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(54) **Continuous-casting crystalliser with increased heat exchange and method to increase the heat exchange in a continuous-casting crystalliser**

Stranggiesskokille mit verbessertem Wärmeaustausch sowie Verfahren zur Erhöhung des Wärmeaustauschs einer Stranggiesskokille

Cristalliseur de coulée continue ayant un échange de chaleur amélioré et procédé pour augmenter l'échange de chaleur d'un cristalliseur de coulée continue

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(56) References cited:

EP-A- 0 686 445 **DE-A- 1 916 503**
DE-A- 2 106 634 **DE-A- 3 423 475**
DE-A- 4 127 333 **FR-A- 2 223 115**
FR-A- 2 661 120 **GB-A- 2 016 977**
US-A- 3 520 352

- **METALLURGICAL TRANSACTIONS B.**, vol. 13B, no. 1, WARRENDALE, PA, US, pages 91-104, SAMARASEKERA ET AL. 'The Thermal Distortion of Continuous-Casting Billet Molds.'
- **PATENT ABSTRACTS OF JAPAN** vol. 008 no. 136 (M-304) ,23 June 1984 & JP-A-59 035856 (KAWASAKI SEITETSU KK) 27 February 1984

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Description

[0001] This invention concerns a continuous-casting crystalliser with increased heat exchange and also a method to increase the heat exchange in a continuous-casting crystalliser, as set forth in the respective main claims.

[0002] The invention is employed in association with a mould used in a continuous casting plant for the production of billets, blooms or slabs of any desired type and section.

[0003] The field of continuous casting still entails a plurality of problems which have not yet been overcome and which are linked to the high temperatures to which the sidewalls of the crystalliser are subjected.

[0004] To be more exact, it is known that the temperature of the sidewalls of the crystalliser, notwithstanding the circulation of cooling fluid, changes in the direction of the casting with a maximum value reached in the vicinity of the meniscus of the molten metal.

[0005] The uneven temperature along the sidewalls of the crystalliser causes an uneven deformation of those sidewalls together with their outward displacement in relation to their initial position in the cold state, this deformation being due to the thermal expansion of the material, with resulting problems linked to the surface faults caused by this uneven deformation on the billets/ blooms/slabs being formed.

[0006] Moreover, it is known that the skin of the solidifying billets/ blooms/slabs during their descent in the crystalliser shrinks according to a law which differs from one material to another.

[0007] The combination of these two factors causes, at least in the lower zone of the crystalliser, a separation of the skin of the billet/bloom/slab from the sidewalls of the crystalliser and reduces considerably the heat exchange between the billet/ bloom/slab and the crystalliser to the extent that the cooling and therefore the formation of the skin are practically halted with very severe results for the billet/bloom/slab being formed.

[0008] In the crystallisers of the state of the art the coefficient of heat exchange between the forming skin and the sidewalls of the crystalliser, at least in the lower zone of the crystalliser, takes on values which are lower than $36000 \text{ W/m}^2 \text{ K}$ and which are therefore not acceptable for an efficient action of cooling and therefore of solidification of the skin being formed.

[0009] The article of J.K. BRIMACOMBE "Empowerment with Knowledge - Towards the Intelligent Mould for the Continuous Casting of Steel Billets", METALLURGICAL TRANSACTIONS B, Volume 24B, DECEMBER 1993, pages 917-935, shows clearly that in crystallisers of the state of the art the heat flux in the zone of the exit of the cast product from the crystalliser is between about 1.2 and 1.4 MW/m^2 , whereas it does not exceed 2 MW/m^2 in the zone where the separation of the skin from the sidewalls of the crystalliser begins.

[0010] In the crystallisers of the state of the art, therefore, the heat exchange has acceptable values only along the first segment of the crystalliser, which extends along about a quarter of the length of a crystalliser and normally about 200 mm. below the meniscus; in this first segment the skin of the billet/bloom/slab is substantially in contact with the sidewalls of the crystalliser.

[0011] So as to ensure that the billet/bloom/slab leaving the crystalliser has a thickness of skin such as to prevent its breakage and the resulting break-out of liquid metal, it is therefore necessary to employ a reduced casting speed.

[0012] Where the billets or blooms have a square, rectangular or generally polygonal cross-section, another problem is linked to the fact that the corners of the billet or bloom undergo a more intense cooling since at those corners the heat is removed on both sides of the corner.

[0013] The result is that at the corners of the billet or bloom the skin forms more quickly and the resulting shrinkage of the material has the effect that the billet or bloom is separated very soon from the sidewalls of the crystalliser, thus interrupting the cooling and solidifying process.

[0014] For this reason the skin of the billet or bloom at the corners is less thick than along the sidewalls of the billet or bloom, and gradients of temperature between the corners and the sides of the billet or bloom are created.

[0015] These temperature gradients generate tensions both within the sidewalls of the crystalliser and within the billet or bloom being cooled, and these tensions lead to the formation of cracks and other surface faults which reduce the quality of the outgoing product.

[0016] The present applicants have designed, tested and embodied this invention to overcome the shortcomings of the state of the art and to achieve further advantages.

[0017] This invention is set forth and characterised in the respective main claims, while the dependent claims describe variants of the idea of the main embodiment.

[0018] The purpose of this invention is to obtain a crystalliser for the continuous casting of billets/blooms/slabs which enables the extraction speed to be increased owing to an increased heat exchange between the sidewalls of the crystalliser and the cooling fluid.

