METHOD OF PRESSURE CASTING AND MEANS THEREFOR

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Fig. 1

Fig. 2

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While the present improvements relate more particularly to the casting of magnesium and so-called light metal alloys in which magnesium is the predominant constituent, it will be understood that the improved method and means involved are also adaptable for the casting of other metals. Difficulties encountered in melting and handling in molten state magnesium or an alloy largely composed of this metal are well known and those difficulties are still present when it is attempted to introduce such metal into a mold in any process of casting. For example, when castings are made in the ordinary way by simply pouring the molten magnesium or light metal alloy into a mold, there is a pronounced tendency for the metal in contact with air or moisture to oxidize and burn, and at the same time where the casting is in the form of a pig, billet, ingot, or heavy section casting, it solidifies adjacent to the mold surface first, and as the solidification continues it contracts which causes a depression or pipe, normally in the upper end of the casting when it is in the form of an ingot, and sometimes a porous interior due to the contraction. Where such ingot is to be subsequently forged, extruded, or otherwise worked without remelting, it is necessary to cut off the end containing the pipe if a good finished article is to be made. It has been well recognized that it would be highly desirable to find a method or procedure wherein the castings could be made with little or no oxidation and at the same time the porosity and piping difficulty avoided. While many attempts have been made to overcome these difficulties, the solutions evolved have in general been only partially satisfactory. I have now discovered a procedure and apparatus wherein castings, for instance ingots, can be made with almost no oxidation and at the same time with the elimination of piping and porosity.

I am aware that molds have been made for casting steel wherein the casting, after solidification, has pressure applied to it for the purpose of consolidating the metal. I am also aware that die castings have been made from aluminum, zinc, lead, and the like. However, the die castings are relatively small and chill almost instantly. The smallness of these castings, generally speaking, substantially overcomes the piping difficulties encountered with large heavy section castings. My present improved procedure, however, differs markedly from such processes and consists in part in melting and maintaining the metal to be cast in molten condition in a suitable container, and where the metal is of a readily oxidizable nature I prefer to keep the molten metal under cover of a flux or the like to avoid or minimize oxidation or burning of the metal. The molten metal is then allowed to pass into a pressure pot in similar manner to die casting practice from whence it is forced through a heated orifice into a mold, for instance an ingot mold, such mold being fed from the bottom and closed at the top except for a small vent opening. As soon as the mold is filled, the metal is subjected to a chilling procedure wherein the metal freezes from the top downwardly while the pressure on the molten metal in the pressure pot is either maintained or gradually increased, which causes the molten metal to continue to feed into the mold to compensate for shrinkage, porosity, and piping of the metal. After the whole ingot is solidified, the pressure in the pressure pot causing the molten metal to flow into the mold, is released and the ingot removed, following which the mold can be put back in place and the cycle repeated.

Accordingly, among the objects of the present invention is the provision of a procedure and apparatus for handling and casting metals, specifically readily oxidizable metals such as magnesium and its alloys, with a minimum of burning and the elimination of porosity and piping. Another object is to provide a method of casting an ingot or heavy section casting and causing it to freeze from the top downwardly while supplying additional metal under pressure at the lower end of the casting to overcome porosity and piping. Other objects and advantages will appear as the description proceeds. To the accomplishment of the foregoing and related ends, the invention, then, consists in the steps...
and apparatus hereinafter fully described and particularly pointed out in the claims, the annexed drawing and the following description setting forth in detail certain means and modes for carrying out my invention.

In said annexed drawing:

Fig. 1 is a diagrammatic plan view of one preferred form of apparatus for carrying out the present invention. Fig. 2 is a vertical cross section of Fig. 1 along line 2—2.

