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(54) **MOULD SIMULATOR**

FORMSIMULATOR

SIMULATEUR DE MOULE

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Description

[0001] The invention relates to a mould simulator for simulating casting conditions in a mould for continuous casting.

[0002] Such a mould simulator is disclosed in "Simulator for solidification in Continuous Casting Mold", Transactions ISIJ, Vol. 25 (1985), p.352. This known mould simulator comprises a water cooled cylinder, a metal cap over the outer end of the cylinder, means to lower and raise the cylinder and cap with respect to a support frame so as to lower cylinder and cap in a bath of molten metal or metal alloy and to lift it from said bath, means to move the cap with respect to the cylinder and means to oscillate the cylinder.

[0003] With this known mould simulator the initial stages of solidification of molten metal in a continuous casting mould including the oscillation marks on the solidified metal can be studied and the consumption of casting powder in the process. Moreover a desired oscillation pattern can be tested and different heat extractions could be simulated and measured.

[0004] In the description the term "metal" will be used and shall have the meaning of metal as well as metal alloy, unless specifically indicated otherwise.

[0005] In EP1596197 a device is disclosed with a cap consisting of two halves, wherein the caps can be moved relative to each other so as to exert a tensile force on the metal adhered to the cap. The device is dipped in a metal melt and lifted from the melt when sufficient metal has adhered to and solidified against the cap halves.

[0006] It is an objective of the present invention to provide a mould simulator that allows to exert a tensile force on the metal adhered to a sample member of the mould simulator while the sample member with the solidified metal is submerged in a bath of molten metal.

[0007] It is another objective of the present invention to provide a mould simulator in which the imposed tensile force will result in cracks in different directions in the metal adhered to the sample member.

[0008] It is another objective of the present invention to provide a mould simulator in which the force exerted on the solidified metal is measured.

[0009] It is still another objective of the present invention to provide a mould simulator which allows to experimentally test mould conditions in an easy and reliable manner.

[0010] According to a first aspect of the invention one or more of the above objectives are realized by providing a mould simulator for simulating casting conditions in a mould for continuous casting, the mould simulator comprising:

- a sample member and a cap at an outer end of the sample member, wherein the cap fits over the sample member and is movable with respect of the sample member,
- means to move the sample member and the cap with

respect to a support frame,

- means to move the cap with respect to the sample member,
- means to oscillate the sample member,
- cooling means for the sample member,

characterised in that,

- the sample member is provided with a separate section which is movable in outward direction with respect to the sample member, and
- that means are provided to move said separate section in said outward direction.

[0011] By providing a separate section that is movable in outward direction different tensile forces can be imposed on the metal adhered to the sample member which corresponds to the tensile forces occurring during continuous casting. In continuous casting transverse as well as longitudinal cracks occur in the cast slab wherein the longitudinal cracks predominantly arise in the part of the trajectory between the vertical position of the slab coming out of the mould and the horizontal position of the slab further down.

[0012] According to the invention it is provided that the separate section of the sample member is at a distance from the outer end of the sample member. Preferably the cap in the maximum overlapping position of the cap with respect to the sample member is positioned over the separate section of the sample member. In this configuration the part of the sample member with the separate section will be covered when the sample member is lowered in a bath of molten metal and the first metal will solidify against the cap. When the cap is moved with respect of the sample member which means that the cap is lowered further into the bath of molten metal, the metal will also start to solidify against the oscillating sample member. With the cap in its end position the solidified metal will also cover the separate section. The immersion depth of the sample member in the bath of molten metal and the dimensions of cap and separate section are taken such that the solidified metal comes against the sample member as well as below as above the separate section. The molten metal will solidify against the cooled sample member while enclosing a slag layer between the solidified metal and the sample member. Because of the oscillating movement of the sample member the solidified metal will show oscillation marks as is typical for continuous casting with an oscillating mould.

[0013] According to a further aspect of the invention it is provided that at least part of the sample member has a circular cross-section and wherein the separate section extends over at most half of the circumference of said part of the sample member. The sample member preferably has a shape that allows solidification of the metal in a more or less equal manner around the circumference, that is sharp corners in said shape are to be avoided. The most obvious shape would be a circular cylinder

shape like a tube which is also the easiest shape to provide. However, since it has appeared that with a tube with a circular cylinder shape the sample member and cap may get stuck during oscillation of the sample member and lowering of the cap while the metal adheres thereto, the sample member is preferably tapered. The smallest diameter of the sample member will be at the end with the cap. This means that a sample member or at least part of it is conical or frusto-conical with a small cone angle cone wherein in most cases a cone angle of less than 5° will suffice.

[0014] According to still a further aspect of the invention the outward direction of movement of the separate section is transverse to the axis of the part of the sample member with said circular cross-section. Although other angles are possible, a transverse direction is preferred because of easier manufacturing of the sample member and separate section and moreover, it will be easier to calculate tensile strain in the solidified metal and other parameters.

