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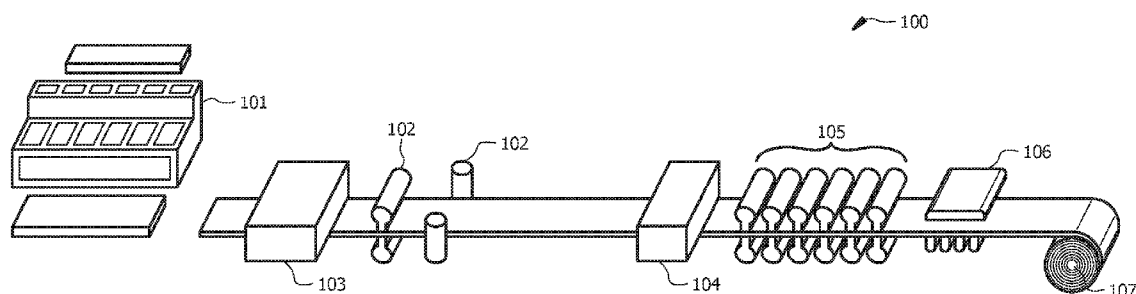


FIG. 1

(57) Abstract: A system and a method for producing high carbon steel with minimum surface and/or edge defects are disclosed. High carbon steel is provided to a hot rolling system. The steel is subsequently descaled, cropped, finished-rolled, and coiled to form steel coils. Throughout the whole process, the coiling of the steel is conducted at a temperature above 620 °C to substantially prevent formation of surface and edge defects on the steel.

PRODUCTION OF API 5CT J55 GRADE FOR QUENCH AND TEMPERING APPLICATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority of U.S. Provisional Patent
5 Application No. 62/809,952, filed February 25, 2019, which is hereby incorporated by
reference in its entirety.

FIELD OF INVENTION

[0002] The present invention generally relates to steel production processes. More
specifically, the present invention relates to processes for producing high carbon steel with
10 minimum surface and edge defects.

BACKGROUND OF THE INVENTION

[0003] Steel coils of API 5CT J55 grade are commonly used for producing pipes for
casings or for tubing. To produce pipes that can be used in the petroleum industry, steel coils
have to be sufficiently strong and tough. Grade API (American Petroleum Institute) 5CT J55
15 steel grade is produced in high carbon content, for subsequent quenching and tempering after
pipes are formed.

[0004] Currently, high carbon steel (e.g., Grade API 5CT J55) coils are
predominantly produced via hot rolling processes including steps of reheating, descaling,
roughing rolling, cropping, finishing rolling, and coiling. One of the most important steps in
20 the hot rolling process for the production of Grade API 5CT J55 steel coils includes re-
heating which induces plasticity due to phase transformation and coiling at optimum
temperature which imparts desired microstructure and strength to steel strip. The
uncontrolled temperature regime during rolling process and method of reduction & sizing of
roll stock can lead to surface and edge defects on the produced steel coils. The quality and
25 value of the steel coils can be greatly reduced by these defects, resulting in the defected steel
failing to meet the industrial standards for many applications.

[0005] Overall, while methods of producing high carbon steel and/or steel pipes via
hot rolling exist, the need for improvements in this field persists in light of at least the
aforementioned drawbacks for the methods.

BRIEF SUMMARY OF THE INVENTION

[0006] A solution to at least some of the above-mentioned problems associated with manufacturing of high carbon steel via hot rolling has been discovered. The solution resides in a method of producing steel comprising rolling the high carbon steel and maintaining a coiling temperature of the steel above 620 °C throughout the steel rolling process. The produced coil can be further processed to form pipes. This can be beneficial for at least preventing the steel from transformation to hard phases such as Bainite phase and Martensite phase in steel and imparting optimum ductility in steel during rolling, thereby minimizing occurrence of surface and edge defects on the steel. Hence, the method is capable of ensuring the quality and value of high carbon steel coils, which can be used to produce pipes and further quenched and tempered to achieve the desired mechanical properties. Therefore, the methods of the present invention provide a technical achievement over at least some of the problems associated with the currently available methods of hot-rolling high steels mentioned above.

