PRELIMINARY COOLING OF CONTINUOUS CASTING MACHINE
4 Claims, 4 Drawing Figs.

ABSTRACT: Cooling a continuous casting machine during the preliminary stages of casting molten metal, in which coolant is sprayed at a relatively low velocity onto the external surfaces of the flexible band and casting wheel which form the mold into which the molten metal is poured. The coolant is applied at the relatively low velocity prior to and during the initial pouring of the molten metal, and when the operator of the casting machine has established a proper constant level of molten metal in the mold and the hazard of splashing and explosion of the molten metal has been reduced, the coolant is applied at increased velocities and volumes and the rate of casting the molten metal is increased.
PRELIMINARY COOLING OF CONTINUOUS CASTING MACHINE

BACKGROUND OF THE INVENTION

In a casting machine which includes a rotatable casting wheel defining a peripheral groove and a continuous flexible band which is applied to the groove and moves with the casting wheel throughout a substantial arc of its rotation to form an arcuate moving mold, liquid coolant such as water is usually applied to the external surfaces of the mold as the molten metal is solidified. The application of the coolant to the external surfaces of the mold increases the heat transfer from the molten metal and the rate of solidification of the metal, and protects the mold from heat deterioration. The casting wheel and flexible band are most vulnerable in the portion of the arcuate mold where the molten metal is poured into the mold, since the molten metal is hottest at this point and the casting wheel and band are heated from a relatively cool temperature to an extremely hot temperature and expand abruptly.

When the operator of a continuous casting machine initially sets the machine in operation, he usually causes the casting wheel to rotate slowly and flows the molten metal into the mold cavity at a comparatively high rate of flow until a pool of molten metal is formed, and he then adjusts the rate of flow of molten metal and increases the rotational speed of the casting wheel while maintaining the pool of molten metal. The usual time lapse between initial pouring of molten metal into the arcuate mold formed by the casting wheel and flexible band and the application of the liquid coolant to the external surfaces of the arcuate mold is approximately 15 seconds. During the initial pouring of the molten metal into the arcuate mold, the casting wheel and the flexible band are cooler than they are after the apparatus has been run for a period of time since the apparatus initially retains a substantial amount of its residual room temperature, and the molten metal will initially solidify in the arcuate mold without the necessity of the application of liquid coolant; however, the shock of the heat transfer from the molten metal to the material of the relatively cool casting wheel and flexible band is significant and causes substantial deterioration of these materials that would not occur if the mold surfaces were continuously cooled during startup.

During this startup procedure there is a substantial hazard that the pool of molten metal will be improperly controlled and overflow the mold. If molten metal contacts the coolant a violent explosion will result. Thus, the operator of the casting machine usually established the pool of molten metal in the arcuate mold before he causes the coolant to be applied to the external surfaces of the casting wheel and flexible band, and carefully avoids overflowing the mold, in spite of the damage caused to the casting wheel and band due to the delay in applying the coolant.

SUMMARY OF THE INVENTION

Briefly described, the present invention comprises a method and apparatus for cooling a continuous casting machine wherein liquid coolant is applied before and during the preliminary operation of the casting machine without any substantial hazard of explosion due to the overflow of molten metal from the casting machine or wet mold surfaces. The liquid coolant is applied to the flexible band and casting wheel at positions about the external surfaces of the arcuate mold where the likelihood of the coolant contacting the internal mold surfaces prior to the initial pouring of the molten metal is remote, thereby allowing molten metal not likely to contact the liquid coolant. The coolant is applied to the flexible band at a low volume and velocity by means of a nozzle assembly positioned between the band positioning roller and the band, and by the band header positioned immediately adjacent the nip nozzle, and by the cooling headers. While the application of the coolant is at a low volume and velocity, it is effective together with the residual room temperature of the casting wheel and flexible band to protect these elements from heat deterioration during the initial pouring of molten metal, and for a span of time sufficient for the average metal casting machine operator to establish the pool of molten metal in the arcuate mold and to begin to bring the casting machine up to operational speed.

Thus, it is an object of this invention to provide a method and apparatus for cooling a continuous casting machine prior to and during the preliminary stages of casting metal substantially without any hazards of explosion due to the inadvertent mixing of the coolant with the molten metal.

Another object of this invention is to provide a preliminary cooling system for a continuous casting machine which functions to protect the casting wheel and flexible band from inadvertent metal fatigue and deterioration during the initial operation of the machine.

