

DESCRIPTION
CUTTING APPARATUS, AND METHOD FOR MANUFACTURING CUT
PRODUCT

5 Technical Field

[0001] The present invention relates to a cutting apparatus and a method for manufacturing a cut product.

Background Art

- 10 [0002] JP 2002-313753A (Patent Document 1) discloses a dicing apparatus. In this dicing apparatus, a workpiece is machined by a machining unit, and cutting water is supplied to the machining unit during machining of the workpiece. The amount of cutting water supplied to the machining unit is regulated by a flow rate regulator. In this dicing apparatus, variation in the flow rate of cutting water is suppressed by controlling
- 15 the flow rate regulator using, as a feedback signal, a detection signal from a flow rate sensor that detects the flow rate of cutting water (see Patent Document 1).

Citation List

Patent Document

- 20 [0003] Patent Document 1: JP 2002-313753A

Summary of Invention

Technical Problem

- [0004] In the dicing apparatus disclosed in Patent Document 1, the flow rate of
- 25 cutting water (an example of process water) supplied to the machining unit is influenced by a disturbance factor (e.g., water pressure variation in the water supply facility that supplies cutting water to the dicing apparatus). Depending on the disturbance factor,

responsiveness in the control of the flow rate of cutting water may deteriorate, and overshooting may occur. Means for solving such problems are not disclosed in Patent Document 1.

[0005] The present invention has been made to solve such problems, and an object of the present invention is to provide a cutting apparatus that can suppress deterioration in responsiveness and the occurrence of overshooting in the control of the flow rate of process water, as well as a method for manufacturing a cut product.

Solution to Problem

[0006] A cutting apparatus according to an aspect of the present invention receives a supply of process water from a water supply facility outside the cutting apparatus. The cutting apparatus includes a cutting unit, a supply unit, a detection unit, an adjustment unit, and a control unit. The cutting unit is configured to cut an object to be cut. The supply unit is configured to directly or indirectly supply the process water received from the water supply facility to at least one of the object to be cut and the cutting unit. The detection unit is configured to detect a flow rate of the process water supplied by the supply unit. The adjustment unit is configured to adjust the flow rate of the process water supplied by the supply unit. The control unit is configured to perform both feedforward control, in which the adjustment unit is controlled based on a disturbance factor before cutting of the object to be cut, and feedback control, in which the adjustment unit is controlled based on a detection result of the detection unit such that the detection result approaches a target value.

[0007] A method for manufacturing a cut product according to another aspect of the present invention is a method for manufacturing a cut product using the above-described cutting apparatus, including cutting the object to be cut using the cutting apparatus.

Advantageous Effects of Invention

[0008] According to the present invention, it is possible to provide a cutting apparatus that can suppress deterioration in responsiveness and the occurrence of overshooting in the control of the flow rate of process water, as well as a method for manufacturing a cut product.

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Brief Description of Drawings

[0009] FIG. 1 is a plan view schematically showing a cutting apparatus.

FIG. 2 is a diagram schematically showing a configuration of a process water flow path in the cutting apparatus.

10 FIG. 3 is a diagram schematically showing a hardware configuration of a computer.

FIG. 4 is a diagram showing an example of change in the flow rate of cutting water in a supply unit when feedback control is performed.

15 FIG. 5 is a control block diagram regarding control of the flow rate of cutting water in the supply unit.

FIG. 6 is a diagram showing an example of a correction value table.

FIG. 7 is a diagram showing an example of change in the flow rate of cutting water in the supply unit when both feedback control and feedforward control are performed.

20 FIG. 8 is a flowchart showing an example of a processing procedure in feedback control.

FIG. 9 is a flowchart showing an example of a processing procedure in feedforward control.

25 Description of Embodiments

[0010] The following describes an embodiment according to an aspect of the present invention (hereinafter also referred to as “the present embodiment”) in detail with

reference to the drawings. In the drawings, identical or corresponding elements are denoted by the same reference numerals, and descriptions of those elements are not repeated. Also, the drawings are schematic drawings in which some elements are omitted or exaggerated as appropriate to facilitate understanding.

5 [0011] [1. Configuration]

<1-1. Overall configuration of cutting apparatus>

FIG. 1 is a plan view schematically showing a cutting apparatus 1 according to the present embodiment. The cutting apparatus 1 is configured to cut a package substrate (example of an object to be cut) in order to divide the package substrate into a plurality of electronic components (package components (example of a cut product)). In the package substrate, substrates or lead frames, each of which has a semiconductor chip mounted thereon, are sealed with resin. Note that the object to be cut does not necessarily need to be a package substrate, and may be a substrate (including a wafer) that is not sealed with resin, for example.

15 [0012] Examples of package substrates include a BGA (Ball Grid Array) package substrate, an LGA (Land Grid Array) package substrate, a CSP (Chip Size Package) package substrate, an LED (Light Emitting Diode) package substrate, and a QFN (Quad Flat No-leaded) package substrate.

[0013] The cutting apparatus 1 is also configured to inspect each of the separated electronic components. In the cutting apparatus 1, an image of the electronic components is captured, and the electronic components are inspected based on the captured image. Inspection data is generated through the inspection, and each electronic component is classified as a “good component” or a “defective component”.