[0015] Furthermore, the separate section preferably has at least one side parallel and at least one side transverse to the axis of the part of the sample member with circular cross-section. Various shapes of the separate section are possible, wherein the sides parallel to said axis are needed to get the longitudinal cracks and the sides transverse to said axis to get cracks parallel to the oscillation marks. With sample member of circular cross-section there is no need to take transverse sides longer than half the circumference. The parallel sides are limited by the size of the cap, more in particular by the overlap of the cap with the outer end of the sample member. A further restriction is the distance the solidified metal should extend over the separate section. The solidified metal should preferably overlap the vertical and horizontal sides of the separate section with a sample member in use. Such an overlap also means that the ferro-static or metallo-static pressure will act on the complete surface area of the solidified metal while performing the test in the submerged condition. This is important because this pressure can be of crucial influence on the generation of some type of cracks and mechanical deformation.

[0016] In some cases it will be sufficient if the vertical sides are overlapped only partially with the upper horizontal side uncovered, such as with simulating longitudinal cracks (so parallel to the axis of the sample member) in very thin solidified metal.

[0017] According to a further aspect of the invention the means to move the separate section in outward direction with respect of the sample member comprise a driving member movable inside the sample member and wherein part of the driving member and separate section form a wedge system. The wedge system includes that driving member and separate section are both provided with an inclined surface with respect to the direction of movement of the driving member. By moving the driving member in one direction the inclined surfaces slide over each other therewith moving the separate section in out-

ward direction.

[0018] The means to move the driving member and therewith drive the separate section in outward direction comprise a pressure cylinder acting on the driving member in the sample member. According to a straightforward embodiment the pressure cylinder is a sleeve shaped cylinder positioned around the sample member with a first part connected to the sample member and a second moving part connected to the driving member.

[0019] In order to be able to measure the force exerted on the solidified metal on the sample member and separate section means to measure the pressure exerted by the pressure cylinder are provided. According to a further aspect of the invention the means to measure the pressure exerted by the pressure cylinder comprise a load cell connected to the pressure cylinder and the sample member. The load cell is provided between the first part of the ring shaped pressure cylinder and the sample member.

[0020] According to a further aspect of the invention the sample member comprises an outer tube and an inner tube wherein the inner tube is connected to a driving body which is in contact with the outer tube over part of the length of the outer tube at the end of the outer tube where the cap is provided. The inner tube and driving body forming the driving member to move the separate section. The driving body is in contact with the outer tube at the location of the separate section. To be able to drive the separate section in outward direction the driving body should be in close contact with the outer tube as to prevent any lateral movement of said driving body.

[0021] Preferably the driving body is in close contact with the outer tube over at least that part of the sample member that will be submerged in a bath of molten metal. Since the inner tube and driving body are needed to drive the separate section in outward direction and since the driving body has to be close against the outer tube, the cooling of the outer tube has to be done through the inner tube and the driving body. To this end a cooling liquid runs along the inside of the inner tube and a connected recess in the driving body therewith cooling the inner tube and the driving body and through the thermal contact between driving body and outer tube, the outer tube will be cooled sufficiently. Between driving body and outer tube a thermally conductive and friction lowering compound may be applied to improve thermal contact between driving body and outer tube and at the same time providing that the driving body and outer tube may be displaced with respect to each other with minimal friction.

[0022] According to a further aspect of the invention the means to move the cap with respect to the sample member comprise a rod or tube positioned in the central part of the sample member and connected at one end to the cap and at the other end to drive means to move the rod or tube and therewith the cap with respect to the sample member. The drive means for the cap are attached to the support frame and can drive the cap independent of the sample member. This setup allows to

move the cap with a certain speed downward in the bath with molten metal while the sample member itself is oscillating in the molten metal.

[0023] For the cooling of the sample member a further tube is positioned between the rod or tube to move the cap and the inner tube and the connected recess in the driving body in spaced relation thereto, forming respectively between the further tube and the rod or tube to move the cap and between the further tube and the inner tube and the connected recess in the driving body the supply and return channel for liquid cooling means.

[0024] The invention will be further explained on hand of the example shown in the drawing, in which:

- fig. 1 shows a view of the mould simulator,
- fig. 2 shows a longitudinal section of the mould simulator,
- fig. 3 shows an upper part of the mould simulator in more detail, and
- fig. 4 shows the lower part of the mould simulator in more detail
- fig. 5 A,B,C,D show various stages in the operation of the mould simulator.

[0025] In fig.1 a view of mould simulator 1 is shown, for clarity's sake without support frame and any further equipment. The said further equipment comprises means to lower and lift the mould simulator in and out a bath of molten metal and means to let at least part of the mould simulator oscillate.

[0026] The mould simulator 1 has a sample member 2 which comprises an outer tube 3 and a cap 4 over the end part of outer tube 3. The outer tube 3 is connected to a base plate 5 by means of coupling nut 6. The means to have at least part of the mould simulator oscillate engage at the base plate 5.

[0027] On the base plate a load cell 7, a sleeve shaped actuator cylinder 8 and inlet and outlet means 9 for a cooling fluid for sample member 2 are provided. At the upper end of the mould simulator a rod or tube 10 extends that runs through the mould simulator and connects to cap 4. The rod 10 is connected at its other end to means with which cap 4 can be lowered independently from other parts of the mould simulator 1.

