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(54) METHOD FOR ROLLING SUPER AUSTENITIC STAINLESS STEEL

(57) The present invention discloses a method for rolling super austenitic stainless steel, and belongs to the technical field of steel rolling. Through technical optimization of billet selection, a steel burning process, a descaling process, a steel rolling process and a straightening process in the method, rolling of super austenitic stainless steel with the specifications of a thickness of below 10 mm and a width of above 2500 mm is achieved, and a steel plate with an N08367 grade of steel with the specifications of a thickness of 8.5 mm and widths of 2510 mm and 2610 mm is rolled successfully. This specification is the widest specification in the world under this thickness, filling a gap in a width range of 2510 to 2610 mm for the N08367 grade of steel at the thickness of 8.5 mm, moreover, a rolled plate shape is stable, and a rolling success rate reaches 95.4%. In addition, N08904 stainless steel with a thickness of 10.0 mm and a width range of 2620 to 2980 mm is further rolled successfully.

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Description

TECHNICAL FIELD

[0001] The present invention belongs to the technical field of steel rolling, and in particular, relates to a method for rolling super austenitic stainless steel.

BACKGROUND

[0002] NAS 254NM (equivalent to UNS N08367) is high corrosion resistant stainless steel containing high chromium and high molybdenum. The specifications of this grade of steel still maintain good corrosion resistance even in the harsh environments of high temperature, seawater or flue gas and desulfurization equipment. It can be on a par with Hastelloy alloys and titanium plates under some environments, and it is highly economical stainless steel with high corrosion resistance.

[0003] N08367 contains 21% of Cr and 6% of Mo, so the deformation resistance thereof in a high temperature range is 2.5 to 3 times larger than that of ordinary grades of steel. When thin specification rolling is conducted to a low temperature section, a rolling pressure is too large, and as the width increases, the load is further increased. According to the existing rolling processes, extremely thin specification rolling cannot be conducted, rolling interrupting or a poor plate shape occurs, and quality goods cannot be obtained.

SUMMARY

[0004] Purpose of the invention: in order to overcome the problems of failing to roll due to too large load, extremely poor plate shape and failing to obtain quality goods when thin specification super austenitic stainless steel is rolled in the art, the present invention provides a method for rolling super austenitic stainless steel. This method can roll super austenitic stainless steel with the specifications of a thickness of below 10 mm and a width of above 2500 mm.

[0005] Technical solution: the method for rolling the super austenitic stainless steel of the present invention, including the following steps:

(1) billet selection: in a case of ensuring that rolling thickness requirements are met, adopting a minimum billet design principle, and selecting a minimum thickness billet loadable into a heating furnace;
(2) a steel burning process: conducting steel burning on the billet at 1250°C to 1270°C, and controlling a temperature difference between upper and lower surfaces to be 25°C to 35°C;
(3) a descaling process: not conducting descaling operation on the billet during rough descaling and fine descaling, and maintaining the temperature difference between the upper and lower surfaces;
(4) a steel rolling process: controlling a final rolling temperature to be above 850°C; adopting 12 passes of rolling, wherein a reduction in the last two passes of rolling is less than 0.8 mm; during rolling, according to deformation resistance at different temperatures, optimizing a thermal expansion coefficient under different thicknesses, and adjusting the thermal expansion coefficient of this stainless steel under different passes separately; and
(5) a straightening process: in a multi-pass straightening mode by a pre-straightening machine, increasing a straightening pressure by 1000 to 1500 tons to ensure straightness of a final plate shape.

[0006] In the Step (1), during billet selection, the minimum thickness billet loadable into the heating furnace is determined according to a minimum billet thickness that can be measured by a laser detector in the heating furnace.

[0007] Further, cogging treatment is adopted for an original billet greater than a design thickness to make the original billet reach the design thickness for billet selection.

[0008] In the Step (2), during steel burning, positions of upper and lower beams are adjusted to ensure a middle position in the steel burning process. A temperature uniformity of the steel plate is improved.

[0009] In the Step (3), in the descaling process, it is ensured that a temperature of the upper surface is higher than that of the lower surface. The steel plate is prevented from head warping.

[0010] In the Step (4), a roll gap parameter for a rolling mill is set to be not less than 3.5 mm. It is avoided that when the roll gap parameter for the rolling mill is set to be less than 3.5 mm, a CVC rolling mill cannot move due to rolling force, resulting in that it cannot move in place, making rolling difficult.

[0011] In the Step (4), when a temperature is below 873°C, the thermal expansion coefficient of the stainless steel is set to be 1.0133×10^{-2}, and when the temperature is higher than 873°C and below 880°C, the thermal expansion coefficient of the stainless steel is set to be 1.0285×10^{-2}.

