

Device and method for separating a shaped substrate
from a stamping tool

The invention relates to the separation of a
5 shaped substrate from a stamping tool having a pair of
chamber parts, which can move with respect to one
another, of a closeable chamber, of which a first
chamber part serves as a support for the stamping tool
and a second chamber part serves as a support for the
10 shapeable substrate.

A method for producing microengineered
components is known under the name of LIGA process
(LIGA is a German acronym for Lithography with
Synchrotron Radiation, Electroplating, Molding using
15 plastics). By pressing a molding tool into a moldable
material, such as for example a layer of thermoplastic,
three-dimensional patterns with heights in the range
from a few nanometers to a few hundred micrometers are
produced, preferably under vacuum and at a temperature
20 which lies above the softening temperature of the
moldable material.

A device in accordance with DE 196 48 844 C1
which is suitable for this purpose contains a chamber
with one chamber part fixed to the frame and one
25 moveable chamber part. Setting the pressure and
temperature conditions inside the chamber is linked to
predetermined values of a force acting on the fixed
chamber part.

After the hot-molding process has finished, the
30 moldable material which has been applied to a substrate
support on the fixed chamber part adheres to the
patterns of the molding tool due to large aspect
ratios, shrinkage processes and surface roughness of
the said molding tool caused by the process, and has to
35 be separated in a suitable manner.

A device in accordance with DE 195 09 452 A1,
which is intended to keep flexural stresses at a low
level during demolding and to avoid geometric

limitations on the molding-tool surface available is used for this demolding.

A mold insert whose microstructure is transferred to a molded part is surrounded, in its edge area, by an ejector which, in order to demold the molded part, can be moved between an at-rest position and a working position. A space which can be filled with a pressurized fluid is provided on that side of the ejector which is remote from the molded part. In the working position of the ejector, the intention is that the fluid should act beneath the edges of the molded part, build up a pressure between the mold insert and the molded part which is to be demolded and, as a result, assist with demolding. Moreover, it is intended that the ejector be moved into its working position with the aid of the pressure from the fluid.

However, in the solution disclosed a method of operation of this nature, in which the space provided for the dual function of the fluid has to be designed as a pressure chamber and, in order to displace the ejector, has to act as a pneumatic cylinder, involves considerable unreliability. This is because the mold insert and the adjoining ejector, together with the layer of the molded part lying above it, are provided as wall elements of the space. The undefined adhesion of the molded part on the ejector may lead to unsealed areas and may have a considerable adverse effect on the function of the device.

Also, the control of the demolding process is undefined, both as a result of the force control applied and the termination by means of mechanical stops. The behaviour of the shaped part remains largely uncontrollable.

A further drawback is the edge-side matching of the ejector to the mold insert, since such a direct interface with an expensive component unnecessarily

increases the risk of damage or of some other adverse effect on the tool.

The object of the invention is to make demolding more operationally reliable and to largely
5 prevent damage to expensive components.

As claimed in the invention, the object is achieved by means of a device for separating a shaped substrate from a stamping tool having a pair of chamber parts, which can be moved with respect to one another,
10 of a closeable chamber, of which a first chamber part serves as a support for the stamping tool and a second chamber part serves as a support for the shapeable substrate. The chamber contains a substrate holder which, when the chamber is closed, fixes the substrate
15 to its support outside the stamping area, with the result that the substrate is detached from the stamping tool when the chamber is opened.

Furthermore, the substrate holder can be displaced parallel to the direction of movement of the
20 chamber parts and, together with the support for the stamping tool, encloses a first pressure chamber. Advantageously, the first pressure chamber is machined into the support for the stamping tool as an annular groove which the substrate holder delimits.

25 The pressure chamber contains the substrate holder as a moveable part and operates, with a high level of reliability, as a pneumatic cylinder with which the substrate holder is moved toward the substrate by increasing the volume of the chamber.

30 It is also advantageous if the substrate holder surrounds a tool holder on the support for the stamping tool, which tool holder engages around the peripheral face of the stamping tool. This avoids a direct interface between the expensive stamping tool and a
35 moveable part, thus considerably reducing the risk of damage.

Furthermore, the substrate holder, where it rests on the substrate, delimits, together with the tool holder, a second pressure chamber, into which at least one duct for compressed air is guided, through the tool holder, in order to assist with detaching the substrate from the stamping tool when the chamber is opened.

The support for the stamping tool contains feed ducts for compressed air, a first of which ducts is connected to the first pressure chamber and a second of which ducts is connected to the duct in the tool holder.

