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(54) **NON-ORIENTED ELECTRICAL STEEL SHEET**

NICHT-ORIENTIERTES ELEKTROSTAHLBLECH

TÔLE D'ACIER ÉLECTRIQUE NON ORIENTÉ

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EP 2 390 376 B1

Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a non-oriented electrical steel sheet suitable for a rotor of a high-speed rotary machine.

BACKGROUND ART

10 **[0002]** A non-oriented electrical steel sheet is used for a rotor of a rotary machine or the like, for example. In general, centrifugal force acting on the rotor is in proportion to a rotation radius, and is in proportion to the square of a rotation speed. For the above reason, extremely large stress acts on the rotor of the high-speed rotary machine. Thus, tensile strength of the non-oriented electrical steel sheet for a rotor is preferably high. That is, the non-oriented electrical steel sheet for a rotor preferably has high tension. As described above, high tensile strength (high tension) is required for the non-oriented electrical steel sheet for a rotor.

15 **[0003]** On the other hand, in a non-oriented electrical steel sheet used for not only a rotor of a rotary machine but also an iron core, it is important that its core loss is low. Particularly, in the non-oriented electrical steel sheet for a rotor of a high-speed rotary machine, it is important that its high-frequency core loss is low. As described above, a low high-frequency core loss is also required for the non-oriented electrical steel sheet for a rotor. That is, high efficiency when the rotary machine is used at a high frequency is also required.

20 **[0004]** However, the high tension and the low high-frequency core loss are in a relationship such that they are contrary to each other physically, and it is extremely difficult to achieve both of them.

[0005] There has been proposed a technique in which the achievement of these is considered, but there has been no technique capable of easily manufacturing a non-oriented electrical steel sheet so far. For example, there has been proposed a technique in which a hot-rolled steel sheet having a high Si content is obtained and thereafter various types of temperature controls are performed, but cold rolling is extremely difficult to be performed because the Si content is high. Further, various types of temperature controls are performed in order to enable cold rolling to be performed, but the above temperature controls are extremely peculiar, resulting that time, labor, and cost required for the above are increased.

30 **[0006]** Patent Document 8 discloses a specific high strength non-oriented electrical steel sheet and a specific method of manufacturing the same.

CITATION LIST

35 PATENT LITERATURE

[0007]

40 Patent Document 1: Japanese Laid-open Patent Publication No. Sho 60-238421
 Patent Document 2: Japanese Laid-open Patent Publication No. Sho 61-9520
 Patent Document 3: Japanese Laid-open Patent Publication No. Sho 62-256917
 Patent Document 4: Japanese Laid-open Patent Publication No. Hei 2-8346
 Patent Document 5: Japanese Laid-open Patent Publication No. 2007-186791
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 45 Patent Document 7: Japanese Laid-open Patent Publication No. 2008-240104
 Patent Document 8: US 5,084,112 A

SUMMARY OF THE INVENTION

50 TECHNICAL PROBLEM

[0008] The present invention has an object to provide a non-oriented electrical steel sheet capable of being manufactured easily and obtaining high tensile strength and a low high-frequency core loss.

55 SOLUTION TO PROBLEM

[0009] The present inventors have conducted earnest studies on a non-oriented electrical steel sheet from the viewpoint of obtaining favorable mechanical properties while suppressing a core loss low by solid solution strengthening, precip-

itation strengthening, work strengthening, grain refining strengthening, strengthening by transformation composition, and so on. Further, the present inventors have repeated researches and analyses with regard to what index a high-frequency core loss to be important in an actual high-speed rotary machine becomes, in other words, with regard to at what frequency a core loss is important to be reduced. Further, greater importance is also given to easiness of processes such as cold rolling in a manufacturing process and avoidance of process complication.

[0010] As a result, details will be described later, but it has been found that contents of Si, Mn, Ni, and so on are set appropriately and a ratio of a content of Ti to a total content of C and N is set appropriately, thereby enabling a high-frequency core loss to be suppressed low while obtaining high tensile strength of 900 MPa or more. Further, as the high-frequency core loss, it has also been found that it is important that a core loss $W_{10/1000}$, which is a core loss in the case of a magnetic flux density being 1.0 T and an excitation frequency being 1000 Hz, is low. Then, the present inventors have reached the following non-oriented electrical steel sheet according to claim 1.