[0007] Embodiments of the invention include a method of producing steel. The method comprises supplying, to a rolling mill, steel comprising 0.14 to 0.40 wt. % carbon. The method further comprises rolling the steel, in a hot rolling mill, to form a coil, while maintaining the coiling temperature of the steel above 620 °C.

[0008] Embodiments of the invention include a method of producing steel. The method comprises supplying, to a rolling mill, steel comprising 0.14 to 0.40 wt. % carbon. The method further comprises rolling the steel, in a hot strip mill, to form a coil, while maintaining the coiling temperature of the steel above 620 °C throughout the rolling.

[0009] The following includes definitions of various terms and phrases used throughout this specification.

[0010] The terms “about” or “approximately” are defined as being close to as understood by one of ordinary skill in the art. In one non-limiting embodiment the terms are defined to be within 10%, preferably within 5%, more preferably within 1%, and most preferably within 0.5%.

[0011] The terms “wt. %”, “vol. %” or “mol. %” refer to a weight, volume, or molar percentage of a component, respectively, based on the total weight, the total volume, or the

total moles of material that includes the component. In a non-limiting example, 10 moles of component in 100 moles of the material is 10 mol.% of component.

[0012] The term “substantially” and its variations are defined to include ranges within 10%, within 5%, within 1%, or within 0.5%.

5 **[0013]** The terms “inhibiting” or “reducing” or “preventing” or “avoiding” or any variation of these terms, when used in the claims and/or the specification, include any measurable decrease or complete inhibition to achieve a desired result.

[0014] The term “effective,” as that term is used in the specification and/or claims, means adequate to accomplish a desired, expected, or intended result.

10 **[0015]** The use of the words “a” or “an” when used in conjunction with the term “comprising,” “including,” “containing,” or “having” in the claims or the specification may mean “one,” but it is also consistent with the meaning of “one or more,” “at least one,” and “one or more than one.”

15 **[0016]** The words “comprising” (and any form of comprising, such as “comprise” and “comprises”), “having” (and any form of having, such as “have” and “has”), “including” (and any form of including, such as “includes” and “include”) or “containing” (and any form of containing, such as “contains” and “contain”) are inclusive or open-ended and do not exclude additional, unrecited elements or method steps.

20 **[0017]** The process of the present invention can “comprise,” “consist essentially of,” or “consist of” particular ingredients, components, compositions, etc., disclosed throughout the specification.

25 **[0018]** The term “primarily,” as that term is used in the specification and/or claims, means greater than any of 50 wt. %, 50 mol. %, and 50 vol. %. For example, “primarily” may include 50.1 wt. % to 100 wt. % and all values and ranges there between, 50.1 mol. % to 100 mol. % and all values and ranges there between, or 50.1 vol. % to 100 vol. % and all values and ranges there between.

[0019] Other objects, features and advantages of the present invention will become apparent from the following figures, detailed description, and examples. It should be understood, however, that the figures, detailed description, and examples, while indicating

specific embodiments of the invention, are given by way of illustration only and are not meant to be limiting. Additionally, it is contemplated that changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description. In further embodiments, features from specific embodiments may be combined with features from other embodiments. For example, features from one embodiment may be combined with features from any of the other embodiments. In further embodiments, additional features may be added to the specific embodiments described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

10 [0020] For a more complete understanding, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

[0021] FIG. 1 shows a schematic diagram of a system for producing steel, according to embodiments of the invention; and

15 [0022] FIG. 2 shows a schematic flowchart of a method of producing steel, according to embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Currently, high carbon steels are produced via steel making and hot rolling process that includes steps of melting, refining, and continuous casting of steel to produce slabs. Hot rolling includes reheating, descaling, rolling, cropping, finishing, and coiling. However, surface and edge defects can frequently occur on the produced steel coils via the currently available hot rolling process, thereby reducing the product quality of the steel and increasing the cost for producing steels that meet the industrial standards for various applications. The present invention provides a solution to the problem. The solution is premised on a method that includes maintaining the coiling temperature above 620 °C during the whole hot-rolling steel production process. The high coiling temperature is capable of minimizing the transformation of the steel to hard phases and improving ductility in steel, thereby substantially preventing the formation of surface and/or edge defects on the produced steel coils. These and other non-limiting aspects of the present invention are discussed in further detail in the following sections.

