Abstract

The present invention relates to a mold (1) for casting molten metal into a strand with a circular or polygonal cross section in a continuous casting machine. It is an object of the invention to provide a mold with which firstly a sufficiently strong casting cone of the mold cavity can be predefined, such that sufficient and homogeneous growth of the strand shell is also ensured along the entire circumference of the casting cross section or of the mold cavity, and secondly unnecessarily high contact pressures and frictional forces of the strand in the mold, in particular jamming of the strand, are reliably prevented. This object is achieved by a mold (1) in which a depression (10) or a recurring sequence consisting of a region with a depression and a region without a depression extends over the longitudinal extent of the region of load relief (8) in the direction of withdrawal, wherein the depression (10) or the recurring sequence has the form of a helix.

(Figure 2)

Claims

1. A mold (1) for casting molten metal into a strand with a circular or polygonal cross section in a continuous casting machine,
   - having a continuous mold cavity (2);
   - wherein the mold cavity (2) is delimited in a direction of withdrawal of the strand by a pouring-in opening (3) for pouring the molten material into the mold and by a withdrawal opening (4) for withdrawing the at least partially solidified strand from the mold (1);
   - wherein the mold cavity (2) is delimited transversely to the direction of withdrawal of the strand by an inner wall (5) of the mold (1); and
   - wherein the mold cavity (2) has a region (8), referred to hereinbelow as "region of load relief (8)", with an associated casting cone (9), referred to hereinbelow as "load-relief casting cone (9)", wherein the region of load relief (8) has a plurality of depressions (10) in the inner wall (5) of the mold (1) for relieving the strand of load;

   characterized in that a depression (10) or a recurring sequence consisting of a region with a depression and a region without a depression extends over the longitudinal extent of the region of load relief (8) in the direction of withdrawal,

   characterized in that the depression (10) or the recurring sequence has the form of a helix; and

   characterized in that a depth or a width of the depression (10) in the inner wall (5) decreases continuously and monotonically over an unwound length of the helix counter to the direction of withdrawal of the strand.

2. The mold as claimed in claim 1, **characterized in that** a depression (10) is formed either as a groove or as a rounded-out portion.

3. The mold as claimed in one of claims 1 to 2, **characterized in that** the region of load relief (8) has a number of n depressions (10), wherein two adjacent depressions each have an angular offset of $360/n^{\circ}$ about a mid-axis of the mold cavity (2).

4. The mold as claimed in one of claims 1 to 3, **characterized in that** a region (6), referred to hereinbelow as "inlet region (6)", with a casting cone (7), referred to hereinbelow as "inlet casting cone (7)", is located upstream of the region of load relief (8), wherein the inlet region (6) extends from the pouring-in opening (3) to the region of load relief (8).

5. The mold as claimed in one of claims 1 to 4, **characterized in that** a region, referred to hereinbelow as "outlet region", with a casting cone, referred to hereinbelow as "outlet casting cone", is located downstream of the region of load relief (8), wherein the outlet region extends from the region of load relief (8) to the pouring-out opening (4).

6. The mold as claimed in one of claims 1 to 5, **characterized in that** one or more cones from the group consisting of the inlet casting cone (7), the load-relief casting cone (9) and the outlet casting cone have a parabolic conicity.

7. The mold as claimed in one of claims 4 to 5, **characterized in that** a transition from one casting cone to a following casting cone is formed continuously, preferably in a repeatedly continuously differentiable manner.

8. The mold as claimed in one of claims 1 to 7, **characterized in that** the mold cavity (2) has a convex curvature.

9. The use of the mold as claimed in one of claims 1 to 8 in a continuous casting installation for producing a metal strand

of steel with a circular or polygonal cross section.

