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(54) **GRAIN-ORIENTED ELECTRICAL STEEL SHEET AND MANUFACTURING METHOD THEREFOR**

KORNORIENTIERTES ELEKTRISCHES STAHLBLECH UND HERSTELLUNGSVERFAHREN DAFÜR

TÔLE D'ACIER ÉLECTRIQUE À GRAINS ORIENTÉS ET SON PROCÉDÉ DE FABRICATION

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(73) Proprietor: **Posco**
Pohang-si, Gyeongsangbuk-do 37859 (KR)

(72) Inventors:
- **JOO, Hyung Don**
  Pohang-si
  Gyeongsangbuk-do 790-300 (KR)
- **PARK, Hyung-Ki**
  Pohang-si
  Gyeongsangbuk-do 790-300 (KR)
- **SEO, Jin-Wook**
  Pohang-si
  Gyeongsangbuk-do 790-300 (KR)
- **HAN, Kyu-Seok**
  Pohang-si
  Gyeongsangbuk-do 790-300 (KR)
- **LIM, Jae-Soo**
  Pohang-si
  Gyeongsangbuk-do 790-300 (KR)
- **KO, Hyun-Seok**
  Pohang-si
  Gyeongsangbuk-do 790-300 (KR)

(74) Representative: **Zech, Stefan Markus**
Meissner Bolte Patentanwälte
Rechtsanwälte Partnerschaft mbB
Postfach 86 06 24
81633 München (DE)

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Description

[Technical Field]

[0001] The present invention relates to an oriented electrical steel sheet and a manufacturing method thereof.

[Background Art]

[0002] Generally, in an oriented electrical steel sheet having an excellent magnetic characteristic, a Goss texture of a {110}<001 > orientation should strongly develop in a rolling direction thereof, and in order to form such a Goss texture, abnormal grain growth corresponding to secondary recrystallization must be formed. The abnormal grain growth occurs when normal grain growth is inhibited by precipitates, inclusions, or elements that are solidified or segregated, unlike the normal grain growth. The oriented electrical steel sheet is mainly manufactured by a manufacturing method in which a precipitate such as AlN, MnS, or the like is used as a grain growth inhibitor to cause secondary recrystallization. The method of manufacturing the oriented electrical steel sheet by using the precipitate such as AlN, MnS, or the like as the grain growth inhibitor has the following problems. In order to use the AlN and MnS precipitates as the grain growth inhibitor, the precipitates should be distributed very finely and uniformly on the steel sheet. In order to uniformly distribute the fine precipitates to the steel sheet, a slab should be heated at a high temperature of 1300 °C or higher for a long time to solidify coarse precipitates present in steel, and then a hot-rolling process should be performed and finished in a very short time in a state in which no precipitation occurs. For this, a large slab heating system is required, and in order to suppress the precipitation as much as possible, the hot-rolling process and a winding process should be managed very strictly and the precipitates solidified in a hot-rolled steel sheet annealing process after the hot-rolling process should be controlled to be finely precipitated. In addition, when the slab is heated at a high temperature, since a slab washing phenomenon occurs due to formation of Fe_2SiO_4 having a low melting point, an actual yield is lowered. Further, a purification annealing process must be performed for a long time at a high temperature of 1200 °C for 30 hours or more in order to remove precipitate components after the completion of the secondary recrystallization, which complicates a manufacturing process and causes a cost burden. Further, in the purification annealing process, after AlN-based precipitates are decomposed into Al and N, Al moves to a surface of the steel sheet and reacts with oxygen in a surface oxide layer to form Al_2O_3 oxide. The formed Al-based oxide and the AlN precipitates not decomposed in the purification annealing process interfere with movement of a magnetic domain in the steel sheet or near the surface, thereby deteriorating iron loss. KR 10-2014-0084770 discloses a non oriented electrical steel with 0.1-4.0 Al.

[DISCLOSURE]

[Technical Problem]

[0003] The present invention has been made in an effort to provide an oriented electrical steel sheet.

[0004] The present invention has also been made in an effort to provide a manufacturing method of the oriented electrical steel sheet.

[Technical Solution]

[0005] An exemplary embodiment of the present invention is given in the claims and provides an oriented electrical steel sheet including Ba alone at about 0.005 wt% to about 0.5 wt%, Y alone at about 0.005 wt% to about 0.5 wt%, or a composite of Ba and Y at about 0.005 wt% to about 0.5 wt%, the remainder including Fe and impurities, based on 100 wt% of a total composition of a base steel sheet thereof.