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A. System for producing high carbon steels

[0024] In embodiments of the invention, the system for producing steels can include a hot rolling system. With reference to FIG. 1, a schematic diagram is shown of hot rolling system 100 that is capable of producing high carbon steels. Hot rolling system 100 can be configured to reheat semi-finished steel slabs, roll the semi-finished slabs into a desired dimension, and coil the rolled steel. In embodiments of the invention, hot rolling system 100 can include a hot strip mill.

[0025] According to embodiments of the invention, hot rolling system 100 includes reheat furnace 101. Reheat furnace 101 is capable of heating semi-finished steel to a target temperature that is sufficient to induce plasticity required for rolling. In embodiments of the invention, the target temperature may be in a range of 1200 °C to 1240 °C and all ranges and values there between including 1200 to 1205 °C, 1205 to 1210 °C, 1210 to 1215 °C, 1215 to 1220 °C, 1220 to 1225 °C, 1225 to 1230 °C, 1230 to 1235 °C, and 1235 to 1240 °C. In embodiments of the invention, reheat furnace 101 may further include transferring means configured to carry the semi-finished steel there through. Non-limiting examples of transferring means may include mechanical arms and a plurality of skids configured to move semi-finished steel from an entrance to an exit of reheat furnace 101.

[0026] When the semi-finished steel slabs pass through reheat furnace 101, oxidized iron may form scales on the surface of the steel slabs. Descaling unit 103 may be installed upstream to roughing mill 102 to remove oxidized iron on the surface of reheated semi-finished steel slabs before they enter roughing mill 102. According to embodiments of the invention, the descaling unit includes one or more high pressure water sprayers. The sprayers may be configured to spray water at a pressure of 2600 to 3335 psi to wash off the scales.

[0027] In embodiments of the invention, reheat furnace 101 may be connected to a roughing mill 102 via the transferring means. Roughing mill 102 can be configured to roll the preheated semi-finished steel slabs into transfer bars, which is thinner than the semi-finished steel slabs. According to embodiments of the invention, the thin transfer bars may have a thickness in a range of 28 to 52 mm and all ranges and values there between. According to embodiments of the invention, roughing mill 102 may include a plurality of rolling mill stands. At least one rolling mill stand of roughing mill 102 includes edger rolls that are substantially perpendicular to the preheated semi-finished steel slab. The edger rolls

can be configured to confine a width of the semi-finished steel slabs when they are rolled thinner in roughing mill 102.

[0028] In embodiments of the invention, hot rolling system 100 further includes cropping unit 104 configured to crop uneven ends and surfaces of transfer bars from
5 descaling unit 103. According to embodiments of the invention, cropping unit 104 may include one or more disc and drum shears. The cropping of transfer bars is configured to ensure a square and/or rectangular sectional surface through lengths of the transfer bars such that transfer bars thread the subsequent process units without causing damage to the subsequent process units.

[0029] According to embodiments of the invention, hot rolling system 100 may further include finishing mill 105 configured to further roll the transfer bars into final steel strips and/or sheets of desired dimensions. In certain aspects, finishing mill 105 can include a plurality of finish-rolling stands aligned in series. The position of each finish-rolling stand and the rolling speed of the finish-rolling stands are determined such that transfer bar can be
15 rolled at a desired finish rolling temperature at the last finish-rolling stand of finishing mill 105. Each transfer bar can be rolled through all the finish-rolling stands in one pass-through. In embodiments of the invention, a rolling force in finishing mill can be in a range of 6000 to 30000 KN (6 Mega Newton to 30 Mega Newton) and all ranges and values there between including 6000 to 7000 KN, 7000 to 8000 KN, 8000 to 9000 KN, 9000 to 10000 KN, 10000
20 to 11000 KN, 11000 to 12000 KN, 12000 to 13000 KN, 13000 to 14000 KN, 14000 to 15000 KN, 15000 to 16000 KN, 16000 to 17000 KN, 17000 to 18000 KN, 18000 to 19000 KN, 19000 to 20000 KN, 20000 to 21000 KN, 21000 to 22000 KN, 22000 to 23000 KN, 23000 to 24000 KN, 24000 to 25000 KN, 25000 to 26000 KN, 26000 to 27000 KN, 27000 to 28000 KN, 28000 to 29000 KN, and 29000 to 30000 KN.

