

NOZZLE CLEANING DEVICE AND NOZZLE CLEANING METHOD FOR COATING AND DEVELOPING APPARATUS

FIELD OF THE INVENTION

The present application relates to the semiconductor field, and in particular to a nozzle cleaning device and a nozzle cleaning method for a coating and developing apparatus.

BACKGROUND

The developing nozzle of a coating and developing apparatus is used for a long time under the condition of high-speed wafer rotation. Since the nozzle is positioned close to the wafer surface, the lower surface of the nozzle and the area around the nozzle orifice are susceptible to contamination by splashing droplets, thereby necessitating cleaning. However, existing apparatuses do not have an automatic nozzle cleaning function. When the contaminated developing nozzle is reused in a subsequent process, the accumulated contaminants on the nozzle may fall onto the wafer surface, causing a risk of defects on the wafer surface.

SUMMARY

The technical problem to be solved by the present application is that the developing nozzles of the existing coating and developing apparatuses cannot be automatically cleaned.

To solve the above technical problem, the present application provides a nozzle cleaning device for a coating and developing apparatus, comprising: a cleaning tank, for containing a cleaning liquid; a vibration generator, for providing vibration waves to the cleaning tank; and a temperature control unit, for controlling the temperature of the cleaning liquid, configured to heat the cleaning liquid first and then cool the cleaning liquid during a nozzle cleaning process.

In an embodiment of the present application, the temperature control unit includes a thermal converter based on the Peltier effect, and the thermal converter is configured to heat or cool the cleaning liquid by adjusting a current direction.

In an embodiment of the present application, the thermal converter includes a plurality of thermal conversion units, and the plurality of thermal conversion units are uniformly distributed on the outer side of the cleaning tank.

In an embodiment of the present application, the nozzle cleaning device further comprises a purging unit, wherein the purging unit includes a swing mechanism and a plurality of spray heads, the plurality of spray heads are disposed on the inner side of the cleaning tank, and the swing mechanism is configured to control each of the spray heads to swing.

In an embodiment of the present application, the plurality of spray heads include at least four spray heads, and the at least four spray heads are respectively disposed on four side walls on the inner side of the cleaning tank.

In an embodiment of the present application, the nozzle is disposed in the cleaning tank and located at a cleaning height when cleaning the nozzle, each of the spray heads is at a height inside the cleaning tank higher than the cleaning height, and each of the spray heads is inclined toward the bottom of the cleaning tank.

In an embodiment of the present application, the swing mechanism is configured to control all the spray heads to swing synchronously, and the synchronous swinging includes the same swinging direction and the same swinging amplitude.

In an embodiment of the present application, the swinging of each of the spray heads includes left-right linear swinging and up-down linear swinging.

In an embodiment of the present application, the plurality of spray heads use the same gas source, the gas source is configured to provide purge gas, and the purge gas includes an inert gas.

In an embodiment of the present application, the nozzle cleaning device further comprises: a liquid supply unit, including a liquid supply pipeline and a liquid supply valve, wherein the liquid supply pipeline is connected to the cleaning tank, and the liquid supply unit is configured to supply the cleaning liquid into the cleaning tank under the control of the liquid supply valve; and a liquid discharge unit, including a liquid discharge pipeline and a liquid discharge valve, wherein the liquid discharge

pipeline is connected to the cleaning tank, and the liquid discharge unit is configured to discharge the cleaning liquid from the cleaning tank under the control of the liquid discharge valve.

The present application further proposes a nozzle cleaning method for a coating and developing apparatus to solve the above technical problem, comprising:

step S1: moving a nozzle into a cleaning tank of a nozzle cleaning device, such that the nozzle is located at a cleaning height;

step S2: injecting a cleaning liquid into the cleaning tank, and when the cleaning liquid reaches a first liquid level, heating the cleaning liquid by using a temperature control unit, the first liquid level being lower than the cleaning height;

step S3: starting a vibration generator to make the cleaning liquid vibrate;

step S4: after the vibration generator has operated for a first duration, cooling the cleaning liquid by using the temperature control unit;

step S5: after a second duration, stopping the vibration generator and the temperature control unit, stopping injecting the cleaning liquid, and emptying the cleaning tank.

In an embodiment of the present application, in the step S4 and the step S5, the method further comprises: controlling the liquid supply amount and the liquid discharge amount of the cleaning tank to maintain the liquid level of the cleaning liquid at a preset height.

In an embodiment of the present application, in the step S4 and the step S5, the method further comprises: discharging the cleaning liquid from the cleaning tank when the temperature of the cleaning liquid reaches a dischargeable temperature.

In an embodiment of the present application, after the step S5, the method further comprises:

step S6: purging the nozzle with purge gas.

The nozzle is configured to perform a chemical liquid ejection action during operation, and after the step S6, the method further comprises:

step S7: controlling the nozzle to complete the chemical liquid ejection action at least once to discharge the cleaning liquid that has entered the interior of the nozzle.

