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(54) CONTINUOUS CASTING AND ROLLING APPARATUS AND CONTINUOUS CASTING AND ROLLING METHOD

(57) A continuous casting and rolling apparatus, according to an embodiment of the present invention, comprises: a continuous casting machine that produces a slab; a rolling mill that includes a roughing mill located on a side of the outlet of the continuous casting machine and a finishing mill located on a side of the outlet of the roughing mill and makes the slab subjected to rolling; a cutting machine located on a side of the inlet of the roughing mill and/or on a side of the inlet of the finishing mill; and a controller that is electrically connected with the cutting machine to control the driving of the cutting machine and determines whether to perform mode switching between a continuous rolling mode in which the slab is supplied as a continuous body from the continuous casting machine and the rolling mill and a discontinuous rolling mode in which the slab is cut by the cutting machine in order to select the continuous or discontinuous rolling mode, wherein a predetermined expression is satisfied in a case where the controller selects the continuous rolling mode.

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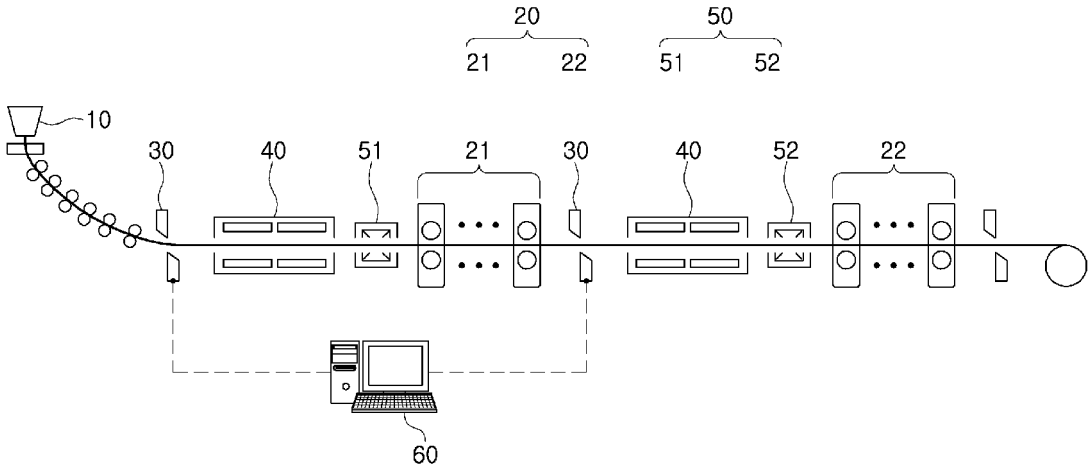

FIG. 1

Description

[Technical Field]

[0001] The present disclosure relates to a continuous casting and rolling apparatus and to a continuous casting and rolling method, and more particularly, to an invention for selecting mode switching between a continuous rolling mode and a discontinuous rolling mode.

[Background Art]

[0002] A process in which rolling is performed in a rolling mill using a high temperature slab, solidified in a caster, is now widely used due to equipment costs and operating costs being lower than those in a process according to the related art.

[0003] Moreover, while a continuous casting and rolling are used, a discontinuous process in which rolling is performed separately to continuous casting may be performed, as disclosed in Korean Patent Application Laid-open Publication No. 1990-7001437.

[0004] In other words, each of a continuous rolling mode continuously performing a continuous casting process and a rolling process and a discontinuous rolling mode discontinuously performing the continuous casting process and the rolling process may be performed.

[0005] Here, in the continuous rolling mode, a slab is continuously provided between a caster and a rolling mill, so that a rolling process in the rolling mill is dependent on a slab production speed, or the like, in the caster. However, in a discontinuous rolling mode, a slab is not continuously provided between a caster and a rolling mill, so a degree to which a rolling process in a rolling mill is dependent on a caster may be mitigated, as compared to that in a continuous rolling mode.

[0006] As described above, process states in a continuous rolling mode and a discontinuous rolling mode may be different. According to the related art, selection of a continuous rolling mode and a discontinuous rolling mode is arbitrary, and selection is not made by any clear criteria.

[0007] In other words, according to the related art, a trial and error process, of confirming whether a continuous rolling mode or a discontinuous rolling mode should be used, is required. In other words, a method of confirming a state of a rolled steel sheet discharged after a process is executed in a continuous rolling mode is used.

[0008] However, in the selection of a mode by a trial and error process, there may be wastage, in which an unnecessary defect product is produced before mode selection. In addition, while a state of a slab is not considered, when a continuous rolling mode or a discontinuous rolling mode is randomly selected, a problem in which a required quality of a rolled steel sheet is not secured may occur.

[0009] Thus, a research into a continuous casting and rolling apparatus and a continuous casting and rolling method is required.

[Disclosure]

[Technical Problem]

[0010] An aspect of the present disclosure may provide a continuous casting and rolling apparatus and a continuous casting and rolling method, selecting mode switching between a continuous rolling mode and a discontinuous rolling mode and producing a rolled steel sheet product in which quality is secured.

[Technical Solution]

[0011] According to an aspect of the present disclosure, a continuous casting and rolling apparatus includes: a caster producing a slab; a rolling mill including a roughing mill located at an outlet of the caster and a finishing mill located at an outlet of the roughing mill, and rolling the slab; a cutter located by at least one of an inlet of the roughing mill or an inlet of the finishing mill; and a controller electrically connected to the cutter and adjusting driving of the cutter, determining whether to perform mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the caster and the rolling mill, and a discontinuous rolling mode in which the slab is cut by the cutter, and selecting the continuous rolling mode or the discontinuous rolling mode. When the controller selects the continuous rolling mode, the following equation is satisfied.

$$HV > \frac{L}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

[0012] Here, H is a slab thickness (mm) at the outlet of the caster, V is a slab speed (m/min) at the outlet of the caster, L is a length (m) from the outlet of the caster to an outlet of the finishing mill, T is an average temperature (°C) of the slab at the outlet of the caster, N_R is a stand number of the roughing mill, N_F is a stand number of the finishing mill, and t is a slab thickness (mm) at an outlet of the finishing mill.