[0019] A further purpose is to provide a crystalliser in which the thermal deformation of that crystalliser is reduced to a minimum.

[0020] Yet another purpose is to provide a method which enables the heat exchange to be increased between the sidewalls of the crystalliser and the skin being formed in a continuous-casting crystalliser.

[0021] The crystalliser according to the invention has sidewalls of a reduced thickness, between 4 and 15

mm., but advantageously between 4 and 10 mm., which enable their behaviour to be made resilient.

[0022] This resilient behaviour of the crystalliser enables a greater quantity of heat to be extracted than with rigid crystallisers of the state of the art since this behaviour enables the sidewalls to be displaced inwards, thus cancelling the deformation due to the thermal field, which instead expands the sidewalls outwards.

[0023] In this way the interspace of air between the sidewalls and the skin being formed is cancelled, thus reducing the very high thermal resistance, calculated as being about 84% of the total thermal resistance, which this interspace creates in the heat exchange between the sidewalls of the crystalliser and the cast product.

[0024] This reduction or cancellation of the interspace makes possible, even in the lower zone of the crystalliser, an extraction of a very great heat flux between 2.5 and 5 MW/m².

[0025] Such a heat flux would entail very high temperatures of the sidewalls of the crystalliser, temperatures which could lead to plastic deformation of the sidewalls.

[0026] Since it is necessary in that lower zone to stay in a condition of resilience of the sidewalls so as to be able to cancel the air interspace created with the forming skin, it becomes necessary to increase the coefficient of heat exchange between the cooling fluid and the sidewalls of the crystalliser to a value between 40,000 and 100,000 W/m² K so as to be able to remove the very high heat flux which is created.

[0027] The sidewalls of the crystalliser cooperate externally with cooling chambers, which contain a specific intermediate wall for each sidewall of the crystalliser for the purpose of defining together with that sidewall a circulation channel for the cooling fluid.

[0028] According to one form of embodiment of the invention the circulation channels have, perpendicular to the axis of the crystalliser, a section having a transverse length shorter than the sidewalls of the crystalliser and a transverse width, or span, of the passage for the cooling fluid having a maximum value of 3 millimetres.

[0029] The scope of the invention comprises the correlation of the pressure or range of pressures of the cooling fluid circulating in the relative circulation channels with the value of the coefficient of heat exchange to be achieved between the sidewalls of the crystalliser and the cooling fluid.

[0030] The invention arranges that by acting on the pressure of the cooling fluid it is possible to deform the sidewalls of the crystalliser in the desired zones in the desired manner.

[0031] In this invention, by cooling fluid is meant water for industrial use, at any rate water which is normally used in moulds to cool the crystalliser.

[0032] According to a variant the invention arranges to employ as a cooling fluid water to which has been added substances which enable that water to be used

even at temperatures of entry into the mould lower than "0" and down to -25°C/-30°C.

[0033] A variant of the invention arranges for the use, as a cooling fluid, of other liquid substances such as glycol, for instance, at a temperature between -10°C/-15°C and -70°C/-80°C upon entry into the mould.

[0034] A further variant of the invention covers the use, as a cooling fluid, of liquefied gases, whether pure or combined with other gases or liquids, at a temperature between -3°C and -270°C upon entry into the mould.

[0035] Hereinafter, the various parameters given refer to a cooling fluid consisting of one of the various types of water, also called normal water, as normally used to cool continuous casting moulds in an industrial process.

[0036] According to the invention, depending on the case in question, the cooling fluid can flow in the same direction as, or in the opposite direction to, the direction of feed of the billet/bloom within the casting chamber.

[0037] The combination of the resiliently working sidewalls and the differentiated pressure of the cooling fluid acting on those sidewalls makes possible a considerable reduction, or even the elimination, of the separation of the skin of the solidifying billet/bloom/slab from the sidewalls of the crystalliser, thus ensuring a constantly great heat exchange.

[0038] Since the thickness of the skin of the billet/bloom/slab is in proportion to the quantity of heat removed, the greater the heat exchange is, the greater the casting speed will be.

[0039] When other conditions are equal, the crystalliser according to the invention therefore makes possible an increase of the casting speed, with a resulting increase of the output of the plant.

[0040] According to a possible form of embodiment of the crystalliser according to the invention the circulation channels do not affect the corner zones of the crystalliser so as to prevent causing an excessive cooling of the corners of the billet/bloom/slab being formed in cooperation with those corner zones.

[0041] In that case the crystalliser according to the invention includes at the corners stiffening elements suitable at least to control the deformations of the crystalliser caused by the thermal expansion as a result of the heating of the crystalliser.

[0042] These stiffening elements are wholly or partially embodied directly in the crystalliser itself or are auxiliary external elements which are secured to, or are caused to cooperate with, the corners of the crystalliser.

[0043] The stiffening elements may be in contact with the corners of the crystalliser so as to determine a no transit area therefore not lapped by the circulation of the cooling fluid.

[0044] According to a variant a passage is included between the stiffening elements and the corners of the crystalliser so as to permit the passage of the cooling fluid in a smaller quantity than at the remaining parts of

the sidewalls of the crystalliser.

[0045] According to another variant the stiffening elements determine at the corners a particular geometry suitable to increase the turbulence of the cooling fluid and to optimise the alignment of the crystalliser.

[0046] According to the invention, so as to increase the heat exchange between the cooling fluid and the sidewalls of the crystalliser, the cross-section of the passage of the cooling fluid is reduced in such a way as to leave a transverse width, or span, between 1.5 and 2.5 millimetres for instance, such as will create a required turbulence and stirring in cooperation with the induced differences of pressure.

