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(54) METHOD OF MANUFACTURING UNIDIRECTIONAL SILICON STEEL SLAB HAVING EXCELLENT SURFACE AND MAGNETIC PROPERTIES.

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PATENT ABSTRACTS OF JAPAN, vol. 8, no. 193 (C-241)[1630], 5th September 1984; & JP-A-59 85 820 (KAWASAKI SEITETSU K.K.) 17-05-1984

(73) Proprietor: **KAWASAKI STEEL CORPORATION**
No. 1-28, 1-Chome Kitahonmachi-Dori
Chuo-Ku, Kobe-Shi Hyogo 651(JP)

(72) Inventor: **INOKUCHI, Yukio**
Kawasaki Steel Corporation Research Laboratories
1, Kawasaki-cho Chiba-shi Chiba 260(JP)
Inventor: **IKEDA, Shigeko**
Kawasaki Steel Corporation Research Laboratories
1, Kawasaki-cho Chiba-shi Chiba 260(JP)
Inventor: **ITO, Yoh**
Kawasaki Steel Corporation Research Laboratories
1, Kawasaki-cho Chiba-shi Chiba 260(JP)

(74) Representative: **Overbury, Richard Douglas et al**
HASELTINE LAKE & CO Hazlitt House 28 Southampton Buildings Chancery Lane London WC2A 1AT(GB)

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Description

TECHNICAL FIELD

The present invention relates to a grain oriented silicon steel sheet formed of a high silicon steel containing not less than 3.1% by weight of silicon (hereinafter referred to briefly as "%") and having improved surface properties and magnetic characteristics.

BACKGROUND ART

As is well known, grain oriented electromagnetic steel sheet, which is mainly used as an iron sheet for transformers, is required to have a high magnetic flux density represented by the B_{10} value (i.e. good magnetization characteristics), a low iron loss represented by the $W_{17/50}$ value, and excellent surface properties. In order to enhance the magnetic characteristics of the grain oriented silicon steel sheet as mentioned above, it is necessary to highly arrange the ⟨001⟩ axis of the secondary recrystallized grains of the product in the rolling direction. There have been heretofore huge improvements for this purpose, and it has now become possible to industrially produce a grain oriented silicon steel sheet having a B_{10} value of larger than 1.89 T (Tesla) and an iron loss $W_{17/50}$ value of not higher than 1.05 W/kg. However, from the standpoint of energy saving, it has recently been required to lower the electric power loss of electric appliances such as transformers, and accordingly to lower the electric power loss of the grain oriented silicon steel sheet used as the iron core material of the transformer and the like. Also, there has been a need to further lower the iron loss value. In addition, there has been a demand to reduce surface defects, such as surface flaws, to form excellent insulating films to improve the surface properties of the product.

On the other hand, the ultimate object of having Si in the grain oriented silicon steel sheet is to increase the electric resistance of the raw material and to thereby lower the eddy current loss, that is, to reduce the iron loss. Therefore, to increase the content of Si is extremely effective for reducing the iron loss value. However, an increase in the content of Si leads to the problem that the surface properties of the steel sheet are deteriorated. That is, in the case of the process of making the grain oriented silicon steel sheet using the AℓN precipitation phase as an inhibitor, the slab is generally required to be heated at a higher temperature than used for ordinary steel prior to hot rolling in order to dissociate and solid-solve MnS to be coexistent as an inhibitor with AℓN. However, if the slab is heated at such a higher temperature, it is likely that hot tear is produced during the slab soaking or hot rolling which results in surface defects in the product. Particularly, if the content of Si exceeds 3.0%, the surface properties of the product conspicuously degrade with a rapid deterioration of the hot processability. Therefore, it has been so far necessary to restrict the content of Si to not higher than 3.0% so as to obtain a product having excellent surface properties. Thus, it has been considered to be actually difficult to reduce the iron loss value by further increasing the content of Si.

DISCLOSURE OF THE INVENTION

Based on the above-mentioned situation, it is an object of the present invention to provide a process for manufacturing a grain oriented silicon steel sheet having excellent surface properties and low iron loss by exceedingly stable steps.

