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(54) IRONING PUNCH

(57) In an ironing punch (1) to be used for metal ironing, a dot-shaped recess (3) is distributed on an outer peripheral surface (1a) of the ironing punch 1, and a raised portion (5) is formed on at least part of a peripheral edge portion of the dot-shaped recess (3).

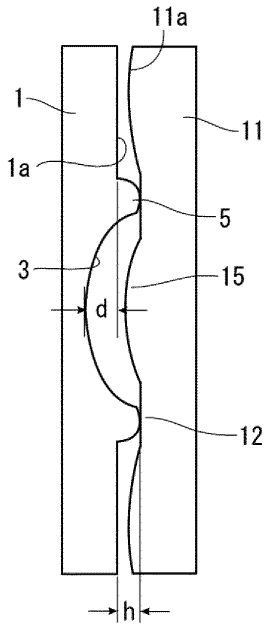

FIG. 2

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Description

Technical Field

[0001] The present invention relates to an ironing punch to be used for ironing and further relates to an ironing method for thinning a metal cylinder by using the punch and an ironing can obtained by the ironing method.

Background Art

[0002] Ironing is a severe plastic processing performed for thinning a metal and is applied to manufacture of a metal cylinder that is thinned and has an increased height (a thinned metal cylinder), for example, a thinned seamless can (also called an ironing can). Such ironing is performed by passing a hollow metal cylinder through a narrow space (intra-die space) surrounded by an annular die using a rod-shaped punch. Specifically, the metal cylinder is thinned by inserting the punch into the metal cylinder to be thinned, sandwiching the metal cylinder between the punch and the annular die, and the punch and relatively moving (sliding) the annular die in this state. For example, Patent Documents 1 and 2 disclose a technique for manufacturing a seamless can (sometimes referred to as an ironing can or a drawing and ironing can) by applying such ironing.

[0003] In such ironing, the punch needs to be pulled out from the thinned metal cylinder after the ironing is completed. Here, the problem is that, in the ironing, an inner surface of a body portion of the metal cylinder as a workpiece is strongly pressed against an outer peripheral surface of the punch, thus a large frictional resistance is exerted, and the punch cannot be smoothly pulled out, lowering the productivity and, in some cases, causing the inner surface of the body portion of the shaped metal cylinder to be damaged by pulling out.

[0004] In fact, the pulling-out property of the punch in such ironing has hardly been examined.

[0005] For example, Patent Document 3 discloses a metal seamless can having a thermoplastic resin layer formed on an inner surface thereof and having a large number of point-shaped protrusions formed on the thermoplastic resin layer on the inner surface. This technique forms point-shaped protrusions to relax a molecular orientation of the thermoplastic resin layer caused by ironing. This suppresses a decrease in dent resistance due to the molecular orientation in the thermoplastic resin layer. That is, in Patent Document 3, to form the point-shaped protrusions in the thermoplastic resin layer on the inner surface of the can, ironing is performed by using a punch in which point-shaped (dot-shaped) recesses are formed on the outer peripheral surface.

[0006] As can be understood from this, the pulling-out property of the ironing punch is not examined at all in Patent Document 3, either.

Citation List

Patent Literature

[0007]

Patent Document 1: WO 2017/033791
Patent Document 2: JP 2018-69256 A
Patent Document 3: JP 3327137 B

Summary of Invention

Technical Problem

[0008] Thus, an object of the present invention is to provide an ironing punch having an excellent pulling-out property after ironing.

[0009] Another object of the present invention is to provide an ironing method for thinning a metal cylinder by using the above-described punch and an ironing can obtained by the ironing method.

Solution to Problem

[0010] As a result of many experiments and studies on the pulling-out property of the punch after ironing, the present inventors have found that the pulling-out property of the punch is greatly improved by forming a large number of dot-shaped recesses on the outer surface of the punch by punching to complete the present invention.

[0011] The present invention provides an ironing punch to be used for metal ironing. In the ironing punch, a dot-shaped

recess is distributed on an outer peripheral surface of the ironing punch, and a raised portion is formed on at least part of a peripheral edge portion of the dot-shaped recess.

[0012] According to a punching type for forming the dot-shaped recess, the above-described ironing punch can take the following configuration:

(1) the raised portion is formed over an entire periphery of the peripheral edge portion of the dot-shaped recess; or
(2) the raised portion is formed on part of a peripheral edge portion of the dot-shaped recess.

[0013] In particular, when the raised portion is formed on part of the peripheral edge portion as in (2) above, the following aspect is preferable:

(2-1) the raised portion (partially raised portion) is formed on part of the peripheral edge portion of the dot-shaped recess on a side opposite to the punch tip side;
(2-2) when viewed in a cross section along an axial direction of the punch, the dot-shaped recess has a shape having the deepest portion disproportionately located on the side opposite to the punch tip side; and
(2-3) the eccentricity ratio of the deepest portion ranges from 30 to 100%.

[0014] The present invention also provides an ironing method including inserting the above-described ironing punch into a metal cylinder, performing ironing by passing the metal cylinder through an annular die, and thinning the metal cylinder by pulling out the punch after the ironing is completed.

[0015] In such an ironing method, the following is desirable:

(3) the metal cylinder includes an organic resin layer on an inner surface of the metal cylinder; and
(4) the organic resin layer is formed of a thermoplastic resin.

[0016] The present invention further provides an ironing can including a body portion having a hollow cylinder and a bottom portion closing a lower end of the body portion. In the ironing can, a dot-shaped protrusion is distributed on an inner peripheral surface of the body portion, and an apex of the dot-shaped protrusion is disproportionately located in a direction opposite to a bottom portion when viewed in a longitudinal section along an axial direction.

[0017] The ironing can is manufactured by ironing using the ironing punch having the raised portion (partially raised portion) as illustrated in (2) above.

[0018] In such an ironing can, the following is suitable:
(5) an organic resin layer is laminated on the inner peripheral surface of the body portion, and the dot-shaped protrusion is distributed on the surface of the organic resin layer.

Advantageous Effects of Invention

[0019] The ironing punch of the present invention has the dot-shaped recess distributed on the outer peripheral surface, and a major feature thereof is that the raised portion is formed on at least part of the peripheral edge portion of the dot-shaped recess.

[0020] That is, performing ironing the metal cylinder by using the punch in which the dot-shaped recess in the above-described form is distributed forms the protrusion corresponding to the dot-shaped recess on the inner peripheral surface of the metal cylinder due to thinning by the ironing. When the punch is pulled out after the ironing, the pressure contact force between the outer surface of the punch and the inner peripheral surface of the metal cylinder is relaxed by the raised portion present on the periphery of the dot-shaped recess. Consequently, the ironing punch can be easily pulled out, allowing productivity to be increased.

[0021] The raised portion as described above is formed over the entire periphery of the peripheral edge portion of the dot-shaped recess or is formed on part of the peripheral edge portion, in particular, in part opposite to the punch tip side (on a side in a direction of pulling out the punch). According to such a form of the raised portion, the ironing punch of the present invention can be divided into an annularly raised type and a partially raised type. In either case, the punch has good pulling-out property.

Brief Description of Drawings

[0022]

FIG. 1 is a view for explaining thinning of a workpiece (metal cylinder) by ironing.
FIG. 2 is a partially enlarged schematic longitudinal section view illustrating a longitudinal section of an ironing punch

(annularly raised type) of the present invention together with a thinned workpiece (metal cylinder).

FIG. 3 is a partially enlarged schematic developed plan view of an outer peripheral surface of the ironing punch illustrated in FIG. 2.

FIG. 4 is a partially enlarged schematic developed plan view of an inner peripheral surface of the workpiece (metal cylinder) illustrated in FIG. 2.

FIG. 5 is a schematic vertical cross-sectional view illustrating an engagement relationship between the ironing punch and a thinned seamless can at the end of ironing when the workpiece is a metal seamless can.

FIG. 6 is a view for explaining a configuration of rollback generated by pulling out the ironing punch.

FIG. 7 is a view illustrating a longitudinal section (X-section in FIG. 8) of the ironing punch (partially raised type) of the present invention.

FIG. 8 is a partially enlarged schematic developed plan view of the outer peripheral surface of the ironing punch illustrated in FIG. 7.