[0012] In the Step (5), a roll gap is pressed down manually by 1 to 1.5 mm according to plate shape conditions.

[0013] Beneficial effects: through technical optimization of the billet selection, the steel burning process, the descaling

process, the steel rolling process and the straightening process in the method, rolling of super austenitic stainless steel with the specifications of a thickness of below 10 mm and a width of above 2500 mm may be achieved, and a steel plate with an N08367 grade of steel with the specifications of a thickness of 8.5 mm and widths of 2510 mm and 2610 mm is rolled successfully. This specification is the widest specification in the world under this thickness, filling a gap in a width range of 2510 to 2610 mm for the N08367 grade of steel at the thickness of 8.5 mm, moreover, a rolled plate shape is stable, and a rolling success rate reaches 95.4%. In addition, N08904 stainless steel with a thickness of 10.0 mm and a width range of 2620 to 2980 mm is further rolled successfully.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0014] A method for rolling super austenitic stainless steel, including the following steps.

(1) Billet selection:

Deformation resistance of the super austenitic stainless steel at a high temperature is 2.5 to 3 times that of ordinary products. Ultra-wide and thin specifications are developed in selection of billet types. In order to ensure a rolling success rate, the minimum number of passes is adopted. It is necessary to ensure that in a case of meeting rolling thickness requirements, a minimum billet design principle is adopted, namely a minimum thickness billet loadable into a heating furnace.

Specifically, the minimum thickness billet loadable into the heating furnace is determined according to a minimum billet thickness that can be measured by a laser detector in the heating furnace. For example, a minimum measurable thickness is 115 mm. When a steel plate with the specifications of a thickness of 8.5 mm and a width of 2610 mm is rolled, a billet with a thickness of 115 mm, a width of 1780 mm and a length of 2610 mm is adopted. For an original billet with a thickness of 142 mm, cogging treatment is first conducted to a thickness of 115 mm, so as to reduce a total number of rolling passes in subsequent processes.

(2) A steel burning process:

By utilizing the characteristic of easy oxidization at a high temperature of the super austenitic stainless steel, steel burning is conducted on the billet at 1250°C to 1270°C. Meanwhile, a temperature difference between upper and lower surfaces of the billet is strictly controlled to be 25°C to 35°C, ensuring that head warping will not happen to the steel plate in a rolling process. Moreover, positions of upper and lower beams are adjusted to ensure a middle position in the steel burning process, improving a temperature uniformity of the steel plate.

(3) A descaling process:

By utilizing the characteristic of non-easy oxidization at the high temperature of the super austenitic stainless steel, a process mode that descaling must be conducted in a normal production process of a steel billet is broken, descaling operation is not conducted on the billet during rough descaling and rolling mill fine descaling, and the temperature difference between the upper and lower surfaces is maintained, preventing head warping of the steel plate caused by descaling.

(4) A steel rolling process:

A final rolling temperature is required to be above 850°C, avoiding a sharp increase in deformation resistance below 850°C.

[0015] According to the maximum distribution of rolling torque and rolling force, 12 passes of rolling are adopted, breaking the limitation that 9 passes of rolling must be adopted for the thin specification in traditional processes.

[0016] Moreover, a reduction in the last two passes of rolling is less than 0.8 mm, avoiding that due to too large reduction, a roll gap for a rolling mill exceeds an equipment limit during actual rolling, resulting in difficult rolling. Meanwhile, it is ensured that a roll gap parameter for the rolling mill is set to be not less than 3.5 mm, avoiding that when the roll gap parameter for the rolling mill is set to be too small, a CVC rolling mill cannot move due to rolling force, resulting in that it cannot move in place.

[0017] A second-level model system optimizes a coefficient under different thicknesses according to the deformation resistance at different temperatures, and meanwhile, adjusts a certain specific pass separately. That is, in order to ensure the measurement accuracy of a thickness gauge, the thermal expansion coefficient of this stainless steel under different passes is adjusted separately according to the deformation resistance at different temperatures. Specifically, the coefficient is adjusted from 1.0132×10^{-2} to 1.0133×10^{-2} at 873°C, and the coefficient is adjusted from 1.0284×10^{-2} to 1.0285×10^{-2} at 880°C, ensuring the accuracy of thickness self-learning correction by a second-level model.

