

Description

Title of Invention

WATER CIRCULATING DEVICE, CUTTING APPARATUS, AND METHOD
FOR PRODUCING CUT PRODUCT

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Technical Field

[0001]

This disclosure relates to a water circulating device, a cutting apparatus, and a method for producing a cut product.

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Background Art

[0002]

Substrates with semiconductor chips or the like mounted thereon are typically sealed up in resin and then cut by a cutting apparatus to be singulated for use as electronic parts. Known cutting apparatuses cut substrates sealed up in resin. When cutting a substrate, such a cutting apparatus uses water (that is, cutting water) to cool a cutting blade and the substrate and remove processing debris resulting from the cutting operation. The cutting apparatus also uses water (cooling water) other than cutting water to cool a spindle section for rotating the blade. The cutting apparatus may be configured to circulate and reuse the water to save water.

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[0003]

Patent Literature 1 discloses a water circulating device configured to circulate and reuse water ("processing water" in Patent Literature 1) for use to, for example, cool a blade and remove processing debris when a cutting apparatus ("processing apparatus" in Patent Literature 1) cuts a substrate sealed up in resin. After the cutting apparatus cuts the substrate, the water contains impurities such as processing debris and is not directly reusable. After the cutting apparatus cuts the substrate, the water circulating device disclosed in Patent Literature 1, for example, filters, emits ultraviolet light to, or removes impurity ions from the water to reproduce and reuse water usable when the cutting apparatus cuts a substrate.

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Citation List

Patent Literature

[0004]

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Patent Literature 1

JP 2021-122794 A

Summary of Invention

Technical Problem

[0005]

5 To circulate water resulting from the cutting apparatus cutting a substrate ("discharged water" in Patent Literature 1), the water circulating device forces out water with use of pumps ("discharged liquid supplying pump" and "clean water supplying pump" in Patent Literature 1). The water circulating device, for example, filters, emits ultraviolet light to, or removes impurity ions from the water forced out to reproduce water
10 usable when the cutting apparatus cuts a substrate. The water circulating device, however, fails to force out water in the event of an abnormality of water circulation due to, for example, a breakdown of a pump. The water circulating device, in such cases, fails to circulate water and supply cutting water to a substrate, with the result that the cutting apparatus fails to cut a substrate.

15 [0006]

 A water circulating device may be configured to use a pump to circulate and reuse water for cooling a spindle section for rotating a blade, while Patent Literature 1 is silent about this. Such a water circulating device also fails to circulate water in the event of a circulation abnormality due to, for example, a breakdown of the pump, failing to cool
20 the spindle section appropriately.

[0007]

 The above circumstances have led to a demand for a water circulating device, a cutting apparatus, and a method for producing a cut product each of which allows water to be supplied continuously even in the event of a circulation abnormality.

25 Solution to Problem

[0008]

 A water circulating device as an embodiment of this disclosure is a water circulating device configured to cool a spindle section with use of first water or second water, the spindle section being configured to rotate a blade for cutting an object to be cut,
30 the water circulating device including: a tank configured to store the first water; a pump connected to the tank and configured to force out the first water from the tank toward the spindle section; a circulation flow path configured to let the first water flow from the tank through the pump and the spindle section back to the tank; a switching valve configured to cause the second water to flow through the circulation flow path instead of the first
35 water; and a control section configured to control operation of the pump and operation of the switching valve, the control section being configured to, in response to detecting an

abnormality of circulation of the first water, control the switching valve to cause the second water to flow through the circulation flow path.

[0009]

A cutting apparatus as an embodiment of this disclosure includes: the above water circulating device; and a cutting mechanism including: a placement mount on which to place the object to be cut; the blade for cutting the object to be cut on the placement mount; and the spindle section configured to rotate the blade.

[0010]

A method as an embodiment of this disclosure for producing a cut product is a method for producing a cut product with use of the above cutting apparatus, the method including: causing the first water to flow through the circulation flow path with use of the water circulating device to cool the spindle section; placing the object to be cut onto the placement mount and then activating a water-sealed vacuum pump to fix the object to be cut to the placement mount; and cutting the object to be cut with use of the cutting mechanism to produce a cut product.

Advantageous Effects

[0011]

This disclosure may be embodied to provide a water circulating device, a cutting apparatus, and a method for producing a cut product each of which allows water to be supplied continuously even in the event of a circulation abnormality.

Brief Description of Drawings

[0012]

Fig. 1 is a perspective view of a molded substrate and electronic parts.

Fig. 2 is a plan view of a cutting apparatus.

Fig. 3 is a diagram illustrating the configuration of a water circulating device.

Description of Embodiments

[0013]

The description below deals with a water circulating device, a cutting apparatus, and a method for producing a cut product as embodiments of this disclosure with reference to drawings. The embodiments below are mere examples for describing a water circulating device, a cutting apparatus, and a method for producing a cut product. The water circulating device, the cutting apparatus, and the method for producing a cut product are not limited to the embodiments below. The water circulating device, the cutting apparatus, and the method for producing a cut product according to this disclosure

may be embodied variously without departing from the scope of this disclosure.

[0014]

Substrates with elements such as semiconductor chips mounted thereon are sealed up in resin and then cut to be singulated for use as electronic parts. Substrates sealed up in resin are cut with use of a dedicated cutting apparatus.

[0015]

Substrates are sealed up in resin as a result of placing substrates on a molding die (not illustrated in the drawings) of a resin molding apparatus and supplying liquid, molten resin into the molding die. The molten resin may be a thermoplastic resin or a thermosetting resin. A thermosetting resin has a viscosity that decreases when heated. Continuing to heat a thermosetting resin polymerizes and cures the thermosetting resin into a cured resin. A thermosetting resin is desirable in resin-sealing substrates with elements such as semiconductor chips mounted thereon. The resin in which the substrates are sealed up protects the elements mounted on the substrates.

