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DESCRIPTION

STEEL SHEET FOR HEAT SHRINK BAND

TECHNICAL FIELD

The present invention relates to a steel sheet for a heat shrink band (hereinafter referred to as an HS band) for fastening a panel periphery of a color cathode ray tube (hereinafter referred to as a CRT).

BACKGROUND ART

A CRT must be subjected to treatment for preventing deformation in a panel face and internal explosion of a tube body because the tube interior is in a high vacuum state of about 1×10^{-7} Torr. As one type of such treatment, what we call heat shrinking treatment has been done. In this treatment, a steel sheet for an HS band formed into a band shape is heated to temperatures in the range from 400 to 600°C for several seconds to several tens seconds to be expanded, and then is fitted on a glass panel of a CRT. Subsequently, the steel sheet is cooled to be shrunk, thereby fastening a panel periphery.

As a steel sheet for an HS band subjected to heat shrinking treatment, a plated cold rolled steel sheet with a thickness of 0.8 to 2mm has so far been used because the steel sheet for an HS band must be light in weight and have high strength and ductility. In recent years, in order to decrease the weight of a CRT, a demand for decreasing the thickness of the steel sheet

for an HS band has been increasing, so that the steel sheet for an HS band has further been required to have higher strength. Also, since it was found that if the magnetic shielding properties of the steel sheet for an HS band against an external magnetic field such as geomagnetism are improved, color deviation caused by landing error of electron beam on the screen can be reduced significantly, a demand for excellent magnetic shielding properties (that is, high magnetic permeability) has become strong increasingly as a TV screen has been made large and flat and as images of computer monitor have been made fine.

As a method for achieving high strength and high magnetic permeability of a steel sheet for an HS band, for example, JP-A-11-86755 has disclosed a method in which 1 to 2 mass% of Si is contained to achieve high strength and high magnetic permeability in a magnetic field of geomagnetism level owing to the solid solution strengthening ability of Si. Also, JP-A-11-158549 has proposed a method in which the crystal grain size of a Si-containing steel sheet is optimized to achieve high strength and the composition of inclusions is optimized to achieve high magnetic permeability.

A problem with the method described in JP-A-11-86755 is that either of the obtained strength and magnetic permeability is not sufficiently high. Also, a problem with the method described in JP-A-11-158549 is that although high strength can be achieved by a finer crystal grain, the finer crystal grain leads to a decrease in magnetic permeability, so that not both

of high strength and high magnetic permeability can be achieved.

DISCLOSURE OF THE INVENTION

An object of the present invention provides a steel sheet for an HS band, which has high strength and high magnetic permeability at the same time.

The above object is achieved by a steel sheet for an HS band, containing, by mass%, 0.005% or less of C, 0.5 to 4% of Si, 2% or less of Mn, 0.2% or less of P, 0.04% or less of S, 0.2% or less of sol.Al, 0.01% or less of N, 0.0003 to 0.004% of B, 0.005% or less of O, and 0.002 to 0.1% of Sb, the balance being substantially formed of Fe.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a graph showing the relationship between relative permeability and content of O;

FIG. 2 is a graph showing the relationship between relative permeability and content of Sb; and

FIG. 3 is a graph showing the relationship between relative permeability and content of B and B/N.

EMBODIMENT FOR CARRYING OUT THE INVENTION

The inventors paid attention to B that easily forms coarse

precipitates advantageous in achieving high magnetic permeability, and conducted studies on the achievement of high magnetic permeability of a B-contained steel sheet. As a result, the following findings were obtained.

1) Since B, which is effective in achieving high magnetic permeability, has a high affinity for O, fine B_2O_3 , capable of being observed under an electron microscope is easily yielded at the time of slab casting, which tends to decrease magnetic permeability.

2) At the time of slab heating before hot rolling, the oxidation of B proceeds in the surface layer of slab and thus a B-exhausted layer is formed, which leads to a decrease in magnetic permeability.

3) Since B has an affinity for N, coarse nitrides are easily formed. However, at the time of slab heating or at the time of annealing after cold rolling, nitriding reaction with N in an atmosphere of heating proceeds in the surface layer of slab or steel sheet, so that it is impossible to sufficiently make the most of the effect of B addition.