[0028] In the longitudinal section of mould simulator 1 according to fig. 2 the details of various parts of the mould simulator 1 are clearly shown. The cap 4 is in a position against the end of the outer tube 3 with rod 10 in an end position relative to the mould simulator 1.

[0029] Inside outer tube 3 an inner tube 11 is provided leaving a free space 12 between outer tube 3 and inner tube 11. The inner tube 11 connects at its lower end to a cylindrical shaped driving body 13, which driving body is with its outer face in contact with the inside face of the outer tube 3. A cooling liquid such as water is fed through tube 11 and a recess in driving body 13 in order to cool driving body 13. The driving body 13 extends over a length that at least corresponds to the immersion depth

of the mould simulator in a bath of molten metal and preferably more than said depth. The reason for that is that cooling of the outer tube has to be done by means of a cooling liquid that runs through the recess in driving body 13, so that the cooling of the outer tube 3 has to be done through the thermal contact of driving body 13 with the outer tube 3. The outer tube 3 and driving body 13 are made of copper or a copper alloy to have a good thermal conductivity.

[0030] In the outside tube 3 a cut-out is made for a separate section 14 which is designed to be pushed out, therewith applying a tensile force and generate cracks in metal solidified against the sample member 2 after immersion in a bath of molten metal. The cut-out and the separate section 14 extend over part of the circumference, but preferably not over more than half of the circumference. At the inner side the separate section 14 is provided with an inclined surface 15 that rests against an inclined face 16 of a recess 17 for separate section 14 in the body 13.

[0031] The upper part of the inner tube 11 is connected at its end with a ring or sleeve shaped actuator cylinder 8 by means of which the inner tube 11 and driving body 13 can be lifted with respect to the outer tube 3 therewith moving the separate section in outward direction. This of course will not be done before cap 4 has been lowered till at least below separate section 14.

[0032] The sleeve shaped actuator cylinder 8 has a fixed part 18 connected to load cell 7 and a moving part 19 connected through in- and outlet means 9 to the upper part of the inner tube 11. The cylinder 8 is actuated by supplying a pressurized medium to the inlet 20 of cylinder 8.

[0033] The load cell 7 is fixed to base plate 5 and measures a reaction force exerted through fixed part 18 which gives a measure of the force exerted by the separate section 14 on a metal solidified against the sample member 2.

[0034] Between the actuator rod 10 for cap 4 and inner tube 11 and the recess in driving body 13 a further tube 21 is provided by means of which the space between rod 10 and inner tube 11 and driving body 13 is divided in a supply channel 22 and a return channel 23 for a cooling liquid. The lower end of tube 21 is at a distance from the end of the inner tube part 13 in that way forming a return connection between supply channel 22 and return channel 23 for the cooling liquid. The inlet and outlet means 9 for the cooling fluid is provided with an inlet 24 and an outlet 25 for the cooling fluid.

[0035] Fig. 3 and 4 show respectively the sleeve shaped actuator cylinder 8 and load cell 7 and the lower part of the mould simulator with cap 4 and separate section 14 in more detail.

[0036] In fig. 5A, B, C, D successive stages in the operation of the mould simulator are shown. In fig. 5A the sample member 2 of the mould simulator is lowered in a bath with molten metal such that cap 4 is below the liquid level 26. The metal will solidify against cap 4 and when

the outer tube 3 comes into contact with the liquid metal the metal will start to solidify against the outer tube 3. Before sample member 2 is put into oscillation cap 4 is first lowered over a distance sufficient to allow the sample member 2 to oscillate freely. The sample member 2 is subjected to an oscillating movement to prevent that solidified metal sticks to the sample member as is also done with a mould for continuous casting.

[0037] Fig. 5B shows a position with cap 4 further lowered therewith taking the solidified metal also further down. By taking the solidified metal down further liquid metal can solidify against the immersed part of sample member 2. In this manner a sleeve of solidified metal is build up around and against the sample member 2 above cap 4, in which the metal sticks against cap 4 but not against the cooled and oscillating sample member 2. The metal solidified against the cooled and oscillating sample member 2 shows oscillation marks in a direction transverse to the oscillation marks, which are similar to those which results from the oscillation of a mould for continuous casting.

[0038] In fig. 5C cap 4 has come to its lower most position wherein only the ultimate end of the oscillating sample member 2 remains covered by cap 4. In this position sample member 2 has solidified metal below and above separate section 14.

[0039] Fig. 5D shows with the cap in its end position how the separate section 14 is pushed outward by lifting the inner tube 11 and therewith driving body 13 by means of sleeve shaped cylinder 8. The force exerted by means of sleeve shaped cylinder 8 is measured by means of load cell 7 between base plate 5 and cylinder 8. By forcing separate section 14 outward the solidified metal will crack longitudinal and transverse to the direction of the oscillation marks on the solidified metal.

[0040] Instead of moving separate section 14 outward when the sample member 2 is still submerged the experiment can also be done by first lifting the sample member out of the liquid metal and then force the separate section in outward direction. When first lifting the sample member out of the liquid metal the sample member is preferably lifted into an oxygen free environment to prevent direct oxidation of the solidified metal. Oxidation of the metal would influence the experiment in an uncontrollable manner.

