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(54) METHOD FOR PRODUCING RAW PLATE FOR SURFACE TREATMENT PLATE FOR CAN USING CONTINUOUS ANNEALING

(57) The method for manufacturing a blackplatet for tinplate and tin-free steel by continuous annealing, comprises the steps of: heating and soaking an as cold rolled steel sheet of low carbon aluminum-killed steel containing not more than 0.1% by weight C and 0.001 to 0.015% by weight N, to temperatures of not less than recrystallization point; applying a first cooling to thus heated and soaked steel sheet to temperatures of from 350 to 480°C at average cooling speeds of from more than 100°C/sec to less than 300°C/sec; applying overaging to thus cooled steel sheet without giving reheating thereto; applying final cooling to thus overaged steel sheet to conduct temper rolling; wherein the temperatures for soaking at not less than recrystallization point are varied depending on aimed temper degree, thus keeping a heat cycle in stages succeeding to the first cooling nearly unchanged independent of the temper degree. With the method, it is possible to manufacture blackplates having different temper degrees separately and stably at a low cost covering all ranges of from soft materials to hard materials without degrading productivity and yield using a compact and inexpensive single CAL facility.

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Description

TECHNICAL FIELD

[0001] The present invention relates to a method for manufacturing a blackplate for tinplate and tin-free steel (TFS) by continuous annealing, and particularly to a method for manufacturing arbitrary grades of blackplates having T1 to T6 temper degrees through a single rolling step without significantly changing the heat cycle after the first cooling step in a continuous annealing process.

BACKGROUND ART

[0002] As defined by JIS G3303, blackplates, tinplates and TFSs for steel cans are grouped depending on their temper degree expressed by Rockwell hardness (HR30T). Among them, the blackplates, tinplates and TFSs which are prepared by a single rolling step are grouped in T1 to T6 temper degrees. Generally, T1 to T3 groups are called soft materials, and T4 to T6 groups are called hard materials. Conventionally the blackplates of soft materials are

[0003] prepared by batch annealing process, and those of hard materials are prepared by continuous annealing process (hereinafter referred to simply as "CAL"). In recent years, however, some of the blackplates of soft materials have also been prepared by CAL.

[0004] There are disclosed methods to prepare blackplates with different temper degrees by CAL. For example, JP-A-70227(1982), (the term "JP-A-" referred to herein signifies "Unexamined Japanese Patent Publication"), discloses a method to prepare blackplates having T4 and T5 temper degrees separately in CAL by adjusting the cooling speed in a range of from 3 to 1000°C/sec. and JP-B-45653(1993), (the term "JP-B-" referred herein signifies "Examined Japanese Patent Publication"), discloses a method to prepare blackplates having T4 and T5 temper degrees separately in CAL by controlling the average cooling speed between 500 and 400°C in the cooling step to either not more than 55°C/sec or not less than 65°C/sec, and further adjusting the reduction rate in the temper rolling. Furthermore, JP-A-92425(1985) discloses a method for manufacturing hard materials by hot rolling low carbon steels containing 0.02 to 0.10% by weight P at temperatures of less than Ar_3 transformation point, coiling the hot rolled steel sheets at a low temperature, cold rolling thus coiled steel sheets, and continuous annealing the cold rolled steel sheet with a cooling speed not less than 30°C/sec. JP-A-80346(1992) discloses a method for manufacturing soft materials by applying rapid cooling and overaging in CAL.

[0005] However, to manufacture blackplates having a wide range of temper degree covering from soft materials to hard materials separately by changing the heat cycle after the first cooling step in CAL, there require separate heat cycles: the one for soft materials, consisting of heating, soaking, rapid cooling, averaging, and cooling; and the other for hard materials, consisting of heating, soaking, slow cooling, and rapid cooling. Thus, there is a need to install two separate CALs each of which is exclusive for each of the heat cycle for manufacturing soft materials and for hard materials, or there is a need to install a large and complex CAL which is provided with a slow cooling unit (for example, cooling tubes) for hard materials, and a rapid cooling unit (for example, gas jet cooling unit or roll cooling unit), and a reheating and heat holding unit for averaging for soft materials. In either case, significant increase in investment and production cost is unavoidable.