By adopting the nozzle cleaning device and the nozzle cleaning method for a coating and developing apparatus according to the present application, vibration control and temperature control are combined. During the cleaning process, the vibration and temperature of the cleaning liquid are controlled such that the cleaning liquid is first rapidly heated and then rapidly cooled while being vibrated. The heating can reduce the adhesion of contaminants on the nozzle and assist the cleaning effect brought by vibration, while the cooling causes contaminants stubbornly attached to the nozzle surface to undergo shrinkage again, further weakening the adhesion of contaminants and thereby causing contaminants to detach. By adopting the nozzle cleaning device and the nozzle cleaning method of the present application, automatic cleaning of the nozzle can be achieved with improved cleaning effect and high efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and performance of the present application are further described by the following embodiments and the accompanying drawings of the embodiments. The accompanying drawings are provided for further understanding of the present application, are incorporated into and constitute a part of the present application, illustrate embodiments of the present application, and together with the present specification serve to explain the principle of the present application. In the accompanying drawings:

FIG. 1 is a schematic diagram of a developing nozzle performing timed ejection;

FIG. 2 is a schematic diagram of an application scenario of a nozzle cleaning device according to an embodiment of the present application;

FIG. 3 is a schematic diagram of a nozzle cleaning device and a nozzle cleaning process according to an embodiment of the present application;

FIG. 4 is a schematic diagram of the thermal effect of a PN semiconductor pair for illustrating the Peltier effect;

FIG. 5 is a schematic diagram of an arrangement of a temperature control unit;

FIG. 6 is a top view schematic diagram of a nozzle cleaning device according to an embodiment of the present application;

FIG. 7 is a side view schematic diagram of a nozzle cleaning device according to an embodiment of the present application;

FIG. 8 is an exemplary flowchart of a nozzle cleaning method for a coating and developing apparatus according to an embodiment of the present application.

PREFERRED EMBODIMENTS OF THE INVENTION

In order to further clarify the technical solutions of the embodiments of the present application, a brief introduction to the accompanying drawings used in the description of the embodiments will be given below. Obviously, the accompanying drawings in the following description are merely some examples or embodiments of the present application, and those of ordinary skill in the art may also apply the present application to other similar scenarios based on these accompanying drawings without making creative efforts. Unless obvious from the linguistic context or otherwise specified, the same reference numerals in the drawings represent the same structures or operations.

As used herein, unless the context clearly indicates an exception, the terms "a," "an," "one," and/or "the" are not specifically limited to the singular and may also include the plural. Generally, the terms "comprise" and "include" merely indicate the inclusion of steps and elements that have been explicitly identified, and these steps and elements do not constitute an exclusive list, and the method or apparatus may also contain other steps or elements.

Unless otherwise specifically stated, the relative arrangement of components and steps, numerical expressions, and numerical values set forth in these embodiments do not limit the scope of the present application. Meanwhile, it should be understood that, for ease of description, the dimensions of the various parts shown in the accompanying

drawings are not drawn to actual scale. Techniques, methods, and apparatuses known to those of ordinary skill in the relevant art may not be discussed in detail, but where appropriate, such techniques, methods, and apparatuses should be regarded as a part of the granted specification. In all examples shown and discussed herein, any specific value should be construed as merely exemplary and not as a limitation. Therefore, other examples of the exemplary embodiments may have different values. It should be noted that similar reference numerals and letters in the following accompanying drawings denote similar items, and therefore, once an item is defined in one accompanying drawing, the item need not be further discussed in subsequent accompanying drawings.

For ease of description, spatially relative terms such as "above," "over," "on the upper surface," "upper," and the like may be used herein to describe the spatial positional relationship between one device or feature and other devices or features as shown in the drawings. It should be understood that the spatially relative terms are intended to encompass different orientations in use or operation in addition to the orientation of the device depicted in the drawings. For example, if the device in the accompanying drawings is turned over, a device described as being "above" or "on" other devices or structures will be positioned "below" or "under" the other devices or structures. Thus, the exemplary term "above" may include both orientations of "above" and "below". The device may also be otherwise oriented (rotated 90 degrees or in other orientations), and the spatially relative description used herein should be interpreted accordingly.

Furthermore, it should be noted that the terms "first", "second", and the like are used to define components merely for the purpose of distinguishing the corresponding components, and unless otherwise stated, the above terms have no special meaning and therefore should not be construed as limiting the scope of protection of the present application. Furthermore, although the terms used in the present application are selected from terms known and commonly used in the art, some terms mentioned in the specification of the present application may be selected by the applicant according to his or her judgment, and the detailed meanings of the terms are explained in the relevant parts of the description herein. Furthermore, the present application is required to be understood not merely by the actual terms used, but also by the meaning embodied in each term.