[0014] In this example, a package substrate P1 is the object to be cut, and the cutting apparatus 1 divides the package substrate P1 into a plurality of electronic components S1. Hereinafter, out of the two main surfaces of the package substrate P1, the resin-sealed surface will be referred to as the mold surface, and the surface opposite to the mold

surface will be referred to as the ball/lead surface. Note that in the case where the object to be cut is a substrate that is not resin-sealed, the surface that faces upward during cutting (cut surface) corresponds to the ball/lead surface in the present embodiment, and the surface on the side opposite to the cut surface corresponds to the mold surface in the present embodiment.

[0015] As shown in FIG. 1, the cutting apparatus 1 includes a cutting module A1 and an inspection/storage module B1 as constituent elements. The cutting module A1 is configured to manufacture a plurality of electronic components S1 by cutting the package substrate P1. The inspection/storage module B1 is configured to inspect each of the manufactured electronic components S1, and then store the electronic components S1 in trays. Various constituent elements of the cutting apparatus 1 can be removed from the other constituent elements and replaced.

[0016] The cutting module A1 mainly includes a substrate supply unit 3, a positioning unit 4, cutting tables 5, spindle units 6, and a transport unit 7.

[0017] A magazine M1 stores a plurality of package substrates P1, and the substrate supply unit 3 supplies the package substrates P1 one by one to the positioning unit 4 by pushing out the package substrates P1 one by one from the magazine M1. At this time, the package substrates P1 are each arranged such that the ball/lead surface faces upward.

[0018] The positioning unit 4 positions the package substrate P1 pushed out from the substrate supply unit 3 by arranging the package substrate P1 on a rail unit 4a. After that, the positioning unit 4 transports the positioned package substrate P1 to the cutting tables 5.

[0019] The cutting tables 5 each hold the package substrate P that is to be cut. Here, the illustrated cutting apparatus 1 has a twin cut table configuration including two cutting tables 5. Each of the cutting tables 5 includes a holding member 5a, a rotating mechanism 5b, and a moving mechanism 5c. The holding member 5a holds the package substrate P1 transported by the positioning unit 4 by suctioning the package substrate P1

from below. The rotating mechanism 5b can rotate the holding member 5a in a $\theta 1$ direction shown in the figure. The moving mechanism 5c can move the holding member 5a along the Y axis shown in the figure.

[0020] The spindle units 6 each divide the package substrate P1 into a plurality of electronic components S1 by cutting the package substrate P1. Here, the illustrated cutting apparatus 1 has a twin spindle configuration including two spindle units 6. The spindle units 6 can be moved along the X axis and the Z axis shown in the figure. Note that the cutting apparatus 1 may have a single spindle configuration including only one spindle unit 6.

[0021] Each of the spindle units 6 includes a blade 6a and a rotation shaft 6c. The blade 6a cuts the package substrate P1 by rotating at high speed, and thus divides the package substrate P1 into a plurality of electronic components S1. The blade 6a is attached to the rotation shaft 6c so as to be clamped between first and second flanges (not shown). The first and second flanges are fixed to the rotation shaft 6c by fastening members (not shown) such as nuts. The first flange is also called an inner flange, and the second flange is also called an outer flange.

[0022] Each of the spindle units 6 includes a cutting water nozzle (supply unit 100, 110 (FIG. 2)), a cooling water nozzle (supply unit 102, 112), a waste removal water nozzle (supply unit 120, 122), and the like. The cutting water nozzle sprays cutting water toward the blade 6a rotating at high speed. The cooling water nozzle sprays cooling water toward the cut region of the package substrate P1. The waste removal water nozzle sprays waste removal water for removing cutting waste and the like. Note that the cutting water, the cooling water, and the waste removal water are each an example of process water.

[0023] After the cutting table 5 suctions the package substrate P1, an image of the package substrate P1 is captured by a first position checking camera 5d, and the position of the package substrate P1 is checked. The checking performed using the first position

checking camera 5d is, for example, checking of the position of a mark provided on the package substrate P1. The mark indicates a cutting position of the package substrate P1, for example.

[0024] After that, the cutting table 5 moves along the Y axis in the figure toward a
5 corresponding one of the spindle units 6. After the cutting table 5 moves to a position below the spindle unit 6, the package substrate P1 is cut by moving the cutting table 5 and the spindle unit 6 relative to each other. After that, if necessary, an image of the package substrate P1 is captured by a second position checking camera 6b provided in the spindle unit 6, and the position or the like of the package substrate P1 is checked.

10 The checking performed using the second position checking camera 6b is, for example, the checking of a cutting position and a cutting width of the package substrate P1.

[0025] After the cutting of the package substrate P1 is complete, the cutting table 5 moves away from the spindle unit 6 along the Y axis in the figure while suctioning the separated electronic components S1. During this moving process, a first cleaner 5e
15 cleans and dries the upper surfaces (ball/lead surfaces) of the electronic components S1. This cleaning may be performed by, for example, directly spraying cleaning water onto the upper surfaces of the electronic components S1, or supplying cleaning water to the upper surfaces of the electronic components S1 via a brush or the like. Note that the cleaning water used in the first cleaner 5e is an example of process water. Also,
20 although the cutting apparatus 1 includes two first cleaners 5e arranged side by side in the X-axis direction in the figure, the number of first cleaners 5e is not limited to this.

[0026] The transport unit 7 suctions the electronic components S1 held on the cutting table 5 from above and transports the electronic components S1 to the inspection table 11 of the inspection/storage module B1. During this transportation process, a second
25 cleaner 7a cleans and dries the lower surfaces (mold surfaces) of the electronic components S1. This cleaning may be performed by, for example, directly spraying cleaning water onto the lower surfaces of the electronic components S1, or supplying

cleaning water to the lower surfaces of the electronic components S1 via a brush or the like. Note that the cleaning water used in the second cleaner 7a is an example of process water.

