MOLD FOR CONTINUOUS CASTING OF HOLLOW OBJECTS

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4 Claims

ABSTRACT OF THE DISCLOSURE

This specification discloses a mold for producing hollow continuously cast bodies. The mold includes an outer mold member and an interior mold member, forming between them a space the shape of the cross section of the cast body. An orifice plate having at least one opening in the space between the mold members feeds molten metal from a source to the mold. The orifice plate includes passageways through it to feed cooling liquid and lubricant to the interior mold member.

This invention concerns a mold for producing hollow continuously cast articles of metal. Such articles are useful as tubes, as structural shapes or as billets for producing hollow extrusions and for many other purposes. Although continuous casting of hollow articles has been accomplished in the past, the construction of suitable molds is difficult, particularly in providing support for the center mold portion. In such casting of hollow bodies, support of the center mold member is a problem, but in continuous casting of molten metal it is even more so because the interior portion of the mold must be supplied with liquid streams necessary for continuous casting. Mandrels supporting the interior mold member and carrying these liquid must pass through the feed box or the mold metal furnace, and in such environment they are vulnerable to attack. Also, passing of cooling fluids through the furnace or feed box causes local cooling of the molten metal, thereby causing loss of necessary superheat or at least making temperature control very difficult. In addition, the presence of mandrels or supporting elements in a feed box or furnace add significantly to the complexity of these elements which are desirably as simple as possible. For example, preventing leakage where packing is not easily installed is required when cooling fluid is carried through a feed box, and forming and mechanically connecting brittle refractories is difficult. In addition, furnaces must be cleaned frequently and interior fittings create great difficulties in cleaning and maintaining these cumbersome pieces of equipment.

The present invention provides a mold for casting hollow bodies that can be installed directly on a furnace or feed box the same as a mold for casting solid bodies. In fact, the mold of this invention can be used interchangeably with molds for casting solid bodies as long as the opening in the source of molten metal to accept such other molds is of a comparable size. The mold of this invention additionally is completely self-contained with regard to supplying cooling fluids to the interior mold members and these fluids pass to the interior mold members without passing through a body of molten metal and without heat exchange with the molten metal stream.

The mold of the present invention includes three interrelated portions. These portions are an orifice plate, an interior mold member, and an exterior mold member. As in all molds for continuous casting of molten metal, a source of molten metal is required and whether that source is a furnace, a feed box of a trough, the orifice plate of this invention is adapted to be interconnected in fluid-tight relationship with the source of molten metal so that molten metal escapes from the source through the opening or openings in the orifice plate. The orifice plate is in liquid-tight relationship also with both the interior and the exterior mold members which are positioned on the orifice plate to form a space between them the shape of the cross section of the article to be cast. One or more molten metal-carrying openings in the orifice plate conducts molten metal from the source to the space between the interior and exterior mold members, and these molten metal carrying openings are preferably, but not necessarily, insulated to prevent rapid heat conduction into the main body of the orifice plate.

The orifice plate is also provided with passageways, preferably drilled into the orifice plate body, that carry fluids other than molten metal that are necessary for casting. The fluids are carried into the orifice plate nonaxially to the flow of the molten metal. For example, an orifice plate having a round cross section may be drilled radially to provide such passageways for bringing cooling fluid and lubricant into the area adjacent the interior mold member. Axial passageways parallel to the axis of the orifice openings may then be drilled intersecting the nonaxial passageways so that these fluids can be provided to the interior mold member without passing through any portion of the assembly other than the mold itself.

The invention is best described with reference to the accompanying drawings which illustrate a mold embodying this invention.

FIG. 1 is a sectional view of a mold taken along the line 1—1 of FIG. 2.

FIG. 2 is a front end view of the mold illustrated in FIG. 1.

FIG. 3 is a schematic cross section of a typical mold which is illustrated connected to a source of molten metal and in operation in casting a tubular article.

In all figures corresponding parts are numbered the same.

Orifice plate 10 is constructed with openings 11 which are illustrated surrounded with insulation 12. Openings 11 are provided to conduct molten metal from a source of molten metal to the space 13 between exterior mold member 15 and interior mold member 16. Although shown with three openings 11, orifice plate 10 may contain any number of openings which may be adapted to provide the required flow rate of molten metal and may be spaced to provide special distribution of molten metal within space 13 if such special distribution is required by the shape or other characteristics of the mold.

In continuous casting of light metals such as aluminum, two fluid streams must be provided to the interior mold member 16 and to the exterior mold member 15. These are a cooling liquid stream which is normally water, and a lubricant stream which is normally a heat-resistant oil,
The coolant stream must be provided in large quantities both to chill the mold wall and to cool by direct contact with the ingot as it emerges from the mold. The lubricant is supplied in relatively small quantities to provide a thin film of lubricant between the mold surface and the ingot surface thereby preventing tearing of the thin solid metal wall as a result of sticking to the mold surface which tearing causes surface defects. The lubricant also acts as a heat conductor and prevents premature cooling of the molten metal, thereby avoiding defects known as cold folds that are thought to result from freezing of the metal meniscus before it comes in contact with the mold wall. Metal is normally introduced into a mold with superheat and any premature cooling of the metal whether by contact with the mold wall or indirectly by heat transfer with fluid streams results in surface defects so that such cooling should be avoided.