The present application uses a flowchart to illustrate the operations performed by the system according to embodiments of the present application. It should be understood that the foregoing or following operations are not necessarily performed in exact sequence. Rather, the various steps may be performed in reverse order or simultaneously. Meanwhile, other operations may be added to these processes, or one or more operations may be removed from these processes.

Current coating and developing apparatuses lack a nozzle cleaning function for developing nozzles, and only performs cleaning on the developing nozzles through timed dummy ejection. FIG. 1 is a schematic diagram of a developing nozzle performing timed ejection. Wherein, a nozzle 11 is located at the front end of a liquid ejecting portion 10 for ejecting a chemical liquid. When the nozzle 11 needs to be cleaned, a nozzle arm 01 first moves the nozzle 11 to a fixed drain tank 12, and then lowers the liquid ejecting portion 10 and the nozzle 11 into the drain tank 12. The drain tank 12 contains liquid, and the nozzle 11 extends into the liquid surface to perform an ejection action, thereby cleaning the nozzle 11. It should be noted that the nozzle cleaning device of the present application can be applied to any nozzle in the coating and developing apparatuses, including but not limited to developing nozzles and coating nozzles.

FIG. 2 is a schematic diagram of an application scenario of a nozzle cleaning device according to an embodiment of the present application. According to FIG. 2, a process chamber 21 and a substrate 22 are shown. After the nozzle 11 completes process steps such as developer coating, the nozzle 11 is moved to a waiting position P1 to wait for the current substrate to complete the full process flow. The nozzle cleaning device 23 of the present application may be disposed near the waiting position P1, or below the waiting position P1. At this time, in order to clean the nozzle 11, the nozzle arm 01 may carry the nozzle 11 downward to position P2, that is, into the nozzle cleaning device 23, to begin the cleaning steps.

FIG. 3 is a schematic diagram of a nozzle cleaning device and a nozzle cleaning process according to an embodiment of the present application. According to FIG. 3, the nozzle cleaning device 23 comprises a cleaning tank 31, a vibration generator 32, and a temperature control unit (not shown). Wherein, the cleaning tank 31 is used to contain a cleaning liquid. The present application does not limit the cleaning liquid,

which may be pure water, a specific cleaning liquid, etc. It should be noted that the position where the nozzle cleaning device 23 is disposed may be the same as or different from the position of the drain tank 12 shown in FIG. 1. If the position is the same, the nozzle cleaning device 23 of the present application may replace the original drain tank 12 without changing the movement path setting of the nozzle arm after the process is completed.

As shown in FIG. 3, the vibration generator 32 is disposed on the outer periphery of the cleaning tank 31, for example, at the bottom. The present application does not limit the installation position of the vibration generator 32. In some embodiments, the vibration generator 32 is disposed inside the cleaning tank 31, for example, a waterproof vibration generator 32 may directly vibrate the cleaning liquid rather than transmitting vibration through the shell of the cleaning tank 31.

In some embodiments, the vibration generator 32 includes an ultrasonic generator for providing ultrasonic waves to the cleaning liquid to produce an ultrasonic cavitation effect. The ultrasonic generator 32 can provide sufficiently large ultrasonic energy to the cleaning liquid. When ultrasonic frequency vibration is transmitted to the cleaning liquid, the interior of the liquid is utilized and compressed. When the liquid is utilized, bubbles are generated; when the liquid is compressed, the bubbles are compressed and then shattered and broken. This is the "ultrasonic cavitation effect." The cavitation action of ultrasonic waves impacts and strips contaminants from the surface of objects. In the scenario of the present application, the contaminants attached to the nozzle can be detached from the nozzle surface and suspended and dissolved in the liquid in the cleaning tank. In some embodiments, the vibration generator 32 may also be a megasonic generator.

In some embodiments, the cleaning tank 31 may have a double-layered shell with an interlayer disposed between layers of the double-layered shell, and the vibration generator 32 may be embedded in the interlayer.

According to FIG. 3, after the nozzle 11 completes the process, the nozzle arm 01 drives the nozzle 11 to move from the process position to position P1. When cleaning is to be performed, the nozzle arm 01 drives the nozzle 11 to move to position P2. At this time, the nozzle 11 is at cleaning height H, ready to begin the cleaning process.

In some embodiments, the temperature control unit in the nozzle cleaning device 23 includes a thermal converter based on the Peltier effect, and the thermal converter is used to heat or cool the cleaning liquid by adjusting a current direction.

FIG. 4 is a schematic diagram of the thermal effect of a PN semiconductor pair for illustrating the Peltier effect, showing a thermocouple composed of a pair of P-type and N-type materials. The Peltier effect utilizes the phenomenon that when a circuit composed of two different conductors P and N is supplied with direct current, in addition to Joule heat, some other heat is released at one junction, while heat is absorbed at the other junction. The phenomenon caused by the Peltier effect is reversible; when the current direction is changed, the junctions that release heat and absorb heat are also changed. The heat absorbed and released is proportional to the current intensity I [A] and is related to the properties of the two conductors and the temperature of the hot end, i.e., $Q_{pn} = I\pi_{pn}$.