[0027] The inspection/storage module B1 mainly includes the inspection table 11, a first optical inspection camera 12, a second optical inspection camera 13, an arrangement unit 14, and an extraction unit 15. Note that the first optical inspection camera 12 may be provided in the cutting module A1.

[0028] The inspection table 11 holds the electronic components S1 for optical inspection of the electronic components S1. The inspection table 11 can be moved along the X axis in the figure. Furthermore, the inspection table 11 can be vertically inverted. The inspection table 11 includes a holding member that holds an electronic component S1 by suctioning the electronic component S1.

[0029] The first optical inspection camera 12 and the second optical inspection camera 13 capture images of the two surfaces (ball/lead surface and mold surface) of the electronic component S1. Based on the captured images (image data) generated by the first optical inspection camera 12 and the second optical inspection camera 13, various aspects of the electronic component S1 are inspected. The first optical inspection camera 12 and the second optical inspection camera 13 are each arranged in the vicinity of the inspection table 11 so as to capture an image of the upper portion of the image capturing target.

[0030] The first optical inspection camera 12 captures an image of the mold surface of the electronic component S1 that has been transported to the inspection table 11 by the transport unit 7. After that, the transport unit 7 places the electronic component S1 on the holding member of the inspection table 11. After the holding member suctions the electronic component S1, the inspection table 11 is vertically inverted. The inspection table 11 moves to a position above the second optical inspection camera 13, and an image of the ball/lead surface of the electronic component S1 is captured by the second optical

inspection camera 13.

[0031] The inspected electronic components S1 are then disposed on the arrangement unit 14. The arrangement unit 14 can be moved along the Y axis in the figure. The inspection table 11 disposes the inspected electronic components S1 on the arrangement unit 14.

[0032] The electronic components S1 that were disposed on the arrangement unit 14 are transferred to a tray by the extraction unit 15. The electronic components S1 are classified as a “good component” or a “defective component” based on the results of the inspections performed using the first optical inspection camera 12 and the second optical inspection camera 13. The extraction unit 15 transfers each of the electronic components S1 to a good component tray 15a or a defective component tray 15b based on the classification results. In other words, good components are stored in the good component tray 15a, and defective components are stored in the defective component tray 15b. When the good component tray 15a or the defective component tray 15b is completely full with electronic components S1, it is replaced with a new tray.

[0033] The cutting apparatus 1 further includes a computer 50 and a monitor 20. The monitor 20 is configured to display images. The monitor 20 is constituted by a display device such as a liquid crystal monitor or an organic EL (Electro Luminescence) monitor.

[0034] The computer 50 controls the operations of various units of the cutting module A1 and the inspection/storage module B1, for example. For example, the computer 50 controls the operations of the substrate supply unit 3, the positioning unit 4, the cutting tables 5, the spindle units 6, the transport unit 7, the inspection table 11, the first optical inspection camera 12, the second optical inspection camera 13, the arrangement unit 14, the extraction unit 15, and the monitor 20. The configuration of the computer 50 will be described in detail later.

[0035] <1-2. Configuration of process water flow path>

As described above, in the cutting apparatus 1, process water is used in the spindle unit 6, the first cleaner 5e, and the second cleaner 7a. The process water is supplied to various portions of the cutting apparatus 1 from a water supply facility 400 (FIG. 2) outside the cutting apparatus 1.

5 [0036] FIG. 2 is a diagram schematically showing the configuration of the process water flow path in the cutting apparatus 1. As shown in FIG. 2, the supply units 100, 102, 110, 112, 120, 122, 130, 132, and 140 are each connected to the water supply facility 400 via a common pipe PL1. The pipe PL1 branches at a branch point PO1, and the supply units are each connected to one of the branches. The supply units 100, 102, 110,
10 112, 120, 122, 130, 132, and 140 are each configured to directly or indirectly supply process water received from the water supply facility 400 to at least either the object to be cut (including the package substrate P1 and the electronic components S1) or the blade 6a.

[0037] The supply units 100 and 102 are provided in one of the spindle units 6. The
15 supply unit 100 is constituted by a cutting water nozzle, and the supply unit 102 is constituted by a cooling water nozzle. The supply unit 102 includes a first nozzle 104 and a second nozzle 106. The first nozzle 104 is also called a standard nozzle, and is used when spraying cooling water onto a standard-sized object to be cut. The second nozzle 106 is also called a fork nozzle, and is used when spraying cooling water onto an
20 object to be cut whose size is smaller than the standard size. The size of the supply opening of the second nozzle 106 is smaller than the size of the supply opening of the first nozzle 104.

[0038] The supply units 110 and 112 are provided in the other spindle unit 6. The supply unit 110 is constituted by a cutting water nozzle, and the supply unit 112 is
25 constituted by a cooling water nozzle. The supply unit 112 includes a first nozzle 114 and a second nozzle 116. The first nozzle 114 is also called a standard nozzle, and is used when spraying cooling water onto a standard-sized object to be cut. The second

nozzle 116 is also called a fork nozzle, and is used when spraying cooling water onto an object to be cut whose size is smaller than the standard size. The size of the supply opening of the second nozzle 116 is smaller than the size of the supply opening of the first nozzle 114.

