CONTINUOUS SLAB CASTING MOLD

Hans Schrewe, Duisburg-Ungelsheim, Germany, assignor to Mannesmann Aktiengesellschaft, Dusseldorf, Germany
Filed Dec. 28, 1965, Ser. No. 516,932
Claims priority, application Germany, Dec. 28, 1964, M 63,631

U.S. Cl. 164—273
Int. Cl. B22d 1/02, 11/12, 27/08

ABSTRACT OF THE DISCLOSURE

An oscillating mold for continuous slab casting has throughout at least portions of the wide mold walls an increased heat resistance.

The invention relates to the continuous casting in liquid cooled molds, of slabs of high melting point, and to the molds for casting these slabs; and relates more particularly to casting methods and molds where the mold oscillates throughout a stroke.

Oscillating molds for continuous casting generally are known, reference being had, for instance, to the article, "The Continuous Casting of Steel," by Leonard V. Gallagher and Bruce S. Old, Scientific American (December 1963), pp. 75—88.

For the continuous casting particularly of metals of a high melting point, it is known to use molds that impart to the casting different cooling effects; this is due to the particular construction of parts of the mold. Thus, for instance German Patent No. 181,379 teaches to form a liquid cooled mold in such a manner that its wall is thinnest at the zone of beginning solidification, thus in the upper one third of the mold, and increases in thickness, either uniformly or stepwise, towards the exit opening of the mold.

A similar cooling effect is described in Austrian Patent No. 176,314 which has a mold the lower part of which carries one or more added layers of a material of lower heat conductivity than that of the mold itself.

For the casting of light metals, German Patent No. 900,861 teaches to subdivide the mold into two zones of different cooling intensity. This German patent teaches, in contrast to the aforesaid Austrian patents, to provide the upper mold part with a material of reduced heat conductivity and the lower part of the mold with a material of increased heat conductivity. The German patent furthermore proposes either to increase the wall thickness in the upper part of the mold or to apply to that upper part a cooling liquid of higher temperature.

The purpose of providing molds of this type is to solidify the casting in the mold. This, however, is not applicable to the continuous casting of metals of high melting point, particularly iron and steel. The same must be said for the proposals made in the French Patent No. 994,138. For it has been found that during the continuous casting of slabs having a width of more than 800 mm., of a metal of high melting point such as iron and steel, the required cooling can not be achieved with mold constructions of the prior art.

A slab, for instance of iron or steel, descending in the mold cavity of a mold of the prior art will have a thin solidified skin, while the remainder of the slab will still be liquid. Not far below the molten metal level there will form a shrink space between the skin of the casting and the mold wall. The shrinking occurs because the mold wall is liquid cooled and thereby rapidly conducts heat away from the casting exterior. This causes the occurrence of the shrink space between the skin and the mold interior.

During the further descent of the casting in the mold, however, the liquid interior will reheat the skin; the skin, on the other hand, is isolated by the shrink space from the cool mold and therefore will, under the heat transfer from the hot liquid interior, be heated and expand until it again makes contact with the mold. This imparts to the skin a corrugation or ripple which ultimately may lead to breaks in the skin or other injuries to the casting exterior.

It is accordingly among the principal objects of the invention to provide methods and means for continuously casting slabs of excellent quality free from skin breaks, composed of metals having a high melting point.

It is a further object of the invention to provide methods and molds that avoid the drawbacks of the prior art.

It is another object of the invention to provide methods and molds of the type referred to which control the heat transfer from the slab to at least some portions of the wide side walls of the mold in such a manner that there is thereby rendered uniform the shrinking of the casting in the mold and the overall heat transfer from the casting to the mold is substantially uniform throughout the mold length.

Further objects and advantages of the invention will be set forth in part in the following specification and in part will be obvious therefrom without being specifically referred to, the same being realized and attained as pointed out in the claims hereof.