FIG. 5 is a schematic diagram of an arrangement of a temperature control unit. According to FIG. 5, a cleaning tank 51 has a double shell, including an inner shell 52 and an outer shell 53. A thermal converter 54 in the temperature control unit is embedded in the interlayer between the inner shell 52 and the outer shell 53. In addition to the thermal converter, the temperature control unit also includes other necessary equipment such as a direct-current (DC) electrode reverser and a DC power supply. Specifically, the thermal converter 54 includes a plurality of thermal conversion units, each of the thermal conversion units includes a pair of PN thermocouples. As shown in FIG. 5, the plurality of thermal conversion units are uniformly distributed on the outer side of the inner shell 52, which can provide a uniform heating effect to the cleaning liquid.

According to FIG. 5, the plurality of thermal conversion units are interconnected to form a series circuit. Both ends of this series circuit are respectively connected to the DC electrode reverser, and further connected to the DC power supply. Assuming heating is required, a forward current is applied to the thermal converter 54, and the DC electrode reverser regulates the current to be applied in the forward direction, making the plurality of thermal conversion units begin generating heat, thereby heating the cleaning liquid. When cooling is required, a reverse current is applied to the thermal converter 54, and the DC electrode reverser regulates the current to be applied in the

reverse direction, making the plurality of thermal conversion units begin absorbing heat, thereby cooling the cleaning liquid.

The temperature control unit in the nozzle cleaning device of the present application is configured to heat the cleaning liquid first and then cool the cleaning liquid during the nozzle cleaning process. Heating the cleaning liquid can reduce the adhesion of contaminants on the developing nozzle, thereby assisting the ultrasonic cleaning capability and facilitating the removal of large particulate contaminants with strong adhesion. The cooling of the cleaning liquid has at least two effects. First, cooling the cleaning liquid indirectly makes the contaminants attached to the nozzle surface undergo shrinkage again, thereby weakening the adhesion of the contaminants and ultimately resulting in detachment. Second, when discharging the cleaning liquid from the cleaning tank, the operation can prevent thermal deformation of the discharge pipeline and loosening or detachment of the discharge pipeline junctions caused by thermal stress, or even leakage. Therefore, the vibration generator 32 and the temperature control unit in the nozzle cleaning device of the present application cooperate and act in combination to efficiently clean the nozzle. It should be noted that the temperature control unit of the present application can rapidly heat and cool the cleaning liquid. Although no limitation is imposed on this speed, such rapid heating and rapid cooling can be achieved by using the thermal converter, which is conducive to accelerating the fatigue of the contaminants and enhancing the ultrasonic cleaning effect.

In some embodiments, the nozzle cleaning device of the present application further includes a purging unit.

FIG. 6 is a top view schematic diagram of a nozzle cleaning device according to an embodiment of the present application, and FIG. 7 is a side view schematic diagram of a nozzle cleaning device according to an embodiment of the present application, neither of FIG. 6 nor FIG. 7 shows the nozzle arm. In combination with FIG. 6 and FIG. 7, the purging unit includes a swing mechanism 61 and a plurality of spray heads 62. The plurality of spray heads 62 are disposed on the inner side of the cleaning tank 31, and the swing mechanism 61 is used to control the swing of each spray head 62.

The purging unit is used to eject purge gas toward the nozzle 11 through the spray

heads 62 to further remove the residual liquid on the nozzle 11. The present application does not limit the purge gas. In some embodiments, the purge gas includes an inert gas or nitrogen.

The present application does not limit the number or positions of the plurality of spray heads 62.

Preferably, the plurality of spray heads 62 include at least four nozzles, and the at least four nozzles are respectively disposed on four side walls on the inner side of the cleaning tank 31. According to FIG. 6, the cleaning tank 31 is substantially rectangular and has four side walls. One spray head 62 is disposed on each side wall of the cleaning tank 31, and the installation height of each spray head 62 in the Z direction is equal, and each spray head 62 is substantially located at the midpoint of the side wall in the X direction or Y direction.

According to FIG. 7, when cleaning the nozzle 11, the nozzle 11 is disposed in the cleaning tank 31, and the nozzle 11 is at the cleaning height H. The height H1 of each spray head 62 inside the cleaning tank 31 is higher than the cleaning height H, and the gas outlet of each spray head 62 is inclined toward the bottom of the cleaning tank 31. The height of the gas outlet of the spray head 62 is taken as the height of the spray head 62 inside the cleaning tank 31. As shown in FIG. 7, it is apparent that each spray head 62 is higher than the nozzle 11; therefore, when cleaning the nozzle 11, each spray head 62 is inclined toward the nozzle 11, that is, inclined downward. In one embodiment, the installation angle of each spray head 62 is inclined downward by approximately 43 degrees, that is, the angle between the axial direction of the spray head 62 and the horizontal direction is approximately 43 degrees, approximately within the range of 40 to 50 degrees. The inventors of the present application have found through experiments that such an installation angle can effectively avoid splashing and overflow of liquid droplets during the purging process, ensuring that no residual cleaning liquid (e.g., pure water) remains on the nozzle surface.

