

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
21 June 2007 (21.06.2007)

PCT

(10) International Publication Number
WO 2007/068687 A2

- (51) **International Patent Classification:** Not classified
- (21) **International Application Number:**
PCT/EP2006/069582
- (22) **International Filing Date:**
12 December 2006 (12.12.2006)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
MI2005A002367
13 December 2005 (13.12.2005) IT
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- (81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW
- (84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:**
— without international search report and to be republished upon receipt of that report
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** CRYSTALLIZER

(57) **Abstract:** A curved crystallizer for continuous casting of blooms or billets comprises a suitable cooling system capable of providing an optimum transfer of the heat from the liquid metal inside the crystallizer towards the outside. The crystallizer according to the present invention satisfies the need to prevent the generation of critical stresses in the cast product during its passage from said crystallizer to the casting machine arranged downstream thereof, and also the need to implement a complete casting plant, comprising the crystallizer and casting machine, which is extremely compact in terms of its height.



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Crystallizer

Field of the invention

The present invention refers to a curved crystallizer, in particular for the continuous casting of blooms and billets.

5 Prior art

Numerous crystallizers for use with continuous casting plants for blooms or billets are known in the prior art. These crystallizers substantially consist of a hollow monolithic body, usually made of copper, the cross-section of which defines the shape of the cast product.

- 10 To cool the molten metal during casting, and start the process of progressive solidification of the metal, the outer wall of a first type of crystallizer is provided with a jacket through which a cooling fluid flows, said cooling fluid usually consisting of water.

Several problems have arisen in connection with the use of this type of crystallizer, due to the very thick copper wall between the cooling water in the jacket and the solidifying metal inside the crystallizer. These problems include:

- the high temperatures that are reached on the wall that comes into contact with the liquid metal;
- the high temperature gradients along the thickness and along the length of the crystallizer;
- excessive deformation of the walls of the crystallizer due to the high thermal stresses, particularly in case of thin walls;
- uneven cooling over the cross-section;
- the impossibility of controlling the internal taper so that the crystallizer cannot correctly follow the shrinkage of the solidifying shell;
- limited life due to the formation of cracks on the chrome coating in the meniscus region;
- the surface quality is not good and oscillation marks are clearly visible;
- the formation of geometrical defects such as rhomboidity;
- the formation of structural defects such as cracks near the corners, known as "off-corner" cracks, that can cause the shell to rupture and the subsequent breakout of liquid metal, etc.

Many of these problems have been solved with a subsequent generation of

crystallizers that incorporate, inside the thickness of their walls, holes through which the cooling water flows. This achieves a better heat transfer while continuing to ensure good crystallizer strength.

One drawback that has not yet been overcome however regards longitudinally
5 curved crystallizers, used to progressively and gradually deform the billet so as to prevent the generation of critical stresses that can result in the formation of cracks inside the cast product.

In order to achieve an effective continuity of the line with the casting machine, which is arranged immediately after the crystallizer, and to create a complete
10 casting plant that is as compact as possible, in particular in terms of its height, it has been found that the crystallizers known in the prior art are not provided with a suitable primary cooling system capable of providing an optimum transfer of the heat from the liquid metal towards the outside of the curved crystallizer.

The need is therefore felt to implement a crystallizer capable of overcoming the
15 drawbacks described above.

Summary of the invention

The main purpose of the present invention is to implement a curved crystallizer for continuous casting of blooms or billets that comprises a suitable cooling system capable of providing an optimum transfer of the heat from the liquid metal inside
20 the curved crystallizer towards the outside.

A second purpose is to prevent, thanks to the curvature of the crystallizer, the generation of critical stresses in the cast product as it passes from the crystallizer to the casting machine.

Another purpose is to provide a complete casting plant, comprising the crystallizer
25 and casting machine, that is as compact as possible in terms of its height.

