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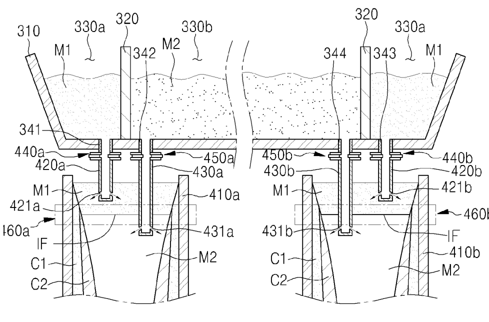
(54) ## CASTING INSTALLATION AND CASTING METHOD

(57) A casting installation according to an embodiment of the present invention comprises: a ladle provided with a first room and a second room, each of which can accommodate molten steel; a tundish having a first accommodation space and a second accommodation space provided therein, the first accommodation space being capable of accommodating first molten steel supplied from the first room, and the second accommodation space being capable of accommodating second molten steel supplied from the second room; and a mold which is disposed below the tundish, solidifies the first molten steel and the second molten steel supplied from the tundish, and casts a double-layered slab in which the components in a surface layer and an inner layer are different. Thus, according to the casting installation according to an embodiment of the present invention, an installation can be configured to include a plurality of strands to improve the production rate of double-layered slabs. Also, by providing the first molten steel and the second molten steel separated from each other in the ladle and supplying same to the tundish, a double-layered slab in which the components are uniform in the longitudinal direction of the slab can be cast.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a casting installation and a casting method, and more particularly, to a casting installation and a casting method, which are capable of casting a double-layered slab.

BACKGROUND ART

[0002] A casting device for manufacturing a double-layered slab in which compositions in a surface layer and a central portion are different includes: a tundish for accommodating first molten steel and second molten steel, which have different compositions; a mold for receiving the molten steel from the tundish and initially solidifying the molten steel into a predetermined shape; first and second nozzles for supplying each of the first and second molten steel in the tundish to the mold; and a magnetic field generation part for generating a direct current magnetic field in the mold.

[0003] In the related art, a beam is prepared in the tundish to separately accommodate the first molten steel and the second molten steel, which have different components, in the tundish, and the inner space is divided into two spaces, i.e., a first space and a second space, based on the beam.

[0004] The beam prepared in the tundish has a length less than a height of the tundish, and a lower end of the beam is spaced apart from a bottom surface of the tundish. Thus, although the inner space is divided through the beam, since the beam is spaced apart from the bottom surface of the tundish, mixture between the first molten steel and the second molten steel may not be completely prevented.

[0005] Particularly, in case of continuous cast of slabs, since an amount of molten steel in the tundish is reduced at a time for replacing the ladle to generate a vortex flow at a lower portion of the tundish, the mixture is inevitably generated. Thus, a slab in which components are not uniform in a longitudinal direction thereof is manufactured by the mixture between the first molten steel and the second molten steel.

[0006] In order to resolve the above-described problem, although bubbling of an argon (Ar) gas toward a bottoms surface of the tundish is performed, since a residence time of the molten steel in the tundish is short, the slab in which components in the longitudinal direction thereof are not uniform is manufactured even by this method.

[0007] Also, since the above-described casting installation has a structure of including one mold and one secondary cooling bed below the tundish, i.e., one strand, a production rate of a double-layered slab is low.

(Related art document)

[0008] (Patent document 1) Korean Patent Publication No. KR 2012-0071475

DISCLOSURE OF THE INVENTION

TECHNICAL PROBLEM

[0009] The present invention provides a casting installation and a casting method, which are capable of improving a production rate of a double-layered slab.

[0010] The present invention also provides a casting installation and a casting method, which are capable of casting a double-layered slab having a target function.

TECHNICAL SOLUTION

[0011] According to an embodiment of the present invention, a casting installation includes: a ladle provided with a first room and a second room, each of which accommodates molten steel; a tundish having a first accommodation space configured to accommodate first molten steel supplied from the first room and a second accommodation space configured to accommodate second molten steel supplied from the second room; and a mold that is disposed below the tundish, solidifies the first molten steel and the second molten steel supplied from the tundish, and casts a double-layered slab in which components in a surface layer and an inner layer are different.

[0012] The ladle may include: a body having an inner space; and a division member installed in the body so that the first room and the second room are formed by dividing the inner space of the body, and a bottom surface of the division member may be connected to a bottom surface of the body.

[0013] The ladle may include: a first plug that passes through a bottom of the first room in a vertical direction so that an inert gas is blown to the first room; a second plug that passes through a bottom of the second room in the vertical direction so that an inert gas is blown to the second room; a first discharge nozzle that passes through the bottom of the first room in the vertical direction to discharge the first molten steel; and a second discharge nozzle that passes through the bottom of the second room in the vertical direction to discharge the second molten steel

[0014] The tundish may include: a main body having an inner space; and a partition wall part installed in the main body so that the first accommodation space is an outer space, and the second accommodation space is an inner space in the main body, and a lower end of the partition wall part may be connected to a bottom of the main body.

[0015] The main body may include: a first body extending in a first extension direction; and a second body extending from the first body in a second extension direction crossing the first extension direction, and the partition wall part may include: a first partition wall extending in the extension direction of the first body and accommodated in the first body; and a second partition wall extending in the direction crossing the extension direction of the first body and having at least a portion accommodated in the second body.

[0016] The mold may be disposed below the first partition and the first body of the tundish, and the ladle may be disposed above the second partition and the second body of the tundish.

[0017] The mold may be provided in plurality, and the plurality of molds may be arranged in the first extension direction below the tundish so as to receive the first molten steel and the second molten steel from the tundish.

[0018] The casting installation may further include: a plurality of upper submerged entry nozzles configured to supply the first molten steel of the tundish to the plurality of molds, respectively; and a plurality of lower submerged entry nozzles configured to supply the second molten steel of the tundish to the plurality of molds, respectively.

[0019] The casting device may include a magnetic field generation part configured to apply a magnetic field into the mold.

[0020] A casting method for manufacturing a double-layered slab, in which components in a surface layer and an inner layer are different, includes: supplying first molten steel accommodated in a first room of a ladle to a first accommodation space of a tundish; supplying second molten steel accommodated in a second room, which is isolated and distinguished from the first room, in the ladle to a second accommodation space of the tundish; and casting a slab by supplying the first and second molten steel of the tundish to a mold.

[0021] The casting method may further include preparing the first molten steel in the first room of the ladle and preparing the second molten steel in the second room, and the preparing of the first molten steel in the first room and the preparing of the second molten steel in the second room may include: inserting an additive into the first room; and charging molten steel having the same component composition to each of the first room and the second room.

[0022] The casting method may further include blowing an inert gas to each of the first room and the second room after the preparing of the first molten steel in the first room and the preparing of the second molten steel in the second room.

[0023] The casting method may further include applying a magnetic field into the mold.

[0024] In the applying of the magnetic field into the mold, a magnetic flux density may be adjusted to form a concentration gradient in which a concentration of an added component contained in the additive decreases in an inner direction from a surface of the surface layer.

[0025] The magnetic field may be applied so that the magnetic flux density in the mold is 0.2 tesla to 0.8 tesla.

[0026] The additive may include ferro-alloy containing at least one added component of Cr, C, Si, Mn, Ni, and Al.

[0027] A double-layered slab according to an embodiment of the present invention has a concentration gradient layer having a concentration gradient on an added component in an inner direction from a surface thereof.

[0028] The concentration gradient layer may have a thickness that is 1.4% to 8.5% of a total thickness of a slab.

ADVANTAGEOUS EFFECTS

[0029] As the casting installation according to the embodiment of the present invention is configured to include the plurality of strands, the production rate of the double-layered slab may improve.

[0030] Also, as the first molten steel and the second molten steel are separately prepared in the ladle and supplied to the tundish, the double-layered slab in which the components are uniform in the longitudinal direction of the slab may be manufactured.

[0031] Also, as the additive is inserted into and the molten steel is charged to any one of the plurality of rooms of the ladle, and then the inert gas is blown through the plug, the molten steel in which the additive and the molten steel are uniformly mixed or the components are uniform may be prepared. Thus, the double-layered slab in which the components in the surface layer are uniform in the longitudinal direction thereof may be manufactured.

[0032] Also, as the casting is performed to exhibit the target function only in the surface layer, the double-layered slab may be cast easier than the related art. Thus, since the great magnetic force is unnecessary to be applied to the mold, the magnetic field generation part is unnecessary to be manufactured with excessively large size and thus advantageous to be commercialized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033]

FIG. 1 is a view illustrating a casting installation according to an embodiment of the present invention.

FIG. 2 is a three-dimensional view for explaining a ladle and a tundish in the casting installation according to an embodiment of the present invention.

FIG. 3 is a view illustrating the ladle according to an embodiment of the present invention.

FIG. 4 is a top view illustrating a tundish according to an embodiment of the present invention.

FIG. 5 is a conceptual view for explaining a density gradient in a double-layered slab cast by a method according to an embodiment of the present invention.

FIG. 6 is a graph representing a thickness of a density gradient region based on an intensity of a magnetic flux density.

FIG. 7 is a flowchart sequentially representing a method for casting a double-layered slab according to an embodiment of the present invention.

MODE FOR CARRYING OUT THE INVENTION

[0034] Hereinafter exemplary embodiments will be described in detail with reference to the accompanying drawings. The present invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the present invention to those skilled in the art.

[0035] The present invention relates to a casting installation capable of casting a double-layered slab and a casting method. More particularly, the present invention provides a casting installation and a casting method, which are capable of improving a production rate of a double-layered slab and casting a double-layered slab to have a target function.