Noting that a silicon steel raw material containing as much as 3.1-4.5% of Si when AℓN precipitation phase is utilized is a material which is intrinsically suitable for the production of a product with a high magnetic flux density and a low iron loss, the present inventors have strenuously made experiments and studies to find out solutions for diminishing the deterioration in the surface properties which is ordinarily a defect in such a case. Consequently, they have found that even when a high content of Si is present, a grain oriented silicon steel sheet having excellent surface properties, high magnetic flux density and low iron loss can be obtained by adding a small amount of Mo to the raw material and putting a special modification upon the heating treatment of the slab prior to hot rolling.

JP-A-59-85820 teaches that grain oriented silicon steel sheets having excellent surface properties and magnetic characteristics can be obtained by increasing the Mo content at the outer surface of the sheet. The sheets are produced from a silicon steel material containing 3.1 to 4.5 wt% Si, 0.005 to 0.06 wt% acid soluble Aℓ, and 0.005 to 0.1 wt% of S and/or Se. The steel material is hot rolled at 950 to 1200°C, quenched, cold rolled at a draft of 80 to 95% with the inclusion of a warm rolling step at 250 to 400°C, decarburization annealed and finish annealed and the Mo content at the outer surface is increased by coating the sheets with from 2 to 50 g/m^2 of a Mo-containing compound prior to the termination of the hot rolling. The steel material used to form the sheets may include a small amount of Mo to improve the magnetic characteristics but, even so, additional Mo is always present to increase the Mo content at the outer surface of the sheets.

According to the present invention there is provided a process for manufacturing a grain oriented silicon steel sheet having excellent surface properties and magnetic characteristics which comprises providing a raw slab for a silicon steel sheet which raw slab has a composition consisting of 0.01-0.08% of C, 3.1-4.5% of Si, 0.005-0.06% of sol Al, 0.003-0.1% of Mo, 0.005-0.1% in total amount of Se and/or S,0.02 - 2.0% of Mn, optionally less than 0.03% of Sb, optionally less than 0.03% of B, and optionally very small amounts of Cr, Ti, V, Zr, Nb, Ta, Co, Ni, Sn, P and As, with the remainder being iron and impurities; heating the slab at a temperature of not lower than 1,270 °C; hot rolling the slab to form a hot rolled sheet; continuously annealing the hot rolled sheet at a temperature of 950-1,200 °C followed by quenching; subjecting the quenched sheet to cold rolling at a draft of 80-95% to obtain a sheet of final thickness and including a warm rolling step at a temperature of 250-400 °C; and subjecting the sheet to decarburization annealing to effect primary recrystallization and to finish annealing to effect secondary recrystallization characterised in that the slab is heated such that the scale loss is from 2.7 to 5.0% and in that the Mo content at the surface of the sheet is not increased by the application of a Mo-containing compound prior to the termination of hot rolling.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made by way of example, to the accompanying drawing, in which Figures 1a and 1b are graphs showing the relationship between scale loss, magnetic characteristics and slab heating temperature for slabs of different composition.

The experimental results from which the invention originated are as follows:-

Each of a steel slab (A) having a composition containing 0.049% of C, 3.47% of Si, 0.030% of Aℓ , 0.016% of Mo, 0.078% of Mn and 0.026% of S and a steel slab (B) having a composition containing 0.49% of C, 3.42% of Si, 0.029% of Aℓ, 0.076% of Mn and 0.025% of S were heated at various temperatures in a range of 1,150 °C-1,400 °C and hot rolled to obtain hot rolled sheets of 2.3 mm thickness which were homogeneously and continuously annealed at 1,150 °C and quenched, and subjected to a strong cold rolling at a draft of about 87% including a warm rolling at 250 °C midway during the cold rolling to obtain a final cold rolled sheet of 0.3 mm in thickness. The cold rolled sheet was decarburization annealed at 840°C in wet hydrogen, and then finish annealed by box annealing at 1,200°C to obtain a grain oriented silicon steel sheet.

The results obtained upon examination of the magnetic characteristics and the surface properties of the steel sheets are plotted respectively in Figs. 1a and 1b.

As is apparent from Fig. 1a, when the heating temperature is not lower than 1,270°C and the scale loss is not smaller than 2.7%, the magnetic characteristics and the surface properties of slab (A) were both excellent. It is particularly noted that a steel sheet having excellent magnetic characteristics with B_{10} being not lower than 1.94 T and $W_{17/50}$ being not higher than 1.00 W/kg can be obtained when the heating temperature is in a range of 1,300-1,400 °C and the scale loss is in a range of 3.0-4.4%. On the other hand, with respect to the slab (B), as shown in Fig. 1b, it can be seen that excellent magnetic characteristics with B_{10} being not lower than 1.92 T and $W_{17/50}$ being not higher than 1.05 W/kg can be obtained when the heating temperature is not lower than 1,300 °C and the scale loss is not lower than 3.2%, but that the surface properties are poor.