[0013] The continuous casting and rolling apparatus may further include: a heater located at an inlet of at least one of the roughing mill or the finishing mill. When the controller selects the continuous rolling mode, the following equation may be satisfied.

$$HWV > \frac{WL - 3902E_H}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

[0014] Here, W is a slab width (mm) at the outlet of the caster, and E_H is calories (MW) received by the slab.

[0015] The continuous casting and rolling apparatus may further include: a scale remover including a first scale remover located at an inlet of the roughing mill and a second scale remover located at an inlet of the finishing mill. When the controller selects the continuous rolling mode, the following equation may be satisfied.

$$HWV > \frac{WL - 3902E_H}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{P_R}{9180} - \frac{P_F}{18360} - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

[0016] Here, P_R is a pressure (bar) input to the first scale remover, and P_F is a pressure (bar) input to the second scale remover.

[0017] According to an aspect of the present disclosure, a continuous casting and rolling method includes: a casting operation of producing a slab in a caster; a rolling operation of rolling the slab by a rolling mill; and a mode selection operation of selecting mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the casting operation and the rolling operation, and a discontinuous rolling mode in which the slab is cut before the rolling operation or during the rolling operation, before the rolling operation. In the mode selection operation, the continuous rolling mode is performed when a temperature at an outlet of the rolling mill is equal to or greater than a temperature at which the slab is able to be provided in an austenitic state, and the discontinuous rolling mode is selected and performed when the temperature at an outlet of the rolling mill is lower than the temperature at which the slab is able to be provided in an austenitic state.

[0018] According to an aspect of the present disclosure, a continuous casting and rolling method includes: a casting operation of producing a slab in a caster; a rolling operation of rolling the slab using a roughing mill located at an outlet of the caster and a finishing mill located at an outlet of the roughing mill; and a mode selection operation of selecting mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the casting operation and the rolling operation, and a discontinuous rolling mode in which the slab is cut before the rolling operation or during the rolling operation, before the rolling operation. In the mode selection operation, the continuous rolling mode is performed when the following equation is satisfied, and the discontinuous rolling mode is selected and performed when the following equation is not satisfied.

$$HV > \frac{L}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

[0019] Here, H is a slab thickness (mm) at the outlet of the caster, V is a slab speed (m/min) at the outlet of the caster, L is a length (m) from the outlet of the caster to an outlet of the finishing mill, T is an average temperature (°C) of the slab at the outlet of the caster, N_R is a stand number of the roughing mill, N_F is a stand number of the finishing mill, and

t is a slab thickness (mm) at an outlet of the finishing mill.

[0020] According to an aspect of the present disclosure, a continuous casting and rolling method includes: a casting operation of producing a slab in a caster; a rolling operation of rolling the slab using a roughing mill located at an outlet of the caster and a finishing mill located at an outlet of the roughing mill; a heating operation of heating the slab using a heater located at an inlet of at least one of the roughing mill and the finishing mill; a scale removing operation of removing scale on a surface of the slab by a first scale remover located at an inlet of the roughing mill and a second scale remover located at an inlet of the finishing mill; and a mode selection operation of selecting mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the casting operation and the rolling operation, and a discontinuous rolling mode in which the slab is cut before the rolling operation or during the rolling operation, before the rolling operation. In the mode selection operation, the continuous rolling mode and the discontinuous rolling mode are selected and performed, based on a slab thickness at the outlet of the caster, a slab width at the outlet of the caster, a slab speed at the outlet of the caster, a length from an outlet of a caster to an outlet of a finishing mill, calories received by the slab, an average temperature of a slab at an outlet of a caster, a stand number of the roughing mill, a stand number of the finishing mill, a pressure input to the first scale remover, a pressure input to the second scale remover, and a slab thickness at an outlet of the finishing mill.

[0021] In the mode selection operation, the continuous rolling mode may be performed when the following equation is satisfied, and the discontinuous rolling mode may be selected and performed when the following equation is not satisfied.

$$HWV > \frac{WL - 3902E_H}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{P_R}{9180} - \frac{P_F}{18360} - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

[0022] Here, H is a slab thickness (mm) at the outlet of the caster, W is a slab width (mm) at the outlet of the caster, V is a slab speed (m/min) at the outlet of the caster, L is a length (m) from the outlet of the caster to an outlet of the finishing mill, E_H is calories (MW) received by the slab, T is an average temperature (°C) of the slab at the outlet of the caster, N_R is a stand number of the roughing mill, N_F is a stand number of the finishing mill, P_R is a pressure input to the first scale remover (bar), P_F is a pressure input to the second scale remover (bar), and t is a slab thickness (mm) at an outlet of the finishing mill.

[0023] When the stand number of the roughing mill (N_R) is 0 to 3, the stand number (N_F) of the finishing mill is 5 to 7, the pressure (P_R) input to the first scale remover is 0 to 200 bar, the pressure (P_F) input to the second scale remover is 200 to 300 bar, and the thickness (t) of the slab at an outlet of the finishing mill is 1.0 to 3.0 mm, in the mode selection operation, the continuous rolling mode may be performed when the following equation is satisfied, and the discontinuous rolling mode may be selected and performed when the following equation is not satisfied.

$$HWV > \frac{WL - 3902E_H}{\frac{T}{2295} - A}$$

[0024] Here, A is 0.3553 to 0.4247.

[0025] When the calories (E_H) received by the slab are 10 to 25 MW, in the mode selection operation, the continuous rolling mode may be performed when the following equation is satisfied, and the discontinuous rolling mode may be selected and performed when the following equation is not satisfied.

$$HWV > \frac{WL - B}{\frac{T}{2295} - A}$$

[0026] Here, A is 0.3553 to 0.4247, and B is 39020 to 97550.

