METHOD OF VACUUM SLAG REFINING OF METAL IN THE COURSE OF CONTINUOUS CASTING
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ABSTRACT OF THE DISCLOSURE

In the casting operation of a metal or alloy, a vacuum is applied to a stream of the metal which is broken up into streams of metal droplets by gases released from the metal, the metal droplets passing through a layer of synthetic slag located in a vacuum chamber which is above the mold. The metal is purified from slurry, nonmetallic inclusions and residual gases and passes into the mold where from a continuous ingot is removed.

The present invention relates to the field of casting metals and alloys.

Known in the prior art is a method and device for casting liquid metal, wherein the liquid metal is supplied from a ladle into a vacuum chamber, itself in the form of a ladle, where there are effected the operations of separating the stream of liquid metal, deoxidizing and alloying it. Then the metal is tapped into the principal casting arrangement, disposed under the chamber.

Metal is supplied into a water-cooled mold through a special hole provided in the lower part of the arrangement.

The whole system, comprising all the equipment ranging from the ladle to the casting arrangement, is hermetically sealed. When the liquid metal is in the casting arrangement, an inert medium is to be maintained above it (see, for example, the U.S. Pat. No. 3,125,440, according to the Class 75-49).

The use of a vacuum in the casting of metal in an inert medium does not prevent the formation of a floating crust in the mold. There is preserved a nonuniformity of solidification and non-metallic inclusions are formed.

The existing method does not prevent the formation of hot longitudinal cracks caused by a retarded shrinkage of the metal skin, the nonuniform solidification along the width of faces and the development of thermal stresses. This method of casting is likely to produce circulation currents in the mold, slowing down the process of solidification and the obtention of a cast billet which is uniform with respect to the content of alloying elements.

An object of the present invention is to provide such a method of casting metals and alloys in a mold, and a device for effecting same, which ensures the reduction of thermal stresses and the obtention of a cast billet which is uniform with respect to the content of alloying elements.

Another object of the present invention is to provide such a method of casting metals and alloys in a mold, and a device for effecting same, which ensures the creation of a uniform solidification front.

A further object of the present invention is to provide such a method and device for casting metals and alloys which enable the cleaning of the metals and alloys from harmful impurities and nonmetallic inclusions.

In conformity with the above and other objects, the method of casting metals and alloys in a mold, in which the stream of metal or alloy being cast is broken up into streams of metal droplets, contemplates, according to the invention, that the streams of metal droplets thus formed are passed through a layer of a fluid refining slag and the liquid metal is thus stored under the layer of slag above the mold level with the subsequent forming of an ingot therefrom in the mold.

It is expedient that the temperature of the layer of the fluid refining slag be maintained below that of the liquid metal or alloy being cast, and above the temperature of the accumulated liquid metal to be refined.

In the process of casting, the heating of the fluid refining slag, liquid metal or alloy to be refined over the mold and in the upper portion of the mold may be effected by utilizing an electromagnetic field.

The method provides for deoxidizing and alloying the liquid metal or alloy to be cast in the process of casting thereof under a layer of slag over the mold, as well as for the renewal of the slag above the mold.

In the device for effecting the method, there is provided a ladle complete with a mold and a vacuum chamber disposed therebetween, said chamber being intended for degassing the metal or alloy to be cast, the vacuum chamber, according to the invention, being made so as to be heated, and being provided with a hermetic channel and a baffle for feeding therein the refining slag, which is retained by the metal stored in the chamber. The internal walls of the chamber in the upper and lower portions thereof are made of a heat-insulating material; in their lower part they are made in the form of the upper section of the mold. The internal wall of the median portion of the chamber are made of an electrically conducting material.

The chamber may be heated by the aid of an inductor, disposed on the periphery of the chamber and thermally insulated from its internal walls.

The inductor is assembled of separate sections so as to enable controlling the temperature throughout the height of the chamber and in the area of its junction with the mold.

The chamber is provided with a heated channel intended for the removal of slag, said channel being disposed above the area of the junction of the chamber with the mold above the level of the liquid metal stored, and a heretical slag collector provided with an exchangeable slag pot.
The chamber may be equipped with a pickup for indicating the level of the accumulated liquid metal and a pickup for indicating the level of the refining slag over the liquid metal stored.

The nature of the present invention will further be made more fully apparent from a consideration of the following description of an exemplary embodiment thereof, taken in conjunction with the drawing, the sole figure of which is a diagrammatic view, partly in section of a device for effecting the method of casting metals or alloys according to the invention.

In conformity with the proposed method, the stream of molten metal, introduced into a chamber under a vacuum, is degassed to a considerable extent and broken up into streams of metal drops. The streams of metal drops thus formed pass through a layer of the fluid refining slag, which results in cleaning the metal from harmful impurities and nonmetallic inclusions, the metal thus cleaned being stored under the slag.

To ensure a more uniform solidification front and enable an interaction between the metal and slag in the process of casting, the level of liquid metal is brought out from the mold into the chamber.

The fact that the fluid slag is present on the heated meniscus of metal above the level of the mold is likely to preclude the formation of the floating crust and prevent the slag from getting into the mold.

In order to provide conditions for a directed heat exchange between the liquid metal and mold, the temperature of the fluid refining slag is to be maintained below the temperature of the metal being cast and above that of the liquid metal being stored. Under these conditions, the accumulated liquid metal is directly formed into an ingot in the mold.