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Fig. 1

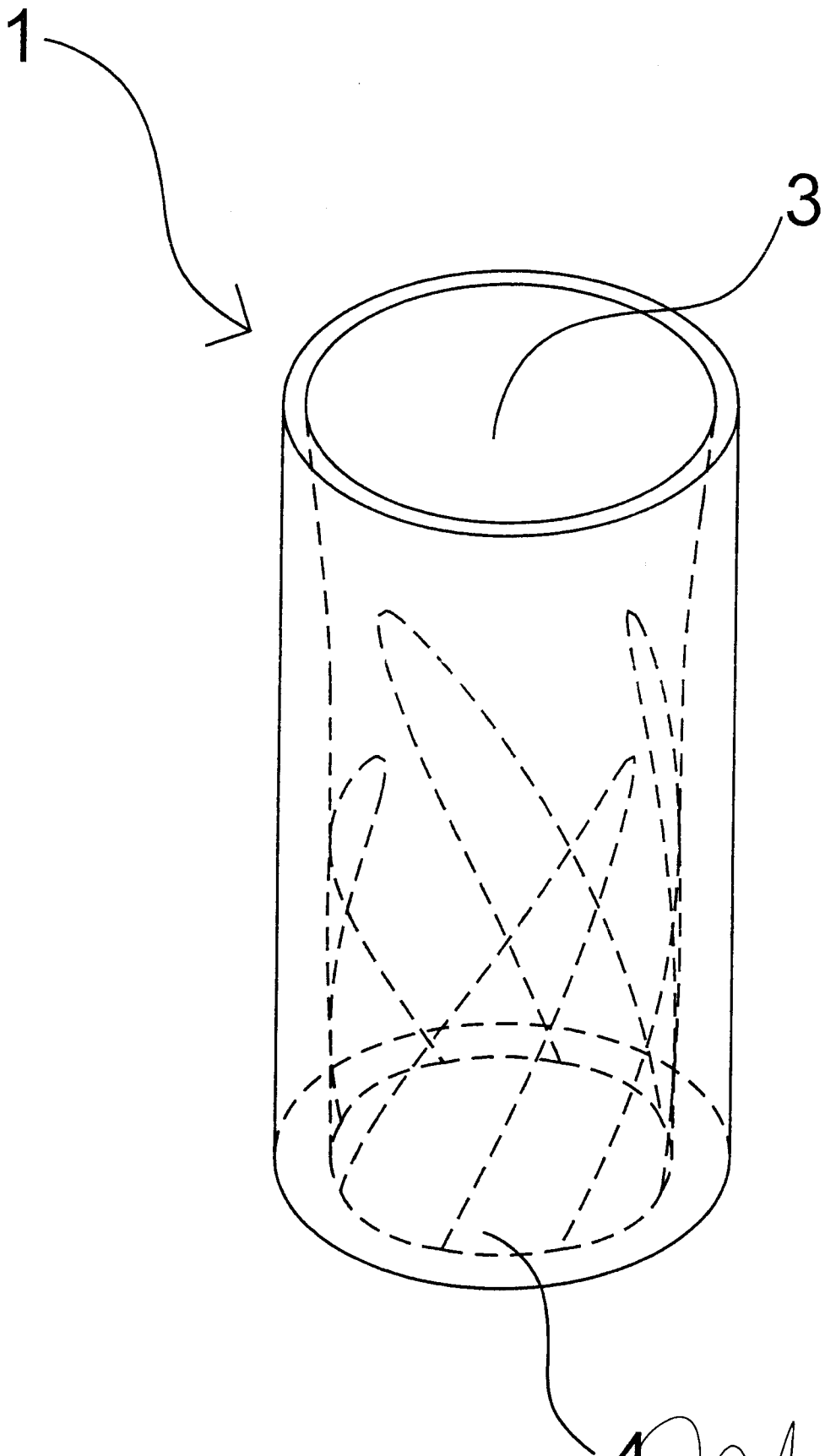

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Fig. 2