FIG. 9 is a partially enlarged side cross-sectional view of the workpiece (metal cylinder) thinned by ironing using the ironing punch of FIG. 7.

FIG. 10 is a view illustrating the engagement relationship between the punch of FIG. 7 and the workpiece (metal cylinder) of FIG. 9 at the end of ironing.

FIG. 11 is a view illustrating an example of a press molding using ironing.

FIG. 12 is a view illustrating an example of an ironing can shaping process when ironing is performed in multiple stages.

Description of Embodiments

Ironing

[0023] Ironing is known as a typical method of plastic processing of a metal, and is widely used, for example, in a method of manufacturing a seamless metal can (also called an ironing can) that is thinned and has an increased height. In the ironing, as illustrated in FIG. 1, when a metal cylinder B, which is a workpiece, is moved in a processing direction by an ironing punch A, an ironing die C is pressed against the outer surface of the cylinder B to rub the cylinder B, thereby thinning the cylinder B. Therefore, in such ironing, the inner peripheral surface of the metal cylinder B is firmly pressed against the outer peripheral surface of the ironing punch A.

[0024] In such ironing, an ironing rate is expressed by the following equation, where t_0 is a plate thickness of the metal cylinder before ironing and t_1 is the plate thickness after ironing. The greater the ironing rate, the greater the surface pressure applied to the ironing die C and the punch A, resulting in severe shaping.

$$\text{Ironing rate } (\%) = 100 \times (t_0 - t_1)/t_0$$

[0025] The ironing punch A has a tubular (cylindrical) shape, and is generally formed of a cemented carbide similar to the ironing die C described below, and is formed relatively thick to prevent deformation during ironing. A drive shaft S (not illustrated in FIG. 1 and indicated by S in FIG. 5) for moving the punch A in the processing direction is connected to the inner surface of one end portion (upstream side with respect to the processing direction in FIG. 1) of the punch A.

[0026] The metal serving as a constituent material of the metal cylinder B to be subjected to the ironing as described above may be various metals or alloy materials, and may be, for example, aluminum, copper, iron, an alloy containing these metals, a tin-plated steel plate such as a tin plate, or a surface-treated steel plate such as an aluminum plate subjected to chemical conversion treatment. The inner peripheral surface of the metal cylinder B (the surface in close contact with the outer peripheral surface of the ironing punch A) may be coated with a thermoplastic resin, for example, a polyester resin such as polyethylene terephthalate. Such resin coating can prevent the inner surface from being corroded or scratched.

[0027] Further, since a remarkably high surface pressure is applied to the ironing die C as the ironing ratio increases, it is necessary to perform the formation with the ironing die C that is a considerably hard material. Examples of such hard materials include so-called cemented carbide obtained by sintering a mixture of tungsten carbide (WC) and a metal binder such as cobalt, cermet obtained by sintering a mixture of a metal carbide such as titanium carbide (TiC), a titanium compound such as titanium carbonitride (TiCN), and a metal binder such as nickel or cobalt, and hard ceramics such as silicon carbide (SiC), silicon nitride (Si_3N_4), alumina (Al_2O_3), and zirconia (ZrO_2). Further, the processing surface of the ironing die C (i.e., the surface in contact with the cylinder B that is a workpiece) may be coated with a carbon film such as a diamond film. Such a carbon film can be formed by vapor deposition such as CVD.

Ironing Punch and Metal Cylinder of Present Invention

[0028] The above-mentioned ironing punch and the metal cylinder are closely engaged with each other at the time of ironing, and the ironing punch of the present invention includes an annularly raised type in which the raised portion is formed in a ring shape over the entire periphery of the peripheral edge portion of the dot-shaped recess and a partially raised type, an arc type, in which the raised portion is formed on part of the peripheral edge portion of the dot-shaped recess.

1. Annularly Raised Type Ironing Punch

[0029] See FIG. 2, which illustrates a longitudinal section of this type of ironing punch together with a thinned workpiece (metal cylinder), and FIG. 3, which illustrates a partially enlarged schematic developed plan view of the punch.

[0030] In FIGS. 2 and 3, the ironing punch 1 has a large number of dot-shaped recesses 3 formed on an outer peripheral surface 1a of the ironing punch 1. The recess 3 is concave in a cone shape such as a conical shape or a pyramidal shape, and a raised portion 5 is formed in a ring shape over the entire periphery of the peripheral edge portion of each of the recesses 3 (see, in particular, FIG. 3). That is, the raised portion 5 is part raised from the punch outer peripheral surface 1a around the recess 3.

[0031] Also, refer to FIG. 4 illustrating a plan developed view of the inner peripheral surface of the metal cylinder that has been thinned by ironing.

[0032] As a result of the formation of the dot-shaped recesses 3 on the outer peripheral surface 1a of the ironing punch 1, a large number of dot-shaped protrusions 15 are formed on an inner peripheral surface 11a of a thinned metal cylinder 11. That is, the dot-shaped protrusions 15 each correspond to the dot-shaped recesses 3 formed in the ironing punch 1 (in particular, see FIGS. 3 and 4).

[0033] When the ironing is completed, the ironing punch 1 is inserted into the thinned metal cylinder 11, and the outer peripheral surface 1a of the ironing punch 1 is held in a state of being firmly in contact with the inner peripheral surface of the thinned metal cylinder 11. For example, a positional relationship between the ironing punch and the thinned metal cylinder 11 in the state in which the ironing is completed is as illustrated in FIG. 5. This positional relationship is exactly the same even when an arc type ironing punch 1 described below is used.

[0034] That is, the thinned metal cylinder 11 has a bottom portion 17 like a seamless can (ironing can), the ironing punch 1 extends to the bottom portion 17 of the cylinder 11, and a region Q where the outer peripheral surface 1a of the punch 1 is in contact with the inner peripheral surface of the metal cylinder 11 is a region functioning as a processing holding surface in ironing. In general, a drive shaft S is connected to part of the punch 1 above the region Q, and by driving the shaft S, the ironing punch 1 moves in the processing direction, and after the ironing is completed, the ironing punch 1 moves in the pull-out direction which is the opposite direction to the processing direction.

[0035] Therefore, after the ironing is completed, as illustrated in FIG. 5, the movement of the metal cylinder 11 in the height direction of the punch 1 is restricted by a stopper 20 in order to pull out the ironing punch 1.

[0036] As illustrated in FIG. 5, in a case where the metal cylinder 11 has the bottom portion 17 like a can, the assist air is blown simultaneously with the pulling out by the drive shaft S, so that the pulling out of the punch 1 can be easily performed. In the case where the metal cylinder 11 does not have the bottom portion 17 as in the case of a hollow pipe, the tip of one side of the cylinder 11 (tip of the processing direction side) is formed to have a small diameter and the punch 1 does not to come off so that the punch 1 can firmly hold and move the metal cylinder 11.

[0037] For example, if the outer peripheral surface of the ironing punch 1 and the inner peripheral surface of the metal cylinder 11 are completely in close contact with each other in the region Q when the ironing punch 1 is pulled out from the configuration after the ironing is completed, the frictional resistance becomes extremely large, the efficiency of the pulling out operation is poor, the productivity is inevitably reduced, the inner peripheral surface of the metal cylinder 11 is roughened (when the thermoplastic resin layer is formed, the thermoplastic resin layer is peeled off) at the time of pulling out, and the load applied to the drive shaft S or the like becomes large, which causes problems such as a reduction in the life of the apparatus. However, according to the present invention, as illustrated in FIGS. 2 and 3, a large number of ring-shaped raised portion 5 is distributed over the entire periphery of the peripheral edge portion of the dot-shaped recesses 3 formed in a large number on the outer peripheral surface 1a of the ironing punch 1, the upper end of the raised portion 5 is pressed against the inner peripheral surface 11a of the metal cylinder 11, and the recess 12 slightly recessed corresponding to the raised portion 5 is formed in a ring shape on the inner peripheral surface 11a of the metal cylinder 11. That is, the contact area between the outer peripheral surface 1a of the punch 1 and the inner peripheral surface 11a of the metal cylinder 11 is remarkably reduced. As a result, according to the present invention, the frictional resistance when the ironing punch 1 is pulled out is greatly reduced, the ironing punch 1 can be smoothly pulled out without applying a large load, and the ironing can be performed with extremely high productivity.

