ABSTRACT

Disclosed is an improvement apparatus of surface roughness of hot/cold rolled stainless steel coils and the method thereof. The present invention provides an improvement apparatus of surface roughness of hot/cold rolled stainless steel coils including a water spray unit for spraying water on a surface of a cast stainless steel slab; a cutting unit for cutting the stainless steel slab; and a high-pressure water spray having at least one nozzle in a region where the stainless steel slab is cut by the cutting unit and discharged and installed to be symmetric in upper and lower parts of the stainless steel slab; and a roller brush installed to be in contact with and symmetric in the upper and lower parts of the stainless steel slab passed through the water spray so as to rotate at a high speed. Accordingly, the improvement apparatus according to the present invention may be useful to produce a stainless steel slab having an excellent surface quality since it is possible to easily remove the scale and mold slag from the stainless steel slab.
FIG. 5

Casting direction
FIG. 8

Spraying distance

Spray impact pressure (bar)
FIG. 9

Index of attached slag in slab

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FIG. 10

Generation rate of surface roughness in cold rolled coil

Prior Art: 21.4
Present Invention: 3.1
IMPROVEMENT APPARATUS OF SURFACE ROUGHNESS DEFECT OF HOT/COLD ROLLED STAINLESS STEEL COILS AND THE METHOD THEREOF

TECHNICAL FIELD

[0001] The present invention relates to an improvement apparatus of surface roughness of hot/cold rolled stainless steel coils and the method thereof, and more particularly to an improvement apparatus of surface roughness of hot/cold rolled stainless steel capable of improving surface roughness of stainless steel slabs by cutting a completely coagulated molten steel using a high-pressure water spray and a roller brush in the continuous casting process of the stainless steel and removing a mold slag and a scale attached to the slab under a high temperature, and the method thereof.

BACKGROUND ART

[0002] In general, hot/cold rolled stainless steel products have been used for general construction applications, etc. by re-heating and rolling slabs produced in a steel and continuous casting mill, followed by making the slabs into desired products through annealing and pickling processes, or used for kitchen utensils, etc. after the cold rolled process.

[0003] Hereinafter, a continuous casting apparatus of stainless steel using a continuous caster will be described in detail, with reference to the accompanying drawings.

[0004] FIG. 1 is a cross-sectional view showing a conventional stainless steel continuous caster. FIG. 2a is a photograph showing surface roughness of a surface of hot roller stainless steel coil in the prior art. FIG. 2b is a mimetic view showing surface roughness of a surface of hot roller stainless steel coil in the prior art.

[0005] Referring to FIG. 1, FIG. 2a and FIG. 2b, a steel-making process for producing steel products is carried out to ensure desired compositions and temperature of a molten steel 10 in a refining furnace after the molten steel 10 is produced in an electric furnace or refining furnace. Then, the molten steel 10 is put into a ladle 20 and cast through a continuous casting process. The molten steel 10 put into the ladle 20 is transferred to a tundish 30, and supplied to a mold 40 through an immersion nozzle provided between the tundish 30 and the mold 40. The molten steel 10 supplied into the mold 40 is poured into a slab supporting roll 50 which is cooled with water, and coagulated in the slab supporting roll 50, and then the molten steel 10 is discharged out of the mold 40 and completely coagulated by means of water spraying of a secondary cooling spray 60. Subsequently, the completely coagulated molten steel 10 is cut into slabs 70 with a constant size, and the cut slabs 70 are charged into a heating furnace and hot-rolled under a conventional heating and rolling condition.

[0006] However, surface roughness appears in a surface of the cut slabs 70 since mold powder and scale are attached to the surface of the cut slabs 70 during a primary cooling process using the slab supporting roll 50, the mold powder being added for the purpose of keeping warmth of the molten steel 10 and its lubrication effect and the scale being formed in a high temperature. If this surface roughness is not solved prior to the heating and rolling process, the scale present inside the cut stainless steel slab 70 is made more fragile to facilitate ununiform oxidation in the heating process of the slab 70, which leads to more rough surface of the slab 70. This indicates that a strip shape of line defect appears in a surface of the products (hot rolled coil) after the hot rolling process, as shown in “A” and “B” of FIGS. 1 and 2.

[0007] FIG. 3 is a mimetic view schematically showing a mechanism on defect generation of a conventional stainless steel slab.

[0008] Referring to FIG. 3, the defect generation caused by the mold slag and the scale in the stainless steel slab 70 is shown sequentially. More particularly, a mechanism on surface roughness (stripes) caused by the unremoved mold powder and scale in the conventional stainless steel slab is schematically shown.