[0047] According to the invention, so as to increase the heat exchange between the cooling fluid and the sidewalls of the crystalliser, at least part of at least one face of each circulation channel includes means to disturb the flow of cooling fluid, these disturbing means being suitable to break up the fluid streams and to maintain a condition of great turbulence.

[0048] According to one embodiment of the invention at least part of the outer surface of the sidewalls of the crystalliser in contact with the cooling fluid cooperates by means of its own flow disturbing means which, by breaking up the fluid streams of the outermost layer running against the sidewalls of the crystalliser, cause the cooling fluid to run in a turbulent manner with a resulting increase of heat exchange.

[0049] The disturbing means can be embodied by means of rough areas, hollows or ridges provided on the outer surface of the sidewalls of the crystalliser and/or on the inner surface of the intermediate walls.

[0050] These hollows may be substantially horizontal or inclined in relation to the direction of flow of the cooling fluid, depending on the effect to be achieved.

[0051] According to the invention the hollows can have a development parallel or not parallel to each other.

[0052] According to a variant at least part of the inner surface of the intermediate walls facing the crystalliser and defining the circulation channels contains alternate narrowings and enlargements, which compel the cooling fluid to carry on a turbulent and swirling motion that assists in breaking up the fluid streams of the outermost layer of the fluid and improves the heat exchange with the sidewalls of the crystalliser.

[0053] According to a variant the rough surface areas can be produced by sanding, shot-blasting or an analogous treatment applied to the inner surface of the intermediate walls and/or to the outer surface of the sidewalls of the crystalliser.

[0054] In a particular form of embodiment of the crystalliser according to the invention the intermediate walls in the circulation channels are movable perpendicularly to the sidewalls of the crystalliser and cooperate with adjustment means for their approach to, or distancing from the sidewalls of the crystalliser so as to alter the transverse width or span of the circulation channels

and therefore the cross-section of the passage for the cooling fluid when that fluid cooperates directly with the outer surface of the sidewalls of the crystalliser.

[0055] It is possible in this way to adjust the pressure and speed of the cooling fluid within the circulation channels.

[0056] According to the invention, when the cooling fluid consists of normal water, the pressure of the cooling fluid is between 5 and 20 bar at least at the inlet of the circulation channel at the lower zone of the crystalliser, where the forming skin is detached from the sidewalls of the crystalliser, whereas in the segment of the circulation channel in the upper zone of the crystalliser the pressure is between about 3 and 15 bar.

[0057] The attached figures are given as a non-restrictive example and show some preferred embodiments of the invention as follows:-

Fig.1	shows a longitudinal section of a mould employing a crystalliser according to the invention;
Figs.2a and 2b	show in an enlarged scale two different partial vertical sections of the crystalliser of Fig.1;
Fig.3	shows the outer surface of the crystalliser of Fig.2 along the line A-A of Fig.2;
Fig.4	shows a partial cross-section of a variant of the crystalliser of Fig.3;
Figs.5a, 5b and 5c	show possible forms of embodiment of the corners of the crystalliser according to the invention;
Figs.6a to 6f	show partial cross-sections of six of the possible forms of embodiment of the stiffening elements associated with the corners of the crystalliser;
Fig.7	shows in an enlarged scale a cross-section of a crystalliser according to the invention.

[0058] The reference number 10 in the attached figures denotes generally a mould according to the invention, with which a nozzle 25 to discharge molten metal is caused to cooperate.

[0059] The mould 10 can have a square, rectangular or polygonal cross-section or any desired cross-section.

[0060] The mould 10 according to the invention comprises a crystalliser 11 the sidewalls of which have a thickness between 4 and 15 mm., but advantageously between 4 and 10 mm.

[0061] The thickness of the sidewalls is always correlated with the range of pressures of the cooling fluid which are used to obtain a substantially resilient behaviour.

[0062] The crystalliser 11 comprises substantially an upper zone 34, which corresponds to the vicinity of

the meniscus 33 and to the zone therebelow as far as the skin being formed of the bloom/billet/slab 24 is supported substantially against the inner surfaces of the crystalliser 11.

[0063] According to the invention the cooling fluid, when it is normal water, has a pressure between 3 and 15 bar in the upper zone 34.

[0064] The crystalliser 11 includes therebelow a lower zone 26, which begins substantially in the vicinity of the point where the forming skin of the bloom/billet/slab 24 being extracted begins to be separated from the inner surfaces of the crystalliser 11 and extends to the end of the crystalliser 11.

[0065] The mould 10 according to the invention comprises containing walls 13 positioned outside the crystalliser 11 and defining therewith one or more cooling chambers 14 in which a cooling fluid under pressure is caused to run.

[0066] According to the requirements of heat exchange between the cooling fluid and the crystalliser 11 and therefore in relation to the process of cooling and solidification of the billet/bloom/slab 24 being formed, the cooling fluid can be caused to run in the opposite direction to, or in the same direction as, the direction of feed of the billet/bloom/slab 24 being formed.

[0067] In this case the cooling chambers 14 include a feeder conduit 22a equipped with an adjustment valve 23a and a discharge conduit 22b also equipped with an adjustment valve 23b.

[0068] In the mould 10 according to the invention these cooling chambers 14 contain, for each side of the crystalliser 11, specific intermediate walls 20, which in the example of Fig.1 are movable transversely according to the arrows 17.

[0069] These intermediate walls 20 may also contain holes, which have the purpose of controlling the pressure of the cooling fluid in circulation channels 21.