5 [0039] The supply units 120 and 122 are each constituted by a waste removal water nozzle. The supply unit 120 is provided in one of the spindle units 6, and the supply unit 122 is provided in the other spindle unit 6. The supply units 130, 132, and 140 are each constituted by a cleaning water nozzle. The supply unit 130 is provided in one of the first cleaners 5e, and the supply unit 132 is provided in the other first cleaner 5e. The
10 supply unit 140 is provided in the second cleaner 7a.

[0040] A flow rate sensor SE10 and a pressure gauge 410 are arranged on the flow path from the water supply facility 400 to the branch point PO1. The flow rate sensor SE10 is configured to detect the amount (flow rate) of process water supplied from the water supply facility 400 to the cutting apparatus 1. The pressure gauge 410 is
15 configured to detect the pressure (water pressure) of process water supplied from the water supply facility 400 to the cutting apparatus 1.

[0041] A solenoid valve 300, a proportional control valve 200, and a flow rate sensor SE1 are arranged in this order on the flow path from the branch point PO1 to the supply unit 100. The solenoid valve 300 is configured to be openable and closable under
20 control of the computer 50. The proportional control valve 200 is configured to be able to adjust the opening degree under control of the computer 50. By adjusting the opening degree of the proportional control valve 200, the flow rate of process water (cutting water) supplied to the supply unit 100 can be controlled. The flow rate sensor SE1 is configured to detect the flow rate of process water supplied to the supply unit 100.

25 [0042] Furthermore, in addition to the above-mentioned solenoid valve 300, a proportional control valve 202, a flow rate sensor SE2, and a 3-port solenoid valve 302 are arranged in this order on the flow path from the branch point PO1 to the supply unit

102. The proportional control valve 202 is configured to be able to adjust the opening degree under control of the computer 50. By adjusting the opening degree of the proportional control valve 202, the flow rate of process water (cooling water) supplied to the supply unit 102 can be controlled. The flow rate sensor SE2 is configured to detect the flow rate of process water supplied to the supply unit 102. The 3-port solenoid valve 302 is configured to switch the supply of process water between supply to the first nozzle 104 and supply to the second nozzle 106 under control of the computer 50.

[0043] A solenoid valve 310, a proportional control valve 210, and a flow rate sensor SE3 are arranged in this order on the flow path from the branch point PO1 to the supply unit 110. The solenoid valve 310 is configured to be openable and closable under control of the computer 50. The proportional control valve 210 is configured to be able to adjust the opening degree under control of the computer 50. By adjusting the opening degree of the proportional control valve 210, the flow rate of process water (cutting water) supplied to the supply unit 110 can be controlled. The flow rate sensor SE3 is configured to detect the flow rate of process water supplied to the supply unit 110.

[0044] Furthermore, in addition to the above-mentioned solenoid valve 310, a proportional control valve 212, a flow rate sensor SE4, and a 3-port solenoid valve 312 are arranged in this order on the flow path from the branch point PO1 to the supply unit 112. The proportional control valve 212 is configured to be able to adjust the opening degree under control of the computer 50. By adjusting the opening degree of the proportional control valve 212, the flow rate of process water (cooling water) supplied to the supply unit 112 can be controlled. The flow rate sensor SE4 is configured to detect the flow rate of process water supplied to the supply unit 112. The 3-port solenoid valve 312 is configured to switch the supply of process water between the first nozzle 114 and the second nozzle 116 under control of the computer 50.

[0045] A solenoid valve 320, a flow rate sensor SE5, and a variable needle throttle valve 322 are arranged in this order on the flow path from the branch point PO1 to the

supply unit 120. The solenoid valve 320 is configured to be openable and closable under control of the computer 50. The flow rate sensor SE5 is configured to detect the flow rate of process water (waste removal water) supplied to the supply unit 120. The variable needle throttle valve 322 is configured to manually receive an instruction to adjust the flow rate of process water from a worker. The worker can adjust the flow rate of process water supplied to the supply unit 120 by operating the variable needle throttle valve 322.

[0046] A solenoid valve 330, a flow rate sensor SE6, and a variable needle throttle valve 332 are arranged in this order on the flow path from the branch point PO1 to the supply unit 122. The solenoid valve 330 is configured to be openable and closable under control of the computer 50. The flow rate sensor SE6 is configured to detect the flow rate of process water (waste removal water) supplied to the supply unit 122. The variable needle throttle valve 332 is configured to manually receive an instruction to adjust the flow rate of process water from a worker. The worker can adjust the flow rate of process water supplied to the supply unit 122 by operating the variable needle throttle valve 332.

[0047] A solenoid valve 340, a flow rate sensor SE7, and a variable needle throttle valve 342 are arranged in this order on the flow path from the branch point PO1 to the supply unit 130. The solenoid valve 340 is configured to be openable and closable under control of the computer 50. The flow rate sensor SE7 is configured to detect the flow rate of process water (cleaning water) supplied to the supply unit 130. The variable needle throttle valve 342 is configured to manually receive an instruction to adjust the flow rate of process water from a worker. The worker can adjust the flow rate of process water supplied to the supply unit 130 by operating the variable needle throttle valve 342.