[0016]

[Configuration of Molded Substrates]

The cutting apparatus 1 (see Fig. 2) as the present embodiment is designed to cut a molded substrate Sb as an object to be cut (which is an example object to be cut). As illustrated in Fig. 1, a molded substrate Sb includes two or more elements 61, a substrate 63 provided with the elements 61 mounted on the substrate 63 and sealed up in resin, and a resin package 65 facing the elements 61. The elements 61 are, for example, integrated circuits (that is, semiconductor chips). The elements 61 each include electrodes 61a opposite to the resin package 65 across the substrate 63 and exposed. In the present embodiment, two or more elements 61 are mounted on a single substrate 63 and each element 61 includes two or more electrodes 61a. Fig. 1 illustrates an example including a single substrate 63, twenty-one elements 61 mounted on the single substrate 63, and four electrodes 61a included in each element 61. The number of elements 61 mounted on a single substrate 63 is not limited to twenty-one. The number of electrodes 61a included in each element 61 is not limited to four. Fig. 1 shows broken lines to indicate portions at which the cutting apparatus 1 cuts (described later). Fig. 1 illustrates three upper right elements 61 as electronic parts Sc (which is an example cut product) that the cutting apparatus 1 as the present embodiment has cut from the molded substrate Sb. Each electronic part Sc includes a single element 61. Examples of the electronic parts Sc include a ball grid array (BGA) substrate, a land grid array (LGA) substrate, a chip size package (CSP) substrate, a light emitting diode (LED) substrate, and a quad flat no-leaded (QFN) substrate. The molded substrate Sb for the present embodiment is not limited a

substrate 63 provided with elements 61 mounted on the substrate 63 and sealed up in resin. The molded substrate Sb may alternatively be, for example, a circuit board provided with no elements 61 mounted on the circuit board and with single-layer or multilayer wiring.
[0017]

5 [Configuration of Cutting Apparatus]

Fig. 2 is a schematic plan view of a cutting apparatus 1 as the present embodiment. The cutting apparatus 1 is configured to cut a molded substrate Sb for singulation into two or more electronic parts Sc (see Fig. 1). The description below uses the term "front face" to refer to that face of a molded substrate Sb which has been sealed
10 up in resin or that face on which the resin package 65 is disposed (that is, the lower face in Fig. 1) and the term "back face" to refer to that face of a molded substrate Sb which is opposite to the front face (that is, the upper face in Fig. 1).
[0018]

The cutting apparatus 1 includes a cutting module A1 (which is an example
15 cutting mechanism) and an inspection/storage module B1. The cutting module A1 cuts a molded substrate Sb to produce two or more electronic parts Sc. The inspection/storage module B1 inspects those electronic parts Sc and then stores the electronic parts Sc on a non-defective item tray 15a or a defective item tray 15b. In the cutting apparatus 1, the cutting module A1 and the inspection/storage module B1 are attachable and detachable
20 as well as replaceable.
[0019]

The cutting apparatus 1 includes a control section 50 including a processor such as a central processing unit (CPU) and a storage device such as a random access memory (RAM) or a read only memory (ROM). The control section 50 is configured such that the
25 processor executes control programs stored in the storage device to control the operation of each section of the cutting module A1 and the inspection/storage module B1. The cutting apparatus 1 operates as described below on the basis of operation instructions from the control section 50 unless otherwise specified. The description below basically omits to deal with operation instructions from the control section 50 and deals as
30 necessary with such operation instructions.
[0020]

The cutting module A1 includes as main components a substrate supply section 3, a positioning section 4, cutting tables 5 (which is an example placement mount), spindle sections 6, a conveying section 7, and a water circulating device 30. The cutting module
35 A1 also includes a portion of a first vacuum pump D1 and second vacuum pumps D2 (which is an example water-sealed vacuum pump).

[0021]

The substrate supply section 3 pushes out molded substrates Sb one by one from a magazine M1 storing two or more molded substrates Sb to supply molded substrates Sb one by one to the positioning section 4.

5 [0022]

The positioning section 4 places on a rail section 4a a molded substrate Sb as pushed out from the substrate supply section 3 to position the molded substrate Sb. The positioning section 4 then conveys the molded substrate Sb as positioned to a cutting table 5.

10 [0023]

The cutting tables 5 hold molded substrates Sb to be cut. The cutting module A1 for the present embodiment includes two cutting tables 5. The two cutting tables 5 are each connected to a second vacuum pump D2 through a second drawing path VR2. The cutting module A1 includes two second vacuum pumps D2 and two second drawing paths VR2. The second vacuum pumps D2 are water-sealed vacuum pumps. Water-sealed vacuum pumps are not detailed here as they have a publicly known configuration.

[0024]

The cutting tables 5 each include a holder 5a, a rotating mechanism 5b, and a moving mechanism 5c. The holder 5a receives a molded substrate Sb conveyed to the positioning section 4 and draws air from below with use of the corresponding second vacuum pump D2 to suck the molded substrate Sb and thereby hold the molded substrate Sb. This fixes the molded substrate Sb to the cutting table 5. A later description will deal with the details of the cutting tables 5 and how the holder 5a sucks a molded substrate Sb for fixation.

25 [0025]

The rotating mechanism 5b is configured to rotate the holder 5a in the direction indicated with $\theta 1$ in Fig. 2. The moving mechanism 5c is configured to move the holder 5a along the Y axis in Fig. 2. Fig. 2 shows a Z axis as a vertical direction, an X axis along which the cutting module A1 and the inspection/storage module B1 are arranged, and a Y axis perpendicular to the X and Z axes (which extends along the depth of each module). $\theta 1$ indicates a direction of rotation about the Z axis.

[0026]

The spindle sections 6 each include a motor 6a and a rotary shaft 6b for outputting rotational driving force from the motor 6a. The rotary shaft 6b is provided with a blade 8. The spindle sections 6 each rotate its rotary shaft 6b with use of rotational driving force to rotate the blade 8. The blade 8 rotates at a high speed to cut a molded

substrate Sb for singulation into two or more electronic parts Sc.