[0030] In embodiments of the invention, hot rolling system 100 further includes cooling unit 106 installed downstream to finishing mill 105. Cooling unit 106 may be configured to cool each final steel strip or sheet to a temperature in a range of 620 to 680 °C and all ranges and values there between including 620 to 625 °C, 625 to 630 °C, 630 to 635
25 °C, 635 to 640 °C, 640 to 645 °C, 645 to 650 °C, 650 to 655 °C, 655 to 660 °C, 660 to 665 °C, 665 to 670 °C, 670 to 675 °C, and 675 to 680 °C. The cooling unit 106 may include a plurality of nozzles configured to spray cooling medium for cooling the final steel strips and/or sheets. A non-limiting example of the cooling medium is water. According to
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embodiments of the invention, a cooling rate can be in a range of 5 °C/s to 25 °C/s and all ranges and values there between including ranges of 5 to 6 °C/s, 6 to 7 °C/s, 7 to 8 °C/s, 8 to 9 °C/s, 9 to 10 °C/s, 10 to 11 °C/s, 11 to 12 °C/s, 12 to 13 °C/s, 13 to 14 °C/s, 14 to 15 °C/s, 15 to 16 °C/s, 16 to 17 °C/s, 17 to 18 °C/s, 18 to 19 °C/s, 19 to 20 °C/s, 20 to 21 °C/s, 21 to 22 °C/s, 22 to 23 °C/s, 23 to 24 °C/s, and 24 to 25 °C/s. The specific cooling rate may be dependent on the final rolling temperature and thickness of strip and composition of the steel. According to embodiments of the invention, hot rolling system 100 can further include coiling unit 107 configured to coil the final steel strips while maintaining a coiling temperature. In embodiments of the invention, the coiling temperature may be in a range of 620 to 680 °C and all ranges and values there between including ranges of 620 to 625 °C, 625 to 630 °C, 630 to 635 °C, 635 to 640 °C, 640 to 645 °C, 645 to 650 °C, 650 to 655 °C, 655 to 660 °C, 660 to 665 °C, 665 to 670 °C, 670 to 675 °C, and 675 to 680 °C.

[0031] According to embodiments of the invention, hot rolling system 100 may include a control system. The control system may be configured to control the temperature of reheat furnace 101, the rolling speed of the rolling stands, the distance between rollers, water pressure of descaling unit 103, the cooling rate of the final steel strips in cooling unit 106, and coiling temperature in coiling unit 107. In embodiments of the invention, the control system may be capable of adjusting rolling force and the strip speed at each roll in the finish-rolling stands to ensure that the transfer bars tread through finishing mill 105 without stretching or tearing and the final rolled steels meet all the desired quality standards. In embodiments of the invention, hot rolling system 100 may further include one or more quality inspection unit(s) configured to monitor the defect formation in the steel throughout the production process.

B. Method of producing steel

[0032] A method of producing steel via a hot rolling process has been discovered to minimize the occurrence of surface and edge defects on the steel. As shown in FIG. 2, embodiments of the invention include method 200 for producing steel. Method 200 may be implemented by hot rolling system 100 as shown in FIG. 1. According to embodiments of the invention, method 200 includes supplying, to hot rolling system 100, steel as shown in block 201. The steel can comprise 0.14 to 0.40 wt. % carbon and all ranges and values there between including ranges of 0.14 to 0.16 wt. %, 0.16 to 0.18 wt. %, 0.18 to 0.20 wt. %, 0.20 to 0.22 wt. %, 0.22 to 0.24 wt. %, 0.24 to 0.26 wt. %, 0.26 to 0.28 wt. %, 0.28 to 0.30 wt. %, 0.30 to 0.32 wt. %, 0.32 to 0.34 wt. %, 0.34 to 0.36 wt. %, 0.36 to 0.38 wt. %, 0.38 to 0.40 wt. %, and 0.40 to 0.42 wt. %.