[0036] FIG. 1 is a view illustrating a casting installation according to an embodiment of the present invention. FIG. 2 is a three-dimensional view for explaining a ladle and a tundish in the casting installation according to an embodiment of the present invention. FIG. 3 is a view illustrating the ladle according to an embodiment of the present invention. FIG. 4 is a top view illustrating a tundish according to an embodiment of the present invention. FIG. 5 is a conceptual view for explaining a concentration gradient in a double-layered slab cast by a method according to an embodiment of the present invention. (b) of FIG. 5 is a conceptual graph representing an added component concentration on one linear line connecting A-A' of (a) of FIG. 5. FIG. 6 is a graph representing a thickness of a concentration gradient region based on an intensity of a magnetic flux concentration.

[0037] Referring to FIGS. 1 and 2, a casting installation according to an embodiment of the present invention includes: a ladle 100 provided with a first room 130a and a second room 130b, which of which may accommodate molten steel therein; a tundish having a first accommodation space 330a and a second accommodation space 330b, which are separated and provided to accommodate the molten steel provided from the first room 130a and the second room 130b, respectively; and first and second casting devices 400a and 400b, each of which includes a mold 410a and 410b, which solidifies the molten steel supplied from the first accommodation space 330a and the second accommodation space 330b of the tundish 300 and casts a double-layered slab, and which are arranged in a longitudinal direction (X-axial direction) of the tundish 300.

[0038] Also, the casting installation according to an embodiment of the present invention includes a first supply nozzle 200a for supplying the molten steel in the first room 130a of the ladle 100 to the first accommodation space 330a of the tundish 300 and a second supply nozzle 200b for supplying the molten steel in the second room 130b to the second accommodation space 330b of the tundish 300.

[0039] Hereinafter, for convenience of description, the molten steel accommodated in the first room 130a of the ladle 100 and the first accommodation space 330a of the tundish 300 is referred to as first molten steel M1, and the molten steel accommodated in the second room 130b of the ladle 100 and the second accommodation space 330b of the tundish 300 is referred to as second molten steel M2.

[0040] Referring to FIGS. 2 and 3, the ladle 100 includes: a body 110 having an inner space capable of accommodating the molten steel; a division member 120 installed in the body 110 to divide the inner space of the body 110 in a width direction (Y-axial direction) crossing the longitudinal direction (X-axial direction) of the tundish 300; a first plug 140a passing through a bottom of the body 110, which corresponds to the first room 130a, in a vertical direction and capable of blowing a gas; a second plug 140b passing through a bottom of the body 110, which corresponds to the second room 130b, in the vertical direction and capable of blowing a gas; a first discharge nozzle 150a passing through the bottom of the body 110, which corresponds to the first room 130a, in the vertical direction and discharging the first molten steel M1 of the first room 130a; and a second discharge nozzle 150b passing through the bottom of the body 110, which corresponds to the second room 130b, in the vertical direction and discharging the second molten steel M2 of the second room 130b.

[0041] The division member 120 may divide the inner space of the body 110 in the width direction (Y-axial direction) of the tundish 300. To this end, the division member 120 extends in the X-axial direction and a height direction of the body 110, and a lower end of the division member 120 contacts or is coupled to an inner bottom surface of the body 110. The division member 120 may have a vertical extension length that is equal to or less than that of the body 110, and thus a height of an upper end of the division member 120 may be equal to or less than that of an upper end of the body 110.

[0042] The division member 120 divides the inner space of the body 110 into the first room 130a and the second room 130b based on the division member 120. In other words, the first room 130a and the second room 130b may be isolated and divided by the division member 120.

[0043] Although the division member 120 according to an embodiment has a plate shape extending in the vertical direction, the embodiment is not limited thereto. For example, the division member 120 may have various shapes capable of dividing the inner space of the body 110 in the width direction (Y-axial direction) of the tundish 300.

[0044] The first plug 140a and the first discharge nozzle 150a are provided at the bottom of the body 110, which corresponds to a lower portion of the first room 130a. Here, the first plug 140a and the first discharge nozzle 150a may be arranged in the width direction (Y-axial direction) of the tundish 300. The first plug 140a may be relatively adjacent to a sidewall of the body 110, and the first discharge nozzle 150a may be relatively adjacent to the division member 120.

[0045] The second plug 140b and the second discharge nozzle 150b are provided at the bottom of the body 110, which corresponds to a lower portion of the second room 130b. Here, the second plug 140b and the second discharge nozzle 150b may be arranged in the width direction (Y-axial direction) of the tundish 300. The second plug 140b may be relatively adjacent to the sidewall of the body 110, and the second discharge nozzle 150b may be relatively adjacent to the division member 120.

[0046] A lower end of each of the first discharge nozzle 150a and the second discharge nozzle 150b may protrude downward from a bottom surface of the ladle 100.

[0047] According to arrangement of the first and second plugs 140a and 140b and the first and second discharge nozzles 150a and 150b, the first discharge nozzle 150a may be disposed between the first plug 140a and the division member 120, and the second discharge nozzle 150b may be disposed between the division member 120 and the second plug 140b.

[0048] Also, a gas supply part for supplying an inert gas such as an argon (Ar) gas may be connected to each of the first and second plugs 140a and 140b. The inert gas supplied through the gas supply part and the first and second plugs 140a and 140b may be blown to each of the first room 130a and the second room 130b to stir each of the first and second molten steel M1 and M2 or float inclusions.

[0049] As described above, the casting installation according to an embodiment of the present invention casts a double-layered slab in which components in a surface layer and an inner layer are different. In other words, the casting installation casts a double-layered slab in which characteristics of a surface layer and an inner layer are different.

[0050] When the first molten steel M1 and the second molten steel M2, which have different components, are provided in the present invention, the first molten steel M1 and the second molten steel M2 are provided in the ladle 100. In more detail, an additive is inserted to one of the first room 130a and the second room 130b of the ladle 100, e.g., the first room 130a, and then the molten steel having the same component composition is charged to the first room 130a and the second room 130b. Thus, as the molten steel charged to the first room 130a is mixed with the additive, the first molten steel M1 is prepared, and the molten steel accommodated in the second room 130b becomes the second molten steel M2 having a composition different from that of the first molten steel M1 by the additive.

[0051] A method for preparing the first molten steel M1 and the second molten steel M2 by inserting the additive into the first room 130a and then charging the molten steel having the same composition to each of the first room 130a and the second room 130b is described above. However, the embodiment is not limited thereto. For example, various methods may be applied as long as the methods allow the first molten steel M1 to be accommodated in the first room 130a and the second molten steel M2 to be accommodated in the second room 130b. For example, the first molten steel M1 and the second molten steel M2, which have different components, may be prepared from the outside of the ladle 100, the first molten steel M1 may be charged to the first room 130a, and the second molten steel M2 may be charged to the second room 130b.

[0052] Here, the additive is a material containing a component that is necessary for the surface layer to have a target function. Hereinafter, the component that is necessary to have a target function or a preferred function is referred to as an 'added component'. Thus, the additive may be described as a material containing the added component.

[0053] Also, the component that is necessary to have a target function of the surface layer, i.e., the added component, may be Cr, and the additive may be a material containing Cr, e.g., ferro-alloy.

[0054] However, the added component is not limited to the Cr. The added component may be at least one of C, Si, Mn, Ni, and A1 according to a function to be added to the surface layer, e.g., a coatability, a weldability, and an electrical property.

[0055] Also, as the molten steel is charged to each of the first room 130a and the second room 130b, to which the additive is inserted, and then an inert gas is blown by using the first and second plugs 140a and 140b, the molten steel and the additive, which are charged to the first room 130a, may be uniformly mixed, and as inclusions generated from each of the first room 130a and the second room 130b may be floated and separated, component adjustment may be further easily performed.

[0056] As illustrated in FIGS. 2 and 4, the tundish 300 includes a main body 310 having an inner space and a partition wall part 320 having an inner space and installed in the main body 310 to divide the inner space of the main body 310 into an inner space and an outer space.

[0057] As the partition wall part 320 having the inner space is installed in the main body 310, the inner space of the main body 310 is divided into a space corresponding to an outer side of the partition wall part 320 and a space corresponding to an inner side of the partition wall part 320. Hereinafter, in the inner space of the main body 310, an outer space of the partition wall part 320 is referred to as a first accommodation space 330a, and an inner space of the partition wall part 320 is referred to as a second accommodation space 330b.

[0058] Hereinafter, a configuration of the tundish 300 will be described in detail.

[0059] The tundish 300 includes a main body 310 having an inner space and a partition wall part 320 installed in the main body 310 to divide the inner space of the main body 310 into a first accommodation space 330a and a second accommodation space 330b that is an inner space of the first accommodation space 330a.

[0060] Also, the tundish 300 includes a first phase nozzle 341 passing a bottom surface of the main body 310, which corresponds to the first accommodation space 330a, in the vertical direction to provide the first molten steel M1 to the mold 410a of the first casting device 400a and a second phase nozzle 342 passing a bottom surface of the main body 310, which corresponds to the second accommodation space 330b, in the vertical direction to provide the second molten steel M2 to the first mold 410a of the first casting device 400a.

[0061] Also, the tundish 300 includes a third phase nozzle 343 passing the bottom surface of the main body 310, which corresponds to the first accommodation space 330a, in the vertical direction to provide the first molten steel M1 to the second mold 410b of the second casting device 400b and a fourth phase nozzle 344 passing the bottom surface of the main body 310, which corresponds to the second accommodation space 330b, in the vertical direction to provide the second molten steel M2 to the second mold 410b of the second casting device 400b.

[0062] The main body 310 has a shape including at least a bottom part and a sidewall part having a predetermined height and surrounding an edge of an upper portion of the bottom part.

[0063] Also, as described above, the first to fourth phase nozzles 341, 342, 343, and 344 are provided at the bottom surface of the main body 310, and, as the ladle 100 is disposed above the main body 310, the first and second molten steel is supplied through the first and second discharge nozzles 150a and 150b an d the first and second supply nozzles 200a and 200b.

