



(11) **EP 3 486 034 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
22.05.2019 Bulletin 2019/21

(51) Int Cl.:
B24C 1/04 (2006.01) B24C 5/02 (2006.01)

(21) Application number: **17856053.8**

(86) International application number:
PCT/JP2017/034538

(22) Date of filing: **25.09.2017**

(87) International publication number:
WO 2018/062101 (05.04.2018 Gazette 2018/14)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(71) Applicant: **Sintokogio, Ltd.**
Nagoya-shi, Aichi 450-6424 (JP)

(72) Inventor: **INOUE Kouichi**
Kitanagoya-shi
Aichi 481-8678 (JP)

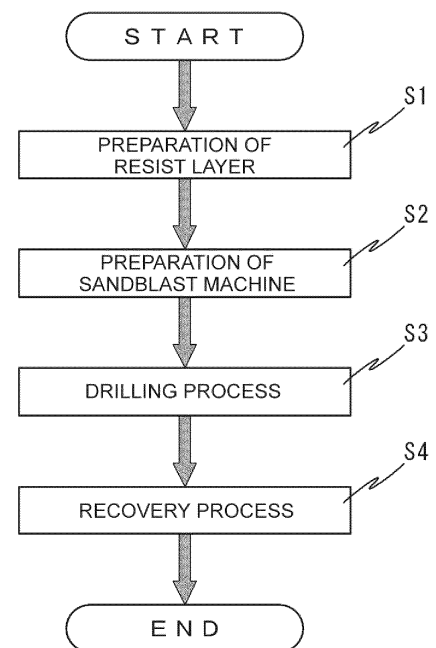
(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(30) Priority: **28.09.2016 JP 2016189185**
08.03.2017 JP 2017043513

(54) **DRILLING METHOD, RESIST LAYER, AND FIBER-REINFORCED PLASTIC**

(57) In an embodiment, provided is a drilling method of forming a hole having a desired diameter in a fiber-reinforced plastic workpiece. The method includes disposing a resist layer, in which an opening having a diameter smaller than the desired diameter is formed, on the workpiece and ejecting blasting abrasives to the workpiece through the resist layer to cut a portion, which is exposed from the opening, in the workpiece while cutting a peripheral edge portion of the opening of the resist layer.

Fig.2



EP 3 486 034 A1

Description**Technical Field**

5 **[0001]** The present disclosure relates to a drilling method, a resist layer, and a fiber-reinforced plastic.

Background Art

10 **[0002]** A fiber-reinforced plastic (FRP) is a composite material in which reinforcing fiber (glass fiber, carbon fiber, aramid fiber, polyethylene fiber, cylon fiber, boron fiber, and the like) is put into a resin (a polyester resin, a vinyl ester resin, an epoxy resin, a phenol resin, and a thermoplastic resin) to improve strength. The FRP has been used in a wide range of fields such as daily necessities, sporting goods, automobiles, and aerospace applications.

15 **[0003]** The FRP may be subjected to drilling to improve joining and sound absorbency in some cases. As a method of forming a hole in an FRP workpiece, drilling performed by using a drill, and sandblasting are used. For example, Patent Literature 1 discloses a configuration in which a resist layer having sandblast resistance is disposed on a surface of the workpiece, and a region which is not covered with the resist layer in the workpiece is removed by sandblasting.

Citation List20 **Patent Literature**

[0004] Patent Literature 1: Japanese Unexamined Patent Publication No. 2012-196751

25 **Summary of Invention****Technical Problem**

30 **[0005]** In drilling performed by using a drill, in a case where the number of holes to be processed is large, a processing time is lengthened, and thus the drilling is not preferable from the viewpoint of productivity. In addition, in the drilling performed by using a drill, fluffing may occur in the vicinity of a hole formed in a workpiece, or peeling-off may occur on a surface of the workpiece.

[0006] In addition, as in a method described in Patent Literature 1, even in a case where a hole is formed in a workpiece by sandblasting, fluffing or peeling-off may occur in the workpiece although the degree of occurrence is lower in comparison to the drilling performed by using a drill.

35 **[0007]** Accordingly, it is desired to form a hole in the fiber-reinforced plastic while suppressing occurrence of fluffing and peeling-off.

Solution to Problem

40 **[0008]** According to one aspect of the present disclosure, there is provided a drilling method of forming a hole having a desired diameter in a fiber-reinforced plastic workpiece. The method includes disposing a resist layer, in which an opening having a diameter smaller than the desired diameter is formed, on the workpiece and ejecting blasting abrasives to the workpiece through the resist layer to cut a portion, which is exposed from the opening, in the workpiece while cutting a peripheral edge portion of the opening of the resist layer.

45 **[0009]** When the blasting abrasives are continuously projected to the workpiece through the resist layer, the blasting abrasives passing through the opening of the resist layer enters a downward side of the resist layer, and thus peeling-off may occur on a surface of the workpiece. When the peeling-off occurs, reinforcing fibers of the workpiece are exposed on the surface of the workpiece as fluffing. In the method according to the aspect, the blasting abrasives are ejected to the workpiece through the resist layer in which the opening having the diameter smaller than the desired diameter is formed. In this method, the blasting abrasives collide with the resist layer and cuts a peripheral edge portion of the opening formed in the resist layer, the diameter of the opening is gradually enlarged with the passage of a processing time. In this manner, when the hole is formed in the workpiece while gradually enlarging the diameter of the opening in the resist layer, even when peeling-off occurs in the workpiece, a peeled-off portion is removed along the progress of processing of the workpiece. As a result, it is possible to suppress occurrence of peeling-off and fluffing on the surface of the workpiece after processing.

55 **[0010]** In one embodiment, a ratio of the diameter of the opening to the desired diameter may be 0.84 or more and 0.94 or less. When the ratio of the diameter of the opening to the desired diameter is set as described above, it is possible to efficiently perform processing while maintaining accuracy in a hole diameter after processing.

[0011] In one embodiment, in the step of ejecting the blasting abrasives to the workpiece, the blasting abrasives may be ejected toward the workpiece from a nozzle, and an angle formed by a surface of the workpiece and a ejecting direction of the blasting abrasives from the nozzle may be $90^\circ \pm 5^\circ$. When the blasting abrasives are ejected to the workpiece at this angle, it is possible to suppress occurrence of peeling-off on the surface layer of the resin. As a result, it is possible to suppress fluffing.

[0012] In one embodiment, the nozzle may be configured to suck the blasting abrasives by introducing compressed air to the inside of the nozzle to eject the blasting abrasives with the compressed air as a solid-gas two-phase flow. The fiber-reinforced plastic is a difficult-to-cut material with respect to blast processing, and thus a considerable time is necessary until processing is completed. In this embodiment, the blasting abrasives can be continuously ejected from the nozzle, it is possible to improve processing efficiency.

[0013] In one embodiment, the workpiece may comprise the fiber-reinforced plastic in which a cut reinforcing fibers are dispersed in a resin. In this type of fiber-reinforced plastic, the reinforcing fibers are dispersed without directionality. Accordingly, in a conventional drilling method, a surface may be peeled off from the reinforcing fibers as the origin, and the fiber-reinforce plastic may be broken. In contrast, according to the drilling method of the one embodiment, even in the workpiece as described above, it is possible to suppress occurrence of peeling-off or fluffing on the surface of the workpiece.

[0014] In one embodiment, the workpiece may comprise the fiber-reinforced plastic in which woven reinforcing fibers infiltrate into a resin. In this type of fiber-reinforced plastic is obtained by alternately laminating reinforcing fibers that are woven in a cloth shape and a resin. Accordingly, in the conventional drilling method, inter-layer peeling-off may occur, and the fiber-reinforced plastic may be broken. According to the drilling method of the one embodiment, even in the workpiece as described above, it is possible to suppress occurrence of peeling-off or fluffing on the surface of the workpiece.

[0015] According to another aspect of the present disclosure, there is provided a resist layer that is used in the drilling method. The resist layer is a polymer including unsaturated polyurethane or an abrasion-resistant rubber as a main component. In a case of using the polymer as a material of the resist layer, when drilling the workpiece, the resist layer is suppressed from being excessively deformed, and thus it is possible to enhance dimensional accuracy of a hole that is formed in the workpiece.

