VACUUM CASTING PROCESS

Inventor: George A. Smiernow, 825 S. 48th Street, Philadelphia, Pa. 19143

Filed: June 13, 1969
Appl. No.: 832,896

U.S. Cl. ........................................ 164/133, 266/42, 266/34 V, 164/62, 164/63, 164/65
Int. Cl. ........................................ B22d 35/00, B22d 37/00
Field of Search .................................. 164/62, 61, 65, 155, 133, 63: 266/42, 38, 34 V

References Cited

UNITED STATES PATENTS
3,099,053 7/1963 Elliot........................................ 164/64
3,125,440 3/1964 Hornak et al...................... 75/49

FOREIGN PATENTS OR APPLICATIONS
2,871,533 2/1959 Swainson.......................... 164/133
3,523,785 8/1970 Gero.............................. 164/133 X

902,495 12/1944 France.............................. 164/133

Primary Examiner—J. Spencer Overholser
Assistant Examiner—V. K. Rising
Attorney—Jackson, Jackson and Chovanes

ABSTRACT

The disclosure relates to a process and apparatus for casting metals by controlling the relative pressure of the space above the molten metal body to be cast with respect to the pressure within the interior of the mold. Numerous features of the mechanism are shown and described.

2 Claims, 4 Drawing Figures
3,677,332

1 VACUUM CASTING PROCESS
DISCLOSURE OF INVENTION

This invention relates to the manufacture of castings by a vacuum pouring process, and particularly to a vacuum pouring apparatus suitable for pouring all ferrous, non-ferrous and special alloy castings and ingots of improved quality, without blow-holes, blow-flaws, or any other defects. When I refer to castings and ingots here I mean to include finished or semi-finished metal products which may be in different operations be referred to as ingots, blooms, billets, slabs, wirebars and castings. The invention aims to provide a single apparatus for vacuum pouring, which is simple in construction and design, and which assures a relatively economical method of manufacturing sound castings and ingots of improved quality.

Another object is to provide a process and apparatus for vacuum pouring which improves the filling of the molds and permits the molds to be filled quickly, with little cooling of the liquid metal; thereby making it possible to manufacture very thin sections of castings, particularly from high viscosity alloys.

Another object is to provide a vacuum pouring process and device that permits the manufacture of castings with improved surface and higher dimensional accuracy. This is achieved through the vacuum during pouring and crystallization, and also due to the possibility of using low permeability molds, hard rammed from very fine-grained sands, or of using permanent and semi-permanent molds, which cannot be used in common pouring methods.

Another object is to provide a vacuum pouring process and device that permits the manufacture of castings and ingots with improved mechanical properties, due to crystallization in vacuum and/or under pressure.

Another object is to provide a vacuum pouring process and device that permits the manufacture of castings and ingots from highly oxidizable alloys, due to vacuum and/or neutral atmosphere in the mold which prevents the liquid metal from coming in contact with the air. A still further object is to provide a relatively economical vacuum pouring process and device for the manufacture of castings from very high temperature alloys, which can be done due to rapid filling of molds with little cooling of the liquid metal, reducing the cutting off and cleaning costs.

A further object is to provide a vacuum pouring process and device that permits the manufacture of castings and ingots from highly oxidizable alloys, due to vacuum and/or neutral atmosphere in the mold which prevents the liquid metal from coming in contact with the air. A still further object is to provide a relatively economical vacuum pouring process and device for the manufacture of castings from very high temperature alloys, which can be done due to rapid filling of molds with little cooling of the liquid metal.

Other objects and advantages of the invention will become apparent from the following detailed description of the apparatus. This description is made in connection with the accompanying drawings in which the same parts throughout the views are indicated by the same numerals as given in the description.

The drawings show vacuum pouring mechanism for practicing the invention.

FIG. 1 is a diagrammatic partially broken plan view of the device of the invention.

FIG. 2 is a diagrammatic partially broken axial section of the mechanism of FIG. 1, showing the insertion of a mold into the lower chamber.

FIG. 3 is a view similar to FIG. 1 showing the lower chamber closed and metal being poured into the mold.

FIG. 4 is an enlarged fragmentary vertical section of the metal ladle and pouring nozzle, along with the upper chamber.