[0009] First, if the slab 70 is charged into a heating furnace without completely removing a mold slag 71 from a surface of the slab 70, on the slab 70 put into the heating furnace is formed an oxidized scaled layer whose inner scale 72 is not easily remove and having a thin and compact structure, since a spreading rate of oxygen is reduced in a region of the mold slag 71. On the contrary, a porous scale having a weak adhesion is formed on a surface layer of the slab 70 having no mold slab 71 since the mold slag 71 is accelerated. Then, the slab 70 is subject to a removal process of the scale 72 during the hot rolled process. At this time, the scale 72, which has a strong cohesion and is formed right below the slab 70 having the mold slag 71 attached thereto, is not easily removed, which leads to surface roughness in the surface of the slab 70.

DISCLOSURE

Technical Problem

[0010] Accordingly, the present invention is designed to solve such drawbacks of the prior art, and therefore an object of the present invention is to provide an improvement apparatus of surface roughness of hot/cold rolled stainless steel capable of improving surface roughness of stainless steel slabs by cutting a completely coagulated molten steel using a high-pressure water spray and a roller brush in the continuous casting process of the stainless steel and removing a mold slag and a scale attached to the slab under a high temperature, and the method thereof.

Technical Solution

[0011] One embodiment of the present invention is achieved by providing an improvement apparatus of surface roughness of hot/cold rolled stainless steel, including at least one water spray unit installed to spray water on a surface of the cast stainless steel slab along a slab supporting roll; a cutting unit arranged in a tip of the water spray unit and cutting the stainless steel slab coagulated with the water spray unit; a high-pressure water spray having at least one nozzle in a region where the stainless steel slab is cut by the cutting unit and discharged and installed to be symmetric in upper and lower parts of the stainless steel slab; and a roller brush installed to be in contact with and symmetric in the upper and lower parts of the stainless steel slab passed through the water spray so as to rotate at a high speed.

[0012] Another embodiment of the present invention is achieved by providing an improvement method of surface roughness of hot/cold rolled stainless steel, comprising steps of spraying water on a surface of a cast stainless steel slab; cutting the water-sprayed stainless steel slab; and removing
foreign substance from a surface of the cut stainless steel slab using a high-pressure water spray and a roller brush.

ADVANTAGEOUS EFFECTS

[0013] The improvement apparatus of surface roughness of hot/cold rolled stainless steel according to the present invention may be useful to improve surface roughness of stainless steel slabs by cutting a completely coagulated molten steel using a high-pressure water spray and a roller brush in the continuous casting process of the stainless steel and removing a mold slag and a scale attached to the slab under a high temperature.

DESCRIPTION OF DRAWINGS

[0014] These and/or other embodiments and features of the invention will become apparent and more readily appreciated from the following description of certain exemplary embodiments, taken in conjunction with the accompanying drawings of which:

[0015] FIG. 1 is a cross-sectional view showing a conventional stainless steel continuous caster;
[0016] FIG. 2a is a photograph showing surface roughness of a surface of hot rolled stainless steel coil in the prior art;
[0017] FIG. 2b is a mimetic view showing surface roughness of a surface of hot rolled stainless steel coil in the prior art;
[0018] FIG. 3 is a mimetic view schematically showing a mechanism for defect generation of a conventional stainless steel slab;
[0019] FIG. 4 is a cross-sectional view showing a stainless steel continuous caster according to the present invention;
[0020] FIG. 5 is a cross-sectional view showing an apparatus for removing foreign substance from a cut stainless steel slab according to the present invention;
[0021] FIG. 6 is an exploded cross-sectional view showing a high-pressure water-spraying apparatus for removing foreign substance from the cut stainless steel slab according to the present invention;
[0022] FIG. 7 is an exploded cross-sectional view showing a roller brush for removing foreign substance from the cut stainless steel slab according to the present invention;
[0023] FIG. 8 is a graph illustrating a spray impact pressure according to the spraying distance of the water spray according to the present invention;
[0024] FIG. 9 is a graph illustrating an amount index of the mold slag attached onto a surface of the slab according to the present invention; and
[0025] FIG. 10 is a graph illustrating a generation rate of surface roughness in a surface of hot rolled coil according to the present invention.

