

Description

The present invention relates to method and apparatus for producing discrete molded shapes from a flowable, moldable or molten material. Specifically, the invention discloses continuously casting discrete shapes using a moving mold casting machine where, for example, the shapes are formed between spaced portions of a pair of endless flexible casting belts which are moved along with opposite surfaces of the metal being cast.

Although the principles of the invention can be used to cast any flowable, moldable or molten material such as plastics, the invention will be described in terms of continuously casting molten metal into discrete and variable shapes, such as ingots, anodes, wirebars or foundry castings.

Discrete metallic shapes are typically cast in individual molds using a discontinuous stream of molten metal. A plurality of mold cavities are supplied sequentially and the flow of metal in the desired quantity to each of the molds is controlled manually by an operator or in an automated manner. Continuous casting is employed, in a variety of forms, in the nonferrous and ferrous metals industry and elsewhere, to decrease production cost and increase product quality. Two basic systems known as the static and moving mold methods are used in continuous casting of shapes such as billets or continuous strips. In the static mold casting machine, the walls of the mold are stationary, while the cast products move against and solidify within them. Moving mold casting machines employ a belt, chain, drum, wheel, or other surface which moves at approximately the same speed as the solidifying metal.

The continuous casting of metal on moving mold casting machines having at least one movable belt and a corresponding fixed or movable surface which together form a mold of two opposed surfaces in which the cast material solidifies is described in detail in the following U.S. patents which are incorporated herein by reference: 2,631,343; 2,904,860; 3,036,348; 3,123,873; 3,123,874; 3,167,830; 3,533,463; 3,864,973; 3,878,883; 3,921,697; 3,937,270; 3,937,274; 3,949,805; 3,955,615; 4,002,197; and 4,854,371.

For a twin belt caster where two movable belts form the mold, in operation, a continuous stream of molten metal is supplied at the inlet of the machine to a cavity formed by a pair of movable flexible casting belts, positioned generally above the other, and side dam blocks, and emerges at the other end of the cavity (outlet of the machine) as a solidified strip or bar of metal. The strip or bar is subsequently fed to other apparatus for mechanical working, or cutting and/or welding, which changes its cross sectional dimensions. For example, twin

belt casters of the type described are used to convert molten copper to a roughly rectangular bar shape which is then continuously fed to a rolling mill having a series of rolling stages for converting the rectangular bar to a round rod. Typically, the rod eventually is drawn to wire of various gauges.

In a previous attempt in the art to produce shaped articles continuously, a twin belt caster was modified by making the dam blocks smaller at certain intervals to provide a cast material having the shape of an anode, i.e., a flat rectangular shape having support arms. After casting, however, the casting had to be cut to form discrete anode shapes.

Another continuous casting moving mold method employs a casting wheel having a peripheral groove therearound. A portion of the peripheral groove is closed by an endless belt to form a mold into which molten metal is poured to be solidified into cast metal and discharged therefrom. Such designs may be seen in U.S. Patent Nos. 3,279,000 and 3,469,620, which patents are hereby incorporated by reference.

Continuous casting using a static mold may be found in U.S. Patent Nos. 2,938,251; 2,946,100; 3,066,364; 3,089,209; 3,098,269; and 3,115,686, which patents are hereby incorporated by reference. Basically, molten metal is continuously fed into the mold, freezes and the frozen product continuously removed from the mold. Generally, the mold is in a vertical position with the molten metal poured into the top of the mold.

While the casting machines described hereinabove are very successful and employed extensively throughout industry, the need still exists for these type continuous casting machines to produce discrete shapes. It is an object of the invention to provide apparatus and methods for the continuous casting of such discrete shapes.

SUMMARY OF THE INVENTION

The present invention is directed to an improvement in continuous casting machines and comprises apparatus and method for using a continuous casting machine to cast discrete shapes such as wire bars, ingots, billets, cakes, strips and foundry shapes from a stream of molten material. Although the invention can be employed in connection with various types of continuous casting machines, the invention for convenience will be described in detail for casting lead pigs using a twin belt caster wherein a pair of moving belts form a moving mold for molten metal.