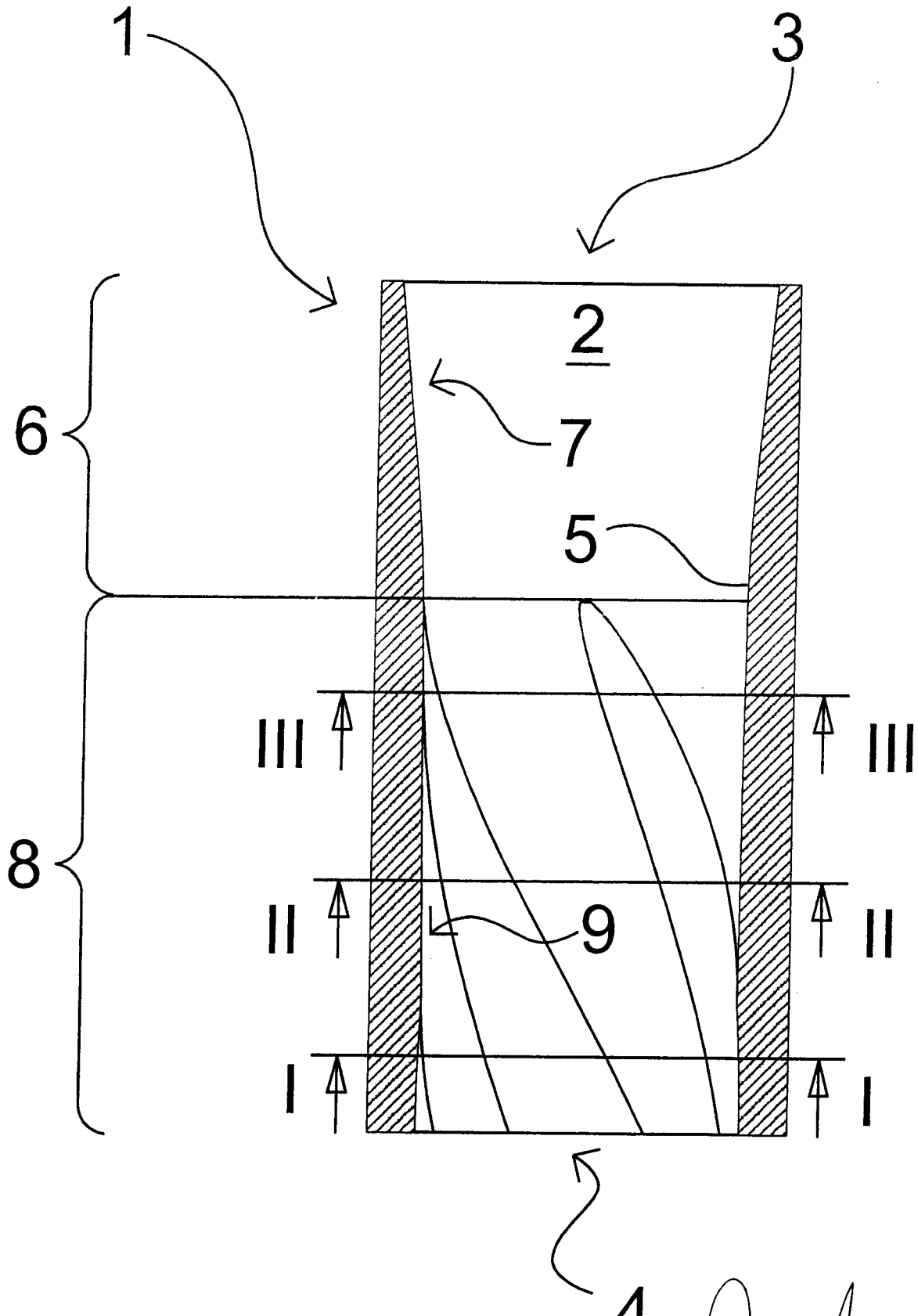

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Fig. 3

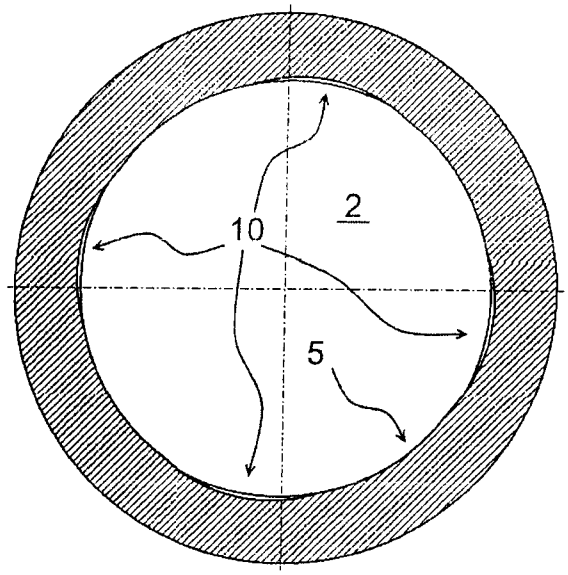

