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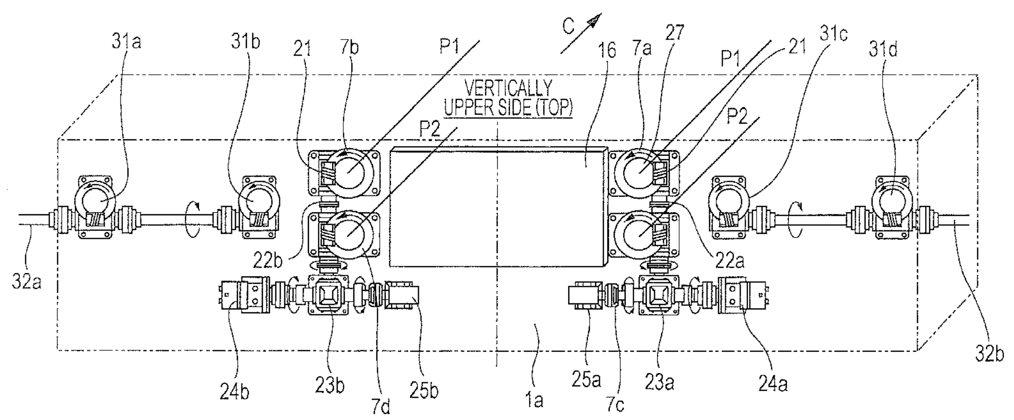
(54) CONTINUOUS CASTING MOLD, TAPER ADJUSTMENT METHOD AND CONTINUOUS CASTING METHOD FOR CONTINUOUS CASTING MOLD

(57) A continuous casting mold is provided in which a first drive mechanism 7a and a third drive mechanism 7c disposed in the top-bottom direction of a stationary mold longer side 1a are operatively connected by a first connecting shaft 22a, a second drive mechanism 7b and a fourth drive mechanism 7d disposed in the top-bottom direction of the stationary mold longer side 1a are operatively connected by a second connecting shaft 22b, and when the first and second connecting shafts 22a and 22b are rotated about their axes, the first to fourth drive mechanisms operate in conjunction with each other, and the first to fourth drive mechanisms change the inclination angle of a movable mold longer side 1b, in which the taper shape of the mold longer sides can be optimized without connection in the left-right direction, and that has simple drive mechanisms compared to the four point independent control system.

FIG. 3



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Description

[Technical Field]

[0001] The present invention relates to a continuous casting mold in which a pair of mold shorter sides are exchangeably sandwiched between a pair of mold longer sides in continuous casting, and a method for adjusting the taper of a continuous casting mold and a method for continuous casting using this continuous casting mold.

[Background Art]

[0002] A technology is known in which mold shorter sides are exchanged online in order to cast cast pieces having different slab thicknesses (see Patent Literature 1). In this online exchange technology, one of a pair of mold longer sides is stationary, and the other mold longer side facing this stationary mold longer side can be moved (that is, movable). A pair of mold shorter sides made according to a desired cast piece thickness are sandwiched between the stationary and movable mold longer sides. Drive mechanisms that move the movable mold longer side are installed in the stationary mold longer side. Opening and closing the pair of mold longer sides with the drive mechanisms allows the exchange of the mold shorter sides.

[0003] By the way, in view of thermal contraction due to temperature difference of the cast piece during continuous casting, the upper end and the lower end of the mold need to be sized differently so that the mold has a taper shape. In order to cast slabs having different thicknesses with optimum taper shapes, the upper and lower widths of the mold shorter sides are changed according to the thickness, and thereby the taper shape is optimized. When the thickness of a cast piece is large, the amount of thermal contraction between the upper and lower ends of the mold is also large. So, the mold is exchanged for a mold in which the size difference between the upper and lower ends of the mold is large (a mold in which the difference between the upper and lower widths of the mold shorter sides is large).

[0004] Patent Literature 1 discloses a technology in which in order to optimally adjust the taper of mold longer sides according to mold shorter sides, a total of four drive mechanisms are disposed in two places in the left-right direction at the upper end of the mold longer sides, and two places in the left-right direction at the lower end of the mold longer sides, and the taper of the mold longer sides is adjusted by the four drive mechanisms. The drive mechanisms in two places in the left-right direction at the upper end of the mold longer sides are operatively connected by a left-right connecting shaft, and the drive mechanisms in two places in the left-right direction at the lower end of the mold longer sides are operatively connected by a left-right connecting shaft. By driving the drive mechanisms in two places at the upper end and the drive mechanisms in two places at the lower end separately, any taper of the mold longer sides is obtained.

[Citation List]

[Patent Literature]

[0005] PTL 1: Japanese Unexamined Patent Application Publication No. 7-164111.

[Summary of Invention]

[Technical Problem]

[0006] However, owing to the recent growing needs for flow control of molten steel using electromagnetic force, the installation area of the molten steel flow control coil is being expanded. For this reason, it is difficult to install connecting shafts for synchronizing the left and right drive mechanisms such that the connecting shafts straddle the molten steel flow control coil.

[0007] In order to solve this problem, four (upper, lower, left, and right) drive mechanisms are controlled independently. In this four point independent control system, a desired amount of taper of longer side mold can be set. However, this system has the following problems: (1) bad installation environment; (2) at the time of driving, the drive mechanisms need to be synchronized, and control is complicated; and (3) the four point independent control is expensive in initial investment cost and maintenance cost.