[0041] The experiment is preferably done with the sample member still submerged in the bath of liquid metal since that resembles most the situation where in continuous casting under ferro-static or metallo-static pressure the transverse and longitudinal cracks in the solidified metal are generated.

Claims

1. Mould simulator for simulating casting conditions in a mould for continuous casting, the mould simulator comprising:

- a sample member and a cap at an outer end of the sample member, wherein the cap fits over the sample member and is movable with respect of the sample member,
- means to move the sample member and the cap with respect to a support frame,
- means to move the cap with respect to the sample member,
- means to oscillate the sample member,
- cooling means for the sample member,

characterised in that,

- the sample member is provided with a separate section which is movable in outward direction with respect to the sample member, and
- that means are provided to move said separate section in said outward direction.

2. Mould simulator according to claim 1, wherein the separate section of the sample member is at a distance from the outer end of the sample member.
3. Mould simulator according to claim 2, wherein at least part of the sample member has a circular cross-section and wherein the separate section extends over at most half of the circumference of said part of the sample member.
4. Mould simulator according to claim 3, wherein the outward direction of movement of the separate section is transverse to the axis of the part of the sample member with said circular cross-section.
5. Mould simulator according to one or more of claims 2-4, wherein the separate section has at least one side parallel and at least one side transverse to the axis of the part of the sample member with circular cross-section.
6. Mould simulator according to one or more of claims 1-5, wherein the cap in the maximum overlapping position of the cap with respect to the sample member is positioned over the separate section of the sample member.
7. Mould simulator according to one or more of claims 1-6, wherein the means to move the separate section in outward direction with respect of the sample member comprise a driving member movable inside the sample member and wherein part of the driving member and separate section form a wedge system.
8. Mould simulator according to claim 7, wherein driving member and separate section are both provided with an inclined surface with respect to the direction of movement of the driving member.

9. Mould simulator according to claim 8, wherein a pressure cylinder is provided acting on the driving member in the sample member.
10. Mould simulator according to claim 9, wherein the pressure cylinder is a sleeve shaped cylinder. 5
11. Mould simulator according to claim 9 or 10, wherein means to measure the pressure exerted by the pressure cylinder are provided. 10
12. Mould simulator according to claim 11, wherein the means to measure the pressure exerted by the pressure cylinder comprise a load cell connected to the pressure cylinder and the sample member. 15
13. Mould simulator according to one or more of claims 1-12, wherein the sample member comprises an outer tube, an inner tube and connected to the inner tube a driving member wherein the driving member is in contact with the outer tube over part of the length of the outer tube at the end of the outer tube where the cap is provided, the inner tube and the driving body forming the driving member to move the separate section. 20 25
14. Mould simulator according to claim 13, wherein the means to move the cap with respect to the sample member comprise a rod or tube positioned in the central part of the sample member and connected at one end to the cap and at the other end to drive means to move the rod or tube with respect to the sample member. 30
15. Mould simulator according to claim 13 or 14, wherein between the rod or tube to move the cap and the inner tube a further tube is positioned in spaced relation thereto forming respectively at the inner and outer side thereof the supply and return channel for liquid cooling means. 35 40

Patentansprüche

1. Formsimulator zum Simulieren von Gießbedingungen in einer Form zum Stranggießen, wobei der Formsimulator Folgendes umfasst: 45
- ein Probenstückglied und einen Aufsatz an einem äußeren Ende des Probenstückglieds, wobei der Aufsatz auf das Probenstückglied aufgesetzt wird und gegenüber dem Probenstückglied beweglich ist, 50
 - Mittel zum Bewegen des Probenstückglieds und des Aufsatzes gegenüber einem Gestell, 55
 - Mittel zum Bewegen des Aufsatzes gegenüber dem Probenstückglied,
 - Mittel zum Oszillieren des Probenstückglieds,