Fig. 4

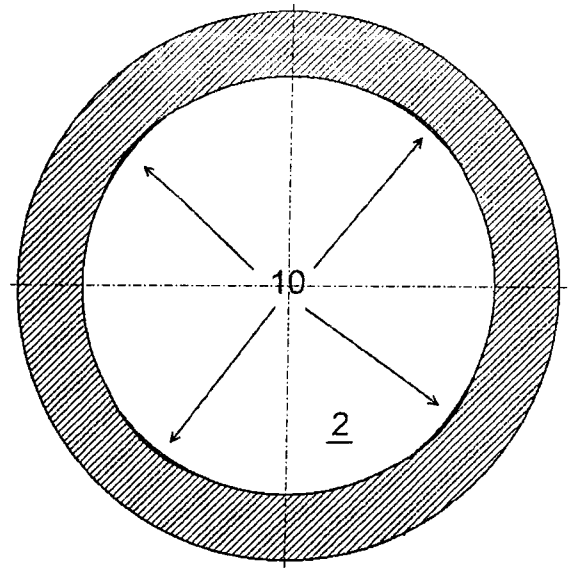

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Fig. 5

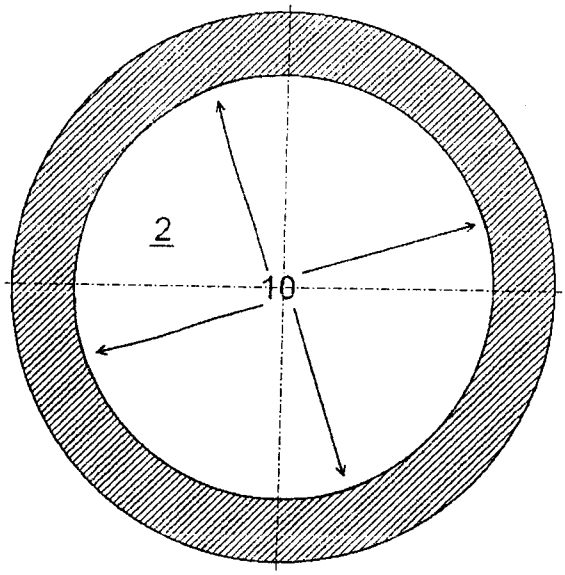