[0006] The base steel sheet thereof may include Si at about 1.0 wt% to about 7.0 wt%, C at about 0.0050 wt% or less (excluding 0 wt%), Al at about 0.005 wt% or less (excluding 0 wt%), N at about 0.0055 wt% or less (excluding 0 wt%), S at about 0.0055 wt% or less (excluding 0 wt%), and Mn at about 0.01 wt% to about 0.5 wt%.

[0007] An area of grains of the electrical steel sheet having a grain size of about 2 mm or less may be about 10 % or less with respect to 100 % of an area of total grains.

[0008] An average size of grains of the electrical steel sheet having a grain size of about 2 mm or more may be about 10 mm or more.

[0009] An angle difference between a <100> plane and a plate plane of the electrical steel sheet may be about 3.5° or less.

[0010] B_{10} corresponding to magnetic flux density of the electrical steel sheet measured at a magnetic field of about 1000 A/m may be about 1.88 or more.

[0011] The electrical steel sheet may include Ba, Y, or a combination thereof that is segregated at grain boundaries.

[0012] Another embodiment of the present invention provides A manufacturing method of an oriented electrical steel sheet, including: heating a slab including Ba alone at about 0.005 wt% to about 0.5 wt%, Y alone at about 0.005 wt% to about 0.5 wt%, or a composite of Ba and Y at about 0.005 wt% to about 0.5 wt%, and the remaining portion including Fe and other inevitably incorporated impurities, based on 100 wt% of a total composition of the slab; producing a hot-rolled steel sheet by hot-rolling the slab; producing a cold-rolled steel sheet by cold-rolling the hot-rolled steel sheet; performing primary recrystallization annealing for the cold-rolled steel sheet; and performing secondary recrystallization annealing for an electrical steel sheet for which the primary recrystallization annealing is completed.

[0013] The slab may include Si at about 1.0 wt% to about 4.5 wt%, C at about 0.001 wt% to about 0.1 wt%, Al at about 0.005 wt% or less, N at about 0.0055 wt% or less, S at about 0.0055 wt% or less, and Mn at about 0.01 wt% to about 0.5 wt%.

[0014] A slab heating temperature in the heating of the slab may be about 1280 °C or lower.

[0015] A soaking temperature in the secondary recrystallization annealing may be about 900 °C to about 1250 °C.

[0016] After the hot-rolling, hot-rolled steel sheet annealing may be performed.

[0017] In the primary recrystallization annealing, the cold-rolled steel sheet may be maintained at a temperature of 750 °C or higher for about 30 seconds or more.

[Advantageous Effects]

[0018] The oriented electrical steel sheet according to the embodiment of the present invention has low iron loss and excellent magnetic characteristics by stably forming Goss grains.

[0019] In addition, since AlN and MnS are not used as the grain growth inhibitor, it is unnecessary to reheat the slab at a temperature higher than 1300 °C.

[0020] Further, since high temperature purification annealing for removing precipitates such as AlN and MnS is not required, manufacturing cost is reduced.

[0021] Further, since there is no need to remove N, S, or the like after the high temperature annealing process, there is no surface defect due to a gasification reaction with N and S in the high temperature purification annealing process.

[Mode for Invention]

[0022] The advantages and features of the present invention and the methods for accomplishing the same will be apparent from the exemplary embodiments described hereinafter with reference to the accompanying drawings. However, the present invention is not limited to the exemplary embodiments described hereinafter, but may be embodied in many different forms. The following exemplary embodiments are provided to make the disclosure of the present invention complete and to allow those skilled in the art to clearly understand the scope of the present invention, and the present invention is defined only by the scope of the appended claims. Throughout the specification, the same reference numerals denote the same constituent elements.

[0023] In some exemplary embodiments, detailed description of well-known technologies will be omitted to prevent the disclosure of the present invention from being interpreted ambiguously. Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art. Further, as used herein, the singular forms "a", "an", and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0024] Further, as used herein, % means wt%, and 1 ppm corresponds to 0.0001 wt%, unless the context clearly indicates otherwise.

[0025] Hereinafter, a manufacturing method of an oriented electrical steel sheet according to an exemplary embodiment of the present invention will be described.

[0026] A slab that includes Ba alone at about 0.005 wt% to about 0.5 wt%, Y alone at about 0.005 wt% to about 0.5 wt%, or a composite of Ba and Y at about 0.005 wt% to about 0.5 wt%, and the remaining portion including Fe and other inevitably incorporated impurities, is provided.