[0070] The circulation channels 21 are included, at least one per each side of the crystalliser 11, between the intermediate walls 20 and the outer surface 12 of the sidewalls of the crystalliser 11.

[0071] By positioning the intermediate walls 20 perpendicularly to the axis of the crystalliser it is possible to alter the transverse width, or span, of the respective circulation channels 21 and therefore the hydraulic conditions of the flow of cooling fluid.

[0072] The crystalliser 11, being heated by the effect of the liquid metal running within the casting chamber 31, is outwardly deformed resiliently, and the pressure of the cooling fluid acts to compensate this deformation by displacing the sidewalls of the crystalliser 11 inwards.

[0073] By changing the pressure of the cooling fluid circulating within the cooling chambers 14 and therefore within the circulation channels 21, it is possible to cause the sidewalls of the crystalliser 11 to adhere substantially to the skin of the billet/bloom/slab 24 even in the

lower zone 26 of the crystalliser 11, thus eliminating the air space being created and thus ensuring a high coefficient of heat exchange along the whole length of the crystalliser 11.

[0074] According to the invention by varying the difference of the pressure of the cooling fluid between the inlet and outlet of the circulation channels 21 it is possible to alter the heat exchange between the sidewalls of the crystalliser 11 and the cooling fluid.

[0075] According to a variant, where the crystalliser 11 has a rectangular cross-section, at least its wider sidewalls face independent cooling chambers 14 and circulation channels 21 having independent pressures and differences of pressures of the cooling fluid.

[0076] According to one form of embodiment of the invention (see Figs.6 and Fig.7 regarding the corners 15a), the circulation channels 21 do not cooperate directly with the corners 15 of the crystalliser 11, which are not cooled by the cooling fluid running within the cooling chambers 14.

[0077] According to the invention a segment of an increased thickness 32 is included at the corners 15 of the crystalliser 11 so as to reduce the heat exchange with the cooling fluid.

[0078] In the embodiments shown in Figs.5a, 5b and 5c the circulation channels 21 cooperate with those segments 32 of an increased thickness included directly in the sidewalls of the crystalliser 11 so as to provide cooling also at the corners 15, but a cooling less intense than at the remaining parts of the sidewalls of the crystalliser 11.

[0079] According to the variant shown in Fig.7 relating to the corner 15b, an auxiliary stiffening and/or alignment element 16 is included and cooperates with the corner 15b and defines therewith a channel 21 of reduced dimensions for circulation of the cooling fluid.

[0080] According to the variant shown in Fig.7 relating to the corner 15c, the auxiliary stiffening and/or alignment element 16 defines with that corner 15c a geometry suitable to increase the turbulence of the circulating cooling fluid and to facilitate the alignment of the crystalliser 11.

[0081] In Fig.7 at the corners 15a, and in Fig.6f, the circulation channels 21 have at their lateral ends inclined walls 30 having an inclination which can be varied as required so as to modulate and graduate the heat exchange at the corners 15 of the crystalliser 11.

[0082] The segment 32 of an increased thickness can be embodied by means of stiffening and/or alignment elements 16 obtained wholly (16a - Fig.6c) or partly (116a - Figs.6b and 6d) directly from the sidewalls of the crystalliser 11 or may consist of independent stiffening elements 16b (Figs.6a, 6e and 6f).

[0083] The stiffening and/or alignment elements 16, may also consist of a plurality of pieces.

[0084] The independent stiffening and/or alignment elements 16b can be associated with or rigidly connected to, by brazing for instance, the corners 15 of the

crystalliser 11 according to the invention.

[0085] The stiffening and/or alignment elements 16a-116a provided in the sidewall of the crystalliser 11 can be conformed as a solid polygon or have a T-shape or another form.

[0086] Where the stiffening and/or alignment elements 16b are independent, they can be conformed as a "T", or an "L" or an "Ω" or can have other forms.

[0087] In the form of embodiment shown in Figs.6d and 6f the stiffening and/or alignment element, which in Fig.6d is provided (116a) from the sidewall of the crystalliser 11, whereas in Fig.6f it is an independent element 16b, is T-shaped and is inserted in a space 29 defined in the segment 32 of an increased thickness.

[0088] The cooling fluid may or may not run through the space 29.

[0089] The stiffening and/or alignment elements 16 perform the triple task of stiffening and of clamping the deformations of the crystalliser 11, of reducing the heat exchange at the corners 15 of the crystalliser 11 and of aligning the crystalliser 11.

[0090] The walls of the circulation channel 21 include disturbing elements 18 to increase the heat exchange between the cooling fluid and the crystalliser 11 in relation to the increase of heat flux to be removed which arises from elimination of the air interspaces between the sidewalls of the crystalliser 11 and the skin.

[0091] These disturbing elements 18 break up the fluid streams of the outermost layer of the fluid running against the sidewalls of the crystalliser 11 and cause the cooling fluid to run with a turbulent motion in the circulation channels 21 with a resulting increase of the heat exchange.

[0092] The disturbing elements 18 can be embodied with rough areas or hollows made in the outer surface 12 of the sidewalls of the crystalliser 11 and/or with rough areas or hollows made in the inner surface of the intermediate walls 20.

[0093] In this case the disturbing elements 18 contain a plurality of hollows 19 into which the cooling fluid penetrates and causes the breaking up of the outermost layer of the cooling fluid running against the outer surface 12 of the sidewalls of the crystalliser 11.