[0016] According to still another aspect of the present disclosure, there is provided a fiber-reinforced plastic having a hole formed by the drilling method. The fiber-reinforced plastic has a plate shape having a thickness of 1.0 mm or more and 2.0 mm or less, and an angle formed by a plane perpendicular to a central axis line of the hole and a wall surface defining the hole is 80° or more and 90° or less. When the angle formed by the plane perpendicular to the central axis line of the hole and the wall surface defining the hole is an angle of 80° or more and 90° or less, it is possible to improve uniformity of a hole diameter in a thickness direction of the fiber-reinforced plastic. Furthermore, the plate shape stated here includes not only a flat plate shape but also a curved plate shape.

[0017] According to still another aspect of the present disclosure, there is provided a drilling method of forming a hole in a fiber-reinforced plastic workpiece having a front surface and a rear surface, the hole being opened on the front surface and the rear surface and having a first opening on the surface side having a first area. The method includes disposing a resist layer having blast resistance higher than blast resistance of the workpiece on the workpiece, the resist layer having a second opening which has a shape corresponding to a shape of the first opening and has a second area smaller than the first area; and ejecting blasting abrasives to the workpiece through the resist layer to cut a portion, which is exposed from the second opening, in the workpiece while cutting a peripheral edge portion of the second opening of the resist layer.

[0018] When the blasting abrasives are continuously projected to the workpiece through the resist layer, the blasting abrasives passing through the second opening enters a downward side of the resist layer, and thus peeling-off may occur on a surface of the workpiece. When the peeling-off occurs, reinforcing fibers of the workpiece are exposed on the surface of the workpiece as fluffing. In the method according to the aspect, the blasting abrasives are ejected to the workpiece through the resist layer in which the second opening having the second area smaller than that of the first area is formed. In this method, the blasting abrasives, which collide with the resist layer, cut a peripheral edge portion of the second opening, and thus the area of the second opening is gradually enlarged with the passage of a processing time. In this manner, when the hole is formed in the workpiece while gradually enlarging the area of the second opening, even when peeling-off occurs in the workpiece, a peeled-off portion is removed along the progress of processing of the workpiece. As a result, it is possible to suppress occurrence of peeling-off and fluffing on the surface of the workpiece after processing.

Advantageous Effects of Invention

[0019] According to various aspects and embodiments of the present disclosure, it is possible to form a hole in a fiber-reinforced plastic while suppressing occurrence of fluffing and peeling-off.

Brief Description of Drawings

[0020]

FIG. 1 is a front view illustrating a sandblast machine that is used in one embodiment in a partially cut-out manner.
 FIG. 2 is a flowchart illustrating a drilling method of one embodiment.
 FIG. 3 is a view schematically illustrating a scanning trajectory of a workpiece of one embodiment.
 FIG. 4 is a cross-sectional view illustrating a workpiece to which a drilling method of one embodiment is applied.
 FIG. 5 is a cross-sectional view illustrating a workpiece to which a conventional drilling method is applied.

Description of Embodiments

[0021] Hereinafter, various embodiments will be described in detail with reference to the accompanying drawings. Furthermore, the same reference sign will be given to the same or equivalent portion in the drawings, and redundant description for the same or equivalent portion will be omitted. In addition, it is not necessary for dimension ratios of the drawings to match actual dimension ratios. Furthermore, right and left directions and upper and lower directions in description represent directions in the drawings unless otherwise stated.

[0022] FIG. 1 is a front view illustrating a sandblast machine 01 according to one embodiment in a partially cut-out manner. The sandblast machine 01 is a device that projects blasting abrasives to a fiber-reinforced plastic workpiece W (workpiece) and forms a hole in the workpiece W. As illustrated in FIG. 1, the sandblast machine 01 includes a housing 10, a fixed-quantity supply mechanism 20, a separation mechanism 30, a suction mechanism 40, a nozzle 50, and a control device 60.

[0023] The housing 10 constitutes a processing chamber R on an inner side thereof. A door 11 is provided in a front surface of the housing 10, and an operator can access the processing chamber R by opening the door 11. A nozzle fixture 12, a processing table 13, and a movement mechanism 14 are provided in the processing chamber R.

[0024] The nozzle fixture 12 is a mechanism that holds the nozzle 50, and can move the nozzle 50 along a height direction. Accordingly, the nozzle fixture 12 is configured to freely adjust a distance between the nozzle 50 and the workpiece W.

[0025] The movement mechanism 14 is provided on a frame 15 that is provided on a lower side of the housing 10, and is disposed on a downward side of the nozzle 50. In one embodiment, the movement mechanism 14 may be plate-shaped body in which a plurality of through-holes are formed. When the through-holes are formed in the movement mechanism 14, it is possible to allow blasting abrasives, which is ejected from the nozzle 50, to propagate toward the bottom of the housing 10.

[0026] The processing table 13 is provided on the movement mechanism 14 and supports the workpiece W that is placed on the processing table 13. For example, the movement mechanism 14 is configured to convey the processing table 13 and the workpiece W supported on the processing table 13 in a horizontal direction by a driving force of a motor. For example, the movement mechanism 14 is an X-Y stage that extends in the horizontal direction and moves the workpiece W in an X direction and a Y direction which are perpendicular to each other (refer to FIG. 3).

[0027] The fixed-quantity supply mechanism 20 is provided on an upper side of the processing chamber R. The fixed-quantity supply mechanism 20 includes a storage hopper 21 and a conveyance path 22, and supplies blasting abrasives in the storage hopper 21 to the nozzle 50 in a fixed quantity through the conveyance path 22. Furthermore, a structure of the fixed-quantity supply mechanism 20 is not limited as long as the fixed-quantity supply mechanism 20 can supply a constant amount of blasting abrasives to the nozzle 50. For example, as the fixed-quantity supply mechanism 20, a screw feeder, a vibration feeder, and a table feeder can be used. In the embodiment illustrated in FIG. 1, the screw feeder is used as the fixed-quantity supply mechanism 20.

[0028] The separation mechanism 30 is provided on an upper side of the storage hopper 21 of the fixed-quantity supply mechanism 20. The separation mechanism 30 is connected to the storage hopper 21 of the fixed-quantity supply mechanism 20. The separation mechanism 30 has an approximately inverted pyramid shape, collects used blasting abrasives, and classifies the blasting abrasives into a blasting abrasives that can be reused, and dust. One end of a first transport pipe P1 is connected to the separation mechanism 30. The other end of the first transport pipe P1 is connected to the bottom of the housing 10. Accordingly, a space in the processing chamber R and a space in the fixed-quantity supply mechanism 20 communicate with each other through the first transport pipe P1. In the embodiment illustrated in FIG. 1, a cyclone type classifier is used as the separation mechanism 30. However, as the separation mechanism 30, arbitrary classifiers such as a wind power type classifier, a screen type classifier can be used.

[0029] In addition, one end of a second transport pipe P2 is connected to the separation mechanism 30. The other end of the second transport pipe P2 is connected to the suction mechanism 40. The suction mechanism 40 is a mechanism that sets the processing chamber R to negative pressure in order for the blasting abrasives not to be leaked to the outside of the processing chamber R, and suctions particles including the blasting abrasives that are ejected. The suction

mechanism 40 collects light particles (a blasting abrasives that becomes a size that is not appropriate for reuse, and chip powders of the workpiece W and a sheet 70) which are classified in the separation mechanism 30 (cyclone type classifier) through the second transport pipe P2. In addition, the suction mechanism 40 has a function of setting an internal space of the separation mechanism 30 to negative pressure, and transporting the blasting abrasives, which is used and collected at the bottom of the housing 10, to the separation mechanism 30.

[0030] The nozzle 50 is a mechanism that ejects the blasting abrasives to the workpiece W, and includes a nozzle holder 51, an air nozzle 52, and an ejecting nozzle 53. The nozzle holder 51 is connected to the fixed-quantity supply mechanism 20 through a blasting abrasive hose H2. A compressor C is connected to the air nozzle 52 through an air hose H1. In one embodiment, an electromagnetic valve VL1 and a valve VL2 may be provided between the air nozzle 52 and the compressor C. When the compressor C is operated, compressed air is ejected from the air nozzle 52, and the inside of the nozzle holder 51 becomes negative pressure. According to this, the blasting abrasives stored in the storage hopper 21 is suctioned into the nozzle holder 51 through the conveyance path 22 and the blasting abrasive hose H2, is mixed with the compressed air in the nozzle holder 51, and is ejected as a solid-gas two-phase flow from an ejecting port of the ejecting nozzle 53 toward the workpiece W. The nozzle 50 having the above-described configuration can continuously eject the blasting abrasives, and thus it is possible to continuously process the workpiece W over a long time.

