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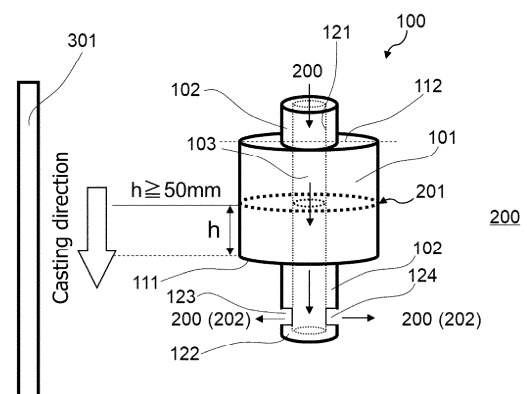
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(54) **IMMERSION NOZZLE FOR CONTINUOUS CASTING, AND CONTINUOUS CASTING METHOD FOR STEEL**

(57) Provided is an immersion nozzle for continuous casting capable of suppressing mold powder entrapment in molten steel. This immersion nozzle is used to pour molten steel from a tundish into a mold of a continuous casting machine and includes: a molten steel flow regulation portion that is immersed in the molten steel and provided at a molten steel surface to be exposed above the molten steel surface formed inside the mold; and a tubular portion that penetrates the molten steel flow regulation portion along a vertical direction and is configured to discharge the molten steel into the mold, wherein at least in a given region extending from the molten steel surface toward a casting direction of the molten steel, the molten steel flow regulation portion has a continuous shape in which its outer circumferential transverse section is formed into an oval or streamlined shape with the major axis oriented in the mold width direction, where a ratio of the minor axis b of the outer circumferential transverse section shape of the molten steel flow regulation portion to a major axis a thereof is 0.95 or less, and wherein an outer circumferential transverse section of the tubular portion is formed into a circular or oval shape in the mold width direction, where the ratio β/α , with α being a length of a first axis sub-

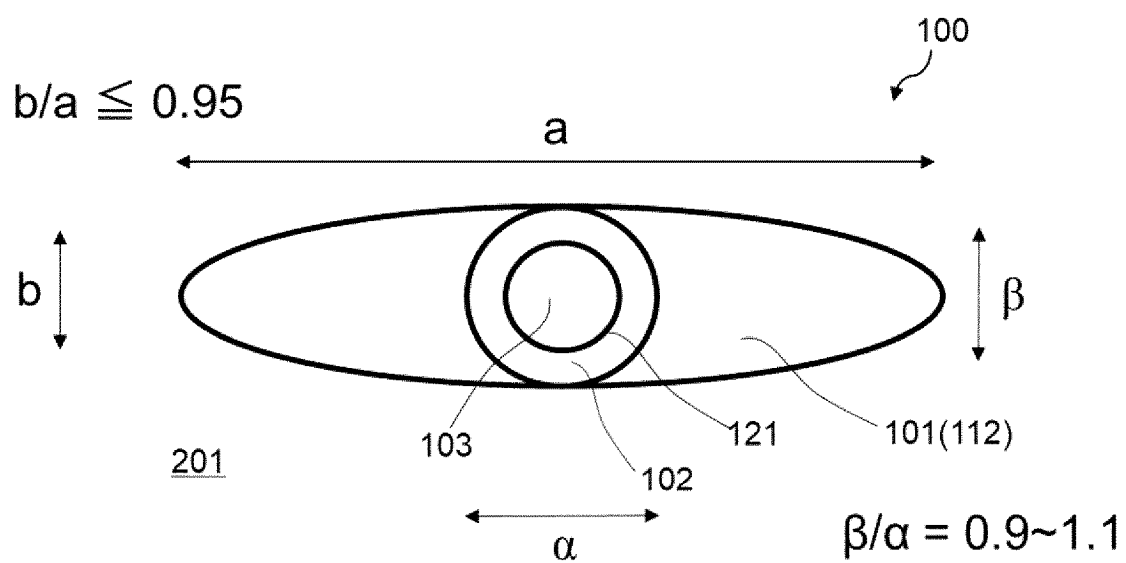
stantially parallel to a wide face of the mold and β being a length of another axis orthogonal to the first axis, is between 0.90 and 1.1.

[Fig. 1A]

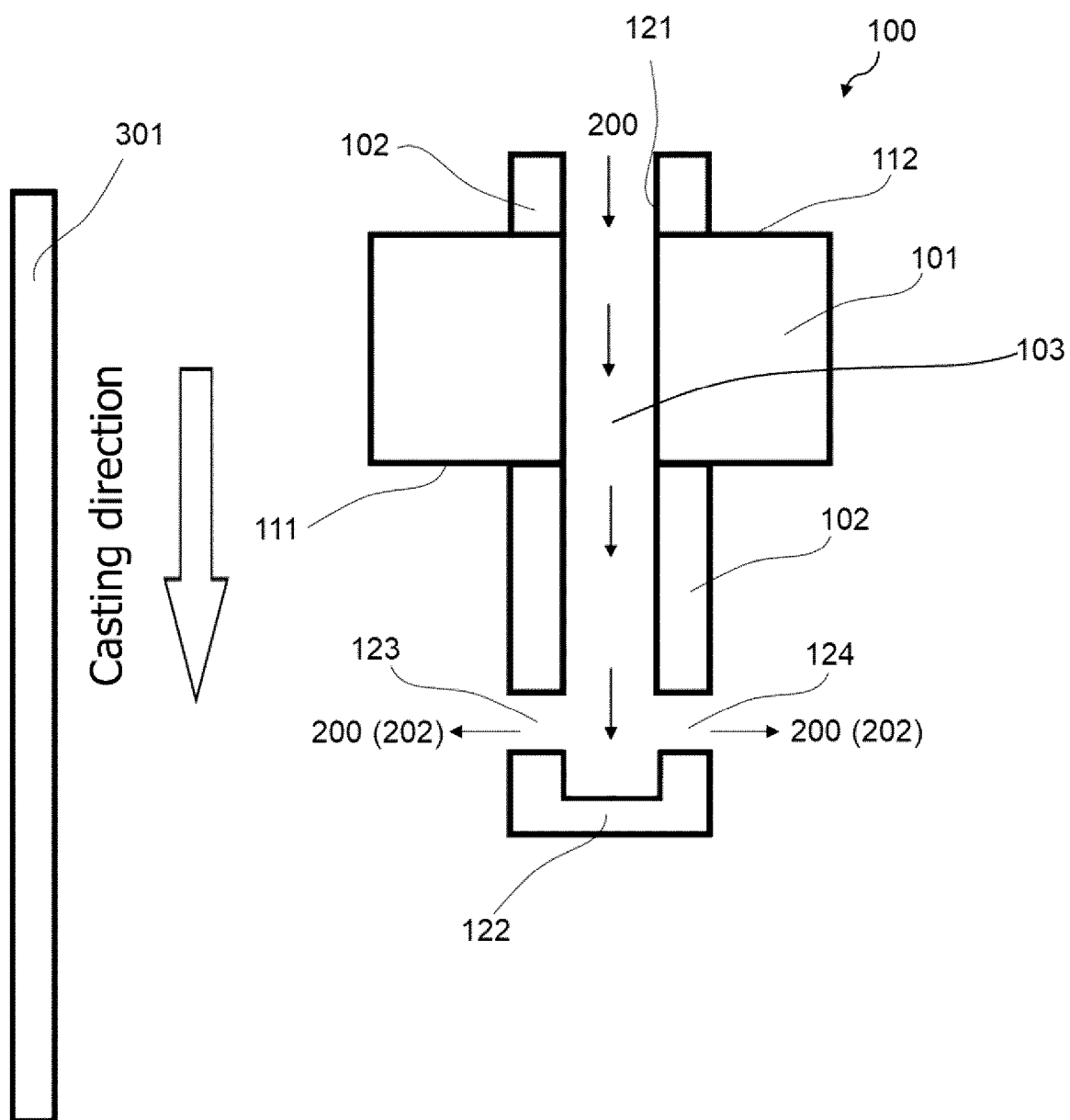


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[Fig. 1B]



[Fig. 1C]