[0006] When the latter case of large scale CAL is applied to produce blackplates having different temper degrees separately, the cooling condition after soaking significantly differs according to the temper degree. The difference in operating conditions likely induces transverse displacement, breaking, buckling, reduction of area, and other troubles on the sheets caused from thermal crown triggered from the temperature difference between the sheet and the furnace immediately after the change in cycle. As a result, a large amount of dummy coils are necessary, which induces degradation of productivity and yield.

[0007] On the other hand, there are presented methods to separately manufacture blackplates having a wide range of temper degree covering from soft materials to hard materials. For example, JP-A-197523(1990) discloses a method using very low C-Nb steels for preparing soft materials by CAL, followed by changing reduction rate of temper rolling, and JP-B-10801(1985) discloses a method of combination of with or without overaging in CAL and reduction rate in dry temper rolling using 300 mm or smaller size work rolls.

[0008] According to the method of JP-A-197523(1990), however, manufacture of hard materials of T4 to T6 groups requires temper rolling at high reduction rate of from 10 to 30%, which condition degrades formability of products, particularly degrades ductility, and needs a temper rolling unit for high reduction rate.

[0009] According to the technology of JP-B-10801(1985), it is necessary to have two kinds of cycles, with or without overaging treatment, to manufacture blackplates having different temper degrees separately. Accordingly, the consumption of above-described dummy coil increases and the productivity decreases. Furthermore, overaging for not less than one minute is required, which extends the overaging zone, and increases the investment. In addition, since the dry temper rolling with small size work rolls is conducted, if the manufacture of soft materials is performed at a low reduction rate of about 1 to 1.5%, the rolling load becomes excessively light, which results in difficulty to assure stable rolling.

DISCLOSURE OF THE INVENTION

[0010] The present invention has been derived to solve the above-described problems in prior art, and an object of the present invention is to provide a method for manufacturing a blackplate for tinplate and TFS by continuous annealing, which method uses a compact and inexpensive single CAL facility, and manufactures blackplates having different temper degrees separately and stably covering all ranges of from soft materials to hard materials without degrading productivity and yield.

[0011] The above-described object is attained by a method for manufacturing a blackplate for tinplate and TFS by continuous annealing, which method comprises the steps of: heating and soaking an as cold rolled steel sheet of low carbon aluminum-killed steel containing not more than 0.1% by weight C and 0.001 to 0.015% by weight N, at temperatures of not less than recrystallization point; applying a first cooling to thus heated and soaked steel sheet to temperatures of from 350 to 480°C at average cooling speeds of from more than 100°C/sec to less than 300°C/sec; applying overaging to thus cooled steel sheet without giving reheating thereto; applying final cooling to thus overaged steel sheet to conduct temper rolling; wherein the temperatures for soaking at not less than recrystallization point are varied depending on aimed temper degree, thus keeping a heat cycle in stages succeeding to the first cooling nearly unchanged independent of the temper degree.

BEST MODE FOR CARRYING OUT THE INVENTION

[0012] The detail of the method according to the present invention is described below.

[0013] Regarding carbon, if the carbon content exceeds 0.1% by weight, the steel sheet becomes excessively hard, which results in difficulty of controlling the shape thereof during cold rolling, and degrades the flatness and the accuracy of sheet thickness thereof. In addition, excess amount of carbon may induce poor travel of sheets in continuous annealing line. Consequently, the carbon content is limited to not more than 0.1% by weight.

[0014] The carbon content is changed depending on the target temper degree. That is, further stable manufacture of blackplates is available by adjusting the carbon content to not more than 0.05% by weight for preparing soft materials of T1 to T3 temper degrees, and adjusting the carbon content to a range of from 0.03 to 0.1% by weight for preparing hard materials of T4 to T6 temper degrees.