[0038] In the present invention, the ring-shaped raised portion 5 to be formed on the outer peripheral surface 1a of the ironing punch 1 is formed by plastically deforming the outer peripheral surface 1a to form the recess 3. Specifically,

the outer peripheral surface 1a of the ironing punch 1 is depressed by punching the outer peripheral surface 1a in the vertical direction by using a rod-shaped punching jig having an axially symmetric tapered shape formed at the tip of the jig, whereby the recess 3 and the raised portion 5 around the recess 3 are formed in a ring shape. For example, Patent Document 3 (JP 3327137 B) describes a means such as ultrasonic processing, ion irradiation, laser processing, and electron beam irradiation as a means for forming a point-shaped recess on the outer peripheral surface 1a of the ironing punch 1 (see paragraph [0064]), but the raised portion cannot be formed by these means. This is because the recess is formed by scraping, not by plastic processing.

[0039] The size of the ring-shaped raised portion 5, for example, the difference (D2-D1) between the outer diameter D2 and the inner diameter D1 (corresponding to the diameter of the dot-shaped recess 3) of the raised portion 5 and the height h depend on the diameter D1 and the depth d of the dot-shaped recess 3 (see FIG. 2). To provide a size such that the raised portion 5 is not damaged at the time of ironing, preferably, the diameter D1 of the dot-shaped recess 3 ranges from about 0.2 to 1.1 mm, and the depth d thereof ranges from about 0.2 to 10.0 μm. Although the above-mentioned ranges are slightly different depending on the material of the punch 1, setting the diameter D1 and the depth d of the dot-shaped recess 3 within the above-mentioned ranges allows the size (D2-D1) and the height h of the raised portion 5 to be appropriate, allowing excessive forceful pulling out to be avoided and the punch 1 to be pulled out without causing unnecessary deformation of the metal cylinder 11 as a workpiece.

[0040] For example, when the diameter D1 or the depth d of the dot-shaped recess 3 is out of the above-mentioned range, the size (D2-D1) or the height h of the ring-shaped raised portion 5 becomes larger or smaller than necessary, and the frequency of occurrence of deformation (rollback) in which the upper end opening portion of the metal cylinder 11 protrudes outward due to the pulling out of the punch 1 becomes considerably high.

[0041] That is, in an ideal shaping form, as illustrated in FIG. 6(a), the upper end opening portion of the metal cylinder 11 is in a straight state. However, if the punch 1 is forcefully pulled out, as illustrated in FIG. 6(b), a rollback in which the upper end opening portion protrudes outward occurs. By setting the diameter D1 or the depth d of the dot-shaped recess 3 within an appropriate range, the occurrence rate of such a rollback can be made substantially zero. When the diameter D1 and the depth d are not within an appropriate range, or when ironing is performed using the punch 1 in which the raised portion 5 is not formed on the peripheral edge portion of the dot-shaped recess 3, the rollback amount is likely to be 5.0 mm or more, and the frequency of occurrence of such a large rollback may be 20 to 30 pieces per 100 pieces or more.

[0042] Further, it is preferable that the ring-shaped raised portions 5 are distributed in the region Q of the ironing punch 1 described above so as to be evenly distributed in the length direction and the circumferential direction of the ironing punch 1 in order to smoothly pull out the ironing punch 1, and further, from the viewpoint of greatly reducing the frictional resistance without greatly reducing the strength of the punch 1, it is desirable that the raised portions 5 are distributed in the region Q at an area ratio of 30 to 400 pieces/cm^2.

[0043] As illustrated in FIGS. 2 and 4, the metal cylinder (workpiece) 11 obtained by ironing (thinning) using the ironing punch 1 as described above has the dot-shaped protrusion 15 formed on the inner peripheral surface 11a thereof corresponding to the dot-shaped recess 3. That is, when the organic resin coating is formed on the inner surface of the cylinder 11, the orientation of the organic resin coating is sufficiently relaxed and the dent resistance is enhanced due to the formation of the protrusion 15.

2. Partially Raised Type Ironing Punch

[0044] In the present invention, see FIGS. 7 to 10 for the partially raised type ironing punch.

[0045] In this type, punching the punching jig from an oblique direction (from the tip portion side to the root portion side) to form the dot-shaped recess 3 allows a raised portion 4 to be formed on part of the peripheral edge portion of the dot-shaped recess 3 (the side opposite to the tip portion of the punch 1). The raised portion 4 can also be formed by punching using a jig having a tip portion corresponding to the shape of the recess 3. Such a raised portion 4 is partially present in the peripheral edge portion of the dot-shaped recess 3. As described in the section of the annularly raised type punch, a means of scraping such as ultrasonic machining or laser machining cannot form the raised portion 4.

[0046] Referring to FIGS. 7 and 8, the recess 3 formed by the above punching has the deepest portion P (corresponding to the apex of the conical shape) having an eccentric shape in the direction opposite to a tip 1b of the punch 1 (on a side in a direction of pulling out the punch 1). That is, since the dent has the shape corresponding to the recess 3, the raised portion 4 is formed on the side where the deepest portion P of the recess 3 is eccentric. For example, the raised portion 4 has an arc shape or a nearly arc shape. In the annularly raised type, the deepest portion of the recess 3 is not eccentric, thus forming the raised portion 5 having a ring shape.

[0047] In the present invention, in the recess 3 of the above-described configuration as illustrated in FIG. 7, the side surface on the tip side of the ironing punch 1 is a gentle slope surface 3a having a small inclination angle α, and the opposite surface is a steeply inclined surface 3b having a large inclination angle β.

[0048] When ironing is performed using the punch 1 having the above-described configuration, a protrusion 13 having a shape having the apex P' that is disproportionately located in the direction opposite to the processing direction side

(that is, the punch tip 1b side) is formed on the inner peripheral surface of the metal cylinder 11 corresponding to the above-described dot-shaped recess 3 as illustrated in FIG. 9. That is, since such a protrusion 13 is formed, when the inner surface thereof is coated with the organic resin, the orientation thereof is relaxed by the protrusion 13 and the lowering of the dent resistance can be suppressed. Since the protrusion 13 has a shape corresponding to the recess 3 described above, the protrusion 13 has a gentle slope surface 13a having a small inclination angle α' corresponding to the gentle slope surface 3a of the recess 3, and has a steeply inclined surface 13b having a large inclination angle β' corresponding to the steeply inclined surface 3b of the recess 3.

[0049] When the ironing is completed, the ironing punch 1 is inserted into the thinned metal cylinder 11, and the outer peripheral surface 1a of the ironing punch 1 is held in a state of being firmly in contact with the inner peripheral surface of the thinned metal cylinder 11. That is, as also illustrated in FIG. 5 described above, the ironing punch 1 extends to the bottom portion 17 of the cylinder 11, and the region Q where the outer peripheral surface 1a of the ironing punch 1 is in contact with the inner peripheral surface of the metal cylinder 11 is a region functioning as a processing holding surface in ironing, as described above. For example, the drive shaft S is connected to part of the ironing punch 1 above the region Q, and by driving the shaft S, the ironing punch 1 moves in the processing direction, and after the ironing is completed, the ironing punch 1 moves in the pull-out direction which is the opposite direction to the processing direction. Therefore, the movement of the metal cylinder 11 in the pull-out direction of the punch 1 is restricted by the stopper 20 in order to pull out the ironing punch 1.

[0050] The recess 3 having a shape having the deepest portion P that is eccentric is formed on the outer peripheral surface 1a by the ironing using the above-described partially raised type ironing punch 1, and correspondingly, the protrusion 13 having a shape having the apex P' that is eccentric is formed on the inner peripheral surface 11a of the thinned metal cylinder 11 (see FIG. 9). Therefore, when the ironing punch 1 is pulled out after the ironing is completed, the gentle slope surface 3a of the recess 3 of the ironing punch 1 is pulled out while the gentle slope surface 3a faces the gentle slope surface 13a of the protrusion 13 of the inner peripheral surface of the metal cylinder 11 as illustrated in FIG. 10. As a result, the ironing punch 1 can be pulled out smoothly, and since the arc-shaped raised portion 4 is formed on the side in the direction of pulling out the punch 1 (the side opposite to the punch tip), the contact area between the outer peripheral surface 1a of the punch 1 and the inner peripheral surface 11a of the metal cylinder 11 is small, and the punch 1 can be pulled out more smoothly. As a result, it is possible to more effectively avoid unnecessary deformation of the metal cylinder 11 that occurs when the metal cylinder 11 is pulled out.