[0027]

The cutting module A1 for the present embodiment includes two spindle sections 6. The spindle sections 6 are each movable along the X and Z axes in Fig. 2. The cutting module A1 may alternatively include a single spindle section 6.

[0028]

The spindle sections 6 are each provided with, for example, a cutting water nozzle, a cooling water nozzle, and a washing water nozzle (not illustrated in the drawings). The cutting water nozzle jets out cutting water onto the blade 8 as the blade 8 rotates at a high speed. The cooling water nozzle jets out cooling water onto the blade 8 and a molded substrate Sb as they are heated by the cutting operation. The washing water nozzle jets out washing water for removing cutting debris and the like. The cutting module A1 discharges cutting water, cooling water, and washing water as jetted out.

[0029]

The cutting apparatus 1 cools each motor 6a with use of water such as industrial water while the motor 6a is being driven, as the motor 6a generates heat when driven. The cutting apparatus 1 includes a water circulating device 30 configured to circulate and reuse first cooling water W1 (which is example first water) for cooling the motor 6a (see Fig. 3). A later description will detail the water circulating device 30.

[0030]

The conveying section 7 sucks electronic parts Sc from above that have been held by the cutting tables 5 and resulted from the cutting operation, and conveys the electronic parts Sc to an inspection table 11 of the inspection/storage module B1. The conveying section 7 is connected to the first vacuum pump D1 through a first drawing path VR1. The first vacuum pump D1 is a water-sealed vacuum pump. The conveying section 7 draws air with use of the first vacuum pump D1 to suck the electronic parts Sc.

[0031]

The inspection/storage module B1 includes as main components an inspection table 11, a first optical inspection camera 12, a second optical inspection camera 13, a placement section 14, and an extraction section 15. The first optical inspection camera 12 may alternatively be included in the cutting module A1. The inspection/storage module B1 includes a portion of the first vacuum pump D1. The first vacuum pump D1 thus has a portion included in the cutting module A1 and a portion included in the inspection/storage module B1.

[0032]

The inspection table 11 holds electronic parts Sc for the first and second optical

inspection cameras 12 and 13 to optically inspect the electronic parts Sc. The inspection table 11 is movable along the X axis in Fig. 2. The inspection table 11 is provided with a holder (not illustrated in the drawings) configured to suck and hold electronic parts Sc by means of a drawing operation by the first vacuum pump D1.

5 [0033]

The first and second optical inspection cameras 12 and 13 capture images of the opposite faces of each electronic part Sc (that is, its front and back faces). The inspection/storage module B1 inspects electronic parts Sc for various aspects on the basis of data on the images captured by the first and second optical inspection cameras 12 and 13. The first and second optical inspection cameras 12 and 13 are proximate to the inspection table 11 and face upward for image capturing.

[0034]

The placement section 14 receives from the inspection table 11 electronic parts Sc as inspected (see Fig. 1). The placement section 14 is connected to the first vacuum pump D1 through the first drawing path VR1.

15 [0035]

The extraction section 15 transfers electronic parts Sc from the placement section 14 to a tray. The extraction section 15 separates electronic parts Sc (see Fig. 1) into non-defective items and defective items on the basis of the result of the inspection involving use of the first and second optical inspection cameras 12 and 13.

20 [0036]

The cutting apparatus 1 further includes a monitor 20 and a sound output section 25. The monitor 20 is configured to display an image. The monitor 20 includes a display device such as a liquid crystal monitor or an organic electroluminescent (EL) monitor. The sound output section 25 is configured to output sound. The sound output section 25 includes a sound output device such as a loudspeaker, a buzzer, or a bell.

25 [0037]

[Configuration of Water Circulating Device]

The description below deals with the water circulating device 30 with reference to Fig. 3. The water circulating device 30, as described above, functions to circulate and reuse first cooling water W1 for cooling each spindle section 6 (the motor 6a in particular). The water circulating device 30 includes a tank 31, a water pump 32 (which is an example pump), a cooler 33, a switching valve 34, a sensor group 35, a first vacuum pump D1, second vacuum pumps D2, a separator 37, a filter 38, and a circulation flow path F for causing first cooling water W1 to flow through the above components. The water circulating device 30 includes a single first vacuum pump D1 and two second vacuum

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pumps D2. Fig. 3 shows only a single second vacuum pump D2 to be described, as the three vacuum pumps including flow path sections are similar to one another.

[0038]

The circulation flow path F includes a first flow path section F1, a second flow path section F2, a third flow path section F3, a fourth flow path section F4, and a fifth flow path section F5. The first flow path section F1 is between the water pump 32 and the motor 6a. The second flow path section F2 is between the motor 6a and the tank 31. The third flow path section F3 is between the first flow path section F1 and the second vacuum pump D2. The fourth flow path section F4 is between the second vacuum pump D2 and the separator 37. The fifth flow path section F5 is between the separator 37 and the tank 31. The third flow path section F3 branches off from the first flow path section F1. The fifth flow path section F5 merges with the second flow path section F2 before reaching the tank 31.

[0039]

The tank 31 stores first cooling water W1 as water to be circulated, for example, industrial water, tap water, or pure water. The water pump 32 is at a portion of the first flow path section F1 which portion is downstream of the tank 31. The water pump 32 draws first cooling water W1 from the tank 31 and forces out the first cooling water W1 to cause the first cooling water W1 to flow through the circulation flow path F for circulation. The cooler 33 is at a portion of the first flow path section F1 which portion is downstream of the water pump 32. The cooler 33 receives first cooling water W1 from the water pump 32, cools the first cooling water W1 by heat exchange with a cooling medium, and lets the first cooling water W1 flow out. The first cooling water W1 has a temperature lower than normal temperature, for example. The water pump 32 and the cooler 33 are not detailed here as they have publicly known configurations.