Description

Technical Field

- 5 **[0001]** The present invention relates to an immersion nozzle, or a submerged entry nozzle (SEN) for continuous casting, and a continuous casting method for steel. Specifically, the invention relates to an immersion nozzle for continuous casting that is used to pour molten steel into a mold when performing continuous casting on the molten steel; and a continuous casting method for steel, which utilizes such an immersion nozzle for continuous casting. More specifically, the invention relates to an immersion nozzle for continuous casting and a continuous casting method for steel capable of inhibiting the
- 10 **[0002]** When using a continuous casting machine to perform continuous casting on molten steel, the molten steel is first poured from a tundish into a mold. An initially solidified shell is then formed on the surface of the molten steel as a result of allowing the molten steel that has been poured into the mold to be cooled. Next, as the molten steel is further cooled by a secondary cooling zone to which the molten steel is subjected after forming the initially solidified shell, solidification of such
- 15 molten steel proceeds to the inner side thereof.
- [0003]** During molten steel casting, a composite oxide, known as mold powder, is constantly supplied into the mold to improve the lubricity between the initially solidified shell and the mold. After being supplied into the mold, the mold powder, in a molten state, begins to flow between the mold and the initially solidified shell.
- 20 **[0004]** Meanwhile, the mold powder, in the molten state remains floating on the molten steel surface (meniscus) in the mold. Such mold powder floating on the molten steel surface (meniscus) of the mold is entrapped by the molten steel flow generated inside the mold. When such mold powder entrapped by the molten steel flow is captured by the initially solidified shell, surface defects become observed when the cast molten steel is turned into a steel product, thus significantly impairing the quality of the resulting steel product.
- 25 **[0005]** Various studies have so far been conducted on the phenomenon in which a mold powder is to be entrapped by the molten steel flow generated in a mold. It is known that this phenomenon is mainly attributed to entrainment due to meniscus erosion by the molten steel flow at the molten steel surface (meniscus) of a mold, and entrapment caused by the vortexes of the molten steel flow. In this regard, there have been proposed approaches employing electromagnetic brake, and approaches effected by optimizing the discharge ports of an immersion nozzle and the inner surface shape thereof, in order to prevent the mold powder from being entrapped in the molten steel flow.
- 30 **[0006]** For example, disclosed in Patent Literature 1 (Japanese Patent No. 3491099) is a method where a static magnetic field is applied to the meniscus so as to impart a brake force to the molten steel, thereby reducing the flow velocity at the meniscus and thus preventing mold powder entrapment.
- [0007]** Further, disclosed in Patent Literature 2 is an immersion nozzle configured to suppress inclusion adhesion to the discharge ports by optimizing the aspect ratios and areas of the discharge ports, thereby suppressing flow deviation
- 35 attributable to discharge port clogging and thus preventing mold powder entrapment.
- [0008]** Furthermore, disclosed in Patent Literature 3 (Japanese Patent No. 6963192) is an immersion nozzle configured to suppress the occurrence of the suction phenomenon at the discharge ports by optimizing the shape of the immersion nozzle's inner pipe, thereby preventing mold powder from being entrapped in the molten steel.
- 40 **[0009]** Patent Literature 4 (Japanese Patent No. 7175513) discloses an immersion nozzle configured to make the flow velocity distribution of the molten steel flow from the discharge ports more uniform by employing a spherical shape as the shape of the inner circumferential surface of each discharge port, thereby preventing mold powder from being entrapped in the molten steel.

Citation List

- 45 Patent Literature

[0010]

- 50 Patent Literature 1: JP-A-H07-314100
 Patent Literature 2: JP-A-2001-129645
 Patent Literature 3: JP-A-2021-094585
 Patent Literature 4: JP-A-2021-126663

- 55 Summary of Invention

Technical Problem

[0011] However, the above conventional techniques have the following problems that still remain unsolved. That is, in the case of the steel continuous casting method disclosed in Patent Literature 1, which employs static magnetic fields, not only a tremendous amount of cost is incurred as equipment for applying static magnetic fields is required, but the effect of suppressing mold powder entrapment is insufficient due to the fact that while an average flow velocity at the meniscus can be restricted, a sufficient flow velocity control is not possible when an abrupt fast flow attributable to nozzle clogging or the like has occurred at the meniscus.

[0012] Further, in the cases of the approaches disclosed in Patent Literatures 2 to 4, which are effected by optimizing the immersion nozzle's discharge ports and the inner surface shapes thereof, the effect of suppressing mold powder entrapment is anticipated during the early stage of casting. However, the immersion nozzles and the like disclosed in Patent Literatures 2 to 4, which are supposed to prevent mold powder entrapment, are such that since immersion nozzle clogging and/or erosion occur to no small degree due to the discharge jets, the shape of the immersion nozzle deviates from a proper form in the later stage of casting, which leads to the abrupt generation of molten steel flows with high flow velocities at the meniscus. Thus, the immersion nozzles and the like disclosed in Patent Literatures 1 to 4 have a problem of not being able to achieve a satisfactory effect of suppressing mold powder entrapment into molten steel.

[0013] The present invention was made in view of the above circumstances. This invention aims to provide an immersion nozzle used for pouring molten steel into a continuous casting mold during steel continuous casting, which is capable of suppressing mold powder entrapment into the molten steel, as well as a continuous casting method for steel.

Solution of Problem

[0014] The inventors conducted various studies in order to solve the above problems. As a result, they found that by employing a uniquely configured immersion nozzle for continuous casting, mold powder entrapment in molten steel can be suppressed, thereby making it possible to obtain a steel product with a small amount of mold powder remaining in a cast piece. The present invention was made based on the above findings, and the gist thereof is as follows.

[0015] The immersion nozzle for continuous casting of the present invention, which is capable of advantageously solving the above problem, is an immersion nozzle used to pour molten steel from a tundish into a mold of a continuous casting machine. This immersion nozzle includes:

- a molten steel flow regulation portion that is immersed in the molten steel and provided at the molten steel surface to be exposed above the molten steel surface formed inside the mold, and
- a tubular portion that penetrates the molten steel flow regulation portion along a vertical direction and is configured to discharge the molten steel into the mold, wherein,
- at least in a given region extending from the molten steel surface toward the casting direction, the molten steel flow regulation portion has a continuous shape in which its outer circumferential transverse section is formed into an oval or streamlined shape with the major axis oriented in the mold width direction, wherein the ratio (b/a) , where a is the major axis and b is the minor axis of the outer circumferential transverse section shape of the molten steel flow regulation portion, is 0.95 or less, and
- an outer circumferential transverse section of the tubular portion is formed into a circular or oval shape in the width direction of the mold, wherein the ratio (β/α) , where α is a length of a first axis substantially parallel to a wide face of the mold and β is a length of another axis orthogonal to the first axis, is between 0.90 and 1.1.

[0016] With regard to the immersion nozzle for continuous casting of the present invention, it is considered that a more preferable solution can be brought when (a) the molten steel flow regulation portion has the continuous shape in a region extending 50 mm or more from the molten steel surface toward the casting direction of the molten steel.

[0017] In addition, the steel manufacturing method of the present invention, which is capable of advantageously solving the above problem, includes pouring molten steel inside a tundish into a mold of a continuous casting machine, using the abovementioned immersion nozzle for continuous casting.

Advantageous Effects of Invention

[0018] According to the immersion nozzle for continuous casting of the present invention, vortex occurrence in the vicinity of the immersion nozzle can be suppressed even when molten steel flows with high flow velocities have been generated at the meniscus due to flow deviation or the like, thereby making it possible to suppress mold powder entrapment in molten steel not only in the early stage but also in the later stage of casting without requiring large-scale equipment.

Brief Description of Drawings

[0019]

[Fig. 1A] is a schematic diagram showing an example of the immersion nozzle for continuous casting of the present invention, i.e., a perspective view of the immersion nozzle for continuous casting.

[Fig. 1B] is a top view of the immersion nozzle for continuous casting.

[Fig. 1C] is a vertical cross-sectional view taken by a plane that passes through a center line of discharge ports of a tubular portion of the immersion nozzle for continuous casting.

[Fig. 2] is a drawing schematically showing a flow condition of molten steel inside a mold when performing molten steel casting, using a normal immersion nozzle.

[Fig. 3] is a drawing schematically showing a flow condition of molten steel inside a mold when performing molten steel casting, using the immersion nozzle for continuous casting of the present invention.

Description of Embodiments

[First embodiment]

[0020] An immersion nozzle for continuous casting of a first embodiment is described. The immersion nozzle for continuous casting of this embodiment is an immersion nozzle for pouring molten steel from a tundish into a mold of a continuous casting machine. This immersion nozzle includes a molten steel flow regulation portion that is immersed in the molten steel and is arranged at a molten steel surface formed inside the mold to be exposed above the molten steel surface; and a tubular portion that penetrates the molten steel flow regulation portion along a vertical direction and is configured to discharge the molten steel into the mold.

[0021] At least in a given region extending from the molten steel surface toward a casting direction of the molten steel, the molten steel flow regulation portion has a continuous shape in which an outer circumferential transverse section of the molten steel flow regulation portion is formed into an oval or streamlined shape that has the major axis in a width direction of the mold, where the ratio (b/a), with a being the major axis and b being the minor axis of the outer circumferential transverse section shape of the molten steel flow regulation portion, is 0.95 or less.