Fig. 6

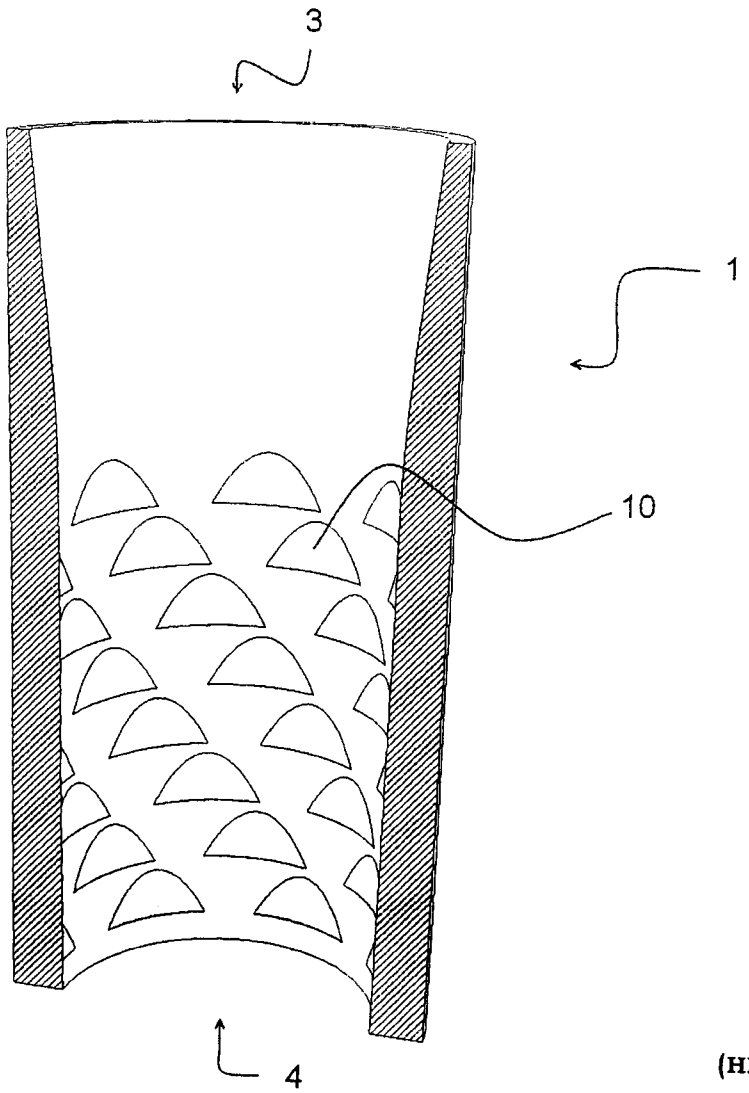

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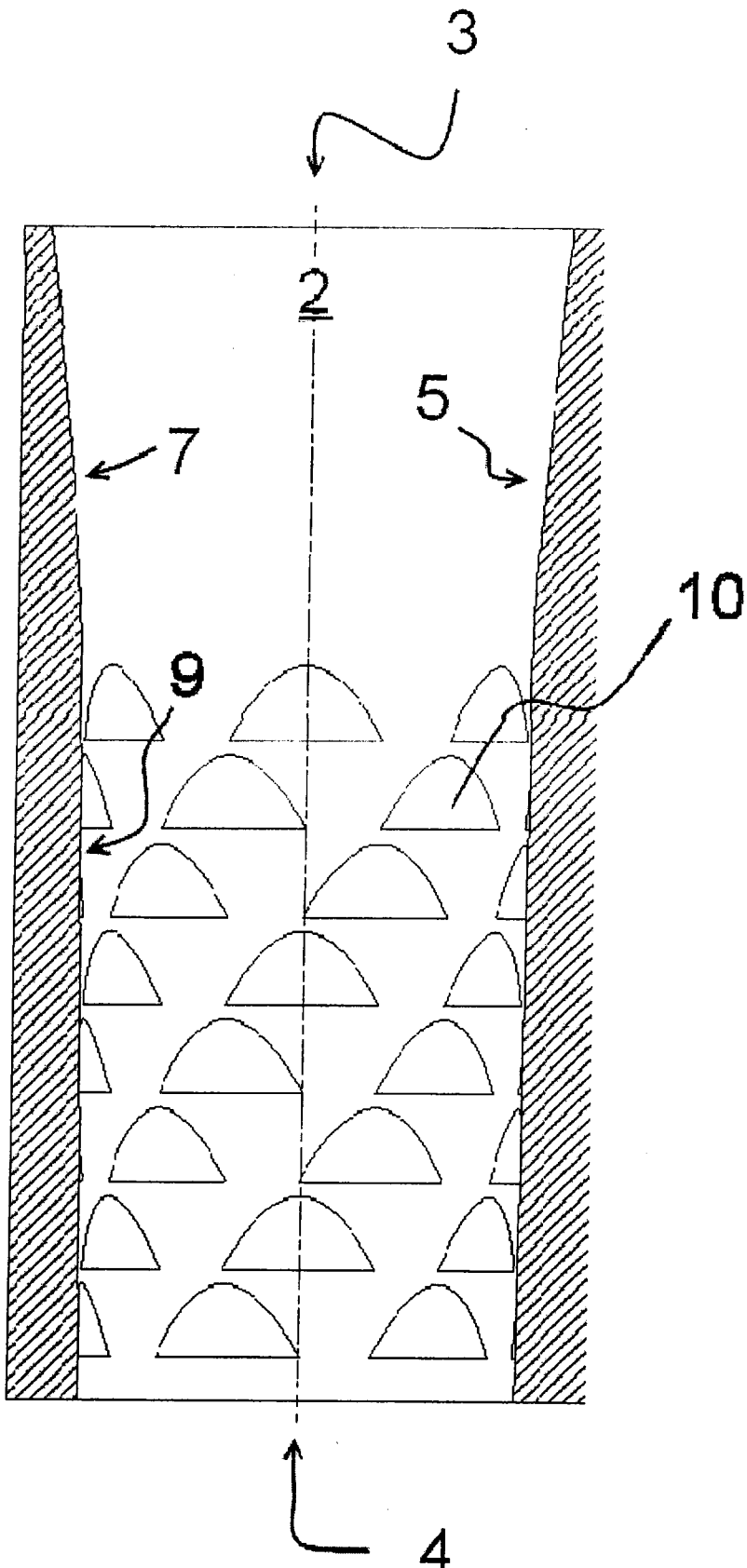
Fig. 7