In some embodiments, the swing of each spray head 62 includes left-right linear swing and up-down linear swing. Both types of swing are reciprocating motions. Typically, the cleaning tank 31 is disposed in the vertical direction (here, the Z direction), the XY plane is a horizontal plane, and each spray head 62 can swing

vertically and horizontally, that is, each spray head 62 can swing in the X direction, Y direction, and Z direction. According to these embodiments, the swing mechanism 61 may include a driving motor 63, a linkage mechanism 64, and a cylinder 65. The driving motor 63 rotationally drives the linkage mechanism 64 to achieve left-right linear swing of the spray heads 62, and the cylinder 65 is used to drive up-down linear swing of the spray heads 62. The driving motor 63 and the cylinder 65 can be controlled by an external controller.

After cleaning, the nozzle 11 remains in a relatively moist state, and the nozzle 11 may still have cleaning liquid droplets attached thereto. These droplets exist in the gap or relatively hidden corners of the nozzle 11, and it is difficult to complete an effective purging step using nitrogen purging at a single angle. Therefore, the purging unit includes a plurality of spray heads 62, and nitrogen purging is performed on the spray heads 62 from all directions, combined with the swing of the spray heads 62, thereby achieving all-around purging.

In the present application, one swing mechanism 61 may be used to control the movement of the plurality of spray heads 62, or an independent swing mechanism 61 may be configured for each spray head 62.

In some embodiments, all spray heads 62 perform synchronous swing, meaning that the swing direction and swing amplitude of all spray heads 62 are the same. In this embodiment, the four spray heads 62 use the same nitrogen source in hardware design, so that the flow rate and intensity of the gas ejected from each spray head 62 are the same, thereby maintaining uniformity in the ejection direction of the spray heads 62 and preventing nonuniform gas flow from causing inconsistent removal of the cleaning liquid and resulting in purging blind spots.

When using the nozzle cleaning device 23 of the present application to perform a cleaning process, the cleaning liquid is injected into and discharged from the cleaning tank 31. The present application does not limit the manner of injecting and discharging the cleaning liquid.

According to FIG. 3, in some embodiments, the nozzle cleaning device 23 further comprises a liquid supply unit and a liquid discharge unit. The liquid supply unit

includes a liquid supply pipeline 33 and a liquid supply valve 34. The liquid supply pipeline 33 is connected to the cleaning tank 31, and the liquid supply unit is used to supply the cleaning liquid to the cleaning tank 31 under the control of the liquid supply valve 34. The liquid discharge unit includes a liquid discharge pipeline 35 and a liquid discharge valve 36. The liquid discharge pipeline 35 is connected to the cleaning tank 31, and the liquid discharge unit is used to discharge the cleaning liquid from the cleaning tank 31 under the control of the liquid discharge valve 36. Wherein, the liquid supply unit may include a plurality of liquid supply pipelines 33, and each liquid supply pipeline 33 is provided with a liquid supply valve 34 for controlling the liquid supply flow rate. Alternatively, as needed, the plurality of liquid supply pipelines 33 may converge into the same main liquid supply pipeline, and a liquid supply valve may also be provided on the main liquid supply pipeline. Similarly, the liquid discharge unit may also include a plurality of liquid discharge pipelines 35, and each liquid discharge pipeline 35 is provided with a liquid discharge valve 34 for controlling the liquid discharge flow rate.

Both the liquid supply unit and the liquid discharge unit may be controlled by a controller to perform liquid supply and discharge according to a set program or command.

The nozzle cleaning device 23 may further include a gas inlet unit. As shown in FIG. 3, the gas inlet unit further includes a gas inlet pipeline 37 and a gas inlet valve 38, which are connected to the respective spray heads 62 to control the gas ejection flow rate of the spray heads 62. The gas inlet unit may also be controlled by the controller to supply gas according to the set program or command.

In order to achieve control over a series of actions such as liquid supply, liquid discharge, vibration, heating, and gas supply, the liquid supply unit, the liquid discharge unit, the vibration generator 32, the temperature control unit, the gas supply unit, and the nozzle 11 may all be communicatively connected to the same controller, and the controller controls the entire nozzle cleaning device 23 to perform cleaning operations according to predetermined timing and logic.