[0018] (5) A straightening process: in a multi-pass straightening mode by a pre-straightening machine, a straightening pressure is increased by 1000 to 1500 tons according to plate shape conditions. If straightening force is too small, it will have no effect. If the straightening force is too large, it will exceed the equipment limit. During operation, pressing down

0.1 mm will increase about 100 tons of pressure, which corresponds to manually pressing down a roll gap by 1 to 1.5 mm

[0019] By adopting the above method, the rolling of an N08367 grade of steel successfully break the width to 2610 mm. Specific implementation of a rolling schedule is shown in Table 1:

Table 1 Rolling schedule table of N08367 with a thickness of 8.5 mm

Rotating steel	Outlet thickness mm	Width mm	Length mm	Roll gap mm	Reduction mm	Reduction rate %	Rolling force kN	Torque Kn/m	Biting speed m/s	Rolling speed m/s
Y	97.73	2656.39	1.91	91.29	17.87	15.46	76277	8691	1.50	1.50
N	80.70	2659.42	2.31	74.26	17.03	17.43	76263	8472	1.75	1.75
N	64.66	2662.27	2.88	58.17	16.04	19.88	76599	8253	1.75	1.75
N	49.82	2664.87	3.73	43.23	14.84	22.95	77495	8032	2.00	2.53
N	36.03	2667.19	5.16	28.35	13.79	27.68	86646	8680	2.25	2.80
N	26.81	2668.06	6.93	19.94	9.22	25.59	79879	6599	2.00	3.03
N	20.03	2667.59	9.27	13.53	6.78	25.28	76749	5488	2.00	3.48
N	15.17	2665.64	12.23	9.15	4.86	24.25	72741	4459	1.50	3.73
N	12.13	2662.62	15.30	6.72	3.44	20.03	67609	3362	2.50	4.33
N	10.27	2659.63	18.08	5.37	1.87	15.40	63273	2562	2.50	4.63
N	9.09	2657.77	20.42	4.86	0.78	11.47	57656	1939	2.25	4.82
N	8.64	2656.78	21.48	7.50	0.45	4.95	32571	722	2.25	4.98
N	8.64	2655.80	21.48	33.64	0.00	0.00	0	0	5.2	5.20

[0020] Rolling specifications and success rates are shown in Table 2:

Table 2 Rolling pass rates of N08367 with a thickness of 8.5 mm

Rolling specifications (thickness*width) mm*mm	Total number of rolled blocks	Number of successfully rolled blocks	Pass rate
8.5*2510	17	17	100%
8.5*2610	70	66	94.3%
Sum	87	83	95.4%

[0021] Performance index requirements of the grade of steel and specifications are shown in Table 3:

Table 3 Performance index requirements of N08367 with a thickness of 8.5 mm

0.2% yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)	Hardness (HRB)
≥310	≥690	≥30	≤241

[0022] Actual performance indexes of the grade of steel and specifications are shown in Table 4:

Table 4 Actual performance indexes of N08367 with a thickness of 8.5 mm

Performance index	0.2% yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)	Hardness (HRB)
Hot rolled plate 8.5 mm	439	762	45	211

[0023] It can be seen that by adopting the rolling method of the present invention, the steel that meets the performance index requirements of the N08367 with the thickness of 8.5 mm can be rolled, and a higher success rate is achieved.

[0024] Moreover, by adopting the above method, the limit specifications of 10*2620 mm, 10*2820 mm, 10*2980 mm, etc., of the same series of grade of steel N08904 are successfully developed. Rolling specifications and success rates thereof are shown in Table 5:

Table 5 Rolling pass rates of N08904 with a thickness of 10.0 mm

Rolling specifications (thickness*width) mm*mm	Total number of rolled blocks	Number of successfully rolled blocks	Pass rate
10.0*2620	8	8	100%
10.0*2820	10	10	100%
10.0*2980	2	2	100%
Sum	20	20	100%

[0025] Performance index requirements of the grade of steel and specifications are shown in Table 6:

Table 6 Performance index requirements of N08904 with a thickness of 10.0 mm

0.2% yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)	Hardness (HRB)
≥220	≥490	≥35	≤90

[0026] Actual performance indexes of the grade of steel and specifications are shown in Table 7:

Table 7 Actual performance indexes of N08904 with a thickness of 10.0 mm

Performance index	0.2% yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)	Hardness (HRB)
10.0 mm	245	598	48	80

[0027] It can be seen that by adopting the rolling method of the present invention, the steel that meets the performance index requirements of the N08904 with the thickness of 10.0 mm can be rolled, and a higher success rate is also achieved.