MODES OF THE INVENTION

[0026] Hereinafter, certain exemplary embodiments according to the present invention will be described with reference to the accompanying drawings. Here, when a first element is described as being coupled to a second element, the first element may be not only directly coupled to the second element but may also be indirectly coupled to the second element via a third element. Further, elements that are not essential to the complete understanding of the invention are omitted for clarity. Also, like reference numerals refer to like elements throughout.

[0027] FIG. 4 is a cross-sectional view showing a stainless steel continuous caster according to the present invention.
[0028] The continuous caster according to the present invention will be described in detail, referring to FIG. 4. First, the cast stainless steel slab 170 is configured to get out of a mold 140 and move by a plurality of slab supporting rolls 150, and water spray units 160 are installed between the slab supporting rolls 150 along a line in which the slab supporting rolls 150 are formed. In the present invention, the water spray unit 160 is formed as a secondary cooling spray, and the secondary cooling spray 160 serves to spray water on a surface of the slab 170 and coagulate the slab 170.

[0029] The coagulated stainless steel slab 170 is cut at a constant size using cutting units 200 installed in tips of the slab supporting roll 150 and the secondary cooling spray 160. A high-pressure water spray 180 having at least one nozzle is installed to be symmetrical in upper and lower parts of the stainless steel slab 170 in one region where the stainless steel slab 170 is cut and discharged. The scale attached to the slab 170 is removed by means of a spray impact pressure between water and the slab 170 when the high-pressure water spray 180 is sprayed on upper and lower parts of the slab 170. And, a roller brush 190 is installed to be in contact with and symmetrical in the upper and lower parts of the stainless steel slab 170 passed through the water spray 180 so as to rotate at high speed, and therefore a mold slag and a scale are finally removed from the stainless steel slab 170 while the roller brush 190 rubs against the stainless steel slab 170.

[0030] Also, the improvement apparatus according to the present invention further includes a sensor for sensing a position of the slab 170. The sensor 191 is installed in one region in a casting opposite direction of the water spray 180 installed in the lower part of the cut slab 170, and the other region of a casting direction of the roller brush 190 installed in the lower part of the cut slab 170. Therefore, operation times of the water spray 180 and the roller brush 190 are optimized by sensing a path in which the slab 170 enters and gets out of the water spray 180 and the roller brush 190 using a sensor 191.

[0031] The sensor 191 is a high-precision laser sensor that is designed to sense the slab 170 by using the laser light.

[0032] Hereinafter, the improvement method of surface roughness using the stainless steel continuous caster according to the present invention will be described in detail. Generally, the steel-making process for producing steel products is carried out to ensure desired compositions and temperature of a molten steel 110 in a refining furnace after the molten steel 110 is produced in an electric furnace or refining furnace. Then, the molten steel 110 is put into a ladle 120 and cast through a continuous casting process. The molten steel 110 put into the ladle 120 is transferred to a tundish 130, and supplied to a mold 140 through an immersion nozzle provided between the tundish 130 and the mold 140. The molten steel 110 supplied into the mold 140 is poured into a slab supporting roll 150 which is cooled with water, and coagulated in the slab supporting roll 150, and then the molten steel 110 is discharged out of the mold 140 and completely coagulated by means of water spraying of a secondary cooling spray 160. Subsequently, the completely coagulated molten steel 110 is cut into slabs 170 with a constant size.

[0033] The mold slag and scale attached to a surface of the cut slab 170 is clearly removed using the high pressure water spray 180 and the roller brush 190.

[0034] Hereinafter, the step of removing the mold slag and scale from the slab using the water spray apparatus and the
roller brush according to the present invention will be described in more detail, referring to FIG. 5 to FIG. 8. FIG. 5 is a cross-sectional view showing an apparatus for removing foreign substance from a cut stainless steel slab according to the present invention. FIG. 6 is an exploded cross-sectional view showing a high-pressure water-spraying apparatus for removing foreign substance from the cut stainless steel slab according to the present invention. FIG. 7 is an exploded cross-sectional view showing a roller brush for removing foreign substance from the cut stainless steel slab according to the present invention. FIG. 8 is a graph illustrating a spray impact pressure according to the spraying distance of the water spray according to the present invention.

[0035] Referring to FIG. 5 to FIG. 8, the high pressure water spray 180 and the roller brush 190 are symmetrically installed respectively in upper and lower parts of a surface of the slab 170 to remove the mold slag and scale attached to the slab 170. Meanwhile, a spray impact pressure (MPa) of the water spray 180 sprayed to the slab 170 should be enhanced so as to remove the mold slag and scale attached to the slab 170 in a more effective manner.