Another object of this invention is to provide a method of cooling a continuous casting machine wherein the operator can operate the machine for an extended period of time during the initial operation of the machine without the use of the main cooling system and without danger of overheating the machine.

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 side elevational view of a continuous casting machine, with some parts eliminated for clarity.

FIG. 2 is a detailed showing of the portion of the casting machine of FIG. 1 where the flexible band initially makes contact with the peripheral groove of the casting wheel.

FIG. 3 is a cross-sectional view of the casting wheel and its cooling headers, taken along lines 3-3 of FIG. 2.

FIG. 4 is a front view of the nip nozzle and the upper portion of the upper band header, taken along lines 4-4 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in more detail to the drawing, in which like numerals indicate like parts throughout the several views, FIG. 1 shows casting machine 10 which includes casting wheel 11, continuous flexible band 12, and band positioning rollers 14a, 14b, 14c and 14d. As shown in FIG. 3, casting wheel 11 comprises an assembly which includes a castable or support plate 15, positioning roller 16, and mandrel 17. Mold ring 19 defines outwardly facing annular peripheral groove 20 which includes inner wall 21 and sloping sidewalks 22. Continuous flexible band 12 closes peripheral groove 20 to form an arcuate mold cavity which extends about the lower portion of casting wheel 11.

As best shown in FIG. 2, band positioning roller 14a functions to move continuous band 12 into contact with mold ring 19, and pouring spout 24 extends into the semicircular mold formed by band 12 and mold ring 19. Pouring spout 24 functions to pour or deposit molten metal into the semicircular mold from pouring port 25 (FIG. 1), so that a pool of molten metal is formed. The rate of flow of molten metal from pouring port 25 through pouring spout 24 is regulated so that the upper level 26 of the pool of molten metal normally covers the lower end of pouring spout 24 to reduce the turbulence of the molten metal in the semicircular mold.

Band positioning roller 14a defines a pair of annular grooves 28 and 29 (FIG. 4), and nip nozzle assembly 30 is positioned closely adjacent band positioning roller 14a and projects into grooves 28 and 29. Nip nozzle assembly 30 is of the type disclosed in U.S. Pat. No. 3,333,629 and includes a supply cut 31 and a pair of spaced wedge shaped nozzles 32 and 33 which project into annular grooves 28 and 29, respectively. Supply duct 31 defines openings 34 within nozzles 32 and 33. Nozzles 32 and 33 each includes a nozzle face plate 35 which is formed with a curvature matching the curvature of
the outside surface of the mold ring 19, and a plurality of nozzle openings 36 extend through nozzle face plate 35. Nozzle openings 36 are formed so that they are directed generally in a downward direction from band positioning roller 14a. Coolant flowing through nozzle openings 36 will flow primarily only in a downward direction. The upper ends of the nozzle face plate 35 are positioned as high within annular grooves 28 and 29 of band positioning roller 14a as practical, and the upper wall 38 of nozzles 32 and 33 is formed with a curvature generally matching the inner surface 39 of grooves 28 and 29.

Upper band header 40 is positioned immediately adjacent and below nip nozzle assembly 30 and extends in a downward direction around casting wheel 11. Lower band header 41 (FIG. 1) is positioned immediately adjacent and below upper band header 40 and extends further in a downward direction and it terminates generally below casting wheel 11. Rear band header 42 extends from the bottom portion of casting wheel 11 up toward band positioning roller 14d, and rear nip nozzle assembly 44 projects between band positioning roller 14d and casting wheel 11, in a manner similar to the projection of nip nozzle assembly 30 between band positioning roller 14a and casting wheel 11.

A pair of side headers 45 are positioned on opposite sides of the arcuate mold and extend from the entrance of the arcuate mold down to the bottom portion of casting wheel 11, and similar side headers 46 extends from the bottom of the casting wheel 11 up toward the exit portion of the arcuate mold.

Casting wheel headers 48, 49, and 50 are positioned adjacent rotatable support plate 15, generally in the same plane as mold ring 19. Casting wheel headers 48—50 each extend through an arc of approximately 90° about casting wheel 11, from band positioning roller 14a, through the lower portion of the casting wheel, up to band positioning roller 14d. A plurality of nozzles 51 extend from the outer curved portion of casting wheel headers 48—50, and function to spray coolant upon the inner surface 52 of mold ring 19.