[0064] Here, a position or a space at which the first and second molten steel M1 and M2 is supplied from the first and second discharge nozzles 150a and 150b to the tundish 300 may be spaced apart from the first to fourth phase nozzles 341, 342, 343, and 344 for discharging the first and second molten steel M1 and M2 to the first and second casting devices 400a and 400b instead of being adjacent thereto.

[0065] To this end, the main body 310 according to an embodiment may include a first body 311 extending in the X-axial direction (longitudinal direction or first extension direction) and a second body 312 extending in the Y-axial direction (width direction or second extension direction) crossing the extension direction (X-axial direction) of the first body 311.

[0066] Here, an extended length of the second body 312 in the X-axial direction is less than that of the first body 311 in the X-axial direction. Also, the first body 311 and the second body 312 may be provided so that a center of the first body 311 in the X-axial direction and a center of the second body 312 in the X-axial direction are positioned on one linear line.

[0067] Thus, the main body 310 may have an overall shape extending in the X-axial direction and protruding in the Y-axial direction. Thus, the inner space of the main body 310 includes a space extending in the X-axial direction and formed by the first body 311 and a protruding space extending in the Y-axial direction from the space extending in the X-axial direction and formed by the second body 312.

[0068] In the tundish 300, a space of the second body 312 receives the first and second molten steel M1 and M2 from the ladle. In other words, the first and second molten steel M1 and M2 of the ladle 100 is supplied to the protruding space in the inner space of the main body 310. To this end, the ladle 100 is disposed above the second body 312 of the tundish 300.

[0069] The partition wall part 320 is installed in the main body 310 to divide the inside of the main body 310 into the first accommodation space 330a and the second accommodation space 330b. The partition wall part 320 may have a shape corresponding to the shape of the main body 310.

[0070] That is, the partition wall part 320 may include a first partition wall 321 extending in an arrangement direction (i.e., X-axial direction) of the first to fourth phase nozzles 341, 342, 343, and 3444 or an extension direction of the first body 311 and a second partition wall 322 extending in a direction (Y-axial direction) crossing an extension direction (i.e., X-axial direction) of the first partition wall 321.

[0071] Here, an extended length of the second partition wall 322 in the X-axial direction is less than that of the first partition wall 321 in the X-axial direction. Also, the first partition wall 321 and the second partition wall 322 may be provided so that a center of the first partition wall 321 in the X-axial direction and a center of the second partition wall 322 in the X-axial direction are positioned on one linear line.

[0072] The partition wall part 320 may be installed in the main body 310 so that the first partition wall 321 is disposed in the first body 311, and at least a portion of the second body 312 is disposed in the second body 312.

[0073] Here, on the basis of the Y-axial direction, the other side surface of the first partition wall 321 may contact or be spaced apart from an inner surface of the first body 311, which faces the other side surface. Also, other side surfaces except for the other side surface among outer surfaces of the first partition wall 321 may be spaced apart from the inner surface of the first body 311.

[0074] Also, the entire second partition wall 322 may be installed in the second body 312, or only a portion of the second partition wall 322 may be installed in the second body 312.

[0075] As described above, the inner space of the tundish 300 is divided into the first accommodation space 330a and the second accommodation space 330b by the main body 310 and the partition wall part 320. That is, the inner space of the tundish 300 is divided into the first accommodation space 330a corresponding to an outer side of the partition wall part 320 and the second accommodation space 330b corresponding to an inner side of the partition wall part 320.

[0076] Also, each of the first and second accommodation spaces 330a and 330b may have an overall shape extending in the X-axial direction and protruding in the Y-axial direction by the shapes of the main body 310 and the partition wall part 320. In other words, each of the first and second accommodation spaces 330a and 330b include a space extending in the X-axial direction and a protruding space extending in the Y-axial direction from the space extending in the X-axial direction.

[0077] In the tundish 300, a space of the second partition wall 322 receives the first and second molten steel M1 and M2 from the ladle 100. In other words, the first and second molten steel M1 and M2 of the ladle is supplied to the protruding space in the inner space of the partition wall part 320.

[0078] To this end, the ladle 100 is disposed above the second partition wall 322 and the second body 312 of the tundish 300. More particularly, the first discharge nozzle 150a for supplying the first molten steel M1 to the tundish 300 is installed between the second body 312 and the second partition 322 in correspondence to the first accommodation space 330a. Also, the second discharge nozzle 150b for supplying the second molten steel M2 to the tundish 300 is installed at an inner side of the second partition 322 in correspondence to the second accommodation space 330b.

[0079] The first supply nozzle 200a is disposed between the first discharge nozzle 150a and the tundish 300 and has an upper end connected to the first discharge nozzle 150a. Thus, the first molten steel M1 discharged from the first discharge nozzle 150a is supplied to the tundish 300 through the first supply nozzle 200a. That is, the first supply nozzle 200a is disposed in correspondence to the first accommodation space 330a of the tundish 300 or the outer space of the second partition wall 322.

[0080] The second supply nozzle 200b is disposed between the second discharge nozzle 150b and the tundish 300 and has an upper end connected to the second discharge nozzle 150b. Thus, the second molten steel M2 discharged from the second discharge nozzle 150b is supplied to the tundish 300 through the second supply nozzle 200b. That is, the second supply nozzle 200b is disposed in correspondence to the second accommodation space 330b of the tundish 300 or the inner space of the second partition wall 322.

[0081] Each of the first to fourth phase nozzles 341, 342, 343, and 344 is a unit for supplying each of the first and second molten steel M1 and M2 to the molds 410a and 410b of each of the first and second casting devices 400a and 400b.

[0082] As described above, the first to fourth phase nozzles 341, 342, 343, and 344 are arranged in the X-axial direction or the arrangement direction of the molds 410a and 410b of the first and second casting devices 400a and 400b.

[0083] More particularly, each of the first and third phase nozzles 341 and 343 discharges the first molten steel M1 and communicates with the first accommodation space 330a of the tundish 300. That is, the first phase nozzle 341 is provided at one outer side of the first partition wall 321, and the third phase nozzle 343 is provided at the other outer side of the first partition wall 321. Thus, the first phase nozzle 341 and the third phase nozzle 343 are spaced apart from each other with the first partition wall 321 therebetween in the X-axial direction.

[0084] Each of the second and fourth phase nozzles 342 and 343 discharges the second molten steel M2 and communicates with the second accommodation space 330b of the tundish 300. That is, the second and fourth phase nozzles 342 and 343 are installed at an inner side of the first partition wall 321, and the second phase nozzle 342 and the fourth phase nozzle 344 are arranged and spaced apart from each other in the X-axial direction.

[0085] Here, when the second phase nozzle 342 and the fourth phase nozzle are provided in the first partition 321, a spaced distance between the first phase nozzle 341 and the second phase nozzle 342 is less than one directional length of the mold 410a of the first casting device 400a, which will be described later, and a spaced distance between the third phase nozzle 343 and the fourth phase nozzle 344 is less than one directional length of the mold 410b of the second casting device 400b.

[0086] Also, a spaced distance between the second phase nozzle 342 and the fourth phase nozzle 344 may be greater than each of the spaced distance between the first phase nozzle 341 and the second phase nozzle 342 and the spaced distance between the third phase nozzle 343 and the fourth phase nozzle 344.

[0087] The first and second casting devices 400a and 400b cast a double-layered slab by receiving the first molten steel M1 and the second molten steel M2 from the tundish 300. The first casting device 400a and the second casting device 400b are overall arranged in the arrangement direction of the first to fourth phase nozzles 341, 342, 343, and 344 or the X-axial direction.

[0088] Hereinafter, the first and second casting devices 400a and 400b will be described.

[0089] The first casting device 400a includes: a first mold 410a for receiving the first and second molten steel M1 and M2 and initially solidifying the molten steel into a predetermined shape; a first upper submerged entry nozzle 420a for receiving the first molten steel M1 from the ladle 100 to supply the first molten steel M1 to the first mold 410a; a first lower submerged entry nozzle 430a for receiving the second molten steel M2 from the ladle 100 to supply the second molten steel M2 to the first mold 410a and discharging the second molten steel M2 at a position lower than the first upper submerged entry nozzle 420a; and a first magnetic field generation part 460a for applying a direct current (DC) magnetic field into the first mold 410a.

[0090] Also, the first casting device 400a includes: a first gate 440a for coupling the first phase nozzle 341 and the first upper submerged entry nozzle 420a to each other and controlling communication between the first phase nozzle 341 and the first upper submerged entry nozzle 420a; a second gate 450a for coupling the second phase nozzle 342 and the first lower submerged entry nozzle 430a to each other and controlling communication between the second phase nozzle 342 and the first lower submerged entry nozzle 430a; and a first cooling bed (not shown) which is provided below the first mold 410a and in which a plurality of first rolls and a plurality of first injection nozzles are consecutively arranged so as to perform a series of mold operations while secondarily cooling a slab in a semi-solidified state, which is drawn from the first mold 410a.

[0091] The first mold 410a is disposed in correspondence to the first and second phase nozzles 341 and 342 of the tundish 300. The first mold 410a receives the molten steel from the tundish 300 and initially solidifies the molten steel into a predetermined shape. The first mold 410a may have, e.g., a rectangular cross-sectional shape. That is, the first mold 410a includes: one pair of long sides each extending in one direction (X-axial direction) and spaced apart from each other in a direction (Y-axial direction) crossing or perpendicular to the extension direction; and one pair of short sides each extending in a direction (Y-axial direction) crossing or perpendicular to the long side and spaced apart from each other in a direction (X-axial direction) crossing or perpendicular to the extension direction. Also, a flow path through which a coolant for cooling the molten steel flows is prepared in each of the short side and the long side of the first mold 410a.

