METHOD OF PRODUCING MULTI-LAYER METAL INGOTS

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ABSTRACT
A method of producing multi-layer metal ingots providing a portion-by-portion filling of metal into the casting mould through liquid slag and crystallization of each portion of metal formed under the liquid slag, the temperature of which is maintained higher than the metal melting temperature of the layer being crystallized under it, each subsequent portion of metal being poured onto the preceding crystallized layer until an interlayer of liquid metal constituting 0.02 to 0.2 of its thickness is maintained over it.

7 Claims, No Drawings
METHOD OF PRODUCING MULTI-LAYER METAL INGOTS

BACKGROUND OF THE INVENTION

The present invention relates to the art of metallurgy, and is particularly concerned with methods of producing multi-layer metal ingots.

Commonly known is a method of producing metal ingots including the establishment of a bath or layer of liquid slag in a casting mould and subsequent pouring of separate portions of metal therein which form a layer in the ingot as a result of crystallization.

Each portion of metal following the first is supplied after the preceding crystallized layer has formed a hard crust of metal contacting the liquid slag layer disposed above it.

This method provides for using the slag as a means of protecting the poured-in layer (portion) of metal from oxidation and for cooling the metal. This is achieved by using a liquid slag at a temperature which is substantially lower than the melting temperature of the poured-in metal layer.

In producing multi-layer ingots the crystallization of metal in the poured layer takes place both upwardly and downwardly, the result being that the bulk of metal of the poured layer is crystallized in a closed space limited by a crust of hard metal formed on the layer surface. This leads to a formation of shrinkage cavities, blow holes and porosity inside the layer.

Besides, the pouring of metal of subsequent layers onto the hard surface of preceding layer covered with cooling slag fails to ensure a high quality of fusion of the layers along the entire surface of the built-up ingot. Poorest quality of fusion of layers, including interlayers of hard slag inclusions, are characteristic of peripheral areas of the ingot contacting the casting mold side walls.

SUMMARY OF THE INVENTION

It is an object of this invention to overcome the foregoing problems.

The principal object of this invention is to provide a method for producing multi-layer ingots possessing fine-grained structure and upwardly directed crystallization.

A further object of the invention is to enhance the fusion of layers in an ingot.

Still another important object of the present invention is the choice of dimension of layers and the conditions of their crystallization at which the contacting layers mix within minimum permissible limits.

Yet another object of the present invention is its economy and efficiency.

These objects and others are accomplished by a method of producing multi-layer metal ingots by establishment of a liquid slag layer in a casting mold and subsequent pouring-in metal in separate portions forming layers of the ingot, wherein, according to the invention, following the pouring-in of each portion of metal, the layer it forms is crystallized under the contacting liquid heated slag, the temperature of which is maintained higher than the temperature of the metal of the layer crystallizing under it, and that each subsequent portion of metal following the first portion is poured onto a liquid surface of metal of the preceding layer which has been crystallized to a degree that an interlayer of liquid metal is formed thereon constituting 0.02 to 0.20 of its thickness.

The crystallization of metal of each poured-in layer under the heated slag layer, the temperature of which exceeds the melting temperature of the metal of the crystallized layer, ensures an upwardly directed crystallization of metal of each layer and of the ingot as a whole. The maintaining of an interlayer of liquid metal having a thickness of 0.02 to 0.20 of the layer thickness on the surface of the previously poured in layer covered with heated slag ensures a high quality of fusion of metal of the this layer with the subsequently poured-in metal along the entire surface of the ingot.

The degree of crystallization of the metal layer at the moment of pouring-in the subsequent layer (crystallization of 0.80 to 0.98 of its thickness) which ensures maintaining the interlayer of liquid metal, allows the formation of a fine-grained structure of ingot metal. An insignificant intermixing of adjacent layers takes place which is permissible for metals of a variety of compositions.

It is preferable to maintain the liquid slag temperature by 50° to 300° C higher than the melting temperature of metal layer contacting it.

This temperature range will ensure the most economical and efficient heating of the metal necessary for upwardly directed crystallization of ingot layers.

It is preferred to keep the ratio of the ingot thickness to its width within 0.01 to 0.5.

Such selection of the thickness of ingot layers will ensure the most efficient upwardly directed crystallization of the metal layer and formation of a fine-grained structure within it.

It is found preferable to supply the further portions of liquid metal following the first portion in a split stream directed onto the surface of preceding layer contacting the side walls of the casting mold at a distance of 0.25 of the ingot width measuring from the side walls.

Such pouring of metal will ensure its distribution over the more cooled, as compared with the central zone, periphery of the ingot which contacts the side walls of the casting mold; enhance the quality of fusion of the layers, and finally, improve the side surface of the ingot.

It is preferred to maintain the casting mold wall temperature higher than the temperature, comprising 0.3 of the melting temperature of the used slag in the zone of its contact with the heated slag.

This feature will enhance the degree of upwardly directed crystallization of metal, and also improve the quality of ingot side surface.