[0027] The slab may include Si at about 1.0 wt% to about 4.5 wt%, C at less than about 0.005 wt%, Al at less than about 0.005 wt%, N at less than about 0.0055 wt%, S at less than about 0.0055 wt%, and Mn at about 0.01 wt% to about 0.5 wt%.

[0028] First, reasons for limiting components will be described.

[0029] Ba and Y serve as grain growth inhibitors to prevent grains of orientations other than Goss grains from growing during secondary recrystallization annealing, thereby improving magnetism of an electrical steel sheet. Ba and Y may be added singly or in combination. When a content of Ba or Y is less than about 0.005 wt%, it is difficult to sufficiently serve as the inhibitor, and when the content thereof is more than about 0.5 wt%, brittleness of the steel sheet increases, thus cracks may occur during rolling.

[0030] Si serves to reduce iron loss by increasing specific resistance of a material. When the content of Si is less than about 1.0 wt% in the slab and the electrical steel sheet, the specific resistance thereof may decrease and the iron loss thereof may deteriorate. In addition, when the content of Si of the slab exceeds about 4.5 wt%, it may be difficult to perform cold-rolling. However, after the cold-rolling, since Si powder may be coated or deposited on a surface of the steel sheet and then Si may be diffused into the steel sheet, a content of Si of a final steel sheet may be about 4.5 wt% or more. However, when the Si content of the oriented electrical steel sheet exceeds about 7 wt%, since it is difficult to process the oriented electrical steel sheet for manufacturing a transformer, the Si content thereof may about 7 wt% or less.

[0031] C is an austenite stabilizing element added to the slab in an amount of about 0.001 wt% or more such that a coarse columnar structure occurring during a continuous casting process may be miniaturized and slab center segregation of S may be suppressed. In addition, it is possible to promote work hardening of the steel sheet during cold-rolling and to promote nucleation of secondary recrystallization of a {110}<001 > orientation in the steel sheet. However, when C exceeds about 0.1 wt%, an edge crack may occur during hot-rolling. Therefore, while the electrical steel sheet is manufactured, a decarburization annealing process is performed, and a C content after the decarburization annealing process may be about 0.0050 wt% or less. Specifically, C may be about 0.0030 wt% or less.

[0032] In the exemplary embodiment of the present invention, since AlN may not be used as a grain growth inhibitor, a content of Al may be positively suppressed. Accordingly, in the exemplary embodiment of the present invention, Al may be added or controlled to about 0.005 wt%.

[0033] Since N forms precipitates such as AlN, (Al, Mn)N, (Al, Si, Mn)N, Si_3N_4, and the like, N may not be added or may be controlled to about 0.0055 wt% or less in the exemplary embodiment of the present invention. Specifically, N may be present at about 0.0035 wt% or less. More specifically, N may be present at about 0.0015 wt% or less.

[0034] S is an element having a high solid solution temperature and a high segregation temperature during hot-rolling, thus it may not be added or may be controlled to 0.0055 % or less in the exemplary embodiment of the present invention. Specifically, S may be present at about 0.0035 wt%. More specifically, S may be present at about 0.0015 wt%.

[0035] In the exemplary embodiment of the present invention, since MnS may not be used as a grain growth inhibitor, Mn may not be added. However, since Mn is a specific resistance element and improves magnetism, a content of Mn of the slab and of the electrical steel sheet may be about 0.01 wt% or more. However, when Mn exceeds about 0.5 wt%, a phase thereof may be transformed after the secondary recrystallization, thus the magnetism may deteriorate.

[0036] Components such as Ti, Mg, Ca, etc. are preferably not added because they react with oxygen in the steel to form oxides. However, they may be controlled to about 0.005 wt% or less in consideration of impurities of the steel.

[0037] The slab is heated. A temperature of heating the slab is not limited, but when the slab is heated at a temperature of about 1280 °C or lower, it is possible to prevent the columnar structure of the slab from being coarsely grown, thereby preventing cracking of the slab in the hot-rolling process. Therefore, the temperature of heating the slab may be about 1000 °C or more and about 1280 °C or less.

[0038] When the reheating of the slab is completed, hot-rolling is performed. A temperature of the hot-rolling and a cooling temperature are not particularly limited, and for example, the hot-rolling may be terminated at about 950 °C or less, followed by water cooling, and then spiral-winding at about 600 °C.

[0039] The hot-rolled steel sheet may be annealed as necessary, or may be cold-rolled without annealing. In the case of annealing the hot-rolled steel sheet, the hot-rolled steel sheet may be heated at a temperature of about 900 °C or higher, soaked, and then cooled so that a hot-rolled structure is made uniform.