[0036] The optimum condition of the spray impact pressure used for removing foreign substance attached to the slab 170 can be determined from the following Equation 1.

\[
\text{Spray Impact Pressure (MPa)} = \frac{kQ^{0.5}}{A} \quad \text{Equation 1}
\]

wherein, K represents a constant number, Q represents a flow rate (ℓ/min), P represents a pressure of a nozzle or a pump (MPa), and A represents an impact area (m²).

[0037] According to the Equation 1, the increase in the flow rate and pressure and the decrease in the impact area should be accompanied to improve the spray impact pressure. The impact area “A” is in inverse proportion to the square root of the distance between the slab and the nozzle through which high-pressure water is sprayed, that is, exponentially functionally in inverse proportion to the spraying distance, and therefore the spraying distance should be shortened to reduce the impact area. This indicates that the spray impact pressure is significantly increased with the shortening spraying distance, as shown in FIG. 8. That is to say, the spray impact pressure exponentially functionally increased with the shortening spraying distance.

[0038] Through this theoretical analysis, the entire flow rate of the high pressure spray 180 according to the present invention is set to 200 to 300 ℓ/min, the number of nozzles are set to 11 in its upper and lower parts (total: 22 = 2 x 11), the type of the nozzle is set to a nozzle (DNH series) for removing scale, the width of a nozzle cover is set to 900 mm, the water pressure in the nozzle for making a high-pressure spray is set to 100 to 200 bar, and the spraying distance between the tip of the nozzle and the slab is set to 100 to 200 mm to ensure a suitable spray impact pressure to effectively remove scale in the slab. Also, three 75 KW-capacity pumps for driving the water spray 180 are installed to meet the set flow rate and the set pressure as described above.

[0040] A flow rate of the water spray 180 is set to 200 to 300 ℓ/min. This is why the spray impact pressure is insufficient to remove the scale from the surface of the slab 170 if the flow rate of the water spray 180 is less than 200 ℓ/min, whereas the removal effect of the scale is not high if the flow rate of the water spray 180 exceeds 300 ℓ/min. The water spray 180 may have, for example, 11 nozzles. This number is set in consideration of the width of the slab 170 produced in a mill having the water spray 180 installed therein. That is to say, the nozzles do not completely cover the width of the produced slab 170 if the number of the nozzle is less than 11, whereas unnecessary nozzles are present if the number of the nozzle in the water spray 180 exceeds 11. The width of the nozzle cover in the water spray 180 is set to 900 mm. This width is set in consideration of the width of the produced slab 170 and the position of the slab 170 with the scale defects by width.

[0041] The water pressure in the nozzle of the water spray 180 is set to 100 to 200 bars. This is why the spray impact pressure is insufficient to remove the scale from the surface of the slab 170 if the water pressure of the water spray 180 is less than 100 bars, whereas the removal effect of the scale is not high if the water pressure of the water spray 180 exceeds 200 bars.

[0042] The spraying distance of the water spray 180 is one of the most important factors in this apparatus, and therefore the spraying distance of the water spray 180 according to the present invention is set to 100 to 200 mm. This is why the spray impact pressure is extraordinarily high if the spraying distance of the water spray 180 is less than 100 mm. In this case, the removal effect of the scale from the slab 170 is good, but a large number of nozzles are required since an area covered by the spray is too small, and therefore it is difficult to ensure a space where these nozzles are installed. However, the removal effect of the scale from the slab 170 is significantly improved, the graph being obtained by preparing a certain area (approximately 5 mm) of the test samples from the slab surface layer and analyzing components, for example calcium (Ca) present in the mold slag. Comparing the indexes of the attached mold slags in the slab calculated from the prior art and the present invention, the index of the mold slag attached onto the slab according to the prior art is shown to be approximately 8.3, whereas the index of the mold slag attached onto the slab according to the present invention is shown to be approximately 1.5. That is to say, the index of the attached mold slags in the slab cleaned using the high pressure water spray and the roller brush is shown to be lower as much as 6.8 than the index of the attached mold slags in the slab according to the prior art.

[0043] FIG. 10 is a graph illustrating a generation rate of surface roughness in a slab of cold rolled coil according to the present invention. Referring to FIG. 10, the generation rate (%) of surface roughness may be determined by employing the high pressure water spray and the roller brush. Comparing the generation rates (%) of surface roughness of cold rolled coils calculated from the prior art and the present invention, the generation rate of surface roughness of cold rolled coils according to the prior art is measured to be approximately 21.4 (%), whereas the generation rate of surface roughness of cold rolled coils according to the present invention is measured to be approximately 3.1 (%). That is to say, the generation rate of surface roughness of cold rolled coils is shown to be lower as much as 18.3 (%) than the generation rate of surface roughness of cold rolled coils according to the prior art if the slab is cleaned lowered with the sudden decrease in the spray impact pressure if the spraying distance exceeds 200 mm.