[0092] The first upper submerged entry nozzle 420a supplies the first molten steel M1 to the first mold 410a, and the first lower submerged entry nozzle 430a supplies the second molten steel M2 to the first mold 410a. The first upper submerged entry nozzle 420a and the first lower submerged entry nozzle 430a are arranged and spaced apart from each other in the extension direction (i.e., the X-axial direction) of the long side of the mold.

[0093] Also, the first upper submerged entry nozzle 420a and the first lower submerged entry nozzle 430a have different heights of discharge holes through which the molten steel is discharged. That is, a discharge hole (hereinafter, referred to as a first upper discharge hole) of the first upper submerged entry nozzle 420a has a height greater than that of a discharge hole (hereinafter, referred to as a first lower discharge hole) of the first lower submerged entry nozzle 430a. In other words, a first lower discharge hole 431a has a height less than that of a first upper discharge hole 421a.

[0094] To this end, the first upper submerged entry nozzle 420a and the first lower submerged entry nozzle 430a may have different lengths, i.e., an extended length of the first upper submerged entry nozzle 420a may be less than that of the first lower submerged entry nozzle 430a, and the discharge hole may be defined at a lower portion of each of the first upper submerged entry nozzle 420a and the first lower submerged entry nozzle 430a. Also, upper ends of the first upper submerged entry nozzle 420a and the first lower submerged entry nozzle 430a is connected to the first and second phase nozzles 431 and 432, respectively, disposed above the first mold 410a so that the upper ends have the same height as each other. Thus, the first upper discharge hole 321a is disposed higher than the first lower discharge hole 431a.

[0095] The first magnetic field generation part 460a is a unit for applying a magnetic force into the first mold 410a, and more particularly, a unit for applying a uniform DC magnetic field in a width direction (Y-axial direction) of the first mold 410a. The first magnetic field generation part 460a may be disposed at an outer side of each of the one pair of short sides of the first mold.

[0096] Although the first cooling bed is not shown, the first cooling bed includes a plurality of first rolls disposed below the first mold 410a and arranged in one direction and a first injection nozzle disposed between the plurality of first rolls to inject coolant toward the slab. Here, each of the first roll and the first injection nozzle may be disposed above a top surface and below a bottom surface of the slab, respectively. Thus, the slab drawn from the first mold is completely solidified such that the slab is secondarily cooled by the coolant injected from the first injection nozzle while moving in an arrangement direction of the first rolls.

[0097] The second casting device 400b has a configuration and a shape, which are similar to those of the first casting device 400a.

[0098] That is, the second casting device 400b includes: a second mold 410b for receiving the first and second molten steel M1 and M2 and initially solidifying the molten steel into a predetermined shape; a second upper submerged entry nozzle 420b for receiving the first molten steel M1 from the ladle 100 to supply the first molten steel M1 to the second mold 410b; a second lower submerged entry nozzle 430b for receiving the second molten steel M2 from the ladle 100 to supply the second molten steel M2 to the second mold 410b and discharging the second molten steel M2 at a position lower than the second lower submerged entry nozzle 420b; and a second magnetic field generation part 460b for generating a magnetic field in the second mold 410b.

[0099] Also, the second casting device 400b includes: a third gate 440b for coupling the third phase nozzle 343 and the second upper submerged entry nozzle 420b to each other and controlling communication between the third phase nozzle 343 and the second upper submerged entry nozzle 420b; a fourth gate 450b for coupling the fourth phase nozzle 344 and the second lower submerged entry nozzle 430b to each other and controlling communication between the fourth phase nozzle 344 and the second lower submerged entry nozzle 430a; and a second cooling bed (not shown) which is provided below the second mold 410b and in which a plurality of second rolls and a plurality of second injection nozzles are consecutively arranged so as to perform a series of mold operations while cooling a semi-solidified slab drawn from the second mold 410b.

[0100] The second mold 410b is spaced apart from the first mold 410a in the X-axial direction and disposed in correspondence to a lower side of the third and fourth nozzles 343 and 344.

[0101] The second upper submerged entry nozzle 420b supplies the first molten steel to the second mold 410b, and the second lower submerged entry nozzle 430b supplies the second molten steel M2 to the second mold 410b. The second upper submerged entry nozzle 420b and the second lower submerged entry nozzle 430b are arranged and spaced apart from each other in the extension direction (i.e., the X-axial direction) of the long side of the second mold 410b.

[0102] Also, the second upper submerged entry nozzle 420b and the second lower submerged entry nozzle 430b have different heights of discharge holes through which the molten steel is discharged. That is, a discharge hole (hereinafter, referred to as a second upper discharge hole 421b) of the second upper submerged entry nozzle 420b has a height greater than that of a discharge hole (hereinafter, referred to as a second lower discharge hole 431b) of the second lower submerged entry nozzle 430b.

[0103] Although the second cooling bed is not shown, the second cooling bed includes a plurality of second rolls disposed below the second mold and arranged in one direction and a second injection nozzle disposed between the plurality of second rolls to inject coolant toward the slab.

[0104] As described above, the slab drawn from the first mold 410a is solidified while moving in the arrangement direction of the plurality of first rolls, and the slab drawn from the second mold 410b is solidified while moving in the arrangement direction of the plurality of second rolls.

[0105] Here, the first mold 410a and the first cooling bed, through which the molten steel and the mold pass, may be referred to as a first strand, and the second mold 410b and the second cooling bed may be referred to as a second strand. That is, the casting installation according to an embodiment includes a plurality of strands.

[0106] Hereinafter, a method for casting a double-layered slab by the first casting device 400a will be described. Here, since the first casting device 400a and the second casting device 400b have the same method for casting the slab, a method for casting the slab in the second casting device 400b will be omitted.

[0107] First, first molten steel and second molten steel, which contain different components, are prepared and supplied to the first mold 410a. Here, each of the first molten steel M1 and the second molten steel M2 may be molten steel for low carbon steel containing 0.018 wt% of C, 0.035 wt% of Si, 1.15 wt% of Mn, and 0.1 wt% of Ni. Also, the second molten steel M2 may further contain 3 wt% of Cr in comparison with the first molten steel M1.

[0108] When the first molten steel M1 is supplied to the first mold 10 through the first upper submerged entry nozzle 420a, as the first molten steel M1 is solidified, a solidification cell (hereinafter, referred to as a first solidification cell C1) is formed. Here, since a flow path through which coolant flows is buried in an inner wall of the first mold 410a, the inner wall of the first mold 410a has a lowest temperature. Thus, when the first molten steel M1 is supplied, the first solidification cell C1 is formed along an inner wall surface of the first mold 410a. Also, since the first solidification cell C1 is formed along the inner wall surface of the first mold 410a, a space surrounded by the first solidification cell C1 is formed, and the second molten steel M2 is supplied to the space through the first lower submerged entry nozzle 430a. In other words, the second molten steel M2 discharged from the first lower submerged entry nozzle 430a is supplied to fill the space partitioned by the first solidification cell C1. Also, when the second molten steel M2 supplied from the first lower submerged entry nozzle 430a is solidified to form a solidification cell (hereinafter, referred to as a second solidification cell C2), the second solidification cell C2 is formed along an inner wall surface of the first solidification cell C1 at a time at which the first molten steel M1 is started to be supplied.

[0109] Also, the first magnetic field generation part 460a is disposed between the first upper discharge hole 421a of the first upper submerged entry nozzle 420a and the first lower discharge hole 431a of the first lower submerged entry nozzle 430a. Thus, the first molten steel M1 discharged from the first upper discharge hole 421a is discharged to an upper side of the first magnetic field generation part 460a, and the second molten steel M2 discharged from the first lower discharge hole 431a is discharged to a lower side of the first magnetic field generation part 460a.

[0110] Here, a magnetic field applied from the first magnetic field generation part 460a serves as a resistor for suppressing the first molten steel M1 from moving the lower side of the first magnetic field generation part 460a and the second molten steel M2 from moving the upper side of the first magnetic field generation part 460a.

[0111] Here, most of the first molten steel M1 discharged from the first upper discharge hole 421a of the first upper submerged entry nozzle 420a stays at the upper side of the first magnetic field generation part 460a or moves in an outside direction of the extension direction of the first magnetic field generation part 460a instead of moving to the lower side of the first magnetic field generation part 460a.

[0112] Thus, on the basis of a position around the first magnetic field generation part 460a or a position corresponding to the first magnetic field generation part 460a in the first mold 410a, a molten steel pool (i.e., upper pool) formed by the first molten steel M1 and a molten steel pool (i.e., lower pool) formed by the second molten steel M2 may be distinguished.

[0113] As described above, the double-layered slab is a slab which is cast by using the first molten steel M1 and the second molten steel M2, which have different components, and in which the components in a surface layer SL and an inner layer IL are different. More particularly, the first molten steel M1 and the second molten steel M2 have different contents of the added components, and thus the contents of the added components in the surface layer SL and the inner layer IL are different. Thus, the surface layer SL and the inner layer IL of the double-layered slab may be defined or distinguished according to the content (or concentration) of the added component.

[0114] Also, the double-layered slab according to an embodiment has a concentration gradient in which a concentration of the added component gradually decreases in a direction from a surface to an inner side of the surface layer SL (refer to FIG. 5). Also, the added component may be inevitably contained with a small amount or may not be contained in each of the second molten steel M2 and the inner layer IL.

[0115] As described above, in the double-layered slab according to an embodiment, a region from the surface of the slab to a point at which the content of the added component contained in the first molten steel M1 is 0.5% may be referred to as the surface layer SL. In other words, a region in which the content of the added component contained in the first molten steel M1 is in a range from 100% to 0.5% (an inner direction from the surface) may be defined as the surface layer.

[0116] Also, a region in which the content of the added component contained in the first molten steel M1 is less than 0.5% (0% inclusive) may be defined as the inner layer IL.

[0117] According to the above definition, the content of the added component in the surface layer SL is varied within a range from 100% to 0.5%. Also, , the content of the added component in the inner layer IL may be less than 0.5% or may be 0%.