[0008] The present invention solves the problems of the above known continuous casting mold. It is an object of the present invention to provide a continuous casting mold in which the taper shape of mold longer sides can be optimized without connection in the left-right direction and that has simple drive mechanisms compared to the four point independent control system, and a method for adjusting the taper of a continuous casting mold and a method for continuous casting using this continuous casting mold.

[0009] The molten steel flow control using electromagnetic force is a technology in which molten steel flow is controlled using electromagnetic force of a coil disposed around a mold. A cast piece contains impurities. During the process of solidifying a cast piece in a mold, the impurities are concentrated inside the cast piece and decreases the quality of the cast piece. The impurities accumulated in the solidified layer can be removed by applying electromagnetic force, and the quality of the cast piece can be maintained. In addition, under high-speed casting conditions, ruffling of the molten steel surface can be prevented by electromagnetic force, and stable operation can be performed.

[Solution to Problem]

[0010] To solve the above problems, an aspect of the present invention is a continuous casting mold in which a pair of mold shorter sides are exchangeably sandwiched between a stationary mold longer side and a movable mold longer side, comprising: first and second drive mechanisms disposed in two places in the left-right direction on the upper side of one of the stationary mold longer side and the movable mold longer side and moving the movable mold longer side relative to the stationary mold longer side; third and fourth drive mechanisms disposed in two places in the left-right direction on the lower side of said one of the stationary mold longer side and the movable mold longer side and moving the movable mold longer side relative to the stationary mold longer side; a first connecting shaft operatively connecting the first drive mechanism and the third drive mechanism disposed in the top-bottom direction; and a second connecting shaft operatively connecting the second drive mechanism and the fourth drive mechanism disposed in the top-bottom direction, wherein when the first connecting shaft is rotated about its axis, the first and third drive mechanisms operate in conjunction with each other, and the first and third drive mechanisms change the inclination angle of the movable mold longer side, and when the second connecting shaft is rotated about its axis, the second and fourth drive mechanisms operate in conjunction with each other, and the second and fourth drive mechanisms change the inclination angle of the movable mold longer side.
Another aspect of the present invention is a method for continuous casting in which a cast piece is continuously casted using the above continuous casting mold.
[0011] Still another aspect of the present invention is a method for adjusting the taper of a continuous casting mold in which a pair of mold shorter sides are exchangeably sandwiched between a stationary mold longer side and a movable mold longer side, the method comprising the steps of: preparing a continuous casting mold in which first and second drive mechanisms that move the movable mold longer side relative to the stationary mold longer side are disposed in two places in the left-right direction on the upper side of one of the stationary mold longer side and the movable mold longer side, and third and fourth drive mechanisms that move the movable mold longer side relative to the stationary mold longer side are disposed in two places in the left-right direction on the lower side of said one of the stationary mold longer side and the movable mold longer side; changing the inclination angle of the movable mold longer side by rotating a first connecting shaft operatively connecting the first drive mechanism and the third drive mechanism disposed in the top-bottom direction and a second connecting shaft operatively connecting the second drive mechanism and the fourth drive mechanism disposed in the top-bottom direction, about their axes; and maintaining the inclination angle of the movable mold longer side constant by locking the rotation (that is, stopping the rotation) of the first and second connecting shafts.

[Advantageous Effects of Invention]

[0012] According to the present invention, drive mechanisms of mold longer sides are operatively connected by connecting shafts in the top-bottom direction, and the taper shape of the mold longer sides can be changed by rotating the connecting shafts in the top-bottom direction. Thus, the taper shape of the mold longer sides can be optimized without connection in the left-right direction. In addition, the drive mechanisms are simple compared to the four point independent control system.

[Brief Description of Drawings]

[0013]

[Fig. 1] Fig. 1 is a plan view of the main part of a continuous casting mold according to an embodiment of the present invention.
[Fig. 2] Fig. 2 is a vertical sectional view of the main part of the continuous casting mold.
[Fig. 3] Fig. 3 is a schematic view of drive mechanisms attached to the stationary mold longer side.
[Fig. 4] Fig. 4 is a schematic diagram showing the moving state of the movable mold longer side when the upper worm jacks and the lower worm jacks are driven.

[Description of Embodiment]

[0014] An embodiment of the present invention will be described with reference to the drawings. Fig. 1 is a plan view of the main part of a continuous casting mold, Fig. 2 is a vertical sectional view of the main part, and Fig. 3 is a schematic view of drive mechanisms attached to the stationary mold longer side. In the present invention, left-right direction means the longer side direction of mold longer sides in plan view (see Fig. 1). Top-bottom direction means the vertical direction (see Fig. 2).

[0015] As shown in Fig. 1, the continuous casting mold has a structure in which a pair of mold shorter sides 2a and 2b are exchangeably sandwiched between a pair of mold longer sides 1a and 1b. That is to say, a shape of "#" is formed on a horizontal plane by the longer sides and the shorter sides. The stationary mold longer side 1a and the movable mold longer side 1b have longer side copper plates 4 and are connected to each other by tie rods 5 serving as rods, and the movable mold longer side 1b can be moved relative to the stationary mold longer side 1a by clamping devices 6 and worm jacks 7. The movable mold longer side 1b is guided slidably and inclinably by guide portions 8 of the stationary mold longer side 1a. Thus, both the mold longer sides 1a and 1b can be set to any taper shape.

[0016] As shown in Fig. 2, one end of each tie rod 5 is expandably incorporated in a worm jack 7 serving as a drive mechanism fixed to the stationary mold longer side 1a. The other end of each tie rod 5 is connected to the movable mold longer side 1b via a clamping device 6. Belleville springs 10 are incorporated in the clamping device 6, and the Belleville springs 10 clamp a pair of mold shorter sides 2a and 2b sandwiched between the pair of mold longer sides 1a and 1b. To move the movable mold longer side 1b, the clamping by the Belleville springs 10 is released by a hydraulic cylinder 9, the movable mold longer side 1b is brought into a free state, then the tie rod 5 is elongated or contracted by the worm jack 7, and thereby the movable mold longer side 1b is moved. The maximum value of the travel distance of the movable mold longer side 1b is determined by the amount of lift of the worm jack 7.

[0017] As shown in Fig. 1, each of the mold shorter sides 2a and 2b includes a base shorter side frame 11, an exchange shorter side frame 12, and a shorter side copper plate 13, and the base shorter side frame 11 and the exchange shorter side frame 12 are detachable. A spindle 14 of a shorter side moving device is connected to the base shorter side frame 11, and the shorter side copper plate 13 is fixed to the exchange shorter side frame 12. The shorter side moving devices move the mold shorter sides 2a and 2b along the mold longer sides 1a and 1b as indicated by arrows a and b in Fig. 1, and can thereby change the cast piece width. To change the cast piece thickness, the exchange shorter side frame 12 is separated from the base shorter side frame 11 by removing bolts and hooks of the exchange shorter side frame 12, and an exchange shorter side frame 12 corresponding to a desired thickness is newly attached.

[0018] As shown in Fig. 3, in two places in the left-right direction (in other words, the longer side direction) on the upper side of the stationary mold longer side 1a, first and second worm jacks 7a and 7b serving as first and second drive mechanisms are disposed with a molten steel flow control coil 16 therebetween. In two places in the left-right direction on the lower side of the stationary mold longer side 1a, third and fourth worm jacks 7c and 7d serving as third and fourth drive mechanisms are disposed with the molten steel flow control coil 16 therebetween. In other words, the first drive mechanism and the third drive mechanism are disposed in two places in the top-bottom direction such that the first drive mechanism is on the upper side, and the second drive mechanism and the fourth drive mechanism are disposed in two places in the top-bottom direction such that the second drive mechanism is on the upper side.

[0019] Each worm jack 7 includes a worm gear and a screw mechanism. When a worm 21 of the worm gear rotates, a worm wheel 27 rotates clockwise and counterclockwise (arrows indicating counterclockwise rotation are shown in Fig. 3). A nut in meshing engagement with a threaded shaft forming the tie rod 5 is formed integrally with the worm wheel 27. With the rotation of the worm wheel 27, the nut rotates integrally with the worm wheel 27, and therefore the threaded shaft moves in a direction perpendicular to the paper plane of Fig. 3. Since the threaded shaft of the worm jack 7 forms the tie rod 5, with the movement of the tie rod 5, the movable mold longer side 1b moves forward and backward relative to the stationary mold longer side 1a. As shown in Fig. 3, when the worm wheel 27 is rotated counterclockwise, the movable mold longer side 1b moves in a C-direction that is the releasing direction.

[0020] The first and third worm jacks 7a and 7c, which are arranged vertically to the right of the molten steel flow control coil 16, are operatively connected to a first connecting shaft 22a extending in the top-bottom direction. The first connecting shaft 22a is coupled to the worms 21 of the first and third worm jacks 7a and 7c and rotates integrally with the worms 21. The first connecting shaft 22a is connected to a first hydraulic motor 24a serving as a first drive source via a gearbox 23a. When the first hydraulic motor 24a rotates, the first connecting shaft 22a also rotates.

[0021] The second and fourth worm jacks 7b and 7d, which are arranged vertically to the left of the molten steel flow control coil 16, are operatively connected by a second connecting shaft 22b extending in the top-bottom direction. The second connecting shaft 22b is coupled to the worms 21 of the second and fourth worm jacks 7b and 7d and rotates integrally with the worms 21. The second connecting shaft 22b is connected to a second hydraulic motor 24b serving as a second drive source via a gearbox 23b. When the second hydraulic motor 24b rotates, the second connecting shaft 22b also rotates.

[0022] The hydraulic motors 24a and 24b are each a device that produces rotational motion of a shaft using pressure oil obtained by operating a hydraulic pump. The output torque can be controlled by controlling the pressure of oil, and the rotational speed of the shaft can be controlled by controlling the flow rate of oil supplied. Mechanical brakes are associated with the hydraulic motors 24a and 24b, so that the connecting shafts 22a and 22b can be locked via the gearboxes 23a and 23b. Eventually, the movable mold longer side 1b can be fixed via the worm jacks 7a to 7d.

[0023] The rotation angles of the first and second hydraulic motors 24a and 24b are monitored by first and second synchro transmitters 25a and 25b and are fed back to the control devices of the first and second hydraulic motors 24a and 24b. The control devices control hydraulic pumps so that the first and second hydraulic motors 24a and 24b rotate in synchronization, that is, so that the rotation angles of the shafts of the first and second hydraulic motors 24a and 24b are equal to each other.

[0024] Worm jacks 31a to 31d for adjusting the center positions of the spindles 14 (see Fig. 1) of the shorter side moving devices are attached to the stationary mold longer side 1a. The worm jacks 31a to 31d are provided two per spindle, and each include a worm gear and a screw mechanism as with the above-described worm jacks 7a to 7d. When operating shafts 32a and 32b are rotationally driven by electric motors (not shown), the worm jacks 31a to 31d move the spindles 14 in the width direction of the mold shorter sides 2a and 2b, that is, the thickness direction of cast piece. Thus, the spindles 14 can be connected to the centers of any size of mold shorter sides 2a and 2b.

[0025] Fig. 4 shows the moving state of the movable mold longer side 1b when the upper worm jacks 7a and 7b and the lower worm jacks 7c and 7d are driven. The leads P1 of screws of the two upper worm jacks 7a and 7b are equal to each other, and the leads P2 of screws of the two lower worm jacks 7c and 7d are also equal to each other. However, the lead P1 of screws of the two upper worm jacks 7a and 7b is different from the lead P2 of screws of the two lower worm jacks 7c and 7d. In this embodiment, single-start screws are used, and therefore the leads P1 and P2 of the screws are equal to the pitches thereof.

[0026] The lead P1 of screws of the two upper worm jacks 7a and 7b is set slightly larger than the lead of the two lower worm jacks 7c and 7d. Therefore, when the first and second connecting shafts 22a and 22b are rotated by the hydraulic motors 24a and 24b, the travel distance in the axial direction of the tie rods 5 of the two upper worm jacks 7a and 7b is larger than the travel distance in the axial direction of the tie rods 5 of the two lower worm jacks 7c and 7d. With the movement of the two upper and lower tie rods 5, the movable mold longer side 1b also slides to the left in the figure. With the sliding motion, the movable mold longer side 1b inclines.

[0027] Specifically, at the position of the upper rod, the amount of inclination to the vertical line V of the movable mold longer side 1b changes from tu to tu' owing to the extension of the tie rod 5. At the position of the lower rod, the amount of inclination to the vertical line V of the movable mold longer side 1b changes from tb to tb' owing to the extension of the tie rod 5. Owing to the difference in the lead of screw, (tu'-tu) > (tb'-tb). Therefore, the inclination angle of the movable mold longer side 1b increases with the extension of the tie rods 5. Making the lead P1 of screws of the upper worm jacks 7a and 7b and the lead P2 of screws of the lower worm jacks 7c and 7d different from each other makes it possible to set the amount of taper to a value predetermined for each thickness of cast piece. The gear ratios of worm gears of the first to fourth worm jacks 7a to 7d are equal to each other.

[0028] The method for exchanging the mold shorter sides 2a and 2b sandwiched between the mold longer sides is as follows. First, the clamping by the Belleville springs 10 is released by the hydraulic cylinders 9, and the movable mold longer side 1b is brought into a free state. Next, the mechanical brakes associated with the first and second hydraulic motors 24a and 24b are released, the first and second hydraulic motors 24a and 24b are rotated, and the first and second connecting shafts 22a and 22b are rotated. Owing to the rotation of the first and second connecting shafts 22a and 22b, the tie rods 5 of the first to fourth worm jacks 7a to 7d are extended, and the movable mold longer side 1b moves away from the stationary mold longer side 1a.

[0029] After the mold shorter sides 2a and 2b are exchanged for desired ones, the first and second hydraulic motors 24a and 24b are rotated in the reverse direction, the tie rods 5 of the first to fourth worm jacks 7a to 7d are shortened, and the mold shorter sides 2a and 2b are sandwiched between the movable mold longer side 1b and the stationary mold longer side 1a.

[0030] Since the lead P1 of screws of the upper worm jacks 7a and 7b is different from the lead P2 of screws of the lower worm jacks 7c and 7d, the movable mold longer side 1b moves toward the stationary mold longer side 1a while inclining slightly, and forms a taper shape according to the mold shorter sides 2a and 2b. When the desired taper shape is obtained, the mechanical brakes associated with the hydraulic motors 24a and 24b are activated. After that, the clamping by the Belleville springs 10 is started by the hydraulic cylinders 9, and thereby the desired taper shape of the movable mold longer side 1b is fixed firmly.

[0031] The above-described continuous casting mold is incorporated in a continuous casting machine. Molten steel taken out of a converter is continuously poured from a ladle, into a continuous casting mold located under the ladle and is cooled. The cooled and solidified cast piece is cut into predetermined length pieces to become slabs, blooms, billets, or the like.

[0032] The present invention is not limited to the above-described embodiment, and various changes may be made without changing the gist of the present invention. For example, when the size of the molten steel flow control coil is

relatively small and there is a space for connecting the first and second connecting shafts, it is preferable to operatively connect the first and second connecting shafts with a third connecting shaft. Since only a single hydraulic motor as a common drive source is needed, the initial investment cost and maintenance cost can be further reduced.
The size of the mold and the size of the taper can be set according to the specifications of equipment, the material casted, and so forth, and are not limited to numerical values of the following examples.

[0033] The first to fourth worm jacks may be disposed on the movable mold longer side instead of being disposed on the stationary mold longer side.
Instead of making the leads of the first to fourth worm jacks different from each other, the gear ratios of the worm gears may be made different from each other. In this case, owing to the difference between the gear ratio of worm gear of the upper (first and third) worm jacks and the gear ratio of worm gear of the lower (second and fourth) worm jacks, the amount of taper can be set to a value predetermined for each thickness. In addition, the upper and lower worm jacks may differ in both lead and gear ratio.

