

TITLE OF THE INVENTION

Blade Replacement Mechanism, Cutting Apparatus and Blade Replacement Method

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to a blade replacement mechanism, a cutting apparatus, and a blade replacement method.

Description of the Background Art

10 For example, Japanese Patent Laying-Open No. 2016-064450 describes a hubless cutting blade replacement system. In the cutting blade replacement system described in Japanese Patent Laying-Open No. 2016-064450, a through hole is provided through a fixing flange brought into contact with a side surface of a cutting blade and the fixing flange is chucked, and the cutting blade is also chucked through the through hole of the fixing flange.

15 SUMMARY OF THE INVENTION

In the cutting blade replacement system described in Japanese Patent Laying-Open No. 2016-064450, however, there is neither described nor suggested how to fasten and remove a fixing nut for fixing the cutting blade and the fixing flange to a spindle. Therefore, those skilled in the art cannot implement automated blade
20 replacement based on the description of Japanese Patent Laying-Open No. 2016-064450.

According to an embodiment disclosed herein, there can be provided a blade replacement mechanism comprising: a first chucking portion configured to chuck a blade; a second chucking portion located inside the first chucking portion and
25 configured to chuck a flange or a hub independently of the chucking by the first chucking portion; and a detachable attachment member rotating portion located inside the second chucking portion and configured to be capable of rotating a detachable attachment member allowing the blade to be detachably attached to a spindle.

According to an embodiment disclosed herein, there can be provided a cutting

apparatus comprising the blade replacement mechanism, a blade and a spindle.

According to an embodiment disclosed herein, there can be provided a blade replacement method employing a blade replacement mechanism comprising: a first chucking portion configured to chuck a blade; a second chucking portion located inside
 5 the first chucking portion and configured to chuck a flange or a hub independently of the chucking by the first chucking portion; and a detachable attachment member rotating portion located inside the second chucking portion and configured to be capable of rotating a detachable attachment member allowing the blade to be detachably attached to a spindle, the method comprising the steps of: chucking the
 10 blade by the first chucking portion and also chucking the flange or the hub by the second chucking portion independently of the chucking by the first chucking portion, and, in that condition, rotating the detachable attachment member by the detachable attachment member rotating portion to remove the detachable attachment member from the spindle; moving a chucking unit including the first chucking portion, the second
 15 chucking portion, and the detachable attachment member rotating portion to an accommodation portion; releasing the chucking by the first chucking portion and accommodating the blade in the accommodation portion; chucking by the first chucking portion a replacement blade accommodated in the accommodation portion; moving the chucking unit to fit the replacement blade to the spindle; and rotating the
 20 detachable attachment member by the detachable attachment member rotating portion to fix the replacement blade to the spindle.

The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

25 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic plan view of a cutting apparatus of an embodiment.

Fig. 2 is a schematic perspective view of an example of a chucking arm used in a blade replacement mechanism of an embodiment.

Fig. 3 is a schematic perspective view of the chucking arm shown in Fig. 2, as

viewed at a different angle.

Fig. 4 is a schematic plan view of a chucking unit shown in Figs. 2 and 3.

Fig. 5 is a schematic cross-sectional view of the chucking unit shown in Figs. 2 to 4.

5 Fig. 6 is a schematic cross-sectional view for illustrating some step of a blade replacement method of an embodiment.

Fig. 7 is a schematic cross-sectional view for illustrating a portion of a process for a blade replacement method of the embodiment.

10 Fig. 8 is a schematic cross-sectional view for illustrating a portion of the process for the blade replacement method of the embodiment.

Fig. 9 is a schematic cross-sectional view for illustrating a portion of the process for the blade replacement method of the embodiment.

Fig. 10 is a schematic cross-sectional view for illustrating a portion of the process for the blade replacement method of the embodiment.

15 Fig. 11 is a schematic perspective view of a cutting apparatus according to an embodiment of an example with the chucking unit in a first operational position.

Fig. 12 is a schematic perspective view of the cutting apparatus shown in Fig. 11, as viewed at a different angle.

20 Fig. 13 is a schematic perspective view of the cutting apparatus according to the embodiment of the example with the chucking unit in a second operational position.