[0040] The cold-rolling is performed by a reverse mill or a tandem mill, and a cold-rolled steel sheet having a thickness of about 0.1 mm to about 0.5 mm may be manufactured by one cold-rolling process, a plurality of cold-rolling processes, or a plurality of cold-rolling processes including an intermediate annealing process.

[0041] Warm-rolling in which a temperature of the steel sheet is maintained at about 100 °C or higher during the cold-rolling may be performed. In addition, a cold-rolled steel sheet having a final thickness of about 0.1 mm to about 0.5 mm may be manufactured through cold-rolling once.

[0042] The cold-rolled steel sheet is subjected to primary recrystallization annealing. In the primary recrystallization annealing, primary recrystallization occurs in which decarburization is performed and nuclei of Goss grains are generated.

[0043] In the primary recrystallization annealing, the cold-rolled sheet may be maintained at a temperature of about 750 °C or higher for about 30 seconds or more. If the temperature is less than about 750 °C, sufficient energy for grain growth may not be provided, and if the energy is provided for less than 30 seconds, the grain growth may be insufficient, thus magnetism may deteriorate.

[0044] In addition, in the manufacturing method of the oriented electrical steel sheet according to the exemplary embodiment of the present invention, after the decarburization annealing process is performed, a nitride annealing process may be omitted. In a conventional manufacturing method of an oriented electrical steel sheet using AlN as a grain growth inhibitor, a nitride annealing process is required for the formation of AlN. However, in the manufacturing method of the oriented electrical steel sheet according to the embodiment of the present invention, since AlN is not used as a grain growth inhibitor, the nitride annealing process is not required.

[0045] After completion of the primary recrystallization annealing, the steel sheet is coated with an annealing separator containing MgO, and is subjected to secondary recrystallization annealing. A soaking temperature during the secondary recrystallization annealing may be about 900 °C to about 1250 °C. If the soaking temperature is less than about 900 °C, Goss grains may not sufficiently grow and magnetism may deteriorate, while if the soaking temperature exceeds about 1250 °C, the grains may coarsely grow such that characteristics of the steel sheet may deteriorate.

[0046] In the manufacturing method of the oriented electrical steel sheet according to the embodiment of the present invention, after the secondary recrystallization annealing is completed, purification annealing may be omitted.

[0047] In a conventional manufacturing method of an oriented electrical steel sheet using MnS and AlN as a grain growth inhibitor, it is necessary to perform a high-temperature purification annealing process to remove precipitates such as AlN and MnS, but in the manufacturing method of the oriented electrical steel sheet according to the embodiment of the present invention, a purification annealing process may not be necessary.

[0048] A base steel sheet of the oriented electrical steel sheet according to the embodiment of the present invention may include about 0.005 wt% to about 0.5 wt% of Ba alone, about 0.005 wt% to about 0.5 wt% of Y alone, or about 0.005 wt% to about 0.5 wt% of a composite of Ba and Y, the remainder including Fe and impurities. In this case, the base steel sheet corresponds to a portion excluding a coated layer formed on a surface of the oriented electrical steel sheet.

[0049] In addition, the base steel sheet may include about 1.0 wt% to about 7.0 wt% of Si, about 0.005 wt% or less of C, about 0.005 wt% or less of Al, about 0.0055 wt% or less of N, about 0.0055 wt% or less of S, and about 0.01 wt% to about 0.5 wt% of Mn.

[0050] Further, the base steel sheet may include about 0.02 wt% to about 0.35 wt% of Ba, Y, or a combination thereof.

[0051] In the oriented electrical steel sheet, an area of grains having a grain size of about 2 mm or less may be about 10 % or less of a total area of grains of 100 %. When the area of the grains having the grain size of about 2 mm or less is more than about 10 % of the whole area of the grains of 100 %, the grains may not sufficiently grow, thus magnetism may deteriorate.

[0052] In addition, in the electrical steel sheet, an average grain size of the grains having the grain size of about 2 mm or more may be about 10 mm or more. When the average grain size of the grains having the grain size of about 2 mm or more is less than about 10 mm, the grains may not sufficiently grow, thus the magnetism may deteriorate.

In addition, in the electrical steel sheet, an angle difference between a <100> plane and a plate plane of the steel sheet may be about 3.5° or less. In this case, the plate plane of the steel sheet means an XY plane of the steel sheet when a rolling direction thereof is an X axis and a width direction thereof is a Y axis. When the angle difference exceeds about 3.5°, the magnetism of the steel sheet may deteriorate.