[0027] When the average temperature (T) at the outlet of the caster is 1000 to 1250°C, the stand number (N_R) of the roughing mill is 3, the stand number (N_F) of the finishing mill is 5, the pressure (P_R) input to the first scale remover is 200 bar, the pressure (P_F) input to the second scale remover is 300 bar, and the thickness (t) of the slab at an outlet of the finishing mill is 1.5 mm, in the mode selection operation, the continuous rolling mode may be performed when the following equation is satisfied, and the discontinuous rolling mode may be selected and performed when the following equation is not satisfied.

$$HWV > \frac{WL - 3902E_H}{C}$$

[0028] Here, C is 0.0315 to 0.1404.

[Advantageous Effects]

[0029] According to an exemplary embodiment in the present disclosure, a continuous casting and rolling apparatus and a continuous casting and rolling method may have an effect of securing a quality of a rolled steel sheet product when mode switching between a continuous rolling mode and a discontinuous rolling mode is selected.

[0030] Furthermore, unnecessary prior trial and error processes for selecting a continuous rolling mode and a discontinuous rolling mode are not required, so there is an advantage in which waste of a slab caused by a trial and error process may be reduced.

[Description of Drawings]

[0031]

FIG. 1 is a side view illustrating a continuous casting and rolling apparatus according to an exemplary embodiment.
FIG. 2 is a flow diagram illustrating a continuous casting and rolling method according to an exemplary embodiment.

[Best Mode for Invention]

[0032] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings. Meanwhile, the spirit of the present invention is not limited to the suggested embodiments, and those skilled in the art to which the present invention pertains could easily suggest a further retrogressive invention or another embodiment which falls within the spirit of the present invention through the addition, modification, and deletion of another component without departing from the spirit of the present invention.

[0033] In the following description, components having the same function within the same scope illustrated in the drawings of the embodiments are illustrated by using the same reference numerals.

[0034] A continuous casting and rolling apparatus and a continuous casting and rolling method according to an exemplary embodiment relate to an invention for selecting mode switching between a continuous rolling mode and a discontinuous rolling mode.

[0035] In other words, a continuous casting and rolling apparatus and a continuous casting and rolling method according to an exemplary embodiment are an invention for securing a quality of a product of a rolled steel sheet product when mode switching between a continuous rolling mode and a discontinuous rolling mode is selected.

[0036] Furthermore, unnecessary prior trial and error processes for selecting a continuous rolling mode and a discontinuous rolling mode are not required, so there is an advantage in which wastage of a slab caused by a trial and error process may be reduced.

[0037] In detail, a continuous casting and rolling apparatus according to an exemplary embodiment may include a caster 10 producing a slab, a rolling mill 20 having a roughing mill 21 located at an outlet of the caster 10 and a finishing mill 22 located at an outlet of the roughing mill 21, and rolling the slab, a cutter 30 located in at least one of an inlet of the roughing mill 21 or an inlet of the finishing mill 22, and a controller 60 electrically connected to the cutter 30 and adjusting driving of the cutter 30, determining whether to perform mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the caster 10 and the rolling mill 20, and a discontinuous rolling mode in which the slab is cut by the cutter 30, and selecting the continuous rolling mode or the discontinuous rolling mode. When the controller 60 selects the continuous rolling mode, Equation 1 may be satisfied.

[Equation 1]

$$HV > \frac{L}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

[0038] Here, H is a slab thickness (mm) at an outlet of the caster 10, V is a slab speed (m/min) at an outlet of the

caster 10, L is a length (m) from an outlet of the caster 10 to an outlet of a finishing mill 22, T is an average temperature (°C) of a slab at an outlet of the caster 10, N_R is a stand number of a roughing mill 21, N_F is a stand number of the finishing mill 22, and t is a slab thickness (mm) at an outlet of the finishing mill 22.

[0039] As described above, when Equation 1 is satisfied, a temperature at an outlet of the finishing mill 22 is equal to or greater than a temperature at which a slab or a final rolled steel sheet able to be provided to be in an austenitic state. In this regard, quality of a rolled steel sheet having been produced may be secured. The following equations are also proposed for the same reason.

[0040] The caster 10 may serve to produce a slab from molten steel through a casting process. In other words, the caster 10 provides molten steel from a tundish to a mold, the molten steel having been provided forms a slab while calories are removed, and the slab is guided by a segment roll and a pinch roll and is moved and provided to a rolling mill 20, which will be described later.

[0041] However, as the caster 10 produces a slab depending on a solidification speed of the molten steel, a production speed is limited in terms of being adjusted. Thus, when a slab, produced in the caster 10, is continuously received, and is then rolled by a rolling mill 20, which will be described later, to produce a product, a speed may be limited.

[0042] However, as an average temperature of the slab, having been discharged from the caster 10, is high, there is an advantage of securing a certain temperature required when a rolling operation is performed in the rolling mill 20.

[0043] The rolling mill 20 may serve to produce a rolled steel sheet by receiving the slab, produced in the caster 10, and rolling the slab. To this end, the rolling mill 20 may allow the slab to pass between a pair of rolling rolls to be rolled, and may include a rolling stand in which the pair of rolling rolls are provided.

[0044] In addition, the rolling mill 20 may include a roughing mill 21 performing rolling to obtain an intermediate thickness before a final rolled steel sheet product in which a slab, provided from the caster 10, is rolled to obtain a final thickness, and a finishing mill 22 producing a rolled steel sheet having a final thickness again using the slab, rolled to obtain the intermediate thickness in the roughing mill 21.

[0045] Here, the roughing mill 21 is located at an outlet of the caster 10 and performs a rolling operation by receiving the slab produced by the caster 10, and the finishing mill 22 is located at an outlet of the roughing mill 21 and performs a rolling operation for producing a final rolled steel sheet product by receiving the slab, in which the rolling operation is performed in the roughing mill 21, and performing rolling.

[0046] In detail, the number of rolling stands provided to the roughing mill 21 and the finishing mill 22 may be adjusted according to characteristics of a material of the rolled steel sheet, having been produced, and the like, the number of rolling stands, secured by the roughing mill 21 or the finishing mill 22 in the entirety of equipment, is not the number of rolling stands, provided by the roughing mill 21 or the finishing mill 22, and the number of rolling stands, actually used for driving, among the number of rolling stands, having been secured, is the number of rolling stands provided by the roughing mill 21 or the finishing mill 22.

