relatively low level, making the intensity of electrical steel improved without prominent deterioration in magnetic property. Cooling process can be controlled in normalizing process and annealing process, which ensures the shape of the strip and stabilizes the magnetic property of product, and solves the problem that cold rolling is difficult as well.

Detailed Description of the Preferred Embodiment of the Invention

[0034] Hereinafter, the present invention will be described in connection with embodiments.

[0035] The compositions in the embodiments can be seen in Table 1.

Table 1

Embodiments	C	Si	Mn	P	S	Al	N	Ti	Nb	V	Cr	Ni	Cu	Sb
1	0.0020	3.0	0.40	0.01	0.0007	0.55	0.002	0.0015	0.0029	0.0022	/	/	/	/
2	0.0014	3.6	0.45	0.1	0.0011	0.75	0.003	0.002	0.002	0.003	/	/	/	/
3	0.0035	2.5	0.25	0.05	0.001	0.25	0.001	0.001	0.0015	0.001	1.0	0.5	/	/
4	0.0010	2.8	0.50	0.02	0.0019	0.45	0.0015	0.0007	0.003	0.002	1.5	2.0	1.0	/
5	0.0031	3.21	0.40	0.009	0.001	0.54	0.0017	0.0017	0.003	0.002	2.0	1.0	/	/
6	0.0021	3.11	0.30	0.015	0.0005	0.6	0.0009	0.0011	0.003	0.002	3.0	2.0	/	/
7	0.0025	3.0	0.42	0.01	0.001	0.5	0.0007	0.001	0.003	0.002	2.5	3.0	2.0	0.05
8	0.0019	2.9	0.39	0.1	0.0015	0.4	0.0014	0.0014	0.0032	0.0025	5.5	2.5	/	/
9	0.0015	3.30	0.45	0.02	0.0019	0.50	0.002	0.0015	0.003	0.002	2.5	3.0	/	0.05
10	0.002	3.5	0.35	0.05	0.0018	0.55	0.0018	0.0008	0.0021	0.0017	8.0	5.0	/	/
11	0.0023	3.0	0.41	0.003	0.0014	0.6	0.0019	0.0011	0.0037	0.0036	2.0	2.0	2.5	/

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[0036] After heating the manufactured slab to 1120 °C and holding this temperature for 60 min, hot rolling this manufactured slab to a strip having 2.3mm of thickness, the end-rolling temperature is 860 °C, and the coiling temperature is 570 °C. After the hot rolled plate is normalized at normalizing temperature 900 °C for 60s of heat preservation time, rolling this hot rolled plate to a cold rolled plate having a thickness of 0.5mm. After the cold rolled plate is annealed at annealing temperature 900°C for 15s of heat preservation time, cooling this cold rolled plate from 900 °C to 500 °C at different cooling speeds, then cooling to room temperature at 70°C/s, the magnetic property of the manufactured sample is measured by means of EPSTINE frame, mechanical performance and high cycle fatigue performance of the sample is measured by means of JIS5 tension (average load is 172MPa, amplitude is 156MPa), the performance measuring results corresponding to compositions and processes can be seen in Table 2.

Table 2

Embodi ments	W15/50 (W/kg)	B50(T)	Ys (MPa)	Fatigue Cycle (10 ⁵)
1	3.25	1.71	450	1.8
2	3.01	1.66	460	0.2
3	3.42	1.69	460	2.1
4	3.5	1.70	580	3.3
5	3.61	1.71	510	2.3
6	3.55	1.72	530	5.8
7	4.2	1.69	720	6.2
8	4.51	1.70	650	5.6
9	3.48	1.73	640	5.1
10	4.78	1.65	690	4.5

[0037] A slab is manufactured with the composition according to Embodiment 11 in Table 1, after heating the slab to 1120°C and holding this temperature for 60 min, this slab is hot rolled to a strip having a thickness of 2.3mm , the end-rolling temperature is 860 °C , and the coiling temperature is 570°C. After the hot rolled plate is normalized at normalizing temperature 900 °C for 60s of heat preservation time, this hot rolled plate is rolled to a cold rolled plate having a thickness of 0.5mm. After the cold rolled plate is annealed at annealing temperature 900 °C for 15s of heat preservation time, this cold rolled plate is cooled from 900 °C to 500 - 600 °C at different cooling speeds (1# to 5#), the cooling process can be seen in Table 3.

