METHOD OF MANUFACTURING THIN MARTENSITIC STAINLESS STEEL SHEET USING STRIP CASTER WITH TWIN ROLLS AND THIN MARTENSITIC STAINLESS STEEL SHEET MANUFACTURED BY THE SAME

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ABSTRACT
Provided is a method of manufacturing a THIN MARTENSITIC STAINLESS STEEL SHEET by casting a thin cast strip using a strip caster including a pair of rotating strip casting rolls and hot rolling the thin cast strip, wherein any one of conditions (a) and (b) is satisfied during the hot rolling, and a THIN MARTENSITIC STAINLESS STEEL SHEET manufactured by the same:

(a) Bending force of rolling rolls: 30 to 500 kN
(b) Size of crowns of rolling rolls: 50 to 250 μm.
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CROSS-REFERENCE TO RELATED APPLICATIONS


FIELD OF THE INVENTION

The present disclosure relates to a method of manufacturing a THIN MARTENSITIC STAINLESS STEEL SHEET using a strip caster with twin rolls and a THIN MARTENSITIC STAINLESS STEEL SHEET manufactured by the same.

BACKGROUND OF THE INVENTION

Martensitic stainless steel is excellent in terms of corrosion resistance, hardness, and wear resistance and is thus used in various items and tools, and in particular, for razors, scalpels, general kitchen knives, scissors, and the like. Martensitic stainless steel is generally manufactured by forming molten steel into ingots or slabs through a continuous casting process, and reheating and hot rolling the ingots or slabs, while the microstructures of the hot rolled steel may have a martensitic phase, a tempered martensitic phase, a ferrite phase, and a residual austenitic phase. Such a hot rolled steel, formed as a coil, may be transformed into ferrite and carbide and softened via a batch annealing process for annealing hot rolled sheets, and the soft material obtained by the hot rolling and annealing may undergo a pickling process for removing scales formed during the hot rolling and annealing. After the pickling, the soft material is transformed into martensitic steel via a heat treatment process after cold rolling and processing of a product.

A higher degree of hardness is required in steel used for producing high quality metal tools, and such a high degree of hardness may be realized by a martensitic microstructure formed in steel used therefor. Martensitic microstructures are very hard microstructures produced when high temperature austenite is rapidly cooled. As the content of carbon dissolved in austenite at high temperature increases, the content of carbon dissolved in martensite increases, and thus the hardness of martensite also increases. Accordingly, in order to manufacture martensitic stainless steel having a high degree of hardness, as much carbon as possible should be contained in steel.

However, in order to manufacture such martensitic steel, the content of carbon therein should be increased, but in this case, segregations may be severely generated and casting efficiency may be reduced. For example, a solid-liquid region may be increased. Further, ingot casting is mainly used to cast martensitic steel, but ingot casting may lead to a reduction in quality in a post-treatment process due to rough precipitates formed as inter-granules and central segregations due to a slow cooling speed, thereby causing many difficulties. In order to solve this problem, a strip casting process is used instead of the ingot casting, in which case, because central segregations are restrained and chrome carbide precipitates are reduced in initial inter-granules, the quality of steel may be improved and the strip casting process is spotlighted as a remarkable process.

With reference to FIG. 1, in strip casting, molten steel 1 is accommodated in a ladle 2, the accommodated molten steel 1 is introduced to a tundish 3, the molten steel 1 being supplied to a sump, a space defined by strip casting rolls 5 and an edge dam 6, through an entry nozzle 4, and the molten steel 1 passes between the strip casting rolls 5 to allow a thin cast strip 7 to be manufactured. Then, a meniscus shield 8 is provided above the strip casting rolls 5 to prevent the oxidation of molten steel, and a suitable gas is injected into the sump to maintain a predetermined atmosphere. The thin cast strip 7 manufactured while being withdrawn from a roll nip 9 at which the strip casting rolls 5 meet is rolled by rolling rolls 10, and is wound by a winding device 11 via a cooling process and is manufactured into a thin steel sheet.

Then, in a twin roll type strip casting process for directly manufacturing a thin steel sheet having a thickness of 10 mm or less from molten steel, supplying molten steel between interior water cooled twin rolls rotating in opposite directions at a high speed through an entry nozzle to manufacture a thin sheet having a desired thickness without any crack and at an improved yield rate is an important technological process.

