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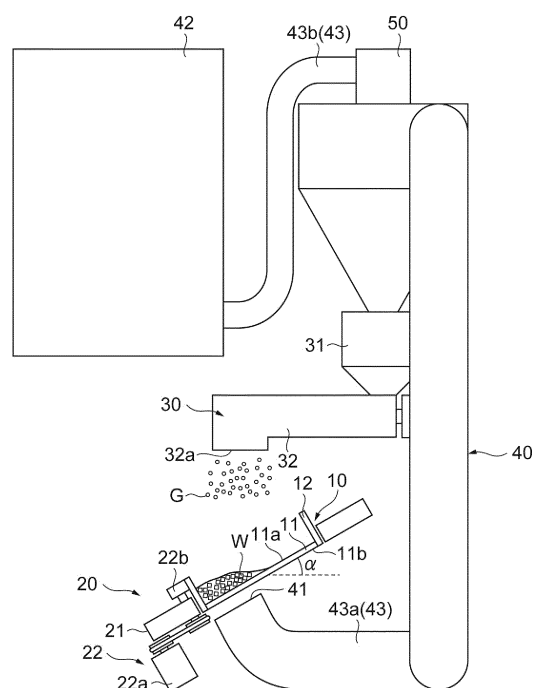
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(54) **BURR REMOVAL DEVICE AND BURR REMOVAL METHOD**

(57) A burr removal method includes: a step of preparing a burr removal device including a processing container and a suction mechanism for generating suction force, and a plurality of objects to be processed; a step of setting the plurality of objects to be processed in the processing container; a step of stirring the plurality of objects to be processed which are set in the processing container; and a step of removing burrs from the plurality of objects to be processed in such a manner that abrasive grains, fed to the plurality of objects to be processed in the stirred state, are accelerated to a predetermined speed by air flow generated by operating the suction mechanism, to thereby contact or collide with the plurality of objects to be processed.

Fig.1

01



Description**Technical Field**

5 [0001] The present disclosure relates to a burr removal device for removing burrs of objects to be processed and a burr removal method for removing burrs of objects to be processed.

Background Art

10 [0002] Electronic components are widely used in many electronic devices, such as a smart phone, a tablet terminal, and a portable music player. Particularly in recent years, smaller electronic components are desired to reduce the size of the electronic devices.

[0003] These electronic components are obtained in such a manner that raw material powders as hard brittle materials, such as ceramics or magnetic material, are molded by a press molding method, a doctor blade method, an injection molding method, or the like, and are then sintered. When the molded body configuring the electronic components has burrs, the burrs cause such as, for example, performance degradation of an electronic device due to the falling of a burr in a mounting process with an automatic mounting machine, or defective mounting resulting from the burrs, or the like. Therefore, the removal of burrs is carried out before mounting.

[0004] As a method for removing burrs of a molded body configuring an electronic component, Patent Literature 1 discloses a method for removing burrs by a wet barrel polishing method. Patent Literature 1 discloses a method in which paste containing raw material is molded into a sheet shape to create a green sheet, and in which burrs of a green chip, which is obtained by cutting the green sheet, are removed by performing wet barrel polishing. The wet barrel polishing method is a polishing method having relatively high polishing ability, and hence, the molded body is excessively polished depending on the strength of the molded body, which affects the dimensional accuracy of the electronic components. Further, in the wet barrel polishing method, the processing of wastewater generated by the polishing, the drying of the molded body after the polishing, and the like, are required, which increases the manufacturing cost.

[0005] As another method for removing burrs of a molded body configuring an electronic component, a method using an air blast apparatus can be considered (for example, described in paragraph 0002 of Patent Literature 2). Generally, in the air blast apparatus, abrasive grains are injected to a workpiece with compressed air having very high pressure, for example 0.2 MPa or more, to form a gas-solid two-phase flow. For this reason, when burrs of a small workpiece, such as an electronic component, are removed by the polishing, the workpiece itself is scattered around by the gas-solid two-phase flow. Further, the method using the air blast apparatus has polishing power higher than that of the above-described barrel polishing method, and hence, may cause a failure, such as cracking and chipping of the workpiece depending on the strength of the workpiece.

Citation List**Patent Literature**

40 [0006]

Patent Literature 1: Japanese Unexamined Patent Publication No. 2008-227314

Patent Literature 2: Japanese Unexamined Patent Publication No. 2010-188470

Summary of Invention**Technical Problem**

50 [0007] In this technical field, a new burr removal device for removing burrs of objects to be processed, and a new burr removal method for removing burrs of objects to be processed.

Solution to Problem

55 [0008] One aspect of the present invention provides a burr removal method for removing burrs of objects to be processed. The burr removal method includes the following steps (1) to (4).

(1) A step of preparing a burr removal device including a processing container and a suction mechanism for generating suction force, and a plurality of objects to be processed.

- (2) A step of setting the plurality of objects to be processed in the processing container.
 (3) A step of stirring the plurality of objects to be processed which are set in the processing container.
 (4) A step of accelerating abrasive grains, fed to the plurality of objects to be processed in the stirred state, to a predetermined speed by air flow generated by operating the suction mechanism, and of allowing the abrasive grains to contact or collide with the plurality of objects to be processed, to thereby remove burrs of the plurality of objects.

[0009] In the burr removal method according to the one aspect, the abrasive grains fed to the objects to be processed are accelerated to the predetermined speed by the air flow generated by operation of the suction mechanism (in the one embodiment, the speed of the abrasive grains, at the time when the abrasive grains contact or collide with the plurality of objects to be processed, is 5 to 30 m/sec). By this acceleration, the kinetic energy suitable for deburring is imparted to the abrasive grains. Therefore, when the abrasive grains contact or collide with the objects to be processed, it is possible to remove burrs from the objects to be processed without excessively cutting the objects to be processed. In this case, the plurality of objects to be processed, which are set in the processing container, are stirred, and thereby, burrs can be uniformly removed from all of the objects to be processed. It should be noted that "feeding of abrasive grains" means simply feeding abrasive grains without initial speed to the objects to be processed, or feeding abrasive grains with a very small initial speed to the objects to be processed, and does not mean injecting or projecting abrasive grains to the objects to be processed as in the blasting device. For example, the abrasive grains may be fed to the objects to be processed by free falling. Also, the abrasive grains may be fed to the objects to be processed with a weak wind volume that does not cause the abrasive grains to scatter around, or does not affect the deburring processing.

[0010] In the burr removal method according to one embodiment, each of the plurality of objects to be processed may be obtained by molding raw material powders, or by calcining an article formed by molding the raw material powders. For example, in a molded body, such as a green chip, formed by molding raw material powders, or a molded body formed by calcining an article formed by molding the raw material powders, that is, a molded body in the state before being sintered to become a sintered body, the strength of burrs is relatively lower than that in the sintered body. For this reason, when the molded body is set as the burr removal target, the deburring can be satisfactorily performed. Here, the sintering means a treatment in which a molded body, formed by pressing and molding raw material particles, is heated to reduce the gap between the particles bonding the adjacent raw material particles, and thereby the molded body is baked and solidified.

[0011] In the burr removal method according to one embodiment, each of the plurality of objects to be processed may be a ceramic or a magnetic material molded by a powder compacting molding method. The molding method of the objects to be processed is not limited in particular. However, in the objects to be processed which are molded by the powder compacting molding method, mutually adjacent raw material particles, between the burr portion and the portion which can be a product, are not bonded to each other by heating. For this reason, burrs existing on the objects to be processed can be removed satisfactorily.

[0012] In the burr removal method according to one embodiment, the plurality of objects to be processed, which are set in the processing container, may be made in a fluidized state and thereby be stirred in the step of stirring the plurality of objects to be processed. The size of the objects to be processed is relatively small (for example, one side is 100 to 1600 μm). Therefore, since the plurality of objects to be processed are made in a fluidized state to thereby be stirred, the plurality of objects to be processed can be uniformly distributed.

[0013] In the burr removal method according to one embodiment, the processing container may include a processing board and a frame body. The processing board may have a first face, and a second face that is a surface on the opposite side of the first face. In the processing board, a plurality of through holes, which penetrate the processing board in the direction from the first face to the second face, may be provided. Each of the plurality of through holes may have a size which enables each of the abrasive grains to pass through the through hole, and which prevents each of the plurality of objects to be processed from passing through the through hole. The frame body may surround the peripheral edge of the processing board on the first face of the processing board. Further, in the step of setting the plurality of objects to be processed in the processing container, the plurality of objects to be processed may be placed on the first face. In this case, without impairing the burr removing capability, it is possible to set the objects to be processed in the processing container and to stir the objects to be processed well.