The invention is based on the recognition of the importance of controlling the heat transfer thereby to control, in turn, the shrinking to avoid the aforesaid repeated contraction and expansion of the slab as it passes through the mold cavity.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description, taken in connection with the accompanying drawings, in which:

FIG. 1 is a fragmentary vertical sectional view of portions of a continuous casting mold in accordance with the prior art;
FIG. 2 is a fragmentary vertical sectional view, similar to FIG. 2, but embodying a modification. In FIG. 1 there is shown a prior art mold which is liquid cooled (the details of the liquid cooling arrangements having been omitted). The mold 1 is of the oscillating type through the well known details of the oscillating mechanism have been omitted for the sake of clarity and simplicity. The wall of the mold 1 is of uniform thickness. The casting that descends in the mold 1 is solidified throughout its thin skin 2; the much larger remaining interior 3 being still liquid. The molten metal level is designated 4, 4' and 4" showing the upper and lower positions of the range of the metal level 4 due to the oscillating strokes.
Not far below the metal level, there occurs a shrink space 5; another shrink space 5a will occur further below, and still another shrink space 5b further down. As previously the mold is filled, the shrinkage results from the cooling effect of the mold wall making contact with the casting. The intervening contact between the skin 2 and the mold wall 1 is due to the subsequent expansion under the influence of the internal heat of the liquid core 3. The contact with the mold wall 1 again brings about a thinning of the skin 2, creating the shrink space 5b. The same sequence of events brings about a renewed contact and shrinking, the latter at the shrink space 5b. This continual shrinking and expanding is detrimental to the slab that is formed of a metal, such as iron or steel, of a high melting point, and the liquid core 3, which extends through the mold.

In contrast to the foregoing representation of the prior art of FIG. 1, the wall 6 of the mold is of non-uniform thickness. For a portion of its length, the mold wall 6 is uniform, while near the range 4'-4" of the molten metal level 4, the wall thickness has a portion 7 of increased thickness; the portion 7 of increased thickness has an increased heat resistance. This increase in thickness of the portion 7 may either be provided by merely making the wall itself thicker, or by being provided by adding to the wall a layer by welding, by spraying, by galvanizing, or by other well known suitable means, adding a different material having a higher heat resistance.

The mold walls of a slab comprise two opposite wide walls and two opposite narrow walls therebetween.

Conventional oscillating means 12 are provided for oscillating the mold 3.

It will be understood that the narrow walls may be made uniformly, relegating the control to the wide mold walls. The wide mold walls, on the other hand, are so constructed, for instance as shown in FIG. 2, that throughout from about 1/4 to about 1/2 of the length of the mold they have a higher heat resistance than throughout the remainder of the mold. The zone of increased heat resistance commences, as seen from the upper mold end, about at the plane 4' of the upper position of the molten metal level of the stroke of the oscillating mold. The increase of heat resistance of the zone should at least be 1/2 times that of the heat resistance of the remainder of the mold wall above and below the aforesaid zone. By arranging the mold in the manner as shown in FIG. 2, of having a portion 7 of increased thickness in the wide mold wall, and above and below it the wide normal wall 8 having a normal thickness, the skin 2, as clearly shown in FIG. 2, will be uniformly spaced at 8 from the mold wall due to shrinking, thereby avoiding the corrugations in the casting of FIG. 1.

At an overall length of the mold of, for instance 700 mm., the length of the thickened portion 7 may, depending on the casting speed, extend from about 70 to about 350 mm., with the greater height assigned to the larger casting speed.

The arrangement described herein and shown in FIG. 2, brings about that the solidified skin 2 transmits within the zone of the portion 7 to the mold wall the same amount of heat as in the portion 6 of reduced wall thickness below the thicker portion 7. This uniform heat transfer avoids the occurrence of non-uniform stresses in the skin 2. The shrink space 8 is built gradually, and is small, and the heat transfer from the casting to the skin 2, creating the shrink space 8 occurs due to the shrink space 5 in the skin 2, creating the shrink space 5c. The same sequence of events brings about a renewed contact and shrinking, the latter at the shrink space 5c. This continual shrinking and expanding is detrimental to the slab that is formed of a metal, such as iron or steel, of a high melting point, and the liquid core 3, which extends through the mold.