Claims

1. A method for rolling super austenitic stainless steel, comprising the following steps:

   (1) billet selection: in a case of ensuring that rolling thickness requirements are met, adopting a minimum billet design principle, and selecting a minimum thickness billet loadable into a heating furnace;
   (2) a steel burning process: conducting steel burning on the billet at 1250°C to 1270°C, and controlling a temperature difference between upper and lower surfaces to be 25°C to 35°C;
   (3) a descaling process: not conducting descaling operation on the billet during rough descaling and fine descaling, and maintaining the temperature difference between the upper and lower surfaces;
   (4) a steel rolling process: controlling a final rolling temperature to be above 850°C; adopting 12 passes of rolling, wherein a reduction in the last two passes of rolling is less than 0.8 mm; during rolling, according to deformation resistance at different temperatures, optimizing a thermal expansion coefficient under different thicknesses, and adjusting the thermal expansion coefficient of this stainless steel under different passes separately; and
   (5) a straightening process: in a multi-pass straightening mode by a pre-straightening machine, increasing a straightening pressure by 1000 to 1500 tons to ensure straightness of a final plate shape.

2. The method for rolling the super austenitic stainless steel according to claim 1, wherein in the Step (1), during billet selection, the minimum thickness billet loadable into the heating furnace is determined according to a minimum billet thickness that can be measured by a laser detector in the heating furnace.

3. The method for rolling the super austenitic stainless steel according to claim 2, wherein cogging treatment is adopted for an original billet greater than a design thickness to make the original billet reach the design thickness for billet selection.

4. The method for rolling the super austenitic stainless steel according to claim 1, wherein in the Step (2), during steel burning, positions of upper and lower beams are adjusted to ensure a middle position in the steel burning process.

5. The method for rolling the super austenitic stainless steel according to claim 1, wherein in the Step (3), in the descaling process, it is ensured that a temperature of the upper surface is higher than that of the lower surface.

6. The method for rolling the super austenitic stainless steel according to claim 1, wherein in the Step (4), a roll gap parameter for a rolling mill is set to be not less than 3.5 mm

7. The method for rolling the super austenitic stainless steel according to claim 1, wherein in the Step (4), when a temperature is below 873°C, the thermal expansion coefficient of the stainless steel is set to be 1.0133×10^{-2}, and when the temperature is higher than 873°C and below 880°C, the thermal expansion coefficient of the stainless steel is set to be 1.0285×10^{-2}.

8. The method for rolling the super austenitic stainless steel according to claim 1, wherein in the Step (5), a roll gap is pressed down manually by 1 to 1.5 mm according to plate shape conditions.

9. The method for rolling the super austenitic stainless steel according to any of claims 1 to 8, wherein model specifications of the rolled stainless steel are N08367 with a thickness of 8.5 mm and a width of 2510 to 2610 mm or N08904 with a thickness of 10 mm and a width of 2620 to 2980 mm.

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER

B21B 1/38(2006.01)i; B21B 45/00(2006.01)i

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)

B21B

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

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

WPI, EPODOC, CNPAT, CNKI: 南京钢铁, 超级奥氏体不锈钢, 烧钢, 加热, 除鳞, 除磷, 轧, 翘头, 厚度, 温度差, 热膨胀系数, 矫直, austenitic, steel, heat+, descal+, roll+, curl+, warp+, thickness, temperature, difference, coefficient, expansion, straighten+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 110773565 A (NANJING IRON & STEEL CO., LTD.) 11 February 2020 (2020-02-11) claims 1-9	1-9
A	CN 107419194 A (ZHENSHI GROUP EASTERN SPECIAL STEEL CO., LTD.) 01 December 2017 (2017-12-01) description, paragraphs 17-18	1-9
A	CN 108787751 A (NANJING IRON & STEEL CO., LTD.) 13 November 2018 (2018-11-13) entire document	1-9
A	CN 107716584 A (ZHANGJIAGANG POHANG STAINLESS STEEL CO., LTD.) 23 February 2018 (2018-02-23) entire document	1-9
A	CN 107641698 A (BAOSTEEL SPECIAL STEEL CO., LTD.) 30 January 2018 (2018-01-30) entire document	1-9
A	CN 110066957 A (SPIC SCIENCE AND TECHNOLOGY RESEARCH INSTITUTE CO., LTD.) 30 July 2019 (2019-07-30) entire document	1-9

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

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Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088** **China**	Authorized officer
Facsimile No. **(86-10)62019451**	Telephone No.

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International application No.
PCT/CN2020/096958

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 108838216 A (SHOUGANG JINGTANG UNITED IRON & STEEL CO., LTD.) 20 November 2018 (2018-11-20) entire document	1-9
A	JP 2003041352 A (SUMITOMO METAL IND.) 13 February 2003 (2003-02-13) entire document	1-9

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2020/096958

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 110773565 A	11 February 2020	None	
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CN 107716584 A	23 February 2018	None	
CN 107641698 A	30 January 2018	CN 107641698 B	17 September 2019
CN 110066957 A	30 July 2019	None	
CN 108838216 A	20 November 2018	None	
JP 2003041352 A	13 February 2003	None	

Form PCT/ISA/210 (patent family annex) (January 2015)