[0014] In the burr removal method according to one embodiment, the thickness of the processing board may be 30 to 100 μm . A dihedral angle portion formed between the first face of the processing board and the frame body may be processed into an R surface having a radius of 0.5 to 5.0 mm. By this configuration, the objects to be processed can be prevented from being retained at the dihedral angle portion of the processing container, or from being caught between the members forming the processing container.

[0015] In the burr removal method according to one embodiment, the suction mechanism may be arranged on the side of the second face. Further, the air flow may be air flow directed from the first face to the second face. By this configuration, the air flow is generated from the side of the first face to the side of the second face in the vicinity of the objects to be processed, that is, in the inside of the processing container, and hence, burrs of the objects to be processed

can be satisfactorily removed.

[0016] The burr removal method according to one embodiment may further include a step of recovering the abrasive grains. In the step of removing burrs of the plurality of objects to be processed, the abrasive grains may be fed from the side of the first face to the plurality of objects to be processed. In the step of recovering the abrasive grains, the abrasive grains reaching the second face may be sucked and recovered by the suction mechanism. The abrasive grains, and fine particles (these abrasive grains and fine particles are hereinafter generally referred to as "powder dust") are made to flow to the suction mechanism, and hence, the powder dust can be prevented from being scattered in an area other than the area in which the deburring is performed. The fine particles include abrasive grains in which cracks or chips are caused, and cutting powder produced by the deburring processing.

[0017] In the burr removal method according to one embodiment, the ratio (passage rate) of the amount of the abrasive grains reaching the second face per unit time, with respect to the amount of the abrasive grains fed from the side of the first face to the plurality of stirred objects to be processed per unit time, may be 80 to 95% by weight. When the passage rate is set in this range, the frequency of contact of the abrasive grains with the objects to be processed can be suppressed from being not less than a fixed value without hindering acceleration of the abrasive grains. For this reason, the abrasive grains can be accelerated satisfactorily, and thereby, burrs of the objects to be processed can be removed satisfactorily.

[0018] In the burr removal method according to one embodiment, the ratio (suction rate) of the volume of the abrasive grains fed from the side of the first face to the plurality of objects to be processed per unit time with respect to the suction amount sucked by the suction mechanism per unit time may be 10 to 50% by volume. When the suction rate is set in this range, the amount of abrasive grains to the extent that burrs can be sufficiently removed can be obtained without hindering acceleration of the abrasive grains. Further, when the suction rate is set in this range, the abrasive grains fed to the plurality of objects to be processed can be sufficiently sucked by the suction mechanism. For this reason, the abrasive grains can be accelerated satisfactorily, and the possibility that the abrasive grains and the fine particles are scattered to the surroundings can be reduced.

[0019] In the burr removal method according to one embodiment, the fixing force of burrs may be reduced by stirring the plurality of objects to be processed in the step of stirring the plurality of objects to be processed. The burr portions of the objects to be processed are brought into contact with the other objects to be processed and the processing container, and thereby, cracks, as starting points of fatigue fracture, are induced. As a result, the deburring can be performed more easily by the abrasive grains.

[0020] The burr removal method according to one embodiment may further include a step of straightening the air flow. In the straightening step, the mode in which the abrasive grains contact or collide with the plurality of objects to be processed may be controlled by straightening the air flow. The action of the abrasive grains with respect to the objects to be processed is controlled by straightening the air flow, and thereby, the form of deburring can be changed. Thereby, the action of the abrasive grains can be changed according to the strength and form of the objects to be processed, the easiness of deburring, and the like.

[0021] In the burr removal method according to one embodiment, and in the step of stirring the plurality of objects to be processed, the processing container is arranged to be inclined at a predetermined angle (30 to 70° in one embodiment), and then, the plurality of objects to be processed may be stirred by rotating the processing container (in one embodiment, the rotational speed of the processing container is 5 to 50% of the critical rotational speed). In this case, the centrifugal force by rotation of the processing container, and the component force of gravity along the processing board are applied to the objects to be processed. When the inclination angle and the number of rotation of the processing container are controlled, the plurality of objects to be processed can be made in a fluidized state by using these forces, so that the plurality of objects to be processed can be stirred satisfactorily.

[0022] Another aspect of the present invention is provided with a burr removal device for removing burrs of objects to be processed. The burr removal device includes: a processing container in which a plurality of objects to be processed are set; a stirring mechanism which stirs the plurality of objects to be processed set in the processing container; an abrasive grain feed mechanism which feeds abrasive grains to the plurality of objects to be processed that are in the state of being stirred by the stirring mechanism; and a suction mechanism which generates air flow in a direction from the abrasive grain feed mechanism to the processing container by suction force. The suction mechanism accelerates the abrasive grains, fed to the plurality of objects to be processed by the abrasive grain feed mechanism, to predetermined speed with the air flow, and removes burrs of the plurality of objects to be processed by causing the accelerated abrasive grains to contact or collide with the plurality of objects to be processed.

[0023] In the burr removal device according to the another aspect, the abrasive grains fed to the objects to be processed are accelerated to the predetermined speed by the air flow generated by operation of the suction mechanism. By this acceleration, the kinetic energy suitable for deburring is imparted to the abrasive grains reaching the objects to be processed. Therefore, when the abrasive grains contact or collide with the objects to be processed, it is possible to remove burrs from the objects to be processed without excessively cutting the objects to be processed. In this case, the plurality of objects to be processed, which are set in the processing container, are stirred, and thereby, burrs can be uniformly removed from all of the objects to be processed.

Advantageous Effects of Invention

[0024] According to the various aspects and each embodiment of the present invention, it is possible to obtain objects to be processed, from which burrs are successfully removed.

Brief Description of Drawings

[0025]

[Fig. 1] Fig. 1 is a schematic view for explaining a burr removal device used in an embodiment of the present invention.

[Fig. 2] Fig. 2 is a schematic view for explaining a burr removal mechanism in the embodiment of the present invention.

[Fig. 3] Fig. 3 is a flowchart showing burr removal steps in the embodiment of the present invention.

Description of Embodiments

[0026] An example of a burr removal device and an example of a burr removal method according to the present invention will be described with reference to the accompanying drawings. In the following description, a molded body obtained by molding and solidifying raw material powder, that is, a molded body before it is sintered to become a sintered body is used as a workpiece (object to be processed). In the following description, the upward, downward, rightward and leftward directions indicate the directions in the drawings unless otherwise noted. Notably, the present invention is not limited to the configurations of the present embodiments but can be properly modified as needed.

[0027] As shown in Fig. 1, a burr removal device 01, which is used in the present embodiment, includes a processing container 10, a stirring mechanism 20, an abrasive grain feed mechanism 30, a suction mechanism 40, and a sorting mechanism 50.

[0028] The processing container 10 is a member for containing a workpiece W. The workpiece W is an object to be processed, and is, for example, a molded body which configures an electronic component. Examples of electronic components include a capacitor, a resistor, an inductor, a varistor, a band pass filter, a piezoelectric element, and the like. The workpiece W may be a molded body obtained by molding raw material powder, or may also be a molded body obtained by calcining an article formed by molding raw material powder. The workpiece W may be ceramics or magnetic material which is molded by a powder compacting molding method. The workpiece W may have a rectangular shape, and one side of the workpiece W may be, for example, about 100 to 1600 μm . The processing container 10 is provided with a processing board 11. The processing board 11 has a first face 11a (placement face) which is a face on which the workpiece W is placed, and a second face 11b which is a reverse face to the first face 11a. The processing board 11 has a plurality of opening portions which have air permeability and can allow the abrasive grains to pass therethrough, but which can prevent the workpiece W from passing therethrough and can allow the workpiece W to be retained on the side of the first face 11a. Specifically, in the processing board 11, a plurality of through holes which penetrate the processing board 11 in the direction from the first face 11a toward the second face 11b are provided. Each of the plurality of through holes has a dimension such that each of abrasive grains G is capable of passing through and the workpiece W is incapable of passing through. The processing board 11 may be, for example, a board configured to be mesh-like, a perforated metal, or a board in which a plurality of slits are provided. The shape of the processing board 11 is not specially limited.