As is shown in FIG. 1, the liquid coolant, such as water, is carried to the nip nozzles and headers of casting machine 10 by means of main conduit 52. A plurality of branch conduits extend from main conduit 52 and communicate with the various nip nozzle assemblies and headers. Branch conduit 54 communicates with nip nozzle assembly 30, branch conduit 55 communicates with upper band header 40, branch conduit 56 communicates with lower band header 41, branch conduit 57 communicates with the rear band header 42, branch conduits 58 and 59 communicate with side headers 45, and branch conduits 60 and 61 communicate with side headers 46. Each branch conduit includes a manual control valve which functions to regulate the flow of coolant from main conduit 52. Branch conduit 62 extends from main conduit 52 and is connected to center valve connection 64 of casting wheel headers 48—50. Valve connection 64 includes control valves 65, 66, and 67 which function to control the flow of coolant from branch conduit 62 into each of casting wheel headers 48—50, respectively.

Main control valve 70 is positioned in main conduit 52 and functions to control the flow of coolant through main conduit 52 toward branch conduits 54—62. Main control valve 70 is pneumatically controlled, and the flow of actuating fluid to pneumatic control motor 71 is governed by solenoid-actuated valve 72.

Main bypass conduit 73 is connected to main conduit 52 upstream of main control valve 70, and bypass conduits 74, 75, and 76 communicate between main bypass conduits 73 and branch conduits 54, 55, and with casting wheel headers 48, respectively. The openings of bypass conduits 74, 75, and 76 are also controlled by manual control valves. Check valves 78 and 79 are positioned in branch conduits 54 and 55 upstream of the connections made between these conduits and their respective bypass conduits 74 and 75. Similarly, a check valve 78 is provided in valve connection 64 to control the flow of coolant from casting wheel header 48 back through valve connection 64 and branch conduit 62. The flow of coolant through main bypass conduit 73 is controlled by solenoid-actuated valve 80.

OPERATION
When the operator is to begin the continuous casting of metal in casting machine 10, he goes through the usual startup procedures, which include heating the metal in the furnace to a temperature of over 2,000° Fahrenheit, preheating the launder and the pour pot, adjusting the band tension, drying the band and wheel to assure that no moisture is present on these surfaces, and the various other preliminary operations. Valve 80 of main bypass conduit 73 is opened so that liquid coolant is supplied through main bypass conduit 73 to bypass conduits 74, 75, and 76. The manual valves of branch bypass conduits 74—76 are preadjusted so that a low velocity and volume of coolant is supplied to nip nozzle assembly 30, upper band header 40, and casting wheel header 48. The coolant emerges from the nozzles connected to these headers, and is applied to the external surfaces of the semicircular mold. The coolant flowing through nip nozzle assembly 30 is directed generally in a downward direction along the external surface of band 12. Since the upper portions of nozzle 32 and 33 of nip nozzle assembly 30 are inserted into annular groove 28 of band positioning roller 14a, the flow of coolant in this area will be confined to annular grooves 28 and 29 of band positioning roller 14a until it flows out of grooves 28 and 29 to the area between nozzle face plate 35 and the external surface of band 12 extending downwardly from band positioning roller 14a. Thus, the direction at which the coolant emerges from nozzle openings 36 together with the confining features of annular grooves 28 and 29 of band positioning roller 14a functioning to prohibit any of the coolant from flowing, splashing, or spraying into the mold cavity defined by peripheral groove 20 of casting wheel 11 and band 12.

The upper nozzles of nozzles 51 which extend from casting wheel header 48 are carefully directed in a downward direction within casting wheel 11 so that the coolant emerging from these nozzles will not flow, splash, or spray into the mold cavity. Furthermore, nozzles 51 are directed against the inside wall 52 (FIG. 3) of mold ring 19, and positioning rings 16 and 18 function to limit the spray of coolant emerging from nozzles 51 to the inside external surface of mold ring 19.

Since upper band header 40 is displaced downwardly from nip nozzle 30, there is little, if any, hazard of the coolant emerging from the nozzles of upper band header 40 from coming into contact with the surfaces of the arcuate mold.

The manual control valves of bypass branch conduit 74, 75, and 76 are regulated so that a relatively low volume and low velocity flow of coolant is established from nip nozzle 30, upper band header 40 and casting wheel header 48, to further reduce any possibility of the coolant inadvertently splashing or spraying onto the surfaces of the arcuate mold. Check valves 78 and 79 in branch conduits 54 and 55, respectively, and the check valve in valve connection 64 prevent the coolant from flowing through the entire system from main bypass conduit 73 during the preliminary coolant flow. Of course, when the main conduit 52 is cut in by main valve 70, these check valves will open.