[0048] A solenoid valve 350, a flow rate sensor SE8, and a variable needle throttle valve 352 are arranged in this order on the flow path from the branch point PO1 to the supply unit 132. The solenoid valve 350 is configured to be openable and closable under

control of the computer 50. The flow rate sensor SE8 is configured to detect the flow rate of process water (cleaning water) supplied to the supply unit 132. The variable needle throttle valve 352 is configured to manually receive an instruction to adjust the flow rate of process water from a worker. The worker can adjust the flow rate of process water supplied to the supply unit 132 by operating the variable needle throttle valve 352.

[0049] A solenoid valve 360, a needle adjustment valve 362, and a flow rate sensor SE9 are arranged in this order on the flow path from the branch point PO1 to the supply unit 140. The solenoid valve 360 is configured to be openable and closable under control of the computer 50. The needle adjustment valve 362 is configured to manually receive an instruction to adjust the flow rate of process water from a worker. The flow rate of process water can be adjusted with higher precision with use of the needle adjustment valve 362 than with use of a variable needle throttle valve (e.g., the variable needle throttle valves 322, 332, 342, and 352). The worker can adjust the flow rate of process water supplied to the supply unit 140 by operating the needle adjustment valve 362. The flow rate sensor SE9 is configured to detect the flow rate of process water (cleaning water) supplied to the supply unit 140. In this way, in the cutting apparatus 1, process water is supplied from the common water supply facility 400 to each of the supply units.

[0050] <1-3. Hardware configuration of computer>

FIG. 3 is a diagram schematically showing the hardware configuration of the computer 50. As shown in FIG. 3, the computer 50 includes a control unit 70, an input/output I/F (interface) 90, an acceptance unit 95, and a storage unit 80, and these elements are electrically connected to each other via a bus.

[0051] The control unit 70 includes a CPU (Central Processing Unit) 72, a RAM (Random Access Memory) 74, a ROM (Read Only Memory) 76, and the like. The control unit 70 is configured to control constituent elements of the computer 50 and constituent elements of the cutting apparatus 1 according to information processing.

[0052] The input/output I/F 90 is configured to communicate with various constituent elements included in the cutting apparatus 1 via signal lines. The input/output I/F 90 is used in the transmission of data from the computer 50 to various constituent elements of the cutting apparatus 1 and in the reception of data transmitted from various constituent elements of the cutting apparatus 1 to the computer 50. The acceptance unit 95 is configured to accept instructions from the user (worker). The acceptance unit 95 includes one or more of the following: a touch panel, a keyboard, a mouse, and a microphone, for example.

[0053] The storage unit 80 is an auxiliary storage device such as a hard disk drive or a solid state drive, for example. The storage unit 80 is configured to store a control program 81, for example. Various operations in the cutting apparatus 1 are realized by execution of the control program 81 by the control unit 70. When the control unit 70 is to execute the control program 81, the control program 81 is loaded to the RAM 74. The control unit 70 then controls various constituent elements by using the CPU 72 to interpret and execute the control program 81 loaded to the RAM 74.

[0054] [2. Suppression of influence of disturbance factor on process water flow rate control]

As described above, for example, during cutting of the package substrate P1, cutting water and cooling water (examples of process water) are sprayed toward the package substrate P1. The flow rate of process water that is sprayed toward the package substrate P1 when the package substrate P1 is cut (hereinafter also referred to as “cutting water and the like”) influences the quality of the manufactured electronic components S1. In order to suppress deterioration in the quality of the electronic components S1, it is important to control the flow rate of cutting water and the like. Since the same can be said for both cutting water and cooling water, the following description will focus on cutting water.

[0055] For example, in order to maintain the flow rate of cutting water at a

predetermined set value (target value), it is conceivable to perform feedback control. For example, in feedback control for bringing the cutting water supply amount in the supply unit 100 (FIG. 2) closer to the target value, the opening degree of the proportional control valve 200 is adjusted based on the detection result of the flow rate sensor SE1 such that the detection result of the flow rate sensor SE1 approaches the target value.

[0056] FIG. 4 is a diagram showing an example of change in the cutting water supply amount when feedback control is performed. In FIG. 4, the horizontal axis indicates time, and the vertical axis indicates the cutting water supply amount.

[0057] For example, when the supply unit 100 is not influenced by a disturbance factor (when process water is supplied to the flow path from the water supply facility 400 to the supply unit 100 (FIG. 2) at the expected flow rate), the cutting water supply amount in the supply unit 100 changes according to change L1 (theoretical value). When focusing on the cutting water supply amount in the supply unit 100, the disturbance factor is an element that influences the amount of process water supplied to the flow path from the water supply facility 400 to the supply unit 100.

[0058] Examples of disturbance factors include the water pressure in the water supply facility 400, the amount of process water supplied from the water supply facility 400, the status of supply of water from the water supply facility 400 to a device other than the cutting apparatus 1 (not shown), the type of nozzle (standard nozzle or fork nozzle) used in the supply units 102 and 112, and the number of supply units that supply process water at the same time in a group including the supply units 100, 102, 110, 112, 120, 122, 130, 132, and 140. For example, as the number of supply units that supply process water at the same time increases, the supply units need to compete for process water flowing through the pipe PL1, and thus the amount of process water supplied to the flow path from the water supply facility 400 to the supply unit 100 is influenced.

[0059] In the case where feedback control is performed, if the supply unit 100 is influenced by a disturbance factor and process water is supplied to the flow path from the

water supply facility 400 to the supply unit 100 at a flow rate lower than expected, the cutting water supply amount in the supply unit 100 changes according to change L2, for example. Specifically, the responsiveness in control of the flow rate of cutting water deteriorates, and a longer time is required for the cutting water supply amount to reach the target value.