Examination of the intergranular fracture after the high temperature impact tests when the above slabs (A) and (B) were subjected to the heat treatment at a heating temperature of 1,300 °C such that the scale losses were 3.0% and 3.2% respectively was carried out and the following results were obtained.

That is, while steel slab (A) to which Mo had been added was completely free from surface cracks and had excellent surface properties, many surface cracks were formed in slab (B) to which no Mo had been added. These results were well in conformity with those of the surface properties of the products shown in Fig. 1.

As mentioned above, it will be understood that the magnetic characteristics and the surface properties are both excellent when the scale loss is not lower than 2.7% in the case of heating the slab at a temperature of not lower than 1,270 °C. Thus, the addition of a small amount of Mo into the raw material not only effectively plays a role as inhibitor together with the AℓN precipitation phase, but also can eliminate the deterioration of the surface properties which are caused during high temperature heating when the Si content is high. The reinforcement of the inhibitor as a result of the added Mo carrying out is believed to be due to the same mechanism previously proposed by the inventors in Japanese Patent Application Publication No. 14,737/1982 in the case of the combined addition of Mo, Sb and Se or S, that is, the inhibiting effect against the primary crystallized grains is remarkably strengthened by the combined addition of a small amount of Mo and Aℓ, so that the effect of the growth of the secondary grains in the {110}⟨001⟩ orientation at the time of the secondary recrystallization annealing is exhibited. Further, the prevention of the deterioration of the surface properties as a result of the added Mo carrying out the latter role is believed to be based on the fact that the surface defects can be effectively prevented by the preferential precipitation of fine precipitates of Mo sulfide (probably Mo_2S_3) compound at the steel sheet surface or in the vicinity thereof, even when the heating is done at a high temperature and the Si content is high.

In the conventional heating treatment prior to hot rolling, the heating temperature is set at about 1,150-1,250° C and the scale loss was about 1.5-2.5% when the economy of the heating step was taken into account.

The reasons why the fundamental ingredients of the raw slab are restricted as mentioned above in accordance with the present invention will be explained below. C: 0.01-0.08

C is an element playing an important role in providing a fine and uniform structure during hot rolling or cold rolling. If it is more than 0.08%, it takes a long time to perform the decarburization-annealing prior to the secondary recrystallization annealing, thereby lowering the productivity and damaging the magnetic characteristics due to insufficient decarburization. On the other hand, if the content is less than 0.01%, it becomes difficult to control the texture at the time of hot rolling, so that large elongated grains are formed which deteriorate the magnetic characteristics. Thus, the content of C is restricted to a range of 0.01-0.08%.

Si: 3.1-4.5%

As mentioned above, since Si is an element which is extremely effective for increasing the electric resistance of the raw material so as to reduce the eddy current loss, not less than 3.1% of Si is used in the present invention. If the content of Si exceeds 4.5%, brittle fractures are likely to be formed at the time of cold rolling. Thus, the content of Si is restricted to 3.1-4.5%. As mentioned above, the content of Si in the conventional grain oriented silicon steel sheet containing Aℓ is 2.8-3.0%, and when the content of Si is increased and the heating is done at a higher temperature, the surface properties of the product are conspicuously deteriorated. In this respect, the occurrence of surface defects can be prevented even with the Si content being as high as 3.1-4.5% by the addition of a small amount of Mo according to the present invention.

sol Aℓ: 0.005-0.06%

When Aℓ is contained in the steel, it bonds with N to form a fine precipitate of AℓN and acts as a powerful inhibitor. Particularly, in order that the secondary recrystallization may be developed by the strong cold rolling at a cold rolling draft of 80-95%, Aℓ is required to be contained in a range of 0.005-0.06 in the form of sol Aℓ. The reason for this is that if Aℓ is less than 0.005%, the amount of AℓN inhibitor precipitated as fine precipitate is not sufficient to provide adequate growth of the secondary recrystallization grains in the {110}⟨001⟩ orientation. If Aℓ exceeds 0.06%, the growth of the secondary recrystallization grains in the {110}⟨001⟩ orientation becomes lower.

