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(54) **STEEL SHEET FOR ULTRA-THIN TWO-PIECE CANS HAVING EXCELLENT ANTI-WRINKLING PROPERTIES AND METHOD FOR PRODUCING THEREOF**

STAHLBLECH FÜR ULTRADÜNNE DOSEN MIT HERVORRAGENDER ANTI-FALTEIGENSCHAFTEN UND VERFAHREN ZU DESSEN HERSTELLUNG

TOLE D'ACIER ULTRA MINCE POUR BOITE BOISSON AYANT UNE RÉSISTANCE À LA FORMATION DE PLI ET PROCEDE DE PRODUCTION ASSOCIE

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a method for producing a steel sheet used as a material for a can produced by drawing, ironing, stretching and succeeding diameter reduction forming as represented by the production of a two-piece can and a method for producing the steel sheet. In the field of can manufacturing, in particular, the present invention provides a steel sheet for an ultra-thin can, capable of being produced with high productivity, small earing and good neck wrinkling resistance and a method for producing the steel sheet.

BACKGROUND TECHNOLOGY

15 **[0002]** In the field of manufacturing beverage cans and food cans, etc., the production amount of cans wherein bottoms and walls are integrally formed in one body, called two-piece cans, is increasing. In a two-piece can, generally, in order to obtain a required can height, a method for increasing the can wall height by ironing or stretching after drawing process is adopted, as is represented by a method for manufacturing a DI can or a DTR can.

20 **[0003]** In these forming processes, it is desired to restrain the generation of earing which deteriorates the yield of a steel sheet and the formability in ironing or stretching. Further, working for reducing the diameter of a can opening (neck forming) is performed in order to reduce the size of a can lid and to decrease the material cost thereof. Then, in case of a two-piece can, there occurs a problem of increasing wrinkle formation (deterioration of neck wrinkling resistance) due to material hardening caused by drawing and ironing or stretching.

[0004] For improving these shortcomings, the technologies disclosed in Japanese Unexamined Published Patent Application Nos. 1-184252, 1-184229 and 2-141535, etc. have been proposed.

[0005] JP-A 10 237 550 and JP-A 9 104 920 both relate to the production of thin steel sheets for cans.

25 **[0006]** For improving anti-wrinkling property, in general, it is said to be effective to decrease the yield stress of a material (when a yield point is not observed, the stress at 0.2% strain). However, the technologies disclosed in the above-mentioned prior arts do not provide the sufficient softening of a material after drawing and ironing. Therefore, when an ultra-thin sheet with a thickness of 0.2mm or less is used as a material, the work hardening of the material or the deterioration of the neck wrinkling resistance, etc. is still concerned in the forming of a can which diameter reduction ratio is further increased as a recent trend. And thus further improvement of material properties is desired.

30 **[0007]** For steel sheets developed for cans until now, no effective means has been found to restrain wrinkle formation during the diameter reduction of the material after it is subjected to heavy forming such as ironing or stretching during forming the can body of a conventional two-piece can. For a thin steel sheet with a thickness of 0.2mm or less, buckling of the steel sheet, called heat-buckle, is generated during annealing and the production efficiency is decreased.

35 **[0008]** As a countermeasure against heat-buckle, a method for processing a steel sheet thicker than a target thickness during annealing, then cold rolling again (2CR), and obtaining the steel sheet with the target thickness has been commercialized. This is a favorable method from the aspect of securing can strength since strength degradation is compensated for with work hardening even when an ultra-low carbon IF steel, which is originally soft, is applied. However, this method markedly deteriorates neck wrinkling resistance because working by drawing, ironing and stretching is applied in addition to working by 2CR.

DISCLOSURE OF THE INVENTION

45 **[0009]** The present invention provides a method for producing a steel sheet according to claim 1 used for a two-piece can produced by drawing and ironing or stretching, having high drawability and avoiding

1. the deterioration of productivity due to buckling at an annealing process,
2. the generation of wrinkle during reducing the diameter of the opening of a can body, and
3. the development of earing for an ultra-thin material with a thickness of 0.2mm or less produced at a high cold-rolling reduction ratio.