[0015] As for nitrogen, if the nitrogen content exceeds 0.015% by weight, the steel sheet becomes excessively hard as in the case of carbon, and the recrystallization temperature increases to increase the annealing temperature. To reduce the nitrogen content below 0.001% by weight, however, the steel making cost increases. Accordingly, the nitrogen content is limited to a range of from 0.001 to 0.015% by weight.

[0016] Contents of other elements such as Si, Mn, P. S, and sol.Al are not specifically limited, and they may be within a range found in low carbon aluminum-killed steels used for ordinary tinplates and TFSs. In addition, carbide/nitride-forming elements such as B and Nb may be added, at need.

[0017] In general, tinplates and TFSs for steel cans are manufactured by preparing a slab of low carbon aluminum-killed steel having compositions above-described, followed by hot rolling, pickling, cold rolling, and annealing. The method according to the present invention, however, there is no specific limitation on the manufacturing conditions before the annealing in CAL, and the manufacturing conditions may be those of common practice. That is, the hot rolling may be conducted at slab heating temperatures of from 1050 to 1250°C, finishing temperatures of from 830 to 900°C, and coiling temperatures of from 500 to 700°C, and the cold rolling may be conducted at reduction rates of from 80 to 95%. Alternatively, it is also applicable that the slab is hot rolled by a direct rolling method or a hot charge rolling method.

[0018] Regarding the manufacturing of blackplates having T1 to T3 temper degrees, if the coiling temperature is less than 600°C, the carbide and AlN grains become fine and their amount of precipitation also decreases, which likely makes the steel sheet harden. If the coiling temperature exceeds 700°C, then the pickling performance degrades. Consequently, the coiling temperature for manufacturing blackplates of T1 to T3 temper degrees is preferably specified to a range of from 600 to 700° C. For the manufacturing of blackplates having T4 to T6 temper degrees, if the coiling temperature is less than 520°C, the steel sheet becomes excessively hard, and if the coiling temperature exceeds 620°C, the steel sheet tends to soften. Therefore, the coiling temperature for manufacturing blackplates of T4 to T6 temper degrees is preferably specified to a range of from 520 to 620°C.

[0019] The as cold rolled steel sheets are annealed in CAL at a heat cycle of: heating, soaking, first cooling, overaging, and final cooling. The core parts of the method according to the present invention are to change the soaking temperature depending on the aimed temper degree, then to keep the heat cycle to nearly fixed independent of the temper degree, and to apply the first cooling to temperatures ranging from 350 to 480°C at average cooling speeds of from more than 100°C/sec to less than 300°C/sec, then applying overaging without reheating. Since the temper degree is changed by changing only the soaking temperature, and since no reheating is applied during the overaging step, it is possible to stably manufacture blackplates having different temper degrees covering from soft materials to hard materials without degrading productivity and yield using a compact and inexpensive single CAL facility. The overaging without reheating does not mean that positive heating is given to above the end point temperature of the first cooling step, but means that the treatment is given to a degree to keep the temperature of the steel sheet. In practice, a small scale heater is installed in the over aging zone of CAL to make the heater always working.

[0020] The reason to specify the average cooling speed in the first cooling step to a range of from more than 100°C/sec to less than 300°C/sec is the following. If the average cooling speed is less than 100°C/sec, the rapid cooling effect cannot be fully attained, and the supersaturation of solid solution carbon before the overaging treatment becomes insufficient, so that the manufacture of soft materials becomes difficult, also the dispersion of characteristics of hard materials increases owing to a slight fluctuation of cooling speed. And, if the average cooling speed is set to not less than 300°C/sec, there is a need of cooling facility with large cooling capacity, and the investment increases.