S and/or Se: 0.005-0.1%

S and Se form MnS and MnSe dispersion precipitation phases respectively to increase the inhibitor effect together with AℓN. If the content of S and Se is less than 0.005% when added alone or in combination, the inhibitor effect due to MnS and Mnse is weak. On the contrary, if the addition amount exceeds 0.1%, the hot rolling and cold rolling processability is extremely deteriorated. Thus, S and Se are required to be in a range of 0.005-0.01% expressed as the total amount of one or both of these elements.

Mo: 0.003-0.1%

If Mo is less than 0.003%, the growth inhibiting effect against primary recrystallization grain drops, and at the same time the surface properties of the steel sheet is deteriorated. On the other hand, if more than 0.1% is present, it is effective for preventing the deterioration of the surface properties of the steel sheet but the processability during hot rolling and cold rolling is lowered and insufficient decarburization at the time of the decarburization-primary recrystallization annealing is likely to occur. Thus, Mo is required to be in a range of 0.003-0.1%.

Mn: 0.02% - 2%

Mn contained in the steel bonds with S or Se to form fine precipitates of MnS and MnSe, and acts as a powerful inhibitor. If Mn is less than 0.02%, the amount of fine precipitate of MnS and MnSe precipitated as inhibitor is inadequate, so that the growth of the secondary recrystallization grains in the {110}⟨001⟩ orientation becomes insufficient. On the other hand, if Mn exceeds 2%, MnS and the like are hardly dissociated and solid-solved during heating the slab and, even if dissociation and solid-solving takes place, MnS, MnSe and the like are hardly dissociated and solid-solved during the hot rolling or the dispersion precipitation phase deposited during the hot rolling is likely to be larger thus damaging the appropriate size distribution of the inhibitor and deteriorating the magnetic characteristics. From these reasons, the content of Mn is from about 0.02%-2%.

Although the reasons for the compounding ranges of the fundamental ingredients have been explained, the present invention does not preclude the presence of other elements which are ordinarily incidentally included in the silicon steel. Thus, one or two kinds of Sb and B, which may be added to ordinary silicon steel as known primary recrystallization grain growth inhibitor, may be contained in a total amount of not higher than about 0.03%. Also, the generally inevitable impurities such as Cr, Ti, V, Zr, Nb, Ta, Co, Ni, Sn, P and As may be present in very small amounts.

Next, the series of the manufacturing steps used in the present invention will be explained.

As the means for melting the raw material used in the method according to the present invention, use may be made of a conventional steel-making furnace such as an LD converter, an open-hearth furnace or the like, which may be, of course, used in combination with a vacuum treatment during vacuum melting. Further, as the slab-making means, use may be favorably made of continuous casting in addition to the ordinary ingot making-slabbing method.

The silicon steel slab obtained as mentioned above is heated and then hot rolled according to the conventional method. The thickness of the hot rolled sheet obtained by this hot rolling depends upon the draft and so on in the succeeding cold rolling step, and is ordinarily about 2-5 mm. In the present invention, care should be given to the slab-heating prior to the above-mentioned hot rolling. That is, as mentioned above, the dissociation and solid-solving of the MnS, MnSe or the like contained in the raw material becomes extremely difficult in the case of silicon steel sheet with a high content of Si or 3.14.5%. Thus it is necessary for the heating to be fully done at a heating temperature of not lower than 1,270 °C in such a manner that the scale loss may be 2.7-5.0%.

The hot rolled plate, having undergone the above-mentioned hot rolling, is subjected to continuous annealing at a temperature range of 950-1,200 °C for 30 seconds to 30 minutes for the purpose of homogenization of the structure and sufficient solid-solving of AℓN and it is then quenched. The quenching treatment after the annealing is necessary for the formation of the fine precipitation phase of AℓN, and it is ordinarily desirable that quenching is carried out from a temperature range of 850-1,050°C to a temperature of not higher than 400°C.

