United States Patent

[11] 3,612,152

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[21] Appl. No. 29,834
[22] Filed Apr. 20, 1970
[45] Patented Oct. 12, 1971
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Zurich, Switzerland
[32] Priority Apr. 15, 1969
[33] Switzerland
[31] 5647/69

[54] **BILLET COOLING METHOD FOR CONTINUOUS CASTING**
5 Claims, 6 Drawing Figs.

[52] U.S. Cl. **164/89,** 134/122, 134/199, 239/1, 239/601
[51] Int. Cl. **B22d 11/00**
[50] Field of Search .... 164/82, 89, 283; 239/1, 11, 13; 134/15, 64, 122, 198, 199; 266/6 S; 15/98

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ABSTRACT: In a method of cooling continuously cast billets of polygonal cross section the surfaces of the casting are sprayed with coolant from atomizing nozzles as it leaves the mold. The sides adjacent the edges are sprayed by nozzles having a relatively high-average delivery per unit area in an approximately rectangular pattern; the central portions of the sides are sprayed with nozzles of relatively low-average delivery and a spray delivery that decreases toward the edge regions.

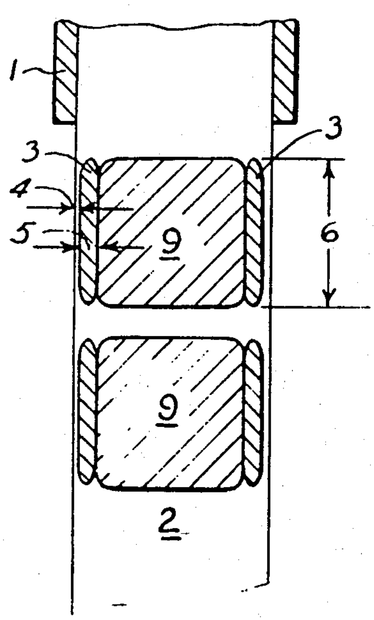

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FIG.1

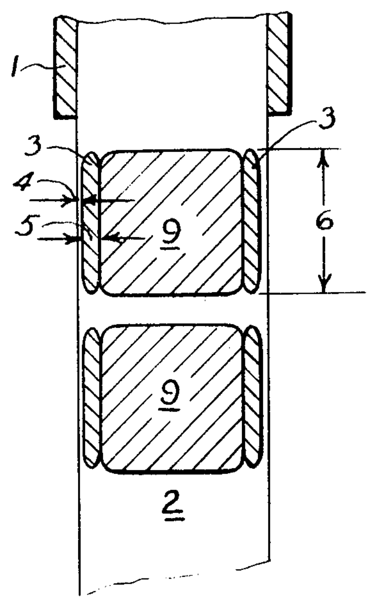


FIG.3

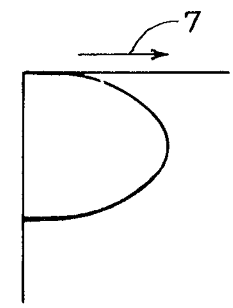


FIG.2

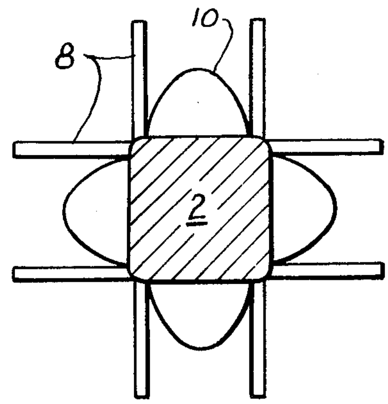


FIG.4

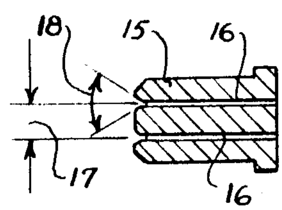


FIG.5

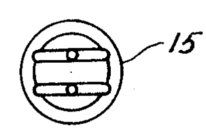
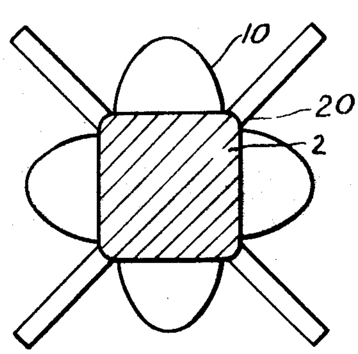


FIG.6



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BILLET COOLING METHOD FOR CONTINUOUS CASTING

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates to a method of cooling a continuous casting issuing from a continuous casting mold, particularly a steel casting.