[0021] The reason to specify the end temperature of the first cooling step to a range of from 350 to 480°C is the following. In the heat cycle according to the present invention that does not use reheating in the overaging step, if the end temperature of the first cooling step is less than 350°C, the carbon diffusion becomes insufficient. If the end temperature of the first cooling step exceeds 480°C, the supersaturation becomes insufficient, and fully softening becomes difficult in the overaging treatment, which results in not capable of manufacturing blackplates covering all ranges from soft materials to hard materials, separately.

[0022] The method for cooling in the first cooling step according to the present invention may be gas jet cooling, air/water cooling, roll cooling, or the like, if only the method controls the cooling speed within the above-described range. Nevertheless, gas jet cooling is most preferable in terms of cooling capacity, stability of cooling, manufacturing cost, and quality of surface of steel sheet.

[0023] To manufacture blackplates having T1 to T3 temper degrees, the soaking temperature of CAL of less than 660°C cannot give sufficient softening. And the soaking temperature of over 780°C needs a heater for high temperature heating, which increases investment and manufacturing cost. Therefore, the soaking temperature of CAL is preferably specified to a range of from 660 to 780°C. To manufacture blackplates having T4 to T6 temper degrees, the soaking temperature of less than 600°C leaves unrecrystallized structure, which induces degradation of formability and dispersion of characteristics. If the soaking temperature exceeds 730°C, the steel sheet becomes soft to fail in obtaining specified temper degree. Consequently, the soaking temperature of CAL is preferably specified to a range of from 600 to 730°C.

[0024] As for the soaking time, less than 5 seconds of soaking time is short for grain growth, and is likely to induce mixed grain sizes, and to increase dispersion of characteristics. Therefore, it is preferable to assure 5 seconds or longer soaking time. However, unnecessarily long time of soaking only results in saturation of stability of characteristics, and in increased size of furnace to raise investment and production cost . Accordingly, the soaking time is preferably specified to not more than around 20 seconds.

[0025] If the overaging time becomes not less than 60 seconds, a very long overaging zone is necessary, which induces increase in investment and production cost. Consequently, the overaging time is preferably less than 60 seconds.

[0026] If the initiation temperature of the final cooling after overaging is less than 300°C, the diffusion of carbon becomes insufficient. If the initiation temperature of the final cooling after overaging exceeds 400°C, the supersaturation of carbon becomes insufficient, and it becomes difficult to fully soften the steel sheet by overaging. Therefore, the initiation temperature of the final cooling is preferably in a range of from 300 to 400°C. With the similar reason, the difference between the inlet and the outlet of the overaging treatment, or the difference between the end temperature of the first cooling and the initiation temperature of the final cooling is preferably not more than 100°C.

[0027] If the reduction rate in the temper rolling after the final cooling is less than 1.0%, it is difficult to attain aimed surface roughness, flatness, and anti-aging performance. If the reduction rate becomes not less than 3.0%, the formability degrades and there occurs necessity of reducing the roll size and changing the lubrication conditions to secure good sheet thickness and flatness. Therefore, the reduction rate in temper rolling after final cooling is preferably in a range of from not less than 1.0% to less than 3.0%.

[0028] The blackplates for tinplate and TFS, which are manufactured by the method according to the present invention, are subjected to coating treatment in Electrical Tin plating Line (ETL) or TFS line, thus producing tinplates and TFSs for steel cans. The method according to the present invention is, however, also applicable to manufacture blackplates for Ni coating steel sheets or other metal coating steel sheets for steel cans.

[0029] According to JIS G3303, the blackplates of T3 and T4 temper degrees overlap the hardness to each other in a range of $58 \leq HR30T \leq 60$. However, the method according to the present invention gives differentiation between T1 to T3 temper degrees and T4 to T6 temper degrees as $HR30T < 59$ and $HR30T \geq 59$, respectively.

