METHOD FOR CONTINUOUS CASTING OF STEEL

Inventors: Gerd Vogt, Strump; Hans-Peter Poeste, Heiligenhaus, both of Germany

Assignee: Mannesmann Aktiengesellschaft, Dusseldorf, Germany

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Primary Examiner—J. Spencer Overholser
Assistant Examiner—John E. Roethel
Attorney—Smyth, Roston & Pavitt and Ralf H. Siegemund

ABSTRACT

Differently melting casting powders are used to control imbalance of heat transfer conditions in the cross section of a mold and ingot.

9 Claims, 1 Drawing Figure
METHOD FOR CONTINUOUS CASTING OF STEEL

The present invention relates to a method for introducing casting powder into a mold as used for continuous casting of steel. It is common practice to charge the mold with a casting powder during continuous casting of a steel ingot. Usually, the same type of casting powder is used throughout the casting operation. However, in copending application, Ser. No. 22,067, filed Mar. 23, 1970, of common assignee, now U.S. Pat. No. 3,642,052 it has been suggested to start casting by covering the surface of the molten material in the mold with a powder of relatively low melting point to obtain rapid liquidification thereof during the initial phase. This way, advantageous lubrication, as well as a controlled heat barrier and insulating effect is obtained between casting product and mold rather early in the operation. Subsequently, casting powder of higher melting point is used.

A casting powder of relatively low melting point forms liquid slag in the surface level of the bath in the mold; the slag is withdrawn from the mold together with the cast ingot, between ingot and mold. On the other hand, a powder of relatively high melting point does not always establish an extensive and continuous slag layer everywhere between ingot and mold.

Casting operations, proceeding in the usual manner as far as cooling of the mold and application of casting powder is concerned, was found to exhibit another particular deficiency having nothing to do with the problem solved in accordance with the aforementioned application. In dependence upon chosen ingot cross section and in further dependence upon the mode of guiding the withdrawn ingot, the solidifying shell or skin grows irregularly fast in thickness, and zones, exhibiting particularly high heat transfer from the ingot, were prone to formation of cracks or fissures in the skin. For example, if mold ingot are curved (e.g., the withdrawn ingot is veered from the vertical to the horizontal), the skin grows faster in thickness on the inside of the curve than on the outside. In case of continuous casting of a tubular ingot, the skin grows faster on the outer surface than on the inner surface of the tube.

The problem solved by the invention is to render growth of skin or shell thickness more uniform or to influence growth for obtaining effects that have an opposite tendency as compared with those inherent functions of the casting equipment, which render skin thickness growth irregular. This is particularly to be the case for casting a hollow ingot for it is often desirable to have the inner skin growth in thickness actually faster than the outer one.

In accordance with the preferred embodiment of the invention, it is suggested to apply two different casting powders concurrently to the mold but in different locations. The two powders are to differ as to melting characteristics and viscosity at operating temperature. In particular, the higher melting casting powder is to be applied to become effective in the vicinity of the (normally) slower growing skin, where the heat transfer is somewhat lower than on the average.

For example, in case of curved casting of a wide slab ingot, higher melting casting powder is applied in the vicinity of that portion of the forming ingot that will be withdrawn along the outer curved withdrawal path. It was found that texture of the ingot throughout its cross section is more uniform, and the final solidification of the liquidous core occurs in the geometric center of the ingot cross section.

In case of casting a tubular ingot, the higher melting casting powder is applied to be effective along the mandrel, so that the heat transfer into and through the mandrel is enhanced, and the inner skin grows faster accordingly. Speeding of growth in that manner does not increase the tendency for the formation of cracks, as upon increasing thickness of the skin the border zone is maintained under pressure due to shrinking during solidification and cooling. Also, the inner surface of the tubular ingot can be expected to be quite smooth which is of advantage for quality and further working of the ingot. Finally, the operation is safer as a whole.

Various kinds of casting powders are available generally and they consist usually of particular mixtures that include high melting oxides. As components for a casting powder mixture, Al₂O₃, SiO₂, CaO and C are predominantly used. A powder that is to have higher melting point has more high melting oxides than a powder that is to have a lower melting point. The latter type powders may include Na₂O and Ca₃P₂, to enhance fluidity. It is, furthermore, suggested, to keep the differently melting powders separated in the mold by means of a refractory divider made, e.g., of ceramic material.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed that the invention, the objects and features of the invention and further objects, features and advantages thereof will be better understood from the following description taken in connection with the accompanying drawings in which:

The FIGURE illustrates somewhat schematically a section view through a mold operated and improved in accordance with the invention.