50 **[0010]** During the course of a study to restrict wrinkle generation during neck diameter reduction after the processes of 2CR, drawing, ironing and stretching using a low carbon steel with about 0.03% of C having a low recrystallization temperature and good drawability as a base material, the present inventors found that there is a correlation between wrinkle generation and the amount and size of precipitates such as AlN and MnS, etc. The mechanism of the phenomena is not clear but it is thought that crystal grain size and crystalline texture formation, etc. after annealing, mainly affect, in combination, the behavior of work hardening of the material and hence neck wrinkling resistance is improved.

[0011] In particular, because the direction of working is varied in a course of processing such as cold rolling after

annealing, drawing, ironing, stretching and diameter reducing, it is thought that a factor like the so-called Bauschinger Effect could have an influence.

[0012] The anti-wrinkling property is improved, as crystal grain size becomes coarser, as the strength of {100} plane becomes higher and the strength of {111} plane becomes lower in crystalline texture, and as precipitates become coarser in size and lower in density. The present invention has been completed by further considering the workability, etc. of a two-piece can annealed at a relatively low temperature for restraining heat-buckle during annealing process.

[0013] Based on the finding that the anti-wrinkling property is influenced by the amount and size of AlN and MnS, the inventors have further studied in detail and obtained the result that the anti-wrinkling property can be evaluated by restricting the ratio of N existing as Al nitrides to N content or the size distribution of AlN and MnS. That is, according to the present invention, a steel sheet for a two-piece can with a thickness of 0.19mm or less and having excellent neck wrinkling resistance and anti-earring property can be produced on condition that AlN and MnS satisfy the following requirements:

1. $(N \text{ existing as AlN}) / (N \text{ content}) > 0.5$,
2. the ratio of the number of AlN with a diameter of $0.01\mu\text{m}$ or less to the number of AlN with a diameter of at least $0.005\mu\text{m}$ is 10% or less (RA),
3. the average diameter of AlN with a diameter of at least $0.005\mu\text{m}$ is 0.01 to $0.10\mu\text{m}$ (DA),
4. the ratio of the number of MnS with a diameter of $0.03\mu\text{m}$ or less to the number of MnS with a diameter of at least $0.005\mu\text{m}$ is 50% or less (RM),
5. the average diameter of MnS with a diameter of at least $0.005\mu\text{m}$ is 0.03 to $0.40\mu\text{m}$ (DM).

BRIEF DESCRIPTION OF THE DRAWING

[0014] Figure 1 is a graph showing the relationship between the average diameter of MnS, hot-rolling conditions (slab heating temperature and coiling temperature) and a critical diameter reduction ratio.

BEST MODES FOR CARRYING OUT THE INVENTION

[0015] The present invention will be explained in detail hereafter.

[0016] Firstly, the chemical compositions of the steel, hereafter in weight percent, will be explained.

[0017] C forms cementite in steel when the content is high. When coarse cementite is exposed on a surface, it may cause the deterioration of the plating properties of a steel sheet. Further, the coarse cementite could be a starting points cracks during ironing, stretching or flange forming in the process for manufacturing a can. It is desirable, therefore, that the upper limit of C content is set to 0.08%.

[0018] When a material with good ductility during ironing, stretching and flange forming is required, in particular, the properties can be markedly improved by setting the upper limit of C to 0.06% or less. However, a reduction of the carbon content of less than 0.008% for controlling aging property, it is not desirable from the aspect of insufficient can strength and the increase of decarburization cost because of the existence of C in solid solution. From these aspects, it is desirable to set C content to at least 0.008%. Further, to obtain a soft material with high ductility desirable for a two-piece can at a low cost without using a vacuum degassing process, it is desirable to limit the C content within the range between 0.02 and 0.04%.

[0019] N is an important element that controls the formation of nitrides. Too much N generates many nitrides, and hence the object of the present invention is hard to achieve. It is desirable, therefore, the upper limit of N be set to 0.0040%. If N is reduced to 0.0020% or less by sufficiently applying a vacuum degassing treatment, it is further desirable because the amount of nitrides generated is decreased and hence the target properties are improved.

[0020] Since a high Si content causes hardening of the material and deterioration of workability, it is desirable that the Si content is set to 0.05% or less. Further, more desirably, it should be set to 0.029% or less.

