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APPARATUS FOR CASTING THAT AUTOMATICALLY CONTROLS THE CORRELATION BETWEEN TIME AND AIR-PRESSURE

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The present invention relates generally to an apparatus for automatically and simultaneously controlling the time and the pressure in a casting process, and it relates more particularly to the time and the pressure controls in a low pressure die casting process.

In low-pressure die casting processes, especially when the object being cast has an excessively elongated form, and if the metal being used has a large specific gravity, the pressure over the molten metal in the melting vessel becomes excessively reduced when the air in the mold is sucked out through the upper part of the mold while the molten metal is sucked into the mold. Therefore, it becomes necessary to supply additional pressure to the surface of the molten metal in the vessel. However, after completion of the solidification of the molten metal in the mold, and before the molten metal would be allowed to solidify in the feeding pipe, the additional pressure applied to the surface of the molten metal in the mold should be reduced back to the atmospheric pressure so that the molten metal which is in the feeding pipe could return into the vessel. In low-pressure die-casting processes, especially in the cases mentioned above, when the object being cast has an excessively elongated form, it becomes very difficult to control the speed of rising and the speed of solidification of the molten metal. Therefore, the above-described so called "suck-in and pressurize" method of casting has not been put into practice so far for the difficulties encountered therein.

It is an object of the present invention to eliminate the existing difficulties of the "suck-in and pressurize" method of casting and to realize it under economically advantageous practical conditions.

It is another object of the present invention to provide an apparatus for controlling a low-pressure die-casting process especially adapted for the die-casting of objects having excessively elongated shape.

It is a further object of the invention to provide an apparatus for low-pressure die-casting of elongated objects, in which the pressure in the entire system is controlled by a centrally operated control apparatus.

The invention will become more readily apparent from the following description of a preferred embodiment thereof shown, by way of example, in the accompanying drawing, in which:

FIG. 1 is a diagrammatic showing of a preferred embodiment of the present invention; and

FIG. 2 is a diagrammatic showing of the control means schematically shown in FIG. 1.

With reference to FIG. 1 of the drawing, the pressurized vessel containing the molten material, is designated by 1 into which a feeding pipe 1a of a mold D extends, while the upper end of the mold D communicates through a filter 2 with a pressure control system such as pneumatic circuit A. The pressure control system A is performing the purging of air from mold D so that the molten metal is able to rise into the mold. The pressure system A includes a cooler 3 for cooling the excessively hot air removed from above the molten metal, and a filter 4 disposed subsequent to cooler 3. The pressure system A includes a vacuum pump 8 communicating with a vacuum

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tank 7 which has a pressure indicator 12 associated therewith. Between tank 7 and filter 4 a pressure responsive valve 5 is disposed, which might be of the type including a diaphragm chamber having a diaphragm 10 therein to one side of which a pressure P_1 is fed through a timer 11, pressure P_1 initially being atmospheric while, after the timer 11 sets in, P_1 will correspond to the pressure leaving the filter 4. At the other side of the diaphragm 10 a pressure P_2 exists which corresponds to the pressure existing before the vacuum tank 7 and after an electromagnetic valve 6 which is regulated by a control apparatus C, hereinafter described.

At the beginning of the operation, pressure P_1 corresponds to the atmospheric pressure, since mold D before the molten metals enters into its, is under atmospheric pressure. Since electromagnetic valve 6 is inserted in the line communicating the vacuum pump 8 with the mold D, therefore, pressure P_2 is dependent on the operation of electromagnetic valve 6, which in turn is controlled by the hereinafter described central control apparatus C.

The vacuum tank of the vacuum pump 8 has a discharge associated therewith, which controls the vacuum so that it remains on the range 10^{-3} ~ 10^{-4} mm. Hg.