In addition, in order to manufacture thin high carbon martensitic stainless steel by applying a twin roll type strip casting process, a casting technology is important, but it is more important to reduce the incidence of edge cracks generated during hot rolling, and the development of an economical casting method in which edge quality can be improved by minimizing a tensile stress causing edge cracks is necessary.

SUMMARY OF THE INVENTION

An aspect of the present disclosure may provide a method of manufacturing a THIN MARTENSITIC STAINLESS STEEL SHEET having an excellent edge quality by controlling a bending force of rolling rolls in manufacturing a THIN MARTENSITIC STAINLESS STEEL SHEET using a twin roll type strip caster and hot rolling rolls and a THIN MARTENSITIC STAINLESS STEEL SHEET manufactured by the same.

An aspect of the present disclosure may also provide a method of manufacturing a THIN MARTENSITIC STAINLESS STEEL SHEET by casting a thin cast strip using a strip caster including a pair of rotating strip casting rolls and hot rolling the thin cast strip, wherein any one of conditions (a) and (b) is satisfied during the hot rolling:

- (a) Bending force of rolling rolls: 30 to 500 kN
- (b) Size of crowns of rolling rolls: 50 to 250 μm.

Another aspect of the present disclosure provides a stainless thin steel sheet, which comprises 0.3 wt % to 0.8 wt % of C, 12.0 wt % to 16.0 wt % of Cr, 0.2 wt % to 1.0 wt % of Si, 0.2 wt % to 1.0 wt % of Mn, 0.2 wt % to 1.0 wt % of Ni, 0.01 wt % to 0.1 wt % of N, 0.05 wt % or less of P, and 0.05 wt % or less of S, and also includes Fe and other inevitable impurities, wherein the size of an edge crack is 30 mm.

BRIEF DESCRIPTION OF DRAWINGS

The above and other aspects, features and other advantages of the present disclosure will be more clearly
understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic view showing a twin roll type strip casting method;

FIG. 2 is a diagram illustrating rolling of a thin cast strip;

FIG. 3 is a picture obtained by observing Invention Example 3 according to an embodiment of the present disclosure; and

FIG. 4 is a picture obtained by observing Comparative Example 3 which departs from the scope of the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. The disclosure may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art.

In the drawings, the shapes and dimensions of elements may be exaggerated for clarity, and the same reference numerals will be used throughout to designate the same or like elements.

An embodiment of the present disclosure provides a method of manufacturing a THIN MARTENSITIC STAINLESS STEEL SHEET by casting a thin cast strip using a strip caster comprising a pair of rotating strip casting rolls and hot rolling the thin cast strip, wherein any one of conditions (a) and (b) is satisfied during the hot rolling:

(a) Bending force of rolling rolls: 30 to 500 kN
(b) Size of crowns of rolling rolls: 50 to 250 μm

In an example of a method of manufacturing the THIN MARTENSITIC STAINLESS STEEL SHEET, as illustrated in FIG. 1, molten steel 1 having undergone a refining process is accommodated in a ladle 2, the accommodated molten steel 1 is introduced to a tundish 3, the molten steel 1 is supplied to a sump, a space defined by strip casting rolls 5 and an edge dam 6 through an entry nozzle 4, and the molten steel 1 passes between the strip casting rolls 5 to manufacture a thin cast strip 7. The manufactured thin cast strip 7 is hot rolled by rolling rolls 10, and is wound by a winding device 11 via a cooling process and is manufactured into a thin steel sheet.

In casting martensitic stainless steel using the twin roll strip casting method, one of the main causes of increases in a defect rate is the lowering of edge quality due to cracking of edges. Martensitic steel has low high-temperature toughness because of the generation of inter-granular carbides due to high carbon, and so is sensitive to cracks. Accordingly, edge cracks are easily generated in a process of rolling cast pieces using a strip casting method, and when the shape of cast pieces is managed or wound into a coil, a crack may be propagated by tensile force between a rolling machine and a winding machine, causing a danger of strip breakage.