The hot rolled steel sheet quenched in the above manner is subjected to strong cold rolling at a draft of 80-95% to obtain a product having the desired sheet thickness. It is necessary that warm rolling is performed at a temperature range of 200-400°C during the cold rolling. As disclosed in Japanese Patent Application Publication No. 13,846/1979, warm rolling is necessary in that the C and N solid-solved into the silicon steel are scatteringly collected at defect portions formed during the warm rolling and the deformation mechanism is changed either by fixing the dislocation by the formation of the Cottrell atmosphere or by interruption of the dislocation movement with the fine precipitates, so that a primary recrystallization texture which is advantageous for the secondary recrystallization is formed. The cold rolled sheet thus treated to have a final sheet thickness of about 0.1-0.5 mm is subjected to decarburization-annealing serving also as the primary recrystallization at a temperature range of 750-870°C. This decarburization-annealing may be ordinarily carried out in a wet hydrogen gas atmosphere or a mixed gas atmosphere of hydrogen and nitrogen at a temperature higher by about 30-65 °C than the dew point for a few minutes.

Next, an annealing separator mainly consisting of MgO is ordinarily applied to the steel sheet after decarburization-annealing and the sheet is subjected to finish annealing to grow the secondary recrystallization grains in the {110}⟨001⟩ orientation. The specific conditions of the finish annealing may be similar to those in the case of conventional annealing and preferably are ordinarily such that the temperature is raised at a temperature rising rate of 3-50 °C/hr up to 1,150-1,250 °C and then the purification annealing is carried out in hydrogen for 5-20 hours.

As mentioned above, according to the present invention, it is possible to industrially and stably manufacture grain oriented electromagnetic steel sheet with a high Si content and having extremely excellent magnetic characteristics with a high magnetic flux density B_{10} of not lower then 1.94 T and an extremely low iron loss $W_{17/50}$ of not higher than 1.00 W/kg and also with excellent surface properties.

<u>The following Examples illustrate the invention</u>

<u>Example 1</u>

A continuously cast slab having a composition containing 0.049% of C, 3.48% of Si, 0.029% of Aℓ, 0.018% of Mo, 0.076% of Mn and 0.026% of S was heated at 1,360 °C such that the scale loss reached 3.5%, and then hot rolled to obtain a hot rolled sheet of 2.3 mm in thickness. Then, after having been subjected to continuous annealing at 1,120 °C, the steel sheet was subjected to a quenching treatment, and to strong cold rolling at a draft of about 87% including a warm rolling step at 250 °C to obtain a final cold rolled sheet of 0.3 mm in thickness. Thereafter, the cold rolled sheet was subjected to decarburization-primary recrystallization annealing at 840°C in wet hydrogen, and was then finish annealed by box annealing at 1,230°C.

The magnetic characteristics and the surface properties of the thus obtained product were as follows:

Magnetic characteristics	B_{10}:	1.95 T,
	$W_{17/50}$:	0.99 W/kg
Surface properties	good	

Example 2

A continuously cast slab having a composition containing 0.055% of C, 3.52% of Si, 0.025% of Aℓ, 0.020% of Mo, 0.019% of Se and 0.070% of Mn was heated and annealed at 1,360°C such that the scale loss reached 3.8%, and hot rolled to obtain a hot rolled sheet of 2.3 mm in thickness. Then, after having been homogenization annealed at 1,160°C, the hot rolled sheet was subjected to a quenching treatment and then to a warm rolling at 320°C to obtain a final cold rolled sheet of 0.3 mm in thickness. Thereafter, the cold rolled sheet was subjected to decarburization-primary recrystallization annealing at 840°C in wet hydrogen. Then the cold rolled sheet was coated with an annealing separator mainly consisting of MgO, and was heated at a rate of 10°C from 800°C to 1,150°C to perform the secondary recrystallization. Subsequently, purification annealing was performed at 1,200°C in hydrogen for 5 hours. The magnetic characteristics and the surface properties of the thus obtained products were as follows:

Magnetic characteristics	B_{10}:	1.96 T,
	$W_{17/50}$:	0.97 W/kg
Surface properties	good	

Example 3

A continuous cast slab having a composition containing 0.048% of C, 3.52% of Si, 0.029% of Aℓ, 0.015% of Mo, 0.023% of Sb, 0.020% of Se and 0.073% of Mn was heated and annealed at 1,340°C such that the scale loss reached 3.2% and then hot rolled to obtain a hot rolled sheet of 2.3 mm in thickness. Then, after having been homogenization annealed at 1,150°C, the steel sheet was subjected to a strong cold rolling at 87% to obtain a final cold rolled sheet of 0.3 mm in thickness. A warm rolling was carried out at 280°C during the cold rolling. Therefore, the cold rolled sheet was subjected to decarburization-primary recrystallization annealing at 840°C in wet hydrogen, coated with an annealing separator mainly consisting of MgO, and heated at a rate of 15°C/h from 850°C to 1,120°C to effect the secondary recrystallization, followed by purification annealing at 1,230°C in hydrogen for four hours. The magnetic characteristics and the surface properties of the thus obtained products were as follows:

