APPARATUS FOR COOLING AND SUPPORTING THE CASTING BELT IN A CONTINUOUS METAL CASTING MACHINE OF THE DRUM AND BELT TYPE


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11 Claims

ABSTRACT OF THE DISCLOSURE

A continuous metal casting machine of the drum and belt type with apparatus for cooling the casting belt as it approaches the drum, as it comes in contact with and as it revolves with the drum to prevent buckling or warping of the belt and to confine the molten metal in the moving mold space without leakage, enabling use of a thinner casting belt which passes along reverse curves including concave and convex portions. A first pulley runs the belt partially around it guiding the front face of the belt toward the revolving drum to define the entrance for molten metal, a second pulley guiding the belt partially around the drum confining the molten metal, with the rear surface of the belt describing a concave curve moving toward the drum and a convex curve as it passes around the drum, deep circumferential grooves in the first pulley and curving coolant feed tubes nestling within the grooves direct coolant toward the concave rear surface of the belt flowing the coolant longitudinally along the rear surface toward the convex region. A pair of support surfaces on the first pulley press the belt against the spaced lands on the drum to seal the entrance to the mold space with the deep grooves and thin fins located between said support surfaces. The convex portion of the belt is cooled with coolant applied in a different direction, and diagonal nozzle means are provided showing a transition in the direction of application of the coolant.


The present invention relates to apparatus for cooling the belt in a metal casting machine of the drum and belt type. In this type of machine a continuously moving mold space is defined between the periphery of a revolving drum and a belt which runs partially around the drum as the drum revolves. This invention relates to apparatus for cooling the casting belt as it approaches the drum and as it comes into contact with and as it revolves with the drum to prevent buckling or warping of the belt and to confine the molten metal in the moving mold space without leakage.

In the prior art, for example as shown in United States Patent No. 2,865,067, issued to Properzi, are disclosed arrangements for cooling the drum by flowing liquid coolant through a network of interconnected passages within the drum. However, great difficulty has been experienced for many years in attempts to cool the casting belt. The prior art arrangements tended to cool the drum more efficiently than the belt. This often set up temperature differentials across the material being cast, producing uneven cooling which adversely affected the cast product. In addition, the flexible casting belt was unevenly cooled, which set up localized stresses in the belt, caused its rapid deterioration and created localized defects in the outer surface of the product being cast. Moreover, there were problems in holding the belt firmly against the drum without buckling and without warping or allowing the belt to separate from the drum, which would allow leakage of the molten material being cast.

In the Properzi machine the belt runs in an oblong path which completely encircles the drum. This requires that the cast product be bent sideways to clear the belt as the product is led out of the machine. In the improved type of machine as shown in FIGURE 1 herein the belt is bent into reverse curves so that it does not encircle the machine and the cast product 33 can be led directly out of the machine without bending sideways.

These problems of cooling the belt are particularly severe in the drum and belt machines of this type as shown in FIGURE 1 for casting molten metal in which the front face of the belt is curved in one direction as it approaches the drum and then passes through a transition region and curves in the opposite direction as it runs adjacent to the drum for confining the molten metal against the front face of the belt. That is, the belt follows a path including concave and convex curving portions with an intermediate transition region. The molten metal is introduced into the moving mold space between the drum and the front face of the belt near the transition region, and this is the region of greatest temperature which requires very intense cooling of the rear face of the casting belt. At the same time this is the region where the belt is changing its curvature and requires accurate firm guidance and support to prevent buckling or warping and to prevent the belt from separating from the drum.

These problems have remained unsolved for many years and have limited the usage of this type of drum and belt machine to the casting of lower melting temperature metals.

Among the advantages provided by the present invention are those resulting from the fact that it enables intense, uniform cooling of the rear face of the casting belt along near the moving mold space, including the input region where the belt follows a reverse curve. The more effective cooling provided by this invention allows the use of a thinner casting belt which does not deteriorate through distortion due to temperature differential between the front and rear face of the casting belt and therefore the operating life of the cooling belt is greatly extended.

In accordance with the cooling apparatus of the present invention in one of its aspects the liquid coolant is impinged against the rear face of the belt near one edge where the rear face follows a convex path around the drum, and the coolant travels transversely across the convex rear face of the belt toward the other edge.

The cooling apparatus of this invention in another of its aspects includes the steps of flowing the coolant longitudinally along a concave portion of the rear face of the belt as it approaches the drum and flowing the coolant transversely of the rear face along the convex portion of the rear space near the drum, and of making a transition from longitudinal flow to transverse flow.