[0047] The cutter 30 may be provided to cut the slab in a middle portion of the continuous casting and rolling apparatus, in order to perform a discontinuous rolling mode.

[0048] In other words, the cutter 30 may be located at an inlet of the roughing mill 21 or an inlet of the finishing mill 22, and, in detail, may be provided in at least one of a position between the roughing mill 21 and the caster 10 or a position between the finishing mill 22 and the roughing mill 21.

[0049] Furthermore, the cutter 30 may be additionally provided at an outlet of the finishing mill 22, in order to discharge a final rolled steel sheet product, completed by rolling the slab.

[0050] In detail, the cutter 30 is electrically connected to a controller 60, which will be described later, thereby adjusting cutting of the slab. In this regard, the controller 60 selects a continuous rolling mode or a discontinuous rolling mode to be performed.

[0051] In other words, when the controller 60 instructs an operation of the cutter 30 to perform cutting of the slab, a discontinuous rolling mode is performed. When the controller 60 does not instruct an operation of the cutter 30, the slab is provided as a continuous body from the caster 10 to the rolling mill 20, so a continuous rolling mode is performed.

[0052] Here, when the controller 60 does not allow the cutter 30 to be driven and a continuous rolling mode is selected and performed, Equation 1 should be satisfied.

[0053] In other words, when Equation 1 is not satisfied and a continuous rolling mode is performed, a rolled steel sheet product, having been finally produced, is produced as a defective product, so the rolled steel sheet product may not be used and may be discarded.

[0054] In addition, a continuous casting and rolling apparatus according to an exemplary embodiment may further include a heater 40, a scale remover 50, and the like, thereby performing a continuous casting and rolling process.

[0055] In other words, the continuous casting and rolling apparatus according to an exemplary embodiment may further include the heater 40 located at an inlet of at least one of the roughing mill 21 or the finishing mill 22. When the controller 60 selects a continuous rolling mode, Equation 2 is satisfied.

[Equation 2]

$$HWV > \frac{WL - 3902E_H}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

[0056] Here, W is a slab width (mm) at an outlet of the caster 10, and E_H is calories (MW) received by the slab.

[0057] In addition, the heater 40 will be described in further detail. The heater 40 is provided to perform rolling by increasing a temperature to a temperature required for rolling by performing heating, when a temperature due to heat included in a slab transferred from the caster 10 is insufficient to perform rolling using the rolling mill 20.

[0058] To this end, the heater 40 may be provided to have a form in which a burner is provided in a heating furnace, but is preferably provided in a form for induction heating in which heating is performed by an induction coil in order to easily control a heating temperature.

[0059] In addition, the heater 40 is preferably provided at an inlet of the roughing mill 21 or the finishing mill 22, and in detail may be installed in at least one of a position between the cutter 30 and the roughing mill 21 or a position between the roughing mill 21 and the finishing mill 22.

[0060] In detail, when a continuous casting and rolling apparatus, including the heater 40, is performed in a continuous rolling mode, Equation 2 should be satisfied. In this regard, a rolled steel sheet product, having been finally produced, is prevented from being produced as a defective product to not be used and to be discarded.

[0061] Moreover, the continuous casting and rolling apparatus according to an exemplary embodiment may further include a scale remover 50 having a first scale remover 51 located at an inlet of the roughing mill 21 and a second scale remover 52 located at an inlet of the finishing mill 22. When the controller 60 selects a continuous rolling mode, Equation 3 is satisfied.

[Equation 3]

$$HWV > \frac{WL - 3902E_H}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{P_R}{9180} - \frac{P_F}{18360} - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

[0062] Here, P_R is a pressure (bar) input to the first scale remover 51, and P_F is a pressure (bar) input to the second scale remover 52.

[0063] Moreover, the scale remover 50 will be described in further detail. The scale remover 50 serves to remove a foreign substance on a surface of the slab. To this end, the scale remover 50 preferably performs scale removal before the slab enters the roughing mill 21 or the finishing mill 22.

[0064] In other words, the scale remover 50 may provide the first scale remover 51 at an inlet of the roughing mill 21 and the second scale remover 52 at an inlet of the finishing mill 22.

[0065] In detail, when a continuous casting and rolling apparatus, including the heater 40, is performed in a continuous rolling mode, Equation 3 should be satisfied. In this regard, a rolled steel sheet product, having been finally produced, is prevented from being produced as a defective product to not be used and to be discarded.

[0066] For example, when H is 80 mm, W is 1000 mm, V is 6.5 m/min, L is 100 m, E_H is 10 MW, T is 1200°C, N_R is 3, N_F is 5, P_R is 200 bar, P_F is 300 bar, and t is 1.5mm, Equation 3 is satisfied as "520000 > 495395". Under the above conditions, even when a continuous rolling mode is performed, a quality of a required rolled steel sheet may be secured.

[0067] Hereinafter, in addition to the continuous casting and rolling apparatus according to an exemplary embodiment, a continuous casting and rolling method according to another exemplary embodiment will be described.

[0068] In other words, a continuous casting and rolling method according to another exemplary embodiment may include a casting operation of producing a slab in the caster 10, a rolling operation of rolling the slab using the rolling mill 20, and a mode selection operation of selecting mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the rolling operation, and a discontinuous rolling mode in which the slab is cut before the rolling operation or during the rolling operation, before the rolling operation. In the mode selection operation, the continuous rolling mode is performed when a temperature at an outlet of the rolling mill 20 is equal to or greater than a temperature at which the slab is able to be provided in an austenitic state, and the discontinuous rolling mode is selected and performed when a temperature of the rolling mill 20 is lower than the temperature at which the slab is able to be provided in an austenitic state.

[0069] In the casting operation, an operation in which a slab is produced by the caster 10, molten steel is received by

continuous casting and a slab is provided. In this case, the slab, produced at the beginning of the casting operation, is provided to the rolling mill 20 to perform a rolling operation.

[0070] The rolling operation is an operation of producing a product of a rolled steel sheet by receiving the slab produced in the casting operation and rolling the slab.