0.30 to 0.32 wt. %, 0.32 to 0.34 wt. %, 0.34 to 0.36 wt. %, 0.36 to 0.38 wt. %, and 0.38 to 0.40 wt. %. In embodiments of the invention, the steel supplied at block 201 may include semi-finished steel.

[0033] According to embodiments of the invention, method 200 further includes
5 rolling the steel, in hot rolling system 100, to form a coil while maintaining a coiling temperature of the steel above 620 °C throughout the rolling step, as shown in block 202. In embodiments of the invention, the rolling at block 202 includes reheating the steel including semi-finished steel provided at unit 101 at a reheating temperature of 1200 to 1240 °C and all ranges and values there between including ranges of 1200 to 1205 °C, 1205 to 1210 °C, 1210
10 to 1215 °C, 1215 to 1220 °C, 1220 to 1225 °C, 1225 to 1230 °C, 1230 to 1235 °C, and 1235 to 1240 °C.

[0034] The rolling at block 202 may further include descaling the transfer bars in descaling unit 103, and cropping uneven surface(s) of the transfer bar(s) in cropping unit 104. The rolling at block 202 may further still include finish-rolling, at finishing mill 105, the
15 cropped transfer bars at a finish rolling temperature to form steel strips and/or sheets of desired dimensions. In embodiments of the invention, the finish-rolling temperature may be in a range of 750 to 1060 °C and all ranges and values there between including ranges of 750 to 775 °C, 775 to 800 °C, 800 to 825 °C, 825 to 850 °C, 850 to 875 °C, 875 to 900 °C, 900 to 925 °C, 925 to 950 °C, 950 to 975 °C, 975 to 1000 °C, 1000 to 1025 °C, 1025 to 1050 °C, and
20 1050 to 1060 °C. The rolling at block 202 may further still include, in cooling unit 106, cooling the steel from finishing mill to a temperature of 620 to 680 °C and all ranges and values there between including ranges of 620 to 625 °C, 625 to 630 °C, 630 to 635 °C, 635 to 640 °C, 640 to 645 °C, 645 to 650 °C, 650 to 655 °C, 655 to 660 °C, 660 to 665 °C, 665 to 670 °C, 670 to 675 °C, and 675 to 680 °C. The rolling at block 202 may further include
25 coiling the cooled steel from cooling unit 106 to form a coil. In embodiments of the invention, coiling is conducted at a coiling temperature of above 620 °C, and preferably 620 to 680 °C and all ranges and values there between including ranges of 620 to 625 °C, 625 to 630 °C, 630 to 635 °C, 635 to 640 °C, 640 to 645 °C, 645 to 650 °C, 650 to 655 °C, 655 to 660 °C, 660 to 665 °C, 665 to 670 °C, 670 to 675 °C, and 675 to 680 °C.

30 [0035] Although embodiments of the present invention have been described with reference to blocks of FIG. 2, it should be appreciated that operation of the present invention is not limited to the particular blocks and/or the particular order of the blocks illustrated in

FIG. 2. Accordingly, embodiments of the invention may provide functionality as described herein using various blocks in a sequence different than that of FIG. 2.

[0036] As part of the disclosure of the present invention, a specific example is included below. The example is for illustrative purposes only and is not intended to limit the invention. Those of ordinary skill in the art will readily recognize parameters that can be changed or modified to yield essentially the same results.

EXAMPLE

(Phase transformation under various coiling temperatures)

[0037] Chemical compositions of steel were simulated in JMatPro[®] to identify the phase transformation temperatures for each of austenite to ferrite, austenite to pearlite, and austenite to Bainite and Austenite to Martensite phase transformation. The results indicate that coiling temperatures of 620 to 680 °C for high carbon steel grade are suitable to this temperature range to avoid transformation of austenite to hard phases during cooling which subsequently leads to hard spots and edge defects. Therefore, the coiling temperature was set as more than 620 °C. With higher coiling temperature, the rolling was smooth and coils were substantially defect free. Based on the results of chemical composition analysis, the optimal coiling temperature is in a range of 620 to 680 °C for producing high carbon steel.