The edge cracks are caused by discrepancies in the shape of a thin cast strip, skulls due to locally overcooled metal, and a rolling condition, and the present disclosure basically solves a problem which may be caused by rolling in addition to a factor due to a thin cast strip. In general, a rolling roll used for hot rolling is provided with a bending unit for controlling a bending change of the rolling roll. In addition, generally, when the bending force of the bending unit is reduced, a reduction ratio of an edge of the thin cast strip increases, and if the bending force of the bending unit increases, the reduction ratio of the edge decreases.

FIG. 2 is a view schematically illustrating a state in which a thin cast strip is rolled, and according to the present disclosure, a crown of a thin cast strip is uniformly rolled with the control of bending force as illustrated in FIG. 2. In more detail, a bending force of a rolling roll 10 is controlled to 30 to 50 kN during hot rolling. When the bending force is less than 30 kN, a reduction ratio applied to an edge is excessively increased, such that an edge wave or a distortion is generated, making rolling control unstable, and when the bending force exceeds 500 kN, a small reduction ratio is applied to the edge, a length of the edge is prolonged less than that of a central portion of the thin case piece such that a tensile stress is generated in the edge, easily causing edge cracks. Accordingly, it is preferable that a bending force of the rolling roll 10 suggested by the present disclosure range from 30 kN to 500 kN, and it is preferable that a bending force of the rolling roll ranges from 30 kN to 300 kN to realize excellent edge quality through reduction of edge cracks. More preferably, it is more preferable that a bending force of the rolling roll range from 30 kN to 150 kN, and it is most preferable that a bending force of the rolling roll range from 30 kN to 100 kN. Meanwhile, the above-mentioned edge wave means that a length of the edge is elongated further than a central part as high reduction ratio is applied to the edge and thus the edge has a wave form, and the distortion refers to a defect generated by a difference between rolling speeds of edges due to a difference between the reduction ratios applied to the edges.

It is preferable that a uniform reduction ratio is applied to the central part and the edges of the thin cast strip to control the crown size of the rolling rolls 10 to 50 μm to 250 μm in order to secure an excellent edge quality. When the crown size of the rolling rolls is less than 50 μm, edge cracks may be easily generated, causing a reduction in a yield rate, and when the crown size of the rolling rolls exceeds 250 μm, the casting process may be stopped because of generation of serpentine marks due to the edge wave or distortion. The crown size of the rolling roll refers to a height difference between the edge and the center of the thin cast strip. Accordingly, it is preferable that a crown size of the rolling roll suggested by the present disclosure range from 50 μm to 250 μm, and it is preferable that a crown size of the rolling roll range from 50 μm to 200 μm to realize an excellent edge quality. More preferably, it is more preferable that a crown size of the rolling roll range from 50 μm to 150 μm, and it is most preferable that a crown size of the rolling roll range from 50 μm to 100 μm.

Meanwhile, according to the present disclosure, the alloy composition of the stainless thin steel sheet is not specifically limited as long as the stainless thin steel sheet has fine martensitic microstructures, but it is preferable that the stainless thin steel sheet include 0.3 wt % to 0.8 wt % of C, 12.0 wt % to 16.0 wt % of Cr, 0.2 wt % to 1.0 wt % of Si, 0.2 wt % to 1.0 wt % of Mn, 0.2 wt % to 1.0 wt % of Ni, 0.01 wt % to 0.1 wt % of N, 0.003 wt % or less of P, and 0.03 wt % or less of S, and also includes Fe and other inevitable impurities. Hereinafter, the alloy composition suggested by the present disclosure will be described.
Carbon (C) is an element which increases hardness of martensitic stainless steel, and 0.3 wt % or more of carbon is included to secure a hardness of 600 Hv or more required by razor steel. As the content of carbon increases, the hardness of martensite produced through heat treatment, but the content of carbide also increases and thus corrosion resistance and cooling processing efficiency are lowered, such that it is preferable that 0.8 wt % or less of carbon is included. Cr: 12.0 wt % to 16.0 wt %

Chrome (Cr) is an element which is added to improve corrosion resistance of martensitic stainless steel, and a chrome oxide film may be densely formed to improve corrosion resistance only in a case in which the content of chrome of a matrix microstructure is 12 wt % or more. In addition, by preventing a large amount of carbide from being formed to lower the content of chrome, it is preferable that 12.5 wt % or more of Cr is added to further improve corrosion resistance due to formation of a chrome oxide film. Meanwhile, because corrosion resistance is improved but the hardness of martensite produced by heat treatment is lowered when the content of chrome exceeds 16 wt %, it is preferable that the content of the chrome be 16 wt % or less.