[0071] Here, the rolling operation may be divided into a rough rolling operation and a finish rolling operation by the roughing mill 21 and the finishing mill 22 to be performed. In other words, the rolling operation may be divided into a rough rolling operation of performing rolling to obtain an intermediate thickness, as an intermediate operation of a final rolled steel sheet thickness in a roughing mill 21 provided in an outlet of the caster 10, and a finish rolling operation of performing rolling to obtain a thickness of the final rolled steel sheet in a finishing mill 22 provided in an outlet of the roughing mill 21.

[0072] The mode selection operation is an operation of selecting the continuous rolling mode and the discontinuous rolling mode, and the mode selection operation is determined according to a slab temperature at an outlet of the rolling mill 20 to be performed.

[0073] In other words, when a temperature of a slab discharged to an outlet of the finishing mill 22 of the rolling mill 20 is equal to or greater than a temperature at which the slab is able to be provided in an austenitic state, a continuous rolling mode is performed. When a temperature of a slab discharged to an outlet of the finishing mill 22 is less than a temperature at which the slab is able to be provided in an austenitic state, a discontinuous rolling mode is performed.

[0074] In addition, dividing of the continuous rolling mode and the discontinuous rolling mode is defined by whether to perform a rolling operation using a slab having been cut, so the mode selection operation should be performed before the rolling operation.

[0075] In further detail, the mode selection operation is preferably performed before the rough rolling operation or the finish rolling operation.

[0076] Thus, as the mode selection operation is performed before the rolling operation, the mode selection operation may be performed before the casting operation.

[0077] Moreover, a continuous casting and rolling method according to another exemplary embodiment may include a casting operation producing a slab in a caster 10, a rolling operation of rolling the slab using a roughing mill 21 located at an outlet of the caster 10 and a finishing mill 22 located at an outlet of the roughing mill 21, and a mode selection operation of selecting mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the casting operation and the rolling operation, and a discontinuous rolling mode in which the slab is cut before the rolling operation or during the rolling operation, before the rolling operation. In the mode selection operation, a continuous rolling mode is performed when Equation 4 is satisfied, and a discontinuous rolling mode is selected and performed when the following equation is not satisfied.

[Equation 4]

$$HV > \frac{L}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

[0078] Here, H is a slab thickness (mm) at an outlet of the caster 10, V is a slab speed (m/min) at an outlet of the caster 10, L is a length (m) from an outlet of the caster 10 to an outlet of a finishing mill 22, T is an average temperature (°C) of a slab at an outlet of the caster 10, N_R is a stand number of the roughing mill 21, N_F is a stand number of the finishing mill 22, and t is a thickness (mm) of a slab at an outlet of the finishing mill 22.

[0079] In other words, in the mode selection operation, a continuous rolling mode and a discontinuous rolling mode may be selected and performed based on Equation 4.

[0080] Moreover, Equation 4 is a condition only satisfied when a heating operation and a scale removal operation, which will be described later, are not included. When the heating operation and the scale removal operation are included, whether to perform mode switching should be determined by Equation 5, which will be described later.

[0081] In other words, a continuous casting and rolling method according to another exemplary embodiment may include a casting operation of producing a slab in a caster 10, a rolling operation of rolling the slab using a roughing mill 21 located at an outlet of the caster 10 and a finishing mill 22 located at an outlet of the roughing mill 21, a heating operation of heating the slab using a heater 40 located at an inlet of at least one of the roughing mill 21 or the finishing mill 22, a scale removing operation of removing scale on a surface of the slab by a first scale remover 51 located at an inlet of the roughing mill 21 and a second scale remover 52 located at an inlet of the finishing mill 22, and a mode selection operation of selecting mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the casting operation and the rolling operation, and a discontinuous rolling mode in which the slab

is cut before the rolling operation or during the rolling operation, before the rolling operation. In the mode selection operation, a continuous rolling mode and a discontinuous rolling mode are selected and performed based on a slab thickness at an outlet of the caster 10, a slab width at an outlet of the caster 10, a slab speed at an outlet of the caster 10, a length from an outlet of the caster 10 to an outlet of the finishing mill 22, calories received by the slab, an average temperature of a slab at an outlet of the caster 10, a stand number of a roughing mill 21, a stand number of a finishing mill 22, a pressure input to a first scale remover 51, a pressure input to a second scale remover 52, and a slab thickness at an outlet of the finishing mill 22 .

[0082] The heating operation is an operation of heating the slab, when a temperature of the slab does not reach a temperature for performing the rolling operation.

[0083] Here, the heating operation may be performed before the rolling operation or during the rolling operation. In other words, the heating operation may be performed before a rough rolling operation of the rolling operation or between a rough rolling operation and a finish rolling operation.

[0084] To this end, the heater 40 described previously is provided at an inlet of the roughing mill 21 or at an inlet of the finishing mill 22 and performs heating with respect to the slab.

[0085] Moreover, the scale removal operation is an operation of removing a foreign substance on a surface of the slab, and may be performed by the scale remover 50 described previously. In detail, the scale removal operation may be performed by a first scale remover 51 at an inlet of the roughing mill 21 or a second scale remover 52 at an inlet of the finishing mill 22.

[0086] Here, in the mode selection operation of the continuous casting and rolling method according to another exemplary embodiment, a continuous rolling mode is performed when Equation 5 is satisfied, and a discontinuous rolling mode is selected and performed when the following equation is not satisfied.

[Equation 5]

$$HWV > \frac{WL - 3902E_H}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{P_R}{9180} - \frac{P_F}{18360} - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

[0087] Here, H is a slab thickness (mm) at an outlet of a caster 10, W is a slab width (mm) at an outlet of the caster 10, V is a slab speed (m/min) at an outlet of the caster 10, L is a length (m) from an outlet of the caster 10 to an outlet of a finishing mill 22, E_H is calories (MW) received by the slab, T is an average temperature (°C) of a slab at an outlet of the caster 10, N_R is a stand number of a roughing mill 21, N_F is a stand number of a finishing mill 22, P_R is a pressure (bar) input to a first scale remover 51, P_F is a pressure (bar) input to a second scale remover 52, and t is a slab thickness (mm) at an outlet of the finishing mill 22.