[0021] Since a high Mn content causes hardening of the material and deterioration of workability and an excessive reduction of Mn leads to a high cost, it is desirable that the Mn content is set within the range between 0.04 and 0.4%. Further, more desirably, it should be set within the range between 0.15 and 0.25%.

[0022] Since a high P content causes hardening of the material and deterioration of workability, it is desirable that the P content is set to 0.04% or less. Further, more desirably, it should be set to 0.010% or less.

[0023] Since a high S content generates many MnS precipitates and causes hardening of the material and deterioration of workability, it is desirable that the S content is set to 0.04% or less. Further, more desirably, it should be set to 0.020% or less.

[0024] Al is, like N, an important element that controls nitrides, which is an important requirement of the present invention. From this aspect, it is desirable that the Al content is set within the range between 0.02 and 0.10%. Further, more desirably, it should be set within the range between 0.050 and 0.080%.

[0025] An important requirement of the present invention is to control the amount of nitrides. The present invention mainly utilizes Al nitrides as precipitates and does not mainly utilize compounds of B, Ti and V, etc. Therefore, B, Ti and V, etc. are not added intentionally.

[0026] Nitrides are mainly composed of AlN and hence the following relation must be satisfied;

$(N \text{ existing as AlN}) / (N \text{ content}) > 0.5.$

[0027] Here, N existing as AlN (N as AlN) is a value obtained by converting the total amount of AlN into the amount of N, wherein the amount of Al in residuals when a steel sheet is dissolved in an iodine alcohol solution is analyzed and that total amount is regarded as composing AlN.

[0028] The size distributions of AlN and MnS are important factors for improving neck wrinkling resistance. The present invention is preferable that, for AlN, the ratio of the number of AlN with a diameter of $0.10\mu\text{m}$ or less to the number of AlN with a diameter of at least $0.005\mu\text{m}$ is 10% or less and the average diameter of AlN is 0.01 to $0.10\mu\text{m}$, and that, for MnS, the ratio of the number of MnS with a diameter of $0.03\mu\text{m}$ or less to the number of MnS with a diameter of at least $0.005\mu\text{m}$ is 50% or less and the average diameter of MnS is 0.03 to $0.40\mu\text{m}$.

[0029] These are the values obtained by observing replicas extracted from steel sheets by the SPEED method with an electron microscope and by measuring the diameter and number of precipitates within the visual field with possibly no maldistribution.

[0030] As described above, by controlling precipitates, the crystal structure and the crystalline texture, etc. can be controlled and hence the neck wrinkling resistance of a thin sheet with a thickness of 0.19mm or less can be improved.

[0031] The size distribution can also be obtained by photographing the visual field and carrying out image analysis, etc. As described above, to improve neck wrinkling resistance, work hardening behavior of a material, including the Bauschinger Effect, should be considered. It is generally thought that fine precipitates greatly influence the work hardening behavior of a material. However, the quantitative and qualitative analyses of fine precipitates are not regarded as perfect even with the latest technologies and could cause large errors. Therefore, the present invention specifies the claims in relation to coarse precipitates in which measuring errors are expected to be reduced.

[0032] MnS of an elongated shape can occasionally be observed, and for MnS with anisotropic shape, the average of the longest diameter and the shortest diameter is defined as the diameter of the precipitate.

[0033] For controlling nitrides and sulfides, the heat history over the overall manufacturing processes is important. In the heat history, the influence of slab heating temperature and coiling temperature is large, and therefore it is necessary to control the slab reheating temperature to within a predetermined range.

[0034] A slab reheating temperature (SRT) is determined in combination with a coiling temperature (CT). When a slab reheating temperature is in the range between 1150 and 1250°C , the coiling temperature must be limited to the range between 690 and 750°C . The reason is not clear, but it is thought that changing the size distribution of AlN precipitates in a steel sheet by keeping it particularly within the temperature range specified above influences the work hardening behavior of a material after recrystallization at cold rolling. Generally speaking, it is thought that reducing the number of fine precipitates directly influences the work hardening behavior of a material, coarsens crystal grain size by promoting crystal grain growth during recrystallization at cold rolling and, in addition, restrains work hardening also through the change of crystal orientation (crystalline texture).