[0011] A non-oriented electrical steel sheet according to the present invention contains: C: not less than 0.003 mass% nor more than 0.05 mass%; N: not less than 0.001 mass% nor more than 0.01 mass%; and Si: not less than 2.8 mass% nor more than 3.5 mass%. The non-oriented electrical steel sheet further contains at least one kind selected from a group consisting of Ni: 4.0 mass% or less and Mn: 2.0 mass% or less, in a total amount of 0.5 mass% or more, and further contains Ti, a value R_{Ti} being not less than 1 nor more than 10, the value R_{Ti} being expressed by $[Ti]/(4 \times ([C] + [N]))$ when a Ti content is expressed as [Ti] mass%, a C content is expressed as [C] mass%, and an N content is expressed as [N] mass%. The Ti content is not less than 0.1 mass% nor more than 0.3 mass%, an Al content is 0.1 mass% or more and 3.0 mass% or less, a P content is 0.001 mass% or more and 0.2 mass% or less, and a balance is composed of Fe and inevitable impurities.

ADVANTAGEOUS EFFECTS OF INVENTION

[0012] According to the present invention, contents of Si, Mn, Ni, and so on and a value R_{Ti} are appropriate, and thus high tensile strength and a low high-frequency core loss can be obtained. Further, the contents of Si and so on are appropriate, and thus processes in a manufacturing process are easy to be performed, and addition of complex processes based on embrittlement and the like can also be avoided.

DESCRIPTION OF EMBODIMENTS

[0013] Hereinafter, the present invention will be explained in detail. First, components of a non-oriented electrical steel sheet according to the present invention will be explained.

[0014] Si has an effect of reducing a core loss such as a high-frequency core loss by increasing electrical resistance of the non-oriented electrical steel sheet to thereby reduce an eddy current loss. Further, Si has an effect of increasing tension of the non-oriented electrical steel sheet by solid solution strengthening. When a Si content is less than 2.8 mass%, these effects is insufficient. On the other hand, when the Si content exceeds 3.5 mass%, a reduction in a magnetic flux density, embrittlement, difficulty in performing processes of cold rolling and the like, and an increase in a material cost are caused. Thus, the Si content is set to not less than 2.8 mass% nor more than 3.5 mass%.

[0015] Al, similarly to Si, has an effect of reducing a core loss such as a high-frequency core loss by increasing the electrical resistance of the non-oriented electrical steel sheet to thereby reduce an eddy current loss. Thus, Al may also be contained as an aim to further reduce a high-frequency core loss. However, when an Al content exceeds 3.0 mass%, a reduction in a magnetic flux density, embrittlement, difficulty in performing processes of cold rolling and the like, and an increase in a material cost are caused. Thus, an upper limit of the Al content is set to 3.0 mass%. Further, when the Al content is less than 0.1 mass%, fine precipitation of AlN is remarkably exhibited to increase a core loss, and thus the Al content is 0.1 mass% or more.

[0016] Ni and Mn contribute to an improvement in tension of the non-oriented electrical steel sheet. That is, Ni has an effect of increasing the tension by solid solution strengthening, and Mn has an effect of increasing the tension by solid solution strengthening and grain refining strengthening. Further, Ni also has an effect of reducing a core loss such as a high-frequency core loss by increasing the electrical resistance of the non-oriented electrical steel sheet to thereby reduce an eddy current loss. Further, Ni also contributes to an improvement in a magnetic flux density in accordance with an increase in a saturated magnetic moment of the non-oriented electrical steel sheet. Mn has an effect of reducing a core loss such as a high-frequency core loss by increasing the electrical resistance of the non-oriented electrical steel sheet to thereby reduce an eddy current loss. When a total amount of a Ni content and a Mn content is less than 0.5 mass%, these effects are insufficient, resulting that tensile strength of 900 MPa or more cannot be obtained. On the other hand, when the Ni content exceeds 4.0 mass%, a reduction in a magnetic flux density ascribable to the reduction in a saturated magnetic moment occurs. Further, when the Mn content exceeds 2.0 mass%, a magnetic flux density is reduced and further a material cost is increased. Thus, it is set in a manner that Ni of 4.0 mass% or less and/or Mn of 2.0 mass% or less are/is contained in a total amount of 0.5 mass% or more.