[0118] As described above, the content of the added component gradually decreases in the inner direction from the surface in the surface layer SL. Here, in the surface layer SL, a region from a point at which the content of the added component contained in the first molten steel M1 is 90% to a point at which the content is a predetermined ratio is defined as a concentration gradient layer CGA.

[0119] Here, the point at which the content of the added component contained in the first molten steel is 90% is a start point As of the concentration gradient layer, and the point at which the content is the predetermined ratio is an end point Ae of the concentration gradient layer.

[0120] Since a concentration of the added component, which is a reference of the start point As of the concentration gradient layer, is that the content of the added component contained in the first molten steel M1 is 90%, this may be expressed by mathematical equation 1 below.

[Mathematical equation 1]

$$CGA\_start\_reference\_concentration = first\_moltensteel\_addedcomponent\_content \times \frac{90}{100}$$

[0121] For example, when a content of Cr that is the added component in the first molten steel M1 is 3 wt%, a reference concentration that is the start point As of the concentration gradient layer calculated by the mathematical equation 1 is 2.7 wt%. Also, a point at which the calculated concentration is true is the start point As of the concentration gradient layer.

[0122] Also, a concentration of the added component, which is a reference of the end point Ae of the concentration gradient layer, is determined by a sum of 5% of the content of the added component contained in the first molten steel M1 and the content of the added component contained in the second molten steel M2 (refer to mathematical equation 2).

[Mathematical equation 2]

$$CGA\_endpoint\_reference\_concentration = concentration\_of\_addedcomponent\_in\_second\_moltensteel$$
$$+ (concentration\_of\_addedcomponent\_in\_first\_moltensteel \times \frac{5}{100})$$

[0123] For example, when a condition, in which a content of Cr that is the added component in the first molten steel M1 is 3 wt% and a content of Cr in the second molten steel M2 is 0.01 wt%, is applied to the mathematical equation 1, a reference concentration that is the end point Ae of the concentration gradient layer is 0.16 wt%. Also, a point that is the reference concentration of the calculated end point may be the end point Ae.

[0124] Thus, the concentration gradient layer CGA is from a point at which the content of the added component is 2.7 wt% or more to a point at which the content of the added component is 0.16 wt% or less.

[0125] For another example, when the added component is not contained in the second molten steel M2 (0%), a reference concentration that is the end point of the concentration gradient layer is 0.15 wt%.

[0126] In an embodiment, a thickness T of the concentration gradient region CGA is 1.4% to 8.5% of a total thickness of the slab. Here, the thickness T of the concentration gradient region CGA represents a length from the start point As of the concentration gradient layer to the end point Ae of the concentration gradient layer.

[0127] In order to cast the double-layered slab in which the components in the surface layer and the inner layer are different, a magnetic field is applied to the mold 410a and 410b by using the magnetic field generation part 460a and 460b. Also, an intensity of a magnetic flux density applied from the first and second magnetic field generation parts 460a and 460b is adjusted to 0.2 tesla to 0.8 tesla so that the surface layer has a concentration gradient or has the concentration gradient layer CGA while the thickness T of the concentration gradient layer CGA is 1.4% to 8.5% of the total thickness of the slab.

[0128] Referring to FIG. 6, the thickness T of the concentration gradient layer CGA increases as the intensity of the magnetic flux density decreases. The concentration gradient region CGA may be 1.4% to 8.5% of the total thickness of the slab S. To this end, as illustrated in FIG. 6, the intensity of the magnetic flux density may be 0.2 tesla to 0.8 tesla (equal to or greater than 0.2 tesla and equal to or less than 0.8 tesla).

[0129] When the intensity of the magnetic flux density is less than 0.2 tesla, a large amount of the first molten steel and the second molten steel are mixed so that a boundary area does not exist in the mold. Thus, the slab in which the contents of the components in the surface layer and the inner layer are equal may be cast. That is, the double-layered slab may not be manufactured.

[0130] On the contrary, when the intensity of the magnetic flux density greater than 0.8 tesla, the casting installation may excessively increase in size and thus may not be commercialized.

[0131] Also, as the thickness of the concentration gradient region CGA decreases, a boundary with respect to the concentrations of the added components between the surface layer and the inner layer becomes clear.

[0132] However, although the thickness of the concentration gradient region CGA is not less than 1.4% of the total thickness of the slab or not clear, and the concentration gradient region CGA is equal to or greater than 1.4%, the surface layer of the slab S may have a function to be added (e.g., corrosion resistance) by the added component. Thus, the thickness of the concentration gradient region CGA is not necessary to be less than 1.4%.

[0133] Thus, in an embodiment, the intensity of the magnetic flux density is adjusted to 0.2 tesla to 0.8 tesla (equal to or greater than 0.2 tesla and equal to or less than 0.8 tesla) so that the thickness of the concentration gradient region CGA is 1.4% to 8.5% of the total thickness of the slab.

[0134] Whether the surface layer has a target property when the double-layered slab is cast by a method according to an embodiment is evaluated. Here, the double-layered slab is cast by the same method as the embodiment using Cr as the added component and the first molten steel and the second molten steel, which have different Cr contents, and as the intensity of the magnetic flux density is adjusted to 0.2 tesla to 0.8 tesla to cast the double-layered slab having the concentration gradient region.

[0135] Also, a specimen is prepared by sampling a portion of the manufactured slab for a corrosion resistance evaluation. Also, the specimen is evaluated in an atmosphere of sulfuric acid (H_2S) that is one of strong acid by applying a tensile stress and measuring a yield strength.

[0136] It is checked that the specimen manufactured by the method according to an embodiment and having a concentration gradient in a thickness direction therein guarantees 110% or more of specified minimum yield strength (SMYA). The double-layered slab according to an embodiment guarantees 110% of yield strength at a room temperature.

[0137] Also, a specimen obtained by sampling a general slab in which a surface layer and an inner layer have the same component guarantees about 90% of specified minimum yield strength (SMYA).

[0138] From this, it is known that even the double-layered slab having the concentration gradient on the added component in the surface layer like an embodiment may have a preferred added function, e.g., corrosion resistance.

[0139] As described above, the double-layered slab according to an embodiment of the present invention may be cast to have a preferred function to be added to the surface layer, e.g., sufficient corrosion resistance, and have a concentration gradient instead of having a distinct boundary on the added component concentration between the surface layer and the inner layer like the related art.

[0140] In other words, the surface of the slab S has the function to be added thereto, e.g., corrosion resistance, and difference between contents of the components in the surface layer and the inner layer based on the boundary between the surface layer and the inner layer is less than the related art. Thus, separation between the surface layer and the inner layer caused by component difference and generation of a crack or a defect may be reduced.

[0141] Hereinafter, a method for casting a double-layered slab according to an embodiment of the present invention will be described with reference to FIGS. 1 to 5 and 7.

[0142] FIG. 7 is a flowchart sequentially representing the method for casting a double-layered slab according to an embodiment of the present invention.

[0143] First, an additive is inserted to one of the first room 130a and the second room 130b, e.g., the first room 130a, in the ladle 100 in a process S100.

[0144] Here, the additive, which is for preparing the first molten steel M1 and the second molten steel M2, which have different component compositions, may be ferro-alloy containing a component to be differentiated. Here, the added component may be Cr, and the additive may be a material containing Cr, e.g., ferro-alloy.

[0145] When the additive containing Cr is inserted to the first room 130a of the ladle 100, molten steel is charged to each of the first room 130a and the second room 130b in a process S200. Here, the molten steel charged to the first room 130a and the second room 130b may have the same component composition. For example, the molten steel charged to the first room 130a and the second room 130b may be molten steel for low carbon steel containing 0.018 wt% of C, 0.035 wt% of Si, 1.15 wt% of Mn, and 0.1 wt% of Ni.

[0146] Also, when the molten steel is charged to the first room 130a, the ferro-alloy is melted by a temperature of the molten steel. Thus, the molten steel accommodated in the first room 130a is manufactured as molten steel having a different Cr content from the molten steel accommodated in the second room 130b or molten steel containing more amount of Cr.

[0147] That is, when the additive containing Cr is inserted into the first room 130a, and then the molten steel is charged to each of the first room 130a and the second room 130b, the molten steel accommodated in the first room 130a and the molten steel accommodated in the second room 130b have different compositions. That is, the first molten steel M1 accommodated in the first room 130a and the second molten steel M2 accommodated in the second room 130b are different in Cr content. Here, the Cr content in the first molten steel M1 may be adjusted to, e.g., 3 wt%, by controlling the insertion amount of the additive and the kind of additive.

[0148] Here, the first molten steel M1 containing Cr is prepared to cast the double-layered slab having improved corrosion resistance of the surface layer.

[0149] When the first molten steel M1 and the second molten steel M2 are prepared in the ladle 100, an inert gas, e.g., an argon (Ar) gas, is blown through each of the first and second plugs 140a and 140b in a process S300. The molten steel and the additive in the first room 130a may be mixed by the Ar gas blown through the first and second plugs 140b, and separation-floatation of inclusions may be generated in each of the first room 130a and the second room 130b.

[0150] Thereafter, the ladle 100 moves above the tundish 300, and the first molten steel M1 and the second molten steel M2 are supplied to the tundish 300 in a process S400. To this end, the ladle 100 is disposed in correspondence to an upper side of the second partition 322 and the second body 312 of the tundish 300, and the first and second supply nozzles 200a and 200b are disposed between the ladle 100 and the tundish 300. Here, the first discharge nozzle 150a and the first supply nozzle 200a is disposed in correspondence to an upper side of the first accommodation space 330a of the tundish, and the second discharge nozzle 150b and the second supply nozzle 200b is disposed in correspondence to an upper side of the second accommodation space 330b of the tundish 300. Thereafter, the first discharge nozzle 150a and the first supply nozzle 200a are coupled to each other, and the second discharge nozzle 150b and the second supply nozzle 200b are coupled to each other.