The lower reduced pressure chamber 16 represents a steel casting with two raising and lowering doors, in-door 22 and out-door 23. At the bottom of the chamber 16 is a vertical hydraulic cylinder 45 which is hermetically sealed with rubber gasket 46. Cylinder 45, whose piston 49 enters chamber 16, is fed through pipe line 130. To piston 49, a roller table 53 is fixed by means of leveling springs 51. Chamber 16 is mounted on beams 9. At the top of the lower reduced pressure chamber 16, upper vacuum chamber 17 is fixed hermetically through rubber seal 73 by bolts 72.

The inside wall of the chamber 17 is protected from radiating heat by a refractory helical pipe coil 91, through which passes cooling water. Lid 76 of upper chamber 17 has double walls with space 75 between the walls for circulation of cooling water. Lid 76 has a quartz glass window 79 for the visual control of the liquid metal 98. Lid 76 swings on hinge 80 and can be hermetically closed through rubber seal 82 by bolts 83.

The bottom of upper chamber 17 is formed by refractory cushion 111 on which a refractory pouring basin or ladle 97 is placed. The basin 97 is surrounded by helical inductor coil 102 of copper tubing, insulated between turns, through which water is passed for cooling the copper. If necessary, high frequency alternating current may be applied to the terminals of the helix, inducing current in the liquid metal 98 and maintaining the metal at the desired pouring temperature. The high frequency current is supplied by a special high frequency generator, not shown on the figures.

The bottom and walls of basin 97 are formed by rammed refractory materials. A pouring channel 118 on the bottom of the basin, in cushion 111, is formed by heavy duty high refractory tubing 113 having embedded in it a helical coil 114 of copper tubing, insulated between turns, through which water is passed for cooling. Under the pouring channel 118 in the ceiling of chamber 16 is placed a refractory ring 119, through which the liquid metal from basin 97, through channel 118, is poured into the mold 70.

Assembled molds in flask 65 on bottom boards 66 reach the vacuum pressure pouring station by a roller conveyor 1 to the roller turntable 4. When the mold is on table 4, the table is turned 90° to the position shown in FIG. 1. The in-door 22, sliding on rails 27, is raised by cable 29 driven by means of motor 34, reducer 35, and drum 31, all of which are mounted on structure 32. The mold is pushed on the roller table 53 into chamber 16 by means of the piston rod 11, supported by piston rod guides 12, from the pneumatic cylinder 10. Then the mold, pushed simultaneously by piston rod 11 and by the piston 41 from an auxiliary horizontal hydraulic cylinder 40, fed from pipe line 43, is fixed in chamber 16 by four flask guiding pins 67 in such a manner that a pouring gate 68 is placed just in front under the pouring ring 69. Then the indoor 22 is closed and by means of piston 49 and vertical hydraulic cylinder 45, the mold is raised and pressed to the ceiling of chamber 16. The leveling springs 51 assure tight contact between the top surface of the mold and the ceiling of chamber 16. Then a reduced pressure is created in chamber 16 by vacuum pump 55, through tank 57 and pipe line 58. This reduced pressure is controlled by gage 60 and valve 59.

A vacuum pump is connected to vacuum chamber 17 through the high vacuum gas pipe line 89a and three-way valve 90. When reduced pressure in chamber 16 and vacuum in chamber 17 are created, pouring can start.

It will be evident that in the preferred embodiment of the invention the vacuum in the upper chamber 16 either will be of a high or reasonable order of magnitude, for example in the range between 10⁻⁴ and 100 millimeters of mercury and preferably between 10⁻⁴ and 1 millimeter of mercury, often controlled by the desired degassing pressure for the particular metal. The reduced pressure in the lower chamber 16 and hence in the mold at the time of pouring, since the mold derives its pressure from the lower chamber, will be considerably higher than the pressure in the upper chamber, at least 1.5 times, and thus will serve to oppose the force of gravity in causing metal to flow into the mold, causing a gradual filling of the mold, free from spatter, avoiding gas cavities, and allowing for a controlled flow rate. It will be understood that depending on the character of the metal or alloy being poured, higher or lower pressure will be used in the chamber 16 and in the mold, but in general for best results the reduced pressure
in the chamber 16 should be in the order of 2 millimeters of mercury to approximately one atmosphere.