[0040]

The sensor group 35 is at a portion of the first flow path section F1 which portion is downstream of the cooler 33. The sensor group 35 detects, for example, the rate of flow, pressure, and/or temperature of first cooling water W1. The sensor group 35 includes, for example, a flow rate sensor, a water pressure sensor, and a water temperature sensor. The sensor group 35 continuously detects the state of first cooling water W1 flowing through the first flow path section F1 and transmits information on the result of the detection to the control section 50.

[0041]

The circulation flow path F includes a sixth flow path section F6 that merges with the first flow path section F1 at a position between the cooler 33 and the sensor group

35. The sixth flow path section F6 allows second cooling water W2 to flow therethrough. The second cooling water W2 differs from the first cooling water W1, which the tank 31 stores, and is supplied from outside the water circulating device 30. The second cooling water W2 is, for example, industrial water, tap water, or pure water, and is desirably the same kind of water as the first cooling water W1. The second cooling water W2 cools the spindle sections 6 similarly to the first cooling water W1. The sixth flow path section F6 is not provided with the cooler 33. The sixth flow path section F6 merges with the first flow path section F1 at a position downstream of the cooler 33, so that the cooler 33 does not cool second cooling water W2. The second cooling water W2 has a normal temperature, for example. The switching valve 34 is in the form of, for example, an electromagnetic valve disposed on the sixth flow path section F6 to open and close the sixth flow path section F6. The switching valve 34, in the closed state, prevents second cooling water W2 from entering the first flow path section F1 and, in the open state, allows second cooling water W2 to enter the first flow path section F1. The switching valve 34 opens and closes under control of the control section 50. The switching valve 34 is closed while the cutting apparatus 1 is operating normally.

[0042]

The water circulating device 30 may include a flow path (not illustrated in Fig. 3) branching off from the sixth flow path section F6 to supply second cooling water W2 into the tank 31. In this case, the second cooling water W2 stored in the tank 31 serves as first cooling water W1.

[0043]

The water circulating device 30 includes one or more flow paths connected to the downstream end of the first flow path section F1 and serving to cool each motor 6a. First cooling water W1 having flown through the first flow path section F1 flows through, for example, a peripheral flow path (not illustrated in the drawings) around the motor 6a and/or an internal flow path (not illustrated in the drawings) inside the motor 6a and proximate to its stator to cool the motor 6a. The first cooling water W1 having flown through the external flow path and/or the internal flow path flows through the second flow path section F2 and returns to the tank 31. The filter 38 is at a portion of the second flow path section F2 which portion is proximate to the tank 31. The filter 38 removes from first cooling water W1 foreign matter and the like that have entered the first cooling water W1 during its flow.

[0044]

As described above, the spindle sections 6 each rotate the corresponding blade 8 with use of rotational driving force from the corresponding motor 6a to cut a molded

substrate Sb for singulation into two or more electronic parts Sc. The holder 5a of the corresponding cutting table 5 sucks the molded substrate Sb. The holder 5a is made of an elastic material such as rubber, and has suction holes 5a1 each in the form of a through hole and blade clearance grooves 5a2 each in the form of a bottomed groove.

5 [0045]

The suction holes 5a1 are so positioned in the holder 5a as to face respective electronic parts Sc resulting from cutting a molded substrate Sb to suck the electronic parts Sc individually. Drawing air through the suction holes 5a1 sucks a molded substrate Sb on the holder 5a for fixation. The blade clearance grooves 5a2 each prevent the blade
10 8 from cutting the holder 5a when cutting a molded substrate Sb. The blade clearance grooves 5a2 are each between mutually adjacent electronic parts Sc of a molded substrate Sb.

[0046]

The cutting table 5 includes a net 5f and a base 5g on which the holder 5a is
15 placed. The net 5f has first air flow paths 5f1 connected to the suction holes 5a1. The base 5g has second air flow paths 5g1 connected to the first air flow paths 5f1, and has a bottom wall with an air discharge hole 5g2 for discharging from the base 5g air drawn through the suction holes 5a1. Fig. 3 shows five second air flow paths 5g1 as if only the central one is connected to the air discharge hole 5g2. The second air flow paths 5g1 are, in
20 actuality, all connected to the air discharge hole 5g2.

[0047]

The air discharge hole 5g2 is connected to a third air flow path 5h, so that air drawn through the suction holes 5a1 flows through the first air flow paths 5f1 and the second air flow paths 5g1 to be discharged through the air discharge hole 5g2 into the
25 third air flow path 5h. The third air flow path 5h has a downstream end (that is, the end opposite to the air discharge hole 5g2) connected to the second vacuum pump D2. Activating the second vacuum pump D2 draws air through the suction holes 5a1 to suck a molded substrate Sb on the holder 5a (or the cutting table 5) for fixation.

[0048]

Back to the description of the circulation flow path F, the third flow path section F3 branches off from the first flow path section F1 at a position between the sensor group
30 35 and the motor 6a. This means that first cooling water W1 flows also through the third flow path section F3 before entering the motor 6a. The third flow path section F3 has a downstream end connected to the second vacuum pump D2, which is in the form of a water-sealed vacuum pump configured to circulate first cooling water W1 with use of
35 driving force of a trochoid pump or the like to generate negative pressure and thereby

draw air.

[0049]

As described above, the second vacuum pump D2 draws air through the suction holes 5a1 in the holder 5a to suck a molded substrate Sb on the holder 5a. The second vacuum pump D2 receives first cooling water W1 and uses it as sealing water. The second vacuum pump D2 draws air through the suction holes 5a1 and discharges it together with first cooling water W1 into the fourth flow path section F4 and then into the separator 37. This means that the fourth flow path section F4 allows water-containing air to flow therethrough that includes the first cooling water W1 as sealing water and the air drawn through the suction holes 5a1. The present embodiment is configured to supply first cooling water W1 into the second vacuum pump D2 as sealing water. This allows first cooling water W1 to cool a driving source (not illustrated in the drawings) for the second vacuum pump D2. The present embodiment may alternatively be configured to cause first cooling water W1 to flow through the third flow path section F3, cool the driving source for the second vacuum pump D2, and then enter the second vacuum pump D2.