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Description

Title of the invention

Mold for casting molten metal into a metal strand with a circular or polygonal cross section in a continuous casting machine

Technical field

The present invention relates to a mold for casting molten metal into a strand with a circular or polygonal cross section in a continuous casting machine.

Specifically, the invention relates to a mold for casting molten metal into a strand with a circular or polygonal cross section in a continuous casting machine,

- having a continuous mold cavity;
- wherein the mold cavity is delimited in a direction of withdrawal of the strand by a pouring-in opening for pouring the molten material into the mold and by a withdrawal opening for withdrawing the at least partially solidified strand from the mold;
- wherein the mold cavity is delimited transversely to the direction of withdrawal of the strand by an inner wall of the mold; and
- wherein the mold cavity has a region of load relief with an associated load-relief casting cone, wherein the region of load relief has a plurality of depressions in the inner wall of the mold for relieving the strand of load.

Prior art

A mold for casting molten metal into a strand, so-called continuous casting, with a substantially polygonal cross section is known from EP 0 958 871 A1, wherein this mold has a

continuous - in the direction of withdrawal of the strand -

mold cavity, which is delimited transversely to the direction of withdrawal of the strand by at least one conical inner wall. For adaptation to the shrinkage of the solidifying strand, the mold has three regions each with different casting cones. A casting cone is understood to mean a conical contour of the inner wall of the mold in the direction of withdrawal of the strand, the conicity (cone) of which is determined substantially by the shrinkage of the solidifying strand. Since the strand contracts upon solidification, the mold cavity is wider in the region of the liquid metal level than in a region located downstream - in the direction of withdrawal.

However, since the shrinkage of the strand during continuous casting is not constant and depends in particular on the chemical composition of the molten material, i.e. the alloy, the operating parameters of the continuous casting, e.g. the speed of withdrawal and the cooling of the strand, complete adaptation of the casting cone or of the casting cones to the shrinkage of the strand is not possible. If the casting cone is too small, i.e. the taper of the casting cone is weaker than the strand shrinkage, the contact between the strand shell and the inner wall of the mold is lost, resulting in a non-uniform and usually weak strand shell formation; if the casting cone is too strong, i.e. the taper of the casting cone is stronger than the strand shrinkage, this leads to sufficient and usually also homogeneous strand shell growth, but unnecessarily high contact pressures and therefore frictional forces are brought about. In this case, the strand becomes jammed to a certain extent in the mold, and therefore in extreme cases the strand may even be torn up or torn off.