[0094] These hollows 19 may have a substantially horizontal or an inclined development (Fig.3).

[0095] The hollows 19 are defined by a height and by a depth "a" of ≤ 0.5 mm. and by a distance of ≥ 5 mm. between one hollow and another.

[0096] According to another embodiment of the invention (Figs.2a and 2b) the intermediate walls 20 have, on their inner surface facing the sidewalls of the crystalliser 11, disturbing elements 18 comprising alternate enlargements 27 and narrowings 28 for the purpose of causing in the circulating cooling fluid a required turbulence

[0097] These enlargements 27 and narrowings 28 may have a polygonal development (Fig.2b) or may have a development producing a Venturi effect (Fig.2a),

which makes the motion of the cooling fluid swirling and turbulent and thus enhances the heat exchange.

[0098] According to a further variant these rough surface areas on the outer surface 12 of the sidewalls of the crystalliser 11 and/or on the inner surface of the intermediate walls 20 are obtained by a treatment of sanding, shot-blasting or an analogous treatment.

Claims

1. Method for increasing the heat exchange in the cooling and removal of heat from at least one sidewall of a crystalliser (11) of a mould (10) employed in a continuous casting of billets, blooms or slabs (24), wherein the crystalliser (11) cooperates externally with a box-shaped structure (13) for creating cooling chambers (14), in which a cooling fluid circulates, and internally with the skin of the billets, blooms or slabs (24) being formed, wherein the cooling chambers (14) comprise intermediate walls (20) creating circulation channels (21) in cooperation with the outer surface (12) of the sidewalls (12) of the crystalliser (11), wherein the crystalliser (11) comprises at least one longitudinal upper zone (34) comprising at least the meniscus (33) of liquid metal and the portion below the meniscus (33) and one longitudinal lower zone (26) beginning in the vicinity of the zone of separation of the forming skin from the inner surfaces of the crystalliser (11) and extending towards the outlet of the crystalliser (11), the method being characterised by the following steps:
 - acting on the cross-section and/or conformation of at least one longitudinal portion of at least one side of the cross-section of the circulation channels (21); and
 - acting on the different pressures of the cooling fluid present between the inlet and outlet of said longitudinal portion of the circulation channels (21) for creating a desired turbulence of said cooling fluid, which turbulence is such as to increase the coefficient of heat exchange to a value greater than $40,000 \text{ W/m}^2 \text{ K}$.
2. Method as in Claim 1, in which the pressure of the cooling fluid at the inlet of the circulation channels (21) is between 5 and 20 bar.
3. Method as in Claim 1 or 2, in which the pressure of the cooling fluid in the upper zone (34) is between 3 and 15 bar.
4. Method as in any claim hereinbefore, in which the pressure of the cooling fluid varies as a function of the thickness of at least a part of the lower zone (26) of said sidewalls (12) whereby making possible the resilient deformation of said sidewalls (12) by

said pressure until said sidewalls (12) take up a position close to, or in contact with, the skin of the solidifying billets, blooms or slabs (24).

5. Method as in any claim hereinbefore, in which the average heat flux removed in the lower zone (26) of the crystalliser (11) is always greater than 2.5 MW/m². 5
6. Method as in any of Claims 1 to 5 inclusive, in which said cooling fluid is constituted by water. 10
7. Method as in any of Claims 1 to 5 inclusive, in which said cooling fluid is constituted by water containing additives at a temperature down to -30°C. 15
8. Method as in any of Claims 1 to 5 inclusive, in which said cooling fluid is constituted by glycol or another substance which can be likened thereto, at a temperature between -10°C and -80°C. 20
9. Method as in any of Claims 1 to 5 inclusive, in which said cooling fluid is constituted by pure liquid gas, or liquid gas to which another gas or liquid has been added, at a temperature between -3°C and -270°C. 25
10. Crystalliser of a mould (10) for the continuous casting of billets, blooms or slabs (24), comprising a plurality of sidewalls (12) which cooperate externally with a box-shaped structure (13) creating cooling chambers (14), in which a cooling fluid circulates, and internally with the skin of the billets, blooms or slabs (24) being formed, wherein said cooling chambers (14) containing intermediate walls (20) creating circulation channels (21) in cooperation with the outer surfaces of said sidewalls (12), and further comprising at least one upper longitudinal zone (34) including at least the meniscus (33) of the liquid metal and the portion just below the meniscus (33), and a lower longitudinal zone (26) beginning in the vicinity of the zone of separation of the forming skin from the inner surface of said sidewalls (12) and extending towards the outlet of the crystalliser (11), the crystalliser (11) being characterised in that it employs the method of one or another of the claims hereinbefore, in that said sidewalls (12) have a thickness between 4 and 15 mm, and in that at least a part of at least one of the walls of said circulation channels (21) includes elements (18) to disturb the flow of said cooling fluid. 30
11. Crystalliser as in Claim 10, in which at least part of the outer surfaces (12) of the sidewalls of the crystalliser (11) in contact with the cooling fluid includes a plurality of hollows (19), which are perpendicular or inclined to the direction of feed of the cooling fluid and are such as to have a height and a depth "a" ≤ 35

0,5 mm. and are at a distance apart "b" ≥ 5 mm.