The apparatus and method of the invention can be employed with any flowable, moldable or molten material such as plastics, ferrous or nonferrous metals including but not limited to steel, iron, cop-

per, lead, bismuth and aluminum. The invention is particularly useful for the continuous casting of brittle or frangible materials which cannot normally be rolled, roll-formed, drawn or drilled in the solid state.

FR-A-2387714 discloses apparatus for continuously casting a metallic strip, which is subsequently cut into segments of desired length. There is no teaching of continuously casting discrete shapes. SU-A-262331 discloses inserting separating means between opposing wheel casters for forming brushes in which dividing means provided by rings are inserted and then removed after the material is cast.

In accordance with the present invention there is provided a method for producing discrete molded shapes as defined in claim 1. There is further provided in accordance with the present invention a continuous casting apparatus for forming discrete molded shapes as defined in claim 3.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic illustration of a twin-belt casting machine showing the improved forming means for forming discrete shapes.

Fig. 2 is a side sectional view taken along a plane perpendicular to the input rolls and including the tundish, dam wall and molten metal.

Fig. 3 is a top view of the lower casting belt showing an ingot shape formed using a particular forming means.

Fig. 4 is a side view of the lower casting belt showing an ingot shape formed using a particular forming means.

DETAILED DESCRIPTION OF THE INVENTION

An illustrative example of a continuous metal casting machine equipped with an embodiment of the present invention is shown in Fig. 1. In this casting machine 10 molten metal 11 is supplied from a pouring box or ladle (not shown) into a tundish 12. From the tundish 12, the molten metal 11 is fed into an input region 13 formed between spaced parallel surfaces of upper and lower endless flexible casting belts 14 and 15, respectively. The cavity formed between the belts 14 and 15 and dam blocks 16 may be defined as the casting region 17 wherein the molten metal is cast into a desired shape and solidified. The casting belts are preferably fabricated from steel, or other alloys, which provide toughness and resistance to abrasion and physical damage as well as resistance to the temperature shocks and heat differential stresses undergone during casting.

The casting belts 14 and 15 are supported on and driven by an upper and lower carriage gen-

erally indicated at 18 and 19, respectively. Both carriages are mounted on a machine frame (not shown). Each carriage includes two main rolls which support, drive and steer the casting belts. These rolls include upper and lower input rolls, 20 and 21, and upper and lower output rolls, 22 and 23, respectively.

A flexible, endless side metal retaining dam 16 is disposed on each side of the casting belts to define the side edges of the casting region for confining the molten metal. The side dams 16 are guided at the input end of the casting apparatus 10 by crescent shaped members 24 which are mounted on the lower carriage 19.

During the casting operation, the two casting belts 14 and 15 are driven at about the same linear speed by a driving mechanism and the upper and lower carriages are preferably downwardly inclined in the downstream direction, so that the casting region 17 between the casting belts is inclined. This downward inclination facilitates flow of molten metal into the casting region.

After the castings have solidified and leave the apparatus as indicated at 25, secondary cooler means 26 may be employed to completely solidify and/or cool the casting. The use of this technique is called "secondary cooling" and is used to generate higher casting speeds. The use of secondary cooling also facilitates removal of the forming means 27 from the cast metal by a thermal shock mechanism caused by different coefficients of expansion between the forming means and the cast metal. Greater differences between the coefficients will have a greater thermal shock and separation effect. The primary cooling means (not shown) is generally accomplished by the use of a high velocity moving liquid coolant travelling along the opposite sides of the belts 14 and 15 which form the mold.

The improved apparatus and method of the invention utilizes forming means 27 on the casting belts to provide a discrete shape in the mold and casting region 17 of the apparatus. The forming means 27 are preferably attached to the upper casting belt 14 and may vary in shape and spacing to define the desired mold shape in the casting region 17 of the apparatus. Exemplary forming means designs are described hereinbelow.