[0051] For example, when the raised portion 4 is not formed on the peripheral edge of the recess 3 formed on the outer peripheral surface 1a of the ironing punch 1, the deepest portion P is not eccentric, and the recess 3 has a line-symmetric shape when viewed in a cross section along the sliding direction, and the inclination angle of the surface to be abutted when the punch 1 is pulled out becomes a large surface, so that the resistance force against the pulling out of the punch 1 is large, the pulling out of the punch cannot be performed smoothly, the productivity is lowered, the load applied to the drive shaft S and the like is increased, and the life of the apparatus tends to be shortened.

[0052] Further, even in the case of using such an arc type ironing punch 1, the pulling-out property of the punch 1 is improved, and the occurrence rate of the rollback as illustrated in FIG. 6(b) can be made substantially zero.

[0053] The eccentricity ratio of the deepest portion P of the recess 3 formed on the outer peripheral surface 1a of the ironing punch 1 is expressed by the following equation.

$$\text{Eccentricity ratio} = 100d/(1/2)\,D = (2d/D) \times 100$$

where d is a distance between the apex P and the center of the recess 3 (amount of eccentricity of the apex P), and D represents the diameter of the recess 3.

[0054] In the present invention, the eccentricity ratio of the deepest portion P preferably ranges from 30 to 100%, and more preferably from 75 to 95%. It has been experimentally confirmed that when the eccentricity ratio is lower than 30%, the inclination angle α of the gentle slope surface of the recess 3 becomes large, the pulling-out property of the punch 1 is impaired, and the occurrence rate of large deformation having a rollback amount of 5.0 mm or more, for example, becomes about 30%, but the occurrence rate of large deformation having a rollback amount of 5.0 mm or more can be made almost zero by setting the eccentricity ratio to 30% or more, particularly 75% or more. When the eccentricity ratio is close to 100%, the edge portion of the recess 3 on the side opposite to the processing direction becomes a sharp corner portion, and the ironing punch 1 tends to be easily damaged.

[0055] The depth of the recess 3 (corresponding to d in FIG. 2) is preferably about 0.2 to 10.0 μm as in the case of the ring-type ironing punch 1. If the depth (d) is excessively large, the pulling-out property of the ironing punch 1 may be impaired, and if the depth (d) is excessively small, the protrusion 13 formed corresponding to the recess 3 becomes small, as a result, the orientation relaxation of the organic resin film becomes insufficient, and the dent resistance tends to be impaired.

[0056] Further, as in the above-described ring-type ironing punch 1, it is preferable that the recesses 3 are evenly

distributed in the length direction and the circumferential direction of the ironing punch 1, and it is preferable that the recesses 3 are distributed at an area ratio of 30 to 400 pieces/cm^2 in the region Q.

[0057] In the present invention, ironing using the arc type ironing punch 1 described above allows the protrusion 13 having the eccentric apex P' corresponding to the recess 3 to be formed on the inner peripheral surface 11a of the metal cylinder 11, the frictional resistance when the ironing punch 1 is pulled out to be greatly reduced, the life of the apparatus to be extended, and productivity to be enhanced.

[0058] When the organic resin coating is formed on the inner surface of the metal cylinder 11, the orientation of the organic resin coating is sufficiently relaxed and the dent resistance is enhanced.

Configuration of Dot-shaped Recess 3

[0059] In the ironing punch 1 of the present invention described above, the planar shape of the dot-shaped recess 3 is not particularly limited and may be a circular shape, an elliptical shape, a square shape, or the like regardless of whether it is the annularly raised type or the partially raised type, but it depends on the shape of the punch used for forming the recess 3 and the planar shape is particularly preferably a circular shape from the viewpoint that it is not anisotropic and is most unlikely to be damaged at the time of pulling out. However, in the arc type ironing punch 1, when the recess 3 is formed by punching the jig obliquely, a slightly distorted circular shape is often formed as illustrated in FIG. 8.

Press Molding Process Using Ironing

[0060] The ironing using the ironing punch 1 described above is utilized to thin the various metal cylinders 11, and is most preferably utilized in press molding for manufacturing an ironing can (seamless can) that is thinned and has an increased height. FIG. 11 illustrates a manufacturing process of such a metal can.

[0061] In FIG. 11, a base plate (for example, an aluminum plate) 101 used for shaping a metal can is first subjected to a punching process, whereby a circular plate 103 for a metal can is obtained (see FIG. 11(a)). An organic resin coating may be laminated on one surface of the base plate 101, in particular, on the side to be the inner surface of the can.

[0062] Although the thickness of the base plate 101 varies depending on the type of metal, the purpose of use of the can, or the size of the can, it is generally preferable to have a thickness of 0.10 to 0.50 mm. Among these, in the case of a surface-treated steel plate, it is preferable to have a thickness of 0.10 to 0.30 mm, and in the case of a light metal plate such as aluminum, it is preferable to have a thickness of 0.15 to 0.40 mm.

[0063] The organic resin coating is a coating derived from a coating material such as an acrylic coating material, a urethane coating material, a silicon coating material, or a fluorine-based coating material, or a coating derived from a thermoplastic resin, and has been conventionally used in order to suppress corrosion resistance and surface roughness during severe shaping. In the present invention, an organic resin coating formed of a thermoplastic resin is particularly preferable.

[0064] That is, the coating with the thermoplastic resin can be easily laminated on the base plate 101 by a laminating roll, and the molecules are oriented by bending and stretching by drawing or ironing, whereby the barrier property against the corrosion component can be enhanced and the heat resistance is also enhanced. On the other hand, as disclosed in Patent Document 3, the molecular orientation of the organic resin coating tends to cause fibrillation of the resin, which tends to cause cracking in the can height direction due to impact, and tends to deteriorate dent resistance. However, in the present invention, ironing using the punch 1 having the dot-shaped recess 3 forms the dot-shaped protrusion 15 (or 13) on the inner surface of the can, causes the molecular orientation to be relaxed by the protrusion 15 (or 13), and allows decrease in the dent resistance to be avoided.

[0065] Note that the above thermoplastic resin may include any of the following resins: polyolefins such as low density polyethylene, high density polyethylene, polypropylene, poly-1-butene, poly-4-methyl-1-pentene, or random or block copolymers of α-olefins such as ethylene, propylene, 1-butene, and 4-methyl-1-pentene; ethylene/vinyl compound copolymers such as ethylene/vinyl acetate copolymers, ethylene/vinyl alcohol copolymers, ethylene/vinyl chloride copolymers; styrenic resins such as polystyrene, acrylonitrile/styrene copolymer, ABS, α-methylstyrene/styrene copolymer; polyvinyl compounds such as polyvinyl chloride, polyvinylidene chloride, vinyl chloride/vinylidene chloride copolymer, polymethyl acrylate, polymethyl methacrylate; polyamides such as nylon 6, nylon 6-6, nylon 6-10, nylon 11, nylon 12; Thermoplastic polyesters such as polyethylene terephthalate and polybutylene terephthalate; polycarbonate, polyphenylene oxide, etc.; or mixtures thereof.

[0066] Among these thermoplastic resins, polyester resins are particularly suitable in terms of processability, corrosion resistance, and flavor retention of the can contents.

[0067] In the punching process, a punching punch 105 having an outer diameter corresponding to the diameter of the circular plate 103 and a die 107 holding the base plate 101 and having an opening corresponding to the diameter of the circular plate 103 are used. That is, punching the base plate 101 held on the die 107 with the punch 105 allows the circular plate 103 having a predetermined size to be obtained.

[0068] Depending on the configuration of the shaped product manufactured by such a manufacturing process, the base plate 101 may be punched into another shape (e.g., a rectangular shape).

[0069] The circular plate 103 obtained as described above is subjected to drawing, whereby a drawn can (a bottomed cylindrical body) 109 having a decreased height is obtained (see FIG. 11(b)).