- Kühlmittel für das Probenstückglied,

dadurch gekennzeichnet, dass

- das Probenstückglied mit einem separaten Abschnitt versehen ist, welcher in Auswärtsrichtung gegenüber dem Probenstückglied beweglich ist, und
 - die Mittel bereitgestellt werden, um den separaten Abschnitt in die Auswärtsrichtung zu bewegen.
2. Formsimulator nach Anspruch 1, wobei der separate Abschnitt des Probenstückglieds entfernt vom äußeren Ende des Probenstückglieds angeordnet ist.
3. Formsimulator nach Anspruch 2, wobei mindestens ein Teil des Probenstückglieds einen kreisförmigen Querschnitt umfasst und wobei sich der separate Abschnitt über höchstens die Hälfte des Umfangs des Teils des Probenstückglieds ausdehnt.
4. Formsimulator nach Anspruch 3, wobei die Auswärtsrichtung der Bewegung des separaten Abschnitts transversal zur Achse des Teils des Probenstückglieds mit dem kreisförmigen Querschnitt verläuft.
5. Formsimulator nach einem oder mehreren der Ansprüche 2-4, wobei der separate Abschnitt mindestens eine Seite, die parallel, und mindestens eine Seite, die transversal zur Achse des Teils des Probenstückglieds kreisförmigem Querschnitt umfasst.
6. Formsimulator nach einem oder mehreren der Ansprüche 1-5, wobei der Aufsatz in der maximalen Überlappungsposition des Aufsatzes gegenüber dem Probenstückglied über dem separaten Abschnitt des Probenstückglieds angeordnet ist.
7. Formsimulator nach einem oder mehreren der Ansprüche 1-6, wobei die Mittel zum Bewegen des separaten Abschnitts in eine Auswärtsrichtung gegenüber dem Probenstückglied ein Antriebsglied umfassen, das im Inneren des Probenstückglieds beweglich ist und wobei ein Teil des Antriebsglieds und des separaten Abschnitts eine Keilanlage bilden.
8. Formsimulator nach Anspruch 7, wobei sowohl das Antriebsglied als auch der separate Abschnitt mit einer Schrägfläche gegenüber der Bewegungsrichtung des Antriebsglieds versehen sind.
9. Formsimulator nach Anspruch 8, wobei ein Druckzylinder bereitgestellt wird, welcher das Antriebsglied im Probenstückglied angreift.
10. Formsimulator nach Anspruch 9, wobei der Druck-

zylinder ein manschettenförmiger Zylinder ist.

11. Formsimulator nach Anspruch 9 oder 10, wobei Mittel zum Messen des durch den Druckzylinder ausgeübten Drucks bereitgestellt werden. 5
12. Formsimulator nach Anspruch 11, wobei die Mittel zum Messen des durch den Druckzylinder ausgeübten Drucks eine Kraftmessdose umfassen, die mit dem Druckzylinder und dem Probenstückglied verbunden ist. 10
13. Formsimulator nach einem oder mehreren der Ansprüche 1-12, wobei das Probenstückglied ein Außenrohr, ein Innenrohr und ein mit dem Innenrohr verbundenes Antriebsglied umfasst, wobei das Antriebsglied mit dem Außenrohr über einen Teil der Länge des Außenrohrs am Ende des Außenrohrs, wo der Aufsatz bereitgestellt ist, in Kontakt ist, wobei das Innenrohr und der Antriebskörper das Antriebsglied zum Bewegen des separaten Abschnitts bilden. 20
14. Formsimulator nach Anspruch 13, wobei die Mittel zum Bewegen des Aufsatzes gegenüber dem Probenstückglied einen Stab oder ein Rohr umfassen, das im Mittelteil des Probenstückglieds angeordnet ist und an einem Ende mit dem Aufsatz und am anderen Ende mit Antriebsmitteln verbunden ist, damit der Stab oder das Rohr gegenüber dem Probenstückglied bewegt werden kann. 30
15. Formsimulator nach Anspruch 13 oder 14, wobei zwischen dem Stab oder Rohr zum Bewegen des Aufsatzes und dem Innenrohr in einem beabstandeten Verhältnis zu diesem ein weiteres Rohr angeordnet ist, wodurch an dessen Innen- bzw. Außenseite der Zuleitungs- und Rücklaufkanal für Flüssigkühlmittel gebildet wird. 35

Revendications

1. Un simulateur de moule permettant de simuler des conditions de moulage pour la coulée continue, le simulateur de moule comprenant : 45
 - un échantillon et un chapeau à l'extrémité extérieure de l'échantillon, le chapeau tenant sur l'échantillon et pouvant être déplacé relativement à l'échantillon, 50
 - un dispositif de déplacement de l'échantillon et du chapeau relativement à un cadre porteur,
 - un dispositif de déplacement du chapeau relativement à l'échantillon, 55
 - un dispositif d'oscillation de l'échantillon,
 - un dispositif de refroidissement de l'échantillon,

caractérisé en ce que

- l'échantillon est muni d'une section distincte pouvant être déplacée vers l'extérieur relativement à l'échantillon, et
 - les dispositifs sont conçus pour déplacer ladite section distincte vers l'extérieur.
2. Un simulateur de moule selon la revendication 1, dans lequel la section distincte de l'échantillon se trouve à une certaine distance de l'extrémité extérieure de l'échantillon.
 3. Un simulateur de moule selon la revendication 2, dans lequel d'une part au moins une partie de l'échantillon possède une section transversale, d'autre part la section distincte s'étend tout au plus sur la moitié de la circonférence de ladite partie de l'échantillon.
 4. Un simulateur de moule selon la revendication 3, dans lequel la direction vers l'extérieur du déplacement de la section distincte est transversale à l'axe de la partie de l'échantillon possédant ladite section transversale circulaire.
 5. Un simulateur de moule selon une quelconque des revendications 2-4, dans lequel la section distincte possède au moins un côté parallèle et au moins un côté transversal à l'axe de la partie de l'échantillon à section transversale circulaire.
 6. Un simulateur de moule selon une quelconque des revendications 1-5, dans lequel le chapeau dans sa position chevauchante maximale relativement à l'échantillon se trouve au-dessus de la section distincte de l'échantillon.
 7. Un simulateur de moule selon une quelconque des revendications 1-6, dans lequel les dispositifs de déplacement de la section distincte vers l'extérieur relativement à l'échantillon comprennent un élément d'entraînement déplaçable à l'intérieur de l'échantillon, une partie de l'élément d'entraînement et de la section distincte formant un système de cale.
 8. Un simulateur de moule selon la revendication 7, dans lequel l'élément d'entraînement et de la section distincte possèdent tous les deux une surface inclinée relativement au sens du déplacement de l'élément d'entraînement.
 9. Un simulateur de moule selon la revendication 8, comprenant un cylindre de pression agissant sur l'élément d'entraînement dans l'échantillon.
 10. Un simulateur de moule selon la revendication 9, dans lequel le cylindre de pression est un cylindre