In a preferred embodiment of the invention, an additional carriage 28 and belt 29 are utilized to allow the forming means 27 to be separated from belt 14, collected in timing device 30 and positioned on belt 14 based on a predetermined desired spacing. By the use of this separator system, the weight (and size) of the discrete shapes cast during the casting operation may be varied by adjusting the timing device 30. Carriage 28 may employ two rolls 31 and 32 as indicated.

The discrete shapes 33 are fed out of the casting apparatus and transported to a desired location.

The caster 10 and the tundish 12 are preferably of the "open pool" type with the tundish outlet specially modified to permit the forming means 27 to enter the casting area 17. The pool of molten metal at the caster inlet 13 preferably fills the inlet so that the forming means 27 contacts the molten metal 11 at the inlet 13.

The tundish tip is preferably made of graphite or other soft, ablating material which will also help the casting and lubrication of the lower belt 15. A drawing of the proposed arrangement is shown in Fig. 2. Since the metal, the belt, and the forming means all meet at approximately the same point, any gas or vapor behind the forming means 27 can escape into the open atmosphere and not cause a bubble to form behind the forming means in the metal casting. The dam blocks 16 preferably have a very slight taper on the internal surface (larger at the bottom) to prevent the forming means from turning or otherwise moving inside the mold.

As the metal passes through the caster, operation will be identical to a standard caster. However, the casting rate will generally be accelerated or inhibited by the use of the forming means 27 which act as heat sinks or insulators depending on the material used for the forming means.

In a preferred embodiment, the forming means 27 are removably attached, e.g., magnetically, to belts 14 and 29. In operation, the forming means will be spaced on belt 14 and, as the belt revolves, the desired casting shape will be formed. After solidification, the discrete casting will be separated from the continuous cast strip (containing the forming means 27) with the forming means becoming magnetically attached and transferred to belt 29. The forming means 27 will then be transferred to the timing device 30 where they will be aligned and released again to belt 14 at the desired spacing.

A device for separating the discrete castings from the strip of castings made in the caster may be conveniently employed at point 34. For example, a bending movement may be applied to the casting with the forming means 27 taken off on belt 29 and transferred to the casting belt 14 as described hereinabove.

The designs for the forming means 27 can be quite variable. As shown in Fig. 3, a U-shape forming means 27 produces an ingot shape 33. Likewise, Fig. 4 shows an inverted T-shape forming means 27 which also produces an ingot shape 33. If required, holes, voids, indentations, brand names or other marks can be put into the casting with suitable forming means.

The forming means 27 may be made from a variety of materials. For magnetic dividers, the

stronger the magnetic force of the forming means, the less internal taper or alignment will be needed to lock the forming means in the mold space. In some applications, it may even be desirable to make the forming means partly or wholly out of foundry sand, or refractory or metal beads as a substitute for drilling or casting complex holes and shapes in a casting or as a divider.

Removal of the forming means 27 from the belt 14 and/or the casting may be facilitated by using forming means which are consumable (such as wood) or disposable. Another design is to employ a thin, flexible walled forming means containing a substance such as water which expands when contacted with the molten metal (because of the generation of vapor or steam in the forming means) and which contracts upon cooling. Thus, as the forming means contact the molten metal 11 the forming means expands and the casting is formed with the expanded forming means. After solidification and cooling, the forming means contracts facilitating its removal. A thin gauge stainless steel forming means may suitably be employed to cast lead pigs.