Fig. 14 is a schematic perspective view of the cutting apparatus according to an embodiment of another example with the chucking unit in a first operational position.

Fig. 15 is a schematic perspective view of the cutting apparatus shown in Fig. 14, as viewed at a different angle.

25 Fig. 16 is a schematic perspective view for illustrating an example of a movement of the chucking unit by a first slide mechanism in the Y direction in an embodiment.

Fig. 17 is a schematic perspective view for illustrating another example of a movement of the chucking unit by the first slide mechanism in the Y direction in the

embodiment.

Fig. 18 is a schematic perspective view for illustrating an example of a movement of the chucking unit by a second slide mechanism in the Z direction in an embodiment.

5 Fig. 19 is a schematic perspective view for illustrating another example of a movement of the chucking unit by the second slide mechanism in the Z direction in the embodiment.

Fig. 20 is a schematic perspective view for illustrating an example of a rotation of the chucking unit by a first rotation mechanism in an X- θ direction in an
10 embodiment.

Fig. 21 is a schematic perspective view for illustrating another example of a rotation of the chucking unit by the first rotation mechanism in the X- θ direction in the embodiment.

Fig. 22 is a schematic perspective view for illustrating an example of a rotation of the chucking unit by a second rotation mechanism in a Y- θ direction in an
15 embodiment.

Fig. 23 is a schematic perspective view for illustrating another example of a rotation of the chucking unit by the second rotation mechanism in the Y- θ direction in the embodiment.

20 Fig. 24 is a schematic perspective view of an accommodation portion in an embodiment.

Fig. 25 is a schematic perspective view of the accommodation portion shown in Fig. 24 when a blade holding member is moved upward in an embodiment.

Fig. 26 is a schematic plan view of a detection unit in an embodiment.

25 Fig. 27 is a flowchart of an example of a method for detecting at least one of abrasion and damage of the blade by the detection unit in an embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, an embodiment will be described. In the drawings used for describing the embodiment, identical reference characters denote identical or

corresponding components.

Fig. 1 is a schematic plan view of a cutting apparatus according to an embodiment serving as an example of a cutting apparatus of the present invention. As shown in Fig. 1, the cutting apparatus of the embodiment is an apparatus that cuts an object into a plurality of individual products. A cutting apparatus 111 according to the embodiment comprises a substrate supplying module A, a substrate cutting module B, and an inspection module C as components. Each component (i.e., modules A to C) is detachably attachable to another component and also replaceable.

Substrate supplying module A for example comprises a substrate supplying mechanism 113 configured to supply a molded substrate 112 corresponding to an example of an object to be cut, and a control unit CTL configured to perform an operation of cutting apparatus 111, control cutting apparatus 111, etc. Molded substrate 112 comprises, for example, a substrate (not shown) composed of a printed board, a lead frame and the like, a plurality of functional elements (a chip such as a semiconductor element) (not shown) attached to a plurality of regions which the substrate has, and a molding resin (not shown) formed so that the plurality of regions are collectively covered. Molded substrate 112 is an object to be cut, which is finally cut and divided into individual pieces. Molded substrate 112 can be transported to substrate cutting module B by a transportation mechanism (not shown) or the like, for example. A molding resin may be called a sealing resin or an encapsulation resin. A molded substrate may be called a sealed substrate or an encapsulated substrate.

Substrate cutting module B can comprise, for example, a cutting table 114 configured to set molded substrate 112 thereon, a movement mechanism 115 configured to move cutting table 114 in the Y direction, a rotation mechanism 116 configured to rotate cutting table 114 in the θ direction, a spindle 21, which will be described later, and a blade replacement mechanism 120 of an embodiment described later. For example, cutting table 114 may comprise a cutting jig (not shown), and when cutting table 114 comprises the cutting jig, molded substrate 112 is placed on the cutting jig.

In Fig. 1, cutting apparatus 111 of the embodiment is shown as a cutting apparatus of a single-spindle configuration having a single spindle 21 for the sake of illustration. However, it is needless to say that cutting apparatus 111 of the embodiment is not limited to the cutting apparatus of the single-spindle configuration, and it may be a cutting apparatus of a double-spindle configuration having two spindles as will be described later.