[0017] P has an effect of greatly increasing the tension of the non-oriented electrical steel sheet. Thus, P may also be contained as an aim to further improve the tension. In order to achieve the above effect, 0.001 mass% or more of P is contained. However, when P content exceeds 0.2 mass%, P segregates in crystal grain boundaries in a manufacturing process to embrittle a hot-rolled steel sheet, resulting that cold rolling thereafter becomes extremely difficult to be performed. Thus, an upper limit of the P content is set to 0.2 mass%.

[0018] Ti has an effect of reacting with C and N to form a fine precipitate containing Ti carbonitride and increasing the tension of the non-oriented electrical steel sheet by precipitation strengthening and grain refining strengthening. Further, Ti being solid-dissolved in the non-oriented electrical steel sheet has an effect of orienting crystal orientations of a surface of the non-oriented electrical steel sheet in {111} when cold rolling, finish annealing, and the like, and increasing the tension of the non-oriented electrical steel sheet. In order to exhibit these effects sufficiently, it is important that appropriate amounts of both Ti to be precipitated as Ti carbonitride and Ti being solid-dissolved in the non-oriented electrical steel sheet are contained.

[0019] When a Ti content is expressed as [Ti] mass%, a C content is expressed as [C] mass%, and an N content is expressed as [N] mass%, if a value R_{Ti} expressed by $[Ti]/(4 \times ([C] + [N]))$ is less than 1, the above-described effects cannot be exhibited sufficiently. Thus, the value R_{Ti} is set to 1 or more. In the case of the value R_{Ti} being 1, all Ti is bonded to C and/or N theoretically, but practically, part of Ti is not bonded to either C or N to be contained in the non-oriented electrical steel sheet as solid solution Ti. Note that the value R_{Ti} is preferably 2 or more, and more preferably 3 or more.

[0020] On the other hand, when the value R_{Ti} exceeds 10, recrystallization is unlikely to occur and further embrittlement is likely to occur. Further, there is sometimes a case that in accordance with an increase in the solid solution Ti, the orientation to {111} is too intensified to increase a core loss. Thus, the value R_{Ti} is set to 10 or less. Incidentally, the value R_{Ti} is preferably 9 or less, and more preferably 7 or less.

[0021] Further, in order to make the value R_{Ti} fall within a range as above, it is set in a manner that the C content is not less than 0.003 mass% nor more than 0.05 mass% and the N content is not less than 0.001 mass% nor more than 0.01 mass%. Incidentally, in the case when the C content exceeds 0.05 mass%, or the N content exceeds 0.01 mass%, core loss properties are remarkably reduced due to magnetic aging or the like.

[0022] Further, in order to make the value R_{Ti} fall within the above-described range, the Ti content is not less than 0.1 mass% nor more than 0.3 mass%, and an upper limit of the Ti content is more preferably 0.25 mass%.

[0023] Note that as metallic elements to form carbonitride in the non-oriented electrical steel sheet, Zr, V, Nb, and Mo are also cited besides Ti. Among them, precipitation strengthening by Ti carbonitride is remarkable.

[0024] The components of the non-oriented electrical steel sheet except the above-described components are Fe and inevitable impurities, for example. Note that as an aim to avoid embrittlement of the crystal grain boundaries with the increase in tension, B may also be contained. In the above case, a B content is preferably 0.001 mass% or more. On the other hand, when the B content exceeds 0.007 mass%, a reduction in a magnetic flux density, embrittlement at the time of hot rolling, and the like are caused. Thus, the B content is preferably 0.007 mass% or less.

[0025] Further, as an aim to further improve various types of magnetic properties, Cu: not less than 0.02 mass% nor more than 1.0 mass%, Sn: not less than 0.02 mass% nor more than 0.5 mass%, Sb: not less than 0.02 mass% nor more than 0.5 mass%, Cr: not less than 0.02 mass% nor more than 3.0 mass%, and/or rare earth metal (REM: rare earth metal): not less than 0.001 mass% nor more than 0.01 mass% may also be contained. That is, one kind or more of the element (elements) selected from a group consisting of these plural kinds of elements may also be contained.