en forme de gaine.

11. Un simulateur de moule selon la revendication 9 ou 10, comprenant un dispositif de mesure de la pression par le cylindre de pression. 5
12. Un simulateur de moule selon la revendication 11, le dispositif de mesure de la pression appliquée par le cylindre de pression comprenant une cellule de charge connectée au cylindre de pression et à l'échantillon. 10
13. Un simulateur de moule selon une ou plusieurs des revendications 1 à 12, dans lequel l'échantillon comprend un tube extérieur, un tube intérieur, et, relié au tube intérieur, un élément d'entraînement, l'élément d'entraînement étant en contact avec le tube extérieur sur une partie de la longueur du tube extérieur à l'extrémité de ce dernier où se trouve le chapeau, le tube intérieur et le corps d'entraînement constituant l'élément d'entraînement pour le déplacement de la section distincte. 15 20
14. Un simulateur de moule selon la revendication 13, dans lequel le dispositif de déplacement du chapeau relativement à l'échantillon comprend une tige ou un tube positionné dans la partie centrale de l'échantillon et relié à un bout du chapeau et à l'autre bout du dispositif d'entraînement pour déplacer la tige ou le tube relativement à l'échantillon. 25 30
15. Un simulateur de moule selon la revendication 13 ou 14, dans lequel, entre la tige ou le tube, est placé, pour déplacer le chapeau et le tube intérieur, un autre tube espacé relativement à ces derniers et formant respectivement aux côtés intérieur et extérieur de ces derniers, le canal de fourniture et de retour du dispositif de refroidissement du liquide. 35

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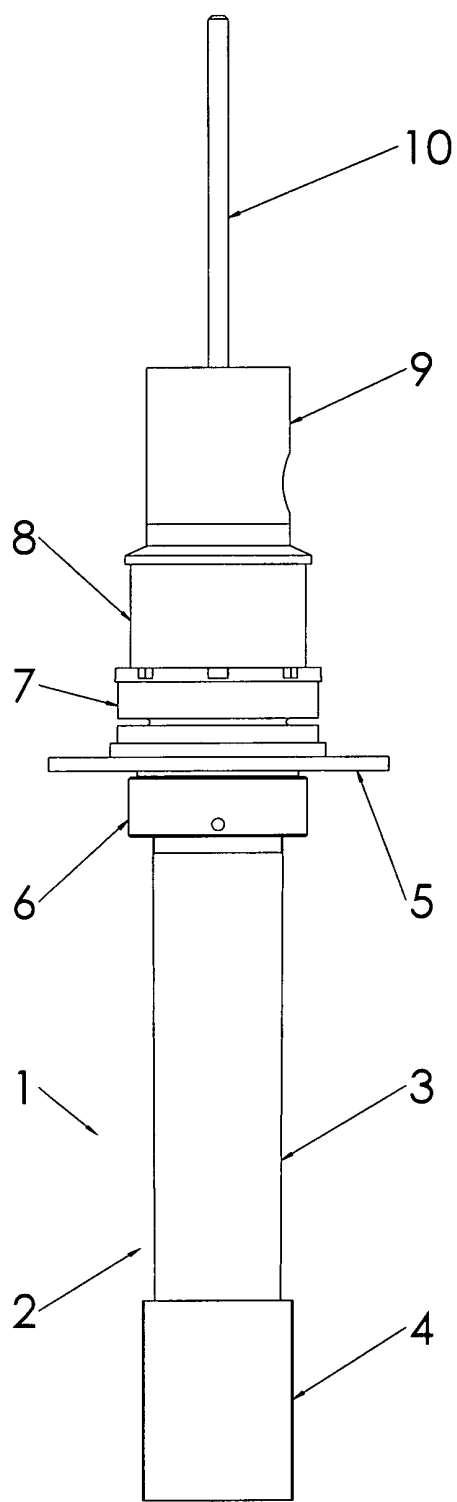