[0035] When a slab reheating temperature is in the prescribed range between 1000 and 1150°C which is lower than the above case, a steel sheet according to the present invention can be obtained without specifying the coiling temperature. The reason is not clear, but it is thought that the precipitation of MnS during slab heating proceeds by setting a slab reheating temperature at a low temperature of 1150°C or less, the amount of fine MnS, which precipitates with a temperature drop during hot-rolling, is reduced, and thus the same effect as the above-mentioned AlN can be obtained. Further, in this case, it is thought that the coiling temperature need not be specified because the precipitation of AlN is also promoted during slab heating.

[0036] Cold-rolling reduction ratio (CR) is in the range between 82 and 94%, but the claimed range is between 90 and 94%. The figure is defined considering the productivity in producing a thin steel sheet and the suppression of in-plane anisotropy from the aspect of material quality. When the cold-rolling reduction ratio is low, the productivity of hot rolling goes down and in-plane anisotropy increases because the thickness of a hot band is required to be thinner. On the other hand, when the cold-rolling reduction ratio is high, the burden on the cold-rolling process becomes heavy and in-plane anisotropy also increases.

[0037] Annealing temperature (AT) is in the range between the recrystallization temperature and 720°C , but the claimed range is between 650 and 670°C . The reason is that securing recrystallization is necessary for obtaining good ductility and the deterioration of productivity in the annealing process is of concern at a temperature exceeding 720°C .

[0038] It is desirable that re-cold-rolling reduction ratio (RCR) after annealing is in the range between 1 and 10%. This is because the effect of re-cold-rolling is obtained at a re-cold-rolling reduction ratio of at least 1%, while too high re-cold-rolling reduction ratio causes the deterioration of workability due to the hardening of a material. Further, more desirably, the re-cold-rolling reduction ratio is in the range between 1 and 2%.

[0039] Further, the effect of the present invention does not disappear even if strengthening elements such as Si, Mn

and P, etc. are added in a large quantities, instead of employing 2CR, to increase the strength of a steel sheet.

[0040] Further, a steel sheet according to the present invention is also used as a substrate for a surface treated steel sheet. However, the surface treatment does not hurt the effect of the present invention at all.

[0041] A steel sheet according to the present invention, when it is used as a surface treated steel sheet for a can, is usually coated with tin or chromium (tin-free), etc. Further, a steel sheet according to the present invention is also used as a substrate for a laminated steel sheet, which is coated with organic film and has been in use recently, without hurting the effect of the present invention.

EXAMPLES

[0042] Steel sheets with a thickness of 0.180mm were produced under the manufacturing conditions shown in Table 2 using steel materials with the chemical compositions shown in Table 1, and then the effect of the present invention was evaluated.

[0043] Cups were formed by drawing in a predetermined condition, and the earing property was evaluated by the earing ratio calculated from the maximum and minimum values of cup wall height using the following equation (1);

$$\text{earing ratio} = (\text{maximum value} - \text{minimum value}) / (\text{minimum value}) \dots\dots\dots (1)$$

[0044] Cans with a thickness of 125μm at the portion where neck-forming is to be performed were produced while maintaining the drawing ratio and ironing ratio constant and the same multi-stage diameter reduction as is applied to conventional actual can manufacturing was applied to the cans and neck wrinkling resistance was evaluated by the value of a critical diameter reduction ratio calculated by the following equation (2) as a threshold of generating wrinkle. Since the allowance of material quality in actual operation becomes larger as the critical diameter reduction ratio becomes higher, wrinkle generation can be suppressed.

$$\text{Critical diameter reduction ratio} = (\text{initial diameter} - \text{diameter at the time of wrinkle generation}) / (\text{initial diameter}) \dots\dots\dots (2)$$

[0045] Heat-buckle was evaluated by the occurrence of heat-buckle when a steel sheet was processed in a continuous annealing line at the temperature of recrystallization temperature + 40°C.

[0046] As is apparent from Table 2, steel sheets produced under conditions within the range specified by the present invention have excellent properties in all of anti-earring property, neck wrinkling resistance and heat-buckle resistance.