Claims

1. A method for producing discrete molded shapes comprising supplying a continuous stream of molten material to a mold, said mold having two opposed moving surfaces with forming means inserted into the space defined between said opposing surfaces at desired intervals so as to divide the molten material into discrete segments, retaining said forming means in said molten material during its transition to a solid state so as to form discrete molded shapes of said material, substantially solidifying said molten material, and removing the solidified material in the form of said discrete shapes, characterized by the fact that said opposed moving surfaces comprise opposed planar surfaces, and said forming means are attached to one or both of said moving surfaces.
2. A method according to claim 1, wherein the opposed moving surfaces are provided by a twin belt casting apparatus.
3. A continuous casting apparatus for forming discrete molded shapes (33) comprising a mold having two movable opposing surfaces, means (12) for supplying a continuous stream of molten material to the mold, one or more forming means (27) which form discrete chambers in the mold and form the molten material in the mold into a cast material in the form of dis-

The discrete shapes 33 are fed out of the casting apparatus and transported to a desired location.

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The tundish tip is preferably made of graphite or other soft, ablating material which will also help the casting and lubrication of the lower belt 15. A drawing of the proposed arrangement is shown in Fig. 2. Since the metal, the belt, and the forming means all meet at approximately the same point, any gas or vapor behind the forming means 27 can escape into the open atmosphere and not cause a bubble to form behind the forming means in the metal casting. The dam blocks 16 preferably have a very slight taper on the internal surface (larger at the bottom) to prevent the forming means from turning or otherwise moving inside the mold.

As the metal passes through the caster, operation will be identical to a standard caster. However, the casting rate will generally be accelerated or inhibited by the use of the forming means 27 which act as heat sinks or insulators depending on the material used for the forming means.

In a preferred embodiment, the forming means 27 are removably attached, e.g., magnetically, to belts 14 and 29. In operation, the forming means will be spaced on belt 14 and, as the belt revolves, the desired casting shape will be formed. After solidification, the discrete casting will be separated from the continuous cast strip (containing the forming means 27) with the forming means becoming magnetically attached and transferred to belt 29. The forming means 27 will then be transferred to the timing device 30 where they will be aligned and released again to belt 14 at the desired spacing.

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stronger the magnetic force of the forming means, the less internal taper or alignment will be needed to lock the forming means in the mold space. In some applications, it may even be desirable to make the forming means partly or wholly out of foundry sand, or refractory or metal beads as a substitute for drilling or casting complex holes and shapes in a casting or as a divider.

Removal of the forming means 27 from the belt 14 and/or the casting may be facilitated by using forming means which are consumable (such as wood) or disposable. Another design is to employ a thin, flexible walled forming means containing a substance such as water which expands when contacted with the molten metal (because of the generation of vapor or steam in the forming means) and which contracts upon cooling. Thus, as the forming means contact the molten metal 11 the forming means expands and the casting is formed with the expanded forming means. After solidification and cooling, the forming means contracts facilitating its removal. A thin gauge stainless steel forming means may suitably be employed to cast lead pigs.

Claims

1. A method for producing discrete molded shapes comprising supplying a continuous stream of molten material to a mold, said mold having two opposed moving surfaces with forming means inserted into the space defined between said opposing surfaces at desired intervals so as to divide the molten material into discrete segments, retaining said forming means in said molten material during its transition to a solid state so as to form discrete molded shapes of said material, substantially solidifying said molten material, and removing the solidified material in the form of said discrete shapes, characterized by the fact that said opposed moving surfaces comprise opposed planar surfaces, and said forming means are attached to one or both of said moving surfaces.
2. A method according to claim 1, wherein the opposed moving surfaces are provided by a twin belt casting apparatus.
3. A continuous casting apparatus for forming discrete molded shapes (33) comprising a mold having two movable opposing surfaces, means (12) for supplying a continuous stream of molten material to the mold, one or more forming means (27) which form discrete chambers in the mold and form the molten material in the mold into a cast material in the form of dis-



crete segments, said apparatus permitting cooling of said segments to the solid state, and separating means (34) to separate the discrete solid segments as discrete molded shapes (33) from the cast material, characterized by the fact that the opposing movable surfaces (14, 15) are substantially planar and the forming means (27) are attached to one or both of said movable surfaces (14, 15).