It is the object of this invention to provide apparatus for cooling the casting belt in a drum and belt machine radically improving the performance and reliability of these machines to the end that their utilization and fields of application may become greatly widespread for continuous casting of metal.
In this specification and in the accompanying drawings are described and shown apparatus embodying the invention for cooling the casting belt in a drum and belt machine for casting metal, and it is to be understood that these are given for purposes of illustrating the best mode currently contemplated for carrying out the invention. In order that others skilled in the art may fully understand the invention and the manner of carrying out the invention in practical use and so that they will understand how to utilize equivalents of this apparatus as may be best suited to the conditions of various particular continuous casting installations.

The various features, aspects, and advantages of the present invention will become more fully understood from a consideration of the following specification in conjunction with the accompanying drawings, in which:

FIGURE 1 is a side elevational view of a casting machine of the drum and belt type for practising the cooling method of the invention and embodying apparatus of the invention;

FIGURE 2 is an end elevational view of the machine of FIGURE 1 as seen from the direction 2—2 in FIGURE 1 and drawn on enlarged scale with the belt shown broken away to disclose underlying structure;

FIGURE 3 is a cross sectional view taken along the line 3—3 of FIGURE 1 in the input region where the molten metal is introduced into the moving mould space. In this specification the molten metal is shown as metal and the apparatus herein is the best mode currently contemplated for carrying out the invention in continuously casting metal.

FIGURE 4 is a cross section taken along the line 4—4 in FIGURE 1 illustrating the cooling apparatus; and

FIGURE 5 is a perspective view illustrating the cooling of concave and convex portions of the rear surface of the belt and also for cooling the intermediate transition or inflection region.

As is seen in FIGURES 1 and 2, the continuous casting machine 10 includes a frame base 12 having a drum 14 rotatably mounted on this base. A flexible casting belt 16 runs in an arcuate path around a portion of the revolving drum and is guided and supported by three pulley wheels 17, 18 and 19. Between the periphery of the revolving drum and the belt is defined a moving mould space 20 (FIGURE 3). This mould space 20 is formed by a peripheral casting groove 22 in the drum 14 with the belt 16 pressing firmly against a pair of lands or rim portions 23 of equal diameter which straddle this groove 22.

As shown in FIGURE 3, the casting belt 16 spans across between the lands 23, and its front face F is toward the mould space, while its rear face R is cooled by fast-travelling liquid coolant 21, for example such as water which is used in this machine. In order to contain the molten metal 25 within the mould space 20 and to cast a product of high quality, it is important that the casting belt 16 be held firmly against the lands 23 and that its front face F continue in a smooth curvature adjacent to them, without any warping or localized distortion.

For cooling the drum 14 there is a network of inter-connected passages 24 (FIG. 3) to which liquid coolant is supplied under pressure through a hollow drum shaft 26 (FIG. 2). The coolant returning from the passages 24 is received in a chamber 27 provided by a conical end plate 28 and then flows into a return duct 29 to circulate back to the intermediate reservoir for holding the coolant.

As shown in FIGURE 1 the molten material 25, is supplied from an insulated pouring container or tundish 30 and feeds down through a spout 31 into the input region or entrance 32 to the mould space 20. This machine is particularly adapted for continuously casting molten metal, such as aluminium, copper or steel. The cast product 33 is led out of the machine at a point which is generally on the opposite side from the entrance 32.

Near the entrance to the mould space, the casting belt 16 runs around the pulley 17, as seen in FIGURE 1. In order to press the belt firmly against the lands 23, the entrance pulley 17 has a pair of support rolls 36 of equal diameter, each of which is directly opposite one of the lands 23. Thus, the belt 16 and drum 14 are held together about the entrance 32 to prevent leakage of the molten metal. The sectional view of FIGURE 3 is taken directly at the entrance plane where the support surfaces 36 are pressing the respective edge areas of the belt 16 tightly against the lands 23. Also, the belt 16 is maintained under tension pulling it tightly against the drum 14 as it runs therearound.

In following the path described by the belt 16 near the entrance 32 it is seen that the rear face R describes a concave curve as it runs around the pulley 17; then the belt flexes through a reverse curve or line of inflection along a transverse line, which is indicated by dashes at 38 (FIG. 5); and then the belt describes a convex curve as it runs around the drum 14.

