APPARATUS FOR FLUXING AND FILTERING OF MOLTEN METAL

Inventors: Joseph A. Bass, Bremen; Lewis A. McKenzie; Frank M. Powers, both of Carrollton, all of Ga.

Assignee: Southwire Company, Carrollton, Ga.

Filed: May 18, 1973

Appl. No.: 361,589

U.S. Cl. 266/34 PP; 266/35; 75/68; 75/93 R; 75/93 AC

Int. Cl. 2 C22B 21/06

Field of Search 75/68 R, 46, 93 A; 266/34 R, 34 PP, 34 T, 35; 210/20, 434

References Cited

UNITED STATES PATENTS

1,889,325 11/1932 Whaley 210/434
2,840,463 6/1958 Straup et al. 266/34 PP
3,025,155 3/1962 Lee et al. 75/68 R
3,281,238 10/1966 Bachowski et al. 75/68 R
3,650,517 3/1972 Messing 266/34 T

Primary Examiner—L. Dewayne Rutledge
Assistant Examiner—M. J. Andrews
Attorney, Agent, or Firm—Van C. Wilks; Herbert M. Hunegan; Stanley L. Tate

ABSTRACT

This disclosure relates to a system for continuously treating molten metal for substantially removing gas and finely-divided solids therefrom. A two-stage tandem system is provided wherein hydrogen gas is fluxed from the molten metal in the first stage, and finely-divided solids are filtered from the molten metal in the second stage by passing the molten metal through a refractory granular filtering medium. The hydrogen is fluxed in the first stage by passing a fluxing gas upwardly therethrough consisting of approximately 15% chlorine gas and approximately 85% nitrogen gas. The granular filtering material in the second stage is adapted to assume a buoyant condition as molten metal is passed upwardly therethrough thereby prohibiting the quick clogging of the material.

19 Claims, 2 Drawing Figures
APPARATUS FOR FLUXING AND FILTERING OF MOLTEN METAL

This invention relates generally to the treatment of metals and metal alloys. More particularly, this invention relates to a method and apparatus for the treatment of metals and metal alloys in the molten state prior to the casting thereof to provide molten metal substantially free of gas and finely-divided solid particles.

In the casting of light metals, e.g., aluminum and aluminum alloys, it has been common practice to melt the metal in open hearth or other types of melting furnaces which are heated by the burning of conventional fuels. In preparing the metal for casting, the charges of metal and desired alloying constituents are generally added to the melting furnace to be melted, and thereafter the molten metal is transferred to a holding furnace where close control of both the composition and the temperature of the molten metal may be maintained. Thereafter, the molten metal may be transferred by suitable means from the holding furnace to either a transfer crucible or directly to the pouring furnace of a casting machine.

In the melting of the metal and its transfer from receptacle to receptacle and finally to the casting machine, hydrogen gas may be entrapped or dissolved within the molten metal. The hydrogen gas is generated by the reaction of the metal with any moisture existing throughout the system. Moreover, oxides of the metal and its alloying constituents may be formed and dispersed throughout the molten metal. Consequently, in the casting of the metal, e.g., in a continuous process, the cast product may contain a large proportion of the hydrogen gas in solution in the solid metal, as well as small occluded oxide particles which tend to nucleate about hydrogen-filled voids within the solidified metal.

The presence of hydrogen gas and finely-divided particles within the cast product is, of course, a serious problem inasmuch as the final product worked from the cast bar, such as continuously-formed rod and wire, will have poor grain structure and, consequently, reduced mechanical properties. Moreover, when the product is used as an electrical conductor, the existence of undesirable constituents may seriously reduce the electrical conductivity of the product. The prior art has, therefore, proposed several methods for fluxing molten metals with inert gases to reduce the hydrogen content thereof, as well as for filtering the molten metal through refractory filter media to remove finely-divided solid particles therefrom.

Conventionally, molten metals have been batch fluxed by treating the entire body of the metal in the holding furnace or in an intermediate receptacle, such as a ladle. However, this method has not been totally satisfactory because it is time-consuming and requires large quantities of fluxing gas. Moreover, large quantities of the hydrogen gas generally remain in the cast article even after the batch fluxing due, primarily, to reabsorption of the hydrogen gas and further generation thereof by reaction of the metal with moisture that may be present throughout the system. Moreover, while prior art methods of filtering molten metals through refractory filter media to remove finely-divided solid particles have been generally satisfactory in this respect, they have not been beneficial in appreciably reducing the gas content of a molten metal.