[0070] In such drawing, the punched circular plate 103 is held on a die 111, and the periphery of the circular plate 103 is held by a jig 113 for suppressing wrinkles. An opening is formed in the die 111, and the drawn can 109 is obtained by pressing the circular plate 103 into the opening of the die 111 using the punch 115 for drawing.

[0071] A radius (curvature portion) is formed at a corner portion (a side holding the circular plate 103) of an upper end of the opening of the die 111, so that the circular plate 103 is quickly pushed into the opening of the die 111 without being broken, and the outer diameter of the punch 115 is set to be smaller than the diameter of the opening of the die 111 by an amount corresponding to substantially the thickness of the circular plate 103. That is, in this drawing, thinning is hardly performed. The drawing may be performed a plurality of times depending on the shape of the shaped product.

[0072] Next, the drawn can 109 obtained above is subjected to ironing, whereby the metal can (thinned seamless can) 11 having an increased height and that is thinned is formed (see FIG. 11(c)).

[0073] In this ironing, the ironing punch 1 of the annularly raised type or the partially raised type according to the present invention is inserted into the drawn can 109 obtained by the above-mentioned drawing, and the punch 1 is lowered while the outer surface of the cylindrical body 109 is pressed against the inner surface of the ring-shaped ironing die 121, whereby the side wall of the drawn can (cylindrical body) 109 is thinned by the die 121. This obtains the metal can (thinned seamless can) 11 of the present invention thinned and increased in height in accordance with the degree of thinning.

[0074] As can be understood from FIG. 11, in the series of steps of the punching, the drawing, and the ironing, the sliding property is not required in the punching, but the more the drawing is changed to the ironing, the more the sliding property is required between the mold used and the workpiece. In particular, in the ironing, since a surface pressure exceeding the yield stress of the workpiece is applied, the highest sliding property is required. That is, a large surface pressure is also applied between the inner peripheral surface of the drawn can 109, which is a workpiece, and the outer peripheral surface 1a of the ironing punch 1, and accordingly, in the ironing punch 1 of the annularly raised type described above, the ring-shaped recess 12 and the dot-shaped protrusion 15 are formed on the inner peripheral surface of the drawn can 109 (metal can 11) by the contact with the raised portion 5 (see FIG. 2).

[0075] The above ironing can also be performed in multiple stages. For example, arranging a plurality of ironing dies in the processing direction and performing ironing in multiple stages can increase the ironing ratio and obtain the metal can 11 that is further thinned and has a further increased height. FIG. 12 illustrates an example of a process in which ironing is performed in multiple stages.

[0076] In the step in FIG. 12, a ring-shaped redraw die 111a and ironing dies 121a to 121c are arranged in this order along the processing direction, a guide ring 135 is arranged on the downstream side of the ironing die 121c located on the most downstream side with respect to the processing direction, and a holding ring 137 and a holding rod 137a for bottom forming are provided in this order further on the downstream side.

[0077] The ironing dies 121a to 121c have a smaller diameter as they are arranged on the downstream side in the processing direction, so that a more severe thinning is performed.

[0078] In such multi-stage ironing (redraw-ironing), holding the drawn can 109 on the redraw die 111a by the holder 141, inserting the ironing punch 1 of the present invention into the drawn can 109 in this state, and moving the punch 1 in the processing direction while pressing the outer surface of the drawn can 109 against the inner surfaces (processing surfaces) of the redraw die 111a and the ironing dies 121a to 121c causes redrawing and ironing to be performed, the sidewall of the drawn can 109 to be thinned, and the metal can 11 (metal cylinder) having a further increased height to be obtained.

[0079] Although three ironing dies are arranged in FIG. 12, the number of ironing dies may be two or more than three.

[0080] After the ironing illustrated in FIGS. 11 and 12 is completed, as illustrated in FIG. 5, the stopper 20 is arranged at the upper end of the metal can 11, and the ironing punch 1 is pulled out in a state in which the movement of the stopper 20 is restricted. That is, in the present invention, the frictional resistance at the time of the pulling out is greatly reduced, and the production efficiency of the ironing is enhanced.

[0081] The drawing step and the ironing step in the process of FIGS. 11, 12 described above can be performed under wet conditions while a coolant flows, or under dry conditions such as a low lubrication method using a solid lubricant or a non-lubrication method not using a lubricant without using a coolant.

[0082] After the ironing punch 1 is pulled out, the metal can 11 (metal cylinder) is subjected to, for example, outer surface printing or neck-in processing, and is sold.

Reference Signs List

[0083]

A: Ironing punch
B: Metal cylinder (workpiece)
C: Ironing die
1: Ironing punch
1a: Outer peripheral surface of ironing punch 1
3: Dot-shaped recess
4, 5: Raised portion
11: Metal cylinder
11a: Inner peripheral surface of metal cylinder 11
13, 15: Dot-shaped protrusion

Claims

1. An ironing punch to be used for metal ironing, wherein

a dot-shaped recess is distributed on an outer peripheral surface of the ironing punch, and
a raised portion is formed on at least part of a peripheral edge portion of the dot-shaped recess.

2. The ironing punch according to claim 1, wherein the raised portion is formed over an entire periphery of the peripheral edge portion of the dot-shaped recess.

3. The ironing punch according to claim 1, wherein the raised portion is formed on part of the peripheral edge portion of the dot-shaped recess.

4. The ironing punch according to claim 3, wherein the raised portion is formed on part of the peripheral edge portion of the dot-shaped recess on a side opposite to a punch tip side.

5. The ironing punch according to claim 4, wherein when viewed in a cross section along an axial direction of the ironing punch, the dot-shaped recess has a shape having a deepest portion disproportionately located on the side opposite to the punch tip side.

6. The ironing punch according to claim 5, wherein an eccentricity ratio of the deepest portion ranges from 30 to 100%.

7. An ironing method, comprising:

inserting an ironing punch described in claim 1 into a metal cylinder;
performing ironing by passing the metal cylinder through an annular die; and
thinning the metal cylinder by pulling out the punch after the ironing is completed.

8. The ironing method according to claim 7, wherein the metal cylinder comprises an organic resin layer on an inner surface of the metal cylinder.

9. The ironing method according to claim 8, wherein the organic resin layer is formed of a thermoplastic resin.

10. An ironing can, comprising:

a body portion having a hollow cylinder; and
a bottom portion closing a lower end of the body portion, wherein
a dot-shaped protrusion is distributed on an inner peripheral surface of the body portion, and
an apex of the dot-shaped protrusion is disproportionately located in a direction opposite to a bottom portion when viewed in a longitudinal section along an axial direction.

11. The ironing can according to claim 10, wherein

an organic resin layer is laminated on the inner peripheral surface of the body portion, and
the dot-shaped protrusion is distributed on a surface of the organic resin layer.

