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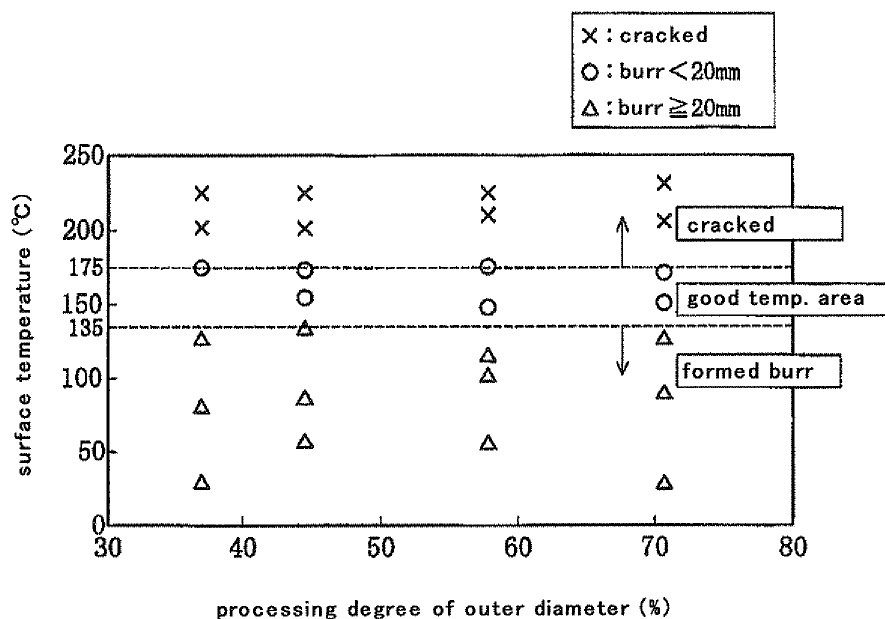
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(54) **METHOD FOR PRODUCTION OF MARTENSITIC STAINLESS STEEL PIPE**

(57) A method for producing martensitic stainless steel pipe containing by mass: 0.15 to 0.22% of C; 0.10 to 1.00% of Si; 0.10 to 1.00% of Mn; 12.00 to 14.00% of Cr; 0.01 to 0.05% of N; 0.020% or less of P; 0.010% or less of S; and the balance being Fe and impurities. The manufactured martensitic stainless steel pipe is cooled

down to a range from 135 to 175°C on the pipe outer surface by air, and the edges of the pipe are then cut. This production method keeps the cracking susceptibility of the pipe at a low level, and cutting the pipe in the specified temperature range prevents forming cracks and burrs on the cutting surface.

FIG.1



Description

TECHNICAL FIELD

[0001] The present invention relates to a method for producing martensitic stainless steel pipe.

BACKGROUND WART

[0002] Martensitic stainless steel pipe containing for example 13 percent chromium is highly susceptible to cracking and so cracks tend to occur when the pipe edges are cut off. A conventional solution was to cool the outer surface (hereafter simply called the "surface") of the pipe prior to cutting, down to 130°C or lower, and preferably 50°C or lower.

[0003] Patent document 1 discloses a process for preventing cracks on the edges of the martensitic stainless steel pipe by a process that air cools hot-worked martensitic stainless steel pipe down to a temperature equal to or below the temperature at which martensite transformation is complete, and then forced cools the pipe by water cooling, and cuts the pipe.

[0004] [Patent document 1] JP H04-2409 A.

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0005] Cooling the pipe surface down to 30°C or below lowers the hot workability of the pipe and increases its resistance to deformation during cutting. Cutting, therefore, generates high processing heat between the cutting surface of the pipe and the saw, and it generates burrs after cutting. The cut pipes are usually carried with several pipes in order to increase production efficiency. However, burrs on the pipe edges might form flaws on the outer surface of the pipe due to mutual contact.

[0006] The invention disclosed in patent document 1 requires installing additional equipment for the forced cooling, which raises the production cost.

[0007] Though the above examples of the background art were intended to prevent forming cracks on the martensitic stainless steel pipe during cutting, these examples did not disclose technology for preventing burrs.

[0008] The present invention therefore has the object of providing a method for producing a martensitic stainless steel pipe that prevents cracks and burrs during cutting of the pipe.