EMBODIMENTS

[0030] Low carbon aluminum-killed steels A to J having compositions given in Table 1 were prepared separately by melting in a converter, followed by continuously casting. The slabs thus obtained were hot rolled and pickled, and were cold rolled to a sheet thickness of 0.20 mm. During the hot rolling, the slab heating temperature was set to a range of from 1150 to 1230°C, the finish temperature was set to a range of from 860 to 900°C, and the coiling temperature was changed as shown in Tables 2 and 3. After cold rolled, the steel sheets were annealed by CAL under the conditions given in Tables 2 and 3, followed by temper rolling to obtain steel sheets Nos. 1 through 22. As of these steel sheets, No. 5 which was treated by secondary rolling after annealed, and No. 17 which was soaked at a low temperature in CAL are the Comparative Examples. All the other steel sheets are Examples according to the present invention.

[0031] Thus prepared steel sheets were observed in terms of structure, and were tested to determine hardness of HR30T, also they underwent the tensile test to determine the total elongation EL.

[0032] The results are shown in Tables 2 and 3.

[0033] In Examples, with the steels A through G which contained not more than 0.05% by weight C, soft materials having T3 or less temper degree are manufactured; with the steels F through J which contained between 0.03 and 0.1% by weight C, hard materials having T4 or higher temper degree are manufactured. For both cases, EL value is high and the formability is excellent.

[0034] On the other hand. No. 5, a Comparative Example, which was subjected to secondary rolling, or No. 17, also a Comparative Example, which was treated at a low soaking temperature and which left unrecrystallized structure give significantly low EL values and give poor formability.

Table 1

									(wt %)
Steel	C	Si	Mn	P	S	sol.Al	N	Nb	B
A	0.0024	0.01	0.15	0.01	0.009	0.055	0.0024	-	-
B	0.0021	0.01	0.25	0.01	0.008	0.050	0.0022	0.021	-
C	0.0018	0.01	0.35	0.01	0.010	0.060	0.0020	-	0.0011
D	0.02	0.01	0.15	0.01	0.011	0.070	0.0018	-	-
E	0.02	0.01	0.25	0.01	0.012	0.052	0.0026	-	-
F	0.04	0.01	0.15	0.01	0.010	0.062	0.0028	-	-
G	0.04	0.01	0.50	0.01	0.012	0.043	0.0098	-	-
H	0.05	0.01	0.25	0.01	0.015	0.046	0.0125	-	-
I	0.07	0.01	0.55	0.01	0.015	0.051	0.0057	-	-
J	0.09	0.01	0.30	0.01	0.015	0.048	0.0035	-	-

Table 2

No.	Steel *1	Coiling temperature (℃)	Conditions of continuous annealing: Soaking temperature (℃)	Soaking time (s)	Average first cooling speed (℃/s)	End temperature of first cooling (℃)	Overaging time (s)	Initiation temperature of final cooling (℃)	Reduction rate in temper rolling (%) *5	Structure *2	Hardness HR30T	Temper degree	EL *3	Classification *4
1	A	640	700	10	200	400	15	350	1.2	○	49	T1	○	Example
2	A	600	660	10	200	400	15	350	2.5	○	52	T2	○	Example
3	B	680	770	10	200	430	10	400	1.5	○	50	T1	○	Example
4	B	620	750	10	200	430	10	400	2.8	○	54	T2.5	○	Example
5	B	620	750	10	200	430	10	400	20	○	63	T4 to T5	×	Comparative Example
6	C	680	700	15	200	430	15	380	1.5	○	49	T1	○	Example
7	C	600	670	15	200	430	15	380	2.5	○	55	T2.5	○	Example
8	D	700	730	20	250	410	20	390	1.2	○	50	T1	○	Example
9	D	640	700	20	250	410	20	390	1.5	○	53	T2	○	Example
10	E	680	720	15	200	400	20	400	1.5	○	51	T1	○	Example
11	E	620	680	15	200	400	15	400	1.5	○	54	T2	○	Example

*1 Corresponding to steel given in Table 1.
*2 ○ : Recrystallized structure × : Unrecrystallized structure is left
*3 ○ : EL≧ 20% × : EL < 20%
*4 Example : Example according to the present invention
Comparative Example : Example not according to the present invention
*5 No. 5 gives a reduction rate of secondary rolling.