4. A continuous casting apparatus according to claim 3, wherein the mold comprises a pair of upper and lower opposed substantially planar surfaces (14, 15) which together form the mold.
5. A continuous casting apparatus according to claim 4, wherein the forming means (27) are positioned on the upper planar surface (14).
6. A continuous casting apparatus according to claim 4 or 5, wherein the two movable planar surfaces (14, 15) are belts.
7. A continuous casting apparatus according to any one of claims 4-6, wherein said forming means (27) are removably attached to said movable planar surface (14).
8. A continuous casting apparatus according to claim 7, which includes means (28, 29, 31, 32) for removing said forming means (27) from said planar surface (14), storing said forming means (27) and repositioning said forming means (27) on said movable planar surface (14).
9. A continuous casting apparatus according any one of claims 3-8, which comprises transversely spaced side dams (16) affixed to at least one of said planar surfaces (14, 15) so as to define a molding space between said dams and said planar surfaces.

Patentansprüche

1. Verfahren zum Herstellen von diskreten formgepreßten Körpern, in dem ein kontinuierlicher Strom von schmelzflüssigem Material einer Form zugeführt wird, die zwei einander entgegengesetzte, sich bewegende Flächen besitzt, und in die zwischen diesen einander entgegengesetzten Flächen in gewünschten Abständen voneinander Formungsmittel eingesetzt werden, die das schmelzflüssige Material in diskrete Segmente teilen, wobei die Formungsmittel in dem schmelzflüssigen Material während dessen Übergang in einem festen Zu-

stand gehalten werden, so daß aus dem Material diskrete formgepreßte Körper gebildet werden, worauf das schmelzflüssige Material in Form der diskreten Körper entformt wird, dadurch gekennzeichnet, daß die einander entgegengesetzten sich bewegenden Flächen einander entgegengesetzte planare Flächen aufweisen und daß die Formungsmittel an einer oder beiden der sich bewegenden Flächen angebracht sind.

2. Verfahren nach Anspruch 1, in dem die einander entgegengesetzten sich bewegenden Flächen von einer Doppelband-Gießvorrichtung gebildet werden.
3. Vorrichtung zum kontinuierlichen Gießen zum Herstellen von diskreten formgepreßten Körpern (33) mit einer zwei einander entgegengesetzten bewegbaren Flächen aufweisenden Form, einer Einrichtung (12) zum Zuführen eines kontinuierlichen Stroms von schmelzflüssigem Material zu der Form, einem oder mehreren Formungsmitteln (27), die in der Form diskrete Kammern bilden und das schmelzflüssige Material in der Form zu einem gegossenen Material in Form von diskreten Segmenten verformen, wobei die Vorrichtung ein Abkühlen der Segmente in den festen Zustand gestattet, und mit einer Trenneinrichtung (34) zum Trennen der diskreten festen Segmente in Form von diskreten formgepreßten Körpern (33) von dem gegossenen Material, dadurch gekennzeichnet, daß die einander entgegengesetzten bewegbaren Flächen (14, 15) im wesentlichen eben sind und daß die Formungsmittel (27) an einer oder beiden der bewegbaren Flächen (14, 15) angebracht sind.
4. Vorrichtung zum kontinuierlichen Gießen nach Anspruch 3, in der die Form eine obere und eine untere im wesentlichen ebene Fläche (14, 15) aufweist, die einander entgegengesetzt sind und zusammen die Form bilden.
5. Vorrichtung zum kontinuierlichen Gießen nach Anspruch 4, in der die Formungsmittel (27) auf der oberen ebenen Fläche (14) vorgesehen sind.
6. Vorrichtung zum kontinuierlichen Gießen nach Anspruch 4 oder 5, in der die zwei bewegbaren ebenen Flächen (14, 15) Bänder sind.
7. Vorrichtung zum kontinuierlichen Gießen nach einem der Ansprüche 4 bis 6, in der die Formungsmittel (27) an der bewegbaren ebenen Fläche (14) abnehmbar angebracht sind.