[0029] The processing container 10 of the present embodiment includes the processing board 11 in a disc shape configured to be mesh-like, and a frame body 12 fixed to the outer edge part of the processing board 11. The frame body 12 surrounds the peripheral edge of the processing board 11 at least on the first face 11a of the processing board 11. Namely, the processing container 10 of the present embodiment has a cylindrical shape in which an upper part above the processing board 11 (first face 11a side) is open.

[0030] The stirring mechanism 20 is connected to the processing container 10, and stirs a plurality of the workpieces W housed (set) in the processing container 10 so that the plurality of workpieces W can be in a fluidized state. The configuration of the stirring mechanism 20 is not specially limited as long as the workpieces W can be stirred. For example, the stirring mechanism 20 may be configured to rotate the processing container 10 or may be configured to vibrate the processing container 10. As the stirring mechanism 20, another known configuration may be used. In the present embodiment, the stirring mechanism 20 rotates the processing container 10 with the center of the plane of the processing board 11 being as an axial center. Specifically, the stirring mechanism 20 includes a retaining member 21 and a rotary mechanism 22. The retaining member 21 rotatably retains the processing container 10 in the state of inclining the processing container 10 at a predetermined inclination angle α .

[0031] The rotary mechanism 22 is a mechanism that rotates the processing container 10 at a predetermined speed. The rotary mechanism 22 includes a motor 22a that generates rotational force, and a rotational force transmission member 22b that transmits the rotational force of the motor 22a to the processing container 10.

[0032] The abrasive grain feed mechanism 30 is a mechanism for feeding the abrasive grains G toward the workpiece W. The abrasive grain feed mechanism 30 includes a reservoir tank 31 and a carrying-out part 32. The reservoir tank 31 is a tank for storing the abrasive grains G. In the carrying-out part 32, a discharge port 32a is provided. The carrying-out part 32 is disposed in such a way that the discharge port 32a is positioned above the first face 11a of the processing board 11. The carrying-out part 32 may be configured so as to be able to discharge the abrasive grains G in the reservoir tank 31 (hopper) through the discharge port 32a by a fixed amount. The carrying-out part 32 may be configured, for example, to include a carrying screw and a trough enclosing the carrying screw, and to put the abrasive grains G in the reservoir tank 31 forward to the discharge port 32a provided at the trough. Moreover, the carrying-out part 32 may include a disc-shaped bottom table and a scraper (not shown in the figure) horizontally rotating with the center of the bottom table being as an axial center. In this case, the carrying-out part 32 may be configured to deposit a predetermined amount of abrasive grains G on the bottom table at an angle of repose by disposing the bottom face of the reservoir tank 31 slightly separated from the bottom table, and to scrape this out by the scraper toward the discharge port 32a. As the carrying-out part 32, another known configuration may be used. In the present embodiment, the carrying-out part 32 includes the former configuration.

[0033] The suction mechanism 40 includes both a function of accelerating the abrasive grains G and a function of sucking the same. The suction mechanism 40 includes a hose 43 and a dust collector 42. One end face of the hose 43 (in the present embodiment, a suction part 41) is provided below the second face 11b of the processing board 11 and is separated from the second face 11b. The dust collector 42 is joined to the hose 43.

[0034] The sorting mechanism 50 is a mechanism that sorts out a reusable abrasive grains from powder dust. Moreover, the sorting mechanism 50 is disposed in the middle of the path from the suction part 41 toward the dust collector 42. Namely, a first hose 43a whose one end face forms the suction part 41 is joined to the sorting mechanism 50, and the sorting mechanism 50 is joined to the dust collector 42 with a second hose 43b. As mentioned later, the sorting mechanism 50 is a mechanism that separates powder dust into the reusable abrasive grains and other fine particles (abrasive grains in which cracks or defects arise and cutting powder, of the workpiece, which arises through the removal of burrs). The sorting mechanism 50 may be configured to perform classification using a difference in specific gravity of the powder dust and an air flow. As the sorting mechanism 50, for example, a cyclone separator, a centrifugal classifier, or another known configuration may be used. In the present embodiment, as the sorting mechanism 50, a cyclone separator is used, and the bottom part of the cyclone separator is joined to the reservoir tank 31.

[0035] Next, a burr removal method is described further using Fig. 2 and Fig. 3.

(S01: Preparing Step)

[0036] The burr removal device 01 and a plurality of workpieces W are prepared. The abrasive grains G are beforehand loaded in the reservoir tank 31 shown in Fig. 1. The material of the abrasive grains G used in the present embodiment can be properly selected depending on the material and the shape of the workpiece W and the purpose of processing the same. For example, the abrasive grains G can be selected from metallic or nonmetallic particles (shot, grid and cut wire), ceramic particles (Al_2O_3 , SiC, ZrO_2 and the like), natural stone particles (emery, silica stone, diamond and the like), plant particles (walnut shells, peach seeds, apricot seeds and the like), and resin particles (nylon, melamine, urea and the like).

[0037] Moreover, the particle diameter of each of the abrasive grains G can also be properly selected depending on the material and the shape of the workpiece W and the purpose of processing the same. It should be noted that the particle diameter of each of the abrasive grains G must be selected such that it is a diameter to be capable of passing through the opening parts (through holes) of the processing container 10. For example, in the case of setting ceramic particles as the abrasive grains G, the particle diameter of each of the abrasive grains G is selected such that the particle size defined by JIS (Japanese Industrial Standards) R6001;1998 is F220, or #240 or more and #1000 or less, and it is a diameter to be capable of passing through the opening parts (through holes) of the processing container 10.

(S02: Step of Containing Workpiece in Processing Container)

[0038] A plurality of workpieces W are contained (set) in the processing container 10 by placing the plurality of workpieces W on the first face 11a of the processing board 11. The contained amount of the workpieces W is properly selected to meet the property of the workpieces W and the size of the processing container 10 so as to be able to retain the workpieces W with the processing container 10 and to stir the plurality of workpieces W by favorably setting the workpieces W in the fluidized state. It should be noted that, in Fig. 2, one workpiece W is illustrated for convenience.

(S03: Step of Stirring Workpieces)

[0039] The motor 22a is operated and the processing container 10 is rotated. The workpieces W contained in the

processing container 10 move along the frame body 12, following the rotation of the processing container 10. Since the processing container 10 is inclined and retained, centrifugal force in the direction toward the frame body 12 and a component of force of the gravity along the processing board 11 are exerted on the workpieces W. When a workpiece W moves (rises) up to a predetermined position, since the component of force of the gravity becomes larger than the centrifugal force, the workpiece W departs from the frame body 12 and falls downward along the processing board 11. In this way, movements and falls of the workpieces W continuously occur, and thereby, the plurality of workpieces W are brought into the fluidized state. Thus, the plurality of workpieces W are stirred. To achieve this fluidized state, the inclination angle α of the processing container 10 may be 30 to 70° relative to the horizontal plane, or may be 40 to 60°. When the inclination angle α of the processing container 10 is too small, the effect of promoting the fluidization by the gravity is small. When the inclination angle α of the processing container 10 is too large, since the component of force of the gravity becomes too larger than the centrifugal force, it is difficult to move the workpieces W, causing them to follow the rotation of the processing container 10.

[0040] Moreover, when the rotational speed of the processing container 10 is too high, since the centrifugal force becomes too strong, it is difficult to cause the workpieces W to fall by the component of force of the gravity. Conversely, when the rotational speed of the processing container 10 is too low, since the centrifugal force becomes too weak, it is difficult to move the workpieces W by the rotation of the processing container 10. In any of these cases, the workpieces W cannot be favorably brought into the fluidized state. To favorably stir the plurality of workpieces W by setting them in the fluidized state, the rotational speed of the processing container 10 may be 5 to 50% of the critical rotational speed or may be 10 to 30% thereof. Here, the critical rotational speed means the rotational speed in the case where, when the rotational speed of the processing container 10 is increased, the centrifugal force applied to the workpieces W becomes larger than the component force of gravity, and thereby, the workpieces W are rotated together with the frame body 12 without falling. When the rotational speed of the processing container 10 is too slow, the effect of gravity is too larger than the effect of the centrifugal force, and thereby, the movement of the workpieces W along the frame body 12 of the processing container 10 is not sufficiently performed. As a result, the fluidization via falling of the workpieces W is not sufficiently caused. When the rotational speed of the processing container 10 is too high, the gravity is too smaller than the centrifugal force, and hence, a part of the workpieces W does not fall while being pressed to the frame body 12 of the processing container 10, and thereby, the sufficiently fall of the workpieces W is not caused.