[0053] In addition, in the steel sheet, B_{10}, magnetic flux density measured at a magnetic field of about 1000 A/m may be about 1.88 or more. Further, Ba, Y, or a combination thereof may be segregated at grain boundaries by serving as inhibitors.

[0054] Hereinafter, exemplary embodiments will be described. However, the following exemplary embodiments are only examples of the present invention, and the present invention is not limited to the exemplary embodiments.

[Exemplary Embodiment 1]

[0055] A slab including with Si at 3.2 wt%, C at 0.051 wt%, Mn at 0.112 wt%, S at 0.0052 wt%, N at 0.005 wt%, Al at 0.029 wt%, barium (Ba) and yttrium (Y) as shown in Table 1, and the remaining portion including Fe and other inevitably incorporated impurities, was prepared.

[0056] The slab was heated at a temperature of 1150 °C for 90 minutes, and then hot-rolled to prepare a hot-rolled steel sheet having a thickness of 2.6 mm. The hot-rolled steel sheet was heated at a temperature of 1050 °C or higher, maintained at 910 °C for 90 seconds, water-cooled, and then pickled. Then, it was cold-rolled to a thickness of 0.29 mm. The cold-rolled steel sheet was heated in a furnace, maintained in a mixed gas atmosphere of hydrogen at 50 vol% and nitrogen at 50 vol%, a dew point temperature of 60 °C, and an annealing temperature of 850 °C for 120 seconds, and then subjected to primary recrystallization annealing. After the primary recrystallization annealing, an amount of carbon was 0.0030 wt%. Then, it was coated with MgO, wound in a coil form, and then subjected to secondary recrystallization annealing.

[0057] In final annealing, it was heated to 1200 °C in a mixed gas atmosphere of nitrogen at 25 vol% and hydrogen at 75 vol%, and after reaching 1200 °C, it was maintained in a gas atmosphere of hydrogen at 100 vol% for 20 hours, and then cooled.

(Table 1)

Sample number	Ba content	Y Content	Magnetic flux density (B10, Tesla)	Classification
A	0	0	1.52	Comparative material
B	0.06	0	1.9	Inventive material

(continued)

Sample number	Ba content	Y Content	Magnetic flux density (B10, Tesla)	Classification
C	0.12	0	1.92	Inventive material
D	0.18	0	1.9	Inventive material
E	0.6	0	Rolling crack occurrence	Comparative material
F	0	0.12	1.9	Inventive material
G	0	0.2	1.93	Inventive material
H	0	0.3	1.9	Inventive material
I	0	0.7	Rolling crack occurrence	Comparative material
J	0.002	0.002	1.52	Comparative material
K	0.08	0.03	1.94	Inventive material
L	0.6	0.03	1.61	Comparative material
M	0.04	0.46	1.91	Inventive material
N	0.12	0.38	1.91	Inventive material
O	0.1	0.6	1.56	Comparative material

[0058] As shown in Table 1, the magnetism of the inventive material in which contents of Ba and Y are controlled in a range of 0.005 % to 0.5 % as a range of the present invention is superior to that of the comparative material.

[Exemplary Embodiment 2]

[0059] A slab including Si at 3.2 wt%, C at 0.051 wt%, Mn at 0.112 wt%, S at 0.0052 wt%, N at 0.005 wt%, Al at 0.029 wt%, barium (Ba) and yttrium (Y) as shown in Table 2, and the remaining portion including Fe and other inevitably incorporated impurities, was prepared.

[0060] The slab was heated at a temperature of 1150 °C for 90 minutes, and then hot-rolled to prepare a hot-rolled steel sheet having a thickness of 2.6 mm. The hot-rolled steel sheet was heated at a temperature of 1050 °C or higher, maintained at 910 °C for 90 seconds, water-cooled, and then pickled. Then, it was cold-rolled to a thickness of 0.29 mm. The cold-rolled steel sheet was heated in a furnace, maintained in a mixed gas atmosphere of hydrogen at 50 vol% and nitrogen at 50 vol%, a dew point temperature of 60 °C, and an annealing temperature of 850 °C for 120 seconds, and then subjected to primary recrystallization annealing. After the primary recrystallization annealing, an amount of carbon was 0.0030 wt%. Then, it was coated with MgO, wound in a coil form, and then subjected to secondary recrystallization annealing.

