

## Title of the Invention

### Drawing apparatus and drawing method

## Background of the Invention

[0001]

The present invention concerns a drawing apparatus and a drawing method, more specifically, a drawing apparatus and a drawing method realized in a way to be capable of taking out a material, the inner surface of which has been formed into a concavo-convex shape with drawing, from a mold with excellent release performance.

[0002]

Conventionally, a method using electron beam has been adopted, in the case where there is a need of forming the inner surface of a product into a concavo-convex shape, as with the vessel of apparatuses for making physical vapor deposition (PVD), chemical vapor deposition (CVD), etc.

## Summary of the Invention

[0003]

However, the above-mentioned method using electron beam had problems such as necessity of expensive equipment, long working time, and high working cost.

[0004]

On the other hand, there are press working and drawing, as general forming method of this type of products, but a problem was that, in the case where an attempt is made to form the inner surface of a product into a desired concavo-convex shape, by means of press working, no sufficient amount of the mass of material flows into the concave part of the mold, thus making it impossible to form the inner surface of the product in desired concavo-convex shape.

Moreover, another problem was that, in the case where the concavo-convex part formed in the inner surface of the product is of a shape causing it to get caught in the direction of pulling out of the product against the mold, no forming can be made by the method of press working or drawing.

[0005]

The objective of the present invention, realized in view of the above-described conventional problems in the case of forming of the inner surface of a product into a concavo-convex shape, is to provide a drawing apparatus and a drawing method capable of taking out a material, the inner surface of which has been formed in concavo-convex shape with drawing, from a mold with excellent release performance, even in the case where the concavo-convex part formed in the inner surface of the product is of a shape causing it to get caught in the direction of pulling out of the product against the mold.

[0006]

To achieve said objective, the drawing apparatus according to the present invention is a drawing apparatus comprising a mold disposed at the tip of a spindle and a squeezing roller for forming a material into a shape along the surface shape of the mold, characterized in that said mold is realized in a split structure having a concavo-convex surface shape and contractible in diameter after the forming of the material.

[0007]

In this case, it may be possible to construct said mold with split molds formed separately in the circumferential direction and a core portion, and incline the split surfaces at which said split molds get in slide contact with each other, in the direction of pulling out of the material which has been submitted to drawing.

[0008]

Furthermore, the drawing method according to the present

invention is a drawing method for forming a material, placed on a mold disposed at the tip of the spindle, into a shape along the surface shape of the mold by means of a squeezing roller, characterized in that it uses, as said mold, a mold realized in a split structure having a concavo-convex surface shape and contractible in diameter after the forming of the material, and consists in forming the material placed on the mold, in the state in which the mold is assembled in prescribed shape, into a shape along the surface shape of the mold by means of a squeezing roller, and then contracting the mold in diameter to release the material which has been submitted to drawing from the mold.

[0009]

In this case, it may be possible to construct said mold with split molds formed separately in the circumferential direction and a core portion, incline the split surfaces at which said split molds get in slide contact with each other, in the direction of pulling out of the material which has been submitted to drawing and, after the forming of the material, cancel the press supporting in radial direction of the split molds by the core, to relatively displace the split molds alternately in the direction of pulling out of the material which has been submitted to drawing.

[0010]

According to the drawing apparatus and drawing method of the present invention, by forming a material placed on a mold, in the state in which the mold is assembled in prescribed shape, into a shape along the surface shape of the mold by means of a squeezing roller, and then contracting the mold in diameter and releasing the material submitted to drawing from the mold, it becomes possible to take out the material the inner surface of which has been form in a concavo-convex shape by means of drawing from a mold with excellent release performance, even in the case where the concavo-convex part formed in the inner surface of

the product is of a shape causing it to get caught in the direction of pulling out of the product against the mold.

[0011]

And, to be more concrete, it becomes possible to release the material, the inner surface of which has been formed into a concavo-convex shape by means of drawing, easily and accurately, without deforming it, after the forming of the material, by cancelling the press supporting in radial direction of the split molds by the core, relatively displacing the split molds alternately in the direction of pulling out of the material which has been submitted to drawing, and contracting the split molds in diameter.

#### Brief Description of the Drawings

Fig. 1 is a partially omitted front elevation showing a first embodiment of the drawing apparatus according to the present invention.

Fig. 2 indicates the mold of the drawing apparatus above, (a) being a front elevation, and (b) a side view.

Fig. 3 is a partially omitted front elevation showing the state in which a material was submitted to drawing with the drawing apparatus above.