Table 1

	(Chemical composition: wt%)						
Steel	C	Si	Mn	P	S	Al	N
a	0.021	0.02	0.24	0.007	0.009	0.066	0.0028
b	0.035	0.01	0.07	0.008	0.009	0.059	0.0016
c	0.035	0.03	0.24	0.015	0.009	0.014	0.0035
d	0.064	0.02	0.20	0.010	0.010	0.068	0.0027
e	0.002	0.02	0.15	0.013	0.010	0.053	0.0018
f	0.083	0.02	0.15	0.006	0.010	0.067	0.0022

Table 2

Steel	SRT (°C)	CT (°C)	CR (%)	AT (°C)	RCR (%)	NasAIN/N (%)	RA (%)	DA (μm)	RM (%)	DM (μm)	Earing ratio (%)	Heat-buckle	Diameter reduction ratio (%)	Evaluation
a	1250	550	93	680	5.0	40	15	0.02	55	0.08	5.6	×	16	Comparative steel
a	1250	690	93	650	5.0	60	5	0.02	35	0.06	2.6	○	22	Invented steel
a	1250	730	93	640	5.0	100	1	0.05	40	0.25	1.3	○	26	Comparative steel
b	1200	550	92	670	1.5	40	20	0.03	40	0.20	4.4	×	12	Comparative steel
d	1200	690	90	650	5.0	40	1	0.04	35	0.10	2.7	○	22	Invented steel
e	1200	600	93	700	5.0	50	15	0.04	70	0.02	3.2	×	16	Comparative steel
e	1200	680	93	670	5.0	90	1	0.06	60	0.05	2.0	×	16	Comparative steel
f	1100	650	92	650	5.0	80	15	0.02	20	0.10	5.8	○	12	Comparative steel

Note: Heat-buckle ○: Did not occur, ×: Occurred

[0047] Figure 1 shows the relationship between the size distribution of MnS and neck wrinkling resistance for steel sheets with 0.03% of C in weight percent. Steel sheets having MnS size distribution within the range specified by the present invention have good neck wrinkling resistance. In Figure 1, the effects of MnS size distribution are separately shown by each slab reheating temperature category. The neck diameter reduction property is improved when slab reheating temperature is 1250°C or less and coiling temperature is at least 690°C even though the size distribution of MnS is almost the same.

INDUSTRIAL APPLICABILITY

[0048] According to the present invention, the rate of wrinkle generation during neck diameter reduction can be reduced. Further, since a steel according to the present invention shows good properties even with an annealing temperature lower than the temperature for a conventional steel, the generation of heat-buckle can be avoided and highly efficient production of a material for an ultra-thin can is made possible.

Claims

1. A method for producing a steel sheet for a two-piece can having excellent neck wrinkling resistance and anti-earring properties, **characterized by:**

said steel sheet containing, in weight percent,

C: 0.08% or less,

Si: 0.05% or less,

Mn: 0.04 - 0.4%,

P: 0.04% or less,

S: 0.04% or less,

Al: 0.02 - 0.10%, and

N: 40ppm or less; with the balance being Fe and unavoidable impurities;

carrying out hot rolling at a slab reheating temperature in the range of 1150 - 1250°C and at a hot-rolling coiling temperature in the range of 690 - 750°C, cold-rolling with a cold-rolling reduction ratio in the range of 90 - 94%, annealing at a temperature in the range of 650 - 670 °C, and re-cold-rolling with a re-cold-rolling reduction ratio in the range of 1 - 10%,

the average diameter of AlN with a diameter of at least 0.005µm being 0.01 to 0.10µm,

the ratio of the number of AlN with a diameter of 0.01 µm or less to the number of AlN with a diameter of at least 0.005µm being 10% or less,

the average diameter of MnS with a diameter of at least 0.005µm being 0.03 to 0.40µm,

the ratio of the number of MnS with a diameter of 0.03µm or less to the number of MnS with a diameter of at least 0.005µm being 50% or less,

the following equation being satisfied,

$(N \text{ existing as AlN}) / (N \text{ content}) > 0.5$, and

the thickness of said steel sheet being 0.19mm or less.

