

DESCRIPTION

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METHOD OF, AND PRESS FOR, CLOSING A MOULD

The invention relates to a method of closing a mould before
5 at least partly filling a cavity of this mould with a solidifiable
liquid, whereby a first mould part is moved towards a second mould
part parallel to a central axis and pressed against the second
mould part by means of a hydraulic system, and subsequently a
mould cavity enclosed by the mould parts is filled with the
solidifiable liquid. The invention also relates to a press
suitable for carrying out this method, which press is provided
with a first mould part and a second mould part, which can be
moved relative to one another parallel to a central axis and can
be pressed against one another by means of a hydraulic system.

A method of the kind described in the opening paragraph and
a press for carrying out this method are known from German Patent
838.438. In a first phase of this known method, a first mould part
is moved from an initial position parallel to a central axis to
a second mould part by means of a liquid medium which is pumped
into a cylinder under a first pressure (for example, 35 at), upon
which in a second phase the same liquid medium is brought under
a second, increased pressure (for example, 200 at) in order to
press the mould parts together. After the solidifiable liquid has
cured, the first mould part is returned to its initial position
by purely hydraulic means. A disadvantage of the known method and
press is that the quantity of liquid medium which is displaced for
opening and closing the mould parts is comparatively great, so
that a comparatively large hydraulic pump is required with an
associated cooling device for cooling the liquid medium. The total
quantity of energy required for opening and closing the mould
parts as a result is comparatively great.

The invention has for its object to provide a method by which
the mould parts can be moved towards one another and pressed
against one another with a comparatively small quantity of liquid
medium having to be pumped.

The method according to the invention is characterised in
that a primary displacement of the first mould part parallel to

hydraulic system by means of a number of drive pins arranged between the follower pins and the hydraulic system and functioning as actuators, which drive pins are collectively rotatable about the central axis for alignment of the centrelines of the follower and drive pins. At the start of the primary displacement, the drive pins are in the idle position and the follower pins are situated between the drive pins. After the primary displacement, the drive pins are collectively rotated about the central axis in order to align the centrelines of the follower and drive pins. The drive pins are then in the operational position. The hydraulic system then exerts a force on the drive pins so that the drive pins are displaced during the secondary displacement, whereby the follower pins are displaced and the first mould part is pressed against the second mould part.

An embodiment of the press according to the invention is characterized in that the follower pins have their bearings in a slide which is displaceable by means of the mechanical drive, while the follower pins can be coupled to the hydraulic system at one side of the slide and cooperate with the first mould part at another side of the slide. The result of this is that the mechanical drive is not loaded when the mould parts are pressed against one another by means of the hydraulic system. Another advantage is that the mould parts can be easily exchanged upon the switch-over to a different product to be formed in the mould cavity, while the slide and the follower pins supported in the slide need not be removed from the press.

A further embodiment of the press according to the invention is characterized in that the follower pins are displaceable relative to one another and that the first mould part can be tilted about a pivot axis which is transverse to the central axis. As a result, the first mould part is pressed against the second mould part with forces evenly distributed over the mould part.

Another embodiment of the press according to the invention is characterized in that the press is provided with at least a stop pin which is situated between two follower pins and whose centreline extends parallel to the central axis. The stop pin determines in a simple manner a change-over position of the first mould part in which the product formed in the mould cavity can be

the central axis in the direction of the second mould part is carried out by means of a mechanical drive in a first displacement range, and subsequently in an adjoining second displacement range a secondary displacement of the first mould part parallel to the central axis in the direction of the second mould part is carried out purely by means of a hydraulic system by actuators which, after the primary displacement of the first mould part, are moved from an idle position to an operational position in which the mould parts are kept pressed against one another by the actuators after the secondary displacement has been completed by the actuators. The hydraulic system is suitable for exerting a comparatively great force during pressing together of the mould parts. A mechanical drive on the other hand is particularly suitable for moving the mould parts. Thus a mould part may be displaced over a comparatively large distance with a comparatively small force thereby. The term "mechanical drive" is here understood to mean any direct drive of the first mould part in which no use is made of a liquid medium for the transfer of forces during the displacement in the first displacement range. During the primary displacement, the mould parts are moved up to a small distance from one another by the mechanical drive. The quantity of liquid to be pumped in the method according to the invention is comparatively small and is used during the secondary displacement for displacing the first mould part over the very small distance which causes the first mould part to lie against the second mould part and for pressing together of the mould parts by means of the actuators.