[0038] The magnetic property of the manufactured sample is measured by means of EPSTINE frame, mechanical performance and high cycle fatigue performance of the sample is measured by means of JIS5 tension (average load is 172MPa, amplitude is 156MPa), the performance measuring results can be seen in Table 4.

Table 3

Embodiment 11	Cooling Speed (°C/s)	Cool Intermediate Temperature (°C)
1#	3	600
2#	10	550
3#	20	550
4#	50	500
5#	80	500

Table 4

Embodiment 11	W/15/50 (W/kg)	B50 (T)	Ys (MPa)	Fatigue Cycle (10 ⁵)
1#	3.43	1.71	690	4.5
2#	3.48	1.70	705	4.5

(continued)

Embodiment 11	W/15/50 (W/kg)	B50 (T)	Ys (MPa)	Fatigue Cycle (10 ⁵)
3#	3.65	1.68	695	3.0
4#	4.05	1.63	710	2.1
5#	4.15	1.59	735	1.2

[0039] As can be seen in Table 3 and Table 4, the annealing cooling temperature is too fast, the magnetic performance of steel plate becomes worse, so that iron loss increases, magnetic induction decreases, and fatigue resistance becomes worse.

Claims

1. A non-oriented electrical steel having relative high magnetic induction and high intensity, wherein the weight percentage of the chemical composition are :

C: $\leq 0.0040\%$

Si: $2.50\% \sim 4.00\%$

Al: $0.20\% \sim 0.80\%$

Cr: $1.0 \sim 8.0\%$

Ni: $0.5 \sim 5.0\%$

Mn: $\leq 0.50\%$

P: $\leq 0.30\%$

S: $\leq 0.0020\%$

N: $\leq 0.0030\%$

Ti: $\leq 0.0030\%$

Nb: $\leq 0.010\%$

V: $\leq 0.010\%$

C+S+N+Ti: $\leq 0.010\%$

and a balance substantially being Fe and inevitable impurities.

2. The non-oriented electrical steel having relative high magnetic induction and high intensity in claim 1, **characterized by** comprising $\text{Cu} \leq 3\%$, as represented by weight percentage.
3. The non-oriented electrical steel having relative high magnetic induction and high intensity in claim 1 or 2, **characterized by** comprising Sb and/or Sn with a total content of no more than 0.5% , as represented by weight percentage.
4. The non-oriented electrical steel having relative high magnetic induction and high intensity in claim 1, **characterized by** $\text{C} \leq 0.02\%$ or $\text{C} \leq 0.0015\%$, as represented by weight percentage.
5. The non-oriented electrical steel having relative high magnetic induction and high intensity in claim 1, **characterized by** having a content of Si of 2.8 to 3.3% , as represented by weight percentage.
6. The non-oriented electrical steel having relative high magnetic induction and high intensity in claim 1, **characterized by** having a content of Al of 0.4% to 0.6% , as represented by weight percentage.
7. The non-oriented electrical steel having relative high magnetic induction and high intensity in claim 1, **characterized by** having a content of Cr of 2.5% to 6% , as represented by weight percentage.
8. The non-oriented electrical steel having relative high magnetic induction and high intensity in claim 1, **characterized by** having a content of Ni of 1.0% to 3.5% , as represented by weight percentage.
9. The non-oriented electrical steel having relative high magnetic induction and high intensity in claim 1, **characterized by** having a content of P of no more than 0.1% , and a content of S of no more than 0.0015% , as represented by weight percentage.