Summary of the invention

Technical object

It is an object of the invention to provide a mold for casting molten metal into a strand with a circular or polygonal cross section in a continuous casting machine, with which firstly a sufficiently strong casting cone of the mold cavity can be predefined, such that sufficient and homogeneous growth of the strand shell is also ensured along the entire circumference of the casting cross section or of the mold cavity, and secondly unnecessarily high contact pressures and frictional forces of the strand in the mold, in particular jamming of the strand, are reliably prevented, even in the case of different chemical compositions of the molten material and in the case of different operating conditions.

Technical solution

This object is achieved by a mold of the type mentioned in the introduction in which a depression or a recurring sequence consisting of a region with a depression and a region without a depression extends over the longitudinal extent of the region of load relief in the direction of withdrawal, wherein the depression or the recurring sequence has the form of a helix. The depression or the recurring sequence provides a "degree of freedom" for the strand, in particular the strand shells which form, in the region of load relief of the mold, wherein a depression in each case realizes a zone in which there is no or only very little contact between the strand and the inner wall of the mold. This ensures that a sufficiently strong casting cone of the inner wall of the mold does not lead to unnecessarily high contact pressures and frictional forces of the strand in the mold, such that jamming of the strand in the mold in particular is reliably prevented. One or a plurality of individual depressions which extend over the longitudinal extent of the region of load relief can be produced easily and cost-effectively, e.g. by means of milling.

The recurring sequence ensures that the strand is relieved of load and contacted again to a more pronounced extent in a regular sequence, which has a positive effect on the quality of the strand. A depression or the recurring sequence in the form of a helix is favorable since the contact conditions are varied over the circumference and therefore it is not always the same region on the circumference which is relieved of load and contacted to a more pronounced extent. Alternatively, it is of course also possible for the depression or the recurring sequence to have a linear form.

Advantageous effects of the invention

In an advantageous embodiment, a depth of a depression in the inner wall decreases continuously and monotonically over an unwound length of the helix counter to the direction of withdrawal. Therefore, the depth of a depression decreases continuously counter to the direction of withdrawal of the strand.

In an advantageous embodiment, a width of a depression in the inner wall decreases continuously and monotonically over an unwound length of the helix counter to the direction of withdrawal of the strand. Therefore, the width of a depression decreases continuously counter to the direction of withdrawal of the strand.

By means of the two latter embodiments, the support of the strand in the direction of withdrawal thereof by the inner wall of the mold decreases continuously and monotonically, i.e. in the direction of withdrawal the strand is initially supported to a more pronounced extent (small thickness of the strand shell) and subsequently to a less pronounced extent (greater thickness of the strand shell).

In a simple embodiment, a depression is formed either as a groove or as a rounded-out portion, since these can be produced easily and cost-effectively.

In an advantageous embodiment, the region of load relief has a number of n depressions, wherein two adjacent depressions each have an angular offset of 360/n° about a mid-axis of the mold cavity. It is therefore possible to uniformly support the strand over the circumference of the mold cavity or the cross section of the strand.

In a further embodiment, the pitch of the helix is $n \cdot L_{II}$, where L_{II} denotes the dimension of the region of load relief in the direction of withdrawal of the strand. A helix which winds upward by 90° over the longitudinal extent of the region of load relief is thereby realized.

In one embodiment, an inlet region with an inlet casting cone is located upstream of the region of load relief, wherein the inlet region extends from the pouring-in opening to the region of load relief.

In one embodiment, an outlet region with an outlet casting cone is located downstream of the region of load relief, wherein the outlet region extends from the region of load relief to the pouring-out opening.

In a further advantageous embodiment, one or more cones from the group consisting of the inlet casting cone, the load-relief casting cone and the outlet casting cone have a parabolic conicity. The formation of the inner wall in the inlet region, in the region of load relief, in the outlet region or preferably in all regions with a parabolic, or less preferably with a linear, casting cone makes good adaptation to the shrinkage behavior of the strand possible.

In an advantageous embodiment, a transition from one casting cone to a following casting cone is formed continuously, preferably in a repeatedly continuously differentiable manner.

Stresses in the strand are thereby reduced or avoided in the transition from one region to the region located downstream.