Exterior mold member 15 is supplied with fluid streams in the same manner as molds for producing solid castings. Line 17 supplies water to the hollow portion 18 of exterior mold member 15. After chilling the walls of mold 15 the water may be discharged as a spray against the formed ingot through passageway 20, which is shown as a slit but which may be a series of drilled holes. Auxiliary water sprays may be used in addition to, or instead of the spray nozzle 20 to cool the exterior of the formed ingot. Lubricant is introduced to exterior mold member 15 through passageway 21 which introduces the lubricant into a groove 22 which is shown greatly enlarged in width. The lubricant distributes itself evenly throughout the groove 22 and feeds slowly into the mold to provide a thin, uniform film of lubricant on casting surface 23. The passageway 21 includes both the drilled passageway through mold member 15 and the feed line that supplies that drilled passageway.

Interior mold member 16 must also be supplied with cooling liquid and lubricant. As mentioned hereinabove, it is desirable to pass fluid streams through the feed box or furnace, and in accordance with this invention these fluid streams are supplied to interior mold member 16 without passing through any apparatus other than the mold itself. Passageway 25 is drilled radially through orifice plate 10 and at an appropriate position an axially drilled passageway 27 that opens into chamber 28 of the interior mold member 16. The cooling fluid in chamber 28 maintains interior mold member 16 cool so that heat is conducted from molten metal contained in space 13 to form a solid shell in the form of the hollow ingot. Slot 30 forms a nozzle that discharges the cooling water in chamber 28 against the interior surface of the ingot that is being formed to provide direct cooling.

Line 31 feeds lubricant to passageway 32 which is drilled radially through orifice plate 10 to intersect passageway 33. Passageway 33 opens into groove 35 in interior mold member 16 which distributes lubricant evenly within groove 35 and causes a uniform film of lubricant to coat casting surface 36. Groove 35 also is shown exaggerated in width. The lubricant on casting surface 36 is important to provide a smooth interior surface for the resultant hollow ingot and to prevent tears and spillovers of the molten metal during the forming process.

FIGURE 3 is a highly schematic sectional view of a mold embodying this invention shown assembled on furnace 40 and in use. The furnace 40 is shown as a steel shell 41 lined with a refractory lining 42. The interior of furnace 40 is completely uncluttered and contains no portion of the mold nor any portion of the transfer lines for supplying the mold with coolant or lubricant. The mold is installed in a suitably formed opening 43 in wall of furnace 40 by having orifice plate 10 inserted into an opening adapted to receive it. Suitable clips or flanges may be employed to hold orifice plate 10 firmly in the opening or it may be installed with cementing material that prevents leakage of molten metal around the orifice plate.

The molten metal from furnace 40 passes through opening 11 and into the mold cavity where it contacts cooled mold walls and begins to solidify in the form of a hollow ingot 45. At first, the solid metal in contact with the mold walls is a thin shell of solid aluminum surrounding a liquid or slushy interior. The solidus line is generally parabolic in shape and, as more heat is extracted, the liquid portion of the cross section becomes smaller and finally disappears altogether. Heat is extracted from the ingot both by conduction to the cooled walls of mold members 15 and 16 and by direct cooling where sprays of water impinge against both the interior and exterior surfaces of ingot 45. As is evident from FIG. 3, in the operation of the mold of this invention temperature control of the molten metal in the furnace is determinative of the amount of superheat in the metal as it enters the mold and no extraneous streams of fluid affect that temperature. It is also evident from FIG. 3 that furnace 40 requires no special adaptation to the mold of this invention and that the mold of this invention may be employed with any furnace adapted to accept any mold of a comparable size and shape. The mold of this invention may be employed to cast hollow ingots either horizontally or vertically and it may be employed with feed boxes, trough systems or any other means for supplying molten metal employed with molds for solid ingots because the mold of this invention is entirely self-contained with respect to supporting the interior mold member and supplying necessary fluid to the interior of the hollow article being cast. FIG. 3 does not illustrate the lubrication system, but a lubrication system such as shown in FIGS. 1 and 2 will normally be employed. The cooling fluid spraying the interior surface of the ingot 45 will discharge through the hollow interior of the ingot and will be conducted away from the ingot and the cast ingot that is being formed. It is evident that the cooling fluid employed for direct chill cooling of the interior mold surface must come from the interior mold member 16. Auxiliary or additional spraying means may be employed in conjunction with mold member 15 as previously discussed.

Having thus described this invention, what is claimed is:

1. A mold for continuously casting hollow metal articles comprising:
   (A) an orifice plate;
   (B) an exterior mold member connected to said orifice plate and adapted to receive lubricant on its casting surface and to receive cooling fluid in heat exchange relationship with said casting surface;
   (C) an interior mold member fixed against said orifice plate, spaced from said exterior member, and containing a cooling liquid chamber in heat exchange relationship with its casting surface and adapted to distribute lubricant on said casting surface, to receive cooling fluid in said chamber, and to distribute cooling fluid against the interior of said formed hollow metal article;
   (D) means for supplying molten metal for casting;
   (E) an opening through said orifice plate connecting said means for supplying molten metal to the space between said interior and exterior mold members;
   (F) a passageway through said orifice plate that is nonaxial with said opening and forming an open passageway through said orifice plate to said cooling liquid chamber;
   (G) a passageway that is nonaxial with said opening connecting to the means to distribute lubricant to the casting surface of said interior mold member.

2. The mold of claim 1 wherein said opening in said
orifice plate is insulated to restrict heat transfer to said orifice plate.

3. The mold of claim 1 wherein the cooling fluid in heat exchange with the casting surface of the exterior mold member is discharged into contact with said hollow metal article.

4. The mold of claim 1 wherein said orifice plate is circular and said non-axial passageways are at least partly radial drilled holes.

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