Means to Solve the Problems

[0009] To accomplish the above and other objects, the method for producing a martensitic stainless steel pipe of the present invention comprises the steps of producing martensitic stainless steel pipe containing, by mass,; 0.15 to 0.22% of C; 0.10 to 1.00% of Si; 0.10 to 1.00% of Mn; 12.00 to 14.00% of Cr; 0.01 to 0.05% of N; 0.020% or less of P; and 0.010% or less of S; with the balance being Fe and impurities; air cooling the outer surface of the pipe down to a range from 135 to 175°C; and then cutting the edges of the pipe.

[0010] In a preferred embodiment, the martensitic stainless steel pipe may further contain, by mass %, at least one selected from: 0.200% or less of V, 0.200% or less of Ti, 0.200% or less of Nb, and 0.0100% or less of, instead of a part of Fe. In another preferred embodiment, the martensitic stainless steel pipe may further contain, by mass %, at least one selected from 0.5% or less of Ni, 0.25% or less of Cu, and 0.0050% or less of Ca, instead of a part of Fe. In still another preferred embodiment, the martensitic stainless steel pipe may further contain 0.1% or less of Al by mass.

[0011] The present invention therefore prevents forming cracks and burrs during cutting of the martensitic stainless steel pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a graph showing the formation of cracks and burrs in relation to the surface temperature of the pipe and the processing degree of outer diameter during cutting.

BEST MODE FOR CARRYING OUT THE INVENTION

[0013] In the method of this invention, the martensitic stainless steel pipe contains the following elements for the

following reasons.

C (Carbon)

5 **[0014]** C is an effective element as well as N for strengthening the solid solution in the manufactured pipe. The C content should be 0.22% or less in order to prevent delayed fractures on impact-machined sections of the pipe caused by the solid solution. However, if the C content is less than 0.15%, then the desired strength cannot be maintained after heat treatment. Since C is an austenite forming element, too small an amount could cause δ -ferrite to form internal flaws on the finished pipe. In view of these circumstances, the C content is set from 0.15 to 0.22%. Preferably, the C content
10 lower limit is set 0.18%. The upper limit is preferably set 0.21%.

Si (Silicon)

15 **[0015]** Si is an effective element serving as deoxidizer in the steel. To achieve the desired effects the Si content should be 0.10% or more. However, if the Si content exceeds 1.00%, the toughness might deteriorate. To obtain the required toughness, the Si content is preferably set 0.75% or less. More preferably, the Si content lower limit is set 0.20%. The upper limit is preferably set 0.35%.

Mn (Manganese)

20 **[0016]** Mn is an effective element for improving the steel strength and has a deoxidizing effect similar to Si. Mn also fixes S in the steel by forming MnS, thereby improving hot workability. The desired effects can be achieved when the Mn content is 0.10% or more. However if the Mn content exceeds 1.00%, the toughness might deteriorate. In view of these circumstances, the Mn content is set between 0.10 to 1.00%.

Cr (Chromium)

25 **[0017]** Cr is an essential element for improving the corrosion resistance of the steel. The resistance to pitting and crevice corrosion significantly improves at a content of 12.00% or more. This improvement in corrosion resistance is even more obvious in a CO₂ environment. However, if the Cr content exceeds 14.00%, then δ -ferrite forms during high temperature working and lowers the hot workability. Moreover, too large a Cr content increases the production costs. In view of these circumstances, the Cr content is set 12.00 to 14.00%. The Cr content lower limit is preferably set 12.40%. The upper limit is preferably set 13.10%.

N (Nitrogen)

35 **[0018]** N is an element for stabilizing the austenite and improves the hot workability of the steel to prevent internal flaws. To achieve the desired effects, the N content should be 0.01% or more. Since too large an N content might cause delayed fractures in the impact-machined sections of the steel, the upper limit is set to 0.05%. Preferably, the N content
40 lower limit is 0.02%. The upper limit is preferably set 0.035%.

P (Phosphorus)

45 **[0019]** P is an impurity element in the steel. Since too large a phosphorus content could degrade the toughness of the heat-treated pipe, the P content should be kept as small as possible with 0.020% as the allowable upper limit value.

S (Sulfur)

50 **[0020]** S is an impurity element in the steel and degrades the hot workability. The S content should be kept as small as possible but a content up to 0.010% can be allowed. The upper limit is preferably set 0.003%.

[0021] The martensitic stainless steel pipe produced by the method of the present invention has the above-described chemical composition with the balance being Fe and impurities To prevent delayed fractures in the impact-machined sections of the steel, the pipe may contain at least one selected from V, Ti, Nb, and B instead of a part of Fe. To improve its hot workability, the pipe may contain at least one selected from Ni, Cu, and Ca instead of a part of Fe. Further, the
55 pipe may contain Al to prevent flaws on the exterior of the pipe. The preferred contents of the optional elements are described as follows.