The slag can be heated during the period of crystallization of the ingot layer using electric current passed between nonconsumable electrodes immersed therein.

This feature will ensure a high degree of efficiency of slag preheating and its uniform heating throughout.

A liquid metal can be poured having a chemical composition other than the metal of the previously poured-in layer.

This can ensure the production of a multi-layer heterogeneous ingot comprised of layers of metal of diverse chemical composition of the same class, such as for instance, steels of different grades as well as heterogeneous metals, such as steel, molybdenum, etc.
DESCRIPTION OF PREFERRED EMBODIMENTS

The invention will now be explained in greater detail with reference to embodiments thereof.

Liquid slag is poured into a casting mold installed on a cooled stool. The slag is heated with electric current passed between nonconsumable electrodes immersed therein. Then a first portion of metal is poured through a layer of liquid slag into the mold in order to form the first layer of the ingot. The volume of the portion is selected taking into account the layer thickness should be 0.01 to 0.5 of the ingot width (mold bottom portion).

Right after the pouring of the first portion of metal the nonconsumable electrodes, elevated above the mould filling level, are immersed into the slag which covers the layer of poured metal and the slag is heated in the area of its contact with the poured metal layer by current passing between the nonconsumable electrodes.

The temperature of the liquid slag is maintained in the region of 50° to 300° C higher than the temperature of metal contacting it. The thermal conditions of heating are maintained along the entire surface of contact of slag with the poured metal during the course of the entire period of crystallization of metal of the this layer.

By regulating the heat dissipation of the mold the temperature of its walls in the area of contact with the slag is maintained higher than the temperature constituting 0.3 of the temperature of melting of the slag used.

Following the crystallization of the first layer of metal to a depth ensuring keeping a thin interlayer of liquid metal on the surface contacting the slag, the thickness of which is 0.01 of the thickness of the first layer, another portion of metal is poured into the mold to form the second layer, the thickness of which layers is 0.05 of the ingot width at the level of its contact.

The thickness of the separate layers of ingot is variable within 0.01 to 0.5 of the width of the ingot.

The metal for the second portion is supplied in a form of a split stream directed onto the surface of the preceding layer contacting the mold side walls at a distance less than 0.25 of the ingot width at the level of this layer.

Right after pouring the second portion of metal the slag which covers the metal is heated to a temperature exceeding the melting temperature of the metal of second layer by 50° to 300° C. The second layer of the ingot is crystallized under the layer of slag heated to this temperature until an interlayer of liquid metal is formed on its surface of a thickness of 0.02 to 0.2 of the second layer thickness.

To form the third layer, a next portion is poured, the metal of which can possess a chemical composition differing from that of the metal of preceding layer.

The above operations are repeated until an ingot of specified size is obtained, by selecting the chemical composition of layers and their dimensions in accordance with the foregoing recommendations.

The method of producing multi-layer metal ingots described is most advantageous for casting ingots having layers of metals having diverse chemical composition, also, for casting large-size high-quality ingots with layers of metals having identical chemical composition.

The pilot tests performed on a six-ton multi-layer ingot have shown that the ingot metal possessed an uniform fine-grained structure with distinct separation of layers, and exhibited high quality fusion of the layers. The sheet metal obtained after rolling the ingot possessed good mechanical properties.

What is claimed is:

1. A method of producing multi-layer metal ingots, comprising the steps of (a) establishing a heated liquid slag bath in a casting mold; (b) pouring a portion of metal therein which forms a first layer of the ingot; (c) crystallizing said first layer of the ingot under said heated liquid slag contacting it, the temperature of which slag being maintained higher than the metal melting temperature of said layer; (d) pouring a further portion of metal to form a second layer of the ingot, which portion is poured onto a liquid surface of metal on the preceding layer which has substantially crystallized under the liquid slag, said liquid surface of metal forming an interlayer and having a thickness equal to 0.02 to 0.2 of the layer thickness; and (e) repeating steps (b) through (d) to build up a predetermined number of layers.

2. The method of claim 1, wherein the temperature of liquid slag is maintained by 50° to 300° C higher than the metal melting temperature of layer contacting it.

3. The method of claim 1, wherein portions of liquid metal are selected such as the ratio of the ingot layer thickness to its width is within 0.01 to 0.5.

4. The method of claim 1, wherein portions of liquid metal following the first portion are supplied in the form of a split stream directed onto the liquid surface of preceding layer contacting the side walls of the casting mold at a distance from side walls of less than 0.25 of ingot width.

5. The method of claim 4, wherein the temperature of the mold side wall at the area of contact with heated slag is maintained higher that the temperature constituting 0.3 of the temperature of melting of used slag.

6. The method of claim 1, wherein the slag is heated during the crystallization period of the ingot layer by means of electric current passed between nonconsumable electrodes immersed therein.

7. The method of claim 1, wherein subsequent poured portions of liquid metal possess a different chemical composition than that of the metal of the first layer to form a heterogeneous ingot.