[0088] In Equation 5, an effect of air cooling in an entire section, an effect of heating in a heater 40, an effect of rolling in a roughing mill 21 and a finishing mill 22, and an effect of a scale removal process in a first scale remover 51 and a second scale remover 52 may be considered.

[0089] First, an effect of air cooling in an entire section occurs due to heat transfer by a temperature difference between a slab and external air, as the slab, generally hot, is exposed to air. In this case, heat is conducted due to conduction inside a material, and heat is transferred due to convection and radiation to external air. Representative variables considering the effect described above are V and L.

[0090] Second, an effect of heating in a heater 40 is an effect caused by heating by a calorie input to the slab in the heater 40. A representative variable considering the effect described above is E_H.

[0091] Third, an effect during rolling in a roughing mill 21 and a finishing mill 22 takes deformation energy, friction energy, and loss energy occurring when a slab is rolled into consideration. In general, rather than a temperature rise effect occurring by the deformation energy and the friction energy, an amount of energy, lost by a rolling roll in a slab, is significant, and, as a result, a temperature is decreased. Representative variables considering the effect described above are N_R and N_F.

[0092] Fourth, an effect by a scale removal process in a first scale remover 51 and a second scale remover 52 is caused by a phenomenon in which cooling is performed by pressure applied by a scale remover 50. In general, when pressure provided by the scale remover 50 is increased, the capability to remove scale is improved, but an amount of energy which a slab loses is increased. Thus, the effect described above is an effect in which a temperature of the slab is decreased. Representative variables considering the effect described above are P_R and P_F.

[0093] Moreover, in a continuous casting and rolling method according to another exemplary embodiment, the stand number (N_R) of the roughing mill 21 is 0 to 3, the stand number (N_F) of the finishing mill 22 is 5 to 7, a pressure (P_R) input to the first scale remover 51 is 0 to 200 bar, a pressure (P_F) input to the second scale remover 52 is 200 to 300 bar, and a thickness (t) of a slab at an outlet of the finishing mill 22 is 1.0 to 3.0 mm. Under conditions described above,

in the mode selection operation, a continuous rolling mode is performed when Equation 6 is satisfied, and a discontinuous rolling mode is selected and performed when the following equation is not satisfied.

[Equation 6]

$$HWV > \frac{WL - 3902E_H}{\frac{T}{2295} - A}$$

[0094] Here, A is 0.3553 to 0.4247.

[0095] Moreover, in a continuous casting and rolling method according to another exemplary embodiment, calories (E_H) received by the slab are 10 to 25 MW. Under conditions described above, in the mode selection operation, a continuous rolling mode is performed when Equation 7 is satisfied, a discontinuous rolling mode is selected and performed when the following equation is not satisfied.

[Equation 7]

$$HWV > \frac{WL - B}{\frac{T}{2295} - A}$$

[0096] Here, A is 0.3553 to 0.4247, and B is 39020 to 97550.

[0097] Moreover, in a continuous casting and rolling method according to another exemplary embodiment, an average temperature (T) at an outlet of the caster 10 is 1000 to 1250°C, the stand number (N_R) of the roughing mill 21 is 3, the stand number (N_F) of the finishing mill 22 is 5, a pressure (P_R) input to the first scale remover 51 is 200 bar, a pressure (P_F) input to the second scale remover 52 is 300 bar, and a slab thickness (t) at an outlet of the finishing mill 22 is 1.5 mm. Under conditions described above, in the mode selection operation, a continuous rolling mode is performed when Equation 8 is satisfied, and a discontinuous rolling mode is selected and performed when the following equation is not satisfied.

[Equation 8]

$$HWV > \frac{WL - 3902E_H}{C}$$

[0098] Here, C is 0.0315 to 0.1404.

[0099] In other words, Equation 6 through Equation 8, equations in which a non-critical variable, among variables of Equation 5, is substituted with a commonly used value, are proposed to more concisely determine the mode selection operation in a general environment.

Claims

1. A continuous casting and rolling apparatus, comprising:

a caster producing a slab;
a rolling mill including a roughing mill located at an outlet of the caster and a finishing mill located at an outlet of the roughing mill, and rolling the slab;
a cutter located in at least one of an inlet of the roughing mill or an inlet of the finishing mill; and
a controller electrically connected to the cutter and adjusting driving of the cutter, determining whether to perform mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the caster and the rolling mill, and a discontinuous rolling mode in which the slab is cut by the cutter, and selecting the continuous rolling mode or the discontinuous rolling mode,
wherein, when the controller selects the continuous rolling mode, the following equation is satisfied,

$$HV > \frac{L}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

where, H is a slab thickness (mm) at an outlet of the caster, V is a slab speed (m/min) at the outlet of the caster, L is a length (m) from the outlet of the caster to an outlet of the finishing mill, T is an average temperature (°C) of the slab at the outlet of the caster, N_R is a stand number of the roughing mill, N_F is a stand number of the finishing mill, and t is a slab thickness (mm) at an outlet of the finishing mill.

2. The continuous casting and rolling apparatus of claim 1, further comprising:

a heater located at an inlet of at least one of the roughing mill or the finishing mill,
wherein, when the controller selects the continuous rolling mode, the following equation is satisfied,

$$HWV > \frac{WL - 3902E_H}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

where, W is a slab width (mm) at the outlet of the caster, and E_H is calories (MW) received by the slab.

3. The continuous casting and rolling apparatus of claim 2, further comprising:

a scale remover including a first scale remover located at an inlet of the roughing mill and a second scale remover located at an inlet of the finishing mill,
wherein, when the controller selects the continuous rolling mode, the following equation is satisfied,

$$HWV > \frac{WL - 3902E_H}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{P_R}{9180} - \frac{P_F}{18360} - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

where, P_R is a pressure (bar) input to the first scale remover, and P_F is a pressure (bar) input to the second scale remover.