[0041] Further, when the workpieces W are stirred in the fluidized state, the workpieces W collide with each other, and thereby, the fixing force of the burrs formed on the workpieces W is reduced, so that the burrs are easily removed from the workpiece W.

(S04: Step of Generating Air Flow)

[0042] When operating the dust collector 42, an air flow from the first face 11a toward the second face 11b in the vicinity of the processing board 11 is generated.

(S05: Step of Straightening)

[0043] By straightening the flow of the air flow, the mode of the abrasive grains G colliding with or contacting with the workpiece W can be intentionally changed (controlled). This step can be performed, for example, by changing the position and the dimension of the suction part 41, the suction amount of the dust collector 42, and the like. Moreover, as mentioned later, since the speed of the abrasive grains G in the occasion when the abrasive grains G collide with or contact with the workpiece W is exceedingly low, the mode of the abrasive grains G colliding with or contacting with the workpiece W can be easily changed by the straightening step (S05). Notably, the straightening step S05 may be omitted.

(S06: Step of Feeding Abrasive Grains)

[0044] When operating the abrasive grain feed mechanism 30, the abrasive grains G loaded in the reservoir tank 31 are discharged through the discharge port 32a by a fixed amount, and are fed (fall in the case of the present embodiment) toward the workpiece W. When the abrasive grains G are discharged from the discharge port 32a, the speed of the abrasive grains G toward the workpieces W is 0 m/sec or is very low. Therefore, even when the abrasive grains G collide or contact with the workpieces W in the state of free fall and without receiving external force, such as suction force, the burrs of the workpieces W are not removed.

(S07: Step of Accelerating Abrasive Grains)

[0045] As shown in Fig. 2, the abrasive grains G discharged through the discharge port 32a reach, by the air flow generated in the step of generating air flow (S04), an acceleration region A (region in which this air flow arises on the

first face 11 a side) through free fall. The abrasive grains G having reached the acceleration region A are accelerated toward the suction part 41 in such a way that the speed in the occasion of colliding with or contacting with the workpiece W is a predetermined speed. This predetermined speed may be a speed at which the burrs of the workpieces W can be favorably removed and neither damage on nor sticking of the abrasive grain G into the workpiece W arise. For example, when the Vickers hardness (defined by JIS Z2244;2009) of the workpiece W is 3 to 200 Hv (testing force is 0.2 N), this predetermined speed may be 5 to 30 m/sec or may be 10 to 20 m/sec. This predetermined speed is very low speed for removing the burrs by contact or collision of the abrasive grains, and hence, cannot be realized by the conventional burr removal method. For example, in the case of the grinding by a blasting device, the injection pressure is high (for example, 0.2 MPa or more), and hence, it is impossible to realize the very slow speed, such as the above-described predetermined speed. If the injection pressure is set very low so that the speed of the abrasive grains becomes the predetermined speed, the amount of the injection material injected from the nozzle is not stabilized, and thereby, unevenness occurs in the finish degree of the workpieces. In the burr removal method of the present embodiment, the speed of the abrasive grains G can be set to very low speed at the time when the abrasive grains G collide or contact with the workpieces W, and hence, the burrs of the workpieces W can be removed by the abrasive grains G with very low speed. Adjustment of this speed can be performed by adjustment of suction amount with the dust collector 42, change of the dimension and the shape of the suction part 41, and the like. The adjustment of the suction amount with the dust collector 42 can be performed, for example, by change of the rotational speed of a motor built in the dust collector 42, adjustment of the degree of opening of a dumper, the dumper for sucking the outside air being provided in the hose 43, or the like.

(S08: Step of Removing Burrs of Workpiece)

[0046] The abrasive grains G having reached the acceleration region A are being accelerated and travelling toward the suction part 41, and reaches the processed surface of the workpiece W. After that, the abrasive grains G collide with or contact with the workpiece W, and after that, further travels toward the suction part 41. Actions F shown in Fig. 2 indicate the actions of the abrasive grains G. Examples of modes of the abrasive grains G colliding with or contacting with the workpiece W are described as actions F1, F2 and F3.

[0047] Action F1: the abrasive grains G linearly collide with the burrs of the workpiece W and then rebound from the workpiece W. The burrs are removed by the impact force when the abrasive grains G collide with the workpiece W.

[0048] Action F2: After colliding with the upper face of the workpiece W, the abrasive grains G travel along the upper face. The burrs are removed with the impact force in the occasion when the abrasive grains G collide with the workpiece W and friction force in the occasion when the abrasive grains G travel along the upper face.

[0049] Action F3: The abrasive grains G travel in such a way as to go along the dihedral angle portions of the workpiece W. The burrs are removed with at least any of the impact force in the occasion when the abrasive grains G collide with the dihedral angle portions of the workpiece W and friction force in the occasion when they pass on the dihedral angle portions.

(S09: Step of Recovering Abrasive Grains)

[0050] The abrasive grains G having collided with or contacted with the workpiece W pass through the processing board 11 and move onto the second face 11b side. The abrasive grains G having moved onto the second face 11b side are sucked from the suction part 41 by the dust collector 42. In this stage, the aforementioned fine particles also pass through the processing board 11 and are sucked from the suction part 41. Powder dust of the abrasive grains G and the fine particles passes through the first hose 43a and is transferred to the sorting mechanism 50. When the sorting mechanism 50 is a cyclone separator, the powder dust introduced from the upper part of the cyclone separator in such a way as to go along the wall surface spirally falls. In this process, the fine particles which are particles light in mass float upward, pass through the second hose 43b connected to the ceiling part of the cyclone separator, and are collected in the dust collector 42. Meanwhile, the abrasive grains G which are reusable and particles heavy in mass move toward the bottom part of the sorting mechanism 50, and are stored in the reservoir tank 31 joined to the bottom part of the sorting mechanism 50. These abrasive grains G are fed again toward the workpiece W through the discharge port 32a.

[0051] As described above, the abrasive grains G which are fed through the discharge port 32a in the abrasive grain feed mechanism 30 disposed on the first face 11 a side and are accelerated at the predetermined speed with the air flow generated by the dust collector 42 collide with or contact with the workpiece W, and thereby, the burrs of the workpiece W are removed. The abrasive grains G after colliding with or contacting with the workpiece W are sucked into the suction part 41 disposed on the second face 11b side. In this way, the abrasive grains G do not scatter around as in blasting processing which is a conventional burr removal method. Moreover, since the speed of the abrasive grains G in the occasion when the abrasive grains G collide with or contact with the workpiece W can be set to be exceedingly slow, even in the case of removing the burrs of the workpiece W that is relatively low in hardness, the burrs of the

workpiece W can be favorably removed without damaging the workpiece W. For example, in the case where a molded body configuring an electronic component is used as the workpiece W, it is possible to manufacture a highly reliable electronic component.

[0052] Here, the thickness of the processing board 11 may be 30 to 100 μm . When the thickness of the processing board 11 is too small, there is a possibility that the processing board 11 is broken while burrs are removed. When the thickness of the processing board 11 is too large, the distance of the processing board 11, through which the abrasive grains G pass, is too long, and thereby, the possibility of clogging of the abrasive grains G is increased and the abrasive grains G are not sufficiently accelerated in the acceleration region A due to the pressure loss. Further, the radius size (dihedral angle radius) of the dihedral angle formed between the frame body 12 and the first face 11a of the processing board 11 may be 0.5 to 5.0 mm. That is, the dihedral angle portion, which is formed between the frame body 12 and the first face 11a of the processing board 11, may be processed into an R surface having a radius of 0.5 to 5.0 mm. When the dihedral angle radius is too small, the possibility that the workpieces W are caught in the dihedral angle portion becomes high, while, when the dihedral angle radius is too large, it becomes difficult to retain the workpieces W in the processing container 10.

[0053] Further, in the present embodiment, two values of "suction rate" and "passage rate" are defined. Here, the "suction rate" means a rate of the volume (volume/ second) of the abrasive grains fed from the abrasive grain feed mechanism 30 per unit time, with respect to the suction amount (volume/ second) sucked by the suction mechanism 40 per unit time. The "passage rate" means a rate of the amount (gram/ second) of the abrasive grains G reaching the side of the second face 11b per unit time, with respect to the amount (gram/ second) of the abrasive grains G fed from the side of the first face 11a to the plurality of workpieces W in the fluidized state per unit time. Here, the amount (gram) of the abrasive grains G fed from the side of the first face 11a to the plurality of workpieces W in the fluidized state means the weight of the abrasive grains G discharged from the discharge port 32a. Further, the amount (gram) of the abrasive grains G reaching the side of the second face 11b means the weight of the abrasive grains G sucked by the suction mechanism 40 through the processing board 11.