[0061] In final annealing, it was heated to 1200 °C in a mixed gas atmosphere of nitrogen at 25 vol% and hydrogen at 75 vol%, and after reaching 1200 °C, it was maintained in a gas atmosphere of hydrogen at 100 vol% for 20 hours, and then cooled.

(Table 2)

Ba content (wt%)	Y content (wt%)	Area ratio of grains of 1 mm or less (%)	Average size of grains of 1 mm or more (mm)	Magnetic flux density (B10, Tesla)
0	0	100	-	1.53
0.08	0.03	2	25	1.92

[0062] As shown in Table 2, in the electrical steel sheet according to the embodiment of the present invention, the area of the grains having the size of 1 mm or less was 10 % or less, and the average size of the grains having the size of 1 mm or more was 10 mm or more.

[0063] While the exemplary embodiments of the present invention have been described hereinbefore with reference to the accompanying drawings, it will be understood by those skilled in the art that various changes in form and details may be made thereto without departing from the scope of the present invention. Therefore, the embodiments described above are only examples and should not be construed as being limitative in any respects. The scope of the present invention is determined not by the above description, but by the following claims

Claims

1. An oriented electrical steel sheet comprising Si at 1.0 wt% to 7.0 wt%, C at 0.0050 wt% or less (excluding 0 wt%), Al at 0.005 wt% or less (excluding 0 wt%), N at 0.0055 wt% or less (excluding 0 wt%), S at 0.0055 wt% or less (excluding 0 wt%), and Mn at 0.01 wt% to 0.5 wt%, Ba alone at 0.005 wt% to 0.5 wt%, Y alone at 0.005 wt% to 0.5 wt%, or a composite of Ba and Y at 0.005 wt% to 0.5 wt%, the remainder including Fe and impurities, based on 100 wt% of a total composition of a base steel sheet thereof.

2. The oriented electrical steel sheet of claim 1, wherein
an area of grains of the electrical steel sheet having a grain size of 2 mm or less is 10 % or less with respect to 100 % of an area of total grains.

3. The oriented electrical steel sheet of claim 2, wherein
an average size of grains of the electrical steel sheet having a grain size of 2 mm or more is 10 mm or more.

4. The oriented electrical steel sheet of claim 3, wherein
an angle difference between a <100> plane and a plate plane of the electrical steel sheet is 3.5° or less.

5. The oriented electrical steel sheet of claim 4, wherein
B10 corresponding to magnetic flux density of the electrical steel sheet measured at a magnetic field of 1000 A/m is 1.88 or more.

6. The oriented electrical steel sheet of any one of claim 1 to claim 5,
wherein Ba, Y, or a combination thereof is segregated at grain boundaries of the electrical steel sheet.

7. A manufacturing method of an oriented electrical steel sheet, comprising
heating a slab including Si at 1.0 wt% to 7.0 wt%, C at 0.0050 wt% or less (excluding 0 wt%), Al at 0.005 wt% or less (excluding 0 wt%), N at 0.0055 wt% or less (excluding 0 wt%), S at 0.0055 wt% or less (excluding 0 wt%), and Mn at 0.01 wt% to 0.5 wt%, Ba alone at 0.005 wt% to 0.5 wt%, Y alone at 0.005wt% to 0.5 wt%, or a composite of Ba and Y at 0.005 wt% to 0.5 wt%, the remaining portion including Fe and other inevitably incorporated impurities, based on 100 wt% of a total composition of the slab;
producing a hot-rolled steel sheet by hot-rolling the slab;
producing a cold-rolled steel sheet by cold-rolling the hot-rolled steel sheet;
performing primary recrystallization annealing for the cold-rolled steel sheet; and
performing secondary recrystallization annealing for an electrical steel sheet for which the primary recrystallization annealing is completed.

8. The manufacturing method of the oriented electrical steel sheet of claim 7, wherein
a slab heating temperature in the heating of the slab is 1280 °C or lower.

9. The manufacturing method of the oriented electrical steel sheet of claim 8, wherein
a soaking temperature in the secondary recrystallization annealing is 900 °C to 1250 °C.

10. The manufacturing method of the oriented electrical steel sheet of claim 9, wherein
after the hot-rolling, hot-rolled steel sheet annealing is performed.

11. The manufacturing method of the oriented electrical steel sheet of claim 10, wherein
in the primary recrystallization annealing, the cold-rolled steel sheet is maintained at a temperature of 750 °C or higher for 30 seconds or more.