2. The method according to claim 1, wherein said steel sheet contains, in weight percent,

C: 0.02 - 0.04%,

Si: 0.029% or less,

Mn: 0.15 - 0.25%,

P: 0.010% or less,

S: 0.020% or less,

Al: 0.050 - 0.080%, and

N: 40ppm or less with the balance being Fe and unavoidable impurities.

Patentansprüche

1. Verfahren zur Herstellung eines Stahlblechs für eine zweiteilige Dose mit ausgezeichneter Beständigkeit gegen Halsfaltenbildung und ausgezeichneten Zipfelverhinderungseigenschaften, **dadurch gekennzeichnet, dass** das Stahlblech in Gewichtsprozent enthält:

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C: höchstens 0,08 %,
Si: höchstens 0,05 %,
Mn: 0,04 bis 0,4 %,
P: höchstens 0,04 %,
S: höchstens 0,04 %,
Al: 0,02 bis 0,10 % und

N: höchstens 40 ppm, wobei der Rest Eisen und unvermeidliche Verunreinigungen sind; und durch Durchführen von Warmwalzen bei einer Brammenwiedererwärmungstemperatur im Bereich von 1150 bis 1250 °C und bei einer Wickeltemperatur nach Warmwalzen im Bereich von 690 bis 750 °C, Kaltwalzen mit einem Walzgrad beim Kaltwalzen im Bereich von 90 bis 94 %, Glühen bei einer Temperatur im Bereich von 650 bis 670 °C sowie erneutes Kaltwalzen mit einem Walzgrad beim erneuten Kaltwalzen im Bereich von 1 bis 10 %, wobei der mittlere Durchmesser von AIN mit mindestens 0,005 µm Durchmesser von 0,01 bis 0,10 µm beträgt, das Verhältnis der Anzahl von AIN mit höchstens 0,01 µm Durchmesser zur Anzahl von AIN mit mindestens 0,005 µm Durchmesser höchstens 10 % beträgt, der mittlere Durchmesser von MnS mit mindestens 0,005 µm Durchmesser von 0,03 bis 0,40 µm beträgt, das Verhältnis der Anzahl von MnS mit höchstens 0,03 µm Durchmesser zur Anzahl von MnS mit mindestens 0,005 µm Durchmesser höchstens 50 % beträgt, die folgende Bedingung erfüllt ist:

(als AIN vorliegender N)/(N-Gehalt) > 0,5, und
die Dicke des Stahlblechs höchstens 0,19 mm beträgt.

2. Verfahren nach Anspruch 1, wobei das Stahlblech in Gewichtsprozent enthält:

C: 0,02 bis 0,04 %,
Si: höchstens 0,029 %,
Mn: 0,15 bis 0,25 %,
P: höchstens 0,010 %,
S: höchstens 0,020 %,
Al: 0,050 bis 0,080 % und
N: höchstens 40 ppm, wobei der Rest Eisen und unvermeidliche Verunreinigungen sind.

Revendications

1. Procédé de production d'une tôle d'acier pour une canette en deux parties ayant une excellente résistance au plissage de col et des propriétés pour éviter la formation de cornes, **caractérisée en ce que** :

ladite tôle d'acier contient, en pourcentage de poids,

C : 0,08% ou moins,

Si : 0,05% ou moins,

Mn : 0,04% - 0,4%,

P : 0,04% ou moins,

S : 0,04% ou moins,

Al : 0,02% - 0,10%, et

N : 40 ppm ou moins ; le reste étant du Fe et des impuretés inévitables ;

il est réalisé un laminage à chaud à une température de réchauffage d'ébauche dans une plage de 1150 - 1250°C et à une température de cintrage de laminage à chaud dans une plage de 690 - 750°C, un laminage à froid avec un rapport de réduction de laminage à froid dans une plage de 90 - 94%, un recuit à une température dans une plage de 650 - 670°C et un re-laminage à froid avec un rapport de réduction de re-laminage à froid dans une plage de 1 - 10%,

le diamètre moyen de l'AIN avec un diamètre d'au moins 0,005 µm est de 0,01 à 0,10 µm,

le rapport du nombre d'AIN avec un diamètre de 0,01 µm ou moins au nombre d'AIN avec un diamètre d'au moins 0,005 µm est de 10% ou moins,

le diamètre moyen du MnS avec un diamètre d'au moins 0,005 µm est de 0,03 à 0,40 µm,

le rapport du nombre de MnS avec un diamètre de 0,03 µm ou moins au nombre de MnS avec un diamètre d'au moins 0,005 µm est de 50% ou moins,