Referring more particularly to the drawing, a furnace 1 having a burner or source of heat 2 and chimney outlet 3 has suspended or mounted therein a receptacle or container 4 for molten metal. Said receptacle 4 has an open top reservoir 5 for molten metal, the upper portion of said reservoir 5 being separated from the other parts of container 4 by means of a curtain 6 which projects downwardly into the molten metal, but has a free passage thereunder for molten metal. A loose cover 7 is laid over the opening to reservoir 5 so as to keep out dirt or the like and at the same time reduce the heat loss from the surface of the molten metal. Within container 4 is placed a pressure pot 8 having a filler opening 9 controlled by a valve 10 of suitable construction, said valve 10 being adapted to seal off opening 9 and prevent leakage therethrough when pressure is applied to the interior of the pressure pot. The upper end of the pressure pot is fitted with a removable cover 11 having a connection 12 for the passage of air or an inert gas under pressure into the top of the pressure pot. The gas passing through said connection 12 is preferably admitted thereto through an office 13 which in turn is connected to a valve-controlled supply line 14. Where the gas used is not substantially inert to the metal or of an oxygen-consuming nature, I prefer to supply a small amount of oxygen-consuming material, such as powdered sulphur, to the gas passing through connection 12 into the top of the pressure pot. This may be accomplished in any convenient manner, for instance, by dropping a small amount of sulphur into funnel shaped opening 15 having a suitable valve connection for dropping the sulphur into connection 12 prior to passing the gas therethrough into the top of the pressure pot. Upon admission of the sulphur into the top of the pressure pot, it will immediately combine with any oxygen present and thus act to prevent oxidation of the metal. A valve-controlled vent 16 is provided in pressure pot cover 11 for releasing the pressure therein after the casting has been formed and solidified. The outlet end of the pressure pot is provided with a nozzle 17 having a suitable seat 18 for tightly contacting with the entrance opening to mold 19. Mold 19 may be held in place by any suitable means during the filling step, for instance, by means of bolts or studs 20. The upper end of the mold is closed except for a small vent 21 which permits air or the like in the mold to pass out while the mold is being filled, such opening 21 being small enough, however, to cause the molten metal to freeze therein and thus prevent the molten metal from continuing to flow therethrough. The sides of the mold are preferably provided with fins 22 or equivalent and the whole enclosed in a jacket 23 having inlet 24 and outlet 25. As soon as the mold is completely filled, air steam, water spray, or the like is forced into jacket 23 through connection 24 and out through connection 25 which causes the casting to freeze from the top down towards the inlet 18, thus permitting the molten metal to flow under pressure through nozzle 17 into the ingot to supply the extra metal necessary to overcome porosity and piping due to contraction of the metal during solidification.

The container 4 may be initially supplied with molten or solid metal either through the top of reservoir 5 or through filling compartment 26. The upper part of compartment 26 is separated from reservoir 5 by means of curtain 6 and is similarly separated from the rest of the interior of container 4 by means of curtain 27, said curtain 27 preferably extending downward to the same level as curtain 6 or slightly lower. It is to be noted that curtains 6 and 27 should project downward to a point below the lowest level attained by the molten metal in container 4 while it is in operation. Where the metal to be cast is of a readily oxidizable nature such as magnesium and its alloys, I prefer to place a small amount of a suitable flux over the surface of the metal in reservoir 5 to protect the metal from the effects of air. While I prefer to use a flux, it is to be understood that it is limited to that exact material since, obviously, an inert gas could be used in equivalent manner. Such flux should be lighter than the molten metal so that it will float thereon and offer the maximum protection from oxidation. Under normal operating conditions filling compartment 26 will be provided with a snug fitting cover to eliminate as much air as possible therefrom, such cover being removed each time that it is necessary to replenish the supply of metal in container 4, following which it is immediately replaced.