Proceeding to the detailed description of the drawing, the FIGURE illustrates a water cooled mold 1, coolant circulation being schematically indicated by arrows at the mold. A mandrel 3 is centrally disposed in the interior of the mold. The mandrel is likewise cooled, coolant circulation is also indicated by arrows. There is, therefore, established a ring-shaped mold cavity 5. Liquid steel 6 pours from a distributing vessel into the mold on a continuous basis and in plural streams. A surface level 11 of liquid steel is dynamically established in the mold by the continuous casting stream while a tubular ingot 9 is withdrawn continuously from the bottom of the mold.

An outer, solidified skin 9a is established already on the wall of the mold 1 and grows in thickness in direction of withdrawal. Likewise, an inner solidified skin 9b forms along the mandrel and grows in thickness, essentially independently from the rate of solidification on the outer skin. A tubular core 9c of still liquidous steel remains at first but decreases as to cross-sectional dimension along the direction of withdrawal as the two skins grow and merge downstream.

A divider ring 13 is provided in the upper part of the mold, circumscribing the mandrel 3 and dipping into the molten bath. Ring 13 is made of refractory material, e.g., ceramic. Two systems of funnels, 15 and 17, are
provided to apply casting powder to the mold. In particular, funnel system 15 provides a first type of casting powder 19 into the ring space between the (upwardly projecting) ring 13 and mandrel 3, while funnel system 17 provides a different casting powder 21 into the ring space between ring 13 and mold 1; ring 13 prevents the two powders from mixing. The arrows on top of the funnels denote replenishing feeding of the casting powders into the funnels.

For the particular case of casting a tubular ingot, powder 19 has higher melting point than casting powder 21. It can, thus, be seen that the higher melting casting powder provides lubricating slag along the mandrel at a higher viscosity which enhances heat transfer so that growth of skin 9b is enhanced accordingly. The lower melting casting powder 21 provides liquidous lubricating slag as lower viscosity. The resulting greater fluidity at the operating temperature, therefore, reduces heat transfer into the outer mold, "reducing," of course, to be understood only on a comparative basis as to heat transfer conditions into the mandrel by operation of the two types of casting powder.

It can be seen further that by selecting the relative proportion of higher melting components in the several powders, the melting point and the viscosity of the slag at operating temperature can be controlled. Thus, the relative speed of growth of skins, 9a and 9b, can be adjusted accordingly for the skins to grow equally fast in thickness or for skin 9b to grow actually faster. It can also be seen that the invention of the copending application can be practiced within the environment of the present invention by changing the composition of each of the powders as casting progresses.

The FIGURE serves also in principle as illustrating the different case of slab ingot casting. Assume the mold to be slightly curved (e.g., to the right) and assume further the mandrel to be removed. The high melting casting powder will be applied to the left side of the mold and low melting powder will be applied more to the right. Instead of a divider ring (13), a ceramic divider wall dipping into the molten path separates the powders and the resulting slags.

The invention is not limited to the embodiments described above but all changes and modifications thereof not constituting departures from the spirit and scope of the invention are intended to be included.

We claim:

1. In a method of continuous casting of steel using a mold for casting a curved ingot comprising the step of applying different casting powders to the mold in different positions thereof for control of the heat transfer conditions along and into the mold wall, the powders selected for differing as to melting point and viscosity after melting, a lower melting powder being applied in the vicinity of the wall along the inner curved contour of the ingot.

2. In a method for continuous casting of a tubular steel ingot, using a mold with a centrally disposed mandrel, and providing a higher melting casting powder in the vicinity of the mandrel and a lower melting powder in the vicinity of the mold proper, for control of relative heat transfer respectively into the mandrel and the mold proper.

3. In a method for continuous casting of steel using a mold having first and second wall portions but a uniform surface level of molten steel therein, applying a first casting powder to the mold to act in the vicinity of the first wall portion; applying a second casting powder to the mold having a higher melting point than the first powder and melting in the vicinity of the second wall portion, so that the heat transfer into the second wall is enhanced due to higher viscosity of the molten second powder as flowing along the second wall portion; and maintaining the first casting powder separated from the second casting in the surface level of the molten steel in the mold, the ingot growing underneath the surface level unimpeded by the slag separation in the surface level.

4. The method as in claim 3, including the step of using a refractory divider dipping into the surface of the bath of the molten steel for separating two differently melting casting powders.

5. The method as in claim 4, the divider selected from ceramic material.

6. The method as in claim 1, comprising the step of using differing casting powders having different content of high melting oxides.

7. The method as in claim 1, comprising the step of using particular, liquidity enhancing components in the low melting casting powder.

8. In a method as in claim 1, including the step of using a divider for maintaining the slag powders separated in the surface level of steel in the mold.

9. In a method as in claim 2, including the step of using a divider for maintaining the slag powders separated in the surface level of steel in the mold.

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