U.S. Pat. Nos. 3,039,864 and 3,172,757 granted, respectively, June 19, 1962 and Mar. 9, 1965 to P. D. Hess et al, disclose methods of treating molten metals to both flux hydrogen gas therefrom as well as to filter out finely-divided non-metallic solids. The method according to each of these patents involves passing the molten metal downwardly through a bed of refractory filter medium while, at the same time, passing an inert gas therethrough. In U.S. Pat. No. 3,039,864 the fluxing gas is disclosed as being passed in counter-current flow relation to the flow of molten metal, while in U.S. Pat. No. 3,172,757 the fluxing gas is disclosed as being passed in co-current flow relation to the flow of molten metal. While chlorine gas is generally recognized by the prior art as the superior and desirable gas for use in fluxing hydrogen from molten aluminum, each of the two above-noted prior art patents teaches that chlorine gas is unsuitable for use in the methods disclosed therein because of its tendency to form chlorides as well as to result in clogging of the filter medium after only short periods of operation. Consequently, the Hess et al patents disclose the use of inert fluxing gases for use in fluxing hydrogen from aluminum, as well as the use of nitrogen gas where the problem of nitride formation is not of significance.

It has been suggested that the reason that chlorine gas is superior for fluxing hydrogen gas from molten aluminum is that the chlorine will break down or otherwise overcome some film or surface phenomenon that exists about the hydrogen gas bubbles, thereby facilitating diffusion of the hydrogen gas into the fluxing chlorine gas. Apparently, this surface phenomenon or film is not broken down as completely with other inert fluxing gases.

It should be apparent, therefore, that even though the methods disclosed in the Hess et al patents recognize the superiority of chlorine gas for fluxing molten aluminum, the fact that the Hess et al methods involve passing the fluxing gas directly through the filter medium prohibits the use of chlorine gas because the formation of chlorides will tend to clog the filter medium.

It is, therefore, a primary object of this invention to provide an improved system for fluxing and filtering of molten metal.

More particularly, it is an object of this invention to provide a system for both fluxing and filtering of molten metals, particularly aluminum and aluminum alloys, that permits the fluxing gas to at least partially include chlorine gas.

Still more particularly, it is an object of this invention to provide a two-stage tandem treating system for fluxing and filtering molten metals wherein the molten metal is fluxed in the first stage of the system to remove hydrogen gas therefrom, and then filtered through a granular filtering medium contained in the second stage to remove finely-divided solids therefrom.

Another object of this invention is to provide a method for continuously fluxing and filtering molten aluminum by passing a fluxing gas at least partially comprised of chlorine gas through the molten aluminum to flux hydrogen gas therefrom and to form chlorides and other related solid products therewith, and then separating the fluxed hydrogen gas, chlorides and other reacted solid products from the fluxed molten aluminum before passing the fluxed molten aluminum through a filtering medium to remove finely-divided solids therefrom.
Still another object of this invention is to provide a method as above described wherein a buoyant condition is effected on the filtering medium as the molten metal is passed upwardly therethrough which tends to prohibit the quick clogging of the filtering medium thus extending the operating time thereof.

Yet another object of this invention is to provide a two-stage tandem apparatus for continuously treating molten metal to substantially remove hydrogen gas and finely-divided solids therefrom, comprising a treating chamber having a refractory weir which divides the chamber into first and second sections, the fluxing gas being admitted near the bottom of the first section and permitted to sweep the hydrogen gas and any solid particles that may be formed by reaction of the fluxing gas with the molten metal upwardly unobstructedly to the surface of the molten metal in the first section, and a filtering medium disposed in the second section for filtering finely-divided solids from molten metal passed upwardly therethrough.