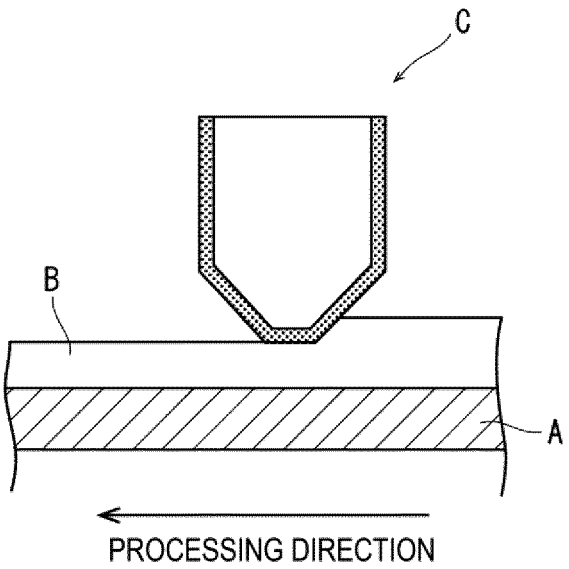

FIG. 1

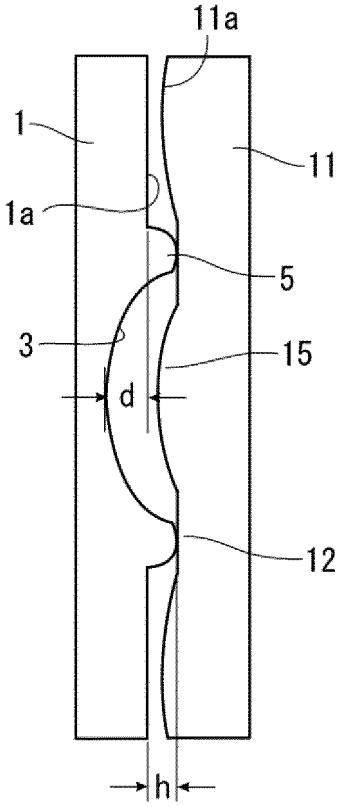

FIG. 2

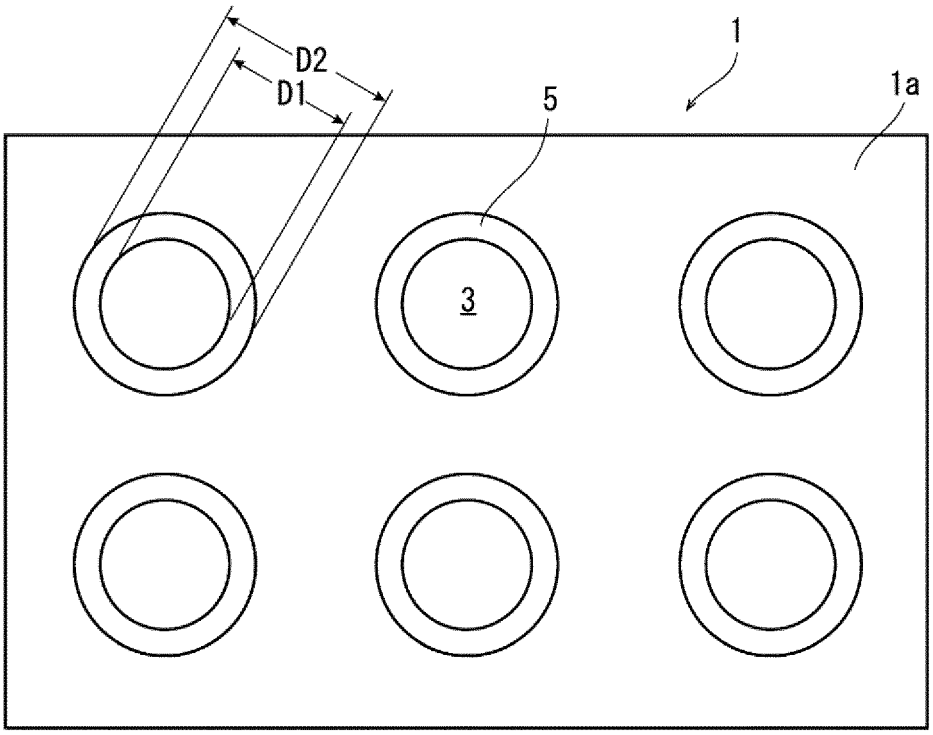

FIG. 3

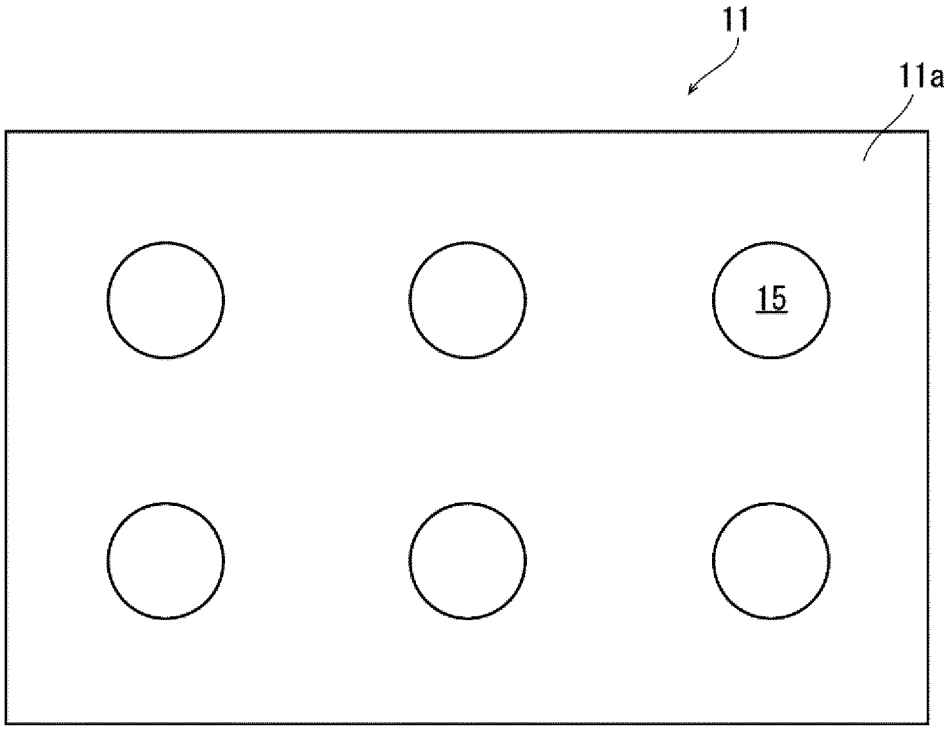

FIG. 4

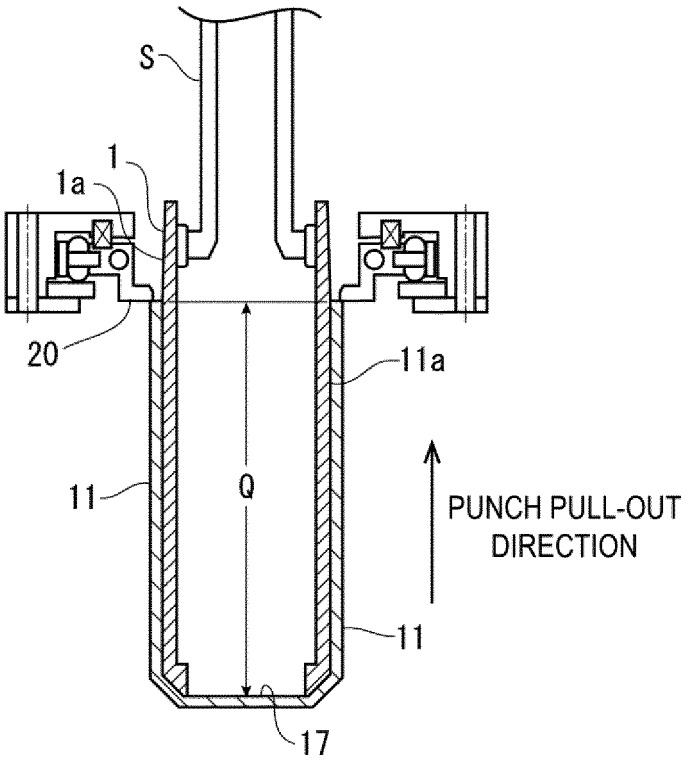

FIG. 5

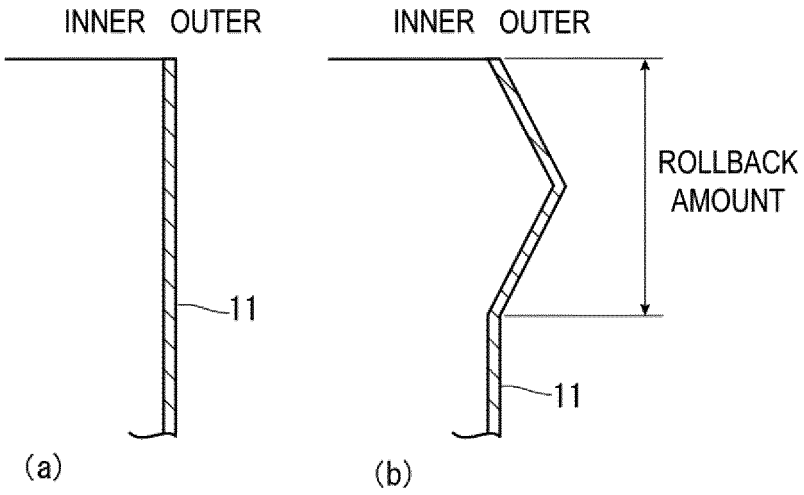

FIG. 6

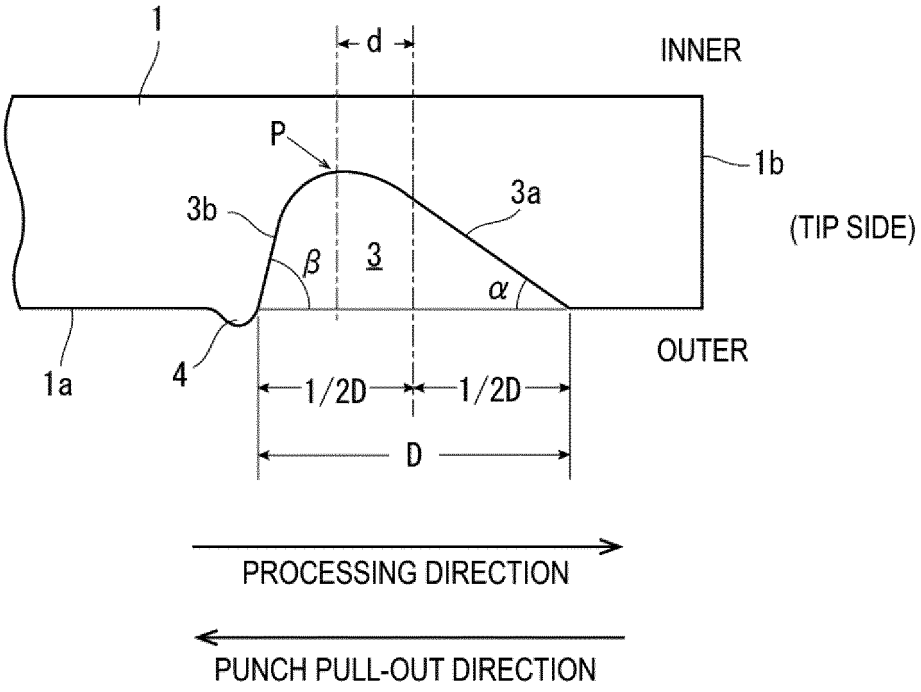
1
d
INNER
P
1b
3b
3a
(TIP SIDE)
β
3
α