For providing an intense cooling of the casting belt 16 adjacent to the input region 32 where the molten metal 25 is at its highest temperature, the entrance pulley 17 has a plurality of deep narrow grooves 40, seen most clearly in FIGURE 3. Between these grooves 40 the pulley 17 has thin knife-like fins 42 which provide support for the middle portion of the belt 16. These jets effectively cool the pulley 17 over the grooves 40 to resist the tension force under which it operates. A plurality of long, coolant-feed nozzles 44 curve approximately half way around the pulley 17, and one of these nozzle tubes 44 nests within each groove 40 beneath the concave rear surface R, as shown in FIGURES 1 and 2. The liquid coolant is fed under high pressure through a line 46 into a manifold 47 to which the base end of each of the nozzle tubes 44 is connected. As shown in FIGURE 2, the manifold 47 is adjustably mounted by bolts 48 secured to a bracket 49, which is attached to the bearing support 50 for the shaft of the pulley 17. This adjustment enables the nozzle tubes 44 to be aligned with the grooves 40 when the machine 10 is set up for operation. High velocity jets of the coolant 21 issue from the tips 52 of the nozzle tubes 44 and impinge against the concave rear surface R to produce jets of the coolant travelling longitudinally along the belt 16. This coolant 21 travels at high speed through the grooves 40 until the line of inflection 38. As the coolant rushes along the concave surface R centrifugal force produces an intimate contact between coolant and belt to provide a highly effective heat transfer so that the belt is intensely cooled.

In order to cool the belt as it runs around the drum, the coolant 21 is impinged against the rear face R near one edge, as shown in FIGURES 4 and 5 so that the coolant travels at high speed across the convex belt surface and flies off from the opposite edge to be caught in a shield 54.

A large number of nozzles 56 are connected to a header pipe 58 extending in an arc concentric with the axis of the drum 14 and located near one edge of the belt 16. In this machine there are approximately sixty of the nozzles 56 and they are uniformly spaced along the length of the header 58. Each nozzle is directed toward the face R to impinge near the edge of the belt. The axis of each nozzle 56 is aimed at a small angle to the surface R, for example this angle is in the range from 6° to 20°, so that the coolant impinges to spread out and form a fast travelling film 60 (FIG. 5) moving transversely across the face R.

In order to remove the longitudinally travelling coolant beyond the line 38 of the reverse curvature, there is an initial sequence of nozzles 61, 62 and 63 which are aimed in the direction of travel at progressively decreasing angles A, B, and C. These nozzles are strategically disposed beneath the longitudinally travelling coolant so as to raise the longitudinal coolant from the face R while deflecting it and sweeping.
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it aside. Thus, a film of high speed coolant is maintained against the face R and a transition is made from longitudinal feed flow. This transition is made at the beginning of the convex curvature of the face R.

The header 58 is made in three sections joined by flanges 64, and coolant is supplied under pressure to the header 58 through a plurality of lines 66. By supplying coolant at a plurality of connections 67, substantially uniform pressure is provided throughout the length of the header 58, that is, internal pressure drop is minimized. Thus, the transversely flowing coolant layer 60 has substantially uniform velocity at all points along the belt. This provides a high rate of heat transfer and uniformity in cooling the solidifying metal being cast. The arcuate header 58 is mounted on the frame 12 by a plurality of supports 68.

In order to obtain the most effective cooling action the flexible metal casting belt 16 is made of metal of high tensile strength relatively thin and having good heat conductivity. For example, in the machine as shown this belt 16 is made of mild steel and is less than .060 of an inch thick. Thus, the intense cooling action along the rear face R produces a substantially uniform temperature at all points of the front face F adjacent to the molten metal 25.

The forms and expressions which I have employed are used in a descriptive and not in a limiting sense, and I have no intention of excluding such equivalents of the invention described as fall within the scope of the claims.

What is claimed is:

1. Apparatus for supporting and cooling the casting belt in a continuous casting machine of the revolving drum and belt type comprising a first pulley having the belt running partially therearound with the rear surface of the belt describing a concave curve as it travels around said pulley, said pulley pressing the front face of the belt against the revolving drum to define an entrance for molten metal to be cast between drum and belt, a second pulley guiding the belt to run partially around the periphery of the drum with the rear surface of the belt describing a convex curve, said first pulley having a plurality of circumferential grooves therein beneath the concave rear surface of the belt, a plurality of cooling coolant feed tubes nesting within said grooves and having nozzles directed toward the concave rear surface of the belt flowing coolant longitudinally therealong toward the region of the entrance, a source of liquid coolant under pressure connected to said coolant feed tubes, and nozzle means applying coolant to said coolant portion of the rear surface of the belt in a direction different from said longitudinal flow.

6. Apparatus for continuously casting molten metal as claimed in claim 5 in which diagonal nozzle means apply coolant diagonally at high speed across the rear face of the belt to provide a transition between the longitudinally flowing coolant on the concave portion of the rear face and high speed coolant in a direction different from said longitudinal flow.
the coolant continues its travel by flying freely off from said other edge, and shield means to catch the flying coolant.

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