[0050]

The separator 37 receives water-containing air from the fourth flow path section F4, separates the water-containing air into first cooling water W1 and air, and stores the first cooling water W1 at a lower portion of the separator 37 and the air at an upper portion thereof. The separator 37 lets the first cooling water W1 at its lower portion flow out into the fifth flow path section F5 and then through the fifth flow path section F5. As the fifth flow path section F5 merges with the second flow path section F2, the first cooling water W1 is filtered through the filter 38 and returns to the tank 31.

[0051]

The separator 37 lets the air at its upper portion flow through a fourth air flow path 39 and enter the tank 31. The fourth air flow path 39 extends from a vertically upper portion of the separator 37 to a vertically upper portion of the tank 31 to prevent entry of first cooling water W1.

[0052]

First cooling water W1, while flowing and circulating through the circulation flow path F, fills the flow paths between the separator 37 and the tank 31, that is, the fifth flow path section F5 and that portion of the second flow path section F2 which extends from the merging point. The tank 31 and the separator 37 each have an internal air pressure equal to atmospheric pressure. The tank 31 and the separator 37 thus store first cooling water W1 with respective surface heights equal to each other. The separator 37 needs a space enough to store air as separated from water-containing air. If the separator

37 received so much first cooling water W1 that its surface height reaches a top wall 37a as a vertically uppermost portion, the separator 37 would no longer have a space for storing air, with the result that the second vacuum pump D2 might fail to sufficiently suck a molded substrate Sb.

5 [0053]

In view of the above, the tank 31 has a water discharge opening 31a below the top wall 37a to discharge excess first cooling water W1 (see the broken line in Fig. 3). The water discharge opening 31a prevents first cooling water W1 in the tank 31 and the separator 37 from having a surface higher than the water discharge opening 31a and thereby prevents the surface height of first cooling water W1 in the separator 37 from reaching the top wall 37a. This ensures that the separator 37 has a space enough to store air as separated from first cooling water W1.

[0054]

The tank 31 has an air discharge opening 31b higher than the water discharge opening 31a through which to discharge air that the tank 31 receives from the separator 37 through the fourth air flow path 39 for storage. Even if first cooling water W1 is erroneously mixed with air as separated in the separator 37 and enters the fourth air flow path 39 connected to the tank 31, the above configuration allows the tank 31 to store such first cooling water W1.

20 [0055]

As described above, while the cutting apparatus 1 is operating normally, the water circulating device 30 causes first cooling water W1 to flow from the tank 31 through the circulation flow path F for circulation to appropriately cool the motor 6a of each spindle section 6 and suck a molded substrate Sb on the holder 5a of each cutting table 5. In the event of a circulation abnormality, that is, if the water circulating device 30 fails to cause first cooling water W1 to circulate through the circulation flow path F due to, for example, a breakdown of the water pump 32, the water circulating device 30 may fail to appropriately cool the motor 6a or suck a molded substrate Sb on the holder 5a.

[0056]

30 The control section 50 determines on the basis of the detection result from the sensor group 35 whether the water circulating device 30 is causing first cooling water W1 to circulate normally or suffering from a circulation abnormality. The control section 50 determines that the water circulating device 30 is suffering from a circulation abnormality, if the detection result from the sensor group 35 indicates, for example, that the flow rate sensor has detected that first cooling water W1 has a flow rate outside a normal range, that the water pressure sensor has detected that first cooling water W1 has a pressure

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outside a normal range, or that the water temperature sensor has detected that first cooling water W1 has a temperature outside a normal range. The detection by the flow rate sensor or the water pressure sensor suggests a breakdown of the water pump 32, whereas the detection by the water temperature sensor suggests a breakdown of the cooler 33.

5 [0057]

In response to determining on the basis of the result of the detection by the sensor group 35 that the water circulating device 30 is suffering from a circulation abnormality, the control section 50 opens the switching valve 34 to let second cooling water W2 flow through the first flow path section F1 of the circulation flow path F instead of first cooling water W1. This causes second cooling water W2 to flow from the first flow path section F1 to the fifth flow path section F5 to appropriately cool the motor 6a of each spindle section 6 and suck a molded substrate Sb on the holder 5a of each cutting table 5. The above configuration thereby allows second cooling water W2 to be supplied subsequently to first cooling water W1 in the event of a circulation abnormality, eliminating the need to stop the cutting apparatus 1 and allowing the cutting apparatus 1 to continue, for example, cutting a molded substrate Sb. The water circulating device 30 is incapable of circulating second cooling water W2 through the circulation flow path F. After the tank 31 receives second cooling water W2 from the fifth flow path section F5 for storage, the tank 31 discharges the second cooling water W2 through the water discharge opening 31a.

20 [0058]

[Method for Producing Electronic Parts]

With reference to Figs. 2 and 3, the description below deals with a method for cutting a molded substrate Sb with use of the cutting apparatus 1 to produce electronic parts Sc. The method for producing electronic parts Sc includes: causing the first cooling water W1 to flow through the circulation flow path F with use of the water circulating device 30 to cool the spindle section 6; placing a molded substrate Sb onto a cutting table 5 and then activating a second vacuum pump D2 to fix the molded substrate Sb to the cutting table 5; and cutting the molded substrate Sb with use of the cutting module A1 to produce electronic parts Sc.

30 [0059]

At the cutting module A1 illustrated in Fig. 2, the substrate supply section 3 pushes out molded substrates Sb one by one from a magazine M1 storing two or more molded substrates Sb to supply molded substrates Sb one by one to the positioning section 4 such that each molded substrate Sb has a back face upward.

35 [0060]

The positioning section 4 places on the rail section 4a the molded substrate Sb

as pushed out from the substrate supply section 3 to position the molded substrate Sb. The positioning section 4 then conveys the molded substrate Sb as positioned to a cutting table 5.