Briefly, these and other objects that may become hereinafter apparent are accomplished in accordance with this invention by providing a two-stage or double-compartment receptacle into which the molten metal to be treated is introduced. A fluxing gas consisting preferably of approximately 15% chlorine gas and 85% nitrogen gas is introduced into the receptacle at or near the bottom of the first compartment or section and passed upwardly through the molten metal contained therein. Approximately 50 cubic feet per hour of this gas mixture is required for completely removing hydrogen gas from an aluminum alloy such as No. 5005 when the metal flow rate is 8000 pounds per hour. This is approximately 5% of the chlorine gas normally used to batch flux a holding furnace of molten aluminum. In one embodiment of the invention, the gas is introduced through a suitable number of carbon or metallic tubes and dispersed in small bubbles through porous carbon heads, thereby furnishing a multitude of bubbles which facilitates contact with a maximum amount of molten metal. In another embodiment of the invention, the fluxing gas is introduced into the receptacle through porous carbon blocks located in the bottom of the fluxing compartment. The chloride and nitrogen gas is metered through valves, regulators and flow meters in such a way as to provide the melt with the proper amount of gas mixture. The top of the receptacle may be sealed with a removable lid and suitable gaskets thereby facilitating the creation of a positive pressure, such as of aluminum chloride, inside the compartment which prohibits the entrance of oxygen and hydrogen-bearing air from the outside, and provides an atmosphere control over the top of the surface of the metal inside the container thereby preventing the molten metal from reabsorbing hydrogen gas fluxed therefrom.

After the molten metal has been fluxed in the first stage of the receptacle, it is then admitted into the second stage and passed upwardly through a granular filtering medium consisting preferably of alumina in the form of balls, crushed alumina, crushed anode butts, or other suitable inert filtering material. By passing the molten metal upwardly through the filter medium, the medium is caused to be buoyant which prohibits the quick clogging of the filter material. Inasmuch as the material has a tendency to float, a perforated screen of stainless steel, cast iron, carbon or other suitable material is placed over the filter material to prohibit the floatation of the filter material downstream into the casting system.

The fluxed and filtered metal is then passed out of the double compartment receptacle through a suitable launder, down spout and float assembly. This structure prevents any turbulence in the pouring tundish and provides gas-free clean metal at the pour point.

With the above and other objects in view that may become hereinafter apparent, the nature of the invention may be more clearly understood by reference to the several views illustrated in the attached drawings, the following detailed description thereof, and the appended claimed subject matter.

IN THE DRAWINGS

FIG. 1 is a perspective view of a two-stage tandem system according to this invention, and illustrates the removable lid disposed above the two-compartment receptacle, and having two gas inlet tubes extending downwardly therefrom for admitting mixtures of fluxing gas into the interior of the receptacle;

FIG. 2 is a vertical sectional view taken along line 2—2 of FIG. 1, and illustrates details of the system including the refractory weir spaced from both the lid and floor of the receptacle which divides the compartment into first and second sections, as well as alternate valve and metering lines for controlling the mixture of fluxing gas.

Referring now to the drawings in detail, there is illustrated a two-stage tandem treating system in accordance with this invention and designated generally by the numeral 10. The system 10 includes a double compartment receptacle 12 having side walls 14, 16, 17 and 19, a floor 18, and a removable lid 20, all of which are formed of suitable refractory material. An inlet launder 22 and an outlet launder 24 extend from the side walls 14, 16, respectively.

Molten metal M is introduced into the system from the melting or holding furnace (not shown) through an intermediate launder 26 which communicates with the inlet launder 22 through a suitable trough 28. Skimmer blocks 30, 32 seal off the interior of the receptacle 12, while permitting molten metal M to flow thereunder. The skimmer blocks 30, 32, in cooperation with the removable lid 20 and suitable gaskets 33, provide a sealed protective atmosphere within the interior of the receptacle 12 above the surface of the molten metal M for a purpose to be described in more detail hereinafter.

As seen most clearly in FIG. 2, the receptacle 12 is divided into first and second sections 34, 36, respectively, by means of a refractory weir 38 adjustable mounted in oppositely facing grooves 39 formed in the side walls 17 and 19. The weir 38 is spaced from the floor 18 so as to provide for communication between the sections 34 and 36. Moreover, the weir 38 is also spaced downwardly from the lid 20 in the fashion of a dam so as to permit overflow of the molten metal M from section 34 to section 36 under certain conditions as will be described hereinafter.