[0054] The suction rate may be in the range of 10 to 50% by volume. When the suction rate is too low, the amount of the abrasive grains G discharged from the discharge port 32a is smaller than the suction amount sucked by the suction mechanism 40, and hence, the burrs of the plurality of workpieces W cannot be sufficiently removed. Further, when the suction rate is too high, the amount of the abrasive grains G discharged from the discharge port 32a is larger than the suction amount sucked by the suction mechanism 40. Therefore, in the acceleration region A, the abrasive grains G cannot be sufficiently accelerated to the speed at which the burrs of the workpieces W can be removed. Further, the abrasive grains G and fine particles are scattered around.

[0055] In the processing container 10, when the distance between the plurality of workpieces W, through which the abrasive grains G pass, is increased, the time during which the abrasive grains G are retained between the plurality of works W is increased, so that the passage rate is reduced. The passage rate may be in the range of 80 to 95% by weight. When the passage rate is too high, the distance between the plurality of workpieces W, through which the abrasive grains G pass, is too short, and thereby, the frequency, at which the abrasive grains G are brought into contact with the workpieces W, becomes low, so that the burrs of the workpieces W cannot be satisfactorily removed. Further, when the passage rate is too low, the distance between the plurality of workpieces W, through which the abrasive grains G pass, is too long, and thereby, the time during which the abrasive grains G are not accelerated by the air flow and retained between the plurality of workpieces W is increased, so that the removal of burrs of the workpieces W is hindered.

[0056] Next, the results at the time of removing burrs of the workpieces W by the above-described burr removal device will be described. Here, two types of workpieces W are selected, and the removal of burrs at the dihedral angle portion is set as the purpose of processing.

Workpiece A: the workpiece A is a ceramic molded article before sintering, which is obtained by molding the composite material ($\text{SiC}/\text{Al}_2\text{O}_3$) by compression molding. The size of the workpiece A is 0.5 mm $\times$ 0.5 mm $\times$ 1.0 mm, and the Vickers hardness of the workpiece A is Hv 100.

Workpiece B: the workpiece B is a ceramic molded article before sintering, which is obtained by molding ferrite powder with spinel crystal structure by compression molding. The size of the workpiece B is 0.5 mm $\times$ 0.5 mm $\times$ 1.0 mm, and the Vickers hardness of the workpiece B is Hv 20.

[0057] As the device, the burr removal device of the above-described embodiment is used. Further, as a comparative example, a prior art blasting device (modification of the drum type blasting device MY-30C manufactured by SINTOKO-GIO, LTD.) is used.

[0058] In the present embodiment, burrs of each of the workpieces W were removed by using the abrasive grain A and the abrasive grain B. The abrasive grain A is alumina particle having an average particle diameter of 18 μm (WA#800 manufactured by SINTOKOGIO, LTD.), and the apparent density of the abrasive grain A is 4.0 g/cm³. The abrasive grain B is ferrite particle having an average particle diameter of 14 μm , and the apparent density of the abrasive grain

B is 2.5 g/cm³.

[0059] The deburring of the workpieces W was performed by operating the burr removal device or the blasting device for 30 minutes, and then, the processed state of each of the workpieces W was evaluated. The evaluation of the processed state was carried out by examining the workpieces, as examination objects, by using a microscope (VHX-2000 manufactured by Keyence Corporation). The workpieces, as examination objects, in the amount of 1/5 of the volume of the processing container, were housed in the processing container. Then, after the deburring of the workpieces was performed (after finishing operation of the device), twenty workpieces, sampled from the total amount of the workpieces, were used as the workpieces as examination objects. The evaluation criteria of the processed state are as follows.

O ... Burrs were removed from all the workpieces without damage on the workpieces (cracks or defects of them or sticking of the abrasive grains into them).

Δ ... There were some workpieces in which burrs slightly remained, but there was no damage on all the workpieces.

X ... Many burrs were not removed or there were some workpieces that were damaged.

[0060] Further, after the deburring of the workpieces W was performed by using the burr removal device of the above-described embodiment, the periphery of the processing container 10 was examined. Further, after the deburring of the workpieces W was performed by using the blasting device, the periphery of the drum was examined. Then, evaluation of scattering of the abrasive grains was taken as "O" when adhesion of the abrasive grains was not observed in the periphery of the processing container 10 or in the periphery of the drum, and evaluation of scattering of the abrasive grains was taken as "X" when adhesion of the abrasive grains was observed in the periphery of the processing container 10 or in the periphery of the drum. Likewise, evaluation of scattering of the workpieces was taken as "O" when workpieces were not observed in the periphery of the processing container 10 or in the periphery of the drum, and evaluation of scattering of the workpieces was taken as "X" when workpieces were observed in the periphery of the processing container 10 or in the periphery of the drum.

[0061] The results of the above-described evaluation in each of the conditions are shown in Table 1. The "inclination angle", as the item of device in Table 1, represents the inclination angle α (°) of the processing container 10 with respect to the horizontal plane in the burr removal device of the above-described embodiment as shown in Fig. 1, and represents the inclination angle of the drum with respect to the horizontal plane in the blasting device. Further, the "rotational speed" represents the ratio (%) of the rotational speed with respect to the critical rotational speed. Further, as the "speed" of abrasive grains, the results are described, which are obtained by measuring beforehand the grain speed of the abrasive grains just before contact with the workpiece W in each of the conditions by using the flow rate measurement system (PIV system manufactured by Flowtech Research Inc.). Further, the "thickness" represents the thickness (μm) of the processing board 11, and the "dihedral angle radius" represents the size (mm) of the radius of the dihedral angle formed between the first face 11a of the processing board 11 and the frame body 12.

[0062] The suction rate is changed by changing the amount (grams/second) of the abrasive grains fed from the side of the first face 11a to the plurality of workpieces W in the fluidized state.

[0063] The amount of the abrasive grains fed from the side of the first face 11 a to the plurality of workpieces W in the fluidized state per unit time, and the amount of the abrasive grains reaching the side of the second face 11b per unit time were measured beforehand, and thereby, the passage rate was calculated. Specifically, the passage rate was calculated in such a manner that sintered products of workpieces A with no burr were used as workpieces, and that the following measurements (1) and (2) were performed when the burr removal device was operated for 1 minute.

(1) The amount of abrasive grains discharged from the discharge port 32a of the abrasive grain feed mechanism 30 (the amount of abrasive grains fed from the side of the first face 11 a to the plurality of workpieces W in the fluidized state per unit time).

(2) the amount of abrasive grains passing through the plurality of workpieces W and the processing board 11 and sucked by the suction mechanism 40 (the amount of abrasive grains reaching the side of the second face 11b per unit time).

[0064] Here, the sintered products of workpieces A with no burr were used as workpieces, in order to reduce the generation of cutting powder, such as burrs of the workpieces W.

[Table 1]

	Deburring conditions										Result		
	Workpiece	Device					Abrasive grain				Processing state	Scattering of abrasive grains	Scattering of workpieces
		Type	Inclination angle (°)	Rotational speed (%)	Thickness (μm)	Dihedral angle radius (mm)	Type	Speed (m/sec)	Suction rate (%)	Passage rate (%)			
Example 1	A	45	30	40	1.0	A	15	30	89	○	○	○	
Example 2	A	45	30	40	1.0	A	15	10	91	○	○	○	
Example 3	A	45	30	40	1.0	A	15	50	91	Δ	○	○	
Example 4	A	45	30	40	1.0	A	15	5	90	×	○	○	
Example 5	A	45	30	40	1.0	A	15	60	90	×	○	○	
Example 6	A	30	30	40	1.0	A	15	30	94	○	○	○	
Example 7	A	70	30	40	1.0	A	15	30	80	Δ	○	○	
Example 8	A	45	5	40	1.0	A	15	30	95	○	○	○	
Example 9	A	45	50	40	1.0	A	15	30	82	○	○	○	
Example 10	A	45	30	40	1.0	A	5	30	90	○	○	○	
Example 11	A	45	30	40	1.0	A	30	30	91	Δ	○	○	
Example 12	A	45	30	30	1.0	A	15	30	88	○	○	○	
Example 13	A	45	30	100	1.0	A	15	30	89	○	○	○	
Example 14	A	45	30	40	0.5	A	15	30	90	○	○	○	
Example 15	A	45	30	40	5.0	A	15	30	92	○	○	Δ	
Example 16	A	45	30	40	1.0	B	15	30	91	○	○	○	
Example 17	B	45	30	40	1.0	B	15	30	91	○	○	○	
Example 18	B	45	30	40	1.0	B	15	10	90	○	○	○	
Example 19	B	45	30	40	1.0	B	15	50	89	Δ	○	○	
Example 20	B	45	30	40	1.0	B	15	5	90	×	○	○	
Example 21	B	45	30	40	1.0	B	15	60	90	×	○	○	
Example 22	B	30	30	40	1.0	B	15	30	95	○	○	○	