When a continuous casting of polygonal cross section initially solidifies inside the mold the edges are necessarily exposed to more intense cooling. The resultant shrinkage effects cause these edges to pull away from the wall of the mold not far from the surface of the liquid pool. Since the several edges do not as a rule all shrink at the same time, the cooling conditions and hence the temperatures, stresses and thicknesses of the frozen shell differ in otherwise comparable surface zones. These drawbacks become more pronounced as the casting continues to move through the mold, and bright and dark edges appear as the casting issues from the mold. At the bright edges the shell that had already frozen remelts in the mold, and in the corners at the solidus front depressions appear in the frozen shell. At these points of weakness the stresses in the frozen shell produce corner cracks which cause breakouts at the edges below the mold. If the casting rate is increased, the likelihood of such breakouts at the edges becomes greater because the shortened cooling time of the casting inside the mold results in the development of a thinner shell of diminished bearing strength.

Moreover, the unequal stresses have yet another undesirable consequence, namely that of causing a type of geometrical distortion shown as rhombic distortion which is a nuisance in subsequent processing of the casting.

It has been proposed to conduct the casting, immediately after it has left the mold, through a cooling zone in which it passes between numerous guide rails and is cooled by flat-type spray nozzles which have a rectangular spray pattern with the short side of the pattern across, and the long side lengthwise of, the casting. All the nozzles around the circumference of the casting have the same cooling effect. The edges themselves are not cooled since they are masked by the guide rails. Between each two nozzles is a zone not sprayed by the water and around the circumference of the casting regularly fluctuating transient surface temperatures are therefore generated which cause stresses in the frozen shell or which increase the stresses that are already present. Moreover, this cooling equipment, particularly in association with curved molds, is very complicated and liable to be damaged by liquid steel when breakouts occur.

According to another prior proposal for cooling billets eight atomizing nozzles are used to achieve a uniform cooling effect around the entire casting circumference. Four nozzles each are disposed on the center axes of the faces and on the diagonals, but there is considerable overlap between neighboring spray patterns. It was not recognized that considerable overlap between spray patterns causes locally uncontrolled cooling. The stresses generated inside the mold are thus further accentuated and these further increase the risk of corner cracks, breakouts, and rhombic distortion.

A principal object of the present invention is to provide a method of cooling billets with atomizing nozzles whereby high casting speeds can be obtained, the development of longitudinal corner cracks, and hence the risk of breakouts, can be diminished, and rhombic distortion can be reduced sufficiently to prevent inconvenience during further processing.

In accordance with the invention there is provided a method of cooling a continuous casting of polygonal cross section issuing from a continuous casting mold, which comprises spraying the surface of the casting directly as it leaves the mold with a coolant liquid sprayed through atomizing nozzles, wherein the region on each side of the billet adjacent the edges are sprayed by nozzles having a relatively high average delivery per unit area and an approximately rectangular spray pattern, and the surface between the edge regions is sprayed by nozzles of relatively lower average delivery and a spray delivery characteristic that decreases towards the edge regions.

This method permits higher casting rates to be employed. Despite this increase the casting requires no direct guide means immediately after leaving the mold, so that the entire surface can be sprayed without being masked.

It has proved advantageous that the nozzles spraying the edge regions should spray strips that are between 10 and 25 mm. wide on both sides of the edge.

The rectangular spray pattern is preferably produced by flat-type spray nozzles.

In order to reduce the number of flat-type spray nozzles required, the rectangular spray pattern covering two edge regions having a common edge may be generated by two narrow sprays issuing from a common nozzle body, said nozzle body being located on a line bisecting the corner angle.

In a preferred arrangement roughly square areas are sprayed by the nozzles cooling the surface between the edge regions.

The proposed method will be hereinafter more particularly described with reference to the accompanying diagrammatic drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a side view of part of a continuous casting plant in which the casting is cooled in accordance with the invention, showing the casting issuing from the mold;

FIG. 2 illustrates the spray delivery characteristics of the nozzles, distributed around the periphery of the casting;

FIG. 3 illustrates the spray delivery characteristics in the longitudinal direction of the casting of a flat-type spray nozzle;

FIG. 4 is a longitudinal section through a nozzle body of a flat-type nozzle for the generation of two narrow sprays;

FIG. 5 is an end view of the nozzle body of FIG. 4; and

FIG. 6 illustrates the spray delivery characteristics of the nozzles distributed around the periphery of the casting when using the flat-type nozzles shown in FIGS. 4 and 5.

DETAILED DESCRIPTION

FIG. 1 is a side view of a continuous steel casting 2 of generally polygonal cross section issuing from a continuous casting mold 1. Directly after the casting 2 leaves the mold a coolant liquid, suitably water, is sprayed through nozzles (not shown) against each side of the casting. The sprayed area of the billet surface is indicated by the cross-hatched outlines. The edge regions 3 on the side of the billet 2 are sprayed by two flat-type atomizing nozzles. The base of the spray pattern, i.e., the sprayed surface, is roughly rectangular, across the casting the base is narrow, whereas in the longitudinal direction it is wide. The elongated orifice of the nozzle body therefore extends parallel to the longitudinal casting axis.

