ABSTRACT

A high capacity casting method and apparatus wherein metal in a molten condition is fed into a mold formed by the peripheral groove in a rotatable casting wheel and a flexible band, the metal is cooled in the mold until the metal has substantially solidified, and the solidified metal is removed from the peripheral groove of the casting wheel at a position substantially above the casting wheel. The cast metal is removed from the peripheral groove of the casting wheel. The cast metal is removed from the peripheral groove of the casting wheel as the cast metal approaches a horizontal direction of movement about the casting wheel, at an elevation above the elevation where the metal is fed in a molten condition into the peripheral groove.

4 Claims, 5 Drawing Figures
HIGH CAPACITY CONTINUOUS CASTING METHOD

BACKGROUND OF THE INVENTION

When continuously casting metal, such as copper or aluminum, the metal in a molten state is poured into and processed through a mold which cools and solidifies the metal. When the metal is extracted from the mold, it is substantially completely solidified, and can be guided to a subsequent processing station, such as a rolling mill, or the like. In a continuous system where the metal is continuously cast into a cast bar, rolled into rod, and coiled, the primary limitation on the speed of the continuous process is the initial casting of the molten metal into the solidified bar where the heat of the molten metal must be extracted from the mass of metal before the metal solidifies. While the metal which comes into direct contact with the surface of the mold quickly solidifies, the molten metal which eventually becomes collant the inner portion of the cast bar usually takes a much longer period of time to solidify since its heat must pass through the surrounding metal of the cast bar to reach the mold and coolant fluid. While additional coolant fluid, changes in mold configuration, a reduction in the cross-sectional area of the mold cavity, and other changes can be made to increase the speed of heat transfer and reduce the time required to solidify the casting, these various adjustments in the process eventually reach a practical limitation in that any further changes become unjustified when compared with increases in production rate, costs, and other parameters. The result is that the cooling time required to solidify molten metal in a continuous casting machine becomes relatively constant from the practical standpoint.

SUMMARY OF THE INVENTION

Briefly described, the present invention comprises a continuous metal casting method which retains molten metal in a mold cavity for approximately the same period of time which is required by the conventional continuous casting apparatus, but which functions to cast the metal at a faster rate. The mold cavity is formed by the annular peripheral groove of a rotatable casting wheel and a flexible band, and the mass of metal being cast is increased over the conventional system by using a casting wheel of a larger diameter, the metal being cast being retained in the casting wheel throughout a longer arc of travel about the casting wheel, and the partially solidified bar being maintained in positive contact with the casting wheel after it has shrunk to a size smaller than the casting cavity defined by the groove of the casting wheel and the continuous band extending about the casting wheel. The size of the casting wheel in relation to the pouring pot is such that the pouring pot and its related equipment require a smaller amount of space and a smaller arc adjacent the casting wheel, so that the metal being cast is passed closely adjacent to the pouring pot and remains in the casting wheel for a longer arc of travel. Furthermore, the larger casting wheel functions to mold a bar which has less curvature, and the bar remains in the casting wheel and closely approaches the pouring mechanism and then is bent from its cast curvature into a linear configuration without an abrupt bending, which also allows the cast metal to remain in the casting wheel for a longer arc of travel.

Thus, it is an object of this invention to provide a metal casting method which has a higher casting capacity than conventional metal casting devices.

Another object of this invention is to provide a continuous casting method which retains the metal being cast in a casting wheel throughout an extended arc of travel about the casting wheel.

Another object of this invention is to provide a continuous metal casting method which maintains the metal being cast in positive contact with the surfaces of the casting wheel after the cast metal has shrunk to a size smaller than the casting cavity thereby increasing the heat transfer from the metal being cast.

Another object of this invention is to provide a casting wheel of large diameter for a continuous metal casting system which wheel rotates at a high angular velocity to produce an increased mass of cast metal, and which functions to cast metal with a small curvature and requires only a small amount of bending to be transformed from its initial cast curvature to a linear configuration.

Other objects, features and advantages of the present invention will become apparent upon reading the following specification, when taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic representation of the high capacity casting process, and apparatus, showing the metal as it is transformed from a molten state to a solid state.