V (Vanadium), Ti (Titanium), Nb (Niobium), and B (Boron)

[0022] While V, Ti, Nb, and B are optional, containing at least one of them is advantageous since these elements prevent delayed fractures in impact-machined sections of the steel. Too large a content could increase the hardness of the pipe due to nitride that forms from heat treatment, resulting in lower corrosion resistance and toughness and causing fluctuations in strength. In view of these circumstances, V, Ti, and Nb each should be restricted to 0.200% or less, and B to 0.0100% or less. While the desired effects can be obtained at even a tiny quantity of these elements, the content of at least one selected from V, Ti, and Nb is preferably 0.005% or more, and the B content is preferably 0.0005% or more.

Ni (Nickel), Cu (Copper), and Ca (Calcium)

[0023] Ni, Cu, and Ca are optional elements.

Ni is an austenite stabilizing element and improves the hot workability of steel. Since too large a content might lower the sulfide stress corrosion cracking resistance, the Ni content is preferably 0.5%. The desired effects, though achievable by a tiny amount of Ni, become obvious when the Ni content is 0.001% or more.

[0024] Cu is an element for improving the corrosion resistance of the steel. Cu is an austenite stabilizing element as well, which improves the hot workability of steel. Since too large a Cu content, which has a low melting point, is detrimental to the hot workability, the Cu content is preferably 0.25% or less. The desired effects, though achievable by a tiny amount of Cu, become obvious when the Cu content is 0.001% or more.

[0025] Ca bonds with the S in the steel to prevent degradation of its hot workability that might otherwise be caused by S grain boundary segregation. Since too large a Ca content could cause sand marks, the Ca content is preferably 0.0050%. The desired effects, though achievable by a tiny amount of Ca, become obvious when the Ca content is 0.001% or more.

Al (Aluminum)

[0026] Al which is an optional element is effective as a deoxidizer in the steel. Al is also effective for preventing flaws on the exterior of the pipe. Since too large an Al content could lower the steel purity and cause clogging in the immersion nozzle during continuous casting, the Al content is preferably 0.1%. The desired effects, though achievable by a tiny amount of Al, become obvious when the Al content is 0.001% or more.

[0027] The method for producing a martensitic stainless steel pipe according to the present invention includes: producing the martensitic stainless steel pipe having the above-described chemical composition; air cooling the outer surface of the pipe down to range of 135 to 175°C; and then cutting the edges of the pipe. The above temperature range is set for the following reasons.

[0028] If the temperature on the outer surface of the pipe exceeds 175°C during cutting, then the pipe might increase cracks on the edges. Cooling down to below 135°C lowers the cracking susceptibility of the pipe but might cause burrs when cutting, posing the possibility of flaws on the exterior of the pipe during carrying.

Examples

[0029] Billets with the chemical compositions shown in Table 1 were molded and hot-worked with Mannesmann mandrel mill to produce 10 meter long seamless steel pipes each having a various outer diameter i.e. various processing degree of outer diameter. Each pipe was reheated in a furnace at 1050°C for 16 minutes and then air-cooled.

[0030] The pipes were cut on the edges with the saw blade specified in Table 2 under the conditions specified in Table 3. Each pipe was cut at various temperatures of the pipe outer surface. The cut pipes were evaluated for cracks and burrs in the following manner. The temperature of the outer surface of each pipe was measured with a radiation thermometer.

Evaluation for cracks

[0031] Each pipe was shot blasted to remove scale on the inner and outer surfaces and then pickled. The edges of each pipe were then visually inspected for formation of cracks.

Evaluation for burrs

[0032] The length of the longest burr on the cut section of each pipe was measured, and a 20 mm length or longer was judged a burr formation.

[0033]

[Table 1]

C	Si	Mn	Cr	N	P	S	Balance
0.19	0.23	0.46	12.49	0.0285	0.013	0.0010	Fe and impurities
(Unit: mass percent)							

[0034]

[Table 2]

Material	Outer diameter (mm)	Number of teeth
S55C	1370	400

[0035]

[Table 3]

Circumferential speed of blade (m/min)	Cutting rate (mm/sec)
6900	5.0

[0036] Fig. 1 shows crack and burr formations in relation to the degree of outer diameter workability and outer surface temperatures during cutting. As shown, cutting carried out in the temperature range (135 to 175°C) of the present invention was satisfactory with no cracks or burrs.