After the metal has been treated in the receptacle 12, it may be conveyed from the outlet launder 24 into a pour pot or tundish 40 through a down spout 42 in the bottom of the outlet launder 24. A float valve 44 may be provided in the tundish 40 for automatically controlling the admission of molten metal M thereto.
In accordance with this invention, fluxing gas may be introduced into the first section 34 of the receptacle 12 through tubes 50, 52 which extend downwardly therein through the lid 20. The tubes 50, 52 may be formed of carbon or suitable refractory metal and include porous carbon heads 54, 56 through which the fluxing gas may be dispersed in small bubbles. In the preferred embodiment of this invention, chlorine and nitrogen gas from suitable sources (not shown) may be supplied and portioned through meters 58, 60 and conducted through line 62 to metered valves 64, 66 which admit the suitably proportioned gas to the tubes 50, 52 for admission into the first section 34 of the receptacle 12.

Alternatively, the chlorine and nitrogen gases may be portioned through meters 68, 70 and conducted through line 72 to metered valves 74, 76 which admit the gas mixture through porous carbon blocks 78, 80 located in the floor 18 of the receptacle 12.

The second section 36 is filled to a predetermined level with a filtering medium 82 consisting of a granular refractory material of suitable mesh size, preferably 3-14 mesh. The filter medium 82 may be any suitable material that is inert with respect to the molten metal which in the case of aluminum, may be alumina in the form of balls, crushed alumina, crushed carbon anode butts, or other suitable material. The particles comprising the filter medium 82 are so chosen and arranged such that they become buoyant upon the occurrence of molten metal being passed upwardly therethrough. This tendency of the part of the filter material 82 to float prohibits the quick clogging of the filter material 82 with small solid particles and thus facilitates longer operating times. Because of the tendency of the filter medium 82 to float, however, a perforated screen 84 is disposed over the filter medium 82 so as to retain the material 82 in the lower portion of the second section 36. The screen 84 may be formed of stainless steel, cast iron, carbon or other suitable material.

In operation of the system 10, molten metal is introduced into the interior of the receptacle 12 through the inlet launder 22 and is flowed through the first section 34, the second section 36, and out through the outlet launder 24. While the molten metal M is in the first section 34, a suitable proportion of chlorine and nitrogen fluxing gases is introduced either through the tubes 50, 52 or the carbon blocks 78, 80. The fluxing gas will bubble upwardly through the molten metal M thereby diffusing hydrogen gas therefrom and sweeping the hydrogen gas upwardly to the top of the receptacle 12 along with any chlorides, nitrates, and other solid oxide particles that are either in the molten aluminum or that have been formed by reaction with the fluxing gases. Thus, a positive pressure of aluminum chloride is maintained inside the sealed receptacle 12 above the surface of the molten metal M which prohibits the entrance of oxygen and hydrogen-bearing air from the outside, and provides an atmosphere control over the top of the surface of the metal M inside the sealed receptacle 12 thereby preventing the molten metal M from reabsorbing the fluxed hydrogen gas. Moreover, the reacted solid particles can be simply skimmed from the surface of the molten metal M periodically or when the buildup so dictates.

The molten metal M then flows under the weir 38, which is preferably spaced approximately one-half inch from the floor 18, and into the second section 36 where it flows upwardly through the filter medium 82, which thus assumes a buoyant condition as above described, thereby having finely-divided solid particles filtered therefrom.

In the event that the filter medium 82 does in fact become clogged with solid particles, the molten metal M in the first section 34 will simply overflow the top of the weir 38 into the second section 36, thus by-passing the filter medium 82 and thereby preventing an overflow of molten metal M from the receptacle 12.

It should be apparent that providing the filtering medium 82 only in the second section 36 of the receptacle 12 leaves the first section 34 free for the fluxing treatment. Thus, the fluxing gas may bubble unobstructedly upward through the molten metal M to the top of the first section 34, thereby sweeping the hydrogen gas and reacted solid particles to the surface of the molten metal M. Inasmuch as the fluxing gas does not have to travel through the filtering medium 82, it does not matter that chlorides or other solid particles may be formed by reaction of the fluxing gas with the molten metal M. Consequently, the fluxing gas may contain a suitable percentage of the superior chlorine fluxing gas, and any chlorides that are formed will be merely swept to the top of the first section 34 and in no way be caused to clog the filtering medium 82.

In view of the foregoing, it should be apparent that there is provided in accordance with this invention a novel method of and apparatus for degussing and filtering molten metals, particularly molten aluminum and aluminum alloys, consisting of a two-stage tandem system for fluxing hydrogen gas and filtering finely-divided solids therefrom which both permits the use of chlorine in the fluxing gas and facilitates long-period operation of the filter sections.

