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Vacuum gripper and workpiece sucking and holding method

Abstract

A plurality of first vacuum pads for suctioning a workpiece are directly or indirectly attached to a main body. A slider is configured to slide in an outward direction of the main body. When the slider slides to protrude in the outward direction of the main body while the first vacuum pads are suctioning the workpiece, a sensor detects an end portion of the workpiece. While the sensor detects the end portion of the workpiece and the slider is stopped, a second vacuum pad holds up the end portion of the workpiece by suctioning the workpiece at a position outside from positions at which the first vacuum pads suction the workpiece.

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Background/Summary

TECHNICAL FIELD

(1) The present disclosure relates to a vacuum gripper and a workpiece sucking and holding method.

BACKGROUND ART

(2) Patent Literature 1 describes an automatic bending system in which a workpiece is automatically bent by cooperation between a press brake and a bending robot. The bending robot holds the workpiece and transports the workpiece to the press brake. The press brake sandwiches the workpiece between a punch and a die, and bends the workpiece when the bending robot that holds the workpiece moves.

(3) Typically, the bending robot transports the workpiece by sucking the workpiece with a vacuum gripper that includes a vacuum pad (see Patent Literature 1 or 2).

CITATION LIST

Patent Literature

(4) Patent Literature 1: Japanese Patent Application Laid-Open Publication No. 2013-107080
Patent Literature 2: Japanese Patent Application Laid-Open Publication No. 2002-211707

SUMMARY

(5) It is necessary for the vacuum gripper to hold and transport only one uppermost workpiece among a plurality of workpieces stacked and arranged at a mounting place. Conventionally, a magnet floater is provided at the mounting place in such a manner as to face the end faces of the plurality of stacked workpieces. Since the magnet floater separates the vertically adjacent workpieces by forming a gap therebetween, the vacuum gripper can hold and transport only the one uppermost workpiece.

(6) When the magnet floater is used, however, there is a problem that the workpiece may be magnetized. Further, although the magnet floater can separate magnetic workpieces, the magnet floater cannot separate non-magnetic workpieces such as an aluminum plate or an austenitic stainless steel. In addition, in order to separate the workpieces by using the magnet floater, it is necessary to stack the plurality of workpieces at the mounting place with the end faces thereof aligned to face the reference plane.

(7) In recent years, a bending robot has appeared in which workpieces arranged at a mounting place are photographed with a camera to detect the position at which the workpieces are arranged so that a vacuum gripper holds and transports one uppermost workpiece. In this case, since it is not necessary to arrange a plurality of workpieces at the mounting place in alignment, the plurality of workpieces may be randomly arranged. Accordingly, this makes it impossible to use the magnet floater to separate the workpieces.

(8) An object of one or more embodiments is to provide a vacuum gripper and a workpiece sucking and holding method capable of sucking and holding one uppermost workpiece among a plurality of stacked workpieces.

(9) According to a first aspect of the one or more embodiments, there is provided a vacuum gripper including a main body, a plurality of first vacuum pads attached directly or indirectly to the main body and configured to suction a workpiece, a slider configured to slide in an outward direction of the main body, a sensor attached to the slider and configured to detect an end portion of the workpiece when the slider slides to protrude in the outward direction of the main body while the first vacuum pads are suctioning, the workpiece, and a second vacuum pad attached to the slider and configured to hold up the end portion of the workpiece by suctioning the workpiece at a position outside from positions at which the first vacuum pads suction the workpiece while the sensor detects the end portion of the workpiece and the slider is stopped.

(10) According to a second aspect of the one or more embodiments, there is provided a workpiece sucking and holding method including suctioning, by a plurality of first vacuum pads attached directly or indirectly to a main body, an uppermost workpiece among a plurality of stacked