[0060] On the other hand, in the case where feedback control is performed, if the supply unit 100 is influenced by a disturbance factor and process water is supplied to the flow path from the water supply facility 400 to the supply unit 100 at a flow rate higher than expected, the cutting water supply amount in the supply unit 100 changes according to change L3, for example. Specifically, overshooting occurs in the cutting water flow rate control, and a situation arises in which the cutting water supply amount temporarily exceeds the target value.

[0061] In the cutting apparatus 1 according to the first embodiment, an innovation has been made in order to suppress the occurrence of these problems. Specifically, in the cutting apparatus 1, when controlling the flow rate of cutting water and the like, feedforward control is performed in addition to feedback control. In feedforward control, an adjustment unit (e.g., the proportional control valve 200) is controlled based on a disturbance factor before cutting of the object to be cut. Since similar control is performed in the supply units 100, 102, 110, and 112, the cutting water flow rate control performed in the supply unit 100 will be described below as a representative example.

[0062] FIG. 5 is a control block diagram regarding cutting water flow rate control performed in the supply unit 100. As shown in FIG. 5, the control unit 70 includes a subtraction unit 710, a feedback control unit 720, a multiplication unit 730, and a feedforward control unit 740.

[0063] The flow rate sensor SE1 detects the cutting water supply amount of the supply unit 100. The subtraction unit 710 calculates the difference between a detection value indicated by the detection result of the flow rate sensor SE1 and the target value of

the cutting water supply amount of the supply unit 100. Information indicating the target value (target value information) is stored in the storage unit 80 (FIG. 3), for example. The feedback control unit 720 generates, based on the calculation result of the subtraction unit 710, a command value that instructs the opening degree of the proportional control valve 200 such that the detection result of the flow rate sensor SE1 approaches the target value, and outputs the generated command value. For example, the opening degree of the proportional control valve 200 is controlled according to the voltage applied to the proportional control valve 200, and the command value generated by the feedback control unit 720 indicates a voltage value.

[0064] The feedforward control unit 740 acquires information regarding the above-mentioned disturbance factor (disturbance factor information). For example, the feedforward control unit 740 acquires information regarding the open/closed states of the solenoid valves 300, 310, 320, 330, 340, 350, and 360, and information regarding the connection states of the 3-port solenoid valves 302 and 312. The feedforward control unit 740 thereby determines the usage state of each of the supply units. The feedforward control unit 740 generates a correction value for correcting the command value generated by the feedback control unit 720, for example, based on the usage states of the supply units.

[0065] FIG. 6 is a diagram showing an example of a correction value table 500. The correction value table 500 is stored in the storage unit 80, for example. As shown in FIG. 6, in the correction value table 500, provisional correction values are associated with combinations of the open/closed states of the solenoid valves 300, 310, 320, 330, 340, 350, and 360 and the types of nozzles used in the supply units 102 and 112. In other words, in the correction value table 500, a provisional correction value is associated with each combination of supply units that supply process water at the same time in a group including the supply units 100, 102, 110, 112, 120, 122, 130, 132, and 140.

[0066] Referring again to FIG. 6, the feedforward control unit 740 refers to the

correction value table 500 to identify the provisional correction value that is associated with the determined combination of usage states of the supply units. For example, the feedforward control unit 740 corrects the provisional correction value based on another disturbance factor (e.g., the water pressure of the water supply facility 400, the amount of process water supplied from the water supply facility 400, or the status of supply of water by the water supply facility 400 to a device other than the cutting apparatus 1), and outputs the corrected correction value. For example, if the water pressure in the water supply facility 400 is lower than expected, the provisional correction value is corrected such that the opening degree of the proportional control valve 200 is larger.

10 [0067] The multiplication unit 730 multiplies the command value output by the feedback control unit 720 by the correction value output by the feedforward control unit 740. The calculation result (corrected command value) obtained by the multiplication unit 730 is output to the proportional control valve 200, and the opening degree of the proportional control valve 200 is adjusted.

15 [0068] FIG. 7 is a diagram showing an example of change in the flow rate of cutting water in the supply unit 100 when both feedback control and feedforward control are performed. In FIG. 7, the horizontal axis represents time, and the vertical axis represents the cutting water supply amount. In the case where both feedback control and feedforward control are performed, the cutting water supply amount in the supply unit 100 changes according to change L4. In this way, by performing both feedback control and feedforward control, it is possible to suppress deterioration in responsiveness and the occurrence of overshooting in the control of the flow rate of cutting water (process water).

[0069] [3. Operation]

25 As described above, the control unit 70 performs both feedback control and feedforward control. In the cutting apparatus 1, similar control (feedback control and feedforward control) is performed regarding the flow rate of process water in each of the supply units 100, 102, 110, and 112. Below, process water flow rate control performed

in the supply unit 100 will be described as a representative example.

[0070] FIG. 8 is a flowchart showing an example of a processing procedure in feedback control. The processing shown in this flowchart is repeatedly executed by the feedback control unit 720 of the control unit 70 while process water supply is performed by the supply unit 100.

[0071] As shown in FIG. 8, the feedback control unit 720 determines whether or not the detection result of the flow rate sensor SE1 is the target value (step S100). In the case of determining that the detection result of the flow rate sensor SE1 is not the target value (NO in step S100), the feedback control unit 720 generates a new command value such that the flow rate of cutting water approaches the target value (step S110).