OUTER
1a
4
1/2D
1/2D
D
PROCESSING DIRECTION
PUNCH PULL-OUT DIRECTION

FIG. 7

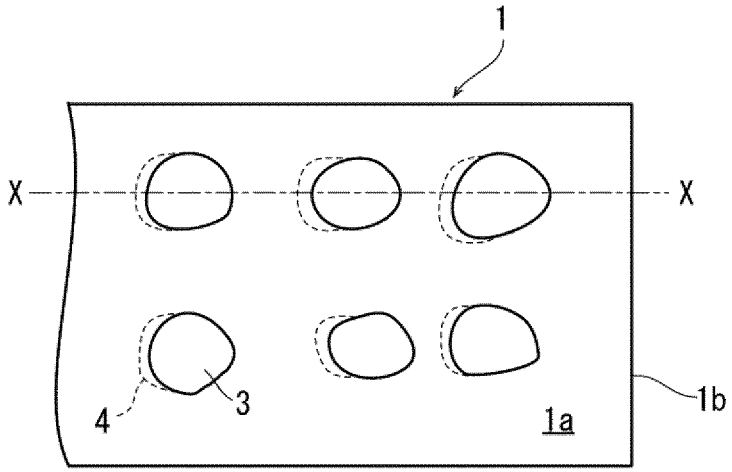

FIG. 8

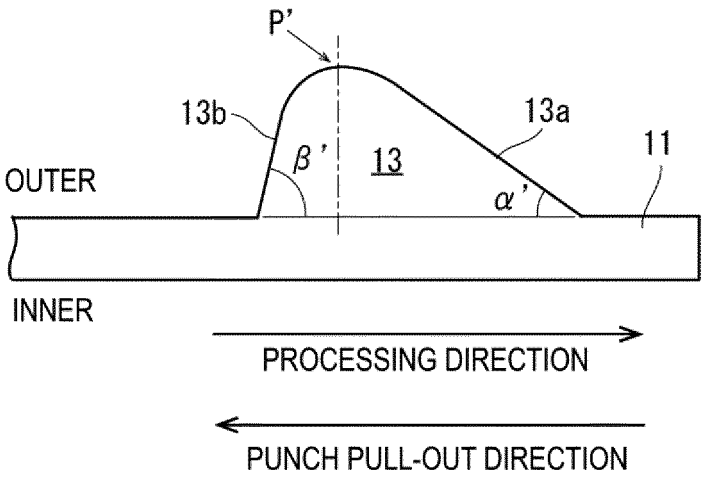
P'
13b
13a
11
β'
13
OUTER
α'
INNER
PROCESSING DIRECTION
PUNCH PULL-OUT DIRECTION

FIG. 9

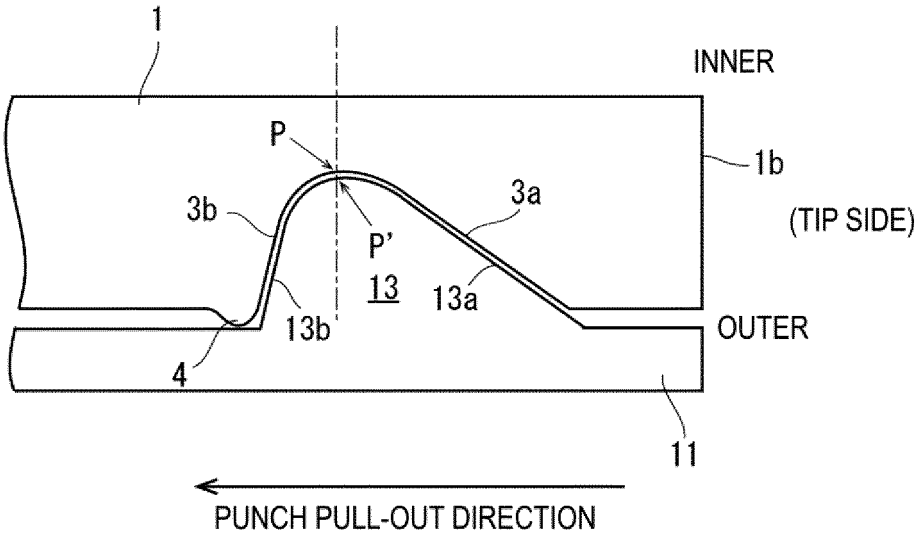
1
INNER
P
1b
3b
3a
(TIP SIDE)
P'
13
13a
13b
OUTER
4
11
PUNCH PULL-OUT DIRECTION