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l'équation suivante est satisfaite, $(N \text{ existant sous la forme d'AIN})/(\text{contenu en N}) > 0,5$, et l'épaisseur de ladite tôle d'acier est de 0,19 mm ou moins.

2. Procédé selon la revendication 1, dans laquelle

- 5 ladite tôle d'acier contient, en pourcentage de poids,
C : 0,02 - 0,04%,
Si : 0,029% ou moins,
Mn : 0,15 - 0,25%,
P : 0,010% ou moins,
10 S : 0,020% ou moins,
Al : 0,050 - 0,080%, et
N : 40 ppm ou moins ; le reste étant du Fe et des impuretés inévitables.

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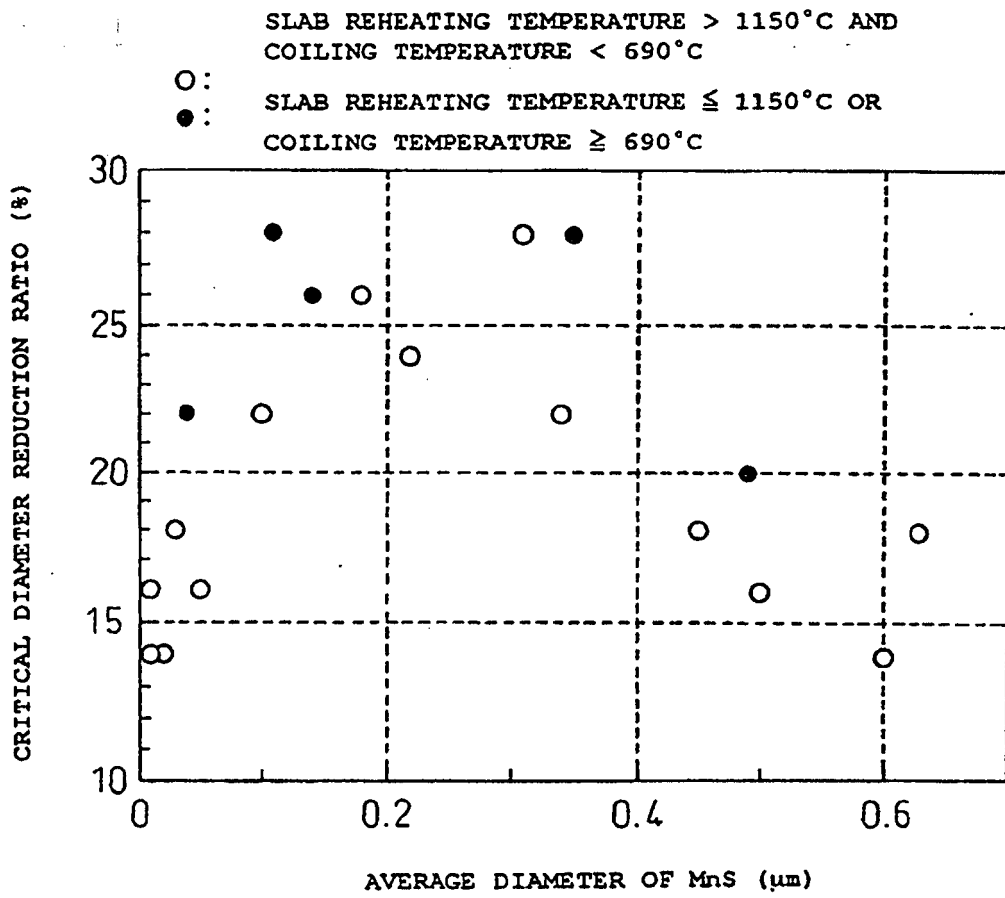
40

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Fig.1



REFERENCES CITED IN THE DESCRIPTION

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