workpieces, sliding a slider configured to slide in an outward direction of the main body so as to protrude in the outward direction of the main body, stopping the slider when a sensor attached to the slider and configured to detect an end portion of the workpiece detects an end portion of the uppermost workpiece, holding up, by a second vacuum pad attached to the slider, the end portion of the workpiece by suctioning the uppermost workpiece at a position outside from positions at which the first vacuum pads suction the workpiece, and stopping suction of the workpiece by the second vacuum pad and suctioning and holding the uppermost workpiece with the first vacuum pads.
(11) According to the vacuum gripper and the workpiece sucking and holding method of the one or more embodiments, it is possible to suck and hold one uppermost workpiece among the plurality of stacked workpieces.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) FIG. **1** is a perspective view showing a schematic configuration example of an automatic bending system provided with a press brake and a bending robot.
(2) FIG. **2** is a top view showing a vacuum gripper of one or more embodiments.
(3) FIG. **3** is a side view showing the vacuum gripper of the one or more embodiments.
(4) FIG. **4** is a partially enlarged side view showing the vacuum gripper of the one or more embodiments.
(5) FIG. **5** is a partially enlarged side view showing a state in which the vacuum gripper of the one or more embodiments is suctioning the uppermost workpiece.
(6) FIG. **6** is a partially enlarged side view showing a state in which an electric slider is slid while the vacuum gripper of the one or more embodiments is suctioning the uppermost workpiece.
(7) FIG. **7** is a partially enlarged side view showing a state in which a vacuum pad for holding up the uppermost workpiece is suctioning an end portion of the uppermost workpiece while the vacuum gripper of the one or more embodiments stops the sliding of the electric slider.
(8) FIG. **8** is a partially enlarged side view showing a state in which the vacuum pad for holding up the uppermost workpiece holds up the end portion of the uppermost workpiece, following the state shown in FIG. **7**.
DESCRIPTION OF EMBODIMENTS
(9) Hereinafter, the vacuum gripper and the workpiece sucking and holding method according to the one or more embodiments will be described with reference to the attached drawings.
(10) First, a schematic configuration example of an automatic bending system provided with a press brake and a bending robot will be described by using FIG. **1**. As shown in FIG. **1**, the automatic bending system is provided with a press brake **10** and a bending robot **20**. The press brake **10** includes an upper table **11** that can vertically move and a lower table **12** that is fixed. A punch Tp, which is an upper tool, is mounted on the upper table **11**, and a die. Td, which is a lower tool, is mounted on the lower table **12**.
(11) The bending robot **20** is arranged on a guide rail **200**, and is configured to be movable in the left-right direction of the press brake **10** along the guide rail **200**. A vacuum gripper **30** for sucking and holding a workpiece W is attached to the distal end of an arm **21**. The vacuum gripper **30** is configured to be able to be installed at and removed from the distal end of the arm **21**.
(12) As an example of a mounting place, a pallet **40** is arranged in front of the bending robot **20**. A plurality of the workpiece W are stacked and arranged on the pallet **40**. The workpiece W is a sheet metal such as a stainless steel, a mild steel, or an aluminum plate.
(13) As will be described later, the vacuum gripper **30** sucks and holds one uppermost workpiece W and transports the uppermost workpiece W between the punch Tp and the die Td. The press brake **10** lowers the upper table **11** to sandwich the workpiece W between the punch Tp and the die Td,

and bends the workpiece W when the bending robot **20** moves the articulated arm **21**. An unillustrated camera may detect the position of the workpiece W on the pallet **40** so that the bending robot **20** positions the vacuum gripper **30** above the workpiece W.

(14) A control device **50** controls movements of the bending robot **20** and the vacuum gripper **30**. The control device **50** may be a control device (an NC device) for controlling the press brake **10**. When the control device for controlling the press brake **10** is provided separately from the control device **50**, the control device **50** controls the movements of the bending robot **20** and the vacuum gripper **30** in collaboration with the control device for controlling the press brake **10**.

(15) Next, the specific configuration of the vacuum gripper **30** will be described with reference to FIGS. **2** to **4**, and how the vacuum gripper **30** sucks the one uppermost workpiece W among the plurality of workpieces W will be described by using FIGS. **5** to **8**.

(16) FIGS. **2** to **4** each shows a state in which the vacuum gripper **30** is removed from the distal end of the arm **21** of the bending robot **20**. As shown in FIG. **2** or **3**, the vacuum gripper **30** is provided with a support column **31** in a quadrangular prism shape. Support columns **32** and **33** each in a quadrangular prism shape, which are orthogonal to the longitudinal direction of the support column **31**, are attached to the both end portions of the support column **31** in the longitudinal direction. The support columns **31**, **32**, and **33** form the main body of the vacuum gripper **30**. The planar shape of the main body is not limited to the shape shown in FIG. **2**, and may be a rectangular shape.