10. The non-oriented electrical steel having relative high magnetic induction and high intensity in claim 1, **characterized by** having a content of N of no more than 0.002%, as represented by weight percentage.

11. The non-oriented electrical steel having relative high magnetic induction and high intensity in claim 1, **characterized by** having a content of Ti of no more than 0.0015%, as represented by weight percentage.

12. A method for manufacturing a non-oriented electrical steel having relative high magnetic induction and high intensity, comprising steps as follows:

1) smelting and pouring

the weight percentage of the chemical compositions of the non-oriented electrical steel are $C \leq 0.0040\%$, Si is 2.50%~4.00%, Al is 0.20%~0.80%, Cr is 1.0~8.0%, Ni is 0.5~5.0%, $Mn \leq 0.50\%$, $P \leq 0.30\%$, $S \leq 0.0020\%$, $N \leq 0.0030\%$, $Ti \leq 0.0030\%$, $Nb \leq 0.010\%$, $V \leq 0.010\%$, $C+S+N+Ti \leq 0.010\%$, and a balance substantially being Fe and inevitable impurities; carrying out smelting, RH vacuum process and being poured to a slab in accordance with the compositions;

2) hot rolling

heating temperature of the slab is 1050°C to 1200°C, holding time is no less than 30min, incipient rolling temperature in planishing process is controlled to 940 °C to 1000 °C, end-rolling temperature is no less than 850 °C, final stand screw-down rate is controlled to 10 to 15%, the coiling temperature is controlled to 500 to 700 °C, the thickness of rolled plate is 2.0 to 2.6mm;

3) hot rolled plate normalizing

the normalizing temperature is 850 to 950°C, holding time is 0.5 to 3min, then being cooled to 650 to 750°C slowly at a cooling speed of 5 to 15°C/s, further being cooled to no higher than 100°C fast at a cooling speed of 20 to 70°C/s;

4) acid pickling and cold rolling

being cold rolled by means of single cold rolled process, total screw-down rate is no less than 70%;

5) annealing with continuous furnace

carrying out annealing treatment with continuous furnace, annealing temperature is 800 °C to 1000°C, holding it 5 s to 60s, then being cooled to 650 °C to 750 °C slowly at a cooling speed of 3 to 10 °C/s, further being cooled to no higher than 100 °C fast at a cooling speed of 20 to 70°C/s.

13. The method for manufacturing a non-oriented electrical steel having relative high magnetic induction and high intensity in claim 12, **characterized by** the non-oriented electrical steel further comprising $Cu \leq 3\%$, as represented by weight percentage.

14. The method for manufacturing a non-oriented electrical steel having relative high magnetic induction and high intensity in claim 12 or 13, **characterized by** the non-oriented electrical steel further comprising Sb and/or Sn, having a total content of no more than 0.5%, as represented by weight percentage.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2011/073368

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: C22C38/-, C21D8/-

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

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

WPI, EPODOC, CN-PAT, CNKI: C, carbon, Si, silicon, silicium, Al, aluminium, aluminum, Cr, chrome, chromium, Ni, nickel, Mn, manganese, Fe, iron, ferrum, roll+, anneal+, strength, non oriented, non directional, electrical steel, electric steel, magnetic steel, silicon steel, si steel

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP2004-339603A(KAWASAKI STEEL CORP)02 Dec.2004(02.12.2004) Paragraph [0049], table 3 table4	1-11
A	CN101333620A(BAOSHAN IRON & STEEL CO LTD)31 Dec.2008 (31.12.2008) whole document	1-14
A	CN101069943A(FENXIANGKE IND TRADE CO LTD et al)14 Nov.2007 (14.11.2007) whole document	1-14

☒ 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
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International application No.

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Continuation of: second sheet, A. CLASSIFICATION OF SUBJECT MATTER

C22C38/40 (2006.01)i

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