[0061]

5 Before or after the positioning section 4 conveys the molded substrate Sb to a cutting table 5, the control section 50 activates the water pump 32 and the cooler 33 of the water circulating device 30 to cause first cooling water W1 to flow from the tank 31 through the circulation flow path F for circulation. The first cooling water W1 starts cooling the motor 6a and the rotary shaft 6b, for example, of the spindle section 6 (cooling step). The tank 31 stores first cooling water W1 in advance in an amount necessary for circulation through the circulation flow path F.

[0062]

15 The control section 50 also activates the second vacuum pump D2 to draw air through the suction holes 5a1 in the holder 5a of the cutting table 5. The second vacuum pump D2 thereby sucks the molded substrate Sb on the holder 5a for fixation to the cutting table 5 (fixing step).

[0063]

20 After the second vacuum pump D2 sucks the molded substrate Sb on the cutting table 5 for fixation, a first position determining camera 5d captures an image of the molded substrate Sb to determine the position of the molded substrate Sb. Then, the cutting table 5 moves along the Y axis in Fig. 2 toward the spindle section 6. After the cutting table 5 reaches a position under the spindle section 6, the control section 50 causes the cutting table 5 and the spindle section 6 to move relative to each other to cut the molded substrate Sb for singulation into two or more electronic parts Sc (cutting step). 25 The molded substrate Sb remains sucked for fixation while the cutting table 5 moves for the blade 8 to singulate the molded substrate Sb. Each spindle section 6 includes, for example, a cutting water nozzle, a cooling water nozzle, and a washing water nozzle (not illustrated in the drawings). While the spindle section 6 is cutting the molded substrate Sb, the cutting water nozzle jets out cutting water onto the blade 8 as the blade 8 rotates at a high speed; the cooling water nozzle jets out cooling water onto the blade 8 and the molded substrate Sb as they are heated by the cutting operation; and the washing water nozzle jets out washing water for removing cutting debris and the like. Then, a second position determining camera 6c captures an image of the electronic parts Sc as necessary to determine, for example, the position of each electronic part Sc.

35 [0064]

After the spindle section 6 finishes cutting the molded substrate Sb, the cutting

table 5 moves away from the spindle section 6 along the Y axis in Fig. 2 while sucking the electronic parts Sc. While the cutting table 5 is moving as such, a first cleaner 5e washes (or cleans) and dries the upper face (that is, the back face) of each electronic part Sc.

5 [0065]

Next, the conveying section 7 sucks from above the electronic parts Sc that the cutting table 5 is holding. The conveying section 7 sucks the electronic parts Sc and conveys the electronic parts Sc to the inspection table 11 of the inspection/storage module B1. While the conveying section 7 is conveying the electronic parts Sc as such, a second
10 cleaner 7a washes and dries the lower face (that is, the front face) of each electronic part Sc.

[0066]

The inspection table 11 holds the electronic parts Sc for the first and second optical inspection cameras 12 and 13 to optically inspect the electronic parts Sc. The
15 inspection table 11 is movable along the X axis in Fig. 2. The inspection table 11 is also invertible upside down.

[0067]

The first optical inspection camera 12 captures an image of the front face of each electronic part Sc as the conveying section 7 conveys the electronic parts Sc to the
20 inspection table 11. Then, the conveying section 7 places the electronic parts Sc onto the holder of the inspection table 11. After the holder sucks the electronic parts Sc, the control section 50 inverts the inspection table 11 upside down. After the inverted inspection table 11 moves to a position above the second optical inspection camera 13, the second optical inspection camera 13 captures an image of the back face of the electronic part Sc.

25 [0068]

The placement section 14 receives the electronic parts Sc as inspected and sucks the electronic parts Sc by means of a drawing operation by the first vacuum pump D1. The placement section 14 is movable along the Y axis in Fig. 2. The inspection table 11 places the electronic parts Sc as inspected onto the placement section 14.

30 [0069]

The extraction section 15 transfers the electronic parts Sc from the placement section 14 to a tray. The extraction section 15 separates the electronic parts Sc into non-defective items and defective items on the basis of the result of the inspection involving use of the first and second optical inspection cameras 12 and 13. The extraction section
35 15 transfers the electronic parts Sc to the non-defective item tray 15a or the defective item tray 15b on the basis of the result of the separation to store non-defective electronic parts

Sc on the non-defective item tray 15a and defective electronic parts Sc on the defective item tray 15b.

[0070]

[Alternative Embodiments]

5 The description below deals with embodiments alternative to the embodiments described above. For ease of understanding, the description below uses the same terms and reference signs as in the description of the above embodiments for similar elements.

[0071]

10 <a> The embodiments described above include a separator 37 disposed downstream of a second vacuum pump D2 and configured to separate water-containing air into first cooling water W1 and air. This disclosure may omit the separator 37 if the tank 31 is configured for such separation.

[0072]

15 The embodiments described above include a sensor group 35 including a flow rate sensor, a water temperature sensor, and a water temperature sensor. This disclosure may alternatively include those sensors separately or include only at least one of those sensors.

[0073]

20 <c> The embodiments described above are configured such that the control section 50 determines an occurrence of a circulation abnormality on the basis of the flow rate, pressure, and temperature of first cooling water W1 as parameters. This disclosure is not limited to such a configuration. Alternative examples of such parameters include an abnormality of the drive circuit or drive current of the water pump 32, an abnormality of the flow rate, pressure, and temperature of a cooling fluid supplied to the cooler 33 for cooling first cooling water W1, and an abnormality of the amount of first cooling water W1 that the tank 31 stores. The control section 50 may be configured to determine as an occurrence of a circulation abnormality any abnormality in the form of a failure to appropriately cool the motor 6a of a spindle section 6 and/or fix a molded substrate Sb to a cutting table 5.

30 [0074]

35 <d> The embodiments described above include a sixth flow path section F6 merging with the first flow path section F1 at a position between the cooler 33 and the sensor group 35. This disclosure is not limited to such a configuration; for instance, the sixth flow path section F6 may alternatively merge with the first flow path section F1 at a position between the water pump 32 and the cooler 33. If a breakdown of the water pump 32 leads to second cooling water W2 flowing through the first flow path section F1,

the above alternative configuration allows the cooler 33 to cool the second cooling water W2 before the second cooling water W2 reaches a spindle section 6. This allows second cooling water W2 to cool the motor 6a of each spindle section 6 similarly to first cooling water W1.