[0072] For example, if the detection result of the flow rate sensor SE1 is below the target value, the command value is generated such that the opening degree of the proportional control valve 200 is increased, whereas if the detection result of the flow rate sensor SE1 exceeds the target value, the command value is generated such that the opening degree of the proportional control valve 200 is decreased.

[0073] On the other hand, in the case of determining in step S100 that the detection result of the flow rate sensor SE1 is the target value (YES in step S100), the feedback control unit 720 maintains the command value (step S120). The feedback control unit 720 outputs the command value generated in step S110 or the command value maintained in step S120 (step S130).

[0074] FIG. 9 is a flowchart showing an example of a processing procedure in feedforward control. The processing shown in this flowchart is repeatedly executed by the feedforward control unit 740 of the control unit 70 while process water supply is performed by the supply unit 100.

[0075] As shown in FIG. 9, the feedforward control unit 740 determines whether or not a disturbance factor that influences the amount of process water supplied to the flow path from the water supply facility 400 to the supply unit 100 was detected (step S200).

In the case of determining that a disturbance factor was not detected (NO in step S200), the processing moves to “return”.

[0076] On the other hand, in the case of determining that a disturbance factor was detected (YES in step S200), the feedforward control unit 740 generates a correction value in accordance with the detected disturbance factor (step S210). The feedforward control unit 740 outputs the generated correction value (step S220).

[0077] As described above, in the control unit 70, the corrected command value is calculated by multiplying the command value generated by the feedback control unit 720 by the correction value generated by the feedforward control unit 740. The control unit 70 adjusts the flow rate of cutting water in the supply unit 100 by controlling the proportional control valve 200 based on the corrected command value.

[0078] [4. Characteristics]

As described above, in the cutting apparatus 1 according to the present embodiment, the control unit 70 performs both feedforward control for controlling an adjustment unit (e.g., the proportional control valve 200) based on a disturbance factor before cutting the object to be cut, and feedback control for controlling an adjustment unit based on the detection result of a detection unit (e.g., the flow rate sensor SE1) such that the detection result approaches a target value. According to the cutting apparatus 1, the adjustment of the adjustment unit according to the disturbance factor is performed separately, thus making it possible to suppress deterioration in responsiveness and the occurrence of overshooting in the control of the flow rate of cutting water (process water).

[0079] Note that the cutting apparatus 1 is an example of a “cutting apparatus” in the present invention. The water supply facility 400 is an example of a “water supply facility” in the present invention. The blade 6a is an example of a “cutting unit” in the present invention. The package substrate P1 is an example of an “object to be cut” in the present invention. The supply units 100, 102, 110, and 112 are each an example of a “supply unit” in the present invention. The flow rate sensors SE1, SE2, SE3, and SE4

are each an example of a “detection unit” in the present invention. The proportional control valves 200, 202, 210, and 212 are each an example of an “adjustment unit” in the present invention. The control unit 70 is an example of a “control unit” in the present invention. The supply units 120, 122, 130, 132, and 140 are examples of at least some of a “plurality of other supply units” in the present invention. The storage unit 80 is an example of a “storage unit” in the present invention.

[0080] [5. Other embodiments]

The idea of the above embodiment is not limited to the embodiment described above. Examples of other embodiments to which the idea of the above embodiment can be applied will be described below.

[0081] <5-1>

In the above, it is described that examples of disturbance factors include the water pressure in the water supply facility 400, the amount of process water supplied from the water supply facility 400, the status of supply of water from the water supply facility 400 to a device other than the cutting apparatus 1, the type of nozzle used in the supply units 102 and 112, and the number of supply units that supply process water at the same time in a group including the supply units 100, 102, 110, 112, 120, 122, 130, 132, and 140. Also, the provisional correction value identified according to the combination of usage states of the supply units is corrected based on another disturbance factor (e.g., the water pressure of the water supply facility 400, the amount of process water supplied from the water supply facility 400, or the status of supply of water by the water supply facility 400 to a device other than the cutting apparatus 1), thus generating a corrected correction value. However, the method of generating the correction value is not limited to this.

[0082] For example, a provisional correction value managed in the correction value table 500 may be used as the correction value without correction. Also, the correction value may be generated based on only at least one of factors including the water pressure in the water supply facility 400, the amount of process water supplied from the water

supply facility 400, the status of supply of water by the water supply facility 400 to a device other than the cutting apparatus 1, the type of nozzle used in the supply units 102 and 112, and the number of supply units that supply process water at the same time in a group including the supply units 100, 102, 110, 112, 120, 122, 130, 132, and 140.

5 [0083] <5-2>

Also, the process water flow rate in the supply units 120, 122, 130, 132, and 140 may be adjusted by a proportional control valve rather than a variable needle throttle valve or a needle adjustment valve. In this case, the opening degree of the proportional control valves may be adjusted by performing both feedback control and feedforward control,
10 similarly to the proportional control valve 200 and the like.

[0084] <5-3>

Also, in the above embodiment, the cutting apparatus 1 includes nine supply units, but the number of supply units included in the cutting apparatus 1 is not limited to this. The cutting apparatus 1 only needs to include at least one supply unit in which the
15 flow rate of process water is adjusted by a proportional control valve.