[0026] Then, the tensile strength of the non-oriented electrical steel sheet composed of these components becomes 900 MPa or more. Therefore, a rotor of a high-speed rotary machine manufactured by using the above non-oriented electrical steel sheet can achieve sufficient high-speed rotation.

[0027] Further, a high-frequency core loss $W_{10/1000}$ of the non-oriented electrical steel sheet composed of these components becomes 100 W/kg or less. Therefore, a rotor of a high-speed rotary machine manufactured by using the above non-oriented electrical steel sheet can contribute to high-efficiency and miniaturization of the rotary machine. That is, energy loss caused by converting from electric energy into mechanical energy and heat generation incidental to the conversion can be suppressed. Then, in order to reduce an eddy current loss to thereby make the high-frequency core loss $W_{10/1000}$ become 100 W/kg or less, a thickness of the non-oriented electrical steel sheet is 0.30 mm or less.

[0028] The present inventors confirmed these effects by the following experiments. First, a slab containing C: 0.017 mass%, Si: 3.12 mass%, Al: 0.65 mass%, Ni: 2.54 mass%, P: 0.02 mass%, N: 0.003 mass%, and Ti: 0.18 mass% was hot-rolled, and a hot-rolled steel sheet was obtained. The value R_{Ti} of the above hot-rolled steel sheet is 2.3. Next, the hot-rolled steel sheet was cold-rolled to have four types of thicknesses shown in Table 1, and a cold-rolled steel sheet was obtained. Thereafter, continuous finish annealing at 780°C for 20 seconds was applied to the cold-rolled steel sheet, and a non-oriented electrical steel sheet was obtained. Then, Epstein samples and tensile test pieces were cut out from the non-oriented electrical steel sheet, and magnetic properties and mechanical properties were measured by using them. Results thereof are also shown in Table 1. In Tables as below, " $W_{15/50}$ " represents a core loss $W_{15/50}$, "B50" represents a magnetic flux density B50, and " $W_{10/1000}$ " represents the core loss $W_{10/1000}$. Further, "YP" represents a yield point, "TS" represents the tensile strength, and "EL" represents elongation.

[Table 1]

[0029]

[Table 1]

Sample No.	Thickness (mm)	Magnetic properties			Mechanical properties		
		$W_{15/50}$ (W/kg)	B50 (T)	$W_{10/1000}$ (W/kg)	YP (MPa)	TS (MPa)	EL (%)
1 *	0.50	9.6	1.58	155	870	921	15
2 *	0.35	9.0	1.57	112	875	928	16
3	0.20	8.6	1.56	87	876	930	18
4	0.15	8.4	1.56	80	881	935	18
* Reference Samples							

[0030] As shown in Table 1, although in Samples No. 1 and No. 2, the tensile strength of 900 MPa or more was obtained and Samples No. 1 and No. 2 had the high tension, the high-frequency core loss $W_{10/1000}$ exceeded 100 W/kg. This is because the thicknesses of the non-oriented electrical steel sheet exceed 0.30mm.

[0031] For the above reason as well, the thickness of the non-oriented electrical steel sheet is 0.30 mm or less.

[0032] Incidentally, the non-oriented electrical steel sheet according to the present invention can be manufactured in the following manner, for example. First, a slab having the above-described composition is melted, and the above slab is heated and hot rolled to obtain a hot-rolled steel sheet. Next, the above hot-rolled steel sheet is cold rolled to obtain a cold-rolled steel sheet. Thereafter, finish annealing is performed. Incidentally, in order to avoid a reduction in strength and embrittlement accompanying growth of crystal grains, hot-rolled sheet annealing is preferably not performed, and intermediate annealing during cold rolling is also preferably not performed. As long as the hot-rolled steel sheet having the above-described composition is used, the effects of the improvement in tension and the reduction in a high-frequency core loss can be obtained without performing hot-rolled sheet annealing and intermediate annealing. Further, hot-rolled sheet annealing is omitted, thereby also enabling bending workability to be improved. That is, since the non-oriented electrical steel sheet according to the present invention has the above-described composition, the improvement in tension and the reduction in a high-frequency core loss can be achieved by the relatively simple processes.