5 [0075]

[Summary of Above Embodiments]

The description below summarizes the water circulating device (30), the cutting apparatus (1), and the method for producing a cut product (Sc) each described above as an embodiment.

10 [0076]

<1> A water circulating device (30) as an aspect is a water circulating device (30) configured to cool a spindle section (6) with use of first water (W1) or second water (W2), the spindle section (6) being configured to rotate a blade (8) for cutting an object to be cut (Sb) including a substrate (63), the water circulating device (30) including: a tank (31) configured to store the first water (W1); a pump (32) connected to the tank (31) and configured to force out the first water (W1) from the tank (31) toward the spindle section (6); a circulation flow path (F) configured to let the first water (W1) flow from the tank (31) through the pump (32) and the spindle section (6) back to the tank (31); a switching valve (34) configured to cause the second water (W2) to flow through the circulation flow path (F) instead of the first water (W1); and a control section (50) configured to control operation of the pump (32) and operation of the switching valve (34), the control section (50) being configured to, in response to detecting an abnormality of circulation of the first water (W1), control the switching valve (34) to cause the second water (W2) to flow through the circulation flow path (F).

25 [0077]

The water circulating device (30) as the above aspect includes a control section (50) configured to, in response to detecting an abnormality of circulation of the first water (W1), switch the switching valve (34) from the closed state to the open state to cause second water (W2) to flow through the circulation flow path (F). This allows second water (W2) to be supplied to the circulation flow path (F) subsequently to first water (W1) and thereby allows the water circulating device (30) to continue cooling the spindle section (6).

[0078]

<2> The water circulating device (30) described in <1> above may preferably be further configured such that the second water (W2) is industrial water.

35 [0079]

With the above configuration, connecting the water circulating device (30) to an industrial water duct allows second water (W2) to be supplied to the circulation flow path (F). This eliminates the need for dedicated equipment for producing second water (W2) and thereby allows the water circulating device (30) to be produced inexpensively.

5 [0080]

<3> The water circulating device (30) described in <1> or <2> above may preferably further include: a water-sealed vacuum pump (D2) disposed partway through the circulation flow path (F) and configured to draw air to suck the object to be cut (Sb) on a placement mount (5), wherein the water-sealed vacuum pump (D2) uses the first
10 water (W1) or the second water (W2) as sealing water.

[0081]

The water circulating device (30) jets out cutting water, cooling water, and washing water onto an object to be cut (Sb) sucked on the placement mount (5) to be cut. With the above aspect, the water-sealed vacuum pump (D2) sucks an object to be cut (Sb)
15 on the placement mount (5). This prevents the operation of the water-sealed vacuum pump (D2) from being affected by cutting water or the like entering an air suction hole for sucking an object to be cut (Sb), and thereby allows the water-sealed vacuum pump (D2) to suck an object to be cut (Sb) on the placement mount (5) stably and continuously. Further, the water-sealed vacuum pump (D2) uses first water (W1) or second water (W2)
20 for cooling the spindle section (6) as sealing water. This eliminates the need for a separate water source for supplying sealing water to the water-sealed vacuum pump (D2) and thereby allows the water circulating device (30) to be simple in configuration and inexpensive.

[0082]

<4> The water circulating device (30) described in <3> above may preferably further include: a separator (37) configured to receive water-containing air including the air and the sealing water (W1, W2) from the water-sealed vacuum pump (D2), separate the water-containing air into the air and the sealing water (W1, W2), and let the air and the sealing water (W1, W2) flow out, wherein the separator (37) is at a portion of the
30 circulation flow path (F) which portion is between the water-sealed vacuum pump (D2) and the tank (31), the tank (31) has a water discharge opening (31a) for discharging an excess of the first water (W1) or of the second water (W2), and the water discharge opening (31a) is lower than a top wall (37a) of the separator (37) which top wall (37a) is a vertically uppermost portion of the separator (37).

35 [0083]

The above configuration prevents first water (W1) or second water (W2) in the

tank (31) and the separator (37) from having a surface higher than the water discharge opening (31a). This in turn prevents the surface height of first water (W1) or second water (W2) from reaching the top wall (37a) of the separator (37) and thereby ensures that the separator (37) has a space enough to store air as separated from first water (W1) or second water (W2).

[0084]

<5> The water circulating device (30) described in <4> above may preferably be further configured such that the tank (31) has an air discharge opening (31b) for discharging the air from the tank (31), the air resulting from the separator (37) separating the water-containing air and having flown out from the separator (37) into the tank (31), wherein the air discharge opening (31b) is higher than the water discharge opening (31a).

[0085]

The above configuration allows the tank (31) to discharge air as separated in the separator (37) without being affected by first water (W1) or second water (W2) in the tank (31). Even if first water (W1) or second water (W2) is erroneously mixed with air as separated in the separator (37) and flows out from the separator (37), the above configuration allows the tank (31) to store such first water (W1) or second water (W2).

[0086]

<6> The water circulating device (30) described in any one of <1> to <5> above may preferably be further configured such that the abnormality of circulation is a breakdown of the pump (32).

[0087]

The pump (32) is essential for forcing out first water (W1) for circulation through the circulation flow path (F). A breakdown of the pump (32) will prevent first water (W1) from circulating and cooling the spindle section (6) appropriately. With the above aspect, a breakdown of the pump (32) is a circulation abnormality. This allows second water (W2) to flow and cool the spindle section (6) appropriately in the event of a failure to force out first water (W1).

[0088]

<7> The water circulating device (30) described in any one of <1> to <5> above may preferably further include: a cooler (33) configured to cool the first water (W1) in the tank (31), wherein the abnormality of circulation is a breakdown of the cooler (33).