Spindle 21 can be configured to be movable in the X direction and the Z direction independently, for example. For example, a disk-shaped blade 22 can be attached to a tip portion of a rotary shaft of spindle 21. For example, blade 22 can be fixed parallel to a surface orthogonal to the axial direction (X direction) of the rotary shaft (i.e., a surface including the Y axis and the Z axis). Further, spindle 21 may comprise a cutting water nozzle (not shown) for spraying cutting water in order to suppress frictional heat generated by blade 22 rotating at high speed, for example. Furthermore, molded substrate 112 can be cut while cutting table 114 is relatively moved with respect to spindle 21. Blade 22 can be configured to cut molded substrate 112, for example, by rotating in a plane including the Y axis and the Z axis.

Inspection module C can comprise, for example, an inspection table 110 and a tray 122. For example, inspection table 110 can be configured so that a cut substrate 121, which is a set of a plurality of products P individualized by cutting molded substrate 112, can be set thereon. A plurality of products P can be inspected with a camera (not shown) for inspection, for example, and thus sorted into non-defective products and defective products. For example, tray 122 can be configured to be capable of accommodating products P selected as non-defective products.

Fig. 2 is a schematic perspective view of an example of a chucking arm used in a blade replacement mechanism of an embodiment. A chucking arm 1 comprises a chucking unit 2 and an arm portion 3 attached to chucking unit 2. Chucking unit 2 is attached to one end of arm portion 3.

Fig. 3 is a schematic perspective view of chucking arm 1 shown in Fig. 2, as viewed at a different angle. Chucking unit 2 comprises a cylindrical first chucking

portion 4, a cylindrical second chucking portion 5, and an annular, detachable attachment member rotating portion 6. In Fig. 2, detachable attachment member rotating portion 6, second chucking portion 5 and first chucking portion 4 are shown such that first chucking portion 4, second chucking portion 5 and detachable attachment member rotating portion 6 have their respective distal surfaces observably in the stated order from the chucking side of chucking unit 2 (or a distal side) toward the side of chucking unit 2 closer to arm portion 3 (or a proximal side). In describing chucking unit 2, the proximal side means a side of chucking unit 2 closer to arm portion 3, and the distal side means the chucking side of chucking unit 2.

Fig. 4 is a schematic plan view of chucking unit 2 shown in Figs. 2 and 3. Second chucking portion 5 is located inside first chucking portion 4 and detachable attachment member rotating portion 6 is located inside second chucking portion 5. First chucking portion 4 comprises a plurality of first chucking ports 4x configured to chuck a blade, which will be described later, and an annular first chucking groove 4y in communication with the plurality of first chucking ports 4x. Second chucking portion 5 comprises a plurality of second chucking ports 5x configured to chuck a flange or a hub, which will be described later, and an annular second chucking groove 5y in communication with the plurality of second chucking ports 5x. Detachable attachment member rotating portion 6 comprises a plurality of mutually spaced, annularly disposed protrusions 6a. While detachable attachment member rotating portion 6 is configured to be rotatable, and, for example, it is rotatable in a direction indicated in Fig. 4 by an arrow, it is needless to say that in which direction detachable attachment member rotating portion 6 is rotated is not particularly limited.

Fig. 5 is a schematic cross-sectional view of chucking unit 2 shown in Figs. 2 to 4. First chucking portion 4 is hollow and hollow second chucking portion 5 is located inside the hollow portion of first chucking portion 4. First chucking portion 4 has the hollow portion surrounded by an external wall provided with a gas flow path 14 configured in communication with first chucking groove 4y via first chucking port 4x to chuck a blade described later. Gas flow path 14 is connected to a gas flow path 4z

communicating with first chucking port 4x. First chucking portion 4 includes a protrusion 4a protruding inward from a proximal portion of the external wall of first chucking portion 4. Protrusion 4a has a proximal surface 4b on a proximal side of protrusion 4a. First chucking portion 4 has a distal surface 4c as a distal surface thereof.