[0031] Furthermore, a so-called direct pressure type nozzle can be used as a nozzle of another type. The direct pressure type nozzle has more excellent cutting capacity in comparison to the nozzle 50 of this embodiment, but it is difficult to continuously perform processing over a long time.

[0032] Examples of a blasting abrasives that is ejected from a nozzle include a metal or nonmetal shot, grid, or cut-wire, ceramic-based particles (alumina-based particles, silicon carbide-based particles, zircon-based particles, and the like), natural stone particles (emery, silica stone, diamond, and the like), plant-based particles (a shell of a walnut, a peach stone, an apricot stone, and the like), resin-based particles (nylon, melamine, urea, and the like), and the like. The fiber-reinforced plastic is a difficult-to-cut material. Accordingly, when selecting a relatively hard material as the blasting abrasives, it is possible to efficiently cut the workpiece W.

[0033] The control device 60 is a computer including a processor, a storage unit, an input device, a display device, and the like, and controls respective units of the sandblast machine 01. In one embodiment, the control device 60 transmits a control signal to the movement mechanism 14, the fixed-quantity supply mechanism 20, the suction mechanism 40, and the electromagnetic valve VL1, and controls positions of the movement mechanism 14 in the X direction and the Y direction, an operation of the fixed-quantity supply mechanism 20, an operation of the suction mechanism 40, and opening and closing of the electromagnetic valve VL1, and the like. As a control device, various operation devices such as a personal computer, a motion controller such as a programmable logic controller (PLC) and a digital signal processor (DSP), a high-function portable terminal, a high-function portable telephone, and the like can be used.

[0034] Hereinafter, description will be given of a drilling method by the sandblast machine 01 of one embodiment with reference to FIG. 2. In this method, a hole H having a desired diameter d_1 is formed in the fiber-reinforced plastic workpiece W. The workpiece W has a flat plate shape, and includes an upper surface (front surface) 82 and a lower surface (rear surface) 84 opposite to each other (refer to FIG. 4). The hole H to be formed in the workpiece W is a through-hole that extends from the upper surface 82 to the lower surface 84, and is opened to the upper surface 82 and the lower surface 84. In the hole H, an opening (first opening) 86 on the upper surface 82 side has the desired diameter d_1 . In other words, the hole H to be formed in the workpiece W is a through-hole including the opening 86 having an area (first area) corresponding to the desired diameter d_1 on the upper surface 82 side. Hereinafter, description will be given of an example in which the workpiece W is constituted by a glass fiber-reinforced plastic (GFRP) that is one kind of the fiber-reinforced plastic.

[0035] Furthermore, the desired diameter d_1 of the opening 86 represents a length of the widest portion in the diameter of the opening 86. For example, in a case where the opening 86 has an elliptical shape, the major axis of the ellipse becomes the desired diameter d_1 . In a case where the opening 86 has a polygonal shape, a length of the longest straight line among straight lines which connect arbitrary two corners of the polygon becomes the desired diameter d_1 . Hereinafter, description will be given of an embodiment in which the opening 86 has a circular shape. In this embodiment, the diameter of the opening 86 becomes the desired diameter d_1 .

<S1: Preparation of Resist Layer>

[0036] In a drilling method according to one embodiment, first, a step S1 is performed. In the step S1, a sheet 70 that functions as a resist layer is prepared. The sheet 70 is constituted by a material that is softer than the blasting abrasives and is capable of absorbing an impact force of the blasting abrasives. Accordingly, the sheet 70 has blast resistance that is higher than that of the workpiece W constituted by the fiber-reinforced plastic.

[0037] One or a plurality of openings (second openings) 71 are formed in the sheet 70 (refer to FIG. 4). Each of the openings 71 has a shape corresponding to a shape of the opening 86 of the hole H. For example, the opening 71 has

a planar shape such as a circular shape, an elliptical shape, and a polygonal shape in correspondence with the shape of the opening 86. In one embodiment, the opening 71 of the sheet 70 has the same shape as that of the opening 86 of the workpiece W. However, a diameter d_2 of the opening 71 is set to smaller than the desired diameter d_1 . In other words, the opening 71 has an area (second area) that is smaller than the area of the opening 86. A ratio (d_2/d_1) of the diameter d_2 of the opening 71 to the desired diameter d_1 may be set in a range of 0.84 to 0.94, particularly, in a range of 0.90 to 0.94. As to be described later, when the ratio is excessively small, a collision chance between the workpiece W and the blasting abrasives are excessively less, and thus a drilling time is lengthened. In contrast, the ratio is excessively large, peeling-off is likely to occur in a surface layer of the workpiece W. Here, the diameter d_2 of the opening 71 represents the largest diameter among diameters defined by the opening 71. For example, in a case where the planar shape of the opening 71 is set to an elliptical shape, the major axis of the opening 71 of the elliptical shape becomes the diameter d_2 . In a case where the planar shape of the opening 71 is set to a polygonal shape, a length of the longest straight line among straight lines which connect arbitrary two corners of the polygon becomes the diameter d_2 . Hereinafter, description will be given of an embodiment in which the planar shape of the opening 71 is a circular shape. In this embodiment, the diameter of the opening 71 becomes the diameter d_2 .

[0038] As a material of the sheet 70, for example, thermoplastic resins such as various rubbers, nylon, polyethylene (PE), polypropylene (PP), polyurethane, and acrylic can be used. For example, as the material of the sheet 70, an abrasion-resistant rubber can be used. Abrasion resistance of a rubber can be easily adjusted by changing a blending ratio of a filling reinforcing material such as calcium carbonate to a natural rubber or a synthetic rubber that is a main raw material. Accordingly, when using the abrasion-resistant rubber as the material of the sheet 70, it is possible to easily obtain a resist material having abrasion resistance that is appropriate for drilling. In one embodiment, an abrasion-resistance rubber in which a reinforcing filling material is blended to a natural rubber or a synthetic rubber in a ratio of 60 wt% to 70 wt% can be used as the material of the sheet 70.

[0039] In addition, polyurethane is comprehensively excellent in elasticity, a thermal deformation temperature, and impact strength. Accordingly, when using polyurethane as the material of the sheet 70, it is possible to improve accuracy of a diameter of the hole H that is formed in the workpiece W. In addition, it is possible to easily form the opening 71 having a small diameter (for example, ϕ 2 mm or less) in the polyurethane sheet 70. As to be described later, in a method of one embodiment, a portion exposed from the opening 71 in the workpiece W is cut while cutting a peripheral edge portion 72 of the opening 71 in the sheet 70 by blasting abrasives. At this time, when the peripheral edge portion 72 of the sheet 70 is cut more than necessary, fluffing or peeling-off may occur on a surface of the workpiece W or dimensional accuracy may deteriorate due to the cutting. Accordingly, the material of the sheet 70 is selected in consideration of elasticity, a thermal deformation temperature, and impact force resistance. For example, unsaturated polyurethane is comprehensively excellent in elasticity, a thermal deformation temperature, and Charpy impact strength, and thus the sheet 70 may be constituted by a polymer that includes unsaturated polyurethane as a main component. In addition, a content rate of the unsaturated polyurethane may be set to 50 wt% or more, or 50 wt% to 70 wt%.

[0040] In one embodiment, the sheet 70 may be formed from a photosensitive resin that is shaped in a film shape. When forming the sheet 70 from the photosensitive resin, first, a transparent pattern mask in which an opening pattern is printed is disposed on the sheet 70, the sheet 70 is irradiated with ultraviolet rays from an ultraviolet ray emission source provided on an upper side of the sheet 70 through the pattern mask. In the sheet 70, a region that does not overlap a printed pattern is cured through irradiation of ultraviolet rays. However, a portion that overlaps the printed opening pattern become shadow, and is not cured. Subsequently, the sheet 70 after being irradiated with ultraviolet rays is washed out by using a development solution, and thus the uncured region of the sheet 70 is removed. A plurality of the openings 71 can be formed in the sheet 70 through a series of processes as described above.