It also will be evident that in some cases it may be desirable to vary the pressure in chamber 16 and in the mold during pouring in order to control the flow rate.

It will be evident that the residual gas in the chambers 16 and 17 need not necessarily be air, but residual gases which will be inert to the particular metal or alloy may be used, for example, depending on the composition of the metal, inert gases such as helium or argon, or relatively inert gases such as nitrogen. Reducing gases such as carbon monoxide or hydrogen may be used. Naturally, in certain cases as where the metal has abnormal solubility for a particular gas, such gas may be avoided.

Pouring is controlled electrically by a high frequency current which flows through helical coil 114 and by the amount of cooling water which passes through the same pipe coil. Before the electric current is applied, cold water passes through the helical pipe coil 114 and the metal in channel 118 is solidified, thereby stopping pouring. By decreasing the amount of cooling water and applying high frequency electric current to the terminals of the coil 114, current is induced in the solidified metal in channel 118. These induced currents cause rapid heating and melting of metal in channel 118 and filling of mold 70. The filling of the mold 70 with liquid metal 98 is done in a precisely controlled way due to maintaining of programmed difference in vacuum in chamber 17 and reduced pressure in the mold from chamber 16. When the electric high frequency current is cut off from coil 114, the amount of cooling water passing through pipe 114 is increased, which solidifies the metal in channel 118 and stops pouring. After the sprue and casting are solidified, the vacuum pumps are stopped, pressure in chamber 16 becomes atmospheric and the in and out doors 22 and 23 are raised. By lowering piston 49, roller table 53 is also lowered to the level of roller conveyor 120. Pneumatic piston rod 11, the mold comes out from chamber 16 on the lead-away roller conveyor 120 to a shake-out station. Then the cycle may be repeated with the next mold.

Other constructions of pouring basins or ladles can be used, for example, a bottom pouring basin with stopper which is opened and closed by means of an electrical solenoid, as well known in the art.

It will be evident that where desired the mold may be preheated to any desired temperature.

It will further be evident that while the invention may find its widest application in the casting of relatively common metals and alloys, such as steel, stainless steel, heat resisting alloys, copper base alloys, aluminum base alloys, magnesium base alloys, nickel base alloys, chromium base alloys, and the like, it is also applicable to the casting of metals and alloys less commonly encountered and particularly those which are highly reactive, as for example titanium, zirconium and niobium.

The principles of the present invention may be utilized in different ways, numerous modifications and alterations, substitution of parts and changes in construction being contemplated, it being understood that the process and apparatus shown in the drawings and described above and the particular methods set forth are given merely for purposes of explanation and illustration, without intending to limit the scope of the claims to the specific details disclosed.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A process of casting molten metals, using a ladle or the like having a pouring nozzle in the lower part thereof and a mold having an entrance opening or gate, which comprises applying the pouring nozzle of the ladle in line with the entrance opening of the mold, artificially cooling the molten metal within the pouring nozzle to initially block the pouring nozzle by solidified molten metal, maintaining a first pressure on the molten metal in the ladle, obtaining a higher pressure in the mold, then melting the metal in the pouring nozzle so that the molten metal flow can begin into the mold and controlling the flow of molten metal to the mold by the relative difference in pressures between the pressure in the ladle and the pressure in the mold.

2. A process of casting molten metal from a ladle or the like having a pouring nozzle at a lower position, into a mold having an inlet opening or gate, which comprises bringing the inlet opening of the mold into line with the pouring nozzle of the ladle, artificially cooling the molten metal in the pouring nozzle to cause it to solidify and initially block the pouring nozzle by solidified molten metal, maintaining a vacuum above the molten metal in the ladle in the range from 10^-4 to 100 millimeters of mercury, maintaining a pressure within the mold in the range of between 2 millimeters of mercury and about one atmosphere and at least 1.5 times the absolute vacuum pressure on the upper surface of the molten metal within the ladle, then melting the metal within the pouring nozzle so that molten metal can begin to flow into the mold, and controlling the flow of molten metal to the mold by the relative difference in pressures between the pressure above the molten metal in the ladle and the pressure in the mold.

* * * * *