Magnetic characteristics	B_{10}:	1.95 T,
	$W_{17/50}$:	0.98 W/kg
Surface properties	good	

INDUSTRIAL APPLICABILITY

According to the present invention, it is possible to advantageously produce grain oriented silicon steel sheet which has excellent magnetic characteristics, that is, it has a high magnetic flux density and a low iron loss without deteriorating the surface properties thereof. Therefore, when the silicon steel sheet thus obtained is used in the iron core of a transformer, it greatly contributes to the miniaturization and energy saving thereof.

Claims

1. A process for manufacturing a grain oriented silicon steel sheet having excellent surface properties and magnetic characteristics which comprises providing a raw slab for a silicon steel sheet which raw slab has a composition consisting of 0.01-0.08% of C, 3.1-4.5% of Si, 0.005-0.06% of sol Al, 0.003-0.1% of Mo, 0.005-0.1% in total amount of Se and/or S,0.02 - 2.0% of Mn, optionally less than 0.03% of Sb, optionally less than 0.03% of B, and optionally very small amounts of Cr, Ti, V, Zr, Nb, Ta, Co, Ni, Sn, P and As, with the remainder being iron and impurities; heating the slab at a temperature of not lower than 1,270 °C; hot rolling the slab to form a hot rolled sheet; continuously annealing the hot rolled sheet at a temperature of 950-1,200 °C followed by quenching; subjecting the quenched sheet to cold rolling at a draft of 80-95% to obtain a sheet of final thickness and including a warm rolling step at a temperature of 250-400 °C; and subjecting the sheet to decarburization annealing to effect primary recrystallization and to finish annealing to effect secondary recrystallization characterised in that the slab is heated such that the scale loss is from 2.7 to 5.0% and in that the Mo content at the surface of the sheet is not increased by the application of a Mo-containing compound prior to the termination of hot rolling.