FIG. 2 is a schematic showing, similar to FIG. 1, but of the prior art process and apparatus.

FIGS. 3, 4, and 5 are cross-sectional views of the metal being cast in FIG. 1, taken along lines 3-3, 4-4, and 5-5, respectively, of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in more detail to the drawings, in which like numerals indicate like parts throughout the several views, FIG. 1 shows a casting machine 10 which includes casting wheel 11, band wheels 12, 13, 14, 15, and 16, continuous flexible band 18, pouring pot 19, and pinch rolls 20. Pouring pot 19 is positioned so that its uppermost surface or protrusion in the plane of casting wheel 11 is adjacent a tangent to the bottom of peripheral groove 22 at the groove's zenith point 32. The groove's nadir is shown at point 34. Pouring pot 19 is constructed so as to be as small as possible in height, and pouring spout 21 extends from pouring pot 19 at an angle which feeds molten metal into the peripheral groove 22 of casting wheel 11. Pouring pot 19 and pouring spout 21 are arranged so that the molten metal emerging from pouring spout 21 flows generally in the direction of movement of peripheral groove 22, and in most instances, the metal is poured at a rate so that the lower end of pouring spout 21 is submerged in the pool of molten metal formed in peripheral groove 22. With this arrangement, a minimum of turbulence in the molten metal is experienced in the mold.

Flexible band 18 is guided by band wheel 12 into engagement with the periphery of casting wheel 11, so that a circular moving mold defined by band 18 and peripheral groove 22 is continuously formed about casting wheel 11. Band 18 moves with casting wheel 11 in the direction as indicated by arrow 24 until it reaches
band wheel 16 at the top of casting wheel 11, whereupon it is guided out of contact with casting wheel 11 and passed around and wheels 15, 14, and 13 back to band wheel 12.

The size and arrangement of band wheel 12, pouring pot 19, and pouring spout 21 are such that the casting mold formed by peripheral groove 22 of casting wheel 11 and flexible band 18 is formed as high as possible in the direction of the top of casting wheel 11 without having the upper surfaces of pouring pot 19 and band wheel 12 protruding above the horizontal tangent extending from the bottom of groove 22 at its zenith point 32. Band wheel 16 is positioned so that it is substantially above the center of casting wheel 11 and groove zenith point 32 and functions to remove flexible band 18 at a position where the cast bar 25 formed by casting wheel 11 is extracted from the peripheral groove 22 and guided through a substantially horizontal path between pinch rolls 20. With this arrangement, the metal being cast by the apparatus remains in peripheral groove 22 throughout the longest possible arc of travel about casting wheel 11. As shown in FIG. 1, the bottom surface 33 of cast bar 25 corresponds to the horizontal tangent extending from the bottom of groove 22 at the groove's zenith point 32.

When the metal is poured in a molten state into the mold defined about casting wheel 11, it contains at least some super-heat but the portion of the molten metal making direct contact with the mold surfaces is the first to begin to solidify, as is best shown in FIG. 3. This initial entry of metal into the mold where the metal making direct contact with the mold begins to crystalize is defined as zone 1 (see FIG. 1). Since the molten metal makes positive contact with the mold surfaces, and since the mold surfaces are initially relatively cool when first contacted by the molten metal so that the temperature difference between the molten metal and the surfaces of the mold is highest at this point, the heat transfer from the molten metal through the surfaces of the mold is greatest in zone 1.

As the molten metal with its outer crust having been formed (see FIG. 4) passes from zone 1 to zone 2, the heat transfer from the molten metal to the mold surfaces remains relatively high, although decreased somewhat from zone 1, and the outer portions of the molten metal continue to solidify at a relatively rapid rate since the outside surface of the metal is still in positive contact with the surfaces of the mold (see FIG. 4) and since the heat from the molten metal does not have to travel through a large mass of solidified metal to reach the mold surfaces. As the mass of solidified metal increases relative to the mass of molten metal, it tends to shrink as it cools, and eventually portions of the outside surface of the metal lose positive contact with the mold surfaces, which creates an air gap (see FIG. 5) between the metal and its mold, and which impedes the transfer of heat from the metal. When this condition begins, the end of zone 2 is reached and zone 3 begins.