[0022] An outer circumferential transverse section of the tubular portion is formed into a circular or oval shape in the width direction of the mold, where the ratio (β/α), with α being a length of a first axis substantially parallel to a wide face of the mold and β being a length of another axis orthogonal to the first axis, is between 0.90 and 1.1.

[0023] In general, a cast piece, which is a semi-finished product called slab that is produced by performing continuous casting where molten steel is poured into a mold of a continuous casting machine, is such that the width thereof is about twice the thickness thereof or larger, which makes the width of a cast piece significantly larger than its thickness. A mold into which molten steel is to be poured has a pair of mold wide faces that face each other in a front-back direction; and a pair of mold narrow faces that face each other in a left-right direction. A mold is configured to allow the mold narrow faces to move within the mold wide faces.

[0024] An immersion nozzle for continuous casting with which molten steel is poured into a mold has a plurality of discharge ports for pouring the molten steel into the mold. The plurality of discharge ports may be formed of a pair of discharge ports. A pair of discharge ports may be formed in such a way that the discharge ports are respectively oriented toward the corresponding mold narrow faces facing each other in the left-right direction. An immersion nozzle for continuous casting is configured to pour molten steel into a mold from each discharge port that is formed to be oriented toward the mold narrow face(s).

[0025] Here, the inventors analyzed the flow condition of molten steel inside a mold. Specifically, they conducted a water model experiment aimed at analyzing the flow condition of molten steel inside a mold, a numerical simulation, a measurement performed by a sensor installed inside the mold, and an analysis of a cast piece (slab) manufactured from molten steel. As a result, the following mechanism was revealed with regard to the flow of molten steel inside a mold.

[0026] First, most of the mold powder entrapment phenomena are caused by molten steel vortexes that occur in the vicinity of an immersion nozzle. Second, when the flow velocity of the molten steel at the molten steel surface (meniscus) in the vicinity of the immersion nozzle is too high, molten steel vortexes are formed in the vicinity of the immersion nozzle, leading to the entrapment of the mold powder into the molten steel. Third, when the molten steel flow from one of the discharge ports that are formed in a pair on the immersion nozzle becomes excessive due to immersion nozzle clogging caused by the inclusions in the molten steel, the flow velocity of the molten steel becomes excessive at the molten steel surface (meniscus). Fourth, even when no nozzle clogging is observed with the pair of discharge ports that are formed on the immersion nozzle, the flow velocity and direction of the molten steel discharge jet discharged from the immersion nozzle change with time. Thus, the flow velocity of the molten steel at the molten steel surface (meniscus) becomes even more excessive when the flow velocity of the molten steel is excessive and the molten steel flow itself is oriented toward the

molten steel surface (meniscus).

[0027] The inventors conducted further research and development based on such a mechanism and newly found that in order to suppress the formation of vortexes in the vicinity of an immersion nozzle, a transverse section shape of the immersion nozzle and a shape thereof in a casting direction are important. In other words, vortexes occur in the vicinity of an immersion nozzle because the flow velocity of the molten steel around the immersion nozzle becomes excessive, causing the molten steel flow to be separated from the immersion nozzle such that vortexes occur beside the immersion nozzle on the downstream side of the mold.

[0028] From this technical perspective, the inventors found that the molten steel flow in the vicinity of an immersion nozzle can be made smooth and the formation of vortexes can therefore be suppressed by employing, as an outer circumferential transverse section shape of the immersion nozzle, a streamlined or oval shape that is wide in the mold width direction. Described hereunder is the structure of the immersion nozzle for continuous casting of this embodiment, which is capable of smoothing the molten steel flow in the vicinity of the immersion nozzle and thereby suppressing the occurrence of vortexes.

<Schematic drawings of immersion nozzle for continuous casting>

[0029] Schematic drawings showing one example of the immersion nozzle for continuous casting of the present invention are illustrated. Fig. 1A is a perspective view of the immersion nozzle for continuous casting; Fig. 1B is a top view of the immersion nozzle for continuous casting; Fig. 1C is a vertical cross-sectional view of the immersion nozzle for continuous casting taken along a plane that passes through the center line of the discharge ports of the immersion nozzle.

[0030] Here, the symbols in Fig. 1A to Fig. 1C are defined as follows. Specifically, 100 represents an immersion nozzle for continuous casting; 123 represents a discharge port (left-side mold narrow face); 124 represents a discharge port (right-side mold narrow face); 101 represents a molten steel flow regulation portion; 103 represents a molten steel flow passage; 122 represents a bottom of a tubular portion 102 (bottom surface of a portion located below the molten steel flow regulation portion); a represents the major axis of the molten steel flow regulation portion 101; b represents the minor axis of the molten steel flow regulation portion 101; α represents the major axis of a part of the tubular portion 102 that is located below the molten steel flow regulation portion; β represents the minor axis of the part of the tubular portion 102 that is located below the molten steel flow regulation portion; h represents a length of the molten steel flow regulation portion 101 that is continuous from the position of a molten steel surface (meniscus) 201 toward a casting direction, i.e., an immersed depth at which the molten steel flow regulation portion 101 is immersed in molten steel 200.

[0031] As shown in Fig. 1A to Fig. 1C, the immersion nozzle for continuous casting 100 of this embodiment is an immersion nozzle for pouring the molten steel 200 from a tundish (not shown) into a mold 300 of a continuous casting machine. The basic structure of the immersion nozzle for continuous casting 100 of this embodiment is the tubular portion 102 that has a substantially straight tubular shape and has an inner hole 121 and a plurality of discharge ports formed near the bottom surface thereof. In addition, the immersion nozzle for continuous casting 100 is technically characterized in that the tubular portion 102 is further equipped with the molten steel flow regulation portion 101 that is configured to reduce the occurrence of the vortexes generated from the molten steel flow occurring at the molten steel surface (meniscus) 201 formed inside the mold 300.

[0032] The immersion nozzle for continuous casting 100 shown in Fig. 1A to Fig. 1C is an example of an immersion nozzle where the outer circumferential transverse section shape of the molten steel flow regulation portion 101 at the position of the molten steel surface (meniscus) 201 is an oval shape. That is, the immersion nozzle for continuous casting 100 is an immersion nozzle that includes the molten steel flow regulation portion 101 and the tubular portion 102 and has a pair of discharge ports, the discharge ports being bilaterally symmetrical with respect to the immersion nozzle's axial core that is provided along a vertical direction of the tubular portion 102. Here, the mold 300 is composed of a mold narrow face 301, a mold wide face 302, and a mold bottom face 303.

[0033] The molten steel flow regulation portion 101 and the tubular portion 102 that compose the immersion nozzle for continuous casting 100 are described hereunder.

<Molten steel flow regulation portion of immersion nozzle for continuous casting>

[0034] The immersion nozzle for continuous casting 100 has the molten steel flow regulation portion 101. This molten steel flow regulation portion 101 is to be immersed in the molten steel 200 and is to be provided at the molten steel surface 201 formed inside the mold 300 in such a manner that the molten steel flow regulation portion 101 is exposed above the molten steel surface 201. That is, while part of the molten steel flow regulation portion 101 is to be immersed in the molten steel 200 inside the mold 300, the rest part of the molten steel flow regulation portion 101 is to be exposed from the molten steel surface (meniscus) 201 formed inside the mold 300 toward the tundish.

[0035] As for the molten steel flow regulation portion 101, it will suffice so long as part of it is to be immersed in the molten steel 200, and the rest part thereof is to be exposed from the molten steel surface (meniscus) 201 formed inside the mold

300 toward the tundish; in view of, for example, the flow velocity of the molten steel flow of the molten steel 200 and fluctuation of the molten steel surface (meniscus) 201, the molten steel flow regulation portion 101 may be disposed in such a manner that said rest part thereof is exposed above the molten steel surface (meniscus) 201 by a range of 0.1 to 50 mm. Particularly, in view of surface fluctuation of the molten steel surface (meniscus) 201, it is preferred that the molten steel flow regulation portion 101 be exposed above an assumed molten steel surface (meniscus) 201 by 1.0 mm or more toward the tundish.

[0036] At least in a given region extending from the molten steel surface 201 toward the casting direction of the molten steel 200, the molten steel flow regulation portion 101 of the immersion nozzle for continuous casting 100 is configured in such a way that an outer circumferential transverse section of the molten steel flow regulation portion 101 is formed into an oval or streamlined shape with the major axis aligned with the width direction of the mold 300. Here, an oval shape includes an oblong shape. Further, instead of an oval shape, there may also be employed an obround shape having parallel side portions and arcuate ends, formed by replacing the shorter sides of a rectangular shape with arcs. Furthermore, a streamlined shape refers to a shape that is composed of such a curved line(s) that when the molten steel flow regulation portion 101 is placed in the flow of the molten steel 200, no vortex is generated therearound, and the resistance brought by the flow of the molten steel 200 is minimized.