Revendications

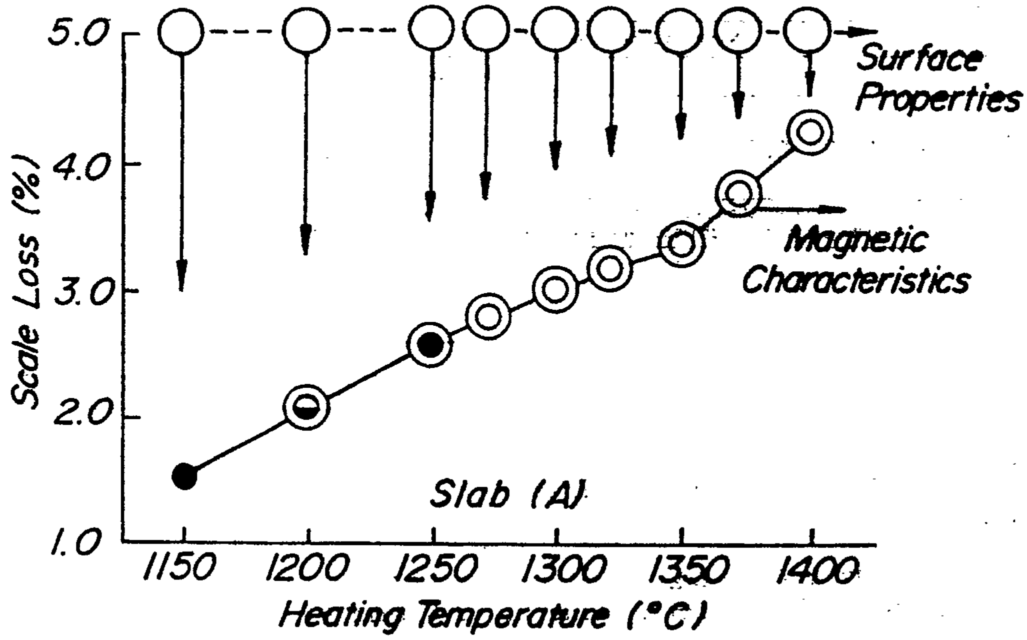
1. Procédé de fabrication de feuilles d'acier au silicium à grain orienté possédant d'excellentes propriétés de surface et de très bonnes caractéristiques magnétiques, le dit procédé prévoyant un brame brut pour de la feuille d'acier au silicium, lequel brame brut est d'une composition consistant en 0,01 - 0,08 % de C, 3,1 - 4,5 % de Si, 0.005 - 0,06 % de sol Al, 0,003 - 0,1 % de Mo, 0,005 - 0,1 % en quantité totale de Se et/ou de S, 0,02 - 2,0 % de Mn, la composition comprenant facultativement moins de 0,03 % de Sb, facultativement moins de 0,03 % de B, et facultativement de très petites quantités de Cr, Ti, V, Zr, Nb, Ta, Co, Ni, Sn, P et As, le reste étant du fer et des impuretés , et le dit procédé comprenant : le chauffage du brame à une température non inférieure à 1.270 ºC ; le laminage à chaud du brame pour former une feuille d'acier laminée à chaud ; le recuit continu de la feuille d'acier laminée à chaud à une température de 950 - 1.200 ºc, le recuit étant suivi d'une opération de trempe ; une opération consistant à soumettre la feuille trempée à un laminage à froid avec un étirage de 80 - 95 % de façon à obtenir une feuille laminée sur une épaisseur finale, la dite opération comprenant une phase de laminage à chaud effectué à une température de 250 = 400 ºC ; et une opération consistant à soumettre la feuille à un recuit de décarburation pour assurer une recristallisation primaire, et à un recuit de finissage pour assurer une recristallisation secondaire, le dit procédé étant caractérisé en ce que le brame est chauffé de manière que la perte au décalaminage se situe entre 2,7 et 5,0 %, et en ce que la teneur en Mo à la surface de la feuille n'est pas augmentée par l'application d'un compound contenant du Mo avant la terminaison du laminage à chaud.

Patentansprüche

1. Verfahren zur Herstellung eines kornorientierten Siliciumstahlbleches mit ausgezeichneten Oberflächeneigenschaften und magnetischen Eigenschaften, bei dem eine Rohbramme für ein Siliciumstahlblech hergestellt wird, wobei diese Rohbramme eine Zusammensetzung besitzt, die aus 0.01 bis 0.08% C, 3,1 bis 4,5% Si, 0,005 bis 0,06% Al-Sol, 0,003 bis 0,1% Mo, insgesamt 0,005 bis 0,1% Se und/oder S, 0,02 bis 2,0% Mn, gewünschtenfalls weniger als 0,03% Sb, gewünschtenfalls weniger als 0,03% B und gewünschtenfalls aus sehr geringen Mengen an Cr, Ti, V, Zr, Nb, Ta, Co, Ni, Sn, P und As, wobei der Rest Eisen und Verunreinigungen sind, besteht; die Bramme auf eine Temperatur von nicht weniger als 1270 °C erhitzt wird; die Bramme zur Herstellung eines heißgewalzten Bleches heißgewalzt wird; das heißgewalzte Blech bei einer Temperatur von 950 bis 1200 °C kontinuierlich glühbehandelt und anschließend abgeschreckt wird; das abgeschreckte Blech einer Kaltwalzbehandlung mit einer Abnah-