Table 3

No.	Steel *1	Coiling temperature (℃)	Conditions of continuous annealing: Soaking temperature (℃)	Soaking time (s)	Average first cooling speed (℃/s)	End temperature of first cooling (℃)	Overaging time (s)	Initiation temperature of final cooling (℃)	Reduction rate in temper rolling (%) *5	Structure *2	Hardness HR30T	Temper degree	EL *3	Classification *4
12	E	620	660	15	200	400	10	400	2.0	○	56	T2.5	○	Example
13	F	700	700	15	200	420	40	370	1.2	○	53	T2	○	Example
14	F	660	680	15	200	420	30	380	1.5	○	55	T2.5	○	Example
15	F	620	660	10	200	420	20	390	1.8	○	57	T3	○	Example
16	F	560	630	10	200	420	10	400	2.0	○	60	T4	○	Example
17	F	620	580	10	200	420	10	400	2.0	×	68	T6	×	Comparative Example
18	G	620	680	30	200	430	10	380	1.5	○	59	T4	○	Example
19	G	560	630	10	200	430	10	380	1.5	○	63	T4 to T5	○	Example
20	H	540	630	10	200	430	10	400	1.5	○	66	T5	○	Example
21	I	540	630	10	200	430	10	400	1.5	○	65	T5	○	Example
22	J	540	630	10	250	430	10	400	1.5	○	69	T6	○	Example

*1 Corresponding to steel symbol given in Table 1.
*2 ○ : Recrystallized structure × : Unrecrystallized structure is left
*3 ○ : EL≧ 20% × : EL < 20%
*4 Example : Example according to the present invention
Comparative Example : Example not according to the present invention

Claims

1. A method for manufacturing a blackplate for tinplate and tin-free steel by continuous annealing, comprising the steps of: heating and soaking an as cold rolled steel sheet of low carbon aluminum-killed steel containing not more than 0.1% by weight C and 0.001 to 0.015% by weight N, to temperatures of not less than recrystallization point; applying a first cooling to thus heated and soaked steel sheet to temperatures of from 350 to 480°C at average cooling speeds of from more than 100°C /sec to less than 300°C /sec; applying overaging to thus cooled steel sheet without steel sheet to conduct temper rolling; wherein the temperatures for soaking at not less than recrystallization point are varied depending on aimed temper degree, thus keeping a heat cycle in stages succeeding to the first cooling nearly unchanged independent of the temper degree.

2. The method according to Claim 1, wherein the content of C is not more than 0.05% by weight in the case of manufacturing blackplates having T1 to T3 temper degrees, and is between 0.03 and 0.1% by weight in the case of manufacturing blackplates having T4 to T6 temper degrees.

3. The method according to Claim 1, wherein the as cold rolled steel sheet is a steel sheet which is prepared by cold rolling a hot rolled steel sheet which was coiled at temperatures of from 600 to 700°C after the hot rolling in the case of manufacturing blackplates having T1 to T3 temper degrees, and is a steel sheet which is prepared by cold rolling a hot rolled steel sheet which was coiled at temperatures of from 520 to 620°C after the hot rolling in the case of manufacturing blackplates having T4 to T6 temper degrees.

4. The method according to Claim 2, wherein the as cold rolled steel sheet is a steel sheet which is prepared by cold rolling a hot rolled steel sheet which was coiled at temperatures of from 600 to 700°C after the hot rolling in the case of manufacturing blackplates having T1 to T3 temper degrees, and is a steel sheet which is prepared by cold rolling a hot rolled steel sheet which was coiled at temperatures of from 520 to 620°C after the hot rolling in the case of manufacturing blackplates having T4 to T6 temper degrees.

5. The method according to Claim 1, wherein the temperature for soaking at not less than recrystallization point is between 660 and 780°C in the case of manufacturing blackplates having T1 to T3 temper degrees, and is between 600 and 730°C in the case of manufacturing blackplates having T4 to T6 temper degrees.