(continued)

	Deburring conditions										Result		
	Workpiece	Device					Abrasive grain				Processing state	Scattering of abrasive grains	Scattering of workpieces
		Type	Inclination angle (°)	Rotational speed (%)	Thickness (μm)	Dihedral angle radius (mm)	Type	Speed (m/sec)	Suction rate (%)	Passage rate (%)			
Example 23	B	70	30	40	1.0	B	15	30	81	Δ	○	○	
Example 24	B	45	5	40	1.0	B	15	30	95	○	○	○	
Example 25	B	45	50	40	1.0	B	15	30	82	○	○	○	
Example 26	B	45	30	40	1.0	B	5	30	87	○	○	○	
Example 27	B	45	30	40	1.0	B	30	30	90	Δ	○	○	
Example 28	B	45	30	30	1.0	B	15	30	88	○	○	○	
Example 29	B	45	30	100	1.0	B	15	30	89	○	○	○	
Example 30	B	45	30	40	0.5	B	15	30	87	○	○	○	
Example 31	B	45	30	40	5.0	B	15	30	90	○	○	Δ	
Example 32	B	45	30	40	1.0	A	15	30	91	×	○	○	
Comparative Example 1	A	45	30	40	1.0	A	120	-	-	×	×	×	
Comparative Example 2	B	45	30	40	1.0	B	120	-	-	×	×	×	

[0065] First, in the burr removal device of the above-described embodiment, reference conditions are set such that the inclination angle of the processing container 10 was set to 45 degrees, the rotational speed was set to 30%, the thickness of the processing board 11 was set to 40 μm , the dihedral angle radius of the processing board 11 was set to 1.0 mm, the speed of abrasive grains was set to 15 m/sec, and the suction rate was set to 30%. In the burr removal device of the above-described embodiment, among the reference conditions, the suction rate was changed between 5 to 60% by volume, and the deburring of the workpieces A was performed by using the abrasive grains A (Examples 1 to 5). Further, in the burr removal device of the above-described embodiment, among the reference condition, the suction rate was changed between 5 and 60% by volume, and the deburring of the workpieces B was performed by using the abrasive grains B (Examples 17 to 21). In the state where the suction rate was set between 10 and 50% by volume, all of the processed states were evaluated as "O" or " Δ " regardless of the type of the workpieces (Examples 1 to 3 and Examples 17 to 19). On the other hand, in the case where the suction rate was outside the range between 10 and 50% by volume, the processed states were evaluated as "X" (Examples 4 and 5 and Examples 20 and 21).

[0066] Next, the deburring of the workpieces A and the workpieces B was performed by changing in order one of "inclination speed", "rotational speed", "speed", "thickness" and "dihedral angle radius" of the above-described reference conditions (Examples 6 to 15 and Examples 22 to 31). It should be noted that the deburring of the workpieces A was performed by using the abrasive grains A, and the deburring of the workpieces B was performed by using the abrasive grains B. As a result, all of the processed states were evaluated as "O" or " Δ ". In the examples in which the processed states were evaluated as " Δ ", burrs were slightly remained on the workpieces, and the workpieces were not damaged, which represent that, when the processing time is further increased, the evaluation of the processed states may become "O".

[0067] Among the above-described Examples 1 to 15 and Examples 17 to 31, the passage ratio was 80 to 95% by weight in the examples (Examples 1 to 3, Examples 6 to 19, Examples 22 to 31), in each of which the evaluation of the processed state was "O" or " Δ ". For this reason, in the passage rate in this range, the deburring can be performed satisfactorily.

[0068] In the burr removal device of the above-described embodiment, on the basis of the above-described reference conditions, the deburring of the workpieces A was performed by using the abrasive grains B made of ferrite material which is different from alumina material used as the material of the workpieces A. As a result of this, since alumina is harder than ferrite, the deburring could be performed satisfactorily without the abrasive grains sticking into the workpieces (Example 16). On the other hand, on the basis of the above-described reference conditions, the deburring of the workpieces B was performed by using the abrasive grains A made of alumina material which is different from ferrite material used as the material of the workpieces B. As a result of this, it was observed that the abrasive grains stick into the workpieces (Example 32). This seems to be because ferrite is softer than alumina. For this reason, it was found that, when the deburring of workpieces made of ferrite material is performed, the deburring can be performed satisfactorily by using abrasive grains made of ferrite material which is the same as the material of the workpieces, or by using abrasive grains made of material softer than ferrite material.

[0069] Further, when, in Examples 1 to 32, the periphery of the processing container 10 was examined after the deburring processing, the adhesion of the abrasive grains to the periphery of the processing container 10, and the falling of the workpieces W were not observed. Thereby, it was found that the burr removal device of the above-described embodiment can remove burrs from the workpieces W without scattering the abrasive grains to the periphery and without blowing off the workpieces.

[0070] On the other hand, when the deburring processing of the workpieces W was performed by using the blasting device, the burrs of the workpieces W were removed, but the workpieces W were damaged, as a result of which the processed state was evaluated as "X" (Comparative Example 1 and Comparative Example 2). Further, when the periphery of the drum, that is, the inside of the processing chamber was examined after the deburring processing, it was observed that the abrasive grains were adhered to the wall surface of the blasting chamber, as a result of which the scattering of the abrasive grains was evaluated as "X". Further, examining the classifying mechanism connected to the blasting device revealed the presence of the workpieces W. This means that, depending on the properties of the workpieces W, the workpieces were blown away from the drum during the deburring processing.

Industrial Applicability

[0071] According to the above-described embodiment, it is possible to provide a new burr removal method. In the burr removal method, abrasive grains are accelerated to a predetermined speed by air flow, to receive kinetic energy suitable for the deburring, and thereby, the abrasive grains having the kinetic energy collide or contact with the workpieces, to remove burrs of the workpieces. Further, the total amount of the abrasive grains and fine particles are recovered by a suction member. Thereby, the following effects are obtained.

- (1) The abrasive grains are not scattered around.

- (2) The workpieces are not blown out from the processing container during the deburring processing.
- (3) The speed of the abrasive grains is about 10 to 30 m/sec, and hence, the deburring processing of the workpieces can be performed by using the abrasive grains having very low speed. Thereby, the deburring of the workpieces, in the state before the workpieces are sintered to become sintered bodies, can be performed particularly well.

[0072] Further, the burr removal method of the one embodiment can be satisfactorily used for workpieces with relatively low hardness (for example, copper, aluminum, or the like).

Reference Signs List

[0073]

01	Burr removal device
10	Processing container
11	Processing board
11a	First face
11b	Second face
12	Frame body
20	Stirring mechanism
21	Retaining member
22	Rotary mechanism
22a	Motor
22b	Rotational force transmission member
30	Abrasive grain feed mechanism
31	Reservoir tank
32	Carry-out part
32a	Discharge port
40	Suction mechanism
41	Suction part
42	Dust collector
43	Hose
43a	First hose
43b	Second hose
50	Sorting mechanism
A	Acceleration region
F (F1, F2, F3)	Action of abrasive grain
G	Abrasive grain
W	Workpiece

Claims

1. A burr removal method of removing burrs from objects to be processed, comprising:

a step of preparing a burr removal device including a processing container and a suction mechanism for generating suction force, and a plurality of objects to be processed;
 a step of setting the plurality of objects to be processed in the processing container;
 a step of stirring the plurality of objects to be processed which are set in the processing container; and
 a step of accelerating abrasive grains, fed to the plurality of objects to be processed in the stirred state, to a predetermined speed by air flow generated by operating the suction mechanism, and of removing burrs from the plurality of objects to be processed by allowing the abrasive grains to contact or collide with the plurality of objects to be processed.