The present invention achieves the purposes described above with a curved crystallizer for continuous casting of blooms or billets that, in accordance with that set forth in claim 1, comprises a tubular structure, having a curved longitudinal axis that defines a first radius of curvature, the cross-section of which on a plane
30 orthogonal to the longitudinal axis defines the shape of said blooms or billets, said tubular structure comprising between an outer wall and an inside wall longitudinal holes through which a cooling fluid can flow, said holes extending for the entire length of the crystallizer and having a substantially circular cross-section, said

inside wall coming into contact with a molten metal, characterized in that said longitudinal holes have a curved longitudinal axis with the same radius of curvature,

and in that the value of said first radius of curvature is between 1 and 5 times the value of a second radius of curvature, said second radius being the smallest radius of curvature of the curvilinear sections that constitute a casting machine, arranged immediately downstream of said crystallizer.

The crystallizer according to the present invention is provided with longitudinal cooling holes, arranged in the thickness of the walls of the crystallizer, very close to the inside wall of the crystallizer and having a curved shape with a curvature identical to that of the crystallizer; advantageously, said arrangement makes it possible to obtain:

- very low temperatures on the wall that comes into contact with the liquid metal;
- low temperature gradients along the thickness and along the length of the crystallizer;
- substantially no deformation of the walls of the crystallizer thanks to its high strength;
- very even cooling over the cross-section;
- good control of its internal taper;
- longer life, three times that of the crystallizers known in the prior art, also thanks to the fact that no cracks are formed on the chrome coating in the meniscus region;
- excellent surface quality with a very small number of oscillation marks;
- excellent structural properties without cracks near the corners;
- no geometrical defects along the cross-sections transversal to the curved longitudinal axis.

The claims attached hereto describe preferred embodiments of the invention.

Brief description of the drawings

Further characteristics and advantages of this invention will become clear from the following detailed description of a preferred, but not exclusive embodiment of a crystallizer, that is merely illustrative and not limitative, with the help of the drawings attached hereto, in which:

Fig. 1 shows a perspective view of a crystallizer according to the invention;

Fig. 2 schematically shows the curvatures of a crystallizer according to the invention and of a casting machine arranged downstream;

Figs. 3, 4, 5 show top views of portions of the wall of the crystallizer;

Fig. 6 shows a longitudinal cross-section of the crystallizer according to the invention.

Detailed description of a preferred embodiment of the invention

With reference to Figs. 1 and 2 a curved crystallizer is shown, globally indicated by reference numeral 1, said crystallizer having a quadrangular cross-section. According to this preferred but not exclusive embodiment, said crystallizer is advantageously provided with a predetermined radius of curvature R_0 so as to optimize the progressive and gradual deformation of the billet, that solidifies inside the crystallizer when it comes into contact with the inside wall 4, so as to guarantee an effective continuity of the line with a casting machine 2 arranged downstream. The generation of critical stresses that may lead to the formation of cracks inside the cast product is thus prevented.

Furthermore, to guarantee the optimum transfer of the heat towards the outer wall 5 of the crystallizer and overcome the drawbacks typically associated with the curved crystallizers known in the prior art, longitudinal through holes or ducts 3, called cooling holes, are provided inside the thickness of the curved crystallizer according to the invention, said cooling holes advantageously having a predetermined radius of curvature that is substantially equal to the radius of curvature R_c of said crystallizer. The value of said radius of curvature R_c is between 1 and 5 times the value of the main radius R_m of the casting machine 2, where the main radius R_m is the minimum radius of curvature among the radii of curvature of the various sections that constitute the casting machine 2.

Advantageously, the distance "D" of the cooling holes 3 from the inside wall 4 of the crystallizer, over which the solidifying liquid metal flows, is constant along the entire length of the curved crystallizer, said distance being between approximately 6 and 20 mm, thus ensuring an even cooling along said length.

The diameter "d" of said cooling holes 3 is advantageously chosen from between approximately 8 and 14 mm and their centre-to-centre distance "i" can vary between approximately 12 and 35 mm.

A further advantage consists of the fact that the cooling water can be made to flow

through these holes 3 in a top-to-bottom direction. This prevents the water from boiling and thus prevents uneven cooling in the meniscus region where the majority of defects in the cast product originate.