6. The method according to Claim 2, wherein the temperature for soaking at not less than recrystallization point is between 660 and 780°C in the case of manufacturing blackplates having T1 to T3 temper degrees, and is between 600 and 730°C in the case of manufacturing blackplates having T4 to T6 temper degrees.

7. The method according to Claim 3, wherein the temperature for soaking at not less than recrystallization point is between 660 and 780°C in the case of manufacturing blackplates having T1 to T3 temper degrees, and is between 600 and 730°C in the case of manufacturing blackplates having T4 to T6 temper degrees.

8. The method according to Claim 4, wherein the temperature for soaking at not less than recrystallization point is between 660 and 780°C in the case of manufacturing blackplates having T1 to T3 temper degrees, and is between 600 and 730°C in the case of manufacturing blackplates having T4 to T6 temper degrees.

9. The method according to Claim 1, wherein the time for soaking at not less than recrystallization point is not less than 5.

10. The method according to Claim 5, wherein the time for soaking at not less than recrystallization point is not less than 5.

11. The method according to Claim 6, wherein the time for soaking at not less than recrystallization point is not less than 5.

12. The method according to Claim 7, wherein the time for soaking at not less than recrystallization point is not less than 5.

13. The method according to Claim 8, wherein the time for soaking at not less than recrystallization point is not less than 5.

14. The method according to Claim 1, wherein the time for overaging is less than 60 seconds.

15. The method according to Claim 5, wherein the time for overaging is less than 60 seconds.

16. The method according to Claim 6, wherein the time for overaging is less than 60 seconds.

17. The method according to Claim 7, wherein the time for overaging is less than 60 seconds.

18. The method according to Claim 8, wherein the time for overaging is less than 60 seconds.

19. The method according to Claim 1, wherein the temperature for initiating the final cooling after overaging is between 300 and 400°C.

20. The method according to Claim 5, wherein the temperature for initiating the final cooling after overaging is between 300 and 400°C.

21. The method according to Claim 6, wherein the temperature for initiating the final cooling after overaging is between 300 and 400°C.

22. The method according to Claim 7, wherein the temperature for initiating the final cooling after overaging is between 300 and 400°C.

23. The method according to Claim 8, wherein the temperature for initiating the final cooling after overaging is between 300 and 400°C.

24. The method according to Claim 1, wherein the reduction rate in the temper rolling is in a range of from not less than 1.0% to less than 3.0%.

25. The method according to Claim 5, wherein the reduction rate in the temper rolling is in a range of from not less than 1.0% to less than 3.0%.

26. The method according to Claim 6, wherein the reduction rate in the temper rolling is in a range of from not less than 1.0% to less than 3.0%.

27. The method according to Claim 7, wherein the reduction rate in the temper rolling is in a range of from not less than 1.0% to less than 3.0%.

28. The method according to Claim 8, wherein the reduction rate in the temper rolling is in a range of from not less than 1.0% to less than 3.0%.

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] C21D9/46, C22C38/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[6] C21D9/46, 9/48, C22C38/00-38/60

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-1999
Kokai Jitsuyo Shinan Koho	1971-1999	Jitsuyo Shinan Toroku Koho	1996-1999

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 63-1374, B (Nippon Steel Corp.), 12 January, 1988 (12. 01. 88) (Family: none)	1-28
X	JP, 63-10213, B (Nippon Steel Corp.), 4 March, 1988 (04. 03. 88) & EP, 171197, A1 & US, 4698102, A & CA, 1240593, A	1-28
A	JP, 61-14216, B (Kawasaki Steel Corp.), 17 April, 1986 (17. 04. 86) (Family: none)	1-28
A	JP, 61-16323, B (Kawasaki Steel Corp.), 30 April, 1986 (30. 04. 86) & EP, 73092, A1 & US, 4561909, A & NO, 8202343, A	1-28

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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