4) In order to prevent the yielding of B_2O_3 at the time of slab casting and the formation of B-exhausted layer or nitrides in the surface layer of slab or steel sheet, a decrease in content of O and addition of Sb at the time of slab casting are effective.

The present invention has been made based on the above-described findings. The detail will be described below.

1. Relationship between relative permeability and content of O

B-added steels containing 0.002% C, 1.2% Si, 1% Mn, 0.07% P, 0.004% S, trace or 0.01% sol.Al, 0.002% N, 0.0016% B, and varied amounts of O in the range from 0.001 to 0.01% were produced by melting, then hot rolled and cold rolled into steel sheets having a thickness of 1.2mm. Subsequently, the steel sheets were annealed at a temperature of 680 to 730°C to change the crystal grain size, by which a yield point (YP) of 330 to 340MPa was prepared. In this case, the content of O was changed by adjusting the degassing time after the addition of Si or Al. Also, if B is added in a state in which the quantity of dissolved oxygen is large, B might be consumed as oxides. Therefore, B was added after degassing and just before casting.

From the obtained steel sheet samples, 25cm Epstein test pieces were taken to measure relative permeability (μ/μ_0 : μ_0 denotes permeability of vacuum) in the case where the test piece was magnetized to 23.9A/m (0.30e). For content of O, because a difference was scarcely found between the analytical values after hot rolling and after annealing, the value after annealing was adopted.

FIG. 1 shows the relationship between relative permeability and content of O. In FIG. 1, ○ denotes samples containing trace of sol.Al, and ● denotes samples containing 0.01% of sol.Al.

FIG. 1 reveals that the magnetic permeability of B-added steel closely relates to content of O, and for both of the samples

containing trace of sol.Al and 0.01% of sol.Al, high relative permeability can be obtained when the content of O is 0.005% or less. The precipitates and inclusions of the sample containing 0.005% or less of O were observed, and it was found that B existed as coarse nitrides almost completely. Also, for the samples containing trace of sol.Al, almost all of oxides were SiO_2 , and for the samples containing 0.01% of sol.Al, almost all of oxides were Al_2O_3 .

2. Relationship between relative permeability and content of Sb

Steels containing 0.002% C, 1.2% Si, 1% Mn, 0.07% P, 0.004% S, 0.02% sol.Al, 0.002% N, trace or 0.0015% B, 0.002% O, and varied amounts of Sb in the range from trace to 0.2% were produced by melting, then hot rolled, cold rolled, and annealed under the aforementioned conditions to prepare samples. The relative permeability was measured by the aforementioned method.

FIG. 2 shows the relationship between relative permeability and content of Sb. In FIG. 2, ○ denotes samples containing 0.0015% of B, and ● denotes samples containing trace of B.

FIG. 2 reveals that the samples to which 0.0015% of B is added exhibit higher relative permeability than the samples containing trace of B, and if Sb in the range from 0.002 to 0.1%, preferably in the range from 0.004 to 0.05%, is added, far higher relative permeability can be obtained.

Chemical analyses of B and N were made in the sheet thickness

direction from the surface layer for the samples containing trace and 0.02% of Sb to which B was added, and it was found that for the sample containing trace of Sb, B content decreased to a point nearly 50 μ m from the surface layer. The reason for this is thought to be that B was oxidized preferentially. Also, N content in a region to nearly 30 μ m from the surface layer was slightly higher than that in the central portion of the sheet thickness, and nitriding of B was observed. On the other hand, for the sample containing 0.02% of Sb, neither oxidation nor nitriding of B was observed.

3. Relationship between relative permeability and content of B and B/N

Steels containing 0.002% C, 1.2% Si, 1% Mn, 0.07% P, 0.004% S, 0.01% sol.Al, 0.003% N, 0.002% O, 0.01% Sb, and varied amounts of B in the range from trace to 0.006% were produced by melting, then hot rolled, cold rolled, and annealed under the aforementioned conditions to prepare samples. The relative permeability was measured by the aforementioned method. Also, for samples containing 0.002% C, 1.2% Si, 1% Mn, 0.07% P, 0.004% S, 0.01% sol.Al, 0.003% N, 0.002 or 0.006% O, and varied amounts of B in the range from trace to 0.006% without the addition of Sb, the same test was conducted.