Fig. 4 is an explanatory drawing of the split molds, (a) showing the pressing force acting on the split mold on one side, (b) the pressing force acting on the split mold on the other side, and (c) the state in which the material has been finally released.

Fig. 5 is a partially omitted front elevation showing a second embodiment of the drawing apparatus according to the present invention, (a) showing a state in which the core press supports the respective split molds in radial direction, and (b) a state in which a chuck press fixes the material.

Fig. 6 is a partially omitted front elevation showing other form of

10, in diameter.

[0015]

The shape of the state in which the mold 10 is assembled with the split molds 11, 12 and the core portion 13 is not particularly restricted, and its corner part may be worked in the shape of a circular arc in sectional view, as shown in Fig. 1, or worked as a straight sloped face.

Moreover, the concavo-convex surface shape of the mold 10 is designed to form a large number of concave parts depressed in the shape of dimples on the curved surface of the mold 10, in this embodiment, though it is not particularly restricted either.

[0016]

The split mold 11 is designed to form split surfaces 11a, 11a at which it gets in slide contact with the adjacent split mold 12 in a shape sloped in a way to spread toward the direction of pulling out of the material W, as shown in Fig. 2 (b), while on the other hand the split mold 12 is designed to form split surfaces 12a, 12a at which it gets in slide contact with the adjacent split mold 11 in a shape sloped opposite to the direction of slope of the split surface 11a in a way to face the split surface 11a.

Furthermore, the inner surface of the split molds 11, 12 is formed in the shape sloped against the shaft center of the spindle 2 in sectional view so that it may get in slide contact with the side face of the core portion 13 in the shape of a cone, truncated cone, pyramid or truncated pyramid.

And, one same number (4 pcs. in this embodiment) of split mold 11 and split mold 12 are combined, to constitute the mold 10 in prescribed shape.

[0017]

The split molds 11, 12 are pressed in the direction perpendicular to the shaft center of the spindle 2 (direction in which the mold 10

diminishes in diameter), by a presser member 4 incorporated in a ring-shaped presser plate 21 attached to a mold base 20 disposed at the tip of the spindle 2.

Still more, the split mold 11 is pressed in the direction parallel to the shaft center of the spindle 2 (direction of pulling out of the material W), by a presser member 5 attached to the mold base 20.

The presser members 4, 5 are designed, though not particularly restricted, to press the split molds 11, 12 by using a spring, in this embodiment.

[0018]

Although the direction of pressing by the presser member 5 is given as the direction of pulling out of the material W, in this embodiment, it is also possible to contract the entire mold 10 in diameter by furnishing the split mold 12 with a tensile force in the direction opposite to the direction of pulling out of the material W.

[0019]

The core portion 13 is not particularly restricted in shape, if only it can press support the split molds 11, 12 in the radial direction, and may take the shape of a cone, truncated cone, pyramid (octagonal pyramid in the case where the split mold is split into 8 parts) or truncated pyramid and, in this embodiment, it takes the shape of a truncated cone so that its shaft center may agree with the shaft center of the spindle 2 in which the spindle 2 and the split molds 11, 12 are expanded in diameter.

The core portion 13 performs pressing and releasing in radial direction against the split molds 11, 12 by moving in the direction parallel to the shaft center of the spindle 2, causing the split molds 11, 12, jointly with the presser member 4, to make actions of expansion and shrinkage of their diameter.

The moving means of the core portion 13 is constructed, though not particularly restricted, integrally with a chuck 31 for fixing the

material W by pressing it against the mold 10, in this embodiment, to move the core portion 13 by means of a tailstock mechanism 3 which makes a tailstock barrel 30, provided with the chuck 31 at its tip, advance or retreat.

Yet more, the core portion 13 may be designed to press support the split molds 11, 12 in the radial direction, by constructing the spindle 2 in a hollow structure and pulling the core portion 13 to the spindle 2 side (left side in Fig. 1).

[0020]

Next, explanation will be given on the method of drawing made by using this drawing apparatus.

In the first place, press support the split molds 11, 12 in the radial direction, as shown in Fig. 1, by pressing the core portion 13 to the left side in the illustration together with the chuck 31 by means of the tailstock mechanism 3, against the split molds 11, 12 of the mold 10 disposed at the tip of the spindle 2. At that time, the material W is also fixed to the mold 10 by the chuck 31.

[0021]

Next, press the squeezing roller R against the material W fixed to the mold 10, as shown in Fig. 3, while turning the spindle 2 by means of a driving mechanism (not illustrated), and form the material W into a shape along the surface shape of the mold 10.