The control valve 5 and its diaphragm 10 are so correlated, that the control valve 5 is fully open when the pressure ratio P_1/P_2 is 1, that is $P_1=P_2$. Timer 11 regulates the operation of control valve 5 in that it sets the time during which diaphragm 10 at one side thereof is exposed to the pressure existing in the upper portion of the mold P.

As has been described above, as soon as the molten metal rises upwardly in the mold D, pressure should be additionally supplied to the surface of the molten metal within the vessel, and to this effect, the vessel 1 has a pressure inlet 1b provided therein, which is connected to a pressure system such as a pneumatic circuit B, which supplies pressurized fluid such as air into the vessel 1 through a system of valves hereinafter described. The pressure system B includes a filter 9 which communicates with a controlled valve V_1 which in turn communicates with a motor controlled valve V_2 having a motor M_1 associated therewith. The pressure in the line between valves V_1 and V_2 is measured by an indicator 13. Valve V_2 directly communicates with a three-way valve V_3 one passage E of which serves as an outlet for releasing air from the system under certain conditions hereinafter described.

The control means C of the apparatus includes a programming board 14 which has graduations provided thereon, in such a manner, that the vertical lines represent the pressure axis and the horizontal lines represent the time axis of the system. The board is adapted to receive thereon a flexible belt-like material, which can be formed into a shape corresponding to a curve describing the desired pressure and time relation of the system. The belt-like material cooperates in slidable relationship with a tracing arm 16 of a potentiometer 17. In order to bring about the tracing of the curve by tracing arm 16, as described by the belt-like material 15, the program board 14 should be moved laterally. To this effect, a motor M_2 is provided for translating board 14 in a lateral direction. The pressure sensing means PIC is an instrument of the type which may have a pair of contacts responsive to a certain degree of pressure in the vessel 1, whereupon the timer will start upon closing or opening of such contact pair, and on the other hand when the timer runs off, the same pair of contacts or another set of contacts within the PIC will cause to actuate three-way valve V_3 such as to open up the outlet passage E thereof, thereby to release the pressure from vessel 1. The control means C further includes in addition to the potentiometer 17, a proportional band controlling means 18 which receives the volt-

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ages supplied by the potentiometer in response to the sliding of tracing arm 16 over the curve formed by the belt-like material 15. The proportional band controlling means preferably feeds its output into a hand reset circuit 19, the output of which is fed into a balancing relay system 20 which in its output has motor M₁, the actuator of electromagnetic valve 6 and that of electromagnetic valve V₃, as well as a pressure-sensing means PIC connected thereto. The tracing of the curve 15 by tracing arm 16 develops a voltage on the potentiometer 17 which will cause M₁ to regulate the opening of valve V₂, so that the pressure over the molten metal in vessel 1 builds up in accordance with the present conditions governed by the pressure-time relationship of the curve 15 on the programming board 14, whereas evacuation of the upper portion of the mold is controlled by the magnitude of opening of valve 6 responding also to the potentiometer voltage fed to it through control apparatus C. The motor M₁ is a servo-type motor known in the art. The potentiometer voltage varying in accordance with the travelling of the tracing arm 16 along curve 15 controls, therefore, the operation of motor M₁, electromagnetic valve 6 and electromagnetic valve V₃.

As pointed out above, the control valve 5, with its diaphragm initially is exposed to atmospheric pressure on one side thereof, so that P₁ is initially at atmospheric pressure. Timer 11 regulates the control valve 5 through timer 11, that is the time the diaphragm 10 is exposed to actual pressures over the mold, whereby pressure P₁ during the time set by timer 11 will correspond to the pressure over the mold.

The pressure responsive and indicative mechanism PIC is connected with one terminal thereof to the inlet 1b of the pressure vessel 1, while the other terminal thereof is connected to respond to the output of the balancing relay means 20 which in turn is responsive to the potentiometer output 17. The pressure sensing and indicating mechanism PIC, as pointed out above, might be of a type known in the art, which is capable of responding to a pressure signal on one terminal, and correspondingly develop an electrical or a pressure signal output at another terminal thereof to control a load, such as the timer in the present situation.