EXAMPLE

(First Experiment)

[0033] First, slabs containing components shown in Table 2 and a balance being composed of Fe and inevitable impurities were hot rolled to obtain hot-rolled steel sheets. Next, the hot-rolled steel sheets were cold rolled to obtain cold-rolled steel sheets having thicknesses of 0.20 mm. Thereafter, continuous finish annealing at 750°C for 30 seconds was applied to the cold-rolled steel sheets to obtain non-oriented electrical steel sheets.

[Table 2]

[0034]

[Table 2]

Sample No.		Components								R_{Ti}
		C	Si	Al	Ni	Mn	P	N	Ti	
Comparative examples	11	0.0059	3.02	0.73	2.01	1.02	0.04	0.0030	0.000	0.00
	12	0.0067	3.07	0.77	2.16	1.11	0.03	0.0027	0.023	0.61
Examples	13	0.0046	3.01	0.70	2.12	0.95	0.03	0.0029	0.257	8.57
	14	0.0055	3.04	0.73	2.04	1.01	0.04	0.0026	0.168	5.12

[0035] Then, Epstein samples and tensile test pieces were cut out from the non-oriented electrical steel sheets. Next,

magnetic properties were measured by using the Epstein samples, and mechanical properties were measured by using the tensile test pieces. Results thereof are shown in Table 3.

[Table 3]

[0036]

[Table 3]

Sample No.		Magnetic properties			Mechanical properties		
		$W_{15/50}$ (W/kg)	B50 (T)	$W_{10/1000}$ (W/kg)	YP (MPa)	TS (MPa)	EL (%)
Comparative examples	11	4.8	1.60	47	688	775	24
	12	5.6	1.59	58	703	785	22
Examples	13	8.1	1.57	84	871	922	17
	14	7.7	1.58	79	902	953	16

[0037] As shown in Table 3, in Comparative examples No. 11 and 12, the high-frequency core loss $W_{10/1000}$ was less than 100 W/kg, but the tensile strength was low, which was less than 900 MPa, because the value R_{Ti} was less than 1. Particularly, in Comparative example No. 11, Ti was not contained at all, and thus the tensile strength was remarkably low.

[0038] On the other hand, in Examples No. 13 and 14, the value R_{Ti} and so on were set appropriately, and thus the high-frequency core loss $W_{10/1000}$ of 100 W/kg or less and the tensile strength of 900 MPa or more could be obtained. Further, the yield point was also high as compared with Comparative examples No. 11 and 12.

(Second Experiment)

[0039] First, slabs containing components shown in Table 4 and a balance being composed of Fe and inevitable impurities were hot rolled to obtain hot-rolled steel sheets. Next, the hot-rolled steel sheets were cold rolled to obtain cold-rolled steel sheets having thicknesses of 0.25 mm. Thereafter, continuous finish annealing at 775°C for 30 seconds was applied to the cold-rolled steel sheets to obtain non-oriented electrical steel sheets.

[Table 4]

[0040]

[Table 4]

Sample No.		Components									R_{Ti}
		C	Si	Al	Ni	Mn	P	B	N	Ti	
Comparative examples	21	0.0066	3.24	0.61	1.85	1.30	0.03	0.0028	0.0024	0.000	0.00
	22	0.0070	3.28	0.60	1.81	1.29	0.02	0.0027	0.0027	0.032	0.82
Examples	23	0.0069	3.25	0.63	1.90	1.31	0.03	0.0029	0.0025	0.278	7.39
	24	0.0073	3.30	0.58	1.88	1.33	0.03	0.0030	0.0023	0.146	3.80

[0041] Then, Epstein samples and tensile test pieces were cut out from the non-oriented electrical steel sheets. Next, magnetic properties were measured by using the Epstein samples, and mechanical properties were measured by using the tensile test pieces. Results thereof are shown in Table 5.