[0037] For example, if the flow of the molten steel 200 is uniform, the tip of the molten steel flow regulation portion 101's streamlined shape may be configured as a sharpened shape. The outer circumferential transverse section of the molten steel flow regulation portion 101 may also be formed into point-symmetric and line-symmetric streamlined shapes. It is preferable if the outer circumferential transverse section of the molten steel flow regulation portion 101 is formed into point-symmetric and line-symmetric streamlined shapes, because the occurrence of the vortexes that are formed from the molten steel flow generated at the molten steel surface (meniscus) 201 inside the mold 300 can be reduced.

[0038] The molten steel flow regulation portion 101 has such a continuous shape that the ratio (b/a), where a is the major axis and b is the minor axis of the outer circumferential transverse section shape of the molten steel flow regulation portion 101, is 0.95 or less. It is preferable that the ratio (b/a) of the minor axis b to the major axis a of the outer circumferential transverse section shape of the molten steel flow regulation portion 101 be 0.95 or less. This is because the molten steel flow regulation portion 101 can thus possess a shape that does not easily contribute to flow separation even when the molten steel flow velocity of the molten steel 200 is excessive, whereby the flow of the molten steel 200 does not separate from the molten steel flow regulation portion 101, which prevents vortexes from occurring beside the nozzle on the downstream side of the casting direction.

[0039] Further, from such technical perspective, the ratio (b/a) of the minor axis b to the major axis a of the outer circumferential transverse section shape of the molten steel flow regulation portion 101 may be 0.85 or less, preferably 0.65 or less, more preferably 0.50 or less.

[0040] The continuous shape where the ratio (b/a) of the minor axis b to the major axis a of the outer circumferential transverse section shape of the molten steel flow regulation portion 101 is 0.95 or smaller, is formed at least in a given region extending from the molten steel surface (meniscus) 201 downward in the casting direction of the molten steel 200. The given region where the continuous shape is formed can be appropriately determined, based on, for example, the height of the molten steel surface (meniscus) 201 formed inside the mold 300 and the flow condition of the molten steel 200, in order to prevent the formation of vortexes at the molten steel surface beside the nozzle due to the separation of the flow of the molten steel 200 from the molten steel flow regulation portion 101.

[0041] Since the outer circumferential transverse section shape of the molten steel flow regulation portion 101 may be worn by the mold powder, it is desirable that the outer diameter shape of the above condition be determined by previously taking a wear amount of the molten steel flow regulation portion 101 into consideration. Further, there may often be employed a technique of preventing a same spot on the molten steel flow regulation portion 101 from coming into contact with the mold powder by changing, with casting time, the depth at which the molten steel flow regulation portion 101 is immersed in the molten steel 200. Even when employing such technique, it is preferred that the above condition be determined in accordance with the assumed depths at which the molten steel flow regulation portion 101 is immersed in the molten steel at both the initial and final stages of casting.

<Tubular portion of immersion nozzle for continuous casting>

[0042] The immersion nozzle for continuous casting 100 includes, inside, the tubular portion 102 that penetrates the molten steel flow regulation portion 101 along a vertical direction. The tubular portion 102 corresponds to an immersion nozzle composed of a substantially straight tubular shape. The molten steel flow regulation portion 101 and the tubular portion 102 may be integrally formed; or the molten steel flow regulation portion 101 and the tubular portion 102 may be separately formed and then assembled. The tubular portion 102 is configured to discharge the molten steel 200 transported from the tundish into the mold 300. The tubular portion 102 has an upper end extended and located in the direction of the tundish, and a lower end extended and located in the direction of the mold bottom face 303.

[0043] Here, the tubular portion 102 has a substantially straight shape, with its upper and lower end shapes being

substantially identical to each other. Further, the tubular portion 102 may have a slightly different shape as long as it is in a shape allowing the molten steel 200 transported from the tundish to flow from the upper end of the tubular portion 102 into the plurality of discharge ports that are formed near the bottom surface. The inner hole 121 is formed inside the tubular portion 102. The tubular portion bottom surface 122 is formed at the bottom part of the tubular portion 102. The inner hole 121 formed inside the tubular portion 102 serves as a molten steel flow passage 103 of the molten steel 200, which allows the molten steel 200 poured from the upper end of the tubular portion 102 to flow to the vicinity of the tubular portion bottom surface 122 of the tubular portion 102.

[0044] Moreover, the tubular portion 102 has, at the lower end part thereof, the discharge ports 123 and 124 as a pair of discharge ports that are used to discharge the molten steel 200 into the mold 300. The discharge port 123 faces the mold narrow face 301 located on the left side of the mold 300 in the width direction thereof. The discharge port 124 faces the mold narrow face 301 located on the right side of the mold 300 in the width direction thereof.

[0045] The molten steel 200 is to be poured from the inner hole 121 formed at the upper end of the tubular portion 102 that protrudes from a central part of an upper surface 112 of the molten steel flow regulation portion 101 and is thus disposed toward the direction of the tundish.

[0046] The inner hole 121 of the tubular portion 102 penetrates an interior region 111 of the molten steel flow regulation portion 101 and is continuous from the upper end of the tubular portion 102 to the lower end of the tubular portion 102. Thus, the molten steel 200 poured from the inner hole 121 formed at the upper end of the tubular portion 102 is transported toward the tubular portion bottom surface 122 of the tubular portion 102 in the casting direction, through the inner hole 121 formed at the lower end of the tubular portion 102 that is formed inside the molten steel flow regulation portion 101.

[0047] The molten steel 200 transported in the casting direction of the inner hole 121 formed in the tubular portion 102 will reach the tubular portion bottom surface 122. The molten steel 200 that has reached the tubular portion bottom surface 122 will then be discharged, as a discharge jet 202, from the discharge ports 123 and 124 of the tubular portion 102 into the mold 300. Later, the molten steel surface (meniscus) 201 will be formed inside the mold 300 as the molten steel 200 discharged in the mold 300 accumulates.

[0048] Next, described are the shape of the tubular portion 102; and the discharge ports 123 and 124 that are formed at the lower part of the tubular portion 102. The lengths of the discharge ports 123 and 124 in a discharge direction are inevitably longer than those of a normal immersion nozzle when the outer circumferential transverse section of the tubular portion 102 is formed into an oval or streamlined shape that is substantially identical to the outer circumferential transverse section shape of the molten steel flow regulation portion 101 down to the vicinity of the discharge ports 123 and 124.

[0049] Thus, there is a dramatically higher risk of immersion nozzle clogging, whereby not only defects attributable to mold powder will be facilitated, but other defects related to steelmaking will also be facilitated as well, which will result in a hindered productivity.

[0050] Further, if performing continuous casting of the molten steel 200 with the same casting width, the discharge position of the molten steel 200 can be brought closer to the mold narrow face 301 of the mold 300 as compared to when using a normal immersion nozzle to perform continuous casting of the molten steel 200. As a result, a speed at which the discharge jet of the molten steel 200 discharged from the discharge ports 123 and 124 that are formed at the tubular portion 102 collides with the mold narrow face 301 will become excessive such that so-called "breakout" will occur, where the initially solidified shell that has been formed on the surface of the molten steel 200 will remelt, and the molten steel 200 will thus leak out due to an insufficient thickness of the initially solidified shell when exiting the mold 300.

[0051] In view of the above conditions, the immersion nozzle for continuous casting 100 in this embodiment is configured such that the outer circumferential transverse section of the tubular portion 102 is formed into a circular or oval shape in the width direction of the mold 300. The ratio (β/α), where α is a length of a first axis substantially parallel to a wide face of the mold 300 and β is a length of another axis orthogonal to the first axis, is between 0.90 and 1.1.

[0052] That is, in the vicinity of the discharge ports 123 and 124 of the tubular portion 102, it is required that the outer circumferential transverse section of the tubular portion 102 be formed into a circular or oval shape in the width direction of the mold 300, and that the ratio (β/α), where α is the length of the first axis substantially parallel to the wide face of the mold 300 and β is the length of another axis orthogonal to the first axis, be set to 0.90 or larger.

[0053] It is preferable that the ratio (β/α), where α is the length of the first axis substantially parallel to the wide face of the mold 300 and β is the length of another axis orthogonal to the first axis, be 0.90 or larger, because the risk of immersion nozzle clogging will not increase, so that not only defects attributable to mold powder will not be facilitated, but other steelmaking defects will not be facilitated as well.

[0054] However, when the value of (β/α) is larger than 1.1, the wall thickness of the discharge port passage will be formed excessively thin, making it impossible to adjust the discharge jet along the vertical direction. Therefore, the upper limit of the value of (β/α) is set to 1.1.