12. Crystalliser as in Claim 10 or 11, in which the disturbing elements (18) are included in the inner surface of the intermediate walls (20) facing towards the crystalliser (11) and comprise alternate enlargements (27) and narrowings (28).
13. Crystalliser as in any of Claims 10 to 12 inclusive, in which the inner surface of the intermediate walls (20) and/or the outer surface (12) of the sidewalls of the crystalliser (11) include rough surface areas produced by a treatment of sanding, shot-blasting or the like.
14. Crystalliser as in any of Claims 10 to 13 inclusive, in which the transverse width or span of passage of the circulation channels (21) is 3 mm. at the most.
15. Crystalliser as in any of Claims 10 to 14 inclusive, in which the geometry of the circulation channels (21) in their cross-section can be varied at least at the corners (15) of the crystalliser (11).
16. Crystalliser as in any of Claims 10 to 15 inclusive, which includes stiffening and/or alignment elements (16) associated with the corners (15) of the crystalliser (11).
17. Crystalliser as in any of Claims 10 to 16 inclusive, in which the stiffening and/or alignment elements (16a-116a) are obtained directly from the sidewalls of the crystalliser (11).
18. Crystalliser as in any of Claims 10 to 17 inclusive, in which the stiffening and/or alignment elements (16b) are auxiliary external elements which cooperate with the corners (15) of the crystalliser (11).
19. Crystalliser as in any of Claims 10 to 18 inclusive, in which at least part of the intermediate walls (20) can be moved as required in relation to the sidewalls of the crystalliser (11).

45 Patentansprüche

1. Verfahren zum Verstärken des Wärmeübergangs beim Kühlen und bei der Wärmeableitung von wenigstens einer Seitenwand eines Kristallisators (11) einer Form (10), die beim Stranggießen von Strängen, Blöcken oder Brammen (24) eingesetzt wird, wobei der Kristallisator (11) außen mit einer kastenförmigen Struktur (13) zusammenwirkt, die Kühlkammern (14) bildet, in denen ein Kühlfluid zirkuliert, und innen mit der Gußhaut der Stränge/Blöcke oder Brammen (24), die hergestellt werden, die Kühlkammern (14), Zwischenwände (20) umfassen, die mit der Außenfläche (12) der 50

Seitenwände (12) des Kristallisators (11) zusammenwirkend Zirkulationskanäle (21) bilden, wobei der Kristallisor (11) wenigstens einen oberen Bereich (34) in Längsrichtung umfaßt, der wenigstens den Meniskus (33) des flüssigen Metalls und den Abschnitt unterhalb des Meniskus (33) umfaßt, und einen unteren Bereich (26) in Längsrichtung, der in der Nähe des Bereichs der Trennung der entstehenden Gußhaut von den Innenflächen des Kristallisators (11) beginnt und sich auf den Auslaß des Kristallisators (11) zu erstreckt, wobei das Verfahren durch die folgenden Schritte gekennzeichnet ist:

Einwirken auf den Querschnitt und/oder Anpassung wenigstens eines Längsabschnitts wenigstens einer Seite des Querschnitts der Zirkulationskanäle (21); und

Einwirken auf die verschiedenen Drücke des Kühlfluids zwischen dem Einlaß und dem Auslaß des Längsabschnitts der Zirkulationskanäle (21), um eine gewünschte Turbulenz des Kühlfluids zu erzeugen, wobei durch die Turbulenz der Wärmeübergangskoeffizient auf einen Wert über 40000 W/m² K erhöht wird.

2. Verfahren nach Anspruch 1, wobei der Druck des Kühlfluids am Einlaß der Zirkulationskanäle (21) zwischen 5 und 20 bar liegt.
3. Verfahren nach Anspruch 1 oder 2, wobei der Druck des Kühlfluids im oberen Bereich (34) zwischen 3 und 15 bar liegt.
4. Verfahren nach einem der vorangehenden Ansprüche, wobei der Druck des Kühlfluids in Abhängigkeit von der Dicke wenigstens eines Teils des unteren Bereiches (26) der Seitenwände (12) variiert, so daß sich die Seitenwände (12) durch den Druck elastisch verformen können, bis die Seitenwände (12) eine Position nah an der Gußhaut der sich verfestigenden Stränge, Blöcke oder Brammen (24) oder in Kontakt damit einnehmen.
5. Verfahren nach einem der vorangehenden Ansprüche, wobei der durchschnittliche Wärmestrom, der in dem unteren Bereich (26) des Kristallisators (11) abgeführt wird, mehr als 2,5 MW/m² beträgt.
6. Verfahren nach einem der Ansprüche 1 bis einschließlich 5, wobei das Kühlfluid aus Wasser besteht.
7. Verfahren nach einem der Ansprüche 1 bis einschließlich 5, wobei das Kühlfluid aus Wasser besteht, das Zusätze bei einer Temperatur bis -30°C enthält.