[0041] In addition, in the step S1, the prepared sheet 70 is disposed on the workpiece W. In one embodiment, the sheet 70 may have stickiness. In this case, after the sheet 70 is stuck to an upper surface of the workpiece W, pressure is reduced in a vacuum chamber. According to this, it is possible to closely stick the sheet 70 onto the workpiece W. In addition, when the workpiece W is subsequently heated at a temperature of 60°C to 90°C, the workpiece W and the sheet 70 can be firmly and closely stuck to each other.

<S2: Preparation of Sandblast Machine>

[0042] Subsequently, in a drilling method according to one embodiment, a step S2 is performed. In the step S2, the sandblast machine 01 is prepared. In the step S2, first, the suction mechanism 40 is operated for suctioning of the processing chamber R. Subsequently, locking of the door 11 is released to open the door 11, and a predetermined amount of blasting abrasives are put into the processing chamber R by an operator as an example. Subsequently, the blasting abrasives are transported to the storage hopper 21 of the fixed-quantity supply mechanism 20 through the first transport pipe P1 and the separation mechanism 30 due to a suction force of the suction mechanism 40. Then, the door 11 is closed and locked. The processing chamber R becomes negative pressure due to suctioning of the suction mechanism 40, and thus external air flows into the processing chamber R from a suction hole (not illustrated) provided to

communicate with the outside.

[0043] In the step S2, for example, the control device 60 of the sandblast machine 01 is operated to set the electromagnetic valve VL1, which is provided in a path through which compressed air is supplied to the nozzle 50, to "open", and to set the fixed-quantity supply mechanism 20 to "ON". Through the setting, the blasting abrasives are supplied to the nozzle 50, and are ejected from the nozzle 50. When the blasting abrasives are ejected from the nozzle 50, the degree of opening of the valve VL2 that adjusts compressed air supply pressure is adjusted, and thus a ejected velocity of the blasting abrasives are adjusted.

[0044] Subsequently, the control device 60 of the sandblast machine 01 is operated to set the electromagnetic valve VL1 to "close", and to set the fixed-quantity supply mechanism 20 to "OFF". Through the setting, ejecting of the blasting abrasives from the nozzle 50 are stopped. Then, the door 11 is opened, and the workpiece W is placed on the processing table 13 and is fixed thereto. Subsequently, the nozzle fixture 12 is operated to adjust a distance and an angle between the nozzle 50 and the workpiece W. When the above-described processes are finished, the door 11 is closed and locked. Furthermore, the workpiece W that is placed on the processing table 13 may be a plate-shaped body having a thickness of 1.0 or more and 2.0 mm or less.

[0045] Subsequently, in the step S2, processing conditions such as a movement trajectory (distances in the X direction and the Y direction in FIG. 3) and a movement velocity of the movement mechanism 14, and the number of times of scanning are input to the control device 60.

<S3: Drilling Process>

[0046] Subsequently, a step S3 is performed. In the step S3, as to be described later, the blasting abrasives are ejected toward the workpiece W through the sheet 70 to cut a portion exposed from the opening 71 in the workpiece W while cutting the peripheral edge portion 72 of the opening 71 in the sheet 70. Hereinafter, an example of the step S3 will be described in detail.

[0047] In the step S3, first, the control device 60 is operated to set the electromagnetic valve VL1 to "open" and to set the fixed-quantity supply mechanism 20 to "ON". According to this, the blasting abrasives are ejected from the nozzle 50. Subsequently, the movement mechanism 14 is set to "ON", and the movement mechanism 14 operates so that the workpiece W is moved in a horizontal direction. For example, as illustrated in FIG. 3, the movement mechanism 14 repeats movement of the workpiece W in a +X direction by a predetermined distance, and movement of the workpiece W in a -X direction after deviating a position of the workpiece W in a +Y direction by a predetermined pitch. According to this, the workpiece W is scanned in a comb-tooth shape with respect to an ejecting region A of the blasting abrasives. The movement mechanism 14 moves the workpiece W along a scanning trajectory T to allow the blasting abrasives to collide with the entire surface of the workpiece W in an approximately uniform manner. In one embodiment, the scanning is performed in a plurality of times to form the hole H in the workpiece W. An ejecting port of the nozzle 50 may have rectangular planar shape. When the ejecting port of the nozzle 50 has a rectangular planar shape and is disposed in such a manner that a long side of the ejecting port matches the Y direction, it is possible to enlarge a collision area of the blasting abrasives when the workpiece W is scanned in the X direction. As a result, it is possible to improve processing efficiency of the workpiece W.

[0048] As described above, when the workpiece W is conveyed in the X direction and the Y direction by the movement mechanism 14, in the workpiece W, the hole H is formed in a region that is not covered with the opening 71 of the sheet 70. Here, as illustrated in FIG. 4, the blasting abrasives are projected from the nozzle 50 toward a region that includes the opening 71 and the peripheral edge portion 72 of the opening 71. Accordingly, in the step S3, as illustrated in FIG. 4, a region exposed from the opening 71 in the workpiece W is cut while the peripheral edge portion 72 of the opening 71 is cut. The sheet 70 has blast resistance higher than that of the fiber-reinforced plastic that constitutes the workpiece W, and thus the peripheral edge portion 72 of the sheet 70 is cut slowly in comparison to the workpiece W. Accordingly, in the step S3, the region exposed from the opening 71 in the workpiece W is cut in such a manner that a cut area of the workpiece W does not become excessive while gradually enlarging a diameter (area) of the opening 71 of the sheet 70. As a result, the peeling-off of the workpiece W in a surface layer is suppressed. In the step S3, projection of the blasting abrasives continues until the diameter of the hole H formed in the workpiece W becomes the desired diameter d_1 .

[0049] FIG. 5 illustrates a shape of the hole H that is formed in the workpiece W when the diameter d_2 of the opening 71 and the desired diameter d_1 are set to be the same as each other. That is, FIG. 5 illustrates a conventional method in which the hole H having the desired diameter d_1 is directly formed in the workpiece W without cutting the peripheral edge portion 72 of the sheet 70. In a case where the fiber-reinforced plastic that constitutes the workpiece W has a structure in which a cut reinforcing fibers are dispersed in a resin, when the blasting abrasives are projected to the workpiece W, the reinforcing fibers dispersed without directionality becomes the origin of fracture, and thus peeling-off occurs on a surface of the workpiece W. In addition, in a case where the fiber-reinforced plastic that constitutes the workpiece W has a structure in which a woven reinforcing fibers infiltrate into a resin, the reinforcing fibers having a cloth shape becomes the origin of fracture, and thus peeling-off occurs on a surface of the workpiece W. When cutting further

continues after the peeling-off occurs, the diameter of the hole H formed in the workpiece W finally becomes larger than the desired diameter d_1 , and a surface layer portion does not become a circle shape. In addition, fluffing of the reinforcing fibers occur on a wall surface of the hole H (refer to a portion surrounded by a circle in the same drawing).

[0050] In the case where an ejection flow of the blasting abrasives are captured microscopically, when the ejection flow flows along the surface of the workpiece W, the surface layer of the workpiece W is likely to be peeled off due to the characteristics of the fiber-reinforced plastic. When peeling-off occurs in the surface layer of the workpiece W, the reinforcing fibers are exposed to surface layer, and thus fluffing occurs. Furthermore, the ejection flow flows in a direction conforming to a wall surface of the opening of the sheet 70 (that is, a direction perpendicular to the X direction and the Y direction), it is possible to suppress peeling-off on the surface layer of the workpiece W. As a result, it is possible to suppress fluffing of the reinforcing fibers. In a case where the fiber-reinforced plastic that constitutes the workpiece W has a structure in which woven reinforcing fibers infiltrate into a resin, the blasting abrasives collide with the workpiece W in a direction in which the reinforcing fibers of the workpiece W is cut, and thus it is possible to further suppress fluffing of the reinforcing fibers. In addition, in a case where the ejection flow is greatly inclined to the surface of the workpiece W, collision energy of the blasting abrasives are not sufficient. Accordingly, the hole H may not be formed in the workpiece W, the reinforcing fibers may not be cut, or the reinforcing fibers may be exposed on an outer peripheral surface of the hole H as fluffing. Here, in one embodiment, the nozzle 50 may be disposed at an angle of 85° to 95° (that is, in a range of $90^\circ \pm 5^\circ$) with respect to the surface of the workpiece W. In other words, the nozzle 50 is disposed so that an angle made by the surface of the workpiece W and an ejecting direction of the blasting abrasives becomes 85° or more and 95° or less.