Patentansprüche

1. Orientiertes elektrisches Stahlblech, umfassend Si mit 1,0 Gew.-% bis 7,0 Gew.-%, C mit 0,0050 Gew.-% oder

weniger (0 Gew.-% ausgeschlossen), Al mit 0,005 Gew.-% oder weniger (0 Gew.-% ausgeschlossen), N mit 0,0055 Gew.-% oder weniger (0 Gew.-% ausgeschlossen), S mit 0,0055 Gew.-% oder weniger (0 Gew.-% ausgeschlossen) und Mn mit 0,01 Gew.-% bis 0,5 Gew.-%, Ba alleine mit 0,005 Gew.-% bis 0,5 Gew.-%, Y alleine mit 0,005 Gew.-% bis 0,5 Gew.-%, oder einen Verbundwerkstoff aus Ba und Y mit 0,005 Gew.-% bis 0,5 Gew.-%, wobei der Rest Fe und Verunreinigungen enthält, auf Grundlage von 100 Gew.-% einer Gesamtzusammensetzung eines Grundstahlblechs von diesem.

2. Orientiertes elektrisches Stahlblech nach Anspruch 1, wobei
ein Bereich von Körnern des elektrischen Stahlblechs mit einer Korngröße von 2 mm oder weniger, 10 % oder weniger in Bezug auf 100 % eines Bereichs aller Körner beträgt.

3. Orientiertes elektrisches Stahlblech nach Anspruch 2, wobei
eine mittlere Größe von Körnern des elektrischen Stahlblechs mit einer Korngröße von 2 mm oder mehr 10 mm oder mehr beträgt.

4. Orientiertes elektrisches Stahlblech nach Anspruch 3, wobei
eine Winkeldifferenz zwischen einer <100>-Ebene und einer Plattenebene des elektrischen Stahlblechs 3,5° oder weniger beträgt.

5. Orientiertes elektrisches Stahlblech nach Anspruch 4, wobei
B10, was einer bei einem Magnetfeld von 1000 A/m gemessenen Magnetflussdichte entspricht, 1,88 oder mehr beträgt.

6. Orientiertes elektrisches Stahlblech nach einem der Ansprüche 1 bis 5,
wobei Ba, Y oder eine Kombination von diesen an Korngrenzen des elektrischen Stahlblechs segregiert ist.

7. Herstellungsverfahren für ein orientiertes elektrisches Stahlblech, umfassend:

Erwärmen einer Bramme, die Si mit 1,0 Gew.-% bis 7,0 Gew.-%, C mit 0,0050 Gew.-% oder weniger (0 Gew.-% ausgeschlossen), Al mit 0,005 Gew.-% oder weniger (0 Gew.-% ausgeschlossen), N mit 0,0055 Gew.-% oder weniger (0 Gew.-% ausgeschlossen), S mit 0,0055 Gew.-% oder weniger (0 Gew.-% ausgeschlossen) und Mn mit 0,01 Gew.-% bis 0,5 Gew.-%, Ba alleine mit 0,005 Gew.-% bis 0,5 Gew.-%, Y alleine mit 0,005 Gew.-% bis 0,5 Gew.-%, oder einen Verbundwerkstoff aus Ba und Y mit 0,005 Gew.-% bis 0,5 Gew.-%, wobei der restliche Teil Fe und weitere, unvermeidbar eingebrachte Verunreinigungen enthält, auf Grundlage von 100 Gew.-% einer Gesamtzusammensetzung der Bramme enthält;
Erzeugen eines warmgewalzten Stahlblechs durch Warmwalzen der Bramme;
Erzeugen eines kaltgewalzten Stahlblechs durch Kaltwalzen des warmgewalzten Stahlblechs;
Durchführen eines primären Rekristallisationsglühens des kaltgewalzten Stahlblechs; und
Durchführen eines sekundären Rekristallisationsglühens eines elektrischen Stahlblechs, für welches das primäre Rekristallisationsglühen abgeschlossen wird.

8. Herstellungsverfahren für das orientierte elektrische Stahlblech nach Anspruch 7, wobei
eine Brammenerwärmungstemperatur beim Erwärmen der Bramme 1280° C oder niedriger ist.

9. Herstellungsverfahren für das orientierte elektrische Stahlblech nach Anspruch 8, wobei
eine Durchwärmungstemperatur beim sekundären Rekristallisationsglühen 900° C bis 1250° C beträgt.

10. Herstellungsverfahren für das orientierte elektrische Stahlblech nach Anspruch 9, wobei
nach dem Warmwalzen ein Glühen des warmgewalzten Stahlblechs erfolgt.