FIG. 3 shows the spray delivery characteristic of such a flat-type nozzle in the lengthwise direction of the casting. In the direction of the arrow 7 the relative quantity of water delivered is shown. In the illustrated example the delivery characteristic is an ogival. However, other delivery characteristics such as a flat characteristic could be used.

An edge region 3 which is sprayed at an average rate of about 0.45 liters/sq. cm./minute at a water pressure of 4 atm. gauge has been found, for a steel casting having the analysis 0.44% C, 0.33% Si and 0.95% Mn and a square cross section of 115×115 mm., to be quite sufficient for increasing the casting rate from 2.5 to 3.5 meters/minute. The distance 4 between the adjoining side of the casting and the sprayed surface, in the case of the described casting, was about 2 mm. and the length 5 of the short side of the narrow base was about 14 mm. The length 6 of the longer side of the base was about 18 cms. The sprayed area was thus 25 sq. cm. However, since this area is not precisely rectangular it is reasonable to take it as representing 23 sq. cm. According to the size of the casting, the nozzles spraying the edge regions are preferably arranged to spray regions 3 extending from the edge a distance of 10 to 25 mm. across each side.

FIG. 2 illustrates the spray delivery characteristics and indirectly the cooling effects of the nozzles around the circumference of the casting. The flat-type nozzles spraying the edge regions 3 provide a roughly rectangular spray pattern 8 across the casting.

The nozzle which cools the surface of the billet 2 between the edge regions 3 sprays an approximately square area 9, i.e., the spray pattern of the nozzle has a square base. FIG. 2 shows that this nozzle produces an ogival delivery characteristic 10. Its average spraying performance in the described example was about 0.08 liters/sq. cm./minute. Since the delivery characteristic of this nozzle decreases towards the edge regions the difference in spraying performance in the areas of contact with the flat-type nozzles is a multiple. The surface 9 is exposed to a lower average spray delivery per unit area than the edge regions 3. Instead of a nozzle having a spray pattern with a square base, it would also be possible to use for instance several flat-type nozzles, each with a flat delivery characteristic, but the cost of providing such nozzles would be greater.

Despite the abrupt difference between the cooling effects in contiguous areas of the regions 3 and 9 longitudinal corner cracks surprisingly do not occur, even when the casting rate is raised by 1 meter/minute. Rhombic distortion is also considerably reduced and no difficulties arise during further processing. This result is due to the fact that the intense cooling at the edge regions consolidates the above-mentioned weak points at the edges. The edge regions consolidate by forming kinds of angles which resist stresses and keep rhombic distortion within 1%.

Experience has shown that two sets of nozzles disposed consecutively along the casting path are sufficient for the so-called angles to form in the above example.

For the purpose of reducing the number of flat-type nozzles required in the case of FIG. 2 and of thus also reducing the number of pipes required to supply the nozzles the rectangular spray pattern may be generated by two narrow sprays issuing from a common nozzle body of a flat-type nozzle situated on the line bisecting the corner angle at the edge. FIG. 4 and 5 illustrate a nozzle 15 of such a kind. It has two parallel passages 16 for the water. These passages 16 are spaced apart in the nozzle body by a distance 17. The notch angles are indicated at 18. By varying the distance 17 and the notch angle 18 the size of the base and the rectangular pattern can be empirically varied. In the longitudinal direction of the casting this nozzle has an ogival delivery characteristic. FIG. 6 illustrates the spray characteristic of the nozzles of FIGS. 4 and 5 around the periphery of the casting 2. The area of the spray pattern 20 across the casting is roughly twice the size of the area 3. The sprayed regions on each side of the edges are roughly of the same size as in FIG. 2 but the cooling effect of the nozzle on an edge is slightly less than that of two flat-type nozzles perpendicularly facing the two sides as in FIGS. 1 and 2.

What is claimed is:

1. A method of cooling a continuous casting of polygonal cross section issuing from a continuous casting mold, which comprises spraying the surface of the casting directly after it leaves the mold with a coolant liquid sprayed through atomizing nozzles, wherein the regions on each side of the casting adjacent the edges are sprayed by nozzles having a relatively high-average delivery per unit area and an approximately rectangular spray pattern, and the surface between the edge regions is sprayed by nozzles of relatively lower average delivery and a spray delivery characteristic that decreases towards the edge regions.

2. A method according to claim 1, wherein the nozzles spraying the edge regions spray strips extending from the edge a distance of about 10 to 25 mm. across the side.

3. A method according to claim 1, wherein the rectangular spray pattern is generated by flat-type spray nozzles.

4. A method according to claim 1, wherein the rectangular spray pattern in two edge regions with a common edge is generated by two narrow sprays issuing from one body of a flat-type nozzle and that the nozzle is located on a line bisecting the corner angle.

5. A method according to claim 1, wherein the nozzles cooling the surface between the edge regions spray approximately square areas.