[0051] When processing is performed so that an angle of a wall surface of the hole H formed in the workpiece W becomes appropriate, the processing is advantageous in performance. For example, the hole H formed in the workpiece W is provided for joining, the higher the perpendicularity of a wall surface defining the hole H is, the more a clearance between a joining member such as a bolt and the wall surface of the hole H becomes uniform in a thickness direction. As a result, it is possible to suppress backlash after joining. In addition, in a case where the hole H formed in the workpiece W is provided to improve sound absorbency, the higher the perpendicularity of the wall surface defining the hole H is, the further sound reflection due to the wall surface of the hole H is prevented. As in the examples, it is preferable that the angle of the wall surface with respect to a plane perpendicular to a central axis line AX of the hole H is close to 90° from the viewpoint of performance. However, as it is close to 90° , productivity further deteriorates. Accordingly, the angle of the wall surface that constitutes the hole H with respect to the plane perpendicular to the central axis line AX of the hole H may be 80° to 90° , or 80° to 85° from the viewpoints of productivity and performance.

[0052] Particles including the blasting abrasives projected to the workpiece W in the step S3 are collected at the bottom of the housing 10, and is transported to the separation mechanism 30 through the first transport pipe P1 due to a suction force of the suction mechanism 40. The particles transported to the separation mechanism 30 are separated into a blasting abrasives that can be reused and dust in the separation mechanism 30. The blasting abrasives that can be reused are accumulated in the storage hopper 21, and light dust is suctioned to the suction mechanism 40 and is collected by a collection filter provided inside the suction mechanism 40. The blasting abrasives that are accumulated in the storage hopper 21 and can be reused are transported to the nozzle 50 in a constant amount, and are ejected again toward the workpiece W.

<S4: Recovery Process>

[0053] After forming the hole H in the workpiece W in the step S3, a step S4 is performed. In the step S4, the control device 60 is operated to set the movement mechanism 14 to "OFF", to set the electromagnetic valve VL1 to "close", and to set the fixed-quantity supply mechanism 20 to "OFF", respectively. Then, locking of the door 11 is released to open the door 11, and the workpiece W is recovered from the processing chamber R. Subsequently, after the sheet 70 stuck to the workpiece W is peeled off, the blasting abrasives and dust which adhere to the workpiece W are removed by using air blow, ultrasonic cleaning, and the like. Through the processes, a series of drilling is terminated.

[0054] Next, description will be given of an experiment example in which drilling of the FRP was performed by using the drilling method of one embodiment. In the experiment example, processing of forming 100 pieces of holes (10 pieces $\times$ 10 pieces) which have a diameter ϕ of 2.0 mm (on a surface to be processed side) and have an approximately circular shape in glass fiber-reinforced glass (GFRP) workpiece W having a plate shape (200 mm $\times$ 200 mm $\times$ t1.0 mm (thickness)) was performed.

[0055] As the resist layer, a sheet (thickness: 0.5 mm), which contains an unsaturated polyurethane or an acrylic resin as a main component and in which an opening having a shape corresponding to a hole to be processed, was used.

Resist A: Unsaturated polyurethane is a main component (contained in 53 wt%)

Resist B: Unsaturated polyurethane is a main component (contained in 73 wt%)

Resist C: Acrylic resin is a main component (contained in 60 wt%)

[0056] Other main processing conditions were set as illustrated in Table 1.

[Table 1]

Blasting abrasives	Silicon carbide particles (average particle size: 150 μm)
Ejecting pressure	0.4 MPa
Distance between workpiece and nozzle	100 mm
Angle of nozzle	90°
Scanning velocity of workpiece	100 mm/sec
Number of times of scanning of workpiece	40 Pass

[0057] After performing drilling with respect to the workpiece W, among 100 pieces of holes which were formed, arbitrary 10 pieces of holes were selected, and were observed by using an electron microscope. Then, evaluation was performed. Evaluation standards were as follows.

<Processing Progress>

[0058]

○ ... All holes are penetrated, and an angle of a wall surface of the all holes is 80° to 90°.

△ ... All holes are penetrated, and the angle of the wall surface of the all holes is 60° to 80°.

× ... Hole which is not penetrated exists, or hole in which the angle of the wall surface of the hole is 59° or less exists.

<Diameter of Hole>

[0059]

○ ... Diameter on a surface to be processed side is less than $\pm 7\%$ of a target dimension (ϕ 2.0 mm) in all holes.

△ ... Diameter on the surface to be processed side is $\pm 8\%$ to $\pm 15\%$ of the target dimension (ϕ 2.0 mm) in the all holes.

× ... Hole in which the diameter on the surface to be processed side is $\pm 16\%$ of the target dimension (ϕ 2.0 mm) exists.

<Presence of Absence of Peeling-Off>

[0060]

○ ... All holes have a circular shape.

△ ... Hole in which a surface-layer peeling-off trace is observed in the vicinity of an outer periphery exists, but the trace is less than 1 mm from an outer periphery of a circle.

× ... Hole in which the surface-layer peeling-off trace is observed in the vicinity of the outer periphery exists, and the magnitude of the trace is 1 mm or greater from the outer periphery of a circle.

<Presence or Absence of Fluffing>

[0061]

○ ... Fluffing is not confirmed in all holes.

△ ... Hole in which slight fluffing is confirmed exists, but an exposed glass fiber is less than 0.1 mm.

× ... Hole in which fluffing is confirmed exists, and the exposed glass fiber is 0.1 mm or greater.

[0062] Hereinafter, processing conditions and evaluation results of various examples and comparative examples are illustrated in Table 2. "Processing" in Table 2 represents an evaluation results relating to "Processing Progress", "Peeling-

Off" represents an evaluation result relating to "Presence or Absence of Peeling-Off", and "Fluffing" represents an evaluation result relating to "Presence or Absence of Fluffing". In addition, "Nozzle angle" in Table 2 represents the angle of the ejection flow of the blasting abrasives with respect to the surface of the workpiece W, and 0° is an angle at which the ejection flow is horizontally ejected toward a scanning direction side in the longitudinal direction of the workpiece W at initiation of scanning. That is, a state in which the ejection flow flows in the +X direction illustrated in FIG. 3 is set as 0°.

[Table 2]

	Resist Layer	d ₂ /d ₁	Nozzle angle (deg.)	Evaluation			
				Processing	Diameter of hole	Peeling-Off	Fluffing
Example 1	A	0.85	92	○	○	○	○
Example 2	A	0.90	92	○	○	○	○
Example 3	A	0.94	92	○	○	○	○
Example 4	A	0.92	85	○	○	○	○
Example 5	A	0.92	94	○	○	○	○
Example 6	B	0.85	92	○	○	○	○
Comparative Example 1	A	0.78	92	×	○	○	○
Comparative Example 2	A	0.98	92	○	△	△	△
Comparative Example 3	A	1.05	92	○	×	×	×
Comparative Example 4	A	0.92	79	△	○	○	△
Comparative Example 5	A	0.92	120	×	○	○	△
Comparative Example 6	C	0.85	92	△	△	△	△

(1) Influence of d₂/d₁

[0063] In Examples 1 to 6, all evaluation items were "○" evaluation, and it was confirmed that drilling was performed in a satisfactory manner. Furthermore, in a qualitative evaluation, although the evaluation was the same "○" evaluation, but Example 2 and Example 3 shown a tendency in which a diameter of a hole after processing was closer to a desired dimension in comparison to Example 1.