8. Verfahren nach einem der Ansprüche 1 bis einschließlich 5, wobei das Kühlfluid aus Glykol oder einer anderen vergleichbaren Substanz bei einer Temperatur zwischen -10°C und -80°C besteht.
9. Verfahren nach einem der Ansprüche 1 bis einschließlich 5, wobei das Kühlfluid aus reinem Flüssiggas oder Flüssiggas, dem ein anderes Gas oder eine andere Flüssigkeit zugesetzt worden ist, bei einer Temperatur zwischen -3°C und -270°C besteht.
10. Kristallisor einer Form (10) für das Stranggießen von Strängen, Blöcken oder Brammen (24), der eine Vielzahl von Seitenwänden (12) umfaßt, die außen mit einer kastenförmigen Struktur (13) zusammenwirken, die Kühlkammern (14) bildet, in denen Kühlfluid zirkuliert, und innen mit der Gußhaut der Stränge, Blöcke oder Brammen (24), die hergestellt werden, wobei die Kühlkammern (14) Zwischenwände (20) enthalten, die mit den Außenflächen der Seitenwände (12) zusammenwirkend Zirkulationskanäle (21) bilden, und des weiteren wenigstens einen oberen Bereich (34) in Längsrichtung umfaßt, der wenigstens den Meniskus (33) des flüssigen Metalls und den Abschnitt unmittelbar unterhalb des Meniskus (33) einschließt, sowie einen unteren Bereich (26) in Längsrichtung, der in der Nähe des Bereiches der Trennung der entstehenden Gußhaut von der Innenfläche der Seitenwände (12) beginnt und sich auf den Auslaß des Kristallisators (11) zu erstreckt, wobei der Kristallisor (11) **dadurch gekennzeichnet** ist, daß das Verfahren nach einem der vorangehenden Ansprüche eingesetzt wird, daß die Seitenwände (12) eine Dicke zwischen 4 und 15 mm haben und daß wenigstens ein Teil wenigstens einer der Wände der Zirkulationskanäle (21) Elemente (18) enthält, die den Strom des Kühlfluids hemmen.
11. Kristallisor nach Anspruch 10, wobei wenigstens ein Teil der Außenflächen (12) der Seitenwände des Kristallisators (11) in Kontakt mit dem Kühlfluid eine Vielzahl von Hohlräumen (19) enthält, die senkrecht oder geneigt zur Transportrichtung des Kühlfluids sind, und die eine Höhe sowie eine Tiefe „a“ ≤ 0,5 mm haben und um einen Abstand „b“ ≥ 5 mm voneinander entfernt sind.
12. Kristallisor nach Anspruch 10 oder 11, wobei die Hemmelemente (18) in die Innenfläche der Zwischenwände (20) dem Kristallisor (11) zugewandt integriert sind und abwechselnde Aufweitungen (27) und Verengungen (28) umfassen.
13. Kristallisor nach einem der Ansprüche 10 bis einschließlich 12, wobei die Innenfläche der Zwischenwände (20) und/oder die Außenfläche (12) der

Seitenwände des Kristallisators (11) raue Oberflächenbereiche einschließen, die durch eine Behandlung mittels Schleifen, Kugelstrahlen oder dergleichen hergestellt wurden.

14. Kristallisator nach einem der Ansprüche 10 bis einschließlich 13, wobei die Quer- bzw. Spannbreite des Durchlasses der Zirkulationskanäle (21) maximal 3 mm beträgt.
15. Kristallisator nach einem der Ansprüche 10 bis einschließlich 14, wobei die Form der Zirkulationskanäle (21) im Querschnitt wenigstens an den Ecken (15) des Kristallisators (11) variiert werden kann.
16. Kristallisator nach einem der Ansprüche 10 bis einschließlich 15, der Versteifungs- und/oder Ausrichtelemente (16) enthält, die mit den Ecken (15) des Kristallisators (11) verbunden sind.
17. Kristallisator nach einem der Ansprüche 10 bis einschließlich 16, wobei die Versteifungs- und/oder Ausrichtelemente (16a - 116a) direkt von den Seitenwänden des Kristallisators (11) her ausgebildet sind.
18. Kristallisator nach einem der Ansprüche 10 bis einschließlich 17, wobei die Versteifungs- und/oder Ausrichtelemente (16b) zusätzliche äußere Elemente sind, die mit den Ecken (15) des Kristallisators (11) Zusammenwirken.
19. Kristallisator nach einem der Ansprüche 10 bis einschließlich 18, wobei wenigstens ein Teil der Zwischenwände (20) je nach Erfordernis in bezug auf die Seitenwände des Kristallisators (11) bewegt werden kann.

Revendications

1. Procédé pour accroître l'échange thermique lors du refroidissement et de l'évacuation de chaleur depuis au moins une paroi latérale d'une lingotière (11) d'un moule (10) employé lors de la coulée continue de billettes/blooms ou brames (24), dans lequel la lingotière (11) coopère extérieurement avec une structure (13) en forme de caisson pour créer des chambres de refroidissement (14) dans lesquelles circule un fluide de refroidissement, et intérieurement avec la peau des billettes/blooms ou brames (24) en formation, les chambres de refroidissement (14) comportant des parois intermédiaires (20) qui créent des canaux de circulation (21) en coopération avec la surface extérieure (12) des parois latérales de la lingotière (11), la lingotière (11) comportant au moins une zone supérieure longitudinale (34) incluant au moins le ménisque (33) de métal liquide et la partie située sous le ménisque

(33) et une zone inférieure longitudinale (26) qui commence au voisinage de la zone de séparation de la peau en formation et des surfaces internes de la lingotière (11), et s'étendant vers la sortie de la lingotière (11), le procédé étant caractérisé par les étapes suivantes, consistant à :

- agir sur la section transversale et/ou la configuration d'au moins une partie longitudinale d'au moins un côté de la section transversale des canaux de circulation (21) ; et
- agir sur les différentes pressions du fluide de refroidissement présent entre l'entrée et la sortie de ladite partie longitudinale des canaux de circulation (21) pour créer une turbulence voulue dudit fluide de refroidissement, laquelle turbulence permet d'accroître le coefficient d'échange thermique jusqu'à une valeur supérieure à 40 000 W/m² K.