When the operator is ready to begin the casting procedure, he rotates the casting wheel at a relatively low angular velocity and he adjusts the metering pin of the pouring pot to create a relatively high rate of molten metal flow into the semicircular mold until a pool of molten metal is established. It is desirable that the level 22 of molten metal be at the open end of pouring spout 24 so that a minimum of turbulence is created in the molten metal present in the mold. After the operator has established the pool of molten metal, main valve 70 of main conduit 52 is opened by energizing its solenoid, and coolant flows at higher volume and higher velocity through the various branch conduits 54—62 to the various nip nozzle assemblies 30 and 44 and headers 40, 41, 42, 43, 44, 48, 49, and 50. This results in the coolant already flowing from
nip nozzle 30, upper band header 40 and casting wheel header 40 increasing in velocity and volume immediately as the
remaining headers cut in. At this point the angular velocity of the casting wheel is increased to cast the metal in larger
volume.

The preliminary cooling during initial casting before the main coolant flow is established allows the operational to
begin to bring the casting wheel up to normal speed even before the main coolant flow is applied. Furthermore, there is
usually a time delay of approximately 3 seconds between the instant when the operator energizes the main valve solenoid
and until the full flow of coolant is effected through the various nozzles of the headers. While this time delay was some-
times critical in the past with the prior art systems and had to be compensated for in advance by the operator, it becomes
less significant with the preliminary cooling system disclosed herein since the preliminary cooling system functions to sub-
stantially reduce mold deterioration and destruction to the ini-
tial heat transfer in the casting machine.

At this point it should be understood that casting wheel header 48 and upper band header 40 are effective to extend
the cooled area of the mold from pouring spout 24 and nip
nozzle assembly 30 down toward the lower part of casting
wheel 11 during the preliminary stages of casting, and the slow
angular velocity of the casting wheel during this stage of cast-
ing allows the heat of the molten metal to dissipate within this
length of casting wheel travel so that the metal is at an ac-
tceptable temperature level which will not damage the materi-
als of the casting machine. Thus, the hazards of operator error
are reduced significantly without any detriment to the normal
function of the machine.

While the invention has been disclosed as being energized
by manually operating the circuits of the valve solenoids, the
system lends itself to an automatic program of operation
where the main valve 70 is opened automatically after the
opening of bypass valve 80. For instance, circuitry has been
developed to open main valve 70 after a predetermined time
delay subsequent to the initial opening of bypass valve 80, to
open main valve 70 when the temperature of the casting wheel
reaches a predetermined level and to open main valve 70
when a pool of molten metal has been detected at the entrance
of the arcuate mold by a nuclear metal level detector. Obvi-
ously, combinations of these arrangements, and various other
automatic control arrangements can be developed.

Circuitry has also been constructed for an automatic start
up system where the molten metal flow rate, casting wheel
speed and cooling water are all automatically controlled.

While this invention has been described in detail with par-
ticular 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 by the appended claims.

1. In a process for continuously casting metal where metal
in a molten state is poured from a pouring spout into a semicir-
cular mold formed by a peripheral groove of a rotatable mold
ring and a continuous flexible band, the improvement therein
comprising first applying a coolant at a relatively low volume
only to the outer surface of the band and the inner surface of
the mold ring at the pouring spout and through a downwardly
directed arc of the mold from the pouring spout as the mold
temperature increases due to the transfer of heat from the
molten metal during the initial stages of casting to prevent the
mold cavity from being wet at the introduction of molten
metal into the cavity, and subsequently increasing the volume
of flow of the coolant to the same surface of the band and the
mold ring and applying additional volumes of the coolant to
the other portions of the external surface of the mold ring and
band as the mold temperature increases after the initial stages
of casting.

2. The invention of claim 1 wherein the step of first applying
a coolant at a relatively low volume to portions of the external
surfaces of the mold includes applying the coolant to the por-
tions of the external surfaces of the mold prior to any increase
in mold temperature and continuing the low volume applica-
tion of coolant during the initial stages of casting.

3. The invention of claim 1 wherein the step of first applying
coolant comprises applying coolant through a nip nozzle ad-
acent the flexible band at the position where the flexible band
first contacts the casting wheel and applying coolant to the
flexible band as it passes through the first portion of its arc
of movement with the casting wheel.

4. The invention of claim 1 wherein the step of applying ad-
ditional volumes of the coolant comprises applying the cool-
tant to the side surfaces of the casting wheel.