As a specific example of the use of my improved procedure and apparatus, I will describe it in terms of casting a magnesium-aluminum alloy consisting of approximately 90 per cent magnesium and 10 per cent aluminum. The metal to be placed in receptacle 4 or container 4 may be either molten or in solid form. Where the metal is used in solid form, cover 7 may be removed and reservoir 5 and adjacent available space within the container piled full. Heat is then supplied by
means of burner 2 or the equivalent to melt the metal, following which additional metal is added until the liquid level rises to a point near the top of the container, for instance as indicated by line 28. To prevent oxidation of the metal in reservoir 5, I prefer to sprinkle a little flux over the surface of the metal. Such flux may consist, for instance, of finely divided or powdered anhydrous magnesium chloride which remains in that form under normal casting conditions, or a mixture of potassium chloride and lithium chloride which is normally fluid under the same conditions. While the proportions of this latter mixture may vary considerably, I have found that the mixture consisting of 80 per cent potassium chloride and 20 per cent lithium chloride is satisfactory for use with the 90 per cent magnesium-10 per cent aluminum alloy described. This flux has a melting point below that of the alloy noted and has also a specific gravity slightly lower than the metal. Ordinarily only a very small amount of flux is used, in fact only enough to place a very thin layer over the upper surface of the metal. Having the metal heated to a suitable casting temperature, for instance at a temperature in the neighborhood of 1200° to 1300° F., it is ready for casting.

At the same time with the bottom filling ingot mold 19 anchored in place over filling orifice 17, the apparatus is ready for casting the billet from the molten metal. Valve 10 is then lifted from its seat 9 to permit the molten metal to flow into pressure pot 8 so as to fill it up to the level of the metal in reservoir 5, following which valve 10 is closed down on valve seat 9. A small amount of powdered sulphur is placed in funnel 15 and dropped into passageway 12. Air is then supplied to the top of pressure pot 8 from supply connection 14, orifice 13 limiting the flow so that the pressure is applied in uniform steady manner to the top of the molten metal in the pressure pot. This causes the metal to flow out through orifice 17 into the bottom of mold 19, the flow preferably being kept at a slow enough rate to avoid turbulence and agitation of the molten metal, i.e. flow non-turbulently, as it enters and fills the mold since turbulence and agitation will tend to entrap air into the metal and cause voids and oxide skins in the finished casting. The air or other gas in mold 19 passes out through orifice 21 in the top thereof while the metal level is rising therein. As soon as the metal reaches the top and starts to flow through said orifice it chills and seals off the opening.

When the mold is full, the pressure on the metal begins to build up due to the continuous supply of air or the like to the top of the pressure pot through supply line 14. This pressure may be built up to from 50 to 400 pounds per sq. in. or more depending upon type and size of casting being made. As soon as the mold is filled, or if desired, after the final pressure on the metal has been reached, a cooling fluid, for instance water spray, is directed upon the outer surface of the mold through opening 24. The hot water or steam generated in the jacket passes out through orifice 25. The cooling fluid may be directed around the mold within the jacket in a spiral direction over cooling fins as shown in the drawing, or in other equivalent manner if desired. The cooling of the ingot in this manner causes it to freeze from the top down towards the bottom which permits the bottom of the metal casting to remain molten and in condition to continuously receive the molten metal under pressure delivered thereto through nozzle 17 to compensate for shrinkage and eliminate internal porosity not infrequently developed due to internal strains set up during solidification. When the ingot is completely solidified, valve-controlled vent 16 is opened so as to release the pressure on the metal in the pressure pot. The mold can then be unfastened and the solidified ingot removed therefrom. The apparatus is then ready for repeating the cycle as soon as the mold is mounted in place. After the initial charging of the receptacle or container 4 with metal, the subsequent supplying of metal thereto either in molten or ingot form is preferably taken care of through filling compartment 26 as described above.

While I have described my invention in terms of applying sulphur to the space above the metal in the pressure pot, I do not wish to be limited to that exact procedure since, obviously, an inert gas could be utilized where the metal is of a readily oxidizable nature, and where the metal is not readily oxidizable, even air alone can in most instances be satisfactorily used.

Other modes of applying the principle of my invention may be employed instead of those explained, change being made as regards the means and the steps herein disclosed, provided those stated by any of the following claims or their equivalent be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. In a method of forming heavy section castings, the steps which consist in filling the casting mold from the bottom with molten metal, solidifying the casting progressively from top to bottom, and supplying additional molten metal to the bottom of said casting throughout the period of its solidification.