Zone 3 is the largest zone about casting wheel 11 and is the zone where at least some contact is lost between the outside surface of the metal being cast and the surfaces of the mold. The transfer of heat in zone 3 is significantly less than that in zone 1 and 2 because of the air gap between the metal being cast and the mold surfaces, and because the heat must be transferred from the molten center portion of the cast bar through the already solidified metal to reach the cooler mold surfaces. The heat transfer rate through air is less than through metal.

Zones 1, 2, and 3, which comprise the entire path of travel of the metal in the mold about casting wheel 11, are each proportionately longer than the corresponding zones in the prior art casting machines, as is shown by comparing FIG. 1 to FIG. 2. In the prior art casting machines, the cast bar 25 is extracted from the peripheral groove of a casting wheel after the metal has passed through an arc of approximately 200° or less. By comparison, the present invention allows the metal being cast to remain in the peripheral groove 22 of the casting wheel throughout an arc of approximately 240° or more. For example, an arc of 310° is shown in FIG. 1 as consisting of the combined arcs of Zones 1, 2 and 3.

In the FIG. 1 embodiment, therefore, the clockwise angle between point 32 and the beginning of Zone 1 is 50°.

One of the limitations on the length of the arc through which the metal being cast remains in the casting cavity is the bending of the metal from its curvature is initially cast about the periphery of the casting wheel to a rectilinear configuration. Traditionally, the curve casting is difficult to straighten without cracking and requires a substantial distance along its length to be transformed from its initial curvature to a rectilinear configuration. However, the less the vertical thickness of the cast bar in comparison to the casting wheel diameter, the less difficulty in straightening the cast bar; that is, the ratio of the thickness of the bar between the bottom of the peripheral groove 22 and the flexible band 18 with respect to the diameter of the casting wheel is maintained relatively low, the bar can be straightened easier. Thus, for a given bar thickness, if the diameter of the casting wheel 11 is increased, the cast bar 25 can be straightened more easily, and requires less length of bar travel to undergo the straightening process. Thus, for a given bar thickness, if the diameter of the casting wheel is increased, the length of the arc that the metal being cast can remain in the peripheral groove of the casting wheel is increased.

The difficulty in straightening the bar extracted from the peripheral groove of the casting wheel lies in the possibility of cracking the bar by straightening it too fast. Of course, if the arc of the bar as initially cast is not extreme, a smaller amount of straightening is required, and the possibilities of cracking the bar are reduced.

When the diameter of the casting wheel is increased, the sizes of the pouring pot 19 and band wheel 12 do not necessarily also have to be increased, so that these structures effectively shrink in relative size with respect to the casting wheel, and occupy a smaller relative space when compared with the prior art of FIG. 2. Of course, this relatively smaller space requirement of pouring pot 19 and band wheel 12 allows the molten metal to be poured into the peripheral groove 22 at a relatively early point of travel of casting wheel 11, and the expected path of bar 25 as it emerges from the peripheral groove 22 of the casting wheel is located closely adjacent pouring pot 19. This effectively increases the arc of the casting mold about the casting wheel. Thus, increasing the diameter of the casting wheel results in the length of the mold cavity formed by the peripheral groove 22 and flexible band 18. Since a given bar-sectional area requires a virtually certain length of time for the heat to be sufficiently transferred.
from the metal and for the metal to become solidified, the metal being cast in the apparatus disclosed in FIG. 1 need only be retained in the peripheral groove of the casting wheel for the same length of time as the metal being cast in the prior art machine of FIG. 2; however, since the mold cavity of my invention has been increased in length because of the increased diameter of the casting wheel and the increased arc through which the metal passes in the peripheral groove of the casting wheel, the casting wheel can be rotated at a significantly higher speed, which results in a significantly larger amount of metal being cast per unit of time when compared to prior art casting rates.