[0064] In Comparative Example 1 in which d₂/d₁ was smaller than 0.84, "Processing Progress" was "×" evaluation. This is assumed to be because a chance for the blasting abrasives to come into contact with the workpiece W was excessively small. In Comparative Example 2 in which d₂/d₁ was greater than 0.94, all evaluations of "Diameter of hole", "Presence or Absence of Peeling-OFF of Surface Layer", and "Presence or Absence of Fluffing" were "△" evaluation. With regard to the "△" evaluation, it can be said that quality deterioration has no problem in practical use, but the quality further deteriorates in comparison to Examples 1 to 5. In addition, in Comparative Example 3 in which d₂/d₁ was greater than 1 (that is, d₂ > d₁), evaluations of "Diameter of hole", "Presence or Absence of Peeling-OFF of Surface Layer", and "Presence or Absence of Fluffing" were "×" evaluation. It is assumed that when d₂/d₁ increases, an effect of suppressing of a processing area due to the opening of the resist layer is reduced, and thus a surface layer of the workpiece W was peeled off.

(2) Influence of Nozzle Angle

[0065] In Examples 1 to 6, all were "○" evaluation, and it was confirmed that drilling was performed in a satisfactory manner. In Comparative Example 4 and Comparative Example 5 in which the angle exceeded 90° ± 5°, it could be seen that quality deteriorates in evaluations of "Processing Progress" and "Presence or Absence of Fluffing". With regard to

"Processing Progress", it is assumed that an inclination angle of the ejection flow with respect to the workpiece W was great and processing capability deteriorated, and thus quality deteriorated. With regard to the "Δ" evaluation, it can be said that quality deterioration has no problem in practical use. However, in Comparative Example 5 in which the nozzle angle was relatively large, evaluation was "×". In addition, with regard to "Presence or Absence of Fluffing", it is assumed that the ejection flow flowed along the surface of the workpiece W, and thus fluffing occurred.

(3) Influence of Material of Resist Layer

[0066] In Example 1, Example 6, and Comparative Example 6, the same processing conditions were set except for a material of the resist layer. In Example 1 and Example 6 in which a main component of the resist layer was unsaturated polyurethane, all evaluation items were "O" evaluation, and it was confirmed that drilling was performed in a satisfactory manner. Furthermore, in a qualitative evaluation, although the evaluation was the same "○" evaluation. However, there was a tendency in which the diameter of the hole after processing was closer to a desired dimension in Example 1 in which a content rate of unsaturated polyethylene was in a range of 50% to 70% in comparison to Example 6.

[0067] On the other hand, in Comparative Example 6 in which the main component of the resist layer was an acrylic resin, evaluation items of "diameter of hole", "Peeling-off", and "Fluffing" were "Δ" evaluation. With regard to the "Δ" evaluation, it can be said that quality deterioration has no problem in practical use. However, it was confirmed that processing accuracy was further lowered in comparison to a case of using a resist layer in which unsaturated polyurethane is a main component.

[0068] Hereinbefore, description has been given of the embodiments, but various modifications can be employed without limitation to the embodiments. For example, in the drilling method according to the embodiment, in the step S1, the sheet 70 in which an opening is formed in advance is disposed on the workpiece W. However, in one embodiment, the opening 71 may be formed in the sheet 70 after disposing the sheet 70, in which the opening 71 is not formed, on the workpiece W.

Industrial Applicability

[0069] In the embodiments, description has been given of drilling with respect to the workpiece W that is constituted by glass fiber-reinforced plastic (GFRP), but the drilling method according to the embodiments is applicable to drilling of a workpiece W that is constituted by all kinds of fiber-reinforced plastics such as carbon fiber-reinforced plastic (CFRP), aramid fiber-reinforced plastic (AFRP), dyneema fiber-reinforced plastic (DFRP), xyron fiber-reinforced plastic, and boron fiber-reinforced plastic (BFRP).

Reference Signs List

[0070] 01: sandblast machine, 10: housing, 11: door, 12: nozzle fixture, 13: processing table, 14: movement mechanism, 15: frame, 20: fixed-quantity supply mechanism, 30: separation mechanism, 40: suction mechanism, 50: nozzle, 51: nozzle holder, 52: air nozzle, 53: ejecting nozzle, 60: control device, 70: sheet, 71: opening, 72: peripheral edge portion, A: ejecting region, H1: air hose, H2: blasting abrasives hose, R: processing chamber, T: scanning trajectory, W: workpiece.

Claims

1. A drilling method of forming a hole having a desired diameter in a fiber-reinforced plastic workpiece, comprising steps of:

disposing a resist layer, in which an opening having a diameter smaller than the desired diameter is formed, on the workpiece; and

ejecting blasting abrasives to the workpiece through the resist layer to cut a portion, which is exposed from the opening, in the workpiece while cutting a peripheral edge portion of the opening of the resist layer.

2. The drilling method according to claim 1, wherein a ratio of the diameter of the opening to the desired diameter is 0.84 or more and 0.94 or less.

3. The drilling method according to claim 1 or 2, wherein in the step of ejecting the blasting abrasives to the workpiece, the blasting abrasives are ejected toward the workpiece from a nozzle, and

an angle formed by a surface of the workpiece and a ejecting direction of the blasting abrasives from the nozzle is $90^\circ \pm 5^\circ$.

4. The drilling method according to claim 3,
wherein the nozzle is configured to suck the blasting abrasives by introducing compressed air to the inside of the nozzle to eject the blasting abrasives with the compressed air as a solid-gas two-phase flow.
5. The drilling method according to any one of claims 1 to 4,
wherein the workpiece comprises the fiber-reinforced plastic in which a cut reinforcing fibers are dispersed in a resin.
6. The drilling method according to any one of claims 1 to 4,
wherein the workpiece comprises the fiber-reinforced plastic in which a woven reinforcing fibers infiltrate into a resin.
7. A resist layer that is used in the drilling method according to any one of claims 1 to 6,
wherein the resist layer is a polymer including unsaturated polyurethane or an abrasion-resistant rubber as a main component.
8. A fiber-reinforced plastic having a hole formed by the drilling method according to any one of claims 1 to 6,
wherein the fiber-reinforced plastic has a plate shape having a thickness of 1.0 mm or more and 2.0 mm or less, and
an angle formed by a plane perpendicular to a central axis line of the hole and a wall surface defining the hole is 80° or more and 90° or less.
9. A drilling method of forming a hole in a fiber-reinforced plastic workpiece having a front surface and a rear surface,
the hole being opened on the front surface and the rear surface and having a first opening on the front surface side
having a first area, comprising:

disposing a resist layer having blast resistance higher than blast resistance of the workpiece on the workpiece,
the resist layer having a second opening which has a shape corresponding to a shape of the first opening and
has a second area smaller than the first area; and
ejecting blasting abrasives to the workpiece through the resist layer to cut a portion, which is exposed from the
second opening, in the workpiece while cutting a peripheral edge portion of the second opening of the resist layer.