The invention also has for its object to provide a press with which the disadvantage of the known press is counteracted. According to the invention, therefore the press suitable for carrying out the said method is characterised in that the press is provided with a mechanical drive by means of which the first mould part can be displaced parallel to the central axis and with a number of follower pins which cooperate with the first mould part and whose centrelines extend parallel to the central axis and which can be coupled to the

removed. The stop pin in this change-over position lies against the drive pin which has been brought into a position intermediate between the idle position and the operational position.

5 A yet further embodiment of the press according to the invention is characterized in that the drive pins have their bearings in a turret which is rotatable about the central axis. The result is that the drive pins are supported and rotated about the central axis in a simple manner.

10 A still further embodiment of a press according to the invention is characterized in that the turret is provided with a ring gear which is in engagement with a pinion and whose centreline coincides with the central axis. Such a turret drive is easy to manufacture and comparatively cheap to purchase and maintain.

15 A yet further embodiment of the press according to the invention is characterized in that the mechanical drive comprises a threaded spindle and a nut which is displaceable over this threaded spindle, the nut being coupled to the first mould part. Such a mechanical drive is particularly suitable for converting a rotary movement of, for example, an electric motor into a translatory movement, which is performed by the first mould part.

20 A still different embodiment of the press according to the invention is characterized in that a side of the first mould part facing away from the second mould part is provided with ribs which are situated opposite faces of the first mould part which can be pressed against the second mould part. In such a mould part, the compression force supplied by the hydraulic system of the press is transmitted *via* the ribs to the faces which can be pressed against the
25 second mould part. A better transfer of forces takes place by this than in the known press, in which the side facing away from the second mould part is entirely flat. The second mould part may also be provided with such ribs.

30 The invention is explained in more detail with reference to the drawing, in which

Figs. 1, 2 and 3 diagrammatically show a press according to the

invention suitable for carrying out the method according to the invention, in which

Fig. 1 shows the press during the first displacement range,

Fig. 2 shows the press during the second displacement range, the actuators being moved into an operational position, and

Fig. 3 shows the press while the two mould parts are pressed against one another;

Fig. 4 shows partly in front elevation and partly in cross-section a press suitable for carrying out the method according to the invention;

Fig. 5 shows a side elevation of the press of Fig. 4;

Fig. 6 shows a first and a second mould part according to the invention.

Corresponding parts have been given the same reference numerals in the various Figures.

The Figs. 1, 2 and 3 diagrammatically show in various phases a press 1 according to the invention suitable for carrying out the method according to the invention. The press 1 is provided with a base plate 3 and an upper plate 7 which is connected to the base plate 3 by means of four columns 5. One column of the three columns 5 is represented in part only for the sake of clarity (the fourth column is invisible). The columns 5 also serve as guides for a plate-shaped slide 9 which is movable along a central axis 13 which extends parallel to and central with respect to the centrelines 11 of the columns 5. The slide 9 is provided with a first support block 15 and a first mould part 17, while the upper plate 7 is provided with a second support block 19 and a second mould part 21, which together with the first mould part 17 encloses three mould cavities 22 (see Figs. 3 and 6). The shape of the mould cavities depends on the products to be formed. The slide 9 can be moved along the columns 5 by means of a mechanical drive which comprises a threaded spindle 23 and a nut 25 which can be moved along the threaded spindle 23 and is connected to the slide 9. The mechanical drive will be explained in more detail with reference to Fig. 4. The base plate 3 is provided with a hydraulic system 27 which will also be explained with reference to Fig. 4. Between the hydraulic system 27 and the bottom of the