[0085] <5-4>

Also, in the embodiment described above, the control unit 70 may update the provisional correction values managed in the correction value table 500 based on the detection result of a flow rate sensor (e.g., the flow rate sensor SE1) after performing
20 feedforward control using the provisional correction values managed in the correction value table 500, for example. In other words, the control unit 70 may update the correction value associated with the combination of supply units that supply process water at the same time based on the detection result of the flow rate sensor, for example. Thereby, the accuracy of the correction values managed in the correction value table 500
25 can be further improved.

[0086] <5-5>

Also, in the above embodiment, instead of supplying only process water, the

supply units may supply two fluids, namely process water and air. By discharging air together with the process water, the process water discharge pressure can be increased.

[0087] The embodiments of the present invention described above are illustrative. In other words, the detailed description and accompanying drawings have been disclosed
5 for the purpose of illustration. Therefore, some of the components described in the detailed description and the attached drawings may not be essential for solving the problem. Accordingly, simply because non-essential components are described in the detailed description and accompanying drawings, such non-essential components are not intended to be immediately identified as essential.

10 [0088] Furthermore, the above embodiments are merely illustrative of the present invention in all respects. Various improvements and changes can be made to the above embodiments within the scope of the present invention. In other words, when implementing the present invention, specific configurations can be adopted as appropriate depending on the embodiment.

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List of Reference Numerals

20	[0089]	1	Cutting apparatus
		3	Substrate supply unit
		4	Positioning unit
		4a	Rail unit
		5	Cutting table
		5a	Holding member
		5b	Rotating mechanism
		5c	Moving mechanism
		5d	First position checking camera
		5e	First cleaner
25		6	Spindle unit

	6a	Blade	
	6b	Second position checking camera	
	6c	Rotation shaft	
	7	Transport unit	
5	7a	Second cleaner	
	11	Inspection table	
	12	First optical inspection camera	
	13	Second optical inspection camera	
	14	Arrangement unit	
10	15	Extraction unit	
	15a	Good component tray	
	15b	Defective component tray	
	20	Monitor	
	50	Computer	
15	70	Control unit	
	72	CPU	
	74	RAM	
	76	ROM	
	80	Storage unit	
20	81	Control program	
	90	Input/output I/F	
	100, 102, 110, 112, 120, 122, 130, 132, 140	Supply unit	
	104, 114	First nozzle	
	106, 116	Second nozzle	
25	200, 202, 210, 212	Proportional control valve	
	300, 310, 320, 330, 340, 350, 360	Solenoid valve	
	302, 312	3-port solenoid valve	

	322, 332, 342, 352	Variable needle throttle valve
	362	Needle adjustment valve
	400	Water supply facility
	410	Pressure gauge
5	500	Correction value table
	710	Subtraction unit
	720	Feedback control unit
	730	Multiplication unit
	740	Feedforward control unit
10	A1	Cutting module
	B1	Inspection/storage module
	L1–L4	Change
	M1	Magazine
	P1	Package substrate
15	PL1	Pipe
	PO1	Branch point
	S1	Electronic component
	SE1–SE10	Flow rate sensor

CLAIMS

1. A cutting apparatus that receives a supply of process water from a water supply facility outside the cutting apparatus, the cutting apparatus comprising:
 - 5 a cutting unit configured to cut an object to be cut;
 - a supply unit configured to directly or indirectly supply the process water received from the water supply facility to at least one of the object to be cut and the cutting unit;
 - a detection unit configured to detect a flow rate of the process water supplied by
 - 10 the supply unit;
 - an adjustment unit configured to adjust the flow rate of the process water supplied by the supply unit; and
 - a control unit configured to perform both feedforward control, in which the adjustment unit is controlled based on a disturbance factor before cutting of the object to
 - 15 be cut, and feedback control, in which the adjustment unit is controlled based on a detection result of the detection unit such that the detection result approaches a target value.
2. The cutting apparatus according to claim 1,
 - 20 wherein the disturbance factor includes at least one of a water pressure of the water supply facility, an amount of the process water supplied from the water supply facility, and a status of supply of water by the water supply facility to a device other than the cutting apparatus.
- 25 3. The cutting apparatus according to claim 1 or 2,
 - wherein a size of a process water supply opening of the supply unit is variable,
 - and

the disturbance factor includes the size of the supply opening used to supply the process water.

4. The cutting apparatus according to any one of claims 1 to 3, further comprising:
5 a plurality of other supply units different from the supply unit,

wherein the plurality of other supply units are each configured to directly or indirectly supply the process water to at least one of the object to be cut and the cutting unit, and

10 the supply unit and the plurality of other supply units receive a supply of the process water from the same water supply facility.

5. The cutting apparatus according to claim 4,

15 wherein at least one supply unit among the plurality of other supply units cleans the object to be cut by directly or indirectly supplying the process water to the object to be cut.

6. The cutting apparatus according to claim 4 or 5,

20 wherein the disturbance factor includes the number of supply units that supply the process water at the same time in a group including the supply unit and the plurality of other supply units.

7. The cutting apparatus according to any one of claims 4 to 6, further comprising:

25 a storage unit configured to store a correction value for each combination of supply units that supply the process water at the same time in a group including the supply unit and the plurality of other supply units,

wherein the control unit performs the feedforward control using the correction values associated with the combinations.

8. The cutting apparatus according to claim 7,
wherein the control unit updates the correction values associated with the combinations based on the detection result of the detection unit.

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9. A method for manufacturing a cut product using the cutting apparatus according to any one of claims 1 to 8, comprising:
cutting the object to be cut using the cutting apparatus.