(17) Brackets are attached to the both end portions of the support column **32** in the longitudinal direction. A vacuum pad **35***a* is attached to one bracket, and a vacuum pad **35***b* is attached to a bracket **34***b* shown in FIG. **3**, which is the other bracket. Brackets **34***c* and **34***d*, and **34***e* and **34***f*, which respectively face each other with the support column **31** interposed therebetween, are attached to the support column **31**. Vacuum pads **35***c*, **35***d*, **35***e*, and **35***f* are attached to the brackets **34***c*, **34***d*, **34***e*, and **34***f*, respectively.

(18) Brackets are attached to the both end portions of the support column **33** in the longitudinal direction. A vacuum pad **35***g* is attached to one bracket, and a vacuum pad **35***h* is attached to a bracket **34***h* shown in FIG. **3**, which is the other bracket. A connector **36** for connecting to the distal end of the arm **21** is arranged at the center of the support column **31**.

(19) Although not illustrated, a tube for suctioning the workpiece W is piped to the vacuum pads **35***a* to **35***h*, respectively. The vacuum pads **35***a* to **35***h* are defined as first vacuum pads. It should be noted that the first vacuum pads only need to be directly or indirectly attached to the main body, and are not limited to a configuration in which the vacuum pads are attached via the brackets. The number of the first vacuum pads is not limited to eight, and may be any plurality.

(20) As shown in FIG. **3**, an electric slider **301** that slides in the longitudinal direction of the support column **31** is attached below the support column **31**. A slider that slides with air may be used instead of the electric slider **301**, and the slider is not limited to the electric slider. FIG. **4** shows a state in which the brackets **34***d* and **34***f* as well as the vacuum pads **35***d* and **35***f* are omitted so that the configuration attached to the electric slider **301** can be easily visually recognized.

(21) As shown in FIG. **3** or **4**, the electric slider **301** is provided with a pressing unit **302** that protrudes downward, a vacuum pad **303** for holding up the uppermost workpiece W, an air cylinder **304** for moving the vacuum pad **303** up and down, a proximity sensor **305**, and an air nozzle **306**. The vacuum pad **303** is defined as a second vacuum pad. Instead of using the air cylinder **304**, the vacuum pad **303** may be electrically moved up and down.

(22) Though it is not mandatory to provide the air nozzle **306**, it is preferable to provide the air nozzle **306**. The vacuum pad **303** has a smaller diameter than those of the vacuum pads **35***a* to **35***h*, but may have the same diameter as those of the vacuum pads **35***a* to **35***h*. Although not illustrated, a tube for suctioning the workpiece W is piped to the vacuum pad **303**.

(23) The vacuum gripper **30** configured as described above sucks and holds the one uppermost workpiece W among the plurality of workpieces W in a manner described below. The control device **50** moves the bending robot **20** so that the vacuum gripper **30** is positioned above the

workpiece W. The bending robot **20** may move along the guide rail **200**, or only the arm **21** may move. As shown in FIG. **5**, the control device **50** moves the arm **21** so as to lower the vacuum gripper **30**, brings the vacuum pads **35***a* to **35***h* into contact with the uppermost workpiece W to suction the uppermost workpiece W.

(24) Depending on the size or the shape of the workpiece W, only a part of the vacuum pads **35***a* to **35***h* may suction the workpiece W.

(25) By way of example, the proximity sensor **305** detects whether or not the proximity sensor **305** faces the workpiece W on the basis of a capacitance value. In the state of FIG. **5**, since the proximity sensor **305** is in close proximity to the workpiece W, the proximity sensor **305** is turned on at the timing at which the vacuum pads **35***a* to **35***h* start suctioning the uppermost workpiece W, or before or after that timing. It should be noted that the vacuum pad **303** is located above and is not in contact with the uppermost workpiece W. The distal end of the pressing unit **302** is in contact with or in close proximity to the uppermost workpiece W.