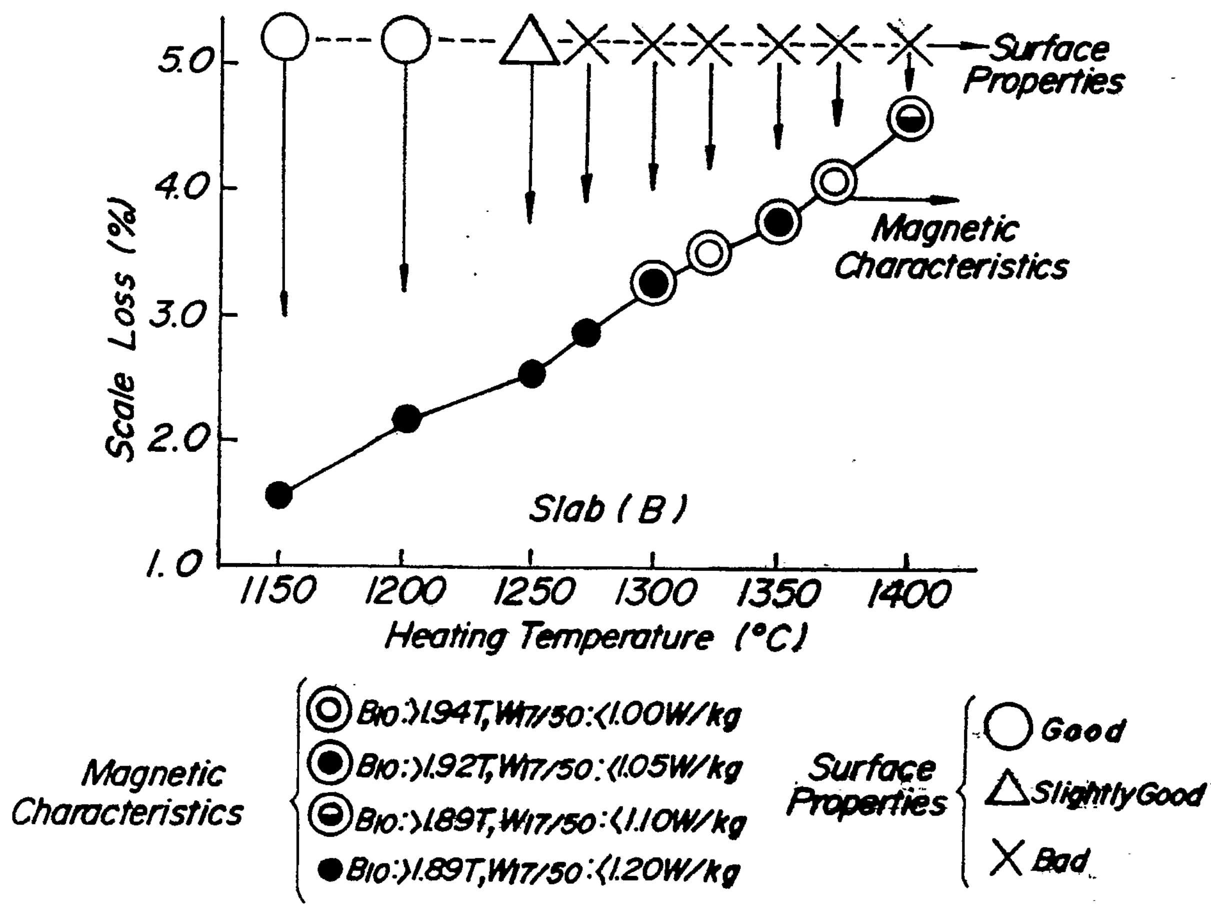
me von 80 bis 85% unterworfen wird, um ein Blech mit der endgültigen Dicke zu erhalten, wobei eine Warmwalzstufe bei einer Temperatur von 250 bis 400 °C zwischengeschaltet wird; und bei dem das Blech einer Entkohlungsglühbehandlung unterworfen wird, um eine primäre Rekristallisation zu bewirken und um die Glühbehandlung zu beenden, so daß eine sekundäre Rekristallisation erreicht wird, dadurch **gekennzeichnet,**
daß die Bramme derart erhitzt wird, daß der Verzunderverlust 2,7 bis 5,0% beträgt, und daß der Mo-Gehalt an der Oberfläche des Bleches durch die Anwendung einer Mo-enthaltenden Verbindung vor dem Ende des Heißwalzens nicht erhöht wird.

FIG. 1a



Surface Properties
Magnetic Characteristics
Scale Loss (%)
5.0
4.0
3.0
2.0
1.0
Slab (A)
1150
1200
1250
1300
1350
1400
Heating Temperature (°C)

FIG. 1b



Surface Properties
Magnetic Characteristics
Scale Loss (%)
5.0
4.0
3.0
2.0
1.0
Slab (B)
1150
1200
1250
1300
1350
1400
Heating Temperature (°C)
Magnetic Characteristics
B10:>1.94T, W17/50:<1.00W/kg
B10:>1.92T, W17/50:<1.05W/kg
B10:>1.89T, W17/50:<1.10W/kg
B10:>1.89T, W17/50:<1.20W/kg
Surface Properties
Good
Slightly Good
Bad