FIG. 3 shows the relationship between relative permeability and content of B and B/N. In FIG. 3, $\bigcirc$ denotes samples containing 0.002% O and 0.01% Sb, $\bullet$ denotes samples containing 0.002% O, and $\blacktriangle$ denotes samples containing 0.006% O.

FIG. 3 reveals that for the sample containing 0.01% of Sb, higher magnetic permeability than that of the sample without the addition of Sb can be obtained in the range from 0.0003 to 0.004% of B, and if B/N is in the range from 0.2 to 1.0, preferably in the range from 0.5 to 0.8, far higher relative permeability can be obtained. In particular, remarkably high relative permeability can be obtained when B/N is 0.7. On the other hand, in the case where Sb is not added, the sample containing 0.002% O and the sample containing 0.006% O exhibit the respective highest relative permeability when B/N is about 0.9 and about 1.2, respectively, but the relative permeability of these samples are not sufficiently high as compared with the sample containing 0.01% Sb.

The following is a description of the reasons for limiting composition elements other than O, Sb and B.

C: If the content of C exceeds 0.005%, carbide precipitates, which decreases the magnetic permeability. Therefore, the content of C should be 0.005% or less.

Si: Si improves the magnetic permeability and increases the strength. For this reason, the content of Si must be 0.5% or more. However, the content of Si exceeding 4% has little effect on the increase in magnetic permeability, and causes deterioration in weldability and brittleness. Therefore, the content of Si should be 0.5 to 4%.

Mn: Mn is an element that has little effect on the magnetic permeability and increases the strength due to solid solution strengthening. For this reason, Mn must be contained to maintain

the strength, but the content of Mn exceeding 2% deteriorates the magnetic permeability. Therefore, the content of Mn should be 2% or less.

P: P has little effect on the magnetic permeability, and also has solid solution strengthening ability even with a minute amount. For this reason, P should preferably be contained, but the content of P exceeding 0.2% significantly deteriorates the weldability. Therefore, the content of P should be 0.2% or less.

sol.Al: sol.Al should preferably be contained to decrease O as oxides, but the content of sol.Al exceeding 0.2% increases the cost. Therefore, the content of sol.Al should be 0.2% or less. Also, in order to stably form SiO_2 as an oxide, the content of sol.Al should preferably be 0.001% or less, and in order to stably form Al_2O_3 , the content of sol.Al should preferably be 0.005% or more.

N: N easily yields precipitates and deteriorates the magnetic permeability. Therefore, the content of N should be 0.01% or less.

Besides, at least one kind of Sn of 0.003 to 0.15% and Cu of 0.05 to 0.2% can be contained to prevent the formation of oxides of B and the nitriding of surface layer, although these elements have less effect than Sb.

The manufacturing method for the steel sheet for an HS band in accordance with the present invention is not subject to any special restriction. For example, after being produced by melting using a converter, a steel whose composition has been

controlled by degassing is cast, then hot rolled, cold rolled, and annealed in the ordinary manner. As necessary, the hot rolled steel can be annealed after hot rolling, or a double cold rolling and annealing method in which a process of cold rolling and annealing is repeated two times can be applied.

Also, from the viewpoint of corrosion resistance, the steel sheet for an HS band can be provided with a plating layer of Zn, Ni, Al, Sn, Cr, Zn-Ni alloy, Zn-Al alloy, etc. Also, the steel sheet can be plated with the above-described metals in multiple layers, or the plating metal and base iron can be alloyed partially or wholly. Furthermore, as necessary, chemical surface treatment can be carried out on the steel sheet or the plating layer.

Example

After being melted using a converter, slabs with various composition which had been controlled by degassing were cast, then heated at 1150°C for one hour, hot rolled to a thickness of 3.2mm and coiled at a coiling temperature of 680°C. After being pickled, the obtained hot rolled steel sheets were cold rolled to a thickness of 1.2mm, and annealed at a temperature of 680 to 820°C for 60 seconds in an atmosphere of 10% H_2 -90% N_2 , by which steel sheet samples 1 to 12 were prepared. Subsequently, steel sheet samples 2 and 9 were subjected to skin pass rolling of an elongation ratio of 0.3 to 1.5%. For steel sheet samples 1 to 12, the chemical analysis of composition and the measurement of yield point using a JIS No. 5 tensile test piece and relative

permeability in the case where a 25cm Epstein test piece was magnetized to 23.9A/m were made.