11. Herstellungsverfahren für das orientierte elektrische Stahlblech nach Anspruch 10, wobei
beim primären Rekristallisationsglühen das kaltgewalzte Stahlblech 30 Sekunden lang oder mehr auf einer Temperatur von 750° C oder höher gehalten wird.

Revendications

1. Tôle d’acier électrique orienté comprenant Si à raison de 1,0 % en poids à 7,0 % en poids, C à raison de 0,0050 %

en poids ou moins (à l'exclusion de 0 % en poids), Al à raison de 0,005 % en poids ou moins (à l'exclusion de 0 % en poids), N à raison de 0,0055 % en poids ou moins (à l'exclusion de 0 % en poids), S à raison de 0,0055 % en poids ou moins (à l'exclusion de 0 % en poids), et Mn à raison de 0,01 % en poids à 0,5 % en poids, Ba seul à raison de 0,005 % en poids à 0,5 % en poids, Y seul à raison de 0,005 % en poids à 0,5 % en poids, ou un composé de Ba et d'Y à raison de 0,005 % en poids à 0,5 % en poids, le reste incluant Fe et des impuretés, sur la base de 100 % en poids d'une composition totale d'une tôle d'acier de base de celle-ci.

2. La tôle d'acier électrique orienté de la revendication 1, sachant que une aire de grains de la tôle d'acier électrique ayant une taille de grain de 2 mm ou moins est de 10 % ou moins par rapport à 100 % d'une aire de grains totaux.

3. La tôle d'acier électrique orienté de la revendication 2, sachant que une taille moyenne de grains de la tôle d'acier électrique ayant une taille de grain de 2 mm ou plus est de 10 mm ou plus.

4. La tôle d'acier électrique orienté de la revendication 3, sachant que une différence d'angle entre un plan de <100> et un plan plat de la tôle d'acier électrique est de 3,5° ou moins.

5. La tôle d'acier électrique orienté de la revendication 4, sachant que B10 correspondant à une densité de flux magnétique de la tôle d'acier électrique mesurée à un champ magnétique de 1000 A/m est de 1,88 ou plus.

6. La tôle d'acier électrique orienté de l'une quelconque des revendications 1 à 5, sachant que Ba, Y, ou une combinaison de ceux-ci, est ségrégé à des joints de grains de la tôle d'acier électrique.

7. Procédé de fabrication d'une tôle d'acier électrique orienté, comprenant
le chauffage d'une brame incluant Si à raison de 1,0 % en poids à 7,0 % en poids, C à raison de 0,0050 % en poids ou moins (à l'exclusion de 0 % en poids), Al à raison de 0,005 % en poids ou moins (à l'exclusion de 0 % en poids), N à raison de 0,0055 % en poids ou moins (à l'exclusion de 0 % en poids), S à raison de 0,0055 % en poids ou moins (à l'exclusion de 0 % en poids), et Mn à raison de 0,01 % en poids à 0,5 % en poids, Ba seul à raison de 0,005 % en poids à 0,5 % en poids, Y seul à raison de 0,005 % en poids à 0,5 % en poids, ou un composé de Ba et Y à raison de 0,005 % en poids à 0,5 % en poids, la partie restante incluant Fe et d'autres impuretés incorporées inévitables, sur la base de 100 % en poids d'une composition totale de la brame ;
la production d'une tôle d'acier laminée à chaud par laminage à chaud de la brame ;
la production d'une tôle d'acier laminée à froid par laminage à froid de la tôle d'acier laminée à chaud ;
l'exécution d'un recuit de recristallisation primaire pour la tôle d'acier laminée à froid ; et
l'exécution d'un recuit de recristallisation secondaire pour une tôle d'acier électrique pour laquelle le recuit de recristallisation primaire est achevé.

8. Le procédé de fabrication de la tôle d'acier électrique orienté de la revendication 7, sachant que une température de chauffage de brame lors du chauffage de la brame est de 1280 °C ou inférieure.

9. Le procédé de fabrication de la tôle d'acier électrique orienté de la revendication 8, sachant que une température de trempe lors du recuit de recristallisation secondaire est de 900 °C à 1250 °C.

10. Le procédé de fabrication de la tôle d'acier électrique orienté de la revendication 9, sachant que après le laminage à chaud, un recuit de la tôle d'acier laminée à chaud est effectué.

11. Le procédé de fabrication de la tôle d'acier électrique orienté de la revendication 10, sachant que lors du recuit de recristallisation primaire, la tôle d'acier laminée à froid est maintenue à une température de 750 °C ou supérieure pendant 30 secondes ou plus.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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