[0055] Here, the immersion nozzle for continuous casting 100 shown in Fig. 1A to Fig. 1C is one in which the angles of the nozzle's discharge ports 123 and 124 are each about 90 degrees with respect to the axial direction of the immersion nozzle; these discharge port angles and shapes as well as a pool depth and shape may be modified to those of appropriate values depending on casting conditions and qualities required for cast pieces.

[0056] In this way, since the immersion nozzle for continuous casting 100 of this embodiment has the molten steel flow regulation portion 101 and the tubular portion 102 that are each formed into a particular shape, the flow of the molten steel 200 will not be separated from the molten steel flow regulation portion 101, and the vortexes of the molten steel 200 will thus not occur beside the nozzle on the downstream side of the casting direction, thereby suppressing risks such as immersion nozzle clogging and inclusion adherence.

[0057] As described above, according to the invention of this embodiment, in the case of an immersion nozzle used to pour molten steel into a mold for continuous casting in steel continuous casting, it is possible to suppress the entrapment of a mold powder into the molten steel.

[Second embodiment]

[0058] An immersion nozzle for continuous casting of a second embodiment is described. The immersion nozzle for continuous casting of this embodiment is based on the immersion nozzle for continuous casting of the first embodiment and is characterized in that the molten steel flow regulation portion thereof has the abovementioned continuous shape in a region extending 50 mm or more from the molten steel surface toward the casting direction of the molten steel. That is, the continuous shape of the immersion nozzle for continuous casting of this embodiment is formed to be continuous by at least 50 mm from the molten steel surface (meniscus) 201 toward the casting direction of the molten steel 200.

[0059] It is preferable that this continuous shape extend for at least 50 mm, because it is unlikely that vortexes generated due to the molten steel 200 flow separation occurring in a lower region of the casting direction where such continuous shape is not present will reach the molten steel surface (meniscus) 201 to cause the molten steel 200 to entrap the mold powder.

[0060] Here, the continuous shape of the molten steel flow regulation portion 101 is formed continuously so as not to interfere with the discharge ports 123 and 124.

[0061] Accordingly, in the case of the immersion nozzle for continuous casting 100 of this embodiment, vortexes formed due to the flow separation of the molten steel 200 will not reach the molten steel surface (meniscus) 201. As a result, the immersion nozzle for continuous casting 100 of this embodiment can more effectively inhibit the mold powder from being entrapped in the molten steel 200.

[0062] As described above, according to the invention of this embodiment, vortexes generated due to the molten steel flow separation occurring in the lower region of the casting direction where the continuous shape does not exist can be inhibited from reaching the molten steel surface (meniscus), thereby preventing the mold powder from being entrapped in the molten steel.

[Third embodiment]

[0063] A steel manufacturing method of a third embodiment is described hereunder. The steel manufacturing method of this embodiment is characterized by manufacturing steel, using the immersion nozzles for continuous casting of the above embodiments. At first, in the steel manufacturing method of this embodiment, the immersion nozzle for continuous casting 100 of the above embodiment(s) is to be attached to the bottom portion of a tundish.

[0064] Next, the tundish is to be placed above the mold 300 in such a way that the immersion nozzle for continuous casting 100 is positioned approximately at the center of a space formed by the mold 300. In this way, in the steel manufacturing method of this embodiment, there are prepared and installed the tundish, the immersion nozzle for continuous casting 100, and the mold 300 for continuous casting that are members required to perform continuous casting on molten steel.

[0065] Moreover, in the steel manufacturing method of this embodiment, while pouring the molten steel 200 into the tundish from a ladle that contains the molten steel 200 manufactured with a refining furnace such as a converter, the molten steel 200 is to be poured from the tundish into the mold 300 through the immersion nozzle for continuous casting 100. By allowing the molten steel 200 to be poured into the mold 300 through the immersion nozzle for continuous casting 100, the molten steel 200 poured into the mold 300 will accumulate therein. As the molten steel 200 that has been poured into the mold 300 accumulates, the molten steel surface (meniscus) 201 will be formed inside the mold 300.

[0066] During continuous casting on the molten steel 200, mold powder is supplied to the molten steel 200 poured into the mold 300. After being supplied into the mold 300, the mold powder, in a molten state, begins to flow into an initially solidified shell formed inside the mold 300 due to the cooling of the molten steel 200. Meanwhile, some of the mold powder supplied to the mold 300, in a molten state, remains floating on the molten steel surface (meniscus) 201 in the mold 300.

[0067] Further, when pouring the mold powder into the mold 300 so as to supply the same to the molten steel 200, an inert gas such as an argon gas and a nitrogen gas may be blown, through a sliding nozzle, an upper nozzle or the like, into the molten steel 200 flowing down the molten steel flow passage 103 of the immersion nozzle for continuous casting 100.

[0068] Fig.2 is a drawing schematically showing a flow condition of molten steel inside a mold when performing molten steel casting, using a normal immersion nozzle. Here, the symbols in Fig.2 are defined as follows. Specifically, 301

represents a continuous casting mold narrow face; 201 represents a molten steel surface (equivalent to meniscus); 202 represents a discharge jet from the discharge port 123; 203 represents a branched upward flow that is formed after the discharge jet 202 from the discharge port is branched; 204 represents a meniscus flow; 205 represents a separated flow that is generated from a separation point along the immersion nozzle; and 206 represents the molten steel 200's vortexes that are formed in the separated flow.

[0069] As shown in Fig.2, it can be observed that the discharge jet of the molten steel 200 discharged from an immersion nozzle 400 changes with time, where the discharge jet 202 of the molten steel 200 from the discharge port 124 on the right side is so intensified that this discharge jet 202 of the molten steel 200 is deeply entrained in a direction diagonal to the casting direction.

[0070] In contrast, as compared to the discharge jet 202 from the discharge port 124 on the right side, the discharge jet 202 from the discharge port 123 on the left side is oriented upward (toward the tundish side), whereby this discharge jet 202 then turns into a flow directed toward the molten steel surface (meniscus) 201 after colliding with the continuous casting mold narrow face 301. Next, after reaching the molten steel surface (meniscus) 201, the discharge jet 202 from the discharge port 123 on the left side will then turn into the meniscus flow 204 directed toward the immersion nozzle 400. At that time, no meniscus flow 204 is generated on the right side of the discharge port 124; a meniscus flow 204 flowing from the left side of the immersion nozzle 400 to the right side thereof is generated.

[0071] In this manner, when the normal immersion nozzle 400 shown in Fig.2 is used to perform casting of the molten steel 200, the separated flow 205 occurs as the discharge jet 202 from the discharge port 123 of the immersion nozzle 400 is separated at the separation point of the meniscus flow 204. As a result, the separated flow 205 induces turbulence in the discharge jet 202 on the right side of the immersion nozzle 400, leading to the formation of the vortex 206 from the molten steel 200. This vortex 206 causes the mold powder floating on the molten steel surface (meniscus) 201 to be entrapped, leading to a deteriorated quality of a steel product.

[0072] Fig.3 is a drawing schematically showing a flow condition of molten steel inside a mold when performing molten steel casting, using an immersion nozzle for continuous casting. Here, the symbols shown in Fig.3 are identical to those shown in Fig.2, where 207 represents a rear side flow of the molten steel 200, which is formed on the rear side of the nozzle when the flow along the nozzle is exempt from separation.

[0073] As shown in Fig.3, if using the immersion nozzle for continuous casting 100 of the above embodiment(s) to perform casting of the molten steel 200, the discharge jet 202 flowing on the left and right sides of the immersion nozzle 100 exhibits no separation from this immersion nozzle.

[0074] Further, even when the molten steel 200's flow flowing on the left and right sides of the immersion nozzle for continuous casting 100 has exhibited separation from this immersion nozzle due to various conditions at the time of performing continuous casting of the molten steel 200, the degree of separation shall be minuscule, whereby the frequency of occurrence of the vortex 206 will decrease dramatically. In addition, if using the immersion nozzle for continuous casting 100 to perform casting of the molten steel 200, since the oval-shaped portion of the nozzle in the casting direction is also formed into a continuous shape securing a given length, it is also possible to suppress the occurrence of the separated flow 205 and vortex 206 attributable to the kind of molten steel 200's flow that is generated below the molten steel surface (meniscus) 201 and is in the same direction as the molten steel surface (meniscus) 201.

[0075] Further, in continuous casting of the molten steel 200, there is known a phenomenon where the discharge ports 123 and 124 of the immersion nozzle for continuous casting 100 are to be clogged with inclusions or the like as the casting time elapses. Of the left and right discharge ports 123 and 124 of the immersion nozzle for continuous casting 100, when clogging occurs in the vicinity of one discharge port, a large amount of the molten steel 200 is discharged only from the other discharge port. When a large amount of the molten steel 200 is discharged only from one discharge port, an increase in the flow velocity of the molten steel toward the molten steel surface (meniscus) 201 is incurred, contributing to mold powder entrapment.