In one embodiment, the mold cavity has a convex curvature. This ensures that the mold cavity is wider in a region located upstream than in a region located downstream - in the direction of withdrawal.

It is particularly advantageous to use the mold according to the invention in a continuous casting installation for producing a metal strand of steel with a circular or polygonal cross section.

Brief description of the drawings

Further advantages and features of the present invention will become apparent from the following description of non-limiting exemplary embodiments, where reference is made to the figures which follow:

figure 1 is a perspective illustration showing a mold for the continuous casting of a strand with a round cross section,

figure 2 is a sectional illustration showing the mold according to figure 1 in a front view,

figures 3 to 5 are sectional illustrations showing the mold according to figure 1 with the sectional planes I-I (figure 3), II-II (figure 4) and III-III (figure 5),

figure 6 is a perspective illustration showing a mold for the continuous casting of a strand with a round cross section,

figure 7 is a sectional illustration showing the mold according to figure 6 in a front view.

Description of the embodiments

Figure 1 shows a mold 1 for the continuous casting of a steel strand with a circular cross section (diameter 300 mm) in a continuous casting machine. In this case, molten steel is poured through a pouring-in opening 3 into a

mold cavity of the mold 1, wherein the molten steel is cooled in the mold cavity and in the process a solid shell of the steel strand is formed. The at least partially solidified strand is withdrawn through a withdrawal opening 4 in the mold and guided, supported and cooled further in a strand supporting device (not shown).

Figure 2 shows the mold according to figure 1 in more detail. In order to improve the clarity of the illustration, the depressions 10 are shown in enlarged form, i.e. on another scale. The mold has in particular a mold cavity 2 which is continuous in the direction of withdrawal of the strand and which is delimited in the direction of withdrawal by the pouring-in opening 3 and the withdrawal opening 4, and transversely to the direction of withdrawal by the inner wall 5. The inner wall 5 has a parabolic conicity which extends over an inlet region 6 and a region of load relief 8 - located immediately downstream of the inlet region 6 - of the mold 1, wherein the mold has a wall thickness of 20 mm at the pouring-in opening 3, a wall thickness of 22 mm at the transition from the inlet region 6 to the region of load relief 8 and a wall thickness of 24 mm at the withdrawal opening 4. The region of load relief 8 has four depressions 10 in the inner wall 5 which are each formed as a rounded-out portion and which extend in the form of a helix over the longitudinal extent of the region of load relief 8, i.e. from the start of the region of load relief 8 to the withdrawal opening 4. The depth and the width of a depression 10 decrease continuously and monotonically over the unwound length of the helix counter to the direction of withdrawal, the depression having a depth of 1 mm at the withdrawal opening 4. The decrease in the depth and in the width of the depressions 10 in the inner wall 5 is shown in more detail in figures 3 to 5, with the depressions being shown in enlarged form in these figures, too. So that the shell of the strand is supported as uniformly as possible over the

circumference of the mold cavity 2 in the region of load relief 8, but nevertheless a significant reduction in the withdrawal force of the strand is achieved, two

adjacent depressions 10 each have an offset of 90°, with respect to the mid-axis of the mold cavity 2 or of the strand.

Figures 6 and 7 show the mold according to figure 1 in another embodiment, wherein the depressions for relieving the strand of load in the inner wall 5 of the mold 1 are formed by a recurring sequence consisting of a region with a depression 10 and a region without a depression in the form of a helix. The transition from the inlet casting cone 7 of the inlet region to the load-relief casting cone 9 of the region of load relief is formed in a "smooth" manner, i.e. in a repeatedly differentiable manner, with both casting cones having a parabolic conicity.

The molds formed according to the invention have the effect that a sufficiently strong casting cone of the inner wall of the mold does not lead to unnecessarily high contact pressures and frictional forces of the strand in the molds, such that in particular jamming of the strand in the molds is reliably prevented.

List of reference signs

1	Mold
2	Mold cavity
3	Pouring-in opening
4	Withdrawal opening
5	Inner wall
6	Inlet region
7	Inlet casting cone
8	Region of load relief
9	Load-relief casting cone
10	Depression