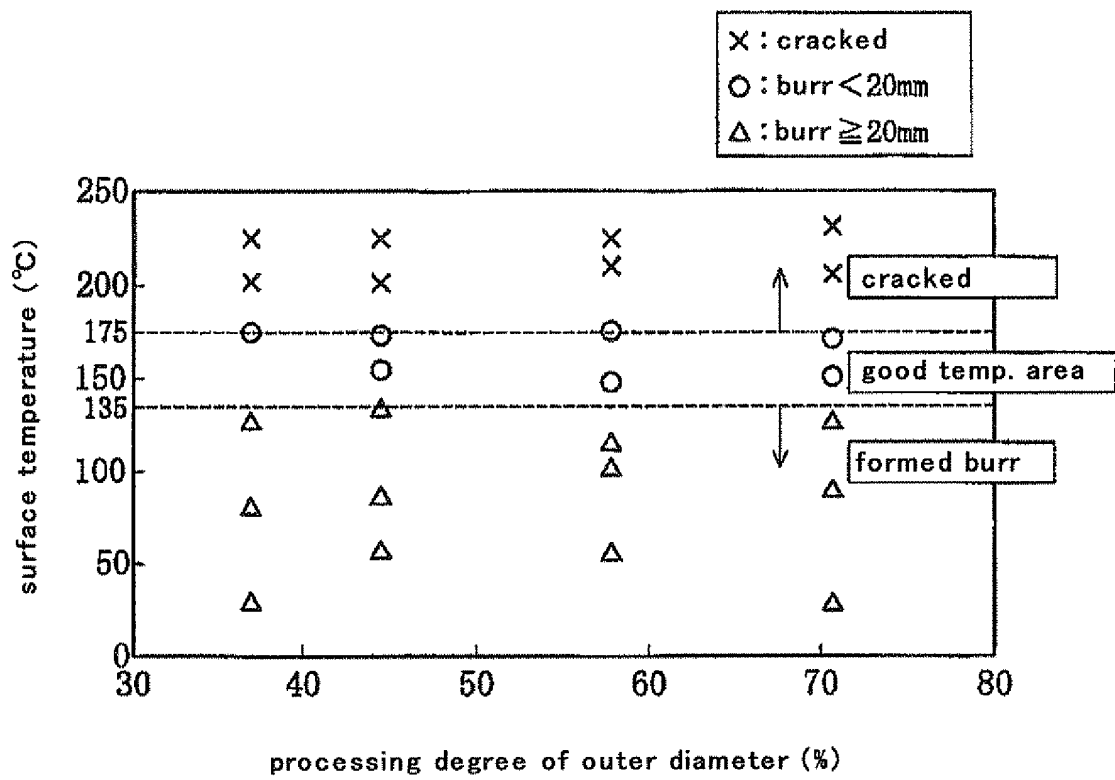
[0037] However, cracks formed during cutting at temperatures in excess of 175°C which is outside the range of this invention. Moreover, burrs formed at cutting performed below 135°C, which is also outside the temperature range of this invention.

[0038] Needless to say the present invention is not limited by the above embodiments and various changes may be made without departing from the technical scope of the appended claims.

Claims

1. A method for producing martensitic stainless steel pipe, comprising the steps of producing martensitic stainless steel pipe containing, by mass %: 0.15 to 0.22% of C; 0.10 to 1.00% of Si; 0.10 to 1.00% of Mn; 12.00 to 14.00% of Cr; 0.01 to 0.05% of N; 0.020% or less of P; and 0.010% or less of S; with the balance being Fe and impurities; air cooling the pipe down to a range from 135 to 175°C on the pipe outer surface; and then cutting the edges of the pipe.
2. The method according to claim 1, wherein the martensitic stainless steel pipe further contains, by mass %, at least one selected from 0.200% or less of V, 0.200% or less of Ti, 0.200% or less of Nb, and 0.0100% or less of B.
3. The method according to claim 1 or 2, wherein the martensitic stainless steel pipe further contains, by mass %, at least one selected from 0.5% or less of Ni, 0.25% or less of Cu, and 0.0050% or less of Ca.
4. The method according to any one of claims 1 to 3, wherein the martensitic stainless steel pipe further contains 0.1% or less of Al by mass.

FIG.1



REFERENCES CITED IN THE DESCRIPTION

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