[0076] However, when casting of the molten steel 200 using the immersion nozzle for continuous casting 100, mold powder entrapment in the molten steel 200 can be suppressed, even if the discharge ports 123 and 124 of the immersion nozzle for continuous casting 100 are clogged with inclusions or the like. That is, by performing continuous casting on the molten steel 200 with the immersion nozzle for continuous casting 100 of the above embodiments, it is possible to obtain a steel product such as a cast piece having an exceptionally fine surface quality with mold powder entrapment being suppressed.

[0077] Here, in recent years' continuous casting operations of molten steel, in order to suppress inclusion capture in cast pieces, magnetic fields are applied to molten steels in continuous casting molds so as to control the flows of the molten steels in these molds. This technique shall pose no problem even when combined with the embodiments of the present invention; this is because even in the case of performing casting of the molten steel 200 with the immersion nozzle for continuous casting 100 of the above embodiments, inclusion entrainment may be suppressed by applying a static magnetic field to the discharge jets, and the effects of the present invention will not be impacted even when applying a moving magnetic field to impart swirling flows for the purpose of achieving a cleaning effect of washing away inclusions.

[0078] In this regard, according to the steel manufacturing method of this embodiment, by performing continuous

casting of the molten steel 200 with the immersion nozzle for continuous casting 100 of the above embodiments, the mold powder entrapped by the molten steel flows is prevented from being captured by the initially solidified shell, whereby no surface defects appear when the cast molten steel 200 is processed into a steel product, and the quality of such steel product is thus not impaired.

[0079] As described above, according to the invention of this embodiment, vortex formation beside an immersion nozzle for continuous casting, which is a major factor contributing to mold powder entrapment, can be suppressed. Consequently, the steel manufacturing method of this embodiment enables stable prevention of mold powder entrapment, thereby allowing the production of cast pieces with an exceptionally fine surface quality.

[Other embodiments]

[0080] The invention of the present application has so far been explained with reference to the embodiments thereof; the invention of this application shall not be limited to the above embodiments. The configuration and details of the invention of this application may be subjected to various modifications that are understandable to those skilled in the art within the technical scope of the invention of the application. Further, systems and/or devices configured by freely combining separate features from each embodiment are also covered by the technical scope of the present invention.

Examples

[0081] The effects of the present invention are described in detail hereunder based on examples. However, the present invention shall not be limited to these examples.

<Invention Example 1>

[0082] In an actual slab continuous casting machine, continuous casting operation was carried out using the immersion nozzle for continuous casting of the present invention. A transverse section of the continuously cast piece (slab) had a thickness ranging from 220 to 260 mm and a width ranging from 1,000 to 2,000 mm. Further, argon gas was used as an inert gas to be blown into the immersion nozzle for continuous casting. A most appropriate mold powder was selected depending on a cast piece withdrawal speed and steel type before being added to the meniscus.

(Design specification of immersion nozzle for continuous casting)

[0083] An immersion nozzle for continuous casting of the present invention was produced, followed by manufacturing a steel, using such produced immersion nozzle for continuous casting. In Invention Example 1, the cross-sectional shape of a molten steel immersion portion as an outer pipe of the immersion nozzle for continuous casting was set to an oval shape. Further, in Invention Example 1, the immersion nozzle for continuous casting was produced in such a manner that the ratio (b/a) was set to 0.91, where a is the major axis and b is the minor axis of an outer circumference of the oval-shaped outer pipe; that a value h , which represents a distance of an oval-shaped portion that was continuous from the position of meniscus toward the casting direction of the molten steel, was set to 50 mm; and that the ratio (β/α) was set to 1.0, where α is the major axis and β is the minor axis of an outer pipe of a tubular portion located below a molten steel flow regulation portion.

(Evaluation on steel product and manufacturing process)

[0084] A steel product was manufactured by performing molten steel casting using the immersion nozzle for continuous casting that was produced in Invention Example 1, at a molten steel flow velocity of 3.4 ton/min. In Invention Example 1, the mold for continuous casting used did not include a magnetic field generator. A slab cast piece manufactured by a slab continuous casting machine was subjected to hot rolling to form a hot-rolled steel sheet, and surface defects on this hot-rolled steel sheet attributable to the mold powder were examined to evaluate the mold powder remaining in the cast piece. In other words, the lower the defect index of the steel product was, the less the mold powder was assessed to remain in the cast piece.

[0085] Further, there was employed a mechanism in which during casting on the molten steel, a solidified shell thickness inside the mold was estimated from the temperature behavior of a thermocouple at the mold narrow face, where an alarm would then go off when the estimated value had reached or fallen below a threshold value as there was now a higher risk of causing breakout. There, in Invention Example 1, as part of an evaluation on operational efficiency in continuous casting, whether the breakout alarm went off was also evaluated.

[0086] As described above, the steel product was evaluated based on the defect index thereof. Further, the steel manufacturing method using the immersion nozzle for continuous casting produced in Invention Example 1 was evaluated

by determining whether the breakout alarm went off. Table 1 presents the design of the immersion nozzle for continuous casting of Invention Example 1 along with the evaluation results of the steel product and manufacturing process.

<Invention examples 2 to 4>

[0087] An immersion nozzle for continuous casting was produced in a similar manner to Invention Example 1, except that the cross-sectional shape of the molten steel immersion portion as the outer pipe of the immersion nozzle for continuous casting; the ratio (b/a) , where a is the major axis and b is the minor axis of the outer pipe in the cross-sectional shape; the value of h , which represents the distance of the oval-shaped portion that was continuous from the position of meniscus toward the casting direction of the molten steel; and the ratio (β/α) , where α is the major axis and β is the minor axis of the outer circumference of the tubular portion, were modified.

[0088] Moreover, steel products were manufactured in a similar manner to Invention Example 1 by performing molten steel casting, except that the immersion nozzles for continuous casting produced in Invention Examples 2 to 4 were used and that the molten steel flow velocities were changed. Further, the steel products manufactured in Invention Examples 2 to 4, and the steel manufacturing methods using these produced immersion nozzles for continuous casting, were evaluated in a similar manner to Invention Example 1. Table 1 presents the designs of the immersion nozzles for continuous casting of Invention Examples 2 to 4, and the evaluation results of the steel products and manufacturing processes.

<Comparative Examples 1 to 4>

[0089] Immersion nozzles for continuous casting of Comparative Examples 1 to 4 were produced by modifying the design of the nozzle for comparison with Invention Examples 1 to 4. Casting was performed using the immersion nozzles for continuous casting e produced in Comparative Examples 1 to 4. That is, casting of the molten steel was carried out under the same conditions as Invention Examples, except that casting was conducted using the immersion nozzles for continuous casting produced in Comparative Examples 1 to 4. Further, the steel products manufactured in Comparative Examples 1 to 4, and the steel manufacturing methods using these produced immersion nozzles for continuous casting, were evaluated in a similar manner as Invention Example 1. Table 1 presents the designs of the immersion nozzles for continuous casting of Comparative Examples 1 to 4, and the evaluation results of the steel products and manufacturing processes.

[0090] As shown in Table 1, the design specifications of the immersion nozzles for continuous casting that were produced in Comparative Examples 1 to 4 are detailed as follows.

Comparative Example 1: immersion nozzle for continuous casting that satisfies $(b/a) > 0.95$

Comparative Example 2: immersion nozzle for continuous casting that satisfies $(b/a) \leq 0.95$ and $h < 50$ mm

Comparative Example 3: immersion nozzle for continuous casting that satisfies $(b/a) \leq 0.95$, $h \geq 50$ mm, and $(\beta/\alpha) < 0.9$

Comparative Example 4: immersion nozzle for continuous casting that satisfies $(b/a) \leq 0.95$, $h \geq 50$ mm, and $(\beta/\alpha) > 1.1$

[Table 1]

Test No.	Design specification of immersion nozzle for continuous casting				Molten steel flow velocity (ton/min)	Defect index of product (-)	Breakout alarm Yes/No
	Cross-sectional shape	(b/a) (-)	h (mm)	(β/α) (-)			
Invention Example 1	Oval shape	0.91	50	1.0	3.4	0.35	No
Invention Example 2	Oval shape	0.83	60	1.0	5.2	0.28	No
Invention Example 3	Oval shape	0.67	50	1.0	5.3	0.22	No
Invention Example 4	Streamlined shape	0.59	60	1.0	5.3	0.26	No
Comparative Example 1-1	Circular shape	1.0	-	1.0	3.3	1.85	No

(continued)