slide 9 are positioned four drive pins 29 which function as actuators and which, after alignment, can exert a pressure force on four follower pins 31 which are slidably supported in the slide 9. The follower pins 31 bear on the first support block 15 above the slide 9. The press 1 has a turret 33 which can rotate about the central axis 13 and which comprises a bush 35 in which the threaded spindle 23 is arranged and two discs 37, 39 fastened to the bush 35 and providing the bearings for the drive pins 29 with sliding possibility. The disc 37 is provided with a ring gear 41 at its circumference which cooperates with a pinion 43 which is coupled to an electric motor 44 (see Fig. 5) via a shaft 42. In the position of the turret 33 shown in Fig. 1, the drive pins 29 are in an idle position. The first mould part 17 is at some distance from the second mould part 21 since the slide 9 has been moved in the direction of the base plate 3 by means of the mechanical drive until the stop pins 46 connected to the slide bear with their bottom ends on the upper ends of the drive pins 29. The follower pins 31 project through openings 45 in the disc 39. To move the mould parts 17, 21 against one another, the slide 9 is moved in the direction of the second mould part 21 in a first displacement range until the bottom ends of the follower pins 31 lie in a plane which, seen from the base plate 3, is higher than a plane in which the upper ends of the drive pins 29 are situated. The first mould part 17 is then at a small distance D from the second mould part 21. The distance D between the mould parts 17, 21 may be equal to 0 mm if the first mould part 17 is moved against the second mould part 21 by the mechanical drive. The position now occupied by the mould parts 17, 21 corresponds to the end of the primary displacement of the slide 9.

In this position of the slide 9 it is possible to rotate the turret 33 until the centrelines of the drive pins 29 are aligned in relation to the centrelines of the follower pins 31. The drive pins 29 are then in the operational position (see Fig. 2). In a second displacement range, the hydraulic system 27 exerts an equal force on each of the drive pins 29, so that the drive pins 29 are moved in the direction of the second mould part 21 until the upper ends of the drive pins 29 and the lower ends of the follower pins 31 lie against one another and exert a force on the follower pins 31 which are moved through the slide 9. A force is

thereby exerted on the first support block 15 which is moved in the direction of the second mould part 21 in the second displacement range until the mould part 17 connected to the support block 15 lies against the second mould part 21 (see Fig. 3). The hydraulic system presses the first mould part 17 against the second mould part 21 via the drive pins 29, the follower pins 31, and the first support block 15. A solidifiable liquid is then introduced into the mould cavity, for example, by means of a diagrammatically shown multi-plunger device 27 of a kind as described in, for example, US Patent 4723899 or German Patent 3336171. The solidifiable liquid may be a thermosetting or thermoplastic, usually electrically insulating synthetic material which is introduced into the mould cavity in liquid form and then cured or solidified. After filling of the mould cavity, the pressure of the hydraulic system 27 is set for zero N/m^2 , the turret 33 is turned into the idle position, and the slide 9 is moved in the direction of the base plate 3, upon which the formed product can be removed from the mould cavity and the press 1 is ready for a new cycle. For the exchange of the mould parts, the turret 33 is turned to a position in which both the follower pins 31 and the stop pins 46 can enter the openings 45 of the disc 39, and the slide 9 may be further moved in the direction of the base plate 3.

Figs. 4 and 5 show a press 2 of which the operational principle corresponds to that of the press 1 diagrammatically shown in Figs. 1, 2 and 3.

The mechanical drive of the press 2 comprises a threaded spindle 23 to which a gear 49 is fixed. The gear 49 is driven by a pinion 53 coupled to an electric motor 51 via a shaft 52. The mechanical drive further comprises a nut 25 which is connected to the slide 9 via coupling rods 54. When the threaded spindle 23 rotates, the nut 25 performs a translation parallel to the central axis 13 in upward or downward direction.