[Table 5]

[0042]

[Table 5]

Sample No.		Magnetic properties			Mechanical properties		
		$W_{15/50}$ (W/kg)	B ₅₀ (T)	$W_{10/1000}$ (W/kg)	YP (MPa)	TS (MPa)	EL (%)
Comparative examples	21	5.4	1.62	63	708	796	26
	22	6.1	1.61	67	745	804	24
Examples	23	8.9	1.59	92	889	931	20
	24	8.7	1.60	90	910	962	21

[0043] As shown in Table 5, in Comparative examples No. 21 and 22, the high-frequency core loss $W_{10/1000}$ was less than 100 W/kg, but the tensile strength was low, which was less than 900 MPa, because the value R_{Ti} was less than 1. Particularly, in Comparative example No. 21, Ti was not contained at all, and thus the tensile strength was remarkably low.

[0044] On the other hand, in Examples No. 23 and 24, the value R_{Ti} and so on were set appropriately, and thus the high-frequency core loss $W_{10/1000}$ of 100 W/kg or less and the tensile strength of 900 MPa or more could be obtained. Further, the yield point was also high as compared with Comparative examples No. 21 and 22.

INDUSTRIAL APPLICABILITY

[0045] The present invention can be utilized in, for example, the electrical steel sheet manufacturing industry and the electrical steel sheet utilizing industry.

Claims

1. A non-oriented electrical steel sheet containing:

C: not less than 0.003 mass% nor more than 0.05 mass%;

N: not less than 0.001 mass% nor more than 0.01 mass%; and

Si: not less than 2.8 mass% nor more than 3.5 mass%,

further containing at least one kind selected from a group consisting of Ni: 4.0 mass% or less and Mn: 2.0 mass% or less, in a total amount of 0.5 mass% or more, and

further containing Ti, a value R_{Ti} being not less than 1 nor more than 10, the value R_{Ti} being expressed by $[Ti]/(4 \times ([C] + [N]))$ when a Ti content is expressed as [Ti] mass%, a C content is expressed as [C] mass%, and an N content is expressed as [N] mass%,

wherein

the Ti content is not less than 0.1 mass% nor more than 0.3 mass%,

an Al content is 0.1 mass% or more and 3.0 mass% or less,

a P content is 0.001 mass% or more and 0.2 mass% or less, and

a balance is composed of Fe and inevitable impurities,

a thickness is 0.30 mm or less,

a tensile strength is 900 MPa or more, and

a core loss in the case of a magnetic flux density being 1.0 T and an excitation frequency being 1000 Hz is 100 W/kg or less.

2. The non-oriented electrical steel sheet according to claim 1, further containing B: not less than 0.001 mass% nor more than 0.007 mass%.

3. The non-oriented electrical steel sheet according to claim 1 or 2, further containing at least one kind selected from a group consisting of:

Cu: not less than 0.02 mass% nor more than 1.0 mass%;

Sn: not less than 0.02 mass% nor more than 0.5 mass%;

Sb: not less than 0.02 mass% nor more than 0.5 mass%;

Cr: not less than 0.02 mass% nor more than 3.0 mass%; and

rare earth metal: not less than 0.001 mass% nor more than 0.01 mass%.

Patentansprüche**1. Ein nicht-orientiertes Elektrostahlblech, enthaltend:**

C: nicht weniger als 0,003 Massen-% und nicht mehr als 0,05 Massen-%;
 N: nicht weniger als 0,001 Massen-% und nicht mehr als 0,01 Massen-%; und
 Si: nicht weniger als 2,8 Massen-% und nicht mehr als 3,5 Massen-%;
 ferner enthaltend mindestens eine Art, ausgewählt aus einer Gruppe bestehend aus Ni: 4,0 Massen-% oder weniger und Mn: 2,0 Massen-% oder weniger, in einer Gesamtmenge von 0,5 Massen-% oder mehr, und
 ferner enthaltend Ti, einen Wert R_{Ti} , der nicht weniger als 1 und nicht mehr als 10 beträgt, wobei der Wert R_{Ti} ausgedrückt wird durch $[Ti]/(4 \times ([C]+[N]))$, wenn ein Ti-Gehalt als [Ti]-Massen-% ausgedrückt wird, ein C-Gehalt als [C]-Massen-% ausgedrückt wird, und ein N-Gehalt als [N]-Massen-% ausgedrückt wird, wobei
 der Ti-Gehalt nicht weniger als 0,1 Massen-% und nicht mehr als 0,3 Massen-% beträgt;
 ein Al-Gehalt 0,1 Massen-% oder mehr und 3,0 Massen-% oder weniger beträgt,
 ein P-Gehalt 0,001 Massen-% oder mehr und 0,2 Massen-% oder weniger beträgt, und
 ein Rest aus Fe und unvermeidbaren Verunreinigungen besteht,
 eine Dicke 0,30 mm oder weniger beträgt,
 eine Zugfestigkeit 900 MPa oder mehr beträgt, und
 ein Kernverlust im Fall einer magnetischen Flussdichte von 1,0 T und einer Anregungsfrequenz von 1000 Hz 100 W/kg oder weniger beträgt.