[0151] Thereafter, when the first discharge nozzle 150a communicates with the first supply nozzle 200a, and the second discharge nozzle 150b communicates with the second supply nozzle 200b, the first and second molten steel M1 and M2 of the ladle 100 is supplied to the tundish. Here, the first molten steel M1 is supplied to the first accommodation space 330a of the tundish 300 by the first discharge nozzle 150a and the first supply nozzle 200a, and the second molten steel M2 is supplied to the second accommodation space 330b of the tundish 300 by the second discharge nozzle 150b and the second supply nozzle 200b.

[0152] Also, communications between the first phase nozzle 341 and the first upper submerged entry nozzle 420a, between the second phase nozzle 342 and the first lower submerged entry nozzle 430a, between the third phase nozzle 343 and the second upper submerged entry nozzle 420b, and between the fourth phase nozzle 344 and the second lower submerged entry nozzle 430b are enabled by operating the first to fourth gates 440a, 450a, 440b, and 450b.

[0153] Thus, the first molten steel M1 in the first accommodation space 330a of the tundish 300 is supplied to the first mold 410a through the first phase nozzle 341 and the first upper submerged entry nozzle 420a, and the second molten steel M2 in the second accommodation space 330b of the tundish 300 is supplied to the first mold 410a through the second phase nozzle 342 and the first lower submerged entry nozzle 430a in a process S500.

[0154] Also, the first molten steel M1 in the first accommodation space 330a of the tundish 300 is supplied to the second mold 410b through the third phase nozzle 343 and the second upper submerged entry nozzle 420b, and the second molten steel M2 in the second accommodation space 330b of the tundish 300 is supplied to the second mold 410b through the fourth phase nozzle 344 and the second lower submerged entry nozzle 430b in the process S500.

[0155] The first molten steel M1 and the second molten steel M2 supplied to each of the first and second molds 410a and 410b are semi-solidified in each of the first and second molds 410a and 410b to manufacture the double-layered slab in which the components in the surface layer and the inner layer are different. That is, the double-layered slab in which the first molten steel M1 supplied to the upper side thereof is the surface layer, and the second molten steel M2 supplied to the lower side thereof is the inner layer is manufactured.

[0156] Here, a magnetic field is applied into the first and second molds 410b by operating each of the first magnetic field generation part 460a and the second magnetic field generation part 460b, and an intensity of the magnetic flux density is 0.2 tesla to 0.8 tesla.

[0157] Also, each of the slabs drawn from the first and second molds 410a and 410b is secondarily cooled by injected coolant and completely solidified while moving along the plurality of first rolls below the first mold 410a and the plurality of second rolls below the second mold 410b.

[0158] The above-described slab S manufactured from the first casting device 400a and the second casting device 400b is the double-layered slab in which the components in the surface layer and the inner layer are different. That is, since the surface layer is cast by using the first molten steel containing 3 wt% of Cr, the surface layer has a characteristic of stainless steel having the corrosion resistance caused by Cr. Also, the inner layer is cast by using the second molten steel and has a characteristic of low carbon steel.

[0159] Also, as the intensity of the magnetic flux density is 0.2 tesla to 0.8 tesla when the magnetic force is applied to each of the first and second molds 410b, the double-layered slab in which the surface layer SL has the concentration gradient on the added component is manufactured. That is, the surface layer SL has the concentration gradient layer CGA in which the concentration of the added component gradually decreases in a direction from the surface to the inner layer. In other words, the concentration of the added component is greater in the surface layer SL than the inner layer, and the concentration of the added component gradually increases in a direction toward an outermost surface of the slab S in the surface layer SL. Also, the thickness of the concentration gradient layer is 1.4% to 8.5% of the total thickness of the slab.

[0160] As described above, although the double-layered slab is manufactured to have the concentration gradient, the surface layer SL has a function corresponding to the surface layer of the double-layered slab without the concentration gradient, e.g., the corrosion resistance. Thus, since the magnetic force greater than 0.8 tesla is unnecessary to be applied when the double-layered slab is manufactured, the installation is unnecessary to be manufactured with excessively large size for applying 0.8 tesla and thus advantageous to be commercialized.

[0161] Also, as the first molten steel M1 and the second molten steel M2 are separately prepared in the ladle 100 and supplied to the tundish, the double-layered slab having the uniform component in the longitudinal direction thereof.

[0162] Also, as the additive is inserted into and the molten steel is charged to the first room 130a of the ladle 100, and then the inert gas is blown through the first plug 140a, the first molten steel in which the additive and the molten steel is uniformly mixed or the components are uniform may be prepared. Thus, the double-layered slab in which the components in the surface layer are uniform in the longitudinal direction thereof may be manufactured.

[0163] Also, as the installation is configured to include the plurality of strands so that the ladle 100 and the tundish 300 accommodate each of the first molten steel M1 and the second molten steel M2, the production rate of the double-layered slab may improve.

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[0164] As the casting installation according to an embodiment of the present invention is configured to include the plurality of strands, the production rate of the double-layered slab may improve. Also, as the first molten steel and the second molten steel are separately prepared in the ladle and supplied to the tundish, the double-layered slab in which the components are uniform in the longitudinal direction of the slab may be cast.

Claims

1. A casting installation comprising:

a ladle provided with a first room and a second room, each of which accommodates molten steel;
a tundish having a first accommodation space configured to accommodate first molten steel supplied from the first room and a second accommodation space configured to accommodate second molten steel supplied from the second room; and
a mold that is disposed below the tundish, solidifies the first molten steel and the second molten steel supplied from the tundish, and casts a double-layered slab in which components in a surface layer and an inner layer are different.

2. The casting installation of claim 1, wherein the ladle comprises:

a body having an inner space; and
a division member installed in the body so that the first room and the second room are formed by dividing the inner space of the body,
wherein a bottom surface of the division member is connected to a bottom surface of the body.

3. The casting installation of claim 2, wherein the ladle comprises:

a first plug that passes through a bottom of the first room in a vertical direction so that an inert gas is blown to the first room;
a second plug that passes through a bottom of the second room in the vertical direction so that an inert gas is blown to the second room;
a first discharge nozzle that passes through the bottom of the first room in the vertical direction to discharge the first molten steel; and
a second discharge nozzle that passes through the bottom of the second room in the vertical direction to discharge the second molten steel.

4. The casting installation of claim 3, wherein the tundish comprises:

a main body having an inner space; and
a partition wall part installed in the main body so that the first accommodation space is an outer space, and the second accommodation space is an inner space in the main body,
wherein a lower end of the partition wall part is connected to a bottom of the main body.

5. The casting installation of claim 4, wherein the main body comprises:

a first body extending in a first extension direction; and
a second body extending from the first body in a second extension direction crossing the first extension direction,
wherein the partition wall part comprises:

a first partition wall extending in the extension direction of the first body and accommodated in the first body; and
a second partition wall extending in the direction crossing the extension direction of the first body and having at least a portion accommodated in the second body.

6. The casting installation of claim 5, wherein the mold is disposed below the first partition and the first body of the tundish, and
the ladle is disposed above the second partition and the second body of the tundish.

7. The casting installation of claim 5, wherein the mold is provided in plurality, and
the plurality of molds are arranged in the first extension direction below the tundish so as to receive the first molten steel and the second molten steel from the tundish.

8. The casting installation of claim 7, further comprising:

a plurality of upper submerged entry nozzles configured to supply the first molten steel of the tundish to the plurality of molds, respectively; and
a plurality of lower submerged entry nozzles configured to supply the second molten steel of the tundish to the plurality of molds, respectively.

9. The casting installation of claim 7, wherein the casting device comprises a magnetic field generation part configured to apply a magnetic field into the mold.

10. A casting method for manufacturing a double-layered slab in which components in a surface layer and an inner layer are different, comprising:

supplying first molten steel accommodated in a first room of a ladle to a first accommodation space of a tundish;

supplying second molten steel accommodated in a second room, which is isolated and distinguished from the first room, in the ladle to a second accommodation space of the tundish; and
casting a slab by supplying the first and second molten steel of the tundish to a mold.

11. The casting method of claim 10, further comprising preparing the first molten steel in the first room of the ladle and preparing the second molten steel in the second room,
wherein the preparing of the first molten steel in the first room and the preparing of the second molten steel in the second room comprises:

inserting an additive into the first room; and
charging molten steel having the same component composition to each of the first room and the second room.

12. The casting method of claim 11, further comprising blowing an inert gas to each of the first room and the second room after the preparing of the first molten steel in the first room and the preparing of the second molten steel in the second room.

13. The casting method of claim 11, further comprising applying a magnetic field into the mold.

14. The casting method of claim 13, wherein in the applying of the magnetic field into the mold, a magnetic flux density is adjusted to form a concentration gradient in which a concentration of an added component contained in the additive decreases in an inner direction from a surface of the surface layer.