2. In a method of forming an ingot from a body of molten light metal such as magnesium or an alloy thereof, the steps which consist in bottom-filling the ingot mold under pressure, solidifying the ingot in a general downward direction, and supplying an additional amount of molten light metal under pressure to said ingot through the bottom
thereof until the ingot is completely solidified.

3. The method of forming a uniform, pipe free ingot for working, from a molten body of light metal such as magnesium or an alloy thereof, which comprises filling a suitable mold with said molten metal under pressure, gradually increasing the pressure on the molten metal to consolidate the ingot and eliminate porosity therein, and solidifying said ingot in a general downward direction while supplying additional molten metal to the bottom of said ingot to compensate for shrinkage.

4. In a method of the character described, the steps which consist in cooling and solidifying a bottom poured heavy section casting progressively from top to bottom, and supplying additional molten metal under gradually increasing pressure to the bottom of said casting until the casting is completely solidified.

5. In a method of casting ingots, the steps which consist in supplying the molten metal to a pressure pot, applying pressure to the molten metal therein to cause it to flow non-turbulently into and fill an ingot mold through the bottom thereof, solidifying the ingot progressively from top to bottom, and supplying additional molten metal to the bottom of said ingot during the period of such solidification.

6. In a method of casting ingots, the steps which consist in supplying the molten metal to a pressure pot, introducing an inert gas under pressure into said pressure pot to cause the molten metal therein to flow non-turbulently into and fill an ingot mold through the bottom thereof, solidifying the ingot progressively from top to bottom, and supplying additional molten metal to the bottom of said ingot during the period of such solidification.

7. In a method of casting ingots of readily oxidizable metal such as magnesium or an alloy thereof, the steps which consist in heating a body of said metal under cover of a suitable flux, transferring part of said metal into a pressure pot immersed therein, applying pressure to the metal after transference to cause it to flow non-turbulently into and fill an ingot mold through the bottom thereof, cooling and solidifying the ingot progressively in a downward direction, and supplying additional molten metal under gradually increasing pressure to the bottom of the ingot during the period of such solidification to overcome porosity and piping.

8. In a method of casting ingots of readily oxidizable metal such as magnesium or an alloy thereof, the steps which consist in heating a body of said metal under cover of a suitable flux, transferring part of said metal into a pressure pot immersed therein, supplying an inert gas producing material to the pressure space above said transferred metal, applying air pressure to the metal after transference to cause it to flow into and fill an ingot mold through the bottom thereof, cooling and solidifying the ingot progressively in a downward direction, and supplying additional molten metal under pressure to the bottom of the ingot during the period of such solidification to overcome porosity and piping.

9. In an apparatus for casting, the combination of a receptacle for the molten metal to be cast, means for heating said receptacle, a pressure pot within said receptacle, a valve means for supplying molten metal from said receptacle to said pressure pot, a bottom filling mold, a nozzle connecting said pressure pot with said mold, means including a jacket surrounding said mold for progressively cooling in a downward direction the metal cast therein, means for applying pressure to the interior of the pressure pot to force the molten metal into the mold, means including a mechanism having a flow-reducing orifice for the pressure medium supplied to the interior of the pressure pot, and means to make said pressure medium non-reactive to the molten metal.

10. In an apparatus for casting, the combination of a receptacle for the molten metal to be cast, means for heating said receptacle, a pressure pot within said receptacle, a valve means for supplying molten metal from said receptacle to said pressure pot, a bottom-filling mold, a nozzle connecting said pressure pot with said mold, means including a jacket surrounding said mold for progressively cooling in a downward direction the metal cast therein, means including a mechanism having a flow-reducing orifice for supplying a gas under pressure to the interior of the pressure pot to force the molten metal into the mold, and means for supplying to said gas a material making it inert to the molten metal being cast.

Signed by me this 4th day of April, 1931.

JOHN E. HOY.