FIG. 8 is an exemplary flowchart of a nozzle cleaning method for a coating and developing apparatus according to an embodiment of the present application. The

nozzle cleaning device 23 described above may be used to execute this nozzle cleaning method; therefore, the foregoing description may also be used to illustrate this nozzle cleaning method. According to FIG. 8, the nozzle cleaning method comprises the following steps:

Step S1: Move the nozzle 11 into the cleaning tank 31 of the nozzle cleaning device 23 so that the nozzle 11 is at the cleaning height H;

Step S2: Inject the cleaning liquid into the cleaning tank 31, when the cleaning liquid reaches a first liquid level, use the temperature control unit to heat the cleaning liquid, and the first liquid level is lower than the cleaning height H;

Step S3: Start the vibration generator 32 to vibrate the cleaning liquid;

Step S4: After the vibration generator 32 has operated for a first duration, use the temperature control unit to cool the cleaning liquid;

Step S5: After a second duration, stop the vibration generator 32 and the temperature control unit, stop injecting the cleaning liquid, and empty the cleaning tank 31.

The above steps S1 to S5 are described below in conjunction with FIG. 3.

As shown in FIG. 3, step S1 indicates that the nozzle 11 is moved from position P1 to position P2, at this time, the nozzle 11 is at the cleaning height H. In step S2, the cleaning liquid is injected into the cleaning tank 31.

It should be noted that, in order to save time, the liquid injection action of step S2 may be started simultaneously during the movement of the nozzle 11 in step S1.

In step S2, the first liquid level is lower than the cleaning height H. At this time, the nozzle 11 has not yet contacted the cleaning liquid, and the temperature control unit is used to heat the cleaning liquid, making the temperature of the cleaning liquid rise.

In step S3, the timing for starting the vibration generator 32 may be when the

cleaning liquid reaches the first liquid level, or after the cleaning liquid has been heated for a period of time, or after the cleaning liquid has been heated to a preset temperature. As described above, the combined effect of ultrasonic vibration and heating is more conducive to making the contaminants on the nozzle 11 detach.

In step S4, as described above, cooling the cleaning liquid can make the cleaning liquid undergo a process from hot to cold, during which the stubborn contaminants on the surface of the nozzle 11 that have strong adhesion and have not been stripped by ultrasonic vibration undergo a shrinkage state caused by thermal volume change, and detach from the nozzle 11 body, and the temperature of the cleaning liquid is reduced to a dischargeable temperature. Exemplarily, the dischargeable temperature is room temperature, for example, approximately 20 degrees.

In step S5, the second duration T2 refers to the duration during which the temperature control unit cools the cleaning liquid in step S4. If the vibration generator 32 is turned on when the cleaning liquid reaches the cleaning height, the sum of the first duration T1 and the second duration T2 may serve as the effective operating duration of the nozzle cleaning device 23. During this period, the nozzle 11 undergoes two types of cleaning processes: vibration + heating and vibration + cooling, both of the types are used to remove the contaminants from the nozzle 11. After the second duration T2, the vibration generator 32 and the temperature control unit are both stopped, the injection of cleaning liquid is stopped, and the cleaning tank 31 is emptied. It can be understood that if the vibration generator 32 is turned on before the cleaning liquid reaches the cleaning height, at this time, the cleaning liquid has not yet contacted the nozzle 11, then the vibration and heating process at this time does not belong to an effective cleaning process, and the effective operating duration is less than the sum of the first duration T1 and the second duration T2.

The above steps S1 to S5 do not impose any limitation on the control of the liquid discharge unit.

In some embodiments, the liquid discharge valve 36 is closed during steps S1 to S3, so that the cleaning liquid can reach the first liquid level relatively quickly in step S2.

In some embodiments, the method further comprises: setting a preset height, when the liquid level of the cleaning liquid reaches the preset height, the cleaning liquid is suitable for cleaning the nozzle 11. As shown in FIG. 3, the nozzle 11 protrudes downward from a lower surface 13 of the liquid ejecting portion 10, and the preset height is a certain distance above the lower surface 13. At this preset height, the nozzle 11 can be completely immersed in the cleaning liquid. The first liquid level is below this preset height.

During the execution of steps S4 and S5, the liquid level may reach the preset height. In some embodiments, in steps S4 and S5, the method further comprises: controlling the liquid supply amount and the liquid discharge amount of the cleaning tank 31 to maintain the liquid level of the cleaning liquid at the preset height. More specifically, the liquid supply amount is adjusted by controlling the opening degree of the liquid supply valve 34, and the liquid discharge amount is adjusted by controlling the opening degree of the liquid discharge valve 36.