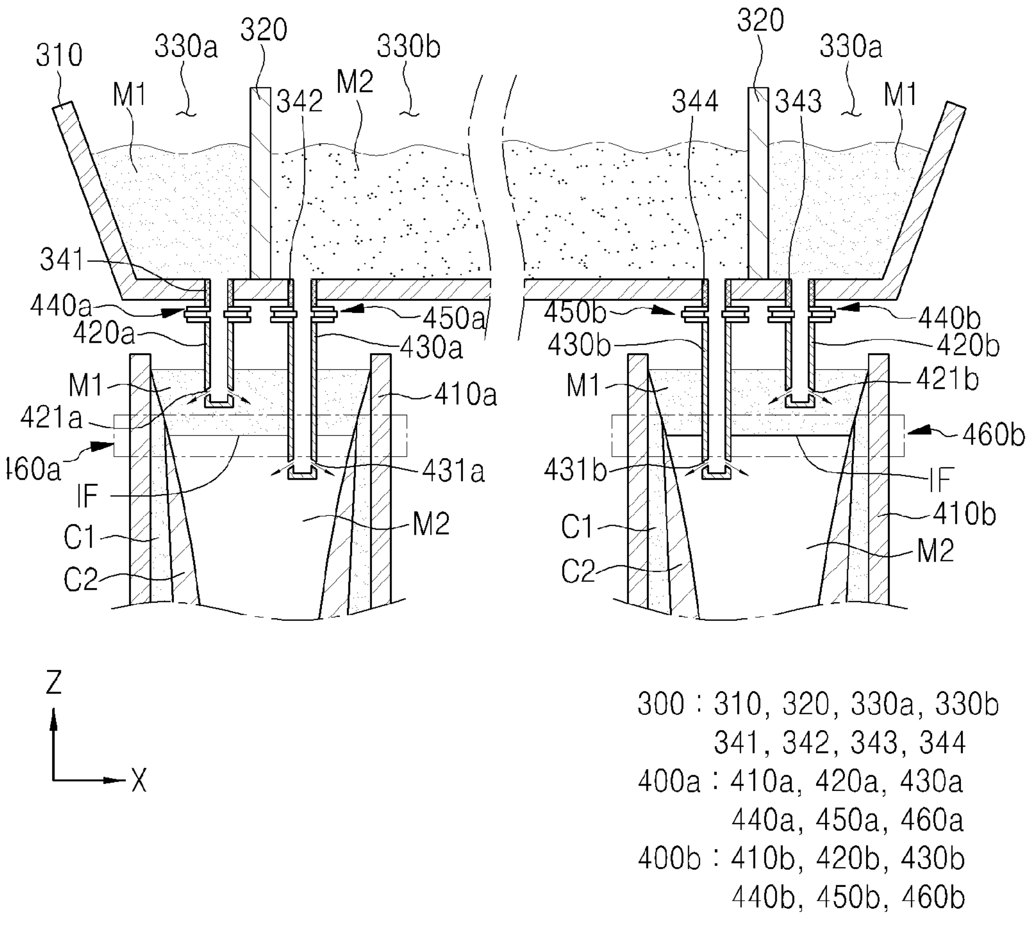
15. The casting method of claim 14, wherein the magnetic field is applied so that the magnetic flux density in the mold is 0.2 tesla to 0.8 tesla.

16. The casting method of claim 14, wherein the additive comprises ferro-alloy containing at least one added component of Cr, C, Si, Mn, Ni, and Al.

17. A double-layered slab manufactured by any one of the casting methods of claims 10 to 16 and having a concentration gradient layer having a concentration gradient on an added component in an inner direction from a surface thereof.

18. The double-layered slab of claim 17, wherein the concentration gradient layer has a thickness that is 1.4% to 8.5% of a total thickness of a slab.

FIG. 1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330b
M1
342
M2
320
330a
344
343
M1
341
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450a
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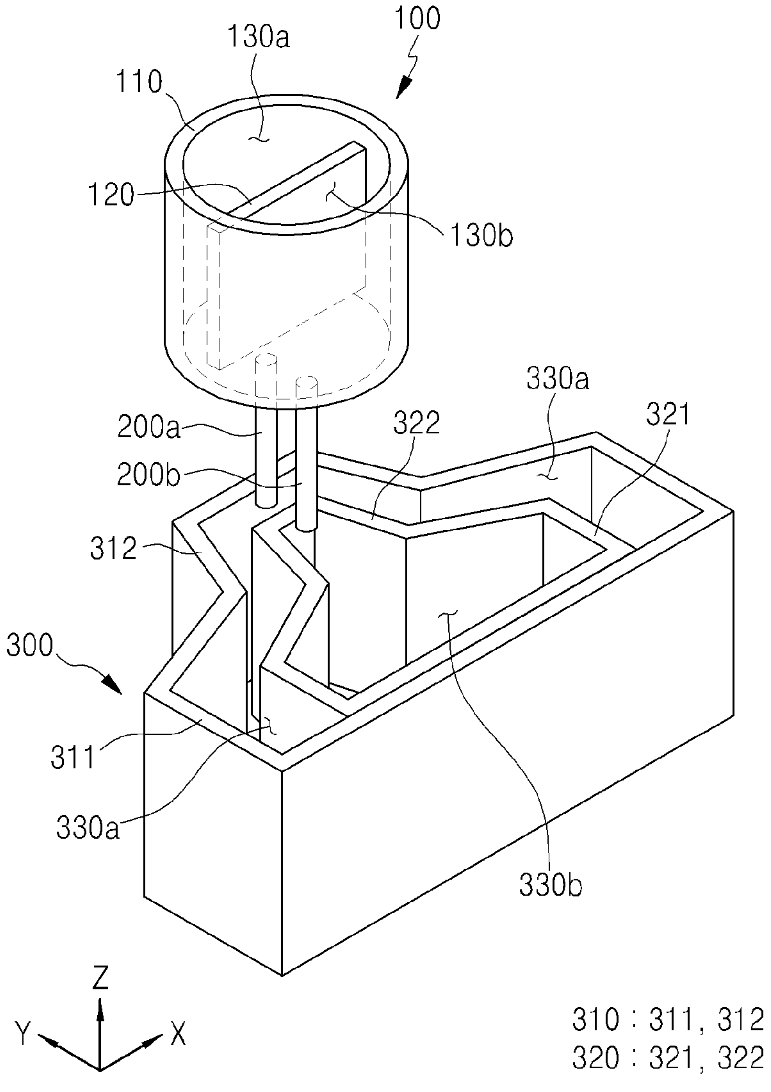
430a
450b
440b
430b
420b
M1
410a
421b
421a
M1
460b
460a
431a
431b
IF
IF
C1
M2
C1
410b
C2
C2
M2
Z
X
300 : 310, 320, 330a, 330b
341, 342, 343, 344
400a : 410a, 420a, 430a
440a, 450a, 460a
400b : 410b, 420b, 430b
440b, 450b, 460b

FIG. 2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130b
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200a
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Z
Y
X
310 : 311, 312
320 : 321, 322

FIG. 3

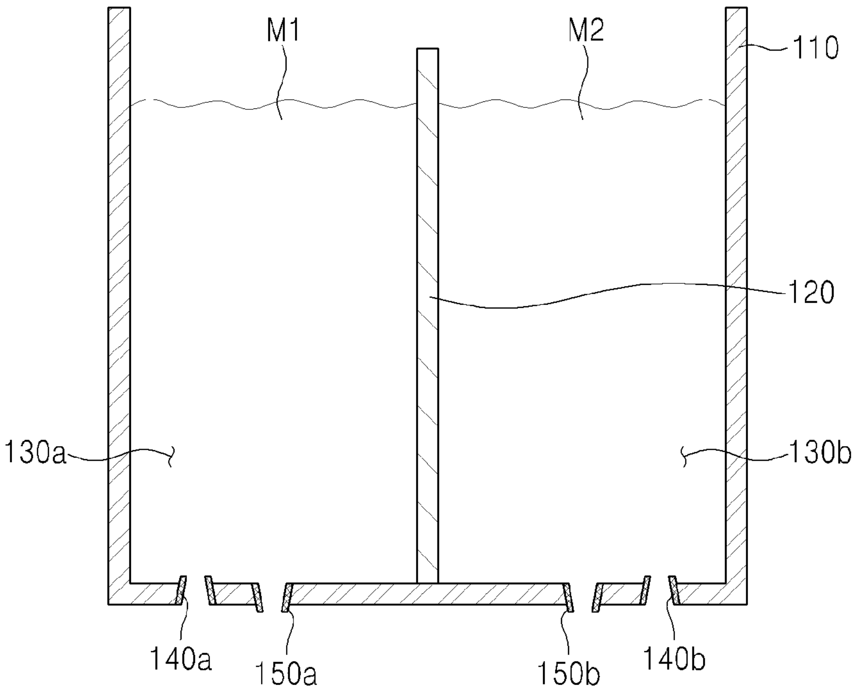
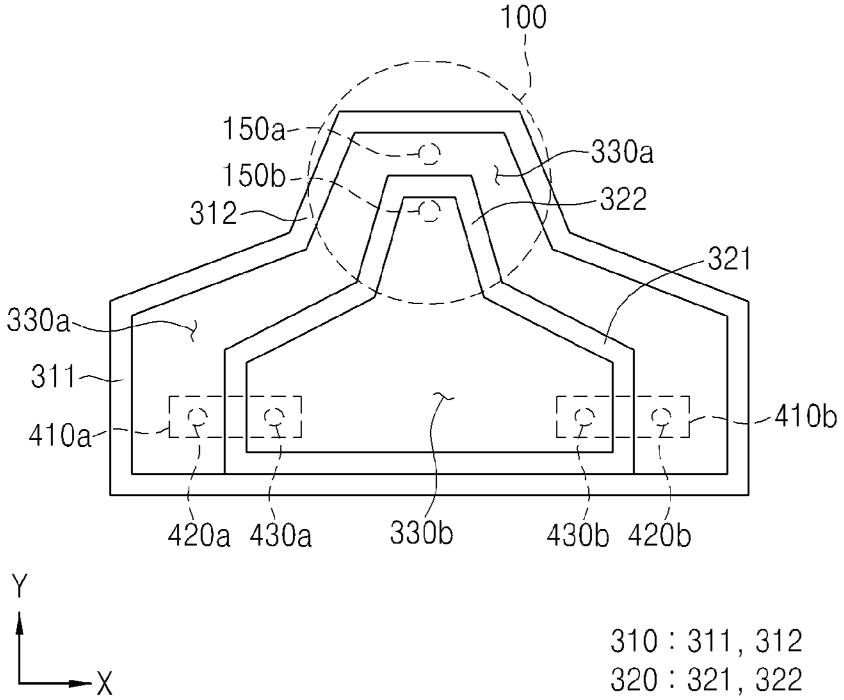