The hydraulic system 27 comprises a pneumatic pump 55, a transmission mechanism (not shown) and four pistons 59 which can move in cylinders 57. The transmission mechanism applies the air pressure of comparatively low value (for example, $3,5 \times 10^5 \text{ N/m}^2$) obtained by means of the pneumatic pump against a piston having an effective surface area A. A plunger is fastened to the piston having an effective surface area B and being in contact

with a liquid medium, for example, oil. The effective surface area B is smaller than area A by a factor X, so that the pressure exerted by the plunger is greater than the air pressure by the same factor X. In this way it is possible to apply oil under a high pressure to the pistons 59 *via* connection openings 61 by means of the pneumatic pump 55 so as to realise a compression force of 150.000 N for each cylinder 57. The pistons 59 each have a portion 63 of reduced diameter which can be moved through an opening 65 in a cover plate 67 of the base plate 3. During rotation of the turret 33, the drive pins 29 slide over the cover plate 67. The diameter of the drive pins 29 is greater than the diameter of the openings 65, so that the drive pins 29 cannot pass through the openings 65. In the second displacement range and during pressing, the portions 63 of reduced diameter of the pistons 59 press against the drive pins 29. The stroke of each piston is approximately 5 mm and is determined by the distance D between the first and second mould parts 17, 21, the distance between the lower ends of the follower pins 31 and the upper ends of the drive pins 29, which is approximately 1-2 mm, and the distance between the lower ends of the drive pins and the ends of the portions 63 of reduced diameter, which is also 1-2 mm. To strip the pistons 59 from the drive pins after pressing, the oil pressure is reduced to zero N/m² and an air pressure (for example, $3,5 \times 10^5$ N/m²) is applied to chambers 71 of the cylinders 57 *via* ducts (not drawn).

Each follower pin 31 is provided with a bore 30 in which an auxiliary peg is located, which is connected at one side 73A to the follower pin 31 and at another side 73B carries a circular support plate 75 which bears on the slide 9 and by means of which the follower pin 31 is suspended from the slide 9. Between the side 73A and the side 73B, the diameter of the bore 30 is greater than the diameter of the auxiliary peg 73, and the auxiliary peg is capable of bending under mechanical load. The circular support plates 75 support hardened plates 77 which are present in recesses 32 of the first support block 15.

When the first mould part 17 and the second mould part 21 are pressed against one another, surfaces of the first mould part 17 are pressed against surfaces of the second mould part 21. In practice, owing to tolerances, not all surfaces of the first mould part 17 will always hit against the surfaces of

the second mould part 21 at the same moment. If the mould part 17 can only be moved parallel to the central axis 13, the result will be that a minimum required clamping force will be applied to only a few surfaces of the mould parts. This results in that plastic material will creep between surfaces of the two mould parts during pressing, since these are insufficiently pressed against one another. To prevent this, the press 2 is provided with a "floating" first mould part 17. This means that the mould part 17 is movable not only parallel to the central axis 13, but is also tiltable about a pivot axis transverse to the central axis 13. The moment the first mould part 17 is already locally in contact with the other mould part 21 via a first follower pin 31 with the maximum force F supplied by the hydraulic system 27, the other follower pins 31 will try to displace the support block 15 and the first mould part 17 in the direction of the second mould part 21 until the force by which each of the follower pins 31 presses is equal to the force F . The support block 15 and the first mould part 17 as a result will tilt about the pivot axis until all follower pins 31 press against the first mould part 17 via the support block 15 with the same force F . This is possible because the follower pins 31 can be moved independently of one another and because the auxiliary pegs 73 are arranged in the follower pins 31 with bending possibility, so that the first support block 15 which rests on the support plates 75 is tiltable about the pivot axis.

Fig. 6 shows the first mould part 17 which is provided with ribs 81 at a side 79 remote from the second mould part 21, which ribs are situated opposite faces 83 of the first mould part 17 which can be pressed against the second mould part 21. The pressure force supplied by the hydraulic system 27 of the press 2 is transmitted to the ribs 81 by the first support block 15, the ribs passing the force on to the faces 83. The use of the mould part 17 depicted in Fig. 6 in combination with the tilting possibility of the mould part described above results in a very good compression of the first mould part 17 against the second mould part 21, so that no plastic material can enter between the surfaces of the two mould parts pressed together. It is possible to construct the first mould part 17 in mirror-symmetrical form, so that in case of wear of the side facing the second mould part, the first mould part 17 may be turned and the side 79 will

face the second mould part 21. For the sake of clarity, the mould parts 17, 21 are drawn in a position in which the mould parts 17, 21 do not lie against one another.

5 The mechanical drive may be realised by means of any known mechanism. As an alternative to the threaded spindle and the nut, for example, a linear motor may be used. The drive pins 29 may also have their bearings in a slide which is movable transverse to the central axis.

10 The term "hydraulic system" as used herein is taken to include systems operated by liquids and by gases.

The method of closing a mould, and press therefor, described herein are particularly suitable for encapsulating electronic components.

**CLAIMS**

1. A method of closing a mould before at least partly filling a cavity of this mould with a solidifiable liquid, whereby a first mould part is moved towards a second mould part parallel to a central axis and pressed against the second mould part and subsequently a mould cavity enclosed by the mould parts is filled with the solidifiable liquid, characterised in that a primary displacement of the first mould part parallel to the central axis in the direction of the second mould part is carried out by means of a mechanical drive in a first displacement range, and subsequently in an adjoining second displacement range a secondary displacement of the first mould part parallel to the central axis in the direction of the second mould part is carried out purely by means of a hydraulic system by actuators which, after the primary displacement of the first mould part, are moved from an idle position to an operational position in which the mould parts are kept pressed against one another by the actuators after the secondary displacement has been completed by the actuators.

2. A press suitable for carrying out the method as claimed in Claim 1, which press is provided with a first mould part and a second mould part, which can be moved relative to one another parallel to a central axis and can be pressed against one another by means of a hydraulic system, characterised in that the press is provided with a mechanical drive by means of which the first mould part can be displaced parallel to the central axis and with a number of follower pins which cooperate with the first mould part and whose centrelines extend parallel to the central axis and which can be coupled to the hydraulic system by means of a number of drive pins arranged between the follower pins and the hydraulic system and functioning as actuators, which drive pins are collectively rotatable about the central axis for alignment of the centrelines of the follower and drive pins.

3. A press as claimed in Claim 2, characterised in that the follower pins have their bearings in a slide which is



displaceable by means of the mechanical drive, while the follower pins can be coupled to the hydraulic system at one side of the slide and cooperate with the first mould part at another side of the slide.

5 4. A press as claimed in Claim 2 or 3, characterised in that the follower pins are displaceable relative to one another and that the first mould part can be tilted about a pivot axis which is transverse to the central axis.

10 5. A press as claimed in Claim 2, 3 or 4, characterised in that the press is provided with at least one stop pin which is situated between two follower pins and whose centreline extends parallel to the central axis.

15 6. A press as claimed in any one of the Claims 2 to 5, characterised in that the drive pins have their bearings in a turret which is rotatable about the central axis.

 7. A press as claimed in Claim 6, characterised in that the turret is provided with a ring gear which is in engagement with a pinion and whose centreline coincides with the central axis.

20 8. A press as claimed in any one of the Claims 2 to 7, characterised in that the mechanical drive comprises a threaded spindle and a nut which is displaceable over this threaded spindle, the nut being coupled to the first mould part.

25 9. A press as claimed in any one of the Claims 2 to 8, characterised in that a side of the first mould part facing away from the second mould part is provided with ribs which are situated opposite faces of the first mould part which can be pressed against the second mould part.

30 10. A method of closing a mould substantially as hereinbefore described with reference to Figures 1, 2, 3, 4 and 5 of the accompanying drawings.

 11. A press for closing a mould substantially as hereinbefore described with reference to, and as shown in, Figures 1, 2, 3, 4, 5 of the accompanying drawings.