This arrangement yields slabs that are free from skin injuries. In the modification of FIG. 3, the mold wall 9 is recessed near the aforesaid range 4'-4," and a material 10 of higher heat resistance fills said recess. It does not make any appreciable difference whether the wide walls of the mold are formed in uniform material or the internal sides facing the casting are provided with an abrasion resistant lining. In FIG. 3, such a lining is shown at 11, and may consist of chromium, or molybdenum, or the like.

It has been found, however, that if in the aforesaid molten metal range the damping layers are too heavy, the skin 2 which at that region is still very thin, tends to stick to the inner mold surface. This tendency to stick, together with the oscillating strokes, leads to a roughness of the skin external which, in turn, adversely influences the aforesaid substantial uniformity of heat transfer. Just like the roughness of the mold interior, so does the roughness of the exterior increase the heat damming effect. The instant invention therefore provides to put the various measures in tuned relationship. For instance, the invention proposes to synchronize the downward stroke of the mold with the withdrawal speed of the slab in the mold, or that the lead of the mold relative to the casting is not more than 2 to 1.

The instant invention furthermore provides for influencing the heat transmission from the casting in connection with the instant mold in such a manner, so as for a predetermined steel quality to decrease the stroke where the heat transmission is too small and, conversely, to increase the stroke of oscillation where the heat transmission is too large. The length of the oscillating stroke of the mold and the magnitude of the heat damming are thus mutually adjustable.

I wish it to be understood that I do not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

Having thus described the invention, what I claim as new and desire to be secured by Letters Patent is as follows:

1. A mold, for use in the continuous casting of a slab of metal having a high melting point and including a liquid core that extends for a relatively long distance in the casting, such as iron or steel, said mold being liquid cooled and oscillating, means operable for oscillating the mold throughout a certain stroke, said mold having opposite wide and narrow side walls defining between an open top and an open bottom a mold cavity having a certain length, said wide molds walls each having through-out at least a portion and increased heat resistance within the range of said oscillating stroke of the molten casting metal bath, whereby the shrinking of the casting away from said wide walls during the passage through the mold will proceed substantially uniformly throughout its breadth and the transfer of heat from the casting skin to the mold wall will thereby be substantially uniform throughout said length of said mold cavity.

2. A mold, as claimed in claim 1, said increased heat resistance being in the zone below the lowermost point in the oscillating range of the molten casting metal level in the mold.

3. A mold, as claimed in claim 2, said portion being from about one eighth to about one-half of said mold cavity length commencing substantially at the upper stroke position of the molten casting metal level.

4. A mold, as claimed in claim 1, said portions of said wide walls having increased heat resistance within the range of the oscillating stroke of the molten casting metal bath of at least 1.5 times the heat resistance of said wall above and below said range.

5. A mold, as claimed in claim 1, said portion of increased heat resistance being formed by an increase in the wall thickness commencing below the mold top.

6. A mold, as claimed in claim 1, said wide walls having adhesions throughout at least a portion of the surface.
3,429,365

facing the cooling liquid and commencing below the mold
top a material of increased heat resistance.
7. A mold, as claimed in claim 6, said surface portion
having at least one recess, said material of increased
heat resistance adhering to said recess.

References Cited

UNITED STATES PATENTS
2,169,893 8/1939 Crampton et al. ------ 164—283
2,496,235 1/1950 Rossi ----------- 164—83
2,983,972 5/1961 Moritz ----------- 164—283 XR
2,242,350 5/1941 Eldred ---------- 164—125 XR

FOREIGN PATENTS
375,106 3/1964 Switzerland.

J. SPENCER OVERHOLSER, Primary Examiner.
R. S. ANNEAR, Assistant Examiner.
U.S. Cl. X.R.