(26) As shown in FIG. **6**, the control device **50** slides the electric slider **301** so that the electric slider **301** protrudes in the outward direction of the vacuum gripper **30**. The control device **50** may slide the electric slider **301** after a predetermined time has passed since the vacuum pads **35***a* to **35***h* started suctioning the uppermost workpiece W.

(27) When the electric slider **301** slides in the outward direction, the state of the proximity sensor **305** is changed to a state in which the proximity sensor **305** is displaced from an end portion of the workpiece W and no longer faces the workpiece W, as shown in FIG. **6**. As a result, the proximity sensor **305** is turned off. In this manner, the end portion of the workpiece W can be detected by the timing at which the state of the proximity sensor **305** changes from an on state to an off state. The control device **50** stops the sliding of the electric slider **301** at the timing when the proximity sensor **305** is turned off.

(28) As shown in FIG. **7**, after stopping the sliding of the electric slider **301**, the control device **50** causes the air cylinder **304** to lower the vacuum pad **303** and bring the vacuum pad **303** into contact with the uppermost workpiece W, and causes the vacuum pad **303** to suction the workpiece W. At the same time, the control device **50** ejects air from the air nozzle **306** to blow the air at the end portion of the workpiece W.

(29) After causing the vacuum pad **303** to suction the uppermost workpiece W, the control device **50** causes the air cylinder **304** to raise the vacuum pad **303**. Then, as shown in FIG. **8**, the end portion of the uppermost workpiece W is held up at a position outside from positions at which the vacuum pads **35***a* to **35***h* suction the workpiece W. Since the pressing unit **302** is in contact with or in close proximity to the uppermost workpiece W, an end portion, which is outside from the pressing unit **302**, of the uppermost workpiece is held up.

(30) After that, the control device **50** causes the vacuum pad **303** to stop suctioning and causes the air nozzle **306** to stop ejecting the air. When the end portion of the workpiece W is held up by the vacuum pad **303**, blowing air at the end portion of the workpiece W is not mandatory. Subsequently, the control device **50** moves the arm **21** to hold up the uppermost workpiece W, which is sucked to the vacuum pads **35***a* to **35***h*, and to transport the uppermost workpiece W to the press brake **10**.

(31) As described above, according to the vacuum gripper and the workpiece sucking and holding method of the one or more embodiments, it is not necessary to use the magnet floater, and the one uppermost workpiece W among the plurality of stacked workpieces W can be sucked and held by the configuration provided in the vacuum gripper.

(32) According to the vacuum gripper and the workpiece sucking and holding method of the one or more embodiments, the problem that the workpiece W is magnetized does not occur. According to the vacuum gripper and the workpiece sucking and holding method of the one or more embodiments, even when the workpiece W is non-magnetic, the one uppermost workpiece W can be sucked and held. According to the vacuum gripper and the workpiece sucking and holding

method of the one or more embodiments, it is not necessary to stack the plurality of workpieces W at the mounting place with the end faces thereof aligned to face the reference plane.
(33) The present invention is not limited to the one or more embodiments described above, and various modifications can be made without departing from the gist of the present invention. In the one or more embodiments, the proximity sensor **305** is used as a sensor for detecting the end portion of the workpiece W. Instead of the proximity sensor **305**, however, any sensor may be used such as a sensor using a sound wave, a sensor using a laser length measuring device, and a photoelectric sensor.
(34) It is preferable that the timing at which the vacuum pad **303** is raised by the air cylinder **304** to hold up the end portion of the uppermost workpiece W coincides with the timing at which the air is ejected from the air nozzle **306**. However, the ejection of the air may be started before the end portion of the workpiece W is held up, or the ejection of the air may be started after the end portion of the workpiece W is held up. It is only necessary to blow air to the end portion of the workpiece W while the end portion of the workpiece W is being held up.
(35) In the one or more embodiments, the vacuum gripper **30** mounted on the bending robot **20** is taken as an example, but the configuration of the one or more embodiments can also be adopted to a vacuum gripper mounted on a transfer robot other than the bending robot **20**.
(36) The present application claims priority based on Japanese Patent Application No. 2019-115153 filed with the Japan Patent Office on Jun. 21, 2019, and all disclosