Automatic control device for variable width continuous casting mold

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ABSTRACT
An automatic controlling device for continuous casting molds, comprising moving means linked, respectively, to the opposing short sides of the mold for continuous casting and an electric actuator means linked to said moving means. There is further provided a short side position setting means, a detector linked to said electric actuator means in order to produce a deviation signal based on the deviation between the set position signal and the short side position setting means, and a sequence control means which controls the electric actuator means for the purpose of moving the right and left short sides alternately to the set position based on said deviation signal.

1 Claim, 5 Drawing Figures
Fig. 4

Fig. 5

a  S  \hspace{1cm} t_3
b  PL_1 \hspace{1cm} PL_2 \hspace{1cm} PL_3
c  x
d  y  \hspace{1cm} z
e  \hspace{1cm} t_1 \\
f  TS_1  \hspace{1cm} t_2 \\
g  TS_3
AUTOMATIC CONTROL DEVICE FOR VARIABLE WIDTH CONTINUOUS CASTING MOLD

BACKGROUND OF THE INVENTION

The present invention relates to a control device for automatically controlling the size of a mold of continuous casting machines depending on a desired molding size.

Conventional methods of changing the molding size in continuous casting machine employs, as shown in FIG. 1, a mold composed of fixed long sides 1 and short sides 2a and 2b which can slide therebetwixt, so that the desired molding size can be obtained by adjusting the distance between the short sides 2a and 2b. And so far, such adjustment has been performed by moving the short sides 2a and 2b by hand thereby measuring the distance with a measurement scale. Hence, the adjustment was very troublesome and a great deal of time was needed, accompanied by difficulties, if it is intended to obtain an accuracy of even about 0.5 percent. In addition, the molten metal poured tends to be cooled and shrinks as it descends down the mold; and hence taking this into consideration, the mold had to be tapered. But with the conventional manual adjustment, control of the tapering was very difficult and furthermore, a lot of clumsy operation was inevitable for centering the mold with the drawer means, and as a whole, the controlling operation was very clumsy and difficult.

OBJECT OF THE INVENTION

Therefore, an object of this invention is to provide a control device which is capable of automatically controlling the distance between the short sides of the mold as well as automatically defining the centering, thereby eliminating the abovementioned drawbacks.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and objects other than those set forth above, will become apparent when consideration is given to the following detailed description thereof. Such description makes reference to the annexed drawings wherein:

FIG. 1 is a perspective view of the mold;
FIG. 2 shows the actuating means for actuating the short sides of the mold and a circuit diagram of an automatic control;
FIG. 3 illustrates the order by which the short sides of the mold move;
FIG. 4 is a circuit diagram of the sequence logic circuit of the automatic control unit; and
FIG. 5 illustrates the operation of the logic circuit of FIG. 4.

DETAILED DESCRIPTION OF THE INVENTION

An embodiment of the invention is illustrated below with reference to the accompanying drawings. First, illustrating the outline of this invention, the short sides 2a and 2b have at their upper and lower sides a moving means and a position detector. The moving device is actuated by the output signal of the detector, in order to move the short sides 2a and 2b sequentially as shown in FIG. 3 thereby giving a determined distance and tapering to said short sides and then to move the central position of the distance between the short edges by a determined amount.

Referring now to FIG. 3, let us suppose that: 1. the short sides 2a and 2b have initially the lower end distance to being tapered, and are then moved so that the lower end distance is l and the upper end distance acquires the set position l + Δl; 2. a starting push button is pushed and the upper end of the short side 2a restores to the perpendicularly standing position; 3. and then the short side 2b restores to its perpendicularly standing position; 4. if both short sides are elected perpendicularly, the short side 2a is moved in parallel to the position where the lower end distance l is acquired; 5. and then the short side 2b moves in parallel to the position where the distance l is acquired; 6. then only the upper end of the short side 2a is moved to the position equivalent to the set distance l + Δl to acquire a determined tapering;
7. and then the short side 2b is moved in the same way so that the mold acquires the determined size.

The above-mentioned operation is carried out automatically by the sequence control device. But, 8) in order to move the center of the distance between the short sides by a, the distance a is moved by a in the order of the short side 2a and then the short side 2b by using part of the operation of said sequence control device after the above-mentioned operation has been completed.

FIG. 2 shows the construction and circuit diagram of this invention. Automatic controlling mechanism of the short sides 2a and 2b are the same and operate alternatingly to move the short sides to the set position as will be mentioned later; hence only one of the controlling mechanisms is illustrated here. But where it is intended to indicate the right or left side mechanism, a symbol a or b will be attached.

To the upper and lower ends of the short side 2a are attached by means of a pin an end of the lead screws 3 and 4 which have been held horizontally for moving purposes, and the male screw members are linked respectively to the reduction devices 5, 6 having equal reduction ratio. And both reduction devices 5, 6 are linked together by the electromagnetic clutch 7a. The input shaft of the reduction device 5 is linked to the reversible motor 9a through the reduction device 8, and is linked to the rotor of the detector 11a composed of a control transformer through the reduction device 10. Hence the upper position of the short side 2a is determined by the number of revolutions of the motor 9a. And the reduction ratio of the reduction device 10 is so determined that the rotor of the detector 11a produces an angular displacement within 180° deg. for the maximum practical revolution of the motor 9a, i.e., for the maximum moving size of the short side 2a, for the purpose of indicating the position of the short side 2a in terms of the rotor angular position within 180° of the detector 11a.

The digital setting device 12 for setting the distance across the short sides 2a and 2b comprises a setting device 12D for providing the lower end distance l which will be changed, a setting device 12T for providing the upper end distance l + Δl, and a setting device 12F for providing the lower end distance l prior to the change effect, and the digital set values of each setting device are converted into analog signals through the digital-to-analog converter incorporated and are fed to the zero point shifter 13 through the changing contacts 16d, 16f, and common line 18.
The zero-point shifter 13 is a device to bring the central position of the distance between the short sides 2a and 2b into alignment with the central position of the drawer next to the mold, and has been so constituted as to rotate the rotors of the control differential generators 13a, 13b belonging to the short sides 2a, 2b in the reverse direction to any angular position by means of a shift lever. The stator coils of the control differential generators 13a, 13b are connected to the common line 18, and the rotor coils are connected, respectively, to the stator coils of the detectors 11a and 11b through the contacts 17a or 17b.

The sequence control unit 19 possesses the relay amplifier 14 and the control unit 15 — in FIG. 2, these have been expressed as 14a, 14b, 15a, 15b, separately on the right and on the left, for convenience. But these need not be provided separately on the right and on the left; a single relay amplifier 14 and a control unit 15 may be used commonly for the right and left short sides 2a and 2b. The relay amplifier 14a possesses a high-speed relay amplifier 14ah and a low-speed relay amplifier 14al. Both relay amplifiers 14ah and 14al receive the rotor output of the detector 11a. When said output is large, the relay amplifier 14ah operates, and when said output is small, the relay amplifier 14al operates to provide signals to the control unit 15a. The control unit 15a, depending on these signals, actuates the motor 9a at a high or low speed in the direction along which the rotor output of the detector 11a becomes 0, and controls to make or break the electromagnetic clutch 7a as well.

The contacts 16d, 16f, and 16f0 open or close in a sequential manner due to the logic circuit mentioned later, and the control device of this invention works as mentioned below.

1. Let it be supposed that the short sides 2a and 2b are in tapered state as shown in FIG. 3, 1), with the contacts 16d, 16f, and 16f0 open, and the contact 17a closed, and the contact 17b open. The electromagnetic clutches 7a, 7b are all open, and the zero-point shifter 13 is at 0 position.

2. Under such condition, if a starter push button is pushed, the starter signal S shown in FIG. 4 produces a signal x to close the contact 16f, and a setting signal (l/2) produced by the setting device 12F enters into the detector 11a through the common line 18, zero-point shifter 13, and the contact 17a. The rotor position of the detector 11a assumes an angular position corresponding to the upper position of the short side 2a prior to its change; hence a signal So representing one-half of the difference in clearance between the upper end and the lower end of the short side 2a will be developed on the rotor of the detector 11a and enters into the relay amplifier 14a. When the difference in said clearance is too great, the relay amplifier 14ah operates so that the control unit 15a actuates the motor 9a at a high speed in the direction along which the signal So becomes small. When said difference is small, the relay amplifier 14al operates to actuate the motor 9a at a low speed. In this case, since the electromagnetic clutch 7a is being opened the lower end of the short side 2a does not move and only the upper end moves inward so that the short side 2a is erected perpendicularly. And as the difference in said clearance is minimized and the signal So is reduced to a definite value, the output of the relay amplifier 14al is terminated and the motor 9a is stopped after some idling, so that the short side 2a is stopped at a position erected perpendicularly (FIG. 3, 2)). And as the signal So acquires 0, the completion signal PR is produced to change the opening-closing state of the contact 17a and 17b.

3. As the contact 17b is closed by the above changing, the setting signal of the setting device 12F enters to the detector 11b, so that the motor 9b is started and the short side 2b is erected perpendicularly as mentioned above (FIG. 3, 3)). As the output signal So of the detector 11b acquires 0, the completion signal PL is produced.

4. Said completion signal PL enters to the logic circuit shown in FIG. 4, and causes the signal x to assume 0 so that the contact 16f is opened, and causes the production of signal y so that the contact 16d is closed. At this time, the completion signal PL changes the opening-closing state of the contacts 17a and 17b again, so that the electromagnetic clutches 7a, 7b are closed.

In this way, the set signal (l/2) of the setting device 12D enters to the stator of the detector 11a. At this time, since the rotor of the detector 11a is in an angular position representing l/2, a signal S1 representing (l−l/2)/2 will be developed on the rotor, causing the motor 9a to start in the same way as in (2) above. At this moment, the electromagnetic clutch 7a is being closed, and hence the short side 2a maintaining a perpendicular condition moves to the position of distance l at which the signal S1 acquires 0 (see FIGS. 3, 4)). At the completion signal PR is developed again to change the opening-closing state of the contacts 17a and 17b.

5. As the contact 17b is closed by this change, said setting signal of the setting device 12D enters to the detector 11b, and the short side 2b maintaining a perpendicular condition moves to the position of distance l in the same way as mentioned in (4) above (FIGS. 3, 5). When the movement is finished, the completion signal PL2 is produced again to change the contacts 17a and 17b, and renders the electromagnetic clutches 7a and 7b to be opened. The completion signal PL2 also renders the signal y to acquire 0 causing the contact 16d to open, and produces a signal z to close the contact 16f, as shown in FIG. 4.

6. In this way, the setting signal (representing (l+Δl)/2) of the setting device 12T enters to the stator of the detector 11a. At this moment, since the rotor of the detector 11a is at an angular position corresponding to l/2, a signal S2 to represent Δl/2 will be developed on the rotor. And since the electromagnetic clutch 7a is being opened, the upper end only of the short side 2a will move to the position of l+Δl. When the movement is finished, the completion signal PR is produced again and the opening-closing state of the contacts 17a and 17b are changed.

7. As the contact 17b is closed by this change, said set signal of the setting device 12T enters to the detector 11b and moves only the upper end of the short side 2b to the position of l+Δf, the same way as mentioned above. When the movement is finished, the completion signal PL3 is produced again so that the signal z acquires 0 causing the contact 16e to open, this changes the opening-closing state of the contact 17a and 17b. In this way, the contacts and the electromagnetic clutch return to their initial condition.

As mentioned in the foregoing, the contacts 17a and 17b are changed — opened and closed — for every production of the completion signals PR, PL. The completion signal PL further causes the production of the sig-
nals x, y, z, in serial mode as well as the production of the starting signal S; for this reason the sequence control unit 19 is equipped with the logic circuit as shown in FIG. 4.

Referring to FIG. 4, numerals 21, 22, 23, 24, and 30 represent AND circuits; 25, 26, 27, and 28 represent OR circuits; 31, 32, and 33 represent NOT circuits; and Ts1 and Ts2 denote delay circuits. In FIG. 4, if a starting signal S is fed with the signals x, y, and z being 0 (contacts 16d, 16f, and 16f being open), the AND circuits 21 produce a signal x (contact 16f is closed) since the outputs of NOT circuits are 1, and this state is maintained by OR circuit 25 (FIG. 5, c).

Then when the first completion signal PL1 is fed, it (first completion signal) is carried through the OR circuit 26 to the AND circuit 22. At this moment, since the outputs of the delay circuits Ts1 and Ts2 are still 0, the outputs of AND circuits 29, 30 will be 0. Hence the output of AND circuit 24 is 0, and the output of NOT circuit 33 is 1. Therefore, the AND circuit 22 produces signal y (contact 16d is closed) and this state is maintained by the OR circuit 26, and feeds a 0 signal to the AND circuit 21 through the NOT circuit 31 rendering the signal x to be 0 (contact 16f is open) (FIG. 5, a).

The signal y also enters to the delay circuit Ts1. But since the delaying time t1 of the delay circuit Ts1 has been set to be greater than the duration t2 of the completion signal PL1, the delay circuit Ts1 does not produce an output as far as the completion signal PL1 is present and produces an output of 1 after the completion signal PL1 has been extinguished (FIG. 5, f).

Then when the completion signal PL2 is fed again, the output of the delay circuit Ts1 will have already been 1; hence the output of the AND circuit 29 is 1. At this moment, since the output of the delay circuit Ts2 is still 0, the output of the AND circuit 30 will be 0, and the output of the NOT circuit 33 will be 1 so that the AND circuit 23 produces an output z (contact 16g is open) (FIG. 5, e) and this state is maintained by the OR circuit 27, and in addition, the signal Z feeds O signal to the AND circuit 22 through the NOT circuit 32 to cause the signal y to be 0 (contact 16f is open).

The signal z is also fed to the delay circuit Ts2. But since the delaying time t2 of the delay circuit Ts2 has been set to be greater than the duration t2 of the completion signal PL2 as in the case of the delay circuit Ts1, the delay circuit Ts2 does not produce an output as far as the completion signal PL2 is present but produces an output 1 after the completion signal PL2 has been extinguished (FIG. 5, g).

Then if the completion signal PL3 has entered, the output of the delay circuit Ts2 will have already been 1, and the output of the AND circuit 30 will acquire 1 and at the same time, the output of the AND circuit 24 will also acquire 1, so that the signal z is turned to 0 due to the 0 output of the NOT circuit 33 (contact 16r is open) (FIG. 5, e). And due to the OR circuit 28, the output of the NOT circuit 33 is maintained at 0 so far as the completion signal PL3 is present, and hence the signal y is maintained at 0 as well. The logic circuit, in this way, returns to its initial state.

Next in order to bring the central position of the distance between the short sides 2a and 2b into alignment with the central position of the drawing device, the upper and lower ends of the short sides 2a and 2b should be adjusted automatically to the set distance as mentioned above, and the following control be carried out. In this case, no sequential control by means of the logic circuit is performed, which was effected in the foregoing.

First, the zero-point shifter 13 is turned by means of a shift lever to set, based on the graduation, the amount a by which the central position of the distance between the short sides 2a, 2b moves. Then, for example, the switch 16c connected in parallel with the contact 16r is closed, and the starter push button is pushed with the electromagnetic clutches 7a, 7b closed. Since the contact 17a has already been closed and the contact 17b has been opened due to the completion signal PL3, a signal (I + ΔI) / 2 + a will be put into the stator of the detector 11a. On the other hand, since the upper end of the short side 2b has already been adjusted to (I + ΔI) / 2 on account of the adjustment effected up to the previous time, a signal of the magnitude of a will appear on the rotor of the detector 11a. This signal a works equal to the signal S mentioned in (1) above, and causes the motor 9a to start. But as the clutch 7a has been closed, the short side moves by a in parallel and stops its movement. The completion signal PR is then produced and changes the contacts 17a, 17b.

At this moment, a signal of a magnitude equal to (I + ΔI) / 2 - a is produced by the control differential generator 13b and enters to the stator of the detector 11b; the motor 9b is then started causing the short side 2b to move by the amount -a, and is stopped. In this way, the center of the distance between the short sides 2a and 2b is moved by the amount a (FIG. 3, 8)).

As mentioned above, according to this invention, the distance between the short sides and the taper can be adjusted automatically only by setting the distance between the short sides 2a and 2b by means of the setting device 12, and in addition the central position of the mold is brought automatically into alignment with the central position of the drawing device by means of the zero-point shifter. In this way, the adjustment of the mold size is performed quickly and accurately. Furthermore, the left and right short sides are controlled alternately and automatically by means of a common setting device and a control unit, and the upper and the lower ends of the short sides are separately or simultaneously moved for the purpose of defining any distance between the short sides and tapered angle. In this way, according to this invention the moving means and the control units have simple construction.

While there is shown and described present preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto, but may be otherwise variously embodied and practiced within the scope of the following claims.

**What we claim is:**

1. An automatic controlling device for continuous casting molds, comprising moving means linked, respectively, to the opposing short sides of the mold for continuous casting, an electric actuator means linked to said moving means, a short side position setting means, a detector linked to said electric actuator means in order to produce a deviation signal based on the deviation between the setting signal and the short side position of the short side position setting means, and a sequence control means which controls the electric actuator means for the purpose of moving the right and left short sides alternately to the set position based on said deviation signal.

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