5 The specific embodiments described in this document are not limitative and this patent application covers all the alternative embodiments of the invention as set forth in the claims.

CLAIMS

1. A curved crystallizer for continuous casting of blooms or billets comprising a tubular structure, having a curved longitudinal axis that defines a first radius of curvature (R_c), the cross-section of which on a plane orthogonal to the longitudinal axis defines the shape of said blooms or billets, said tubular structure comprising
5 between an outer wall (5) and an inside wall (4) longitudinal holes (3) through which a cooling fluid can flow, said holes extending for the entire length of the crystallizer and having a substantially circular cross-section, said inside wall coming into contact with a molten metal,
10 characterized in that
said longitudinal holes (3) have a curved longitudinal axis with the same radius of curvature (R_c), and in that the value of said first radius of curvature (R_c) is between 1 and 5 times the value of a second radius of curvature (R_m), said second radius being the smallest radius of curvature of the curvilinear sections that constitute a
15 casting machine (2), arranged immediately downstream of said crystallizer.
2. Crystallizer according to claim 1, wherein the distance (D) between said longitudinal holes (3) and said inside wall (4) is constant along the entire length of the crystallizer, said distance being between approximately 6 and 20 mm.
3. Crystallizer according to claim 1 or 2, wherein said longitudinal holes (3) have a
20 diameter (d) of between approximately 8 and 14 mm.
4. Crystallizer according to one or more of the previous claims, wherein the centre-to-centre distance (i) between said holes (3) is between approximately 12 and 35 mm.