Si: 0.2 wt % to 1.0 wt %

Silicon (Si) is an element which is added for the purpose of deoxidation, and because such a deoxidation effect cannot be sufficiently obtained when the content of silicon is 0.2 wt % or less, it is preferable that the content of silicon be 0.2 wt % or more. Meanwhile, because cooling processing efficiency is significantly low when the content of silicon exceeds 1.0 wt %, it is preferable that the content of silicon be 1.0 wt % or less.

Mn: 0.2 wt % to 1.0 wt %

Manganese (Mn) is an element which is added for the purpose of deoxidation and to increase dissolution of nitrogen, and because a deoxidation effect is not sufficient when the content of manganese is 0.2 wt % or less, it is preferable that the content of manganese be 0.2% or more. Meanwhile, because corrosion resistance is low when the content of manganese is 1.0 wt %, it is preferable that the content of manganese be 1.0 wt % or less.

Ni: 0.2 wt % to 1.0 wt %

Nickel (Ni) is an element which is added to martensitic stainless steel to improve the corrosion resistance of the basis material without forming carbide. It is preferable that 0.2 wt % or more of nickel be added to sufficiently obtain corrosion resistance. Meanwhile, when the content of nickel (Ni) exceeds 1.0%, an excessive amount of residual austenite is formed after reinforcing heat treatment so that high degree of hardness cannot be obtained. Although the corrosion resistance of the microstructures of martensitic stainless steel according to the related art is remarkably changed after the reinforcing heat treatment by austenitization temperature and time conditions during the reinforcing heat treatment, but according to the present disclosure, addition of 0.2 wt % to 1.0 wt % of Ni supplements the disadvantage, and in particular, local corrosion resistance such as pitting or crevice corrosion can be improved.

Nitrogen (N) is an element which is added to increase hardness through a reinforcing heat treatment and improve resistance against pitting and crevice corrosion. It is preferable that 0.01 wt % of nitrogen be added to obtain the effect, but because nitrogen bubbles are generated to form pores or pin holes during the casting process when the content of nitrogen exceeds 0.1 wt %, it is preferable that the content of N range from 0.01 wt % to 0.1 wt %.

P: 0.03 wt % or less

Phosphorus (P) is an element existing as impurities of steel, and because inter-granular crystals are present and a hot processing property is lowered if the content of phosphorus (P) is excessive, the upper limit is defined to 0.03 wt % or less.

S: 0.03 wt % or less

Sulfur (S) is an element existing as impurities of steel like phosphorus, and because hot processing efficiency is lowered as sulfur exists in inter-granular crystals or sulfides if the content of sulfur is excessive, the upper limit is defined to 0.03 wt %.

In accordance with the method of manufacturing a THIN MARTENSITIC STAINLESS STEEL SHEET according to the present disclosure provided as described above, the difference between the reduction ratios of the central part and the edge of the thin cast strip during hot rolling is 0.8 or less so that a very uniform reduction ratio can be given, and accordingly, edge cracks of 30 mm or less may be generated or no edge cracks may be generated, making it possible to secure a considerably excellent edge quality. In general, when martensitic stainless steel is manufactured, edge cracks of 60 mm or less may be generated, and accordingly, when it is considered that the edge of the thin steel sheet is trimmed by about 60 mm, it can be seen that the method of the present disclosure secures a very excellent edge quality.

Hereinafter, exemplary embodiments of the present disclosure will be described in detail. Meanwhile, the following embodiments of the present disclosure are merely examples for describing the present disclosure in detail, and do not limit the scope of the present disclosure.