Test No.	Design specification of immersion nozzle for continuous casting				Molten steel flow velocity (ton/min)	Defect index of product (-)	Breakout alarm Yes/No
	Cross-sectional shape	(b/a) (-)	h (mm)	(β/α) (-)			
Comparative Example 1-2	Circular shape	1.0	-	1.0	5.2	2.15	No
Comparative Example 1-3	Oval shape	0.97	60	1.0	3.4	1.74	No
Comparative Example 2-1	Oval shape	0.67	20	1.0	3.6	1.05	No
Comparative Example 2-2	Oval shape	0.67	30	1.0	5.2	1.67	No
Comparative Example 3-1	Oval shape	0.83	50	0.77	3.4	0.40	Yes (Alarm went off)
Comparative Example 3-2	Oval shape	0.83	50	0.83	5.2	- Casting stopped	Yes (Alarm went off)
Comparative Example 4-1	Oval shape	0.67	50	1.25	3.4	0.42	No
Comparative Example 4-2	Oval shape	0.67	50	1.25	5.2	0.68	No

[0091] The operation conditions and operation results are presented in Table 1. As a result of comparing Invention Examples 1 to 4 with Comparative Examples 1-1 to 1-3, the defect indexes of the steel products manufactured in Invention Examples 1 to 4 of the present invention were confirmed to have been significantly improved. Further, although Comparative Examples 2-1 and 2-2 exhibited more improvements than Comparative Examples 1-1 to 1-3, these improvements were not sufficient. In Comparative Examples 3-1 and 3-2, while the steel products manufactured exhibited favorable product qualities, casting was stopped as the breakout alarm went off during the latter half of casting.

[0092] Moreover, in Comparative Example 3-2, casting was stopped as the breakout alarm went off during the early stage of casting. As a result, a cast piece suitable for producing a steel product could not be obtained, and the product quality of the steel product was unable to be evaluated. In Comparative Examples 4-1 and 4-2, although steel products with product quality comparable to those in Invention Examples 1 to 4 were obtained, casting was stopped as the inner pipe portion of the immersion nozzle became clogged with inclusions during casting. This demonstrates that using the immersion nozzle for continuous casting of the present invention can significantly reduce the defect index of a steel product and enable stable operation in manufacturing

Industrial Applicability

[0093] According to the immersion nozzle for continuous casting of the present invention, mold powder entrapment can be suppressed by preventing the formation of vortexes in the vicinity of the immersion nozzle, thereby making it possible to obtain a steel product such as a cast piece with an exceptionally favorable surface quality and achieve a stable continuous casting operation of molten steel. Thus, the immersion nozzle for continuous casting of the present invention is industrially useful as it contributes to the development of related industries such as the steelmaking industry.

Description of symbols

[0094]

100 Immersion nozzle for continuous casting

101 Molten steel flow regulation portion

102 Tubular portion (portion located below molten steel flow regulation portion)

103 Molten steel flow passage

111 Flow regulation portion lower surface

112 Flow regulation portion upper surface
 121 Inner hole
 122 Tubular portion bottom surface (bottom surface of portion located below molten steel flow regulation portion)
 123 Discharge port (left-side mold narrow face)
 124 Discharge port (right-side mold narrow face)
 200 Molten steel
 201 Molten steel surface (meniscus)
 202 Discharge jet
 203 Branched upward flow
 204 Meniscus flow
 205 Separated flow
 206 Vortex (molten steel)
 207 Rear side flow
 300 Mold
 301 Mold narrow face
 302 Mold wide face
 303 Mold bottom face
 400 Immersion nozzle (conventional product)
 a Molten steel flow regulation portion major axis
 b Molten steel flow regulation portion minor axis
 α Axis of tubular portion (first axis)
 β Axis of tubular portion (second axis)
 h Length of flow regulation portion continuous from position of molten steel surface (meniscus) toward casting direction

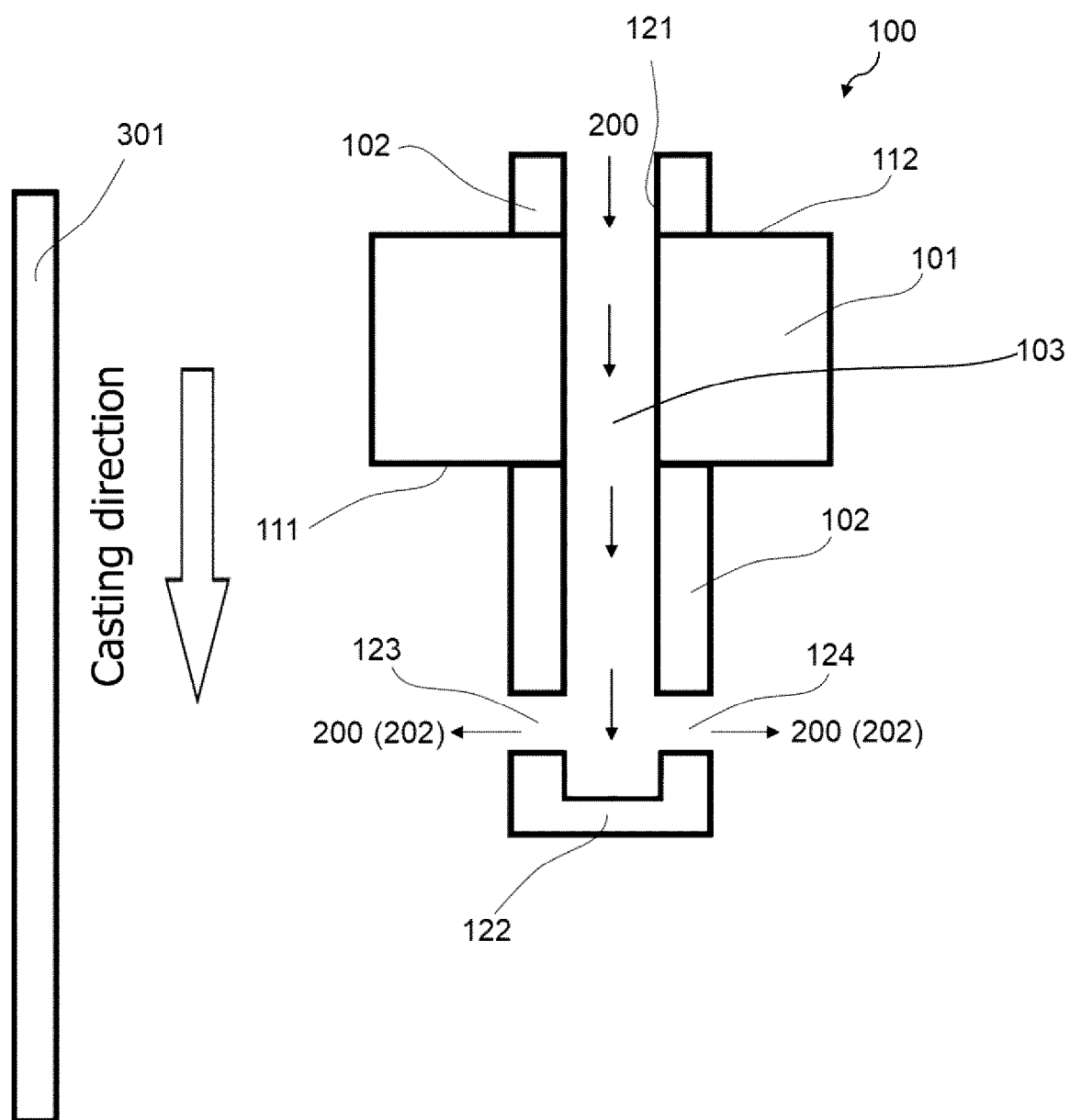
Claims

1. An immersion nozzle for continuous casting used to pour molten steel from a tundish into a mold of a continuous casting machine, comprising:
 - a molten steel flow regulation portion that is immersed in the molten steel and provided at the molten steel surface to be exposed above the molten steel surface formed inside the mold, and
 - a tubular portion that penetrates the molten steel flow regulation portion along a vertical direction and is configured to discharge the molten steel into the mold,