Fig.1

01

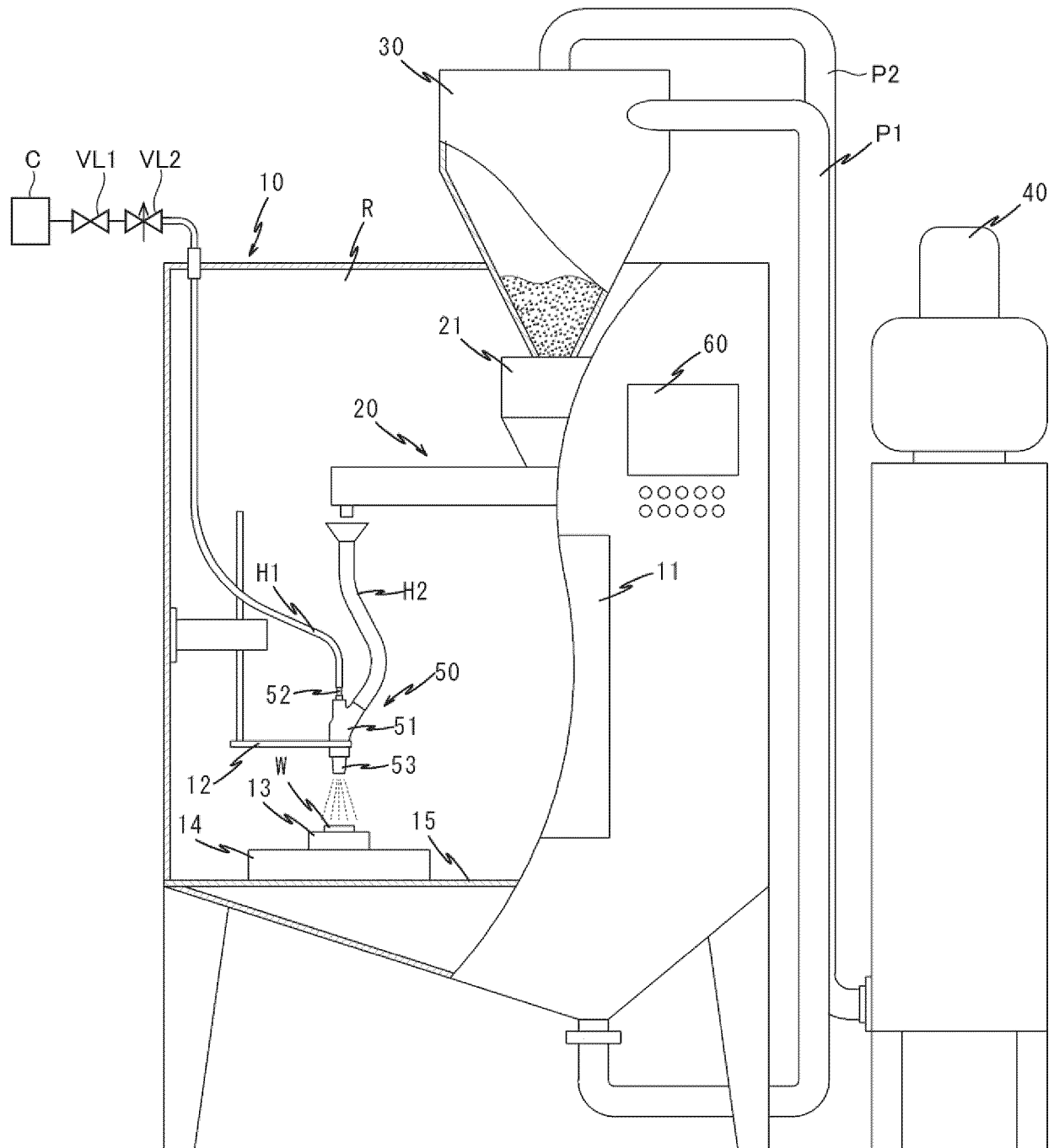


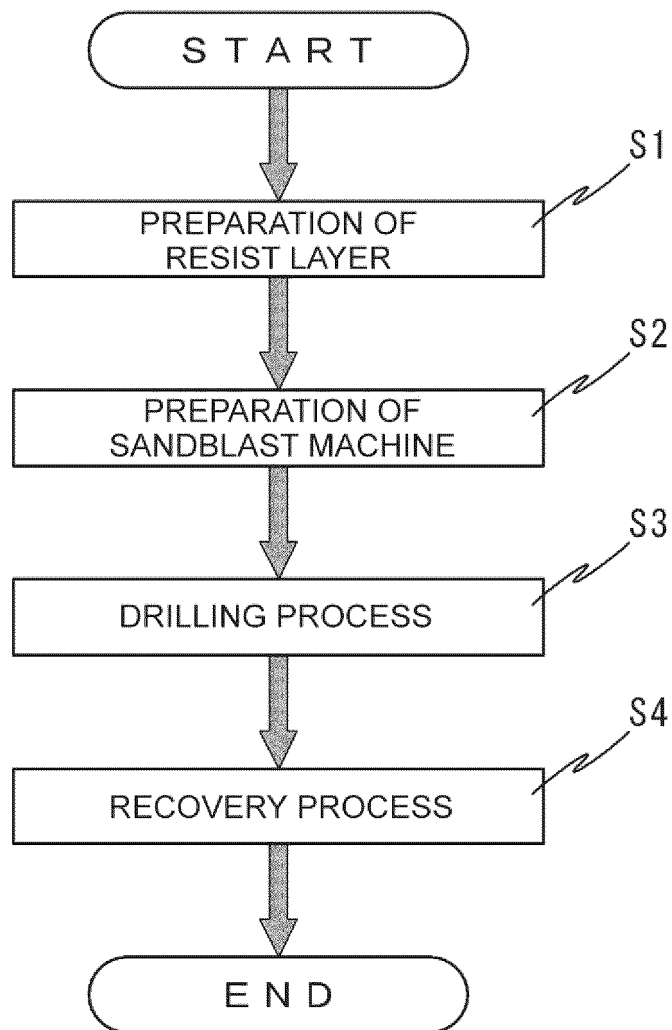
Fig.2

Fig.3

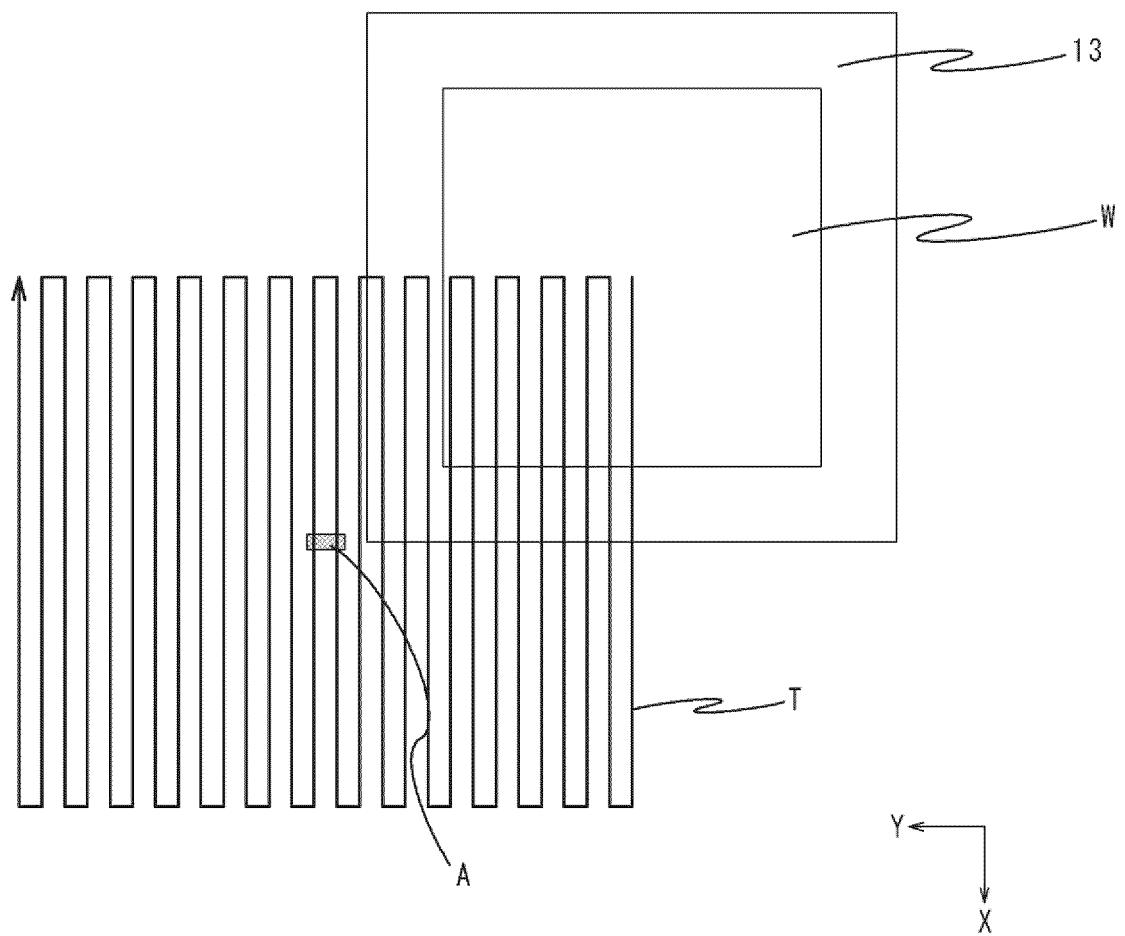


Fig.4

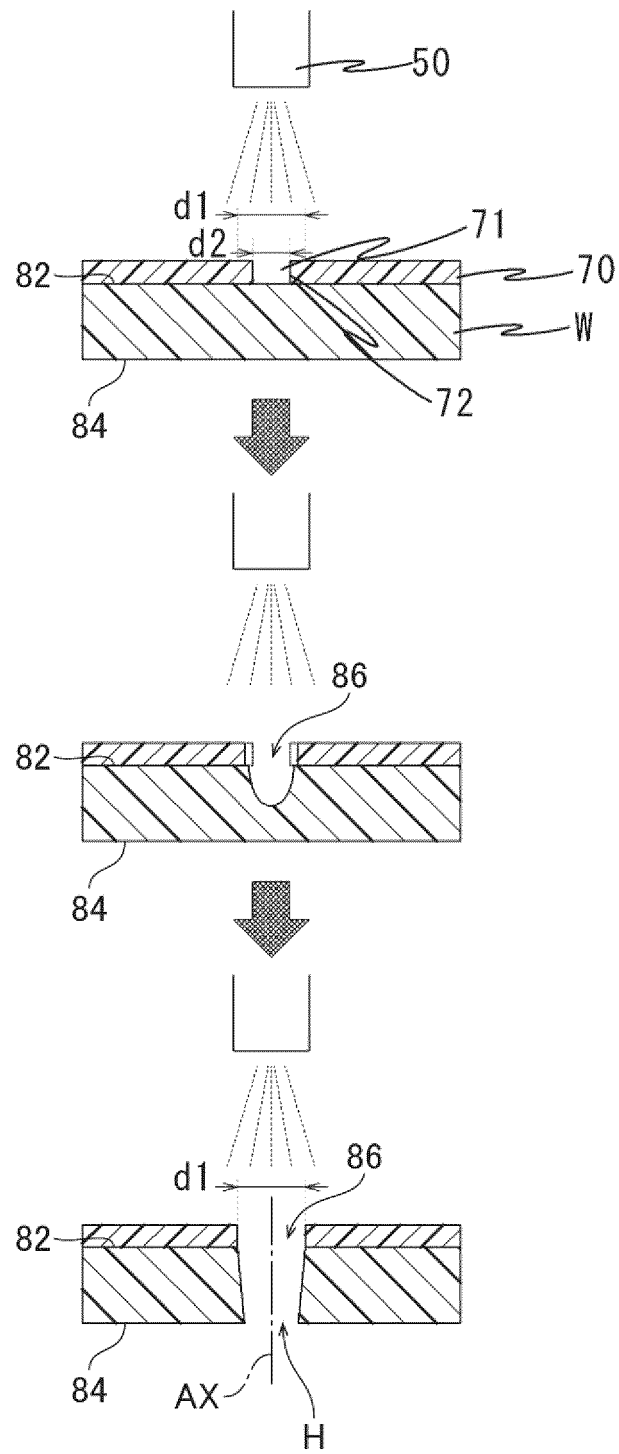
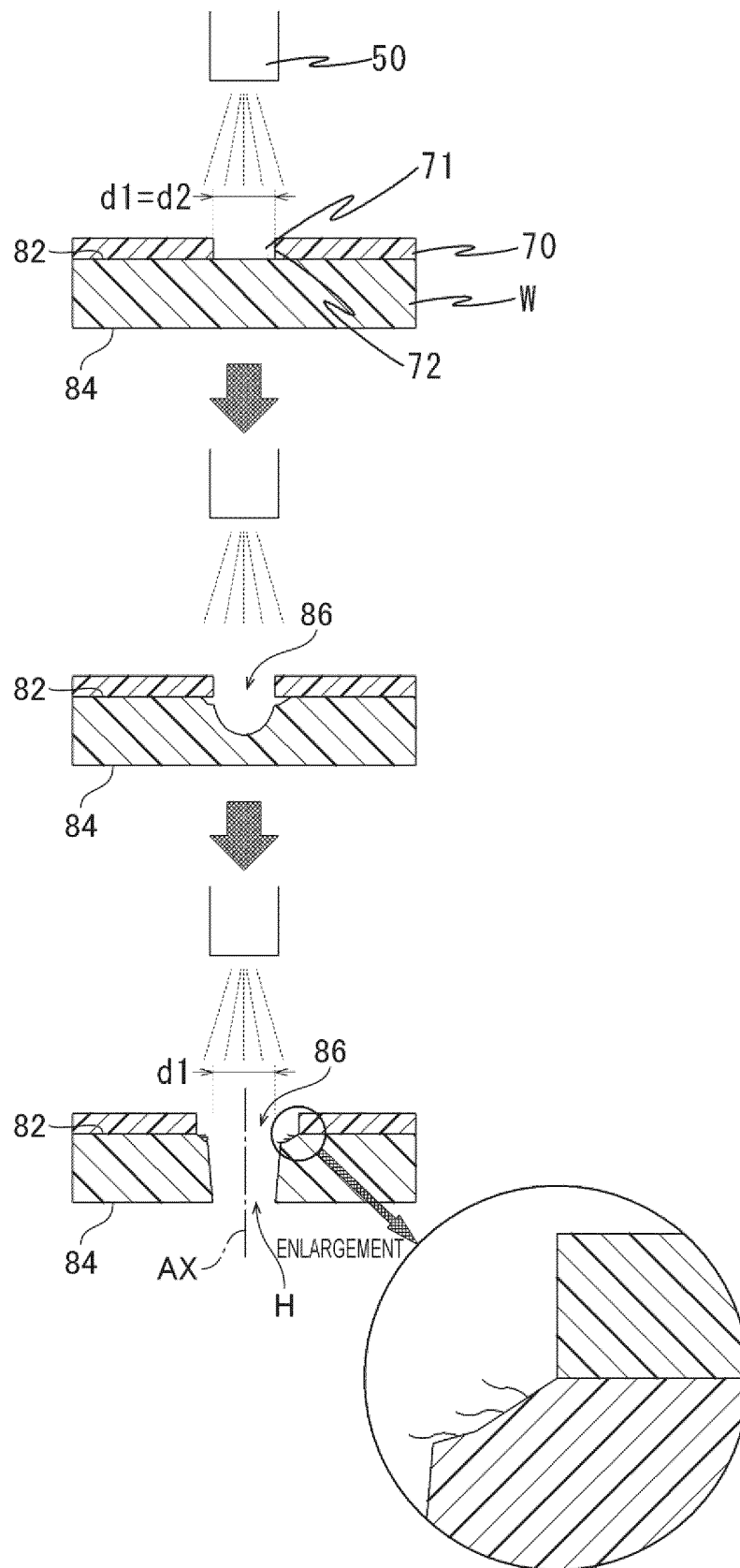


Fig.5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/034538

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. B24C1/04 (2006.01) i, B24C5/02 (2006.01) i

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)

Int.Cl. B24C1/00-11/00

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 1971-2017

Registered utility model specifications of Japan 1996-2017

Published registered utility model specifications of Japan 1994-2017

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

DWPI (Derwent Innovation)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2012-196751 A (MITSUBISHI PAPER MILLS LIMITED) 18 October 2012, paragraphs [0009]-[0022] (Family: none)	7-8 1, 3-6, 9 2
Y A	JP 2002-353425 A (KYOCERA CORP.) 06 December 2002, paragraph [0020], fig. 1-2 (Family: none)	1, 3-6, 9 2, 7-8
Y A	JP 2013-146851 A (SINTOKOGIO, LTD.) 01 August 2013, paragraph [0037], fig. 1 & CN 102672625 A	4-6 1-3, 7-9



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
07 December 2017 (07.12.2017)Date of mailing of the international search report
19 December 2017 (19.12.2017)Name and mailing address of the ISA/
Japan Patent Office
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/JP2017/034538

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 58-175632 A (ASAHI KASEI CHEMICALS CORP.) 14 October 1983, page 1, lower right column, lines 2-7, page 2, upper left column, line 19 to upper right column, line 5 (Family: none)	7 1-6, 8-9
A	WO 2007/091476 A1 (ASAHI KASEI MICRODEVICES CORPORATION) 16 August 2007, entire text & CN 101378880 A	1-9
A	JP 4-69167 A (NITTO DENKO CORP.) 04 March 1992, entire text, all drawings (Family: none)	1-9

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2012196751 A [0004]