2. The burr removal method according to claim 1, wherein each of the plurality of objects to be processed is obtained by molding raw material powders, or by calcining the molded raw material powders.

3. The burr removal method according to claim 2, wherein each of the plurality of objects to be processed is a ceramic or a magnetic material which is molded by a powder compacting molding method.

4. The burr removal method according to any one of claim 1 to claim 3, wherein, in the step of stirring the plurality of objects to be processed, the plurality of objects to be processed, which are set in the processing container, are made to be in a fluidized state, and thereby, the plurality of objects to be processed are stirred.

5. The burr removal method according to any one of claim 1 to claim 4, wherein:

the processing container includes

a processing board having a first face, and a second face that is a surface on the side opposite to the first face, and
a frame body which surrounds the peripheral edge of the processing board on the first face of the processing board,

the processing board is provided with a plurality of through holes which penetrate the processing board in a direction from the first face to the second face;
each of the plurality of through holes has a size which enables each of the abrasive grains to pass therethrough, and prevents each of the plurality of objects to be processed from passing therethrough; and
in the step of setting the plurality of objects to be processed in the processing container, the plurality of objects to be processed are placed on the first face.

6. The burr removal method according to claim 5, wherein the thickness of the processing board is 30 to 100 μm , and a dihedral angle portion, which is formed between the frame body and the first face of the processing board, is processed to have an R surface of 0.5 to 5.0 mm in radius.

7. The burr removal method according to claim 5 or claim 6, wherein the suction mechanism is arranged on the side of the second face, and the air flow is air flow directed from the first face to the second face.

8. The burr removal method according to any one of claim 5 to claim 7, further comprising a step of recovering the abrasive grains,
wherein, in the step of removing burrs from the plurality of objects to be processed, the abrasive grains are fed from the side of the first face to the plurality of objects to be processed, and
in the step of recovering the abrasive grains, the abrasive grains reaching the second face are sucked and recovered by the suction mechanism.

9. The burr removal method according to any one of claim 5 to claim 8, wherein the ratio of the amount of the abrasive grains reaching the second face per unit time, with respect to the amount of the abrasive grains fed from the side of the first face to the plurality of stirred objects to be processed per unit time, is 80 to 95% by weight.

10. The burr removal method according to any one of claim 5 to claim 9, wherein the ratio of the volume of the abrasive grains fed from the side of the first face to the plurality of objects to be processed per unit time, with respect to the suction amount sucked by the suction mechanism per unit time is 10 to 50% by volume.

11. The burr removal method according to any one of claim 1 to claim 10, wherein, in the step of stirring the plurality of objects to be processed, the fixing force of burrs is reduced by stirring the plurality of objects to be processed.

12. The burr removal method according to any one of claim 1 to claim 11, wherein the speed of the abrasive grains is 5 to 30 m/sec when the abrasive grains contact or collide with the plurality of objects to be processed.

13. The burr removal method according to any one of claim 1 to claim 12, further comprising a step of straightening the air flow,
wherein, in the straightening step, the mode, in which the abrasive grains contact or collide with the plurality of objects to be processed, is controlled by straightening the air flow.

14. The burr removal method according to any one of claim 1 to claim 13, wherein, in the step of stirring the plurality of objects to be processed, the processing container is arranged to be inclined at a predetermined angle, and the plurality of objects to be processed are stirred by rotating the processing container.

15. The burr removal method according to claim 14, wherein the predetermined angle is 30 to 70°.

16. The burr removal method according to claim 14 or claim 15, wherein the rotational speed of the processing container is 5 to 50% of the critical rotational speed.

17. The burr removal method according to any one of claim 1 to claim 16, wherein one side of each of the plurality of objects to be processed is 100 to 1600 μm .

18. A burr removal device for removing burrs of objects to be processed, comprising:

a processing container in which a plurality of objects to be processed are set;
a stirring mechanism which stirs the plurality of objects to be processed set in the processing container;
an abrasive grain feed mechanism which feeds abrasive grains to the plurality of objects to be processed that are in the state of being stirred by the stirring mechanism; and
a suction mechanism which generates, by suction force, air flow in a direction from the abrasive grain feed mechanism to the processing container,
wherein the suction mechanism accelerates the abrasive grains, fed to the plurality of objects to be processed by the abrasive grain feed mechanism, to predetermined speed with the air flow, and removes burrs of the plurality of objects to be processed by causing the accelerated abrasive grains to contact or collide with the plurality of objects to be processed.