2. Procédé selon la revendication 1, dans lequel la pression du fluide de refroidissement à l'entrée des canaux de circulation (21) est comprise entre 5 et 20 bars.
3. Procédé selon la revendication 1 ou 2, dans lequel la pression du fluide de refroidissement dans la zone supérieure (34) est comprise entre 3 et 15 bars.
4. Procédé selon l'une quelconque des revendications précédentes, dans lequel la pression du fluide de refroidissement varie en fonction de l'épaisseur d'au moins une partie de la zone inférieure (26) desdites parois latérales (12), ce qui rend possible la déformation élastique desdites parois latérales (12) par ladite pression jusqu'à ce que lesdites parois latérales (12) prennent une position proche ou au contact de la peau des billettes, blooms ou brames (24) en cours de solidification.
5. Procédé selon l'une quelconque des revendications précédentes, dans lequel le flux de chaleur moyen évacué dans la zone inférieure (26) de la lingotière (11) est toujours supérieur à 2,5 MW/m².
6. Procédé selon l'une quelconque des revendications 1 à 5 incluse, dans laquelle ledit fluide de refroidissement est constitué par de l'eau.
7. Procédé selon l'une quelconque des revendications 1 à 5 incluse, dans lequel ledit fluide de refroidissement est constitué par de l'eau contenant des additifs à une température pouvant descendre jusqu'à - 30°C.
8. Procédé selon l'une quelconque des revendications 1 à 5 incluse, dans lequel ledit fluide de refroidisse-

ment est constitué par du glycol ou une autre substance pouvant être assimilée à celui-ci, à une température comprise entre -10°C et -80°C.

9. Procédé selon l'une quelconque des revendications 1 à 5 incluse, dans lequel ledit fluide de refroidissement est constitué par un gaz liquide pur, ou par un gaz liquide auquel a été ajouté un autre gaz ou un liquide, à une température comprise entre -3°C et -270°C. 5
10. Lingotière d'un moule (10) pour la coulée continue de billettes, blooms ou brames (24), comprenant une pluralité de parois latérales (12) qui coopèrent extérieurement avec une structure (13) en forme de caisson créant des chambres de refroidissement (14), dans lesquelles circule un fluide de refroidissement, et intérieurement avec la peau des billettes, blooms ou brames (24) en formation, dans lequel lesdites chambres de refroidissement (14) 15 comportent des parois intermédiaires (20) créant des canaux de circulation (21) en coopération avec les surfaces extérieures desdites parois latérales (12), et comportant en outre au moins une zone longitudinale supérieure (34) incluant au moins le ménisque (33) du métal liquide et la partie située juste au-dessous du ménisque (33), et une zone longitudinale inférieure (26) commençant au voisinage de la zone de séparation de la peau en formation et de la surface intérieure desdites parois latérales (12) et s'étendant vers la sortie de la lingotière (11), la lingotière (11) étant caractérisée en ce qu'elle emploie le procédé selon l'une ou l'autre des revendications précédentes, en ce que lesdites parois latérales (12) ont une épaisseur comprise 20 entre 4 et 15 mm et en ce qu'au moins une partie d'au moins une des parois desdits canaux de circulation (21) comporte des éléments (18) pour perturber l'écoulement dudit fluide de refroidissement. 25
11. Lingotière selon la revendication 10, dans laquelle au moins une partie des surfaces extérieures (12) des parois latérales de la lingotière (11) au contact du fluide de refroidissement comporte une pluralité de creux (19) perpendiculaires ou inclinés par rapport à la direction d'avance du fluide de refroidissement, et tels qu'ils ont une hauteur et une profondeur "a" $\leq$ 0,5 mm et sont mutuellement séparés par une distance "b" $\geq$ 5 mm. 30
12. Lingotière selon la revendication 10 ou 11, dans laquelle les éléments perturbateurs (18) sont disposés dans la surface interne des parois intermédiaires (20) en regard de la lingotière (11) et comportent une alternance d'élargissements (27) 35 et de rétrécissements (28). 40
13. Lingotière selon l'une quelconque des revendica-

tions 10 à 12 incluse, dans laquelle la surface interne des parois intermédiaires (20) et/ou la surface extérieure (12) des parois latérales de la lingotière (11) comporte(nt) des zones à surface rugueuse créées par sablage, grenailage ou analogue.

14. Lingotière selon l'une quelconque des revendications 10 à 13 incluse, dans laquelle la largeur transversale ou envergure de passage des canaux de circulation (21) est au maximum de 3 mm. 10
15. Lingotière selon l'une quelconque des revendications 10 à 14 incluse, dans laquelle la géométrie des canaux de circulation (21) en ce qui concerne leur section transversale peut être modifiée au moins aux angles (15) de la lingotière (11). 15
16. Lingotière selon l'une quelconque des revendications 10 à 15 incluse, comportant des éléments de raidissement et/ou d'alignement (16) associés aux angles (15) de la lingotière (11). 20
17. Lingotière selon l'une quelconque des revendications 10 à 16 incluse, dans laquelle les éléments de raidissement et/ou d'alignement (16a-116a) sont réalisés directement à partir des parois latérales de la lingotière (11). 25
18. Lingotière selon l'une quelconque des revendications 10 à 17 incluse, dans laquelle les éléments de raidissement et/ou d'alignement (16b) sont des éléments auxiliaires externes qui coopèrent avec les angles (15) de la lingotière (11). 30
19. Lingotière selon l'une quelconque des revendications 10 à 18 incluse, dans laquelle au moins une partie des parois intermédiaires (20) peut être déplacée de la manière nécessaire par rapport aux parois latérales de la lingotière (11). 35