[EXAMPLES]

[EXAMPLE 1]

[0034] The pitch of the upper worm jacks of the movable mold longer side (equal to the lead because of single-start screws) was 12.038 mm, and the pitch of the lower worm jacks was 12.000 mm. When the mold was set to each slab thickness, optimum taper shapes (longer side taper = difference between the upper and lower ends) shown in Table 1 were able to be obtained. The distance between the mold longer sides is set slightly larger than the slab thickness.

[0035]

[Table 1]

slab thickness	longer side taper (difference between upper and lower ends)
220 mm thick	2.00 mm
235 mm thick	2.15 mm
260 mm thick	2.48 mm
300 mm thick	3.00 mm

[0036] In a comparative example in which the longer side taper was fixed, the longer side taper was fixed to 2.3 mm (upper end of shorter side - lower end of shorter side) in order for an existing continuous casting machine to operate within a proven operation range when the slab thickness is 235 mm and 260 mm. In this case, the longer side taper when the slab thickness is 220 mm is also 2.3 mm.
Table 2 shows the comparative example in which the longer side taper is fixed.

[0037]

[Table 2]

slab thickness	longer side taper (difference between upper and lower ends)
220 mm thick	2.3 mm
235 mm thick	2.3 mm
260 mm thick	2.3 mm

[EXAMPLE 2]

[0038] The mold of the present invention example and the mold of the comparative example were incorporated in continuous casting machines, and a comparison was made on how much the maximum casting speed can be increased, using real machines. Table 3 shows the specifications of the continuous casting machines used. The mold of the present invention example was incorporated in a continuous casting machine A, and the mold of the comparative example was incorporated in a continuous casting machine B.

[0039]

[Table 3]

	shorter sides of mold	longer side taper	maximum casting speed on equipment [m/min]	
continuous casting machine A	online quick exchange type	present invention example	220 thick	3.0
			235 thick	2.7
			260 thick	2.4
continuous casting machine B	online quick exchange type	comparative example (constant)	220 thick	3.0
			235 thick	2.7
			260 thick	2.4

[0040] Table 4 and Table 5 show the result of experiment. The operability was determined on the basis of powder consumption, the existence or absence of seizure, withdrawal resistance, and so forth. The symbol "O" denotes "operable," and the symbol "x" denotes "inoperable."

[0041]

[Table 4]

continuous casting machine A (present invention)												
	longer side taper [mm]	casting speed [m/min]										
		2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
220 thick	2.00	O	O	O	O	O	O	O	O	O	O	O
235 thick	2.15	O	O	O	O	O	O	O	O	/	/	/
260 thick	2.48	O	O	O	O	O	/	/	/	/	/	/
/: range exceeding maximum casting speed of continuous casting machine												

[0042]

[Table 5]

continuous casting machine B (comparative example)												
	longer side taper [mm]	casting speed [m/min]										
		2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
220 thick	2.30	O	O	O	O	O	O	O	O	O	×	×
235 thick	2.30	O	O	O	O	O	O	×	×	/	/	/
260 thick	2.30	O	O	O	O	O	/	/	/	/	/	/
/: range exceeding maximum casting speed of continuous casting machine												

[0043] In the comparative example, when the slab was 220 mm thick, increasing the casting speed to 2.9 m/min or higher made the machine inoperable, and the maximum casting speed within the operable range was 2.8 m/min. When the slab was 235 mm thick, increasing the casting speed to 2.6 m/min or higher made the machine inoperable, and the maximum casting speed within the operable range was 2.5 m/min.

[0044] In the present invention example, when the slab was 220 mm thick, reducing the longer side taper to 2 mm was able to increase the operable maximum casting speed from 2.8 m/min to 3.0 m/min. 3.0 m/min is the maximum casting speed on the equipment of the continuous casting machine A. When the slab was 235 mm thick, the operable maximum casting speed was able to be increased from 2.5 m/min to 2.7 m/min, the maximum casting speed on the equipment. It was found that changing the longer side taper enables increased production of cast pieces.

[0045] Compared to the four point independent control system, the number of sets of drive mechanisms was able to be reduced from four to two, and the construction cost was also able to be reduced.

[Industrial Applicability]

[0046] According to the present invention, the taper shape of mold longer sides can be optimized without connection in the left-right direction. In addition, the mold has simple drive mechanisms compared to the four point independent control system.

[Reference Signs List]

[0047]

1a stationary mold longer side
1b movable mold longer side
2a, 2b mold shorter side
5 tie rod (rod)
6 clamping device
7 worm jack
7a first worm jack (first drive mechanism)
7b second worm jack (second drive mechanism)
7c third worm jack (third drive mechanism)
7d fourth worm jack (fourth drive mechanism)
9 hydraulic cylinder
10 Belleville springs
11 base shorter side frame
12 exchange shorter side frame
13 shorter side copper plate
14 spindle
16 molten steel flow control coil
21 worm
22a first connecting shaft
22b second connecting shaft
23a, 23b gearbox
24a first hydraulic motor (first drive source)
24b second hydraulic motor (second drive source)
25a first synchro transmitter
25b second synchro transmitter
27 worm wheel
31a to 31d worm jacks (for moving the spindles)
32a, 32b operating shaft
P1 lead of screws of worm jacks 7a and 7b
P2 lead of screws of worm jacks 7c and 7d
V vertical line
tu, tu' the amount of inclination of the longer sides (at the position of the upper rod)
tb, tb' the amount of inclination of the longer sides (at the position of the lower rod)