4. A continuous casting and rolling method, comprising:

a casting operation of producing a slab in a caster;
a rolling operation of rolling the slab by a rolling mill; and
a mode selection operation of selecting mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the casting operation and the rolling operation, and a discontinuous rolling mode in which the slab is cut before the rolling operation or during the rolling operation, before the rolling operation,
wherein, in the mode selection operation, the continuous rolling mode is performed when a temperature at an outlet of the rolling mill is equal to or greater than a temperature at which the slab is able to be provided in an austenitic state, and the discontinuous rolling mode is selected and performed when the temperature at an outlet of the rolling mill is lower than the temperature at which the slab is able to be provided in an austenitic state.

5. A continuous casting and rolling method, comprising:

a casting operation of producing a slab in a caster;
a rolling operation of rolling the slab using a roughing mill located at an outlet of the caster and a finishing mill located at an outlet of the roughing mill; and
a mode selection operation of selecting mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the casting operation and the rolling operation, and a discontinuous rolling

mode in which the slab is cut before the rolling operation or during the rolling operation, before the rolling operation,
wherein, in the mode selection operation, the continuous rolling mode is performed when the following equation is satisfied, and the discontinuous rolling mode is selected and performed when the following equation is not satisfied,

$$HV > \frac{L}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

where, H is a slab thickness (mm) at the outlet of the caster, V is a slab speed (m/min) at the outlet of the caster, L is a length (m) from an outlet of the caster to an outlet of the finishing mill, T is an average temperature (°C) of the slab at the outlet of the caster, N_R is a stand number of the roughing mill, N_F is a stand number of the finishing mill, and t is a slab thickness (mm) at an outlet of the finishing mill.

6. A continuous casting and rolling method, comprising:

a casting operation of producing a slab in a caster;
a rolling operation of rolling the slab using a roughing mill located at an outlet of the caster and a finishing mill located at an outlet of the roughing mill;
a heating operation of heating the slab using a heater located at an inlet of at least one of the roughing mill and the finishing mill;
a scale removing operation of removing scale on a surface of the slab by a first scale remover located at an inlet of the roughing mill and a second scale remover located at an inlet of the finishing mill; and
a mode selection operation of selecting mode switching between a continuous rolling mode in which the slab is provided as a continuous body in the casting operation and the rolling operation, and a discontinuous rolling mode in which the slab is cut before the rolling operation or during the rolling operation, before the rolling operation,
wherein, in the mode selection operation, the continuous rolling mode and the discontinuous rolling mode are selected and performed, based on a slab thickness at the outlet of the caster, a slab width at the outlet of the caster, a slab speed at the outlet of the caster, a length from an outlet of a caster to an outlet of a finishing mill, calories received by the slab, an average temperature of a slab at an outlet of a caster, a stand number of the roughing mill, a stand number of the finishing mill, a pressure input to the first scale remover, a pressure input to the second scale remover, and a slab thickness at an outlet of the finishing mill.

7. The continuous casting and rolling method of claim 6, wherein, in the mode selection operation, the continuous rolling mode is performed when the following equation is satisfied, and the discontinuous rolling mode is selected and performed when the following equation is not satisfied,

$$HWV > \frac{WL - 3902E_H}{\left[\frac{T}{2295} - \frac{1}{153}N_R - \frac{2}{459}N_F - \frac{P_R}{9180} - \frac{P_F}{18360} - \frac{17}{4074}(t-2) - \frac{50}{153}\right]}$$

where, H is a slab thickness (mm) at the outlet of the caster, W is a slab width (mm) at the outlet of the caster, V is a slab speed (m/min) at the outlet of the caster, L is a length (m) from the outlet of the caster to an outlet of the finishing mill, E_H is calories (MW) received by the slab, T is an average temperature (°C) of the slab at the outlet of the caster, N_R is a stand number of the roughing mill, N_F is a stand number of the finishing mill, P_R is a pressure (bar) input to the first scale remover, P_F is a pressure (bar) input to the second scale remover, and t is a slab thickness (mm) at an outlet of the finishing mill.

8. The continuous casting and rolling method of claim 7, wherein, when the stand number (N_R) of the roughing mill is 0 to 3, the stand number (N_F) of the finishing mill is 5 to 7, the pressure (P_R) input to the first scale remover is 0 to 200 bar, the pressure (P_F) input to the second scale remover is 200 to 300 bar, and the thickness (t) of the slab at an outlet of the finishing mill is 1.0 to 3.0 mm,
in the mode selection operation, the continuous rolling mode is performed when the following equation is satisfied, and the discontinuous rolling mode is selected and performed when the following equation is not satisfied,

$$HWV > \frac{WL - 3902E_H}{\frac{T}{2295} - A}$$

where, A is 0.3553 to 0.4247.

9. The continuous casting and rolling method of claim 8, wherein, when the calories (E_H) received by the slab are 10 to 25 MW,
in the mode selection operation, the continuous rolling mode is performed when the following equation is satisfied, and the discontinuous rolling mode is selected and performed when the following equation is not satisfied,

$$HWV > \frac{WL - B}{\frac{T}{2295} - A}$$

where, A is 0.3553 to 0.4247, and B is 39020 to 97550.

10. The continuous casting and rolling method of claim 7, wherein, when the average temperature (T) at the outlet of the caster is 1000 to 1250°C, the stand number (N_R) of the roughing mill is 3, the stand number (N_F) of the finishing mill is 5, the pressure (P_R) input to the first scale remover is 200 bar, the pressure (P_F) input to the second scale remover is 300 bar, and the thickness (t) of the slab at an outlet of the finishing mill is 1.5 mm,
in the mode selection operation, the continuous rolling mode is performed when the following equation is satisfied, and the discontinuous rolling mode is selected and performed when the following equation is not satisfied,

$$HWV > \frac{WL - 3902E_H}{C}$$

where, C is 0.0315 to 0.1404.