For example, in steps S4 and S5, the liquid discharge valve 36 is in an open state. At the beginning, in order to raise the liquid level, the liquid supply amount may be made greater than the liquid discharge amount, with the liquid supply valve 34 having a relatively large opening degree and the liquid discharge valve 36 having a relatively small opening degree. During the process of the liquid level rising from the first liquid level to the preset height, when the liquid level is about to reach the preset height, the controller may perform fine adjustments to the opening degrees of the liquid supply valve 34 and the liquid discharge valve 36, for example, gradually decreasing the opening degree of the liquid supply valve 34 while gradually increasing the opening degree of the liquid discharge valve 36, so that the liquid level reaches the preset height. When the liquid level reaches the preset height, the liquid supply valve 34 and the liquid discharge valve 36 are adjusted so that the liquid supply amount is equal to the liquid discharge amount, thereby maintaining the liquid level at the preset height.

In other embodiments, in steps S4 and S5, the liquid discharge valve 36 is opened only when the temperature of the cleaning liquid reaches a dischargeable temperature. For example, in step S4, after the temperature control unit cools the cleaning liquid, the liquid discharge valve 36 is opened after a period of time. When the thermal converter has high working efficiency, this cooling time can be very short. In addition,

the temperature of the cleaning liquid injected into the cleaning tank 31 is, for example, room temperature or lower than the heated temperature, and the continuous injection of cleaning liquid is also conducive to rapid cooling of the cleaning liquid. During the second duration T in step S5, the liquid discharge valve 36 remains open, and by controlling and adjusting the opening degrees of the liquid supply valve 34 and the liquid discharge valve 36, the liquid supply amount and the liquid discharge amount are kept balanced, maintaining the liquid level at the preset height.

In order to prevent the discharged cleaning liquid from reaching an excessively high temperature, after the temperature control unit cools the cleaning liquid for a period of time and the cleaning liquid reaches the dischargeable temperature, the liquid discharge valve 36 is then opened, so that the temperature of the discharged cleaning liquid is less than or equal to the dischargeable temperature. During this process, if the liquid level of the cleaning liquid has already reached the preset height while the temperature of the cleaning liquid is still higher than the dischargeable temperature, in order to avoid an excessively high liquid level, the liquid supply valve 34 may be closed first to stop injecting the cleaning liquid. It should be noted that if the capacity of the cleaning tank 31 is sufficient and the components of the liquid ejecting portion 10 located above the nozzle 11 can be immersed in the cleaning liquid, then the injection of cleaning liquid may not be stopped.

In step S5, during this second duration T2, the liquid supply amount and the liquid discharge amount are kept balanced, so that the contaminants entering the cleaning liquid can be dynamically discharged from the cleaning tank 31, which is equivalent to the nozzle 11 being in a flowing cleaning liquid, and is more conducive to removing all contaminants. Thereafter, the liquid supply valve 34 is closed to stop injecting the cleaning liquid, the liquid discharge valve 36 is kept fully open, and the cleaning liquid in the cleaning tank 31 is completely emptied.

In some embodiments, the nozzle cleaning method of the present application further comprises, after the step S5:

Step S6: Purge the nozzle with purge gas.

Step S7 may be performed by the purging unit described above.

In some embodiments, the nozzle 11 is used to perform a chemical liquid ejection action during operation, and after step S6, the method further comprises:

Step S7: Control the nozzle 11 to complete the chemical liquid ejection action at least once to discharge the cleaning liquid that has entered the interior of the nozzle 11.

For a developing nozzle, the developer is ejected from the nozzle 11 when performing the chemical liquid ejection action, which can discharge the cleaning liquid that has entered the interior of the nozzle 11 in the reverse direction, thereby avoiding contamination of the developer due to the presence of cleaning liquid during the next use.

The basic concept has been described above. Obviously, for those skilled in the art, the above disclosure of the application is merely exemplary and does not constitute a limitation of the present application. Although not explicitly stated herein, those skilled in the art may make various modifications, improvements, and corrections to the present application. Such modifications, improvements, and corrections are suggested in the present application, and therefore still fall within the spirit and scope of the exemplary embodiments of the present application.

Meanwhile, the present application uses specific terms to describe the embodiments of the present application. Terms such as "one embodiment," "an embodiment," and/or "some embodiments" mean a certain feature, structure, or characteristic related to at least one embodiment of the present application. Therefore, it should be emphasized and noted that references to "an embodiment" or "one embodiment" or "an alternative embodiment" made two or more times at different locations in this specification do not necessarily refer to the same embodiment. Furthermore, certain features, structures, or characteristics in one or more embodiments of the present application may be appropriately combined.

Similarly, it should be noted that, in order to simplify the disclosure of the present application and thereby assist in understanding one or more embodiments of the present invention, in the foregoing description of the embodiments of the present application, various features are sometimes combined into a single embodiment, accompanying drawing, or description thereof. However, this method of disclosure

does not imply that the features required for the subject matter of the present application are more than the features mentioned in the claims. In fact, the features of the embodiments are fewer than all the features of the single embodiment disclosed above.