Fig. 1

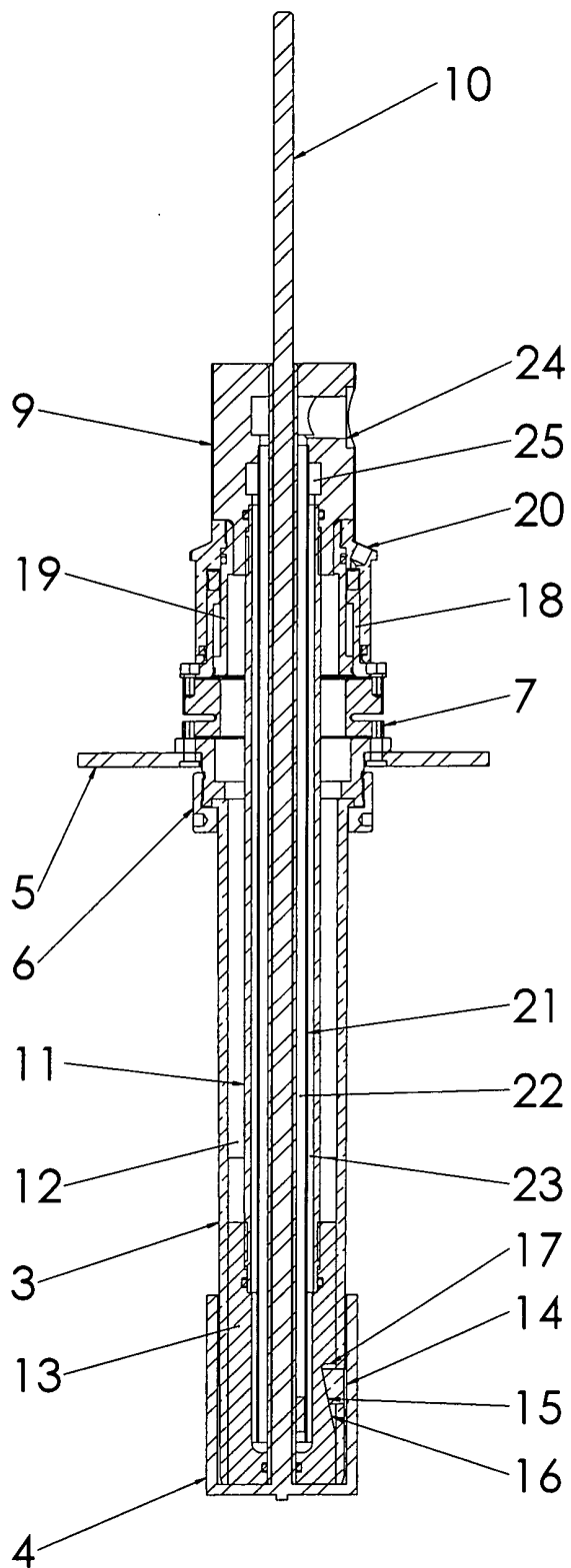


Fig. 2

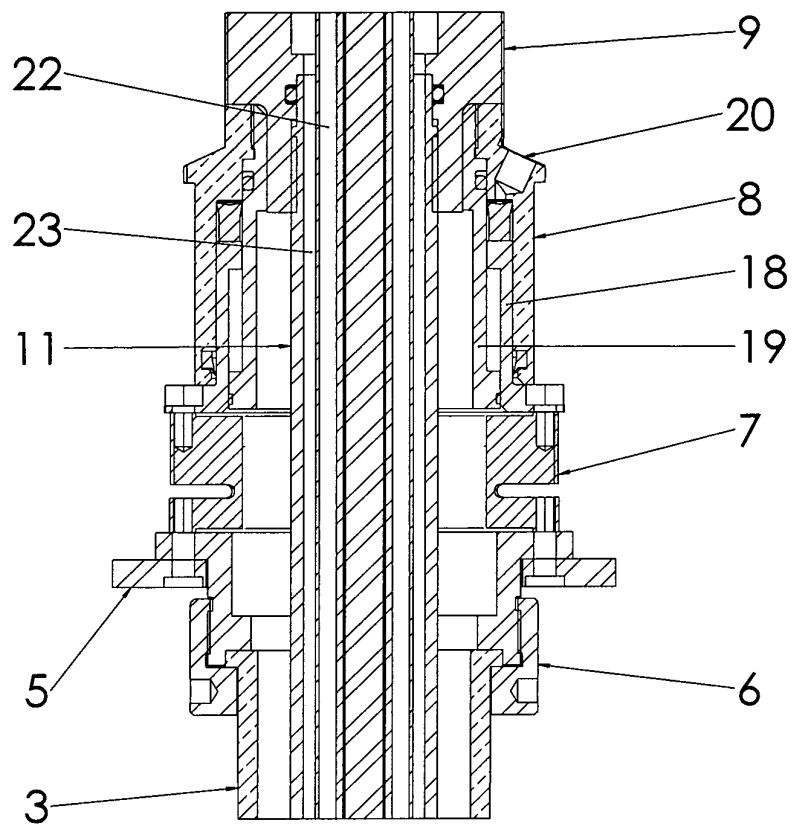


Fig. 3

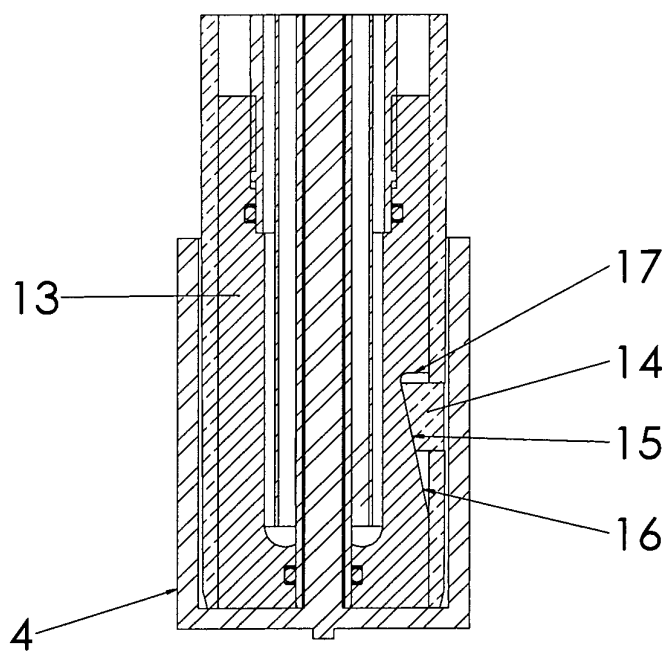


Fig. 4