Claims

1. A continuous casting mold in which a pair of mold shorter sides are exchangeably sandwiched between a stationary mold longer side and a movable mold longer side, comprising:

first and second drive mechanisms disposed in two places in the left-right direction on the upper side of one of the stationary mold longer side and the movable mold longer side and moving the movable mold longer side relative to the stationary mold longer side;
third and fourth drive mechanisms disposed in two places in the left-right direction on the lower side of said one of the stationary mold longer side and the movable mold longer side and moving the movable mold longer side relative to the stationary mold longer side;
a first connecting shaft operatively connecting the first drive mechanism and the third drive mechanism disposed in the top-bottom direction; and
a second connecting shaft operatively connecting the second drive mechanism and the fourth drive mechanism disposed in the top-bottom direction,
wherein when the first connecting shaft is rotated about its axis, the first and third drive mechanisms operate in conjunction with each other, and the first and third drive mechanisms change the inclination angle of the movable mold longer side, and
when the second connecting shaft is rotated about its axis, the second and fourth drive mechanisms operate in conjunction with each other, and the second and fourth drive mechanisms change the inclination angle of the movable mold longer side.

2. The continuous casting mold according to Claim 1, wherein the first to fourth drive mechanisms include first to fourth worm jacks having rods bridged between the stationary mold longer side and the movable mold longer side,
so that the travel distance in the axial direction of the rod of the first worm jack is different from the travel distance in the axial direction of the rod of the third worm jack, the lead of the screw of the first worm jack is different from the lead of the screw of the third worm jack, and/or the gear ratio of the worm gear of the first worm jack is different from the gear ratio of the worm gear of the third worm jack, and
so that the travel distance in the axial direction of the rod of the second worm jack is different from the travel distance in the axial direction of the rod of the fourth worm jack, the lead of the screw of the second worm jack is different from the lead of the screw of the fourth worm jack, and/or the gear ratio of the worm gear of the second worm jack is different from the gear ratio of the worm gear of the fourth worm jack.

3. The continuous casting mold according to Claim 2,
wherein so that the travel distance in the axial direction of the rod of the first worm jack is equal to the travel distance in the axial direction of the rod of the second worm jack, the lead of the screw of the first worm jack is equal to the lead of the screw of the second worm jack, and the gear ratio of the worm gear of the first worm jack is equal to the gear ratio of the worm gear of the second worm jack, and
so that the travel distance in the axial direction of the rod of the third worm jack is equal to the travel distance in the axial direction of the rod of the fourth worm jack, the lead of the screw of the third worm jack is equal to the lead of the screw of the fourth worm jack, and the gear ratio of the worm gear of the third worm jack is equal to the gear ratio of the worm gear of the fourth worm jack.

4. The continuous casting mold according to any one of Claims 1 to 3, wherein the continuous casting mold further comprises
a first drive source that rotationally drives the first connecting shaft about its axis,
a second drive source that rotationally drives the second connecting shaft about its axis, and
a control device that controls the first drive source and the second drive source so that the first connecting shaft and the second connecting shaft operate in conjunction with each other.

5. The continuous casting mold according to any one of Claims 1 to 3, wherein the continuous casting mold further comprises
a third connecting shaft that operatively connects the first connecting shaft and the second connecting shaft, and
a common drive source that rotationally drives the third connecting shaft about its axis.

6. A method for continuous casting in which a cast piece is continuously casted using the continuous casting mold according to any one of Claims 1 to 5.

7. A method for adjusting the taper of a continuous casting mold in which a pair of mold shorter sides are exchangeably sandwiched between a stationary mold longer side and a movable mold longer side, the method comprising the steps of:

preparing a continuous casting mold in which first and second drive mechanisms that move the movable mold

longer side relative to the stationary mold longer side are disposed in two places in the left-right direction on the upper side of one of the stationary mold longer side and the movable mold longer side, and third and fourth drive mechanisms that move the movable mold longer side relative to the stationary mold longer side are disposed in two places in the left-right direction on the lower side of said one of the stationary mold longer side and the movable mold longer side;
changing the inclination angle of the movable mold longer side by rotating a first connecting shaft operatively connecting the first drive mechanism and the third drive mechanism disposed in the top-bottom direction and a second connecting shaft operatively connecting the second drive mechanism and the fourth drive mechanism disposed in the top-bottom direction, about their axes; and
maintaining the inclination angle of the movable mold longer side constant by locking the rotation of the first and second connecting shafts.

8. The method for adjusting the taper of a continuous casting mold according to Claim 7,
wherein the first to fourth drive mechanisms include first to fourth worm jacks having rods bridged between the stationary mold longer side and the movable mold longer side,
the lead of the first and second worm jacks on the upper side is larger than the lead of the third and fourth worm jacks on the lower side, and
when the first and second connecting shafts are rotated about their axes, the travel distance of the upper side of the movable mold longer side is larger than the travel distance of the lower side.