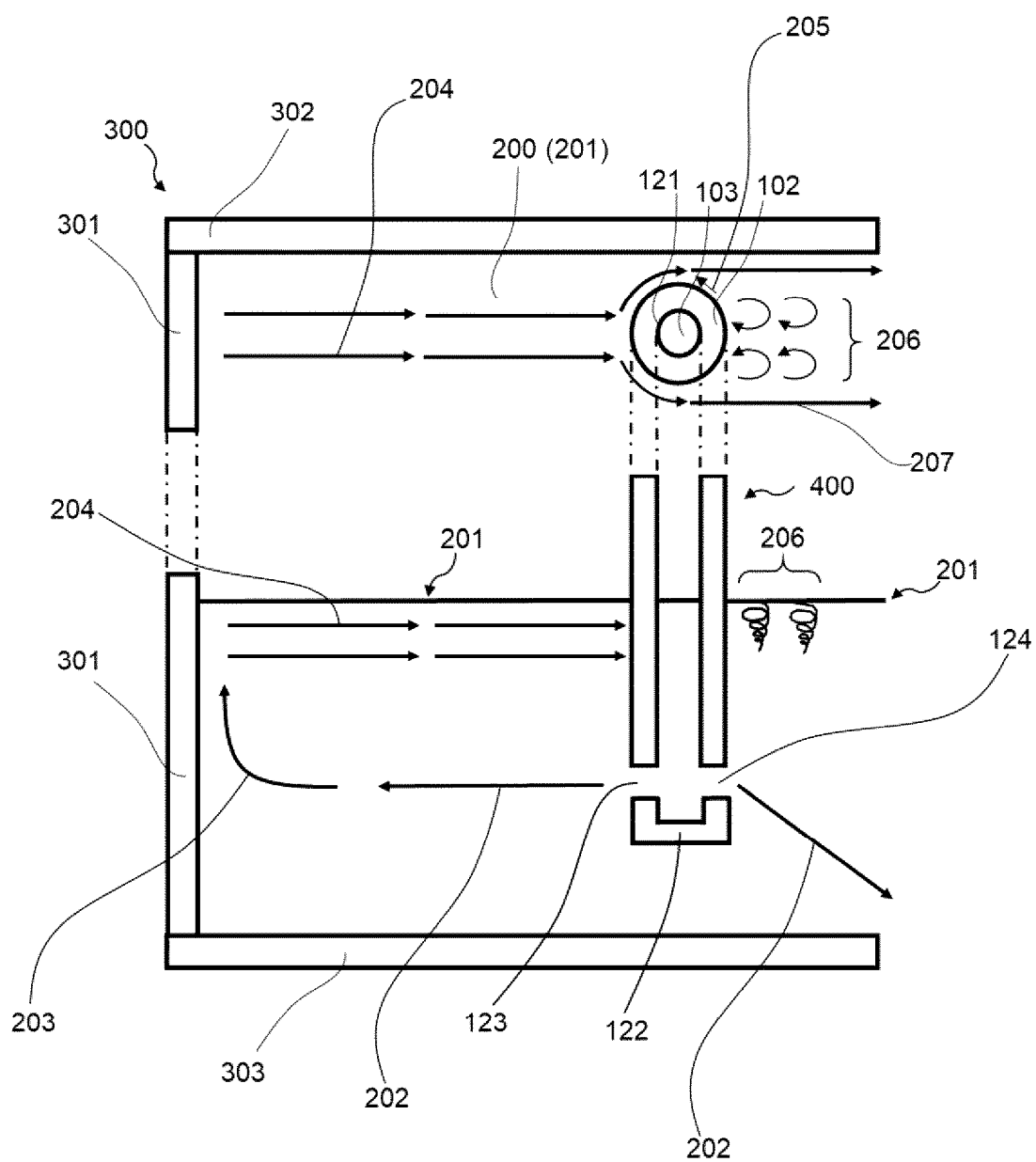
characterized in that

 - at least in a given region extending from the molten steel surface toward the casting direction, the molten steel flow regulation portion has a continuous shape in which its outer circumferential transverse section is formed into an oval or streamlined shape with the major axis oriented in the mold width direction, wherein the ratio (b/a), where a is the major axis and b is the minor axis of the outer circumferential transverse section shape of the molten steel flow regulation portion, is 0.95 or less, and
 - an outer circumferential transverse section of the tubular portion is formed into a circular or oval shape in the width direction of the mold, wherein the ratio (β/α), where α is a length of a first axis substantially parallel to a wide face of the mold and β is a length of another axis orthogonal to the first axis, is between 0.90 and 1.1.
2. The immersion nozzle for continuous casting according to claim 1, wherein the molten steel flow regulation portion has the continuous shape in a region extending 50 mm or more from the molten steel surface toward the casting direction of the molten steel.
3. A continuous casting method for steel, comprising:
 - pouring molten steel inside a tundish into a mold for continuous casting, using the immersion nozzle for continuous casting according to claim 1 or 2.

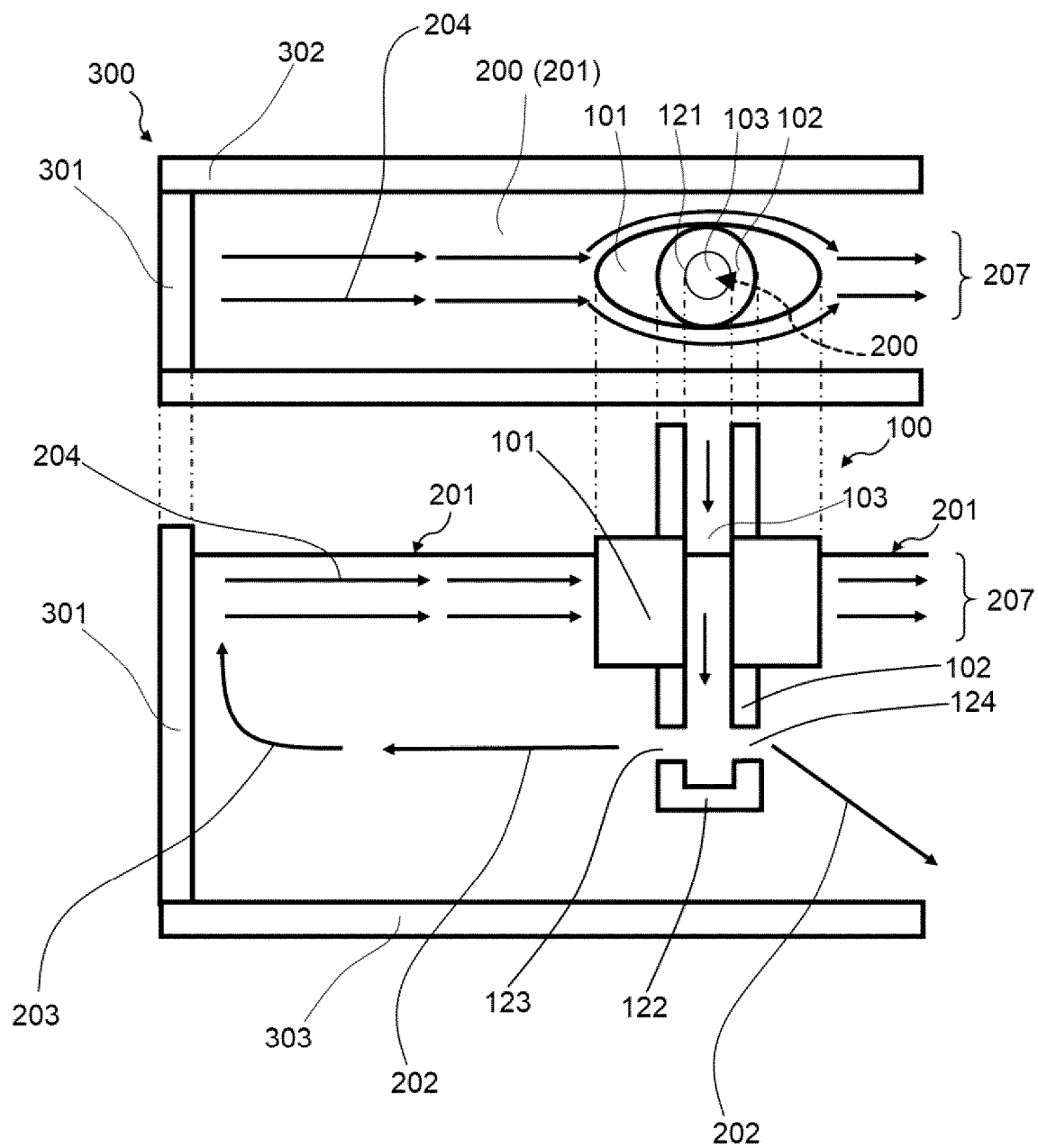
[Fig. 1C]



[Fig.2]



[Fig. 3]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/039810

A. CLASSIFICATION OF SUBJECT MATTER

B22D 11/10(2006.01)i; **B22D 41/50**(2006.01)i
FI: B22D11/10 330H; B22D41/50 520

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)

B22D11/10; B22D41/50

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2025
Registered utility model specifications of Japan 1996-2025
Published registered utility model applications of Japan 1994-2025

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 8-267202 A (NIPPON STEEL CORPORATION) 15 October 1996 (1996-10-15) claims 1-3, paragraphs [0001], [0008], [0011], fig. 1	1-3

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

* Special categories of cited documents:

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Date of the actual completion of the international search

07 January 2025

Date of mailing of the international search report

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Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
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Japan

Authorized officer

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2024/039810

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP	8-267202	A	15 October 1996	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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