When the metal being cast passes in an upward direction through the second half of zone 3 and passes from a vertical direction of movement and begins to move in a lateral direction, the weight of the cast bar will cause it to be urged against the side surfaces 28 and the bottom surfaces 29 of peripheral groove 22 of the casting wheel, so that positive contact between these lower surfaces of the cast bar and the peripheral groove will be maintained. Of course, the tension on flexible band 18 also assures that the cast bar will always be properly maintained within the peripheral groove 22 when there is no air gap; however, the force of gravity exerted on the cast bar assures that any spaces or gaps (such as gap 30 in FIG. 5) will occur primarily only between the flexible band and the cast bar 25, and the side and bottom surfaces of the cast bar will be maintained in positive contact with the casting wheel where it can be efficiently cooled on at least three of its four sides. Furthermore, the cast bar 25 passes in a substantially lateral path from casting wheel 11 through pinch rolls 30, and pinch rolls 20 function to guide the cast bar and to place the cast bar under a slight tension, which further functions to urge the portion of the cast bar extending back into the peripheral groove 22 of the casting wheel into positive contact with the surfaces of the peripheral groove. Moreover, the tension applied to the cast bar by pinch rolls 20 functions to assist in the straightening process of the bar as it emerges from the peripheral groove of the casting wheel, and the weight of the portion of the cast bar extending between its point of extraction 32 from the peripheral groove of the casting wheel and the pinch rolls aids in the straightening process. Thus, the tension exerted by pinch rolls 20 and the weight of the bar itself apply straightening forces to the bar; however, if a segment of the bar emerging from the peripheral groove of the casting wheel is difficult to straighten, the tension applied to the bar and the weight of the bar is not such as to force an abrupt straightening of the bar in this particular segment and create cracks in the bar, because these forces are gradually applied throughout the bar travel between the point of extraction 32 to pinch rolls 20, and beyond. Thus, the horizontal movement of the bar as it is extracted from the casting wheel results in the bar's own weight assisting in a general straightening of the bar, which reduces the hazard of cracks appearing in the bar.

At this point, it should be apparent that the invention specifically disclosed herein provides an unexpected increase in casting capacity in a continuous metal casting process. While this invention has been described in detail with particular reference to preferred embodiments thereof, it will be understood that variations and modifications can be effected within the spirit and scope of the invention as described hereinbefore and as defined in the appended claims.

I claim:

1. In a continuous metal casting process for casting a cast bar of a given thickness, the method of increasing the casting rate of said cast bar having said given thickness comprising the steps of:

feeding metal in a molten condition into a given depth mold formed by the peripheral groove in a rotatable casting wheel and a flexible band, cooling the metal in the given depth mold until the metal has substantially solidified into the cast bar of given thickness, and removing the metal and the band from the peripheral groove of the casting wheel, the improvement comprising:

said removing occurring on a horizontal tangent to said groove, said feeding occurring in close proximity to said point of horizontal tangency, said improved method of feeding acting to increase the casting rate of said cast bar of given thickness by permitting the rotational speed of said casting wheel to be increased without a corresponding decrease in the predetermined necessary amount of time that the metal be in the mold.

2. The invention of claim 1 wherein the step of removing the metal and the band from the peripheral groove of the casting wheel occurs after the metal and the band have travelled through an arc about the casting wheel of approximately 310°.

3. In a continuous metal casting process, the steps of providing apparatus for continuously casting metal comprised of an endless band guided about a portion of a peripheral groove in a rotatable casting wheel thereby forming an arcuate mold, pouring metal in a molten state into said arcuate mold so formed by said peripheral groove and band, cooling said molten metal until it is substantially solidified, cooling said cast metal additionally from said point at which said gap is created and continuing the cooling thereafter for a distance of travel of said arcuate mold such that said last-mentioned additional cooling occurs as the cast metal travels through an arc about said casting wheel of more than 180° prior to its removal from said casting wheel, and then removing said cast metal and said band from said casting wheel at a point which is within approximately 10° of either side of a line running between the center of the casting wheel and the zenith point of the peripheral groove.

4. The invention of claim 19 and further comprising the step of:

maintaining the cast bar in positive contact with the peripheral groove throughout the cast bar's entire travelling period through said arc.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,759,314
Dated September 18, 1973

Inventor(s) John H. Murphy

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the front page after Assignee, "Southwine" should read--Southwire--; Column 1, line 20, after becomes, cancel "collant"; Column 6, line 61, after claim, "19" should read--3--.

Signed and sealed this 1st day of January 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

RENE D. TEGTMeyer
Acting Commissioner of Patents