The device for effecting the method comprises a ladle 1 with a liquid metal and a batcher 2 for slag, both mounted on a working platform disposed above a heated vacuum chamber 3.

The internal walls of the chamber 3 in the upper and lower portions thereof are made of a heat-insulating material, and in the lower part they are made in the form of the upper section of the mold 4. Such a shape of the lower part of the chamber 3 is adapted to facilitate the heating of the metal introduced therein which eliminates the probability of its scalding in the area of junction of the chamber 3 with the mold 4. The internal walls of the chamber in its median part are made of an electrically conducting material.

The chamber is heated by an inductor 5, assembled of separate sections, disposed on the periphery of the chamber 3 and thermally insulated from its internal walls.

The heating of slag in the chamber is effected through internal, electrically conducting walls of the chamber by eddy currents.

From the batcher 2 the refining slag is supplied through a hermetic channel 6 into the chamber, the slag being retained there by the liquid metal stored in the chamber. The used slag is tapped through a heated channel 7 into a slag collector 8 connected to the heated chamber 3.

In the casting process, deoxidizers and alloying additives are also introduced through the hermetic channel 6 into the chamber 3. The interaction of the deoxidizers with metal occurs both in the slag and in the liquid metal in the chamber.

Oxides resulting from the deoxidation of metal are removed into the heated slag, which prevents the formation of a floating crust and surface defects in the ingot.

In the beginning of the casting process, a dummy bar is placed in the upper part of the mold 4 below the chamber. The pickup 9 indicating the level of metal in the chamber (which is conventionally shown in the drawing) sends a signal to the block 10 for controlling the supply of metal, which signal causes the stopper of the ladle to rise through a drive 11. The metal fills the upper part of the mold 5 and the lower portion of the chamber 3 up to the specified level.

The liquid metal brought into the chamber 3 serves as a hydraulic seal, and provides for maintaining the desired vacuum in the space above the slag.

The same volume of liquid metal prevents the metal from getting into the mold.

The fact that the level of metal is maintained in the heated chamber 3 above the mold under conditions in which the level varies in the casting process, is likely to facilitate the process of automatic control of the liquid metal feed from the ladle into the chamber, and then into the mold, not affecting thereby upon the established conditions of heat transfer between the liquid metal and mold.

After the chamber 3 has been filled with liquid metal, the block 10 for controlling the feed of metal actsuates a speed presetting device 12, which is intended to maintain the speed of the ingot withdrawal by the aid of a drive 13. Simultaneously, the optimum speed of supplying liquid metal into the chamber 3 is automatically established by a signal of the block 10 for feeding metal into the chamber, the optimum speed being adopted in such a manner as to allow the level of liquid metal to vary only in the prescribed range.

When the lower part of the chamber 3 is filled with liquid metal up to the specified level, prescribed by the block 10 for controlling the feed of metal, there are automatically actuated the systems for creating a vacuum and supplying slag into the chamber on the liquid metal.

As soon as the required height of the slag is achieved, a pickup 14, which indicates the level of slag, generates a signal to actuate, through a block 15 which controls the slag supply and a drive 16, the batcher 2 for feeding the slag.

When the median part of the chamber 3 is being filled with slag, the latter begins to flow out through the heated channel 7 into the slag collector 8 under a pressure equal to that present in the heated chamber.

If the pickup 9, indicating the level of metal in the heated chamber 3, sends a signal indicative of a deviation of the separation boundary metal-slag, i.e., the speed of supplying liquid metal from the ladle into the chamber proves to be faster or slower than the speed of the ingot withdrawal, established by the presetting device, then the block 10 for controlling the supply of liquid metal into the chamber will vary (through the drive 11 by the aid of the ladle stopper) the feed of metal in such a manner that the separation boundary metal-slag returns to the specified level.

In a similar manner, when the position of the boundary slag-gas varies, a signal is emitted by the pickup 14 and the boundary is established at a certain level by the batcher 2.

After the metal is no longer fed into the heated chamber in the position "stopper closed" in ladle 1, the separation boundary of metal and slag, fixed by the pickup 9, is lowered to the adopted value. Then the block 10 for controlling the supply of metal into the heated chamber disconnects the presetting device 12 and stops the batcher 2.

The remaining refining slag flows from the heated chamber into the slag pot 8, upon which the ingot remaining in the mold is to be extracted.

What is claimed is:

1. A method of continuous casting of metals, said method comprising discharging a stream of metal being cast into a vacuum chamber where the stream is broken up into streams of liquid, metal drops, then passing the streams of metal drops thus formed through a layer of fluid refining slag introduced into said chamber so as to remove harmful impurities and nonmetallic inclusions therefrom, accumulating the liquid metal under the slag above the level of a mold and continuously withdrawing an ingot from the mold wherein the metal is formed.
2. A method according to claim 1, wherein the temperature of the layer of the fluid refining slag in the vacuum chamber is maintained below the temperature of the metal being cast and above that of the refined, liquid metal accumulated in the mold.

3. A method according to claim 1, wherein in the process of vacuum slag refining and casting of metal, the fluid refining slag above the mold in the vacuum chamber and the metal in the upper part of the mold are heated by an electromagnetic field.

4. A method according to claim 1, wherein the metal is deoxidized and alloyed in the vacuum chamber under the layer of slag and above the mold.

5. A method according to claim 1 comprising changing the refining slag above the mold as the metal is being removed from the vacuum chamber.

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