[0038] In the context of the present invention, at least the following 16 embodiments are described. Embodiment 1 is a method of producing steel. The method includes supplying, to a rolling mill, steel comprising 0.14 to 0.40 wt. % carbon. The method further includes rolling the steel, in hot strip mill, to form a coil, while maintaining the coiling temperature of the steel above 620 °C throughout the rolling. Embodiment 2 is the method of embodiment 1, wherein the steel is suitable for pipe manufacturing and/or casing and tubing manufacturing. Embodiment 3 is the method of either of embodiments 1 or 2, wherein the method is capable of substantially avoiding surface and edge defects on the steel. Embodiment 4 is the method of embodiment 3, wherein the method is capable of substantially avoiding the steel phase transformation to Bainitic/martensitic structure. Embodiment 5 is the method of any of embodiments 1 to 4, wherein the steel is produced in a continuous process. Embodiment 6 is the method of any of embodiments 1 to 5, wherein the rolling mill is a hot strip mill. Embodiment 7 is the method of any of embodiments 1 to 6, wherein the step of rolling the steel in the hot strip mill comprises reheating the steel at a reheating temperature of 1200 to 1240 °C. Embodiment 8 is the method of embodiment 7,

wherein the step of rolling the steel in the hot strip mill further includes descaling the reheated steel to form descaled steel, cropping the descaled steel to form cropped steel, finishing-rolling the cropped steel to form finished steel, and coiling the finished steel into coils.

5 **[0039]** Embodiment 9 is method of producing steel. The method includes the steps of supplying, to a rolling mill, steel comprising 0.14 to 0.40 wt. % carbon; and rolling the steel, in hot strip mill, to form a coil, while maintaining the coiling temperature of the steel above 620 °C throughout the length of the coil. Embodiment 10 is the method of embodiment 9, wherein the steel is suitable for pipe manufacturing and/or casing and tubing
10 manufacturing. Embodiment 11 is the method of either of embodiments 9 or 10, wherein the method is capable of substantially avoiding surface and edge defects on the steel. Embodiment 12 is the method of embodiment 11, wherein the method is capable of substantially avoiding the steel phase transformation to Bainitic/martensitic structure. Embodiment 13 is the method of any of embodiments 9 to 12, wherein the steel is produced
15 in a continuous process. Embodiment 14 is the method of any of embodiments 9 to 13, wherein the rolling mill is a hot strip mill. Embodiment 15 is the method of any of embodiments 9 to 15, wherein the step of rolling the steel in the hot strip mill comprises reheating the steel at a re-heating temperature of 1200 to 1240 °C. Embodiment 16 is the method of embodiment 15, wherein the step of rolling the steel in the hot strip mill further
20 includes descaling the reheated steel to form descaled steel, cropping the descaled steel to form cropped steel, finishing-rolling the cropped steel to form finished steel, and coiling the finished steel into coils.

Although embodiments of the present application and their advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be
25 made herein without departing from the spirit and scope of the embodiments as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the above disclosure, processes, machines, manufacture,
30 compositions of matter, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized. Accordingly, the appended

claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

CLAIMS

What is claimed is:

1. A method of producing steel, the method comprising:
supplying, to a rolling mill, steel comprising 0.14 to 0.40 wt. % carbon; and
rolling the steel, in hot strip mill, to form a coil, while maintaining the coiling temperature of the steel above 620 °C throughout the length of the coil.
2. The method of claim 1, wherein the steel is suitable for pipe manufacturing and/or casing and tubing manufacturing.
3. The method of any of claims 1 and 2, wherein the method is capable of substantially avoiding surface and edge defects on the steel.
4. The method of claim 3, wherein the method is capable of substantially avoiding the steel phase transformation to Bainitic/martensitic structure.
5. The method of any of claims 1 to 4, wherein the steel is produced in a continuous process.
6. The method of any of claims 1 to 5, wherein the rolling mill is a hot strip mill.
7. The method of any of claims 1 to 6, wherein the step of rolling the steel in the hot strip mill comprises reheating the steel at a re-heating temperature of 1200 to 1240 °C.
8. The method of claim 7, wherein the step of rolling the steel in the hot strip mill further comprises descaling the reheated steel to form descaled steel, cropping the descaled steel to form cropped steel, finishing-rolling the cropped steel to form finished steel, and coiling the finished steel into coils.