In some embodiments, reference numbers are used to describe components and attributes. It should be understood that such numbers used for describing the embodiments are, in some examples, modified by the modifiers "about," "approximately," or "substantially". Unless otherwise specified, the modifiers "about," "approximately," or "substantially" indicate that the stated number allows a variation of $\pm 20\%$. Accordingly, in some embodiments, the numerical parameters used in the present application are approximate values, and the approximate values may vary according to the characteristics required by individual embodiments. In some embodiments, the numerical parameters should take the specified significant digits into account and adopt general digit retention methods. Although the numerical ranges and parameters used in some embodiments of the present application to confirm the broad scope are approximate values, in specific embodiments, the setting of such numerical values is as precise as possible within the feasible range.

What is claimed is:

1. A nozzle cleaning device applied to a coating and developing apparatus, comprising:

a cleaning tank, for containing a cleaning liquid;

a vibration generator, for providing vibration waves to the cleaning tank;

a temperature control unit, for controlling the temperature of the cleaning liquid, configured to heat the cleaning liquid first and then cool the cleaning liquid during a nozzle cleaning process.

2. The nozzle cleaning device according to claim 1, wherein the temperature control unit includes a thermal converter based on the Peltier effect, and the thermal converter is configured to heat or cool the cleaning liquid by adjusting a current direction.

3. The nozzle cleaning device according to claim 2, wherein the thermal converter includes a plurality of thermal conversion units, and the plurality of thermal conversion units are uniformly distributed on the outer side of the cleaning tank.

4. The nozzle cleaning device according to claim 1, wherein the nozzle cleaning device further comprises a purging unit, the purging unit includes a swing mechanism and a plurality of spray heads, the plurality of spray heads are disposed on the inner side of the cleaning tank, and the swing mechanism is configured to control each of the spray heads to swing.

5. The nozzle cleaning device according to claim 4, wherein the plurality of spray heads include at least four spray heads, and the at least four spray heads are respectively disposed on four side walls on the inner side of the cleaning tank.

6. The nozzle cleaning device according to claim 4, wherein when cleaning the nozzle, the nozzle is disposed in the cleaning tank and located at a cleaning height, each of the spray heads is at a height inside the cleaning tank higher than the cleaning height, and each of the spray heads is inclined toward the bottom of the cleaning tank.

7. The nozzle cleaning device according to claim 4, wherein the swing mechanism is configured to control all the spray heads to swing synchronously, and the synchronous swinging includes the same swinging direction and the same swinging amplitude.

8. The nozzle cleaning device according to claim 4, wherein the swinging of each of the spray heads includes left-right linear swinging and up-down linear swinging.

9. The nozzle cleaning device according to claim 4, wherein the plurality of spray heads use the same gas source, the gas source is configured to provide purge gas, and the purge gas includes an inert gas.

10. The nozzle cleaning device according to claim 1, wherein the nozzle cleaning device further comprises: a liquid supply unit including a liquid supply pipeline and a liquid supply valve, the liquid supply pipeline is connected to the cleaning tank, and the liquid supply unit is configured to supply the cleaning liquid into the cleaning tank under the control of the liquid supply valve; and a liquid discharge unit including a liquid discharge pipeline and a liquid discharge valve, the liquid discharge pipeline is connected to the cleaning tank, and the liquid discharge unit is configured to discharge the cleaning liquid from the cleaning tank under the control of the liquid discharge valve.

11. A nozzle cleaning method for a coating and developing apparatus, comprising:

step S1: moving a nozzle into a cleaning tank of a nozzle cleaning device, such that the nozzle is located at a cleaning height;

step S2: injecting a cleaning liquid into the cleaning tank, and when the cleaning liquid reaches a first liquid level, heating the cleaning liquid by using a temperature control unit, the first liquid level being lower than the cleaning height;

step S3: starting a vibration generator to make the cleaning liquid vibrate;

step S4: after the vibration generator has operated for a first duration, cooling the cleaning liquid by using the temperature control unit;

step S5: after a second duration, stopping the vibration generator and the temperature control unit, stopping injecting the cleaning liquid, and emptying the cleaning tank.

12. The nozzle cleaning method according to claim 11, wherein in the step S4 and the step S5, the method further comprises: controlling the liquid supply amount and the liquid discharge amount of the cleaning tank to maintain the liquid level of the cleaning liquid at a preset height.

13. The nozzle cleaning method according to claim 11, wherein in the step S4 and the step S5, the method further comprises: discharging the cleaning liquid from the cleaning tank when the temperature of the cleaning liquid reaches a dischargeable temperature.

14. The nozzle cleaning method according to claim 11, wherein after the step S5, the method further comprises:

step S6: purging the nozzle with purge gas.

15. The nozzle cleaning method according to claim 14, wherein the nozzle is configured to perform a chemical liquid ejection action during operation, and after the step S6, the method further comprises:

step S7: controlling the nozzle to complete the chemical liquid ejection action at least once to discharge the cleaning liquid that has entered the interior of the nozzle.