FIG. 4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Y
X
310 : 311, 312
320 : 321, 322

FIG. 5

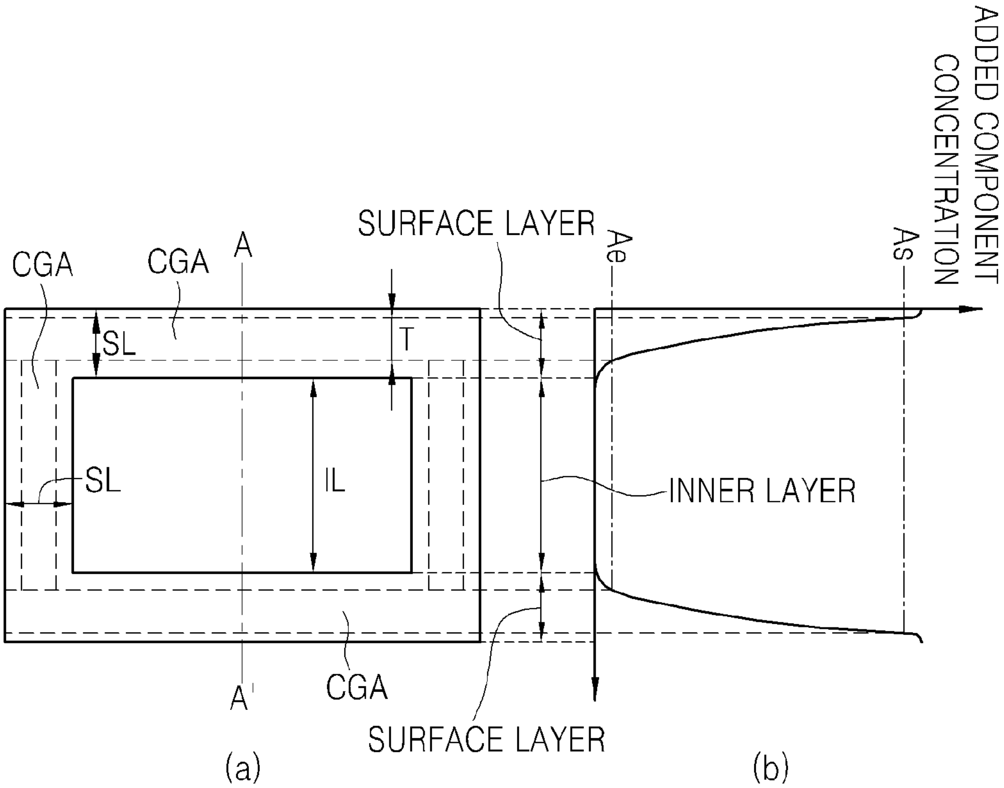

ADDED COMPONENT CONCENTRATION
SURFACE LAYER
CGA
CGA
A
Ae
As
SL
T
SL
IL
INNER LAYER
A'
CGA
SURFACE LAYER
(a)
(b)

FIG. 6

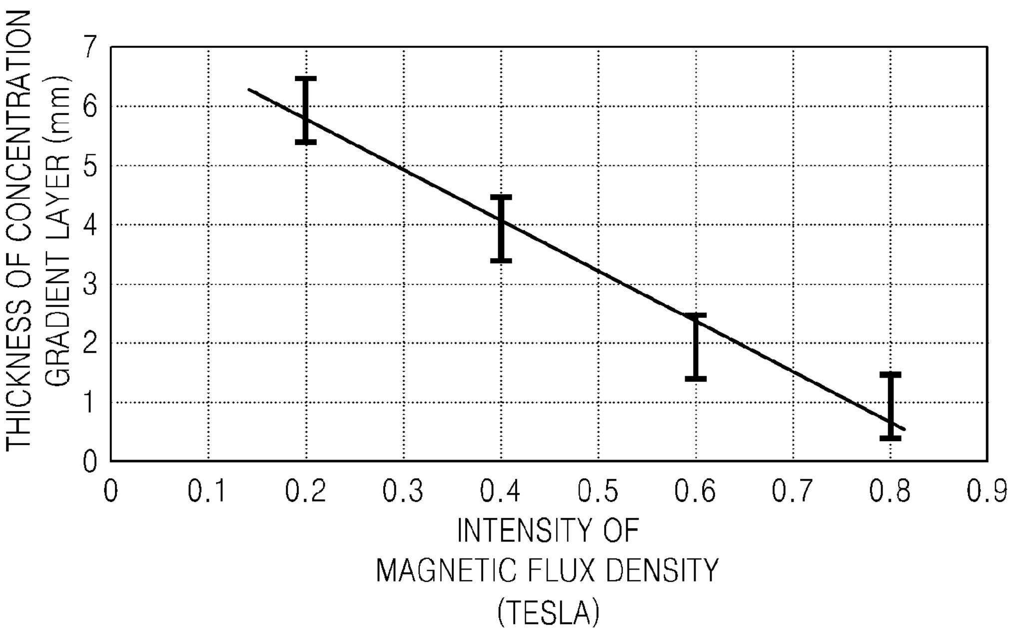
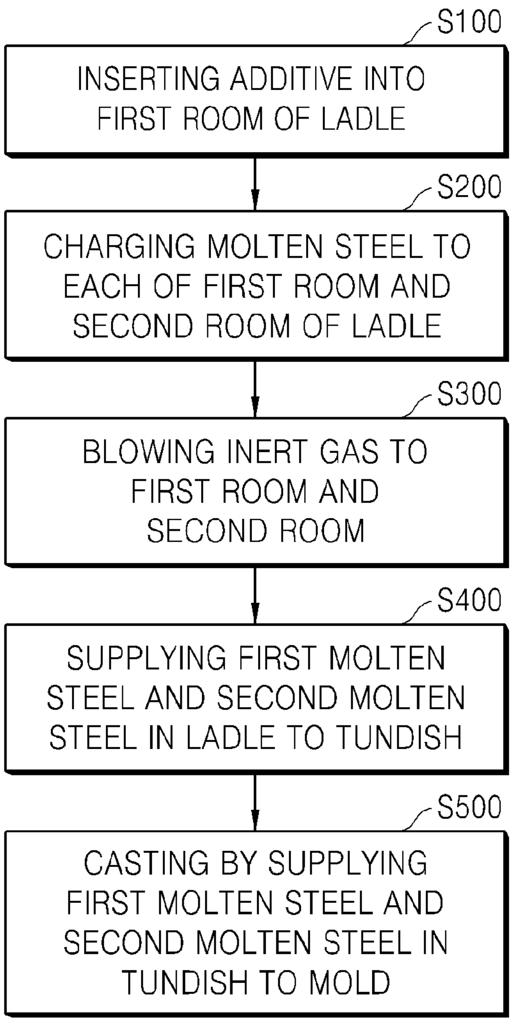

THICKNESS OF CONCENTRATION GRADIENT LAYER (mm)
7
6
5
4
3
2
1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
INTENSITY OF
MAGNETIC FLUX DENSITY
(TESLA)

FIG. 7


S100
INSERTING ADDITIVE INTO FIRST ROOM OF LADLE
S200
CHARGING MOLTEN STEEL TO EACH OF FIRST ROOM AND SECOND ROOM OF LADLE
S300
BLOWING INERT GAS TO FIRST ROOM AND SECOND ROOM
S400
SUPPLYING FIRST MOLTEN STEEL AND SECOND MOLTEN STEEL IN LADLE TO TUNDISH
S500
CASTING BY SUPPLYING FIRST MOLTEN STEEL AND SECOND MOLTEN STEEL IN TUNDISH TO MOLD

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2019/013908

A. CLASSIFICATION OF SUBJECT MATTER

B22D 11/00(2006.01)i, B22D 11/103(2006.01)i, B22D 11/04(2006.01)i, B22D 11/16(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 11/00; B22D 11/103; B22D 11/108; B22D 11/11; B22D 11/18; B32B 15/01; B22D 11/04; B22D 11/16

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: casting equipment, radle, tundish, mold, casting, multi layer, molten steel

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 06-320232 A (NIPPON STEEL CORP.) 22 November 1994 See paragraphs [0009]-[0018], claims 1-2 and figure 1.	1-2,10,17-18
A		3-9,11-16
X	JP 05-104223 A (NIPPON STEEL CORP.) 27 April 1993 See paragraphs [0037]-[0042] and figure 1.	1-2,10,17-18
A	JP 2018-114549 A (NIPPON STEEL & SUMITOMO METAL) 26 July 2018 See paragraphs [0023]-[0027] and figures 1, 5.	1-18
A	KR 10-2018-0066175 A (NIPPON STEEL & SUMITOMO METAL) 18 June 2018 See paragraphs [0025]-[0040] and figure 1.	1-18
A	WO 2009-024601 A1 (ALERIS ALUMINUM KOBLENZ GMBH.) 26 February 2009 See claims 1-4 and figure 1.	1-18

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

* Special categories of cited documents:
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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
28 JANUARY 2020 (28.01.2020)	**29 JANUARY 2020 (29.01.2020)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex Daejeon Building 4, 189, Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea Facsimile No. +82-42-481-8578	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2019/013908

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JP 05-104223 A	27/04/1993	JP 07-108441 B2	22/11/1995
JP 2018-114549 A	26/07/2018	None	
KR 10-2018-0066175 A	18/06/2018	BR 112018008552 A2	23/10/2018
		CA 3003574 A1	04/05/2017
		CN 108348989 A	31/07/2018
		EP 3369495 A1	05/09/2018
		JP 2017-080788 A	18/05/2017
		TW 201720548 A	16/06/2017
		TW I633954 B	01/09/2018
		US 2018-0304349 A1	25/10/2018
		WO 2017-073784 A1	04/05/2017
WO 2009-024601 A1	26/02/2009	None	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 20120071475 **[0008]**