[0089]

The cooler (33) is essential for cooling first water (W1) to cool the spindle section (6). A breakdown of the cooler (33) will prevent first water (W1) from cooling the spindle section (6) appropriately through circulation, as first water (W1) remains

uncooled. With the above aspect, a breakdown of the cooler (33) is a circulation abnormality. This allows second water (W2) to flow and cool the spindle section (6) appropriately in the event of a failure to cool first water (W1).

[0090]

5 <8> A cutting apparatus (1) as an aspect includes: a water circulating device (30) described in any one of <1> to <7>; and a cutting mechanism (A1) including: a placement mount (5) on which to place the object to be cut (Sb); the blade (8) for cutting the object to be cut (Sb) on the placement mount (5); and the spindle section (6) configured to rotate the blade (8).

10 [0091]

 The cutting apparatus (1) as the above aspect includes the water circulating device (30) described above. This allows second water (W2) to be supplied subsequently to first water (W1) in the event of a circulation abnormality. This in turn allows the cutting apparatus (1) to cool the spindle section (6) appropriately and continue, for example,

15 cutting an object to be cut (Sb).

[0092]

 <9> A method as an aspect for producing a cut product (Sc) with use of the cutting apparatus (1) described in <8> above includes: causing the first water (W1) to flow through the circulation flow path (F) with use of the water circulating device (30) to

20 cool the spindle section (6); placing the object to be cut (Sb) onto the placement mount (5) and then activating a water-sealed vacuum pump (D2) to fix the object to be cut (Sb) to the placement mount (5); and cutting the object to be cut (Sb) with use of the cutting mechanism (A1) to produce a cut product (Sc).

[0093]

25 The method as the above aspect for producing a cut product (Sc) includes: causing the first water (W1) to flow through the circulation flow path (F) with use of the water circulating device (30) to cool the spindle section (6); placing the object to be cut (Sb) onto the placement mount (5) and then activating a water-sealed vacuum pump (D2) to fix the object to be cut (Sb) to the placement mount (5); and cutting the object to be cut

30 (Sb) with use of the cutting mechanism (A1) to produce a cut product (Sc). This allows second water (W2) to be supplied subsequently to first water (W1) in the event of a circulation abnormality. This in turn allows the cutting apparatus (1) to cool the spindle section (6) appropriately and continue, for example, cutting an object to be cut (Sb), and thereby allows the cutting apparatus (1) to continue producing a cut product (Sb).

35

Industrial Applicability

[0094]

This disclosure is applicable to a water circulating device, a cutting apparatus, and a method for producing a cut product.

5 Reference Signs List

[0095]

	1	Cutting apparatus
	5	Cutting table (placement mount)
	6	Spindle section
10	8	Blade
	30	Water circulating device
	31	Tank
	31a	Water discharge opening
	31b	Air discharge opening
15	32	Water pump (pump)
	33	Cooler
	34	Switching valve
	37	Separator
	37a	Top wall
20	50	Control section
	61	Element
	63	Substrate
	A1	Cutting module (cutting mechanism)
	D2	Second vacuum pump (water-sealed vacuum pump)
25	F	Circulation flow path
	Sb	Molded substrate (object to be cut)
	Sc	Electronic part (cut product)
	W1	First cooling water (first water)
	W2	Second cooling water (second water)
30		

Claims

1. A water circulating device configured to cool a spindle section with use of first water or second water, the spindle section being configured to rotate a blade for cutting an object to be cut,
the water circulating device comprising:
a tank configured to store the first water;
a pump connected to the tank and configured to force out the first water from the tank toward the spindle section;
a circulation flow path configured to let the first water flow from the tank through the pump and the spindle section back to the tank;
a switching valve configured to cause the second water to flow through the circulation flow path instead of the first water; and
a control section configured to control operation of the pump and operation of the switching valve,
the control section being configured to, in response to detecting an abnormality of circulation of the first water, control the switching valve to cause the second water to flow through the circulation flow path.
2. The water circulating device according to claim 1, wherein the second water is industrial water.
3. The water circulating device according to claim 1 or 2, further comprising:
a water-sealed vacuum pump disposed partway through the circulation flow path and configured to draw air to suck the object to be cut on a placement mount,
wherein the water-sealed vacuum pump uses the first water or the second water as sealing water.
4. The water circulating device according to claim 3, further comprising:
a separator configured to receive water-containing air including the air and the sealing water from the water-sealed vacuum pump, separate the water-containing air into the air and the sealing water, and let the air and the sealing water flow out,
wherein the separator is at a portion of the circulation flow path which portion is

between the water-sealed vacuum pump and the tank,

the tank has a water discharge opening for discharging an excess of the first water or of the second water, and

the water discharge opening is lower than a top wall of the separator which top
5 wall is a vertically uppermost portion of the separator.

5. The water circulating device according to claim 4, wherein

the tank has an air discharge opening for discharging the air from the tank, the
10 air resulting from the separator separating the water-containing air and having flown out from the separator into the tank,

wherein the air discharge opening is higher than the water discharge opening.

15 6. The water circulating device according to any one of claims 1 to 5, wherein the abnormality of circulation is a breakdown of the pump.

7. The water circulating device according to any one of claims 1 to 5, further
20 comprising:

a cooler configured to cool the first water in the tank,

wherein the abnormality of circulation is a breakdown of the cooler.

25 8. A cutting apparatus, comprising:

a water circulating device according to any one of claims 1 to 7; and

a cutting mechanism including:

a placement mount on which to place the object to be cut;

the blade for cutting the object to be cut on the placement mount; and

30 the spindle section configured to rotate the blade.

9. A method for producing a cut product with use of the cutting apparatus according to claim 8,

35 the method comprising:

causing the first water to flow through the circulation flow path with use of the

water circulating device to cool the spindle section;

placing the object to be cut onto the placement mount and then activating a water-sealed vacuum pump to fix the object to be cut to the placement mount; and

5 cutting the object to be cut with use of the cutting mechanism to produce a cut product.