During operation, when the pressure-indicating and controlling mechanism PIC senses that the pressure over the molten metal in pressure vessel 1 has reached a point when purging of the air from the system A should begin, then mechanism PIC turns the timer on, whereupon the diaphragm 10 at pressure side P₁ thereof will be exposed to the actual pressure over the mold, at the same time the mold is under suction, since magnetic valve 6 has been slowly turned on as the initial requirement of the operation. The opening of the magnetic valve 6 is governed by the time and pressure relation described by the belt-like material on the program board 14 and traced by the tracing arm 16. The more suction is applied by the vacuum pump 8 to the system A, that is to the upper portion of the mold D, the further will control valve 5 be opened since pressure P₁ decreases from its initial atmospheric pressure and, as pointed out above, under condition that pressure P₁ and P₂ are equal, the control valve 5 becomes entirely open. The termination of the timer 11 may be set in accordance with considerations flowing from the nature of the casting process and the materials used, to expose diaphragm 10 to atmospheric pressures again after a certain time, whereupon pressure indicating mechanism PIC in response to the timer operation, will open the outlet E of three-way valve V₃, whereupon the pressure from vessel 1 is released and the still unsolidified molten metal is able to return into the vessel 1 from the feeding pipe 1a.

Although the invention has been described with refer-

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ence to a specific embodiment thereof, it is not intended that the invention should be limited to such specific embodiment alone, but it should be interpreted and defined by the scope of the appended claims.

What is claimed is:

1. In an apparatus for controlling a casting process in which a molten metal body is raised from a container into a mold by application of pressurized medium to the surface of the molten metal in the container and by the application of suction to the mold, a first pneumatic circuit including vacuum pump means for applying suction to said mold, a second pneumatic circuit for applying pressure to said container over said molten metal, programming means including a time-pressure curve following means adapted to trace a predetermined time-pressure curve, potentiometer means connected to respond to said time-pressure curve following means for developing an output signal in proportion to said curve, first valve means disposed in said first pneumatic circuit between said vacuum pump means and said mold and responsive to said output signal for opening said first pneumatic circuit in response thereto and permitting said pressurized medium to enter said container, second valve means disposed in said second pneumatic circuit and responsive to said output signal for opening said second pneumatic circuit in response thereto and permitting said pressurized medium to enter said container, third pressure responsive valve means disposed in said first pneumatic circuit between said first valve means and said mold, said third valve means having a diaphragm chamber including a control diaphragm connected to respond to a difference in the pressures existing at said vacuum pump means and at said mold, timing means disposed in a branch circuit connecting said diaphragm chamber at one side of said diaphragm to said pneumatic circuit at the pressure branch thereof nearer to said mold, said timing means controlling the period during which said third valve means is open, pressure responsive means for sensing a predetermined pressure in said container and actuating said timer means, and further valve means disposed in said second pneumatic circuit for releasing pressure from said container in response to lapse of a predetermined period measured by said timing means.

2. The combination as claimed in claim 1, wherein said one side of said diaphragm of said third valve means is initially exposed to the atmosphere, said timing means connecting said one side of said diaphragm to said mold pressure in response to said pressure responsive means, said third valve means becoming fully open when the pressures on both sides of said diaphragm are equal.

3. The combination as claimed in claim 1, wherein said programming means comprises a board having a time-pressure scale thereon, said time-pressure curve is formed on said board by mechanical means having a surface, said tracing arm being adapted to slide on said surface.

4. The combination as claimed in claim 3, wherein said tracing arm is mechanically connected to the wiper arm of said potentiometer means.

References Cited by the Examiner

UNITED STATES PATENTS

1,013,548	1/1912	Grey	22—69 X
3,006,043	10/1961	Goldhammer	22—209 X

FOREIGN PATENTS

236,238	8/1960	Australia.
158,102	3/1957	Sweden.

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