The results of chemical analysis are given in Table 1, and the results of measurement of yield point and relative permeability are given in Table 2.

It can be seen from Table 2 that the steel sheets for an HS band according to the present invention have both of high yield point and high relative permeability at the same time.

For the comparative examples, when the yield point is high, the relative permeability is low, or when the relative permeability is high, the yield point is low, that is, both of the characteristics cannot be achieved at the same time.

Table 1

Steel sheet No.	Chemical composition (mass%)										B/N	Remarks
	C	Si	Mn	P	S	solAl	N	B	Sb	O		
1	0.0015	0.5	0.7	0.11	0.002	0.02	0.0012	0.0011	0.003	0.002	0.92	Example
2	0.0018	1.2	1.1	0.07	0.004	0.03	0.0021	0.0015	0.005	0.003	0.71	Example
3	0.0029	2.4	1.6	0.05	0.002	0.02	0.0018	0.0015	0.008	0.003	0.83	Example
4	0.0024	1.2	1.0	0.08	0.001	0.01	0.0016	0.0002	0.012	0.002	0.13	Example
5	0.0010	1.3	1.1	0.07	0.003	0.02	0.0018	0.0024	0.030	0.004	1.33	Example
6	0.0018	1.2	1.0	0.07	0.003	tr.	0.0022	0.0012	0.080	0.002	0.55	Example
7	0.0022	1.3	1.0	0.08	0.002	0.11	0.0015	0.0011	0.050	0.001	0.73	Example
8	0.0016	1.3	1.0	0.07	0.002	0.02	0.0025	0.0010	tr.	0.002	0.40	Comparative example
9	0.0023	1.3	1.1	0.07	0.005	0.01	0.0021	0.0019	0.005	0.008	0.90	Comparative example
10	0.0021	1.2	1.1	0.07	0.004	0.03	0.0018	tr.	0.007	0.003	0	Comparative example
11	0.0019	1.2	1.0	0.07	0.002	0.02	0.0022	0.0045	0.003	0.003	2.05	Comparative example
12	0.0018	1.2	1.0	0.07	0.004	0.27	0.0021	0.0018	0.004	0.003	0.86	Comparative example

Table 2

Steel sheet No.	Skin pass elongation ratio (%)	YP (N/mm ²)	$\mu / \mu 0$	Remarks
1	—	310	660	Example
2	—	350	750	Example
2	0.3	320	700	Example
2	0.8	330	620	Example
2	1.5	370	540	Example
3	—	390	830	Example
4	—	340	680	Example
5	—	350	680	Example
6	—	350	690	Example
7	—	350	740	Example
8	—	350	650	Comparative example
9	—	340	640	Comparative example
9	0.3	310	590	Comparative example
9	0.8	320	510	Comparative example
9	1.5	350	440	Comparative example
10	—	340	650	Comparative example
11	—	350	580	Comparative example
12	—	350	610	Comparative example

CLAIMS

1. A steel sheet for a heat shrink band, containing, by mass%, 0.005% or less of C, 0.5 to 4% of Si, 2% or less of Mn, 0.2% or less of P, 0.04% or less of S, 0.2% or less of sol.Al, 0.01% or less of N, 0.0003 to 0.004% of B, 0.005% or less of O, and 0.002 to 0.1% of Sb, the balance being substantially formed of Fe.

2. The steel sheet for a heat shrink band according to claim 1, wherein content of Sb is 0.004 to 0.05%.

3. The steel sheet for a heat shrink band according to claim 1, wherein the ratio of content of B to content of N (B/N) is further in the range from 0.2 to 1.

4. The steel sheet for a heat shrink band according to claim 2, wherein the ratio of content of B to content of N (B/N) is further in the range from 0.2 to 1.

5. The steel sheet for a heat shrink band according to claim 3, wherein the (B/N) is in the range from 0.5 to 0.8.

6. The steel sheet for a heat shrink band according to claim 4, wherein the (B/N) is in the range from 0.5 to 0.8.

7. A heat shrink band formed of the steel sheet according

to any one of claims 1 to 6.