FIG. 1

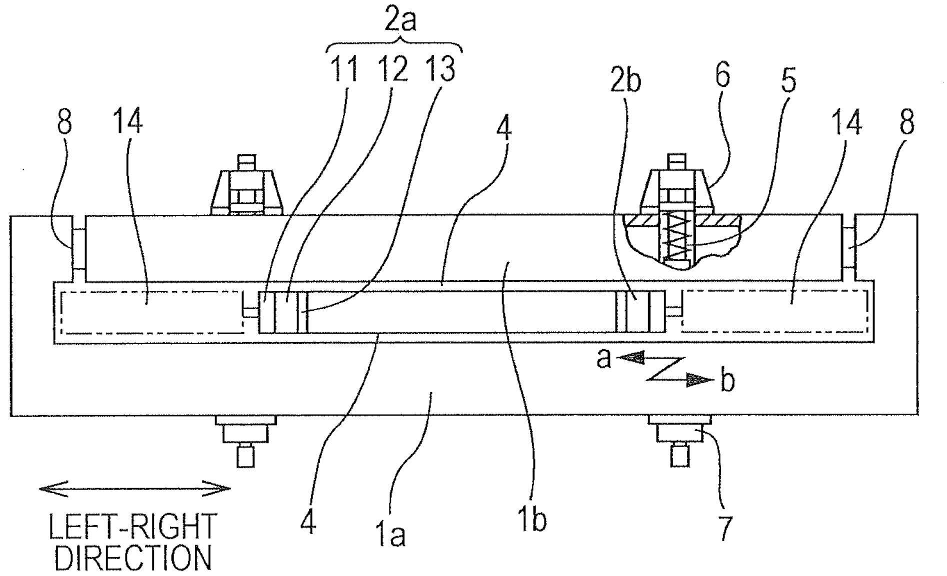

2a
11 12 13
2b
6
5
8
14
4
14
8
a
b
4
1a
1b
7
LEFT-RIGHT
DIRECTION

FIG. 2

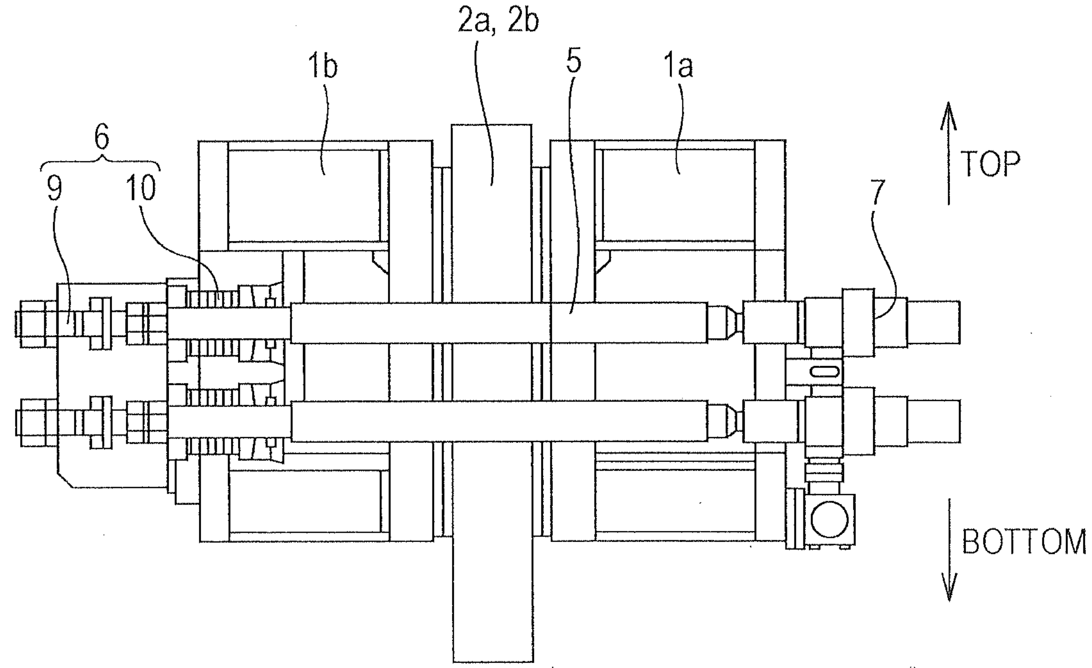

2a, 2b
1b
5
1a
6
9
10
TOP
7
BOTTOM

FIG. 3

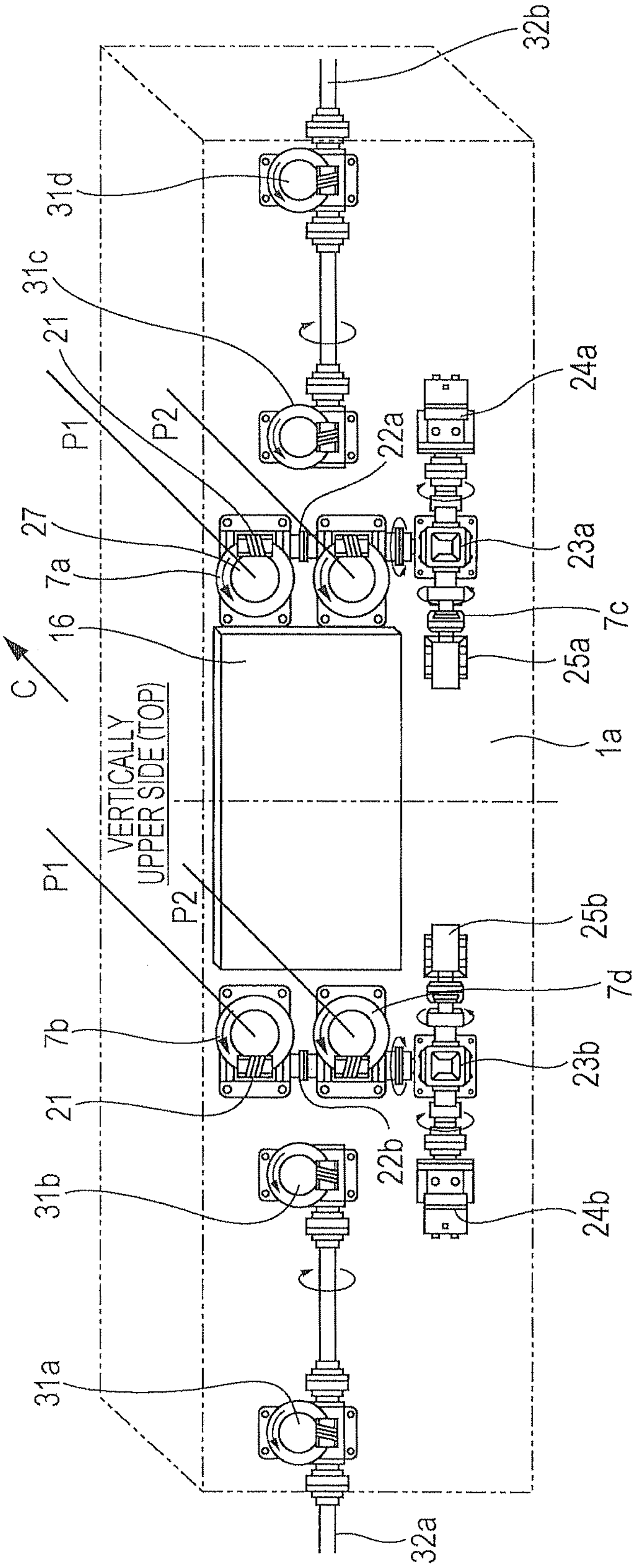
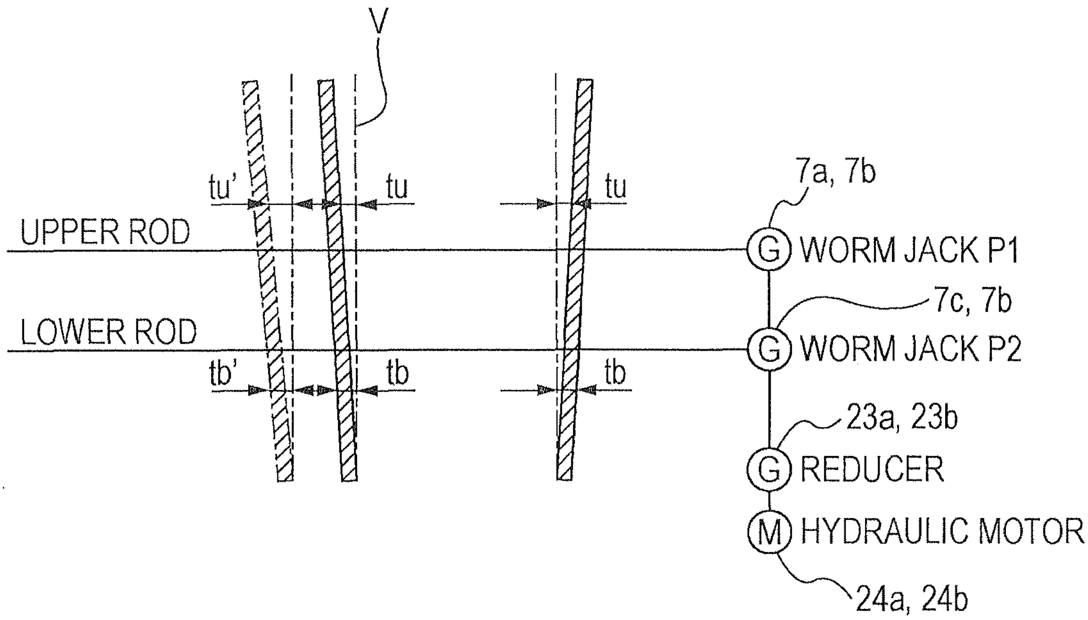

32b
31d
31c
21
P1
P2
22a
24a
27
7a
23a
16
7c
C
25a
VERTICALLY
UPPER SIDE (TOP)
1a
P1
P2
25b
7d
7b
23b
21
22b
31b
24b
31a
32a

FIG. 4


V
tu'
tu
tu
7a, 7b
UPPER ROD
WORM JACK P1
7c, 7b
LOWER ROD
WORM JACK P2
tb'
tb
tb
23a, 23b
REDUCER
HYDRAULIC MOTOR
24a, 24b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/058472

A. CLASSIFICATION OF SUBJECT MATTER
B22D11/05(2006.01)i, *B22D11/04*(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)
B22D11/05, B22D11/04

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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.
A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 88766/1992(Laid-open No. 54449/1994) (Sumitomo Heavy Industries, Ltd.), 26 July 1994 (26.07.1994), entire text (Family: none)	1-8
A	JP 2003-251439 A (JFE Steel Corp.), 09 September 2003 (09.09.2003), entire text (Family: none)	1-8

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 June, 2011 (16.06.11)	28 June, 2011 (28.06.11)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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Patent documents cited in the description

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