Second chucking portion 5 has a hollow portion surrounded by an external wall provided with a gas flow path 13 configured in communication with second chucking groove 5y via second chucking port 5x to chuck a flange or a hub. Gas flow path 13 has one end with a gas suction port 12 attached thereto and configured to suck the gas in gas flow path 13. Gas flow path 13 has the other end connected to a gas flow path 5z communicating with second chucking port 5x. Second chucking portion 5 has a proximal end with an inwardly projecting hook-shaped portion 5a. Hook-shaped portion 5a has a distal surface 5b as a distal surface thereof and a proximal surface 5c as a proximal surface thereof. Second chucking portion 5 has a distal surface 5d as a distal surface thereof.

Second chucking portion 5 is also hollow, and detachable attachment member rotating portion 6 is located inside the hollow portion of second chucking portion 5. Protrusion 6a of detachable attachment member rotating portion 6 is a member which is a distally protruding portion of detachable attachment member rotating portion 6. A rotatable, rotary drive member 9 is attached on a proximal side of detachable attachment member rotating portion 6. As rotary drive member 9 rotates about a shaft 10, detachable attachment member rotating portion 6 can also rotate. A distal portion of detachable attachment member rotating portion 6 projects to be outer than rotary drive member 9. The outwardly projecting portion of detachable attachment member rotating portion 6 has a proximal surface 6b as a proximal surface thereof. Rotary drive member 9 also has a proximal side with a portion projecting outward. The outwardly projecting portion of rotary drive member 9 has a distal surface 9a as a distal surface of the proximal projecting portion.

A cylindrical sleeve 15 is positioned to surround detachable attachment member

rotating portion 6, rotary drive member 9 and shaft 10. Sleeve 15 comprises a housing portion 15a configured to house detachable attachment member rotating portion 6 and a supporting portion 15b configured to support housing portion 15a. Housing portion 15a projects to be outer than supporting portion 15b. Housing portion 15a has a proximal surface 15c as a proximal surface thereof. The housing portion's proximal surface 15c faces the hook-shaped portion's distal surface 5b. Supporting portion 15b has a distal surface 15d as a distal surface thereof.

On a proximal side of sleeve 15, a coupling portion 11 configured to be capable of coupling chucking unit 2 and arm portion 3 is attached. Coupling portion 11 is attached to sleeve 15 by having a distal protrusion 11a thereof fitted into a proximal hollow portion of sleeve 15. Coupling portion 11 has an inner proximal surface 11b facing the hook-shaped portion's proximal surface 5c, and an outer proximal surface 11c facing the proximal surface 4b of the protrusion 4a. The coupling portion's outer proximal surface 11c is located more proximally and outwardly than the coupling portion's inner proximal surface 11b.

A first spring 16 is positioned to surround rotary drive member 9 between the rotating portion's proximal surface 6b and proximal projecting portion's distal surface 9a. First spring 16 can expand and contract as a distance between the rotating portion's proximal surface 6b and the proximal projecting portion's distal surface 9a varies.

A second spring 8 is positioned to surround supporting portion 15b between the hook-shaped portion's proximal surface 5c and the coupling portion's inner proximal surface 11b. Second spring 8 can expand and contract as a distance between the hook-shaped portion's proximal surface 5c and the coupling portion's inner proximal surface 11b varies.

A third spring 7 is positioned to surround second spring 8 between the proximal surface 4b of the protrusion 4a and the coupling portion's outer proximal surface 11c. Third spring 7 can expand and contract as a distance between the proximal surface 4b of the protrusion 4a and the coupling portion's outer proximal surface 11c varies.

Hereinafter, a blade replacement method according to an embodiment using a blade replacement mechanism of an embodiment comprising a chucking arm as described above, will be described. While in the present embodiment a case where blade 22 is a hubless blade having no hub will be described, the present embodiment is not limited to a hubless blade, and it needless to say that the present invention is also applicable to blade 22 having a hub, i.e., a hubbed blade.

First, as shown in the schematic cross-sectional view of Fig. 6, chucking unit 2 is brought closer to a used blade 22. Here, the used blade 22 to be replaced is sandwiched between a proximal flange 20 and a distal flange 23 of spindle 21. Distal flange 23 is clamped to proximal flange 20 by a detachable attachment member 24 such as a nut and blade 22 is thus fixed between proximal flange 20 and distal flange 23 of spindle 21. It should be noted that proximal flange 20 is a flange which is proximal with respect to spindle 21 and distal flange 23 is a flange which is distal with respect to spindle 21.