Although the invention has been specifically illustrated and described herein with reference to specific embodiments thereof, it is to be understood that further minor modifications could be made therein without departing from the spirit of the invention.

We claim:

1. A two-stage tandem apparatus for continuously treating molten metal to substantially remove gas and finely-divided solids therefrom, comprising a treating chamber including an inlet and an outlet for the molten metal and having side walls and a floor, a refractory weir dividing said chamber into first and second sections, said weir extending vertically and being spaced from said floor for providing communication between said first and second sections, a removable lid completely covering said first and second sections, means for introducing a fluxing gas into said first section for fluxing hydrogen gas from molten metal contained therein, a filtering medium disposed only in said second section for filtering finely-divided solids from molten metal passed upwardly therethrough, and means for providing a protective atmosphere above the surface of the molten metal in said first and second sections to prevent the reabsorption of hydrogen gas into the metal after it has been fluxed therefrom, said means for providing including sealing means associated with said removable lid.

2. Apparatus as defined in claim 1 wherein said filtering medium is adapted to assume a buoyant condition as molten metal is passed upwardly therethrough, and including means disposed over said filtering means for preventing flotation thereof.
3. Apparatus as defined in claim 2 wherein said flotation preventing means is a perforated screen.
4. Apparatus as defined in claim 1 wherein said filtering medium includes alumina balls.
5. Apparatus as defined in claim 1 wherein said filtering medium includes crushed alumina.
6. Apparatus as defined in claim 1 including means for by-passing molten metal past said filtering medium in the event of clogging thereof.
7. Apparatus as defined in claim 6 wherein said by-passing means includes spacing said weir from said removable lid to define a by-pass flow path for the molten metal from said first section to said outlet over the top of said weir.
8. Apparatus as defined in claim 7 wherein said weir is adjustably mounted in oppositely facing grooves formed in opposite ones of said side walls whereby the spacing of said weir from said removable lid may be varied.
9. Apparatus as defined in claim 1 wherein said means for introducing a fluxing gas includes at least one tube extending downwardly through said first section and having a porous downwardly disposed at the lower end thereof for dispersing fluxing gas bubbles into the molten metal adjacent the bottom of said chamber.
10. Apparatus as defined in claim 1 wherein said means for introducing a fluxing gas includes at least one porous carbon block mounted in the bottom of said first section for dispersing fluxing gas bubbles upwardly through the molten metal.
11. A two-stage tandem apparatus for continuously treating molten metal to substantially remove gas and finely-divided solids therefrom, comprising a treating chamber having side walls, a floor and a removable lid, a refractory weir dividing said chamber into first and second sections, said weir extending vertically and being spaced from said floor for providing communication between said first and second sections, means for introducing a fluxing gas into said first section for fluxing hydrogen gas from molten metal contained therein, a filtering medium disposed only in said second section for filtering finely-divided solids from molten metal passed upwardly therethrough, and means for providing a protective atmosphere above the surface of the molten metal to prevent the reabsorption of hydrogen gas into the metal after it has been fluxed therefrom, said means for providing including sealing means associated with said removable lid.
12. Apparatus as defined in claim 11 wherein said means for introducing a fluxing gas includes at least one porous carbon block mounted in the bottom of said first section for dispersing fluxing gas bubbles upwardly through the molten metal.
13. Apparatus as defined in claim 11 wherein said filtering medium is adapted to assume a buoyant condition as molten metal is passed upwardly therethrough, and including means disposed over said filtering means for preventing flotation thereof.
14. Apparatus as defined in claim 13 wherein said flotation preventing means is a perforated screen.
15. Apparatus as defined in claim 11 wherein said filtering medium includes alumina balls.
16. Apparatus as defined in claim 11 wherein said filtering medium includes crushed alumina.
17. Apparatus as defined in claim 11 including means for by-passing molten metal past said filtering medium in the event of clogging thereof.
18. Apparatus as defined in claim 17 wherein said by-passing means includes spacing said weir from said removable lid to permit the flow of molten metal over said weir from said first section into said second section on the downstream side of said filtering medium.
19. Apparatus as defined in claim 11 wherein said means for introducing a fluxing gas includes at least one tube extending downwardly through said first section and having a porous carbon head disposed at the lower end thereof for dispersing fluxing gas bubbles into the molten metal adjacent the bottom of said chamber.