[0044] Also, the three 75 KW pumps for driving the water spray 180 are used to meet the set flow rate and the set pressure as described above.
As described above, foreign substance (i.e., scale, mold slag and the like) present in the slab surface is removed with a strong spray impact pressure of the high-pressure spray, and foreign substance attached inside the slab 170 is completely removed using a high-speed rotating roller brush 190. For example, the roller brush 190 is spaced apart from the water spray 180 and symmetrically installed in upper and lower parts of a surface of the slab 170, and then rotated to give a friction to the surface of the slab 170 so as to peel off the mold slag and scale. At this time, the width of the roller brush 190 is set to 1000 mm in consideration of the width of the produced slab and the defect generation position, which is effective to remove the foreign substance.

As described above, the slab 170 with a clean surface may be charged into a heating furnace and hot-rolled under conventional heating and rolling conditions by removing foreign substance from the surface of the slab 170 using the water spray 180 and the roller brush 190.

FIG. 9 is a graph illustrating an amount index of the mold slag attached onto a surface of the slab according to the present invention; and

Referring to FIG. 9, this is a graph showing amounts of mold slag in test using the high-pressure water spray and the roller brush.

Although exemplary embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes might be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

1. An improvement apparatus of surface roughness defect of hot/cold rolled stainless steel, comprising:
   - at least one water spray unit installed to spray water on a surface of the cast stainless steel slab along a slab supporting roll;
   - a cutting unit arranged in a tip of the water spray unit and cutting the stainless steel slab congealed with the water spray unit;
   - a high-pressure water spray having at least one nozzle in a region where the stainless steel slab is cut by the cutting unit and discharged and installed to be symmetric in upper and lower parts of the stainless steel slab; and
   - a roller brush installed to be in contact with and symmetric in the upper and lower parts of the stainless steel slab passed through the water spray so as to rotate at a high speed.

2. The improvement apparatus of surface roughness defect of hot/cold rolled stainless steel according to claim 1, wherein a flow rate of the water spray sprayed on the surface of the cut stainless steel slab ranges from 200 to 300 l/min, and a water pressure in the nozzle of the water spray ranges from 100 to 200 bar.

3. The improvement apparatus of surface roughness defect of hot/cold rolled stainless steel according to claim 1, wherein a distance from the tip of the nozzle to the surface of the cut stainless steel slab ranges from 100 to 200 mm.

4. The improvement apparatus of surface roughness defect of hot/cold rolled stainless steel according to claim 1, further comprising a sensor for sensing a position of the cut stainless steel slab in one region in a casting direction of the water spray installed in the lower part of the cut stainless steel slab and in the other region in a casting direction of the roller brush installed in the lower part of the cut stainless steel slab.

5. An improvement method of surface roughness defect of hot/cold rolled stainless steel, comprising steps:
   - spraying water on a surface of a cast stainless steel slab;
   - cutting the water-sprayed stainless steel slab; and
   - removing foreign substance from a surface of the cut stainless steel slab using a high-pressure water spray and a roller brush.

6. The improvement method of surface roughness defect of hot/cold rolled stainless steel according to claim 5, wherein a flow rate of the high-pressure water spray sprayed on the surface of the cut stainless steel slab ranges from 200 to 300 l/min, and a water pressure in the nozzle of the water spray ranges from 100 to 200 bar.

7. The improvement method of surface roughness defect of hot/cold rolled stainless steel according to claim 6, wherein a distance from the tip of the nozzle to the surface of the cut stainless steel slab ranges from 100 to 200 mm.

8. The improvement method of surface roughness defect of hot/cold rolled stainless steel according to claim 5, wherein the step of removing foreign substance from a surface of the cut stainless steel slab using a high-pressure water spray and a roller brush further comprises a step of including a sensor for sensing a position of the cut stainless steel slab.

9. The improvement method of surface roughness defect of hot/cold rolled stainless steel according to claim 5, after the step of removing foreign substance from a surface of the cut stainless steel slab using a high-pressure water spray and a roller brush, further comprising a step of charging the cut stainless steel slab into a heating furnace and hot-rolling the cut stainless steel slab.