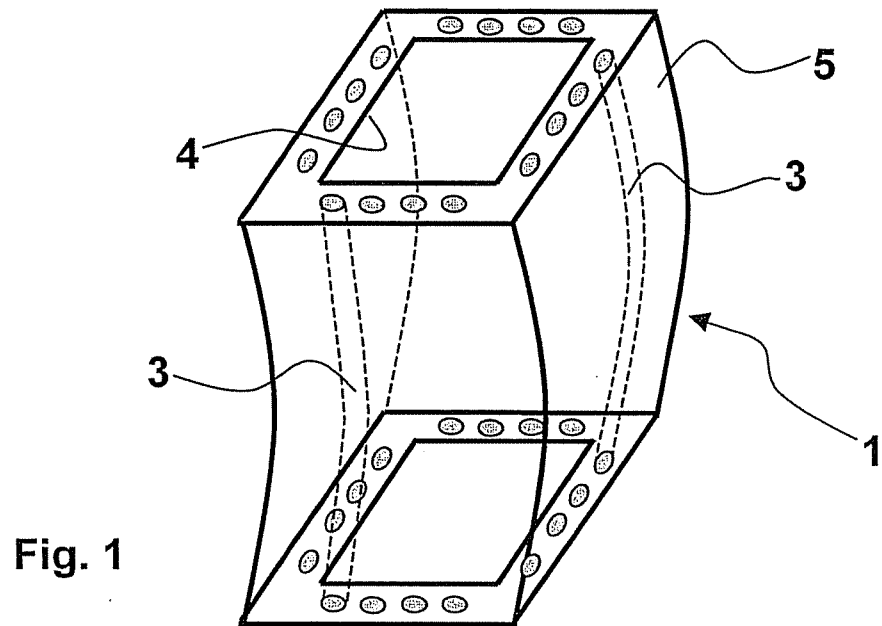
$1/2$ 

Fig. 1

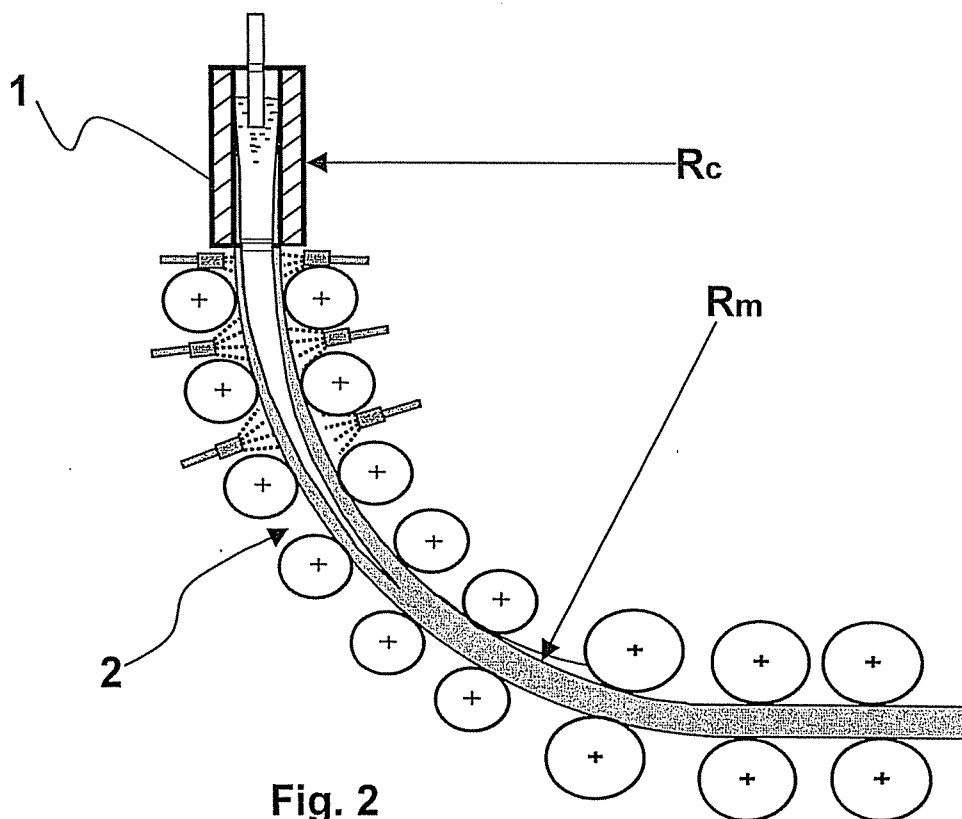


Fig. 2

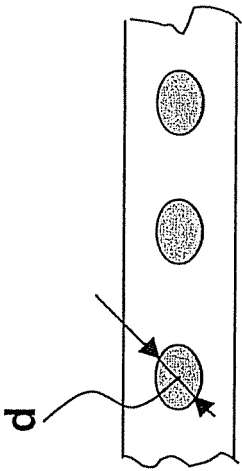


Fig. 3

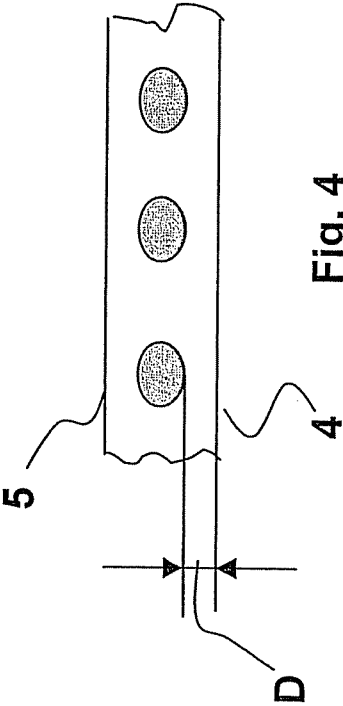


Fig. 4

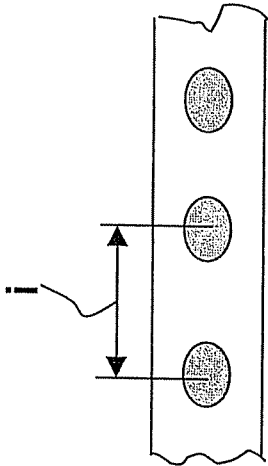


Fig. 5

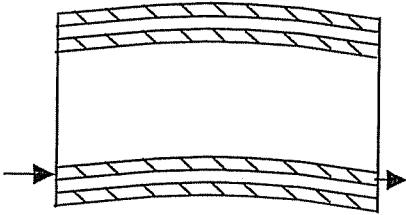


Fig. 6