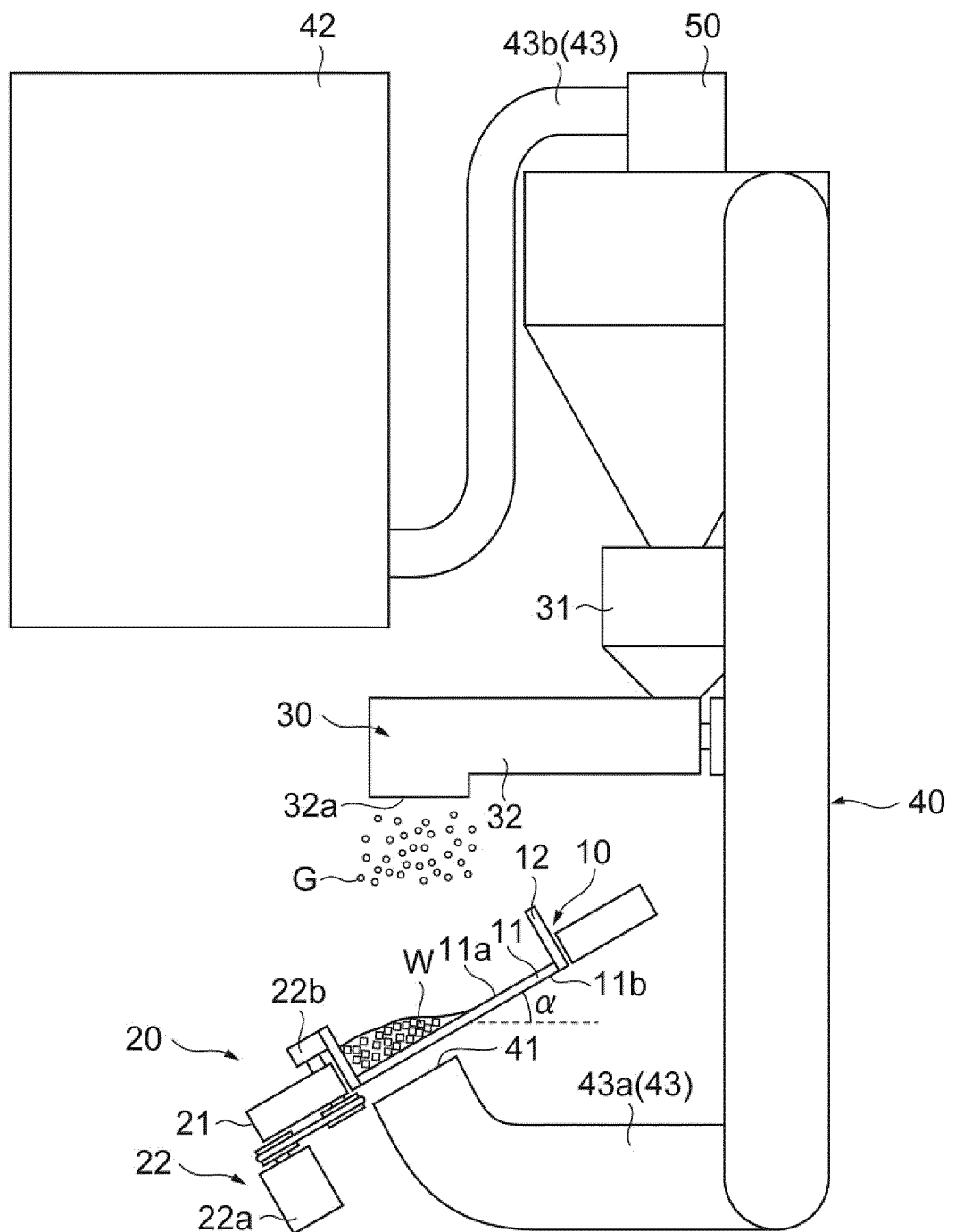
Fig.101

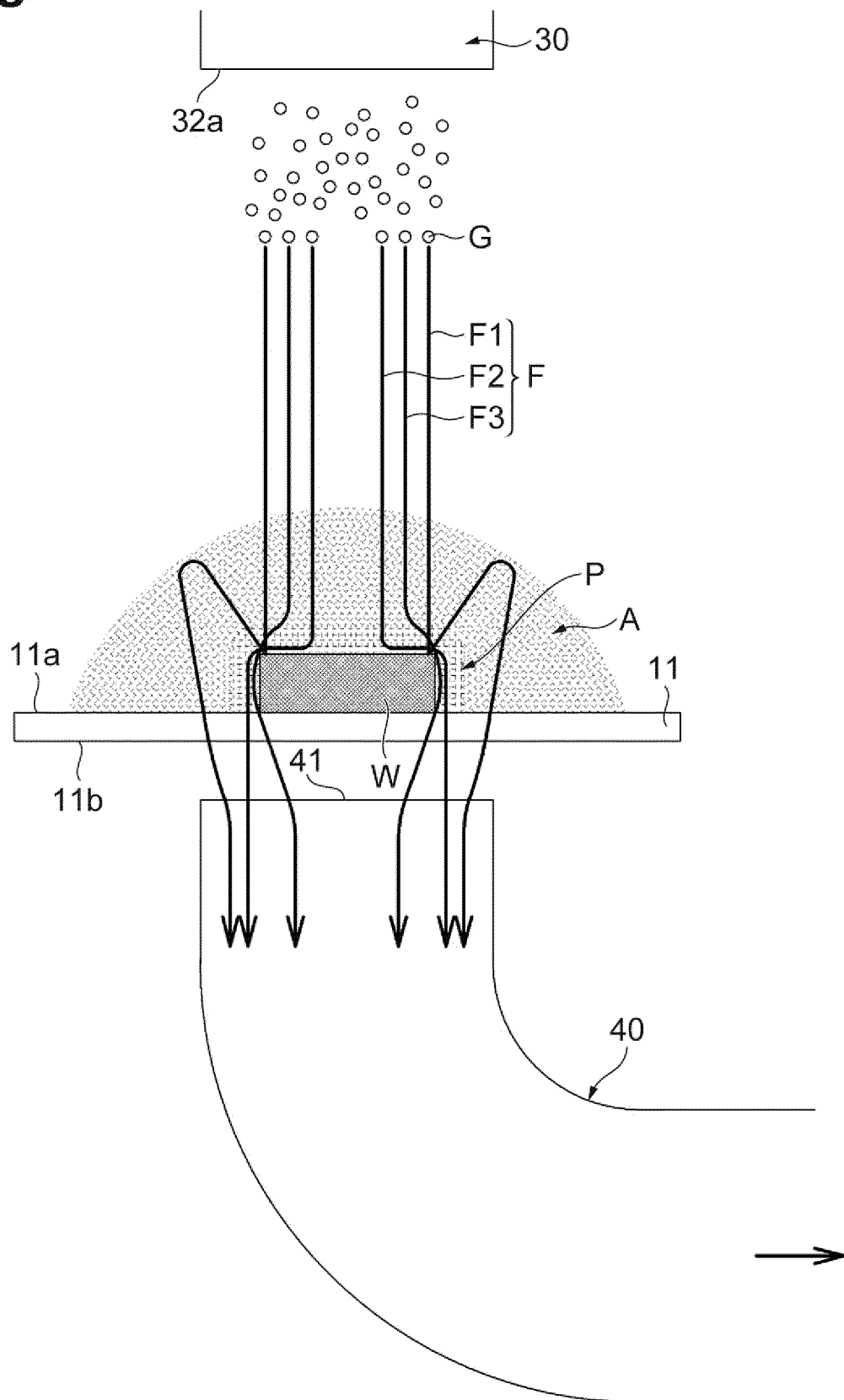
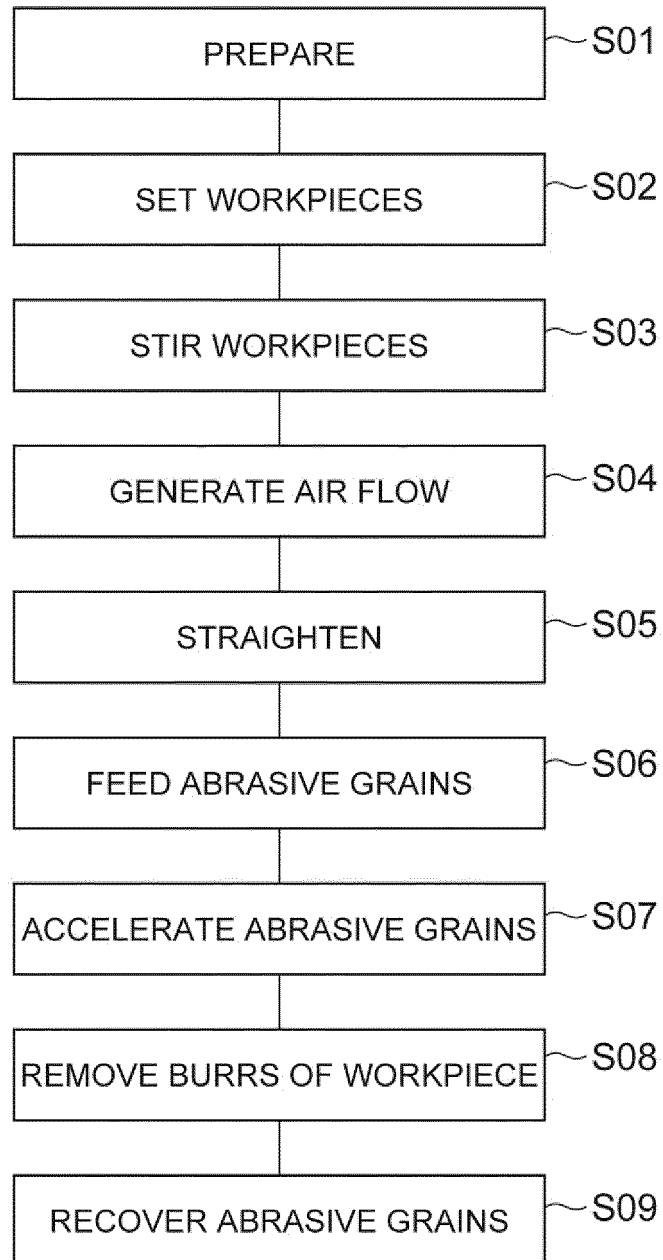
Fig.2

Fig.3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/080599

A. CLASSIFICATION OF SUBJECT MATTER

B24C1/00(2006.01)i, B24C3/26(2006.01)i, B24C3/32(2006.01)i, B24C5/00
(2006.01)i, B24C9/00(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)

B24C1/00, B24C3/26, B24C3/32, B24C5/00, B24C9/00

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

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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 A	JP 10-151566 A (Osaka Oxygen Industries, Ltd.), 09 June 1998 (09.06.1998), paragraphs [0019] to [0041]; fig. 1 to 6 (Family: none)	1, 4-18 2, 3
Y A	JP 62-34778 A (Kabushiki Kaisha Niigata Tekkosho), 14 February 1987 (14.02.1987), page 2, upper left column, line 18 to page 4, lower right column, line 2; fig. 1 to 7 & US 4741130 A column 2, line 66 to column 8, line 5; fig. 1, 3 to 8	1, 4-18 2, 3

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

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Date of the actual completion of the international search
14 December 2015 (14.12.15)

Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/080599

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 9-103960 A (Takashi SATO), 22 April 1997 (22.04.1997), paragraphs [0009] to [0032]; fig. 1 to 6 (Family: none)	1, 4-18 2, 3
A	JP 7-100767 A (Showa Tansan Co., Ltd.), 18 April 1995 (18.04.1995), entire text; fig. 1 to 15 (Family: none)	1-18
A	JP 2008-194792 A (Kabushiki Kaisha Sanpo), 28 August 2008 (28.08.2008), entire text; fig. 1 to 6 (Family: none)	1-18
A	JP 2013-180365 A (JFE Steel Corp.), 12 September 2013 (12.09.2013), entire text; fig. 1 to 2 (Family: none)	1-18
A	JP 2000-334661 A (Taiyo Densan Kabushiki Kaisha), 05 December 2000 (05.12.2000), entire text; fig. 1 to 5 (Family: none)	1-18

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008227314 A [0006]
- JP 2010188470 A [0006]