Subsequently, as shown in the schematic cross-sectional view of Fig. 7, until first chucking portion 4 has distal surface 4c brought into contact with a proximal surface of blade 22 (i.e., a surface thereof closer to arm portion 3), chucking unit 2 is moved further distally (i.e., toward spindle 21).

Subsequently, as shown in the schematic cross-sectional view of Fig. 8, arm portion 3 is distally moved (toward spindle 21) so that chucking unit 2 is further distally moved (toward spindle 21). At the time, blade 22 exerts force to first chucking portion 4 from the distal side (or the spindle 21 side) toward the proximal side (or the arm portion 3 side), however, third spring 7 comes into contact with the proximal surface 4b of the protrusion 4a and thus contracts, and accordingly, movement of first chucking portion 4 is suppressed and an excessive load applied to blade 22 is suppressed. In the state in which movement of first chucking portion 4 is suppressed, second chucking portion 5 distally moves (toward spindle 21) and second chucking portion 5 has distal surface 5d coming into contact with distal flange 23.

After second chucking portion 5 has distal surface 5d coming into contact with

distal flange 23 when detachable attachment member rotating portion 6 does not have protrusion 6a fitted into through hole 24a of detachable attachment member 24 first spring 16 contracts and detachable attachment member rotating portion 6 proximally moves (toward arm portion 3) in a direction indicated by an arrow 31. At the time,
 5 second chucking portion 5 receives a force exerted by distal flange 23 from the distal side (or the spindle 21 side) toward the proximal side (or the arm portion 3 side), however, second spring 8 contacts the hook-shaped portion's proximal surface 5c and contracts, and movement of second chucking portion 5 is suppressed.

Subsequently, as shown in the schematic cross section of Fig. 9, when
 10 detachable attachment member rotating portion 6 does not have protrusion 6a fitted into through hole 24a of detachable attachment member 24 detachable attachment member rotating portion 6 is rotated in a direction indicated by an arrow 32 for example. Detachable attachment member rotating portion 6 rotates, and when protrusion 6a of detachable attachment member rotating portion 6 reaches the position of through hole
 15 24a of detachable attachment member 24, first spring 16 extends, and protrusion 6a fits into through hole 24a.

Subsequently, detachable attachment member rotating portion 6 is rotated to rotate detachable attachment member 24. This releases the clamping of distal flange 23 by detachable attachment member 24 with respect to proximal flange 20.
 20 Subsequently, first chucking portion 4 chucks blade 22 and second chucking portion 5 chucks distal flange 23. Subsequently, by moving chucking unit 2 toward the proximal side (or arm portion 3), as shown in the schematic sectional view of Fig. 10, for example, blade 22 and distal flange 23 are removed from spindle 21 together with detachable attachment member 24.

25 Subsequently, chucking unit 2 is moved from a first operational position allowing blade 22 to be attached/detached, as shown in the schematic perspective views of Figs. 11 and 12, to a second operational position allowing a replacement blade to be ejected/accommodated from/into accommodation portion 51, as shown in the schematic perspective view of Fig. 13. Figs. 11 and 12 are schematic perspective views of a

cutting apparatus according to an embodiment of an example in a state where chucking unit 2 is positioned at the first operational position, and Fig. 13 is a schematic perspective view of the cutting apparatus according to the embodiment of the example in a state where chucking unit 2 is positioned at the second operational position.

5 The cutting apparatus of the embodiment shown in Figs. 11 to 13 comprises a second spindle 25 in a position facing spindle 21. For example, as shown in the schematic perspective views in Figs. 14 and 15, chucking unit 2 of the blade replacement mechanism of the embodiment enables not only attachment and detachment of blade 22 on spindle 21 but also attachment and detachment of blade 22
10 on spindle 25. Figs. 14 and 15 show schematic perspective views of the cutting apparatus of an embodiment of another example when chucking unit 2 assumes the first operational position.