2. Das nicht-orientierte Elektrostahlblech nach Anspruch 1, ferner enthaltend B: nicht weniger als 0,001 Massen-% und nicht mehr als 0,007 Massen-%.**3. Das nicht-orientierte Elektrostahlblech nach Anspruch 1 oder 2, ferner umfassend mindestens eine Art, ausgewählt aus der Gruppe bestehend aus:**

Cu: nicht weniger als 0,02 Massen-% und nicht mehr als 1,0 Massen-%;
 Sn: nicht weniger als 0,02 Massen-% und nicht mehr als 0,5 Massen-%;
 Sb: nicht weniger als 0,02 Massen-% und nicht mehr als 0,5 Massen-%;
 Cr: nicht weniger als 0,02 Massen-% und nicht mehr als 3,0 Massen-%; und
 Seltenerdmetall: nicht weniger als 0,001 Massen-% und nicht mehr als 0,01 Massen-%.

Revendications**1. Tôle d'acier électrique non-orienté contenant :**

C : pas moins de 0,003 % en masse ni plus de 0,05 % en masse ;
 N : pas moins de 0,001 % en masse ni plus de 0,01 % en masse ; et
 Si : pas moins de 2,8 % en masse ni plus de 3,5 % en masse,
 contenant de plus au moins un type choisi dans un groupe consistant en Ni : 4,0 % en masse ou inférieur et Mn : 2,0 % en masse ou inférieur, dans une quantité totale de 0,5 % en masse ou supérieure, et
 contenant de plus Ti, une valeur R_{Ti} n'étant pas inférieure à 1 ni supérieure à 10, la valeur R_{Ti} étant exprimée par $[Ti]/(4 \times ([C]+[N]))$ lorsqu'une teneur en Ti est exprimée par [Ti] % en masse, une teneur en C est exprimée par [C] % en masse, et une teneur en N est exprimée par [N] % en masse, dans laquelle
 la teneur en Ti n'est pas inférieure à 0,1 % en masse ni supérieure à 0,3 % en masse,
 une teneur en Al est de 0,1 % en masse ou supérieure et de 3,0 % en masse ou inférieure,
 une teneur en P est de 0,001 % en masse ou supérieure et de 0,2 % en masse ou inférieure, et
 un reste est constitué de Fe et d'impuretés inévitables,
 une épaisseur est de 0,30 mm ou inférieure,
 une résistance à la traction est de 900 MPa ou supérieure, et
 une perte dans le noyau dans le cas d'une densité de flux magnétique étant de 1,0 T et d'une fréquence d'excitation étant de 1 000 Hz est de 100 W/kg ou inférieure.

2. Tôle d'acier électrique non-orienté selon la revendication 1, contenant de plus B : pas moins de 0,001 % en masse

EP 2 390 376 B1

ni plus de 0,007 % en masse.

3. Tôle d'acier électrique non orienté selon la revendication 1 ou 2, contenant de plus au moins un type choisi dans un groupe consistant en :

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Cu : pas moins de 0,02 % en masse ni plus de 1,0 % en masse ;

Sn : pas moins de 0,02 % en masse ni plus de 0,5 % en masse ;

Sb : pas moins de 0,02 % en masse ni plus de 0,5 % en masse ;

Cr : pas moins de 0,02 % en masse ni plus de 3,0 % en masse ; et

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métal de terre rare : pas moins de 0,001 % en masse ni plus de 0,01 % en masse.

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REFERENCES CITED IN THE DESCRIPTION

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