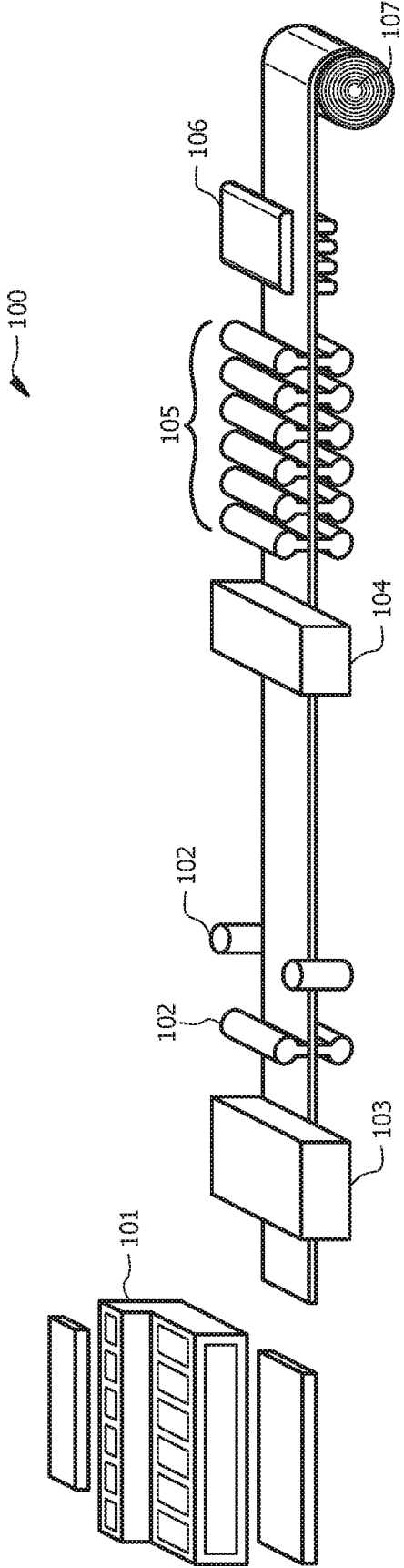
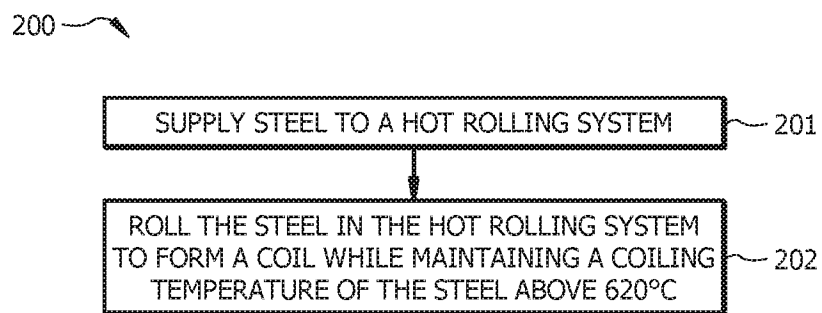


FIG. 1

*FIG. 2*

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2020/051563

A. CLASSIFICATION OF SUBJECT MATTER

INV. C21D8/02 C21D9/52 C22C38/00
ADD.

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)

C21D C22C 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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 2016 0082602 A (POSCO [KR]) 8 July 2016 (2016-07-08) abstract paragraphs [0019], [0029], [0072], [0075], [0077], [00957]; examples A-I; table 1 & 3 -----	1-8
X	JP 2006 265583 A (SUMITOMO METAL IND) 5 October 2006 (2006-10-05) examples B-I; table 1 paragraphs [0065], [0069]; examples H6,H11,H17,H19,H22,H24; table 2 -----	1,3,4,7
X	CN 101 153 367 A (SHANGHAI MEISHAN IRON & STEEL [CN]) 2 April 2008 (2008-04-02) abstract; example 1; tables 1-2 page 2, paragraph 3 ----- -/-	1,3



Further documents are listed in the continuation of Box C.



See patent family annex.

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