 As shown in the schematic perspective views of Figs. 11 to 15, a blade replacement mechanism of an embodiment comprises a movement mechanism 40
15 including a first slide mechanism 41 and a second slide mechanism 42. For example as shown in Figs. 16 and 17, first slide mechanism 41 allows chucking unit 2 to move by sliding in the Y direction indicated by arrows 61, 62. The movement of chucking unit 2 in the Y direction can be utilized, for example, for moving chucking unit 2 to the first operational position and moving to the second operational position.

20 As shown in the schematic perspective views of Figs. 18 and 19 for example, second slide mechanism 42 allows chucking unit 2 to move by sliding in the Z direction indicated by arrows 71 and 72. The movement of chucking unit 2 in the Z direction can be utilized, for example, for one step for movement from the first operational position to the second operational position and one step for movement from the second
25 movement position to the first movement position, and so forth. Note that the Z direction indicated by arrows 71 and 72 in Figs. 18 and 19 intersects the Y direction indicated by arrows 61 and 62 in Figs. 16 and 17.

 A blade replacement mechanism of an embodiment comprises a first rotation mechanism 43 shown in the schematic perspective views of Figs. 20 and 21 and a

second rotation mechanism 44 shown in the schematic perspective views of Figs. 22 and 23.

As shown in Figs. 20 and 21, for example, first rotation mechanism 43 is configured so that chucking unit 2 can rotate within a first imaginary plane 82 in an X- θ direction indicated by an arrow 81. The rotation of chucking unit 2 in the X- θ direction can be utilized, for example, for one step for movement from the first operational position to the second operational position and one step for movement from the second operational position to the first operational position, and so forth.

As shown in Figs. 22 and 23, for example, second rotation mechanism 44 is configured so that chucking unit 2 can rotate within a second imaginary plane 93 in a Y- θ direction indicated by arrows 91, 92. The movement of chucking unit 2 in the Y- θ direction can be utilized, for example, for movement of chucking unit 2 from spindle 21 to second spindle 25 and movement of chucking unit 2 from second spindle 25 to spindle 21. Note that second imaginary plane 93 is a imaginary plane different from first imaginary plane 82, and first imaginary plane 82 and second imaginary plane 93 intersect with each other.

Fig. 24 is a schematic perspective view of accommodation portion 51 of a blade replacement mechanism of an embodiment. Accommodation portion 51 comprises a first blade magazine 53a, a second blade magazine 53b, and a third blade magazine 53c successively from the uppermost stage to the lowermost stage. Accommodation portion 51 also comprises a first blade holding member 54a, a second blade holding member 54b, and a third blade holding member 54c. First blade holding member 54a, second blade holding member 54b, and third blade holding member 54c are configured to hold blades accommodated in first blade magazine 53a, second blade magazine 53b, and third blade magazine 53c, respectively, around their respective blade magazines. This can prevent a blade from falling from a blade magazine.

After chucking unit 2 of the blade replacement mechanism of the embodiment has removed a used blade from spindle 21 or second spindle 25, as described above, chucking unit 2 is moved to the second operational position shown in Fig. 13 together

with the used blade chucked on chucking unit 2. At the time, as shown in the schematic perspective view of Fig. 25, for example, at least one of first blade holding member 54a, second blade holding member 54b, and third blade holding member 54c is raised to release a blade.

5 Then, chucking unit 2 having chucked the used blade approaches an available blade magazine which does not have a blade accommodated therein, and fits the used blade at a center opening to the available blade magazine. Thereafter, chucking unit 2 stops only the chucking of the used blade by the first chucking portion 4, and moves away from the blade magazine. The used blade can thus be accommodated in the
10 available blade magazine.

Subsequently, chucking unit 2 moves to another blade magazine having a replacement blade accommodated therein. A blade holding member holding the replacement blade is raised to release the replacement blade. Subsequently, chucking unit 2 is brought close to the replacement blade and distal surface 4c of first chucking
15 portion 4 of chucking unit 2 is brought into contact with a surface of the replacement blade. Then, by suctioning from gas suction port 12 through gas flow path 13 of first chucking portion 4, the replacement blade is chucked to the first chucking portion's distal surface 4c.