First Embodiment

A thin cast strip is obtained from 0.65 wt % of C, 13.5 wt % of Cr, 0.3 wt % of Si, 0.65 wt % of Mn, 0.2 wt % of Ni, 0.03 wt % of N, 0.02 wt % of P, and 0.001 wt % of S, Fe and other inevitable impurities by using a twin roll type strip casting method. The width of the thin cast strip is 1300 mm and the thickness of the thin cast strip is 3.0 mm, and the thin cast strip is hot rolled and wound and is manufactured into a thin steel sheet having a thickness of 2 mm. Meanwhile, the bending force of the rolling roll is controlled as illustrated in Table 1 during hot rolling, and the crown size of the rolling roll is 30 mm. In this way, for the manufactured thin steel sheet, edge cracks exceeding 30 mm, an edge wave, a distortion, and a difference between reductions of the central part and the edge of the thin steel sheet were observed and the result is illustrated in Table.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Tension force (kN)</th>
<th>Generation of edge crack (30 mm or more)</th>
<th>Generation of edge wave (serpentine mark)</th>
<th>Generation of distortion between reduction ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparative example 1</td>
<td>10</td>
<td>x</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
As can be seen from Table 1, in Invention Examples 1 to 5 satisfying the bending force condition suggested by the present disclosure, a uniform reduction ratio was given such that edge cracks exceeding 30 mm were not generated and surface quality was excellent, and neither an edge wave nor a distortion was generated such that an excellent shape quality was secured.

However, in Comparative Examples 1 and 2 which do not reach the condition of bending force suggested by the present disclosure, a high reduction ratio was given to the edge such that edge cracks were not generated but an edge wave and a distortion were generated by an excessive reduction ratio.

Meanwhile, in Comparative Examples 3 and 4 which exceed the bending force suggested by the present disclosure, it can be seen that edge cracks were generated as a low reduction ratio was given to the edge as compared with the central part, and in particular, in Comparative Example 4, edge cracks were severely generated so that a strip breakage was generated.

FIGS. 3 and 4 illustrate pictures obtained by observing the thin steel sheets of Invention Example 3 and Comparative Example 3. As can be seen from FIGS. 3 and 4, it can be seen that in Invention Example 3 satisfying the condition of the present disclosure, edge cracks were not generated so that quality of the edge was excellent, but it can be seen that in Comparative Example 3, edge cracks were generated as an excessive bending force is given.

A thin steel sheet was manufactured in the same condition as the first embodiment except that the bending force was set to 600 kN and the crown of the rolling roll is controlled as illustrated in Table 2, and for the manufactured thin steel sheet, edge cracks exceeding 30 mm, an edge wave, and a distortion were observed, and the result is illustrated in Table 2.
edge quality can be manufactured by effectively reducing edge cracks which may be easily generated during hot rolling in manufacturing a THIN MARTENSITIC STAINLESS STEEL SHEET using a strip caster.

What is claimed is:

1. A method of manufacturing a THIN MARTENSITIC STAINLESS STEEL SHEET by casting a thin cast strip using a strip caster comprising a pair of rotating strip casting rolls and hot rolling the thin cast strip, wherein any one of conditions (a) and (b) is satisfied during the hot rolling:
   (a) Bending force of rolling rolls: 30 to 500 kN
   (b) Size of crowns of rolling rolls: 50 to 250%.

2. The method of claim 1, wherein the bending force of the rolling rolls is 30 to 300 kN.

3. The method of claim 1, wherein the size of the crowns of the rolling rolls is 50 to 200 μm.

4. The method of claim 1, wherein the stainless thin steel sheet comprises 0.3 wt % to 0.8 wt % of C, 12.0 wt % to 16.0 wt % of Cr, 0.2 wt % to 1.0 wt % of Si, 0.2 wt % to 1.0 wt % of Mn, 0.2 wt % to 1.0 wt % of Ni, 0.01 wt % to 0.1 wt % of N, 0.03 wt % or less of P, and 0.03 wt % or less of S, and also includes Fe and other inevitable impurities, wherein a size of an edge crack is no more than 30 mm.

5. The method of claim 1, wherein a difference between reduction ratios of the central part and the edge of the thin cast strip is 0.8% or less during hot rolling.

6. A THIN MARTENSITIC STAINLESS STEEL SHEET, comprising 0.3 wt % to 0.8 wt % of C, 12.0 wt % to 16.0 wt % of Cr, 0.2 wt % to 1.0 wt % of Si, 0.2 wt % to 1.0 wt % of Mn, 0.2 wt % to 1.0 wt % of Ni, 0.01 wt % to 0.1 wt % of N, 0.03 wt % or less of P, and 0.03 wt % or less of S, and also includes Fe and other inevitable impurities, wherein a size of an edge crack is no more than 30 mm.

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