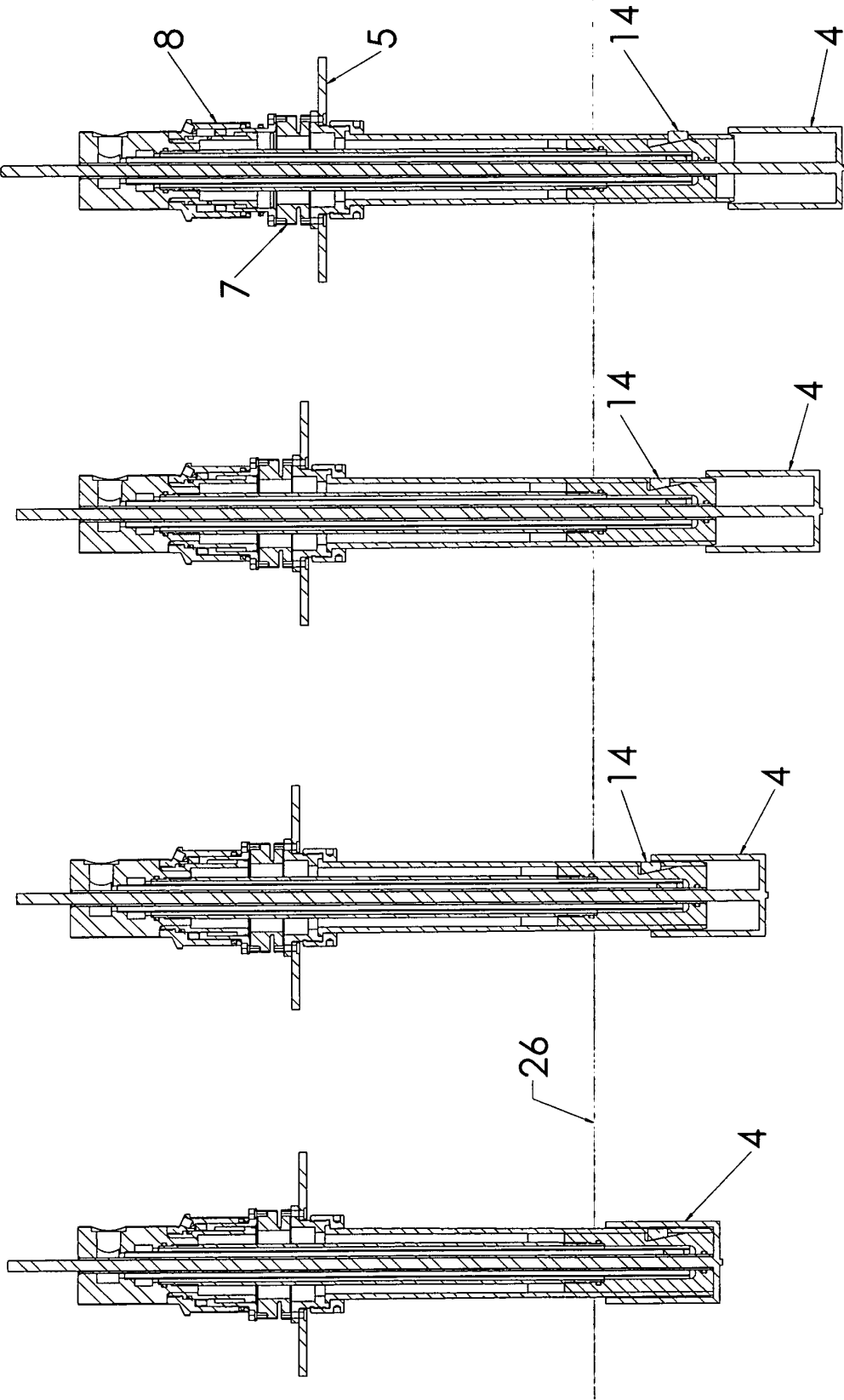


Fig. 5d

Fig. 5c

Fig. 5b

Fig. 5a

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 1596197 A [0005]

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