Chucking unit 2 having chucked the replacement blade is moved from the
20 second operational position shown in Fig. 13 to the first operational position shown in Figs. 11 and 12. Then, as shown in Fig. 10, chucking unit 2 is distally moved and thus caused to approach spindle 21.

Subsequently, as shown in Fig. 9, chucking unit 2 is further distally moved (toward spindle 21). This causes distal flange 23 to contact proximal flange 20 of
25 spindle 21 and sandwich a replacement blade 22 between proximal flange 20 and distal flange 23. Subsequently, detachable attachment member rotating portion 6 is rotated in a direction opposite to the direction of arrow 32 to rotate detachable attachment member 24 and by detachable attachment member 24 distal flange 23 is clamped to proximal flange 20. Replacement blade 22 can thus be fixed between proximal flange

20 and distal flange 23. Subsequently, the chucking of replacement blade 22 by first chucking portion 4 is stopped, and the chucking of distal flange 23 by second chucking portion 5 is stopped.

5 Subsequently, as shown in Fig. 6, chucking unit 2 is proximally moved (toward arm portion 3) and thus separated from spindle 21. This completes attaching replacement blade 22 to spindle 21.

Thus in an embodiment, automated replacement of blade 22 can be achieved.

10 Fig. 26 is a schematic plan view of a detection unit 100 used in a blade replacement mechanism of an embodiment. In the embodiment, detection unit 100 includes a laser sensor 101 and a motor 103. Detection unit 100 is configured such that laser sensor 101 can be moved in the direction of an arrow 102 as motor 103 is driven.

15 Fig. 27 is a flowchart of an example of a method for detecting at least one of abrasion and damage of blade 22 by detection unit 100. Initially, in step 1 (S1), a positionally adjusted laser light shielding ratio A is measured. Step S1 can be performed as follows, for example.

Initially, laser sensor 101 is positionally adjusted. Note that, for example, laser sensor 101 is positionally adjusted such that the cutting edge of blade 22 before cutting starts is located between a laser light emitting unit (not shown) and a laser light
20 detection unit (not shown). Subsequently, with laser sensor 101 positionally adjusted, the emitting unit of laser sensor 101 emits laser light which is in turn detected by the detection unit. Subsequently, in that state, a laser light shielding ratio (positionally adjusted laser light shielding ratio A) is measured. Positionally adjusted laser light shielding ratio A is a ratio of an amount of laser light detected by the laser light
25 detection unit to an amount of laser light emitted in a state after laser sensor 101 is positionally adjusted before cutting starts. The cutting edge of blade 22 before cutting starts tends to shield incidence of laser light on the detection unit, and accordingly, positionally adjusted laser light shielding ratio A can be high.

Subsequently, in step 2 (S2), an abrasion or damage detecting laser light

shielding ratio A' is measured. Step S2 can be performed as follows, for example.

Initially, spindle 21 is rotated to rotate blade 22. Subsequently, the rotating blade 22 cuts an object to be cut. With the rotating blade 22 cutting the object to be cut, the emitting unit of laser sensor 101 emits laser light which is in turn detected by the detection unit. Subsequently, in that condition, a laser light shielding ratio (abrasion or damage detecting laser light shielding ratio A') is measured. When cutting has abraded or damaged blade 22, the cutting edge of blade 22 less shields incidence of laser light on the detection unit than before cutting starts, and accordingly, abrasion or damage detecting laser light shielding ratio A' can be smaller than positionally adjusted laser light shielding ratio A .

Subsequently, in step 3 (S3), positionally adjusted laser light shielding ratio A measured in step S1 is compared with abrasion or damage detecting laser light shielding ratio A' measured in step S2. When positionally adjusted laser light shielding ratio A is equal to abrasion or damage detecting laser light shielding ratio A' , cutting the object by the rotating blade 22 is not stopped, and the process returns to S2 to again measure abrasion or damage detecting laser light shielding ratio A' .

In contrast, in step S3 when positionally adjusted laser light shielding ratio A is not equal to abrasion or damage detecting laser light shielding ratio A' , then in step S4 (S4) rotating blade 22 is stopped, and blade 22 is automatically replaced, as has been described above.