FIG. 10

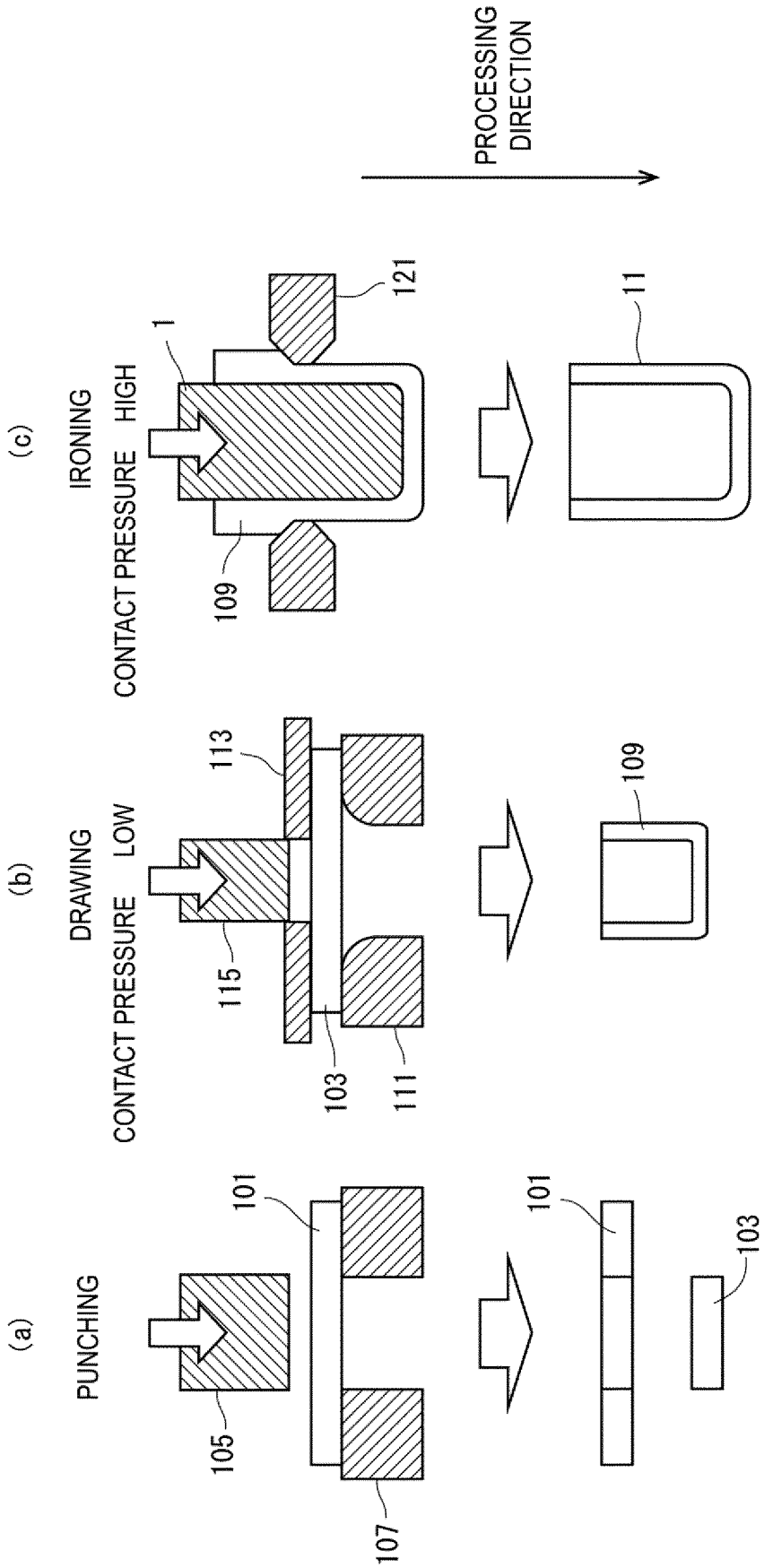
PROCESSING DIRECTION
(a)
PUNCHING
(b)
DRAWING
CONTACT PRESSURE LOW
(c)
IRONING
CONTACT PRESSURE HIGH
101
105
107
113
115
103
111
109
1
121
11

FIG. 11

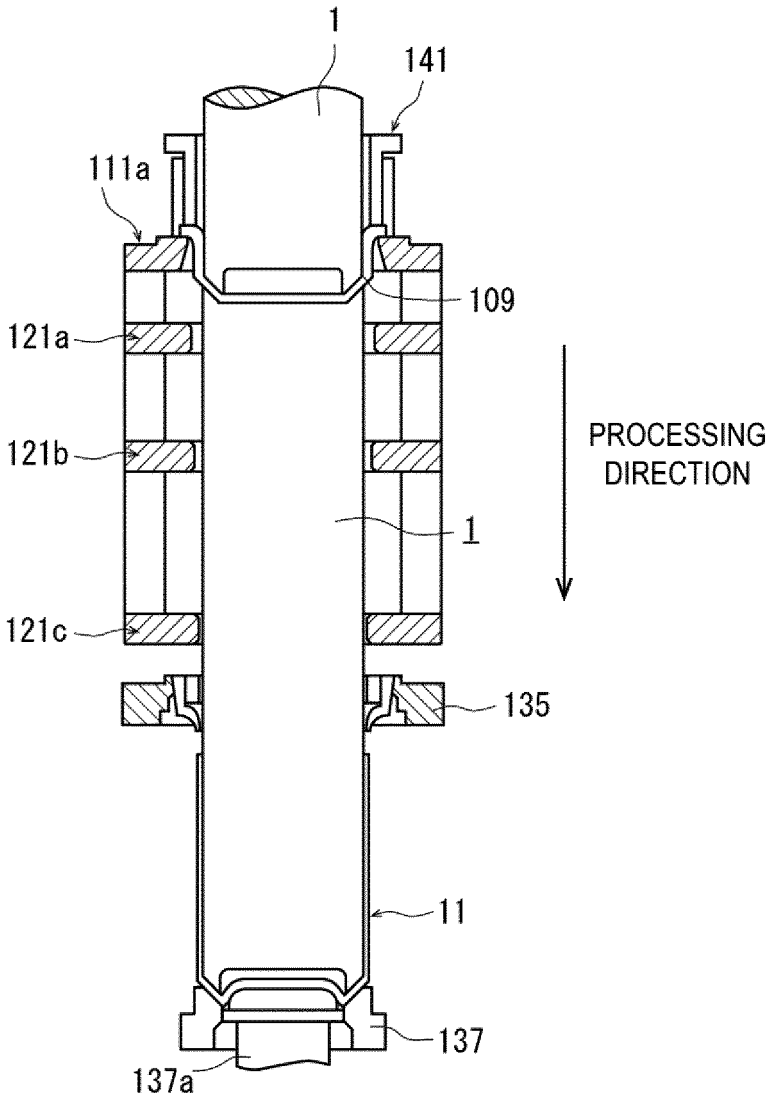
1
141
111a
109
121a
121b
1
121c
135
11
137
137a
PROCESSING
DIRECTION

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/025313

A. CLASSIFICATION OF SUBJECT MATTER

B21D 22/28(2006.01)i; ***B21D 51/26***(2006.01)i
FI: B21D22/28 J; B21D51/26 X

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B21D22/28; B21D51/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 61-209731 A (TOYO SEIKAN KAISHA, LTD.) 18 September 1986 (1986-09-18) page 1, right column, line 11 to page 5, upper right column, fig. 1-8	1-2, 7-9
A		3-6, 10-11
Y	JP 2006-122993 A (SAKURATECH CO., LTD.) 18 May 2006 (2006-05-18) paragraph [0032]	1-2, 7-9
Y	JP 3327137 B2 (TOYO SEIKAN KAISHA, LTD.) 24 September 2002 (2002-09-24) paragraphs [0039]-[0041]	8-9
A		3-6, 10-11
A	JP 62-013812 A (MATSUSHITA ELECTRIC IND. CO., LTD.) 22 January 1987 (1987-01-22) page 2, lower left column, line 3 to page 3, upper right column, line 13, fig. 1-2	1-9
A	WO 2017/033791 A1 (TOYO SEIKAN GROUP HOLDINGS, LTD.) 02 March 2017 (2017-03-02) entire text, all drawings	1-11

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 August 2022	**06 September 2022**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/025313

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 07-124656 A (MITSUBISHI MATERIALS CORP.) 16 May 1995 (1995-05-16) paragraphs [0011]-[0019], fig. 1-5	1-11
A	JP 2018-069256 A (TOYO SEIKAN GROUP HOLDINGS, LTD.) 10 May 2018 (2018-05-10) entire text, all drawings	1-11

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/025313

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 61-209731 A	18 September 1986	(Family: none)	
JP 2006-122993 A	18 May 2006	(Family: none)	
JP 3327137 B2	24 September 2002	US 5803301 A column 8, line 66 to column 9, line 24	
JP 62-013812 A	22 January 1987	(Family: none)	
WO 2017/033791 A1	02 March 2017	US 2018/0229287 A1 entire text, all drawings EP 3342501 A1 CN 107921518 A KR 10-2018-0035897 A BR 112018003601 A2 TW 201718240 A	
JP 07-124656 A	16 May 1995	(Family: none)	
JP 2018-069256 A	10 May 2018	US 2020/0071017 A1 entire text, all drawings WO 2018/079434 A1 EP 3533528 A1 KR 10-2019-0060845 A CN 109890530 A	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2017033791 A **[0007]**
- JP 2018069256 A **[0007]**
- JP 3327137 B **[0007] [0038]**