8. Vorrichtung zum kontinuierlichen Gießen nach Anspruch 7, mit einer Einrichtung (28, 29, 31, 32) zum Entfernen der Formungsmittel (27) von der ebenen Fläche (14), zur Lagerung der Formungsmittel (27) und zum Wiederanbringen der Formungsmittel (27) auf der bewegbaren ebenen Fläche (14).

9. Vorrichtung zum kontinuierlichen Gießen nach einem der Ansprüche 3 bis 8, in der an mindestens einer der ebenen Flächen (14, 15) in Querabständen voneinander angeordnete Seitendämme (16) befestigt sind, die zwischen den Dämmen und den ebenen Flächen einen Formungsraum begrenzen.

Revendications

1. Procédé pour produire des formes moulées discrètes, comprenant les étapes consistant à fournir un flux continu de matériaux fondus dans un moule, ledit moule comportant deux surfaces opposées en déplacement, avec des moyens de formage introduits dans l'espace défini entre lesdites surfaces opposées à des intervalles désirés de manière à diviser le matériau fondu en segments discrets, à retenir lesdits moyens de formage dans ledit matériau fondu pendant sa transition jusqu'à un état solide de manière à réaliser des formes moulées discrètes dudit matériau, à solidifier de manière substantielle ledit matériau fondu, et à enlever le matériau solidifié qui se présente sous lesdites formes discrètes, caractérisé par le fait que lesdites surfaces opposées en déplacement comprennent des surfaces planes opposées, et que lesdits moyens de formage sont attachés à l'une ou aux deux desdites surfaces en déplacement.

2. Procédé selon la revendication 1, dans lequel les surfaces opposées en déplacement sont constituées par un appareil de coulée à courroies jumelées.

3. Appareil de coulée en continu pour réaliser des formes discrètes moulées (33), comprenant un moule présentant deux surfaces mobiles opposées, des moyens (12) pour fournir un flux continu de matériau fondu dans le moule, un ou plusieurs moyens de formage (27) qui forment des chambres discrètes dans le moule et qui forment le matériau fondu dans le moule en un matériau coulé sous la forme de segments discrets, ledit appareil permettant le refroidissement desdits segments jusqu'à l'état solide, et des moyens de séparation (34) pour séparer les segments solides et discrets en

tant que formes moulées discrètes (33) par rapport au matériau coulé, caractérisé par le fait que les surfaces mobiles opposées (14, 15) sont sensiblement planes, et que les moyens de formage (27) sont attachés sur l'une ou sur les deux desdites surfaces mobiles (14, 15).

4. Appareil de coulée en continu selon la revendication 3, dans lequel le moule comprend une paire de surfaces opposées sensiblement planes supérieure et inférieure (14, 15) qui forment ensemble le moule.

5. Appareil de coulée en continu selon la revendication 4, dans lequel les moyens de formage (27) sont placés sur la surface plane supérieure (14).

6. Appareil de coulée en continu selon la revendication 4 ou 5, dans lequel les deux surfaces planes mobiles (14, 15) sont des courroies.

7. Appareil de coulée en continu selon l'une quelconque des revendications 4 à 6, dans lequel lesdits moyens de formage (27) sont attachés de manière amovible sur ladite surface plane mobile (14).

8. Appareil de coulée en continu selon la revendication 7, qui comprend des moyens (28, 29, 31, 32) pour enlever lesdits moyens de formage (27) depuis ladite surface plane (14), pour stocker lesdits moyens de formage (27), et pour replacer lesdits moyens de formage (27) sur ladite surface plane mobile (14).

9. Appareil de coulée en continu selon l'une quelconque des revendications 3 à 8, comprenant des barrages latéraux espacés dans le sens transversal (16) fixés sur l'une au moins desdites surfaces planes (14, 15) de manière à définir un espace de moulage entre lesdits barrages et lesdites surfaces planes.