Thus, when the blade replacement mechanism of the embodiment includes detection unit 100 configured to be capable of detecting at least one of abrasion and damage of blade 22, then, after at least one of abrasion and damage of blade 22 is detected, cutting by the rotating blade 22 can automatically stops, and automated replacement of blade 22 in the embodiment can be performed. This enables further automation of replacement of blade 22.

While embodiments have thus been described, it is also initially planned to combine the configuration of each embodiment described above with another, as appropriate.

While the present invention has been described in embodiments, it should be understood that the embodiments disclosed herein are illustrative and non-restrictive in any respect. The scope of the present invention is defined by the terms of the claims, and is intended to include any modifications within the meaning and scope equivalent
5 to the terms of the claims.

INDUSTRIAL APPLICABILITY

The embodiments disclosed herein are applicable to blade replacement mechanisms, cutting apparatuses and blade replacement methods.

WHAT IS CLAIMED IS:

1. A blade replacement mechanism comprising:
a first chucking portion configured to chuck a blade;
a second chucking portion located inside the first chucking portion and
configured to chuck a flange or a hub independently of the chucking by the first
5 chucking portion; and
a detachable attachment member rotating portion located inside the second
chucking portion and configured to be capable of rotating a detachable attachment
member allowing the blade to be detachably attached to a spindle.
2. The blade replacement mechanism according to claim 1, wherein the
detachable attachment member is a nut.
3. The blade replacement mechanism according to claim 1 or 2, further
comprising an arm portion, wherein the arm portion is attached to a chucking unit
including the first chucking portion, the second chucking portion, and the detachable
attachment member rotating portion.
4. The blade replacement mechanism according to claim 3, further comprising
an accommodation portion capable of accommodating a replacement blade.
5. The blade replacement mechanism according to claim 4, further comprising
a movement mechanism configured to be capable of moving the chucking unit between
a first operational position allowing the blade to be attached and detached and a second
operational position allowing the replacement blade to be ejected from the
5 accommodation portion.
6. The blade replacement mechanism according to claim 5, wherein the

movement mechanism includes a first slide mechanism configured to be capable of moving the chucking unit in a first direction, a second slide mechanism configured to be capable of moving the chucking unit in a second direction intersecting the first direction, and a rotation mechanism configured to be capable of rotating the chucking unit.

7. The blade replacement mechanism according to claim 6, wherein the rotation mechanism includes a first rotation mechanism configured to be capable of rotating the chucking unit in a first imaginary plane, and a second rotation mechanism configured to be capable of rotating the chucking unit in a second imaginary plane different from the first imaginary plane.

8. The blade replacement mechanism according to any one of claims 1 to 7, further comprising a detection unit configured to be capable of detecting at least one of abrasion and damage of the blade.

9. A cutting apparatus comprising a blade replacement mechanism according to any one of claims 1 to 8, the blade, and the spindle.

10. A blade replacement method employing a blade replacement mechanism comprising: a first chucking portion configured to chuck a blade; a second chucking portion located inside the first chucking portion and configured to chuck a flange or a hub independently of the chucking by the first chucking portion; and a detachable attachment member rotating portion located inside the second chucking portion and configured to be capable of rotating a detachable attachment member allowing the blade to be detachably attached to a spindle, the method comprising the steps of:

chucking the blade by the first chucking portion and also chucking the flange or the hub by the second chucking portion independently of chucking by the first chucking portion, and, in that condition, rotating the detachable attachment member by the

detachable attachment member rotating portion to remove the detachable attachment member from the spindle;

15 moving a chucking unit including the first chucking portion, the second chucking portion, and the detachable attachment member rotating portion to an accommodation portion;

releasing the chucking by the first chucking portion, and accommodating the blade in the accommodation portion;

chucking by the first chucking portion a replacement blade accommodated in the accommodation portion;

20 moving the chucking unit to fit the replacement blade to the spindle; and

rotating the detachable attachment member by the detachable attachment member rotating portion to fix the replacement blade to the spindle.

11. The method according to claim 10, further comprising the step of detecting at least one of abrasion and damage of the blade.