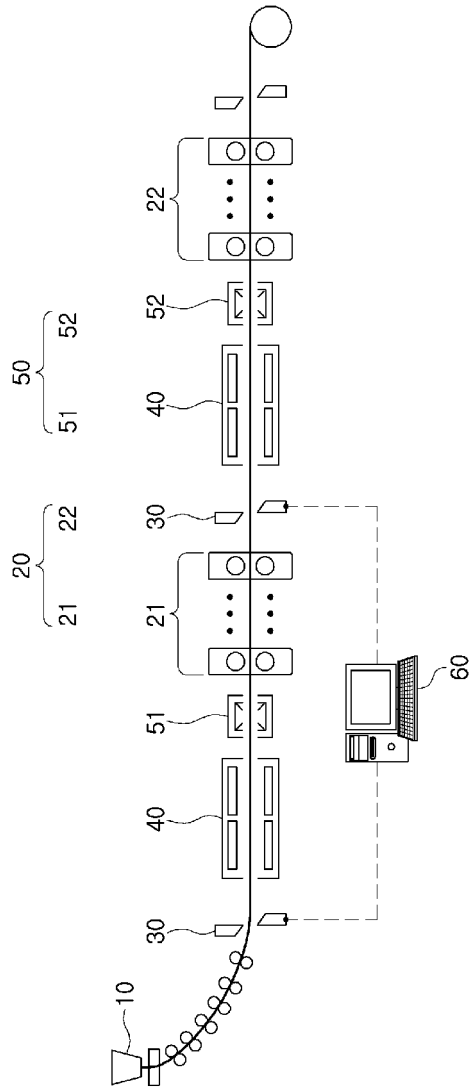

FIG. 1

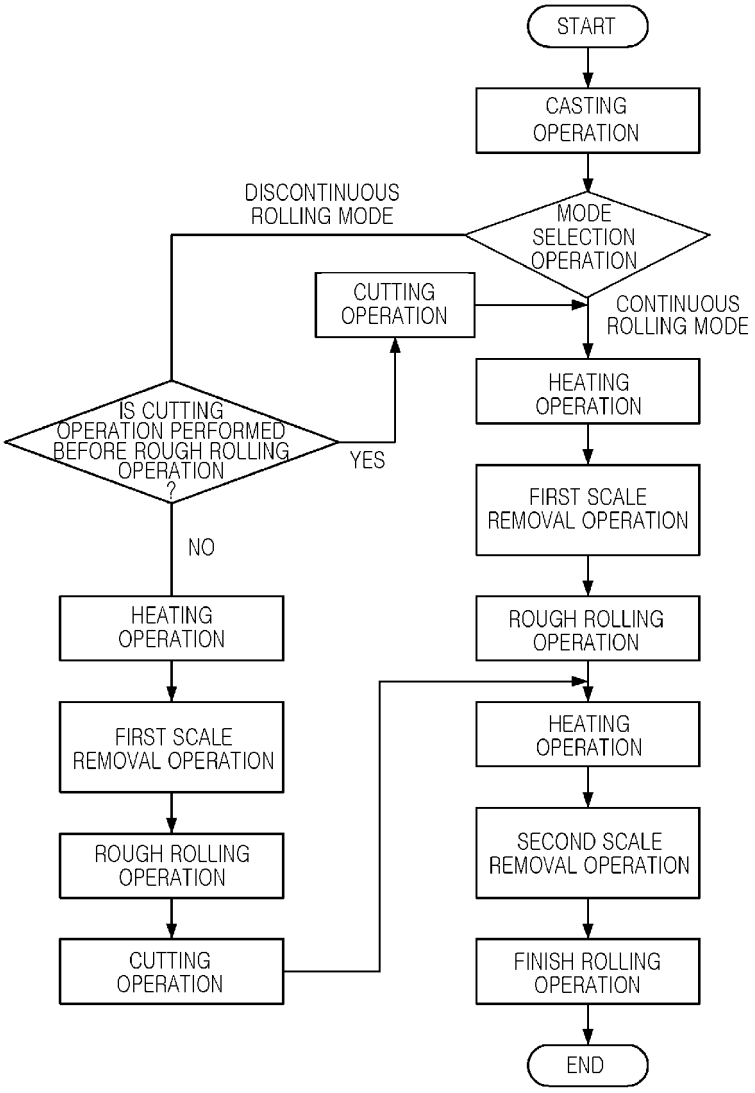
START
CASTING OPERATION
MODE SELECTION OPERATION
DISCONTINUOUS ROLLING MODE
CONTINUOUS ROLLING MODE
CUTTING OPERATION
HEATING OPERATION
FIRST SCALE REMOVAL OPERATION
ROUGH ROLLING OPERATION
HEATING OPERATION
SECOND SCALE REMOVAL OPERATION
FINISH ROLLING OPERATION
END
IS CUTTING OPERATION PERFORMED BEFORE ROUGH ROLLING OPERATION ?
YES
NO
HEATING OPERATION
FIRST SCALE REMOVAL OPERATION
ROUGH ROLLING OPERATION
CUTTING OPERATION

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2015/010112

A. CLASSIFICATION OF SUBJECT MATTER

B22D 11/16(2006.01)i, B22D 11/20(2006.01)i, B21B 1/46(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B22D 11/16; B22D 27/02; B21B 45/00; B21B 13/22; C21B 13/00; B22D 23/00; B21B 1/46; B21B 1/26; B22D 11/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: continuous mode, discontinuous mode, thickness, heating, speed, slab, continuous casting, control, cutting, rough mill and finishing mill

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2013-0075799 A (POSCO) 08 July 2013 See paragraphs [0021]-[0022], [0035]-[0046], [0063]-[0070], claims 1-11, 16 and figures 3a-3b.	1-10
A	US 2010-0212856 A1 (ROSENTHAL et al.) 26 August 2010 See paragraphs [0048]-[0059], claim 1 and figure 1.	1-10
A	KR 10-1067758 B1 (POSCO) 28 September 2011 See abstract, paragraphs [0052]-[0060] and claim 1.	1-10
A	KR 10-1359115 B1 (POSCO) 06 February 2014 See paragraphs [0067]-[0072], claims 1, 20 and figure 7b.	1-10
A	JP 06-320203 A (HITACHI LTD.) 22 November 1994 See paragraphs [0032]-[0036] and claims 1, 3.	1-10

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 FEBRUARY 2016 (05.02.2016)	**11 FEBRUARY 2016 (11.02.2016)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 189 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2015/010112

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