[0022]

And, after forming the material W, cancel the press supporting in radial direction of the split molds 11, 12 by the core portion 13, relatively displace the split molds 11, 12 in the direction of pulling out of the material W which has been submitted to drawing, and contract the split molds 11, 12, namely the entire mold 10, in diameter.

To be more concrete, on the split mold 11, a pressing force 4Pa in the diameter contracting direction by the pressure member 4 and a

pressing force  $5P$  in the direction of pulling out of the material  $W$  by the pressure member 5 act, as shown in Fig. 4 (a) and on the split mold 12, a pressing force  $4P_b$  in the diameter contracting direction by the pressure member 4 acts respectively, as shown in Fig. 4 (b), and the split mold 12 moves in the direction of bottom left (inside) in the illustration relatively against the material  $W$ , in this embodiment. As a result, the convex portion formed on the inner surface of the material  $W$  is released from the concave portion formed on the surface of the split mold 12.

And, the split mold 11, while moving to the right side in the illustration under the pressing force  $5P$  in the direction of pulling out of the material  $W$  by the pressure member 5, in linkage with said motion of the split mold 12, diminishes in diameter, together with the split mold 12, under the pressing forces  $4P_a$ ,  $4P_b$  in the diameter reducing direction by the pressure member 4, thus enabling the material  $W$  to be released from the split mold 11.

[0023]

Fig. 5 indicates a second embodiment of the drawing apparatus and drawing method according to the present invention.

This drawing apparatus is identical to that of the first embodiment in the construction of the split molds 11, 12 of the mold 10, and therefore explanation on their construction will be omitted.

And, the drawing apparatus of this embodiment is realized in a way to connect the core portion 13 with the chuck 31, for pressing the material  $W$  against the mold 10, through a buffer mechanism 6, to firmly fix the material  $W$ , even in the case where the thickness of the material  $W$  is uneven, thus enabling to accurately perform the press supporting in radial direction of the split molds 11, 12 by the core portion 13.

[0024]

The buffer mechanism 6 may be composed, though not particularly restricted, of a hole portion 63 opened in the chuck 31 fixed to the tip of

press supporting in radial direction of the split molds 11, 12 by the core portion 13, as shown in Fig. 6 (b).

[0028]

Other constructions and the procedure and action of the drawing method in this embodiment are the same as those in the first embodiment described above.

[0029]

Explanation has so far been made on the drawing apparatus and drawing method according to the present invention based on a plurality of embodiments. However, the present invention is not restricted to the constructions described in the above-mentioned embodiments, but may be modified in construction as required within a range not deviating from the main purpose of the invention, such as fixing the spindle, to enable application to a drawing apparatus which performs drawing by disposing a squeezing roller on a rotary shaft, etc.

[0030]

The drawing apparatus and drawing method according to the present invention have an advantage of being capable of taking out a material, the inner surface of which has been formed into a concavo-convex shape with drawing, from a mold with excellent release performance, even in the case where the concavo-convex part formed in the inner surface of the product is of a shape causing it to get caught in the direction of pulling out of the product against the mold and, for that reason, they can be used widely in the case of forming of the inner surface of a product into a concavo-convex shape.

## Claims

1. A drawing apparatus comprising a mold disposed at the tip of a spindle and a squeezing roller for forming a material into a shape along the surface shape of the mold, characterized in that said mold is realized in a split structure having a concavo-convex surface shape and contractible in diameter after the forming of the material.

2. A drawing apparatus as defined in Claim 1, wherein said mold is constructed with split molds formed separately in the circumferential direction and a core portion, and the split surfaces at which said split molds get in slide contact with each other is inclined in the direction of pulling out of the material which has been submitted to drawing.

3. A drawing method for forming a material, placed on a mold disposed at the tip of the spindle, into a shape along the surface shape of the mold by means of a squeezing roller, characterized in that it uses, as said mold, a mold realized in a split structure having a concavo-convex surface shape and contractible in diameter after the forming of the material, and consists in forming the material placed on the mold, in the state in which the mold is assembled in prescribed shape, into a shape along the surface shape of the mold by means of a squeezing roller, and then contracting the mold in diameter to release the material which has been submitted to drawing from the mold.

4. A drawing method as defined in Claim 3, wherein said mold is constructed with split molds formed separately in the circumferential direction and a core portion, and the split surface at which said split molds get in slide contact with each other is inclined in the direction of pulling out of the material which has been submitted to drawing and, after the forming of the material, the press supporting in radial direction of the split molds by the core is cancelled, to relatively displace the split molds alternately in the direction of pulling out of the material which has been submitted to drawing, and contract the split molds in diameter.