Moreover, the invention also relates to a method for separating a shaped substrate from a stamping tool inside a closed chamber which contains a pair of chamber parts which can move with respect to one another, of which a first chamber part serves as a support for the stamping tool and a second chamber part serves as a support for the shapeable substrate. The substrate is fixed to its support in an edge area which lies outside a stamping area and is detached from the stamping tool by opening the chamber.

It is advantageous if an initial detachment area which is formed in the fixed edge area when the chamber is opened is increased in size by means of compressed air and further opening of the chamber until the substrate is completely separated from the stamping tool.

In contrast to the known solution in accordance with DE 195 09 452 A1, in which the molded part is detached from the mold insert in functional terms only by means of force control by way of the ejector, the detachment of the substrate from the stamping tool is divided into various functional sequences which can be controlled differently. While the substrate is held to its support in the edge area, it is possible to separate it from the stamping tool by suitably

regulating the opening of the chamber. The performance of the molded part remains largely controllable. The substrate is not stripped off or ejected, but rather is initially held in place and is then pulled off.

5 For the functional sequences which can be carried out by means of compressed air, separate pressure chambers are provided, in which stable pressure conditions prevail at any time. Advantageously, the detachment operation can at any time be
10 reliably controlled in such a way that the moldable material is removed evenly, without spring-back effects and without tearing off patterns from the tool. The avoidance of manual rework, together with the possibility of automating the separate process steps
15 which can be reproduced subsequent to molding, lead to an increase in productivity.

The invention is to be explained in more detail below with reference to the diagrammatic drawing, in which:

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Fig. 1 shows a device for molding microengineered patterns

Fig. 2 shows a demolding device contained in the device in accordance with Fig. 1,

25 Fig. 3 shows an excerpt from the demolding device after demolding has taken place.

The molding device in accordance with Fig. 1, which operates under a vacuum, is constructed as a
30 closeable chamber and comprises chamber parts 1, 2 which can move with respect to one another, of which one chamber part 1 contains a support for a stamping tool 3 and the other chamber part 2, on a substrate support 4, contains a shapeable substrate 5.
35 Temperature-control plates 6, 7 set a temperature required for hot-stamping.

As can be seen more clearly from Fig. 2, the support for the stamping tool 3 contains a cylindrical tool holder 8, which is attached to a base plate 9 and sealed by a sealing ring 10 and engages around the peripheral face of the stamping tool 3. An annular groove 13, the inner cylindrical face 14 of which is extended by the cylindrical circumferential face 15 of the tool holder 8, is machined in the base plate 9, which is attached to the temperature-control plate 6 and sealed via sealing rings 11, 12. An annular substrate holder 16, which can be displaced parallel to the direction of movement of the chamber parts, forms, together with the groove 13 and the circumferential face 15 which extends it, a first pressure chamber 17, into which a first feed duct 18 for compressed air is guided through the base plate 9. The substrate holder 16, which on the end side has a projection 19, which serves as a blank holder, with a surrounding seal 20, bears, by way of sealing means 21, 22, against the outer cylindrical face 15 of the tool holder 8 and against the outer cylindrical face 23 of the groove 13, respectively. This ensures that the substrate holder 16, which can move in the axial direction, is able to operate like the piston of a pneumatic cylinder. The range of movement is delimited in one direction by the base plate 9 and in the other direction by stops, which are not shown. Restoring springs 24 serve to return the substrate holder 16 to its at-rest position after the feed of compressed air has been stopped. In the at-rest position, the substrate holder 16 is raised sufficiently far for the projection 19, together with the surrounding seal 20, not to project beyond the structured surface of the stamping tool 3, although this is not shown in any of the figures.

A second feed duct 25 for compressed air in the base plate 9 opens into a vertically running duct 26 and is extended, by a further duct 27 in the tool

holder 8, as far as an end-side outlet. The two feed ducts 18, 25 are supplied by a molding-device pneumatic control system (not shown) and can be activated separately.

5 The stamping cycle, in which the pattern of the surface of the stamping tool 3 is transferred to the substrate, for example in accordance with DE 196 48 844 C1, begins with the closure of the molding device. At this time, the substrate holder 16
10 is in the at-rest position. After the appropriate atmospheric conditions (vacuum) have been set using the pneumatic control system and the desired temperature has been set using the temperature-control plates 6, 7, the two chamber parts 1, 2 are positioned vertically
15 with respect to one another in a force- and distance-controlled manner until the stamping tool 3 comes into contact with the shapeable substrate 5. Then, by means of a force-controlled positioning operation, the substrate 5 is pressed into the stamping tool 3 in
20 accordance with set process parameters. After that, the chamber is cooled to a process-dependent demolding temperature by means of the temperature-control plates 6, 7. During this period, the surface contact between the stamping tool 3 and the substrate 5 which has been
25 brought about by the stamping operation is maintained in a force-regulated manner.

When the demolding temperature has been reached, standard atmospheric pressure conditions are again established in the chamber. After the pressure
30 equalization has taken place, compressed air is applied to the feed duct 18 by means of the pneumatic unit, compressed air being understood to mean a pressurized, gaseous medium which is suitable for the process.

As a result of the pressure building up in the
35 first pressure chamber 17, the substrate holder 16 is displaced towards the chamber part 2 until the projection 19, together with the surrounding seal 20,

rests on the surface of the substrate 5. Since this contact stops the movement, the substrate 5 is pressed towards the substrate support 4 with a force which is proportional to the air pressure. The sealed bearing of the annular projection 19 on the substrate 5 produces a second pressure chamber 28 which is also delimited by the substrate 5, the tool holder 8 and the stamping tool 3 and into which the duct 27 opens out.

After the pressure chamber 28 has been filled with compressed air via the ducts 25, 26, 27, the distance between the two chamber parts 1, 2 is continuously increased. The substrate 5, which is constantly pressed on to the substrate support 4 by the substrate holder 16 due to the pressure prevailing in the first pressure chamber 17, is pulled off the stamping tool 3 from the edge. The compressed air present in the second pressure chamber 28 immediately flows into the gap which is formed and assists with detachment of the substrate 5, with a demolding force which is proportional to the air pressure. The increase in the area on which the air acts, which increase is related to the progressive detachment, leads to a further increase in the demolding force. The detachment process is uniformly distributed over the periphery of the substrate 5 and is not associated with any spring-back effects.

The continuous movement of the chamber parts 1, 2 is carried out with a defined, uniform speed for a predetermined distance. After the end of this movement, the compressed-air feed to the pressure chambers 17 and 28 is interrupted. The restoring springs 24 move the substrate holder 16 back into its at-rest position.

When the substrate 5 has been completely detached from the stamping tool 3, the chamber can be opened.

Patent claims

1. A device for separating a shaped substrate from a stamping tool having a pair of chamber parts, which
5 can move with respect to one another, of a closeable chamber, of which a first chamber part serves as a support for the stamping tool and a second chamber part serves as a support for the shapeable substrate, wherein the chamber contains a substrate holder (16)
10 which, when the chamber is closed, fixes the substrate (5) to its support outside the stamping area, with the result that the substrate (5) is detached from the stamping tool (3) when the chamber is opened.
2. The device as claimed in claim 1, wherein the
15 substrate holder (16) can be displaced parallel to the direction of movement of the chamber parts (1, 2) and, together with the support for the stamping tool (3), encloses a first pressure chamber (17).
3. The device as claimed in claim 2, wherein the
20 substrate holder (16) surrounds a tool holder (8) on the support for the stamping tool, which tool holder engages around the peripheral face of the stamping tool (3).
4. The device as claimed in claim 3, wherein the
25 first pressure chamber (17) is machined into the support for the stamping tool (3) as an annular groove (13) which the substrate holder (16) delimits.
5. The device as claimed in claim 4, wherein the
30 substrate holder (16), where it rests on the substrate (5), delimits, together with the tool holder (8), a second pressure chamber (28), into which at least one duct (27) for compressed air is guided, through the tool holder (8), in order to assist with detaching the substrate (5) from the stamping tool (3) when the
35 chamber is opened.
6. The device as claimed in claim 5, wherein the support for the stamping tool (3) contains feed ducts

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(18, 25) for compressed air, a first of which ducts is connected to the first pressure chamber (17) and a second of which ducts is connected to the duct (27) in the tool holder.

- 5 7. A method for separating a shaped substrate from a stamping tool inside a closed chamber which contains a pair of chamber parts which can move with respect to one another, of which a first chamber part serves as a support for the stamping tool and a second chamber part
10 serves as a support for the shapeable substrate, wherein the substrate (5) is fixed to its support in an edge area which lies outside a stamping area and is detached from the stamping tool (3) by opening the chamber.
- 15 8. The method as claimed in claim 7, wherein an initial detachment area which is formed in the fixed edge area when the chamber is opened is increased in size by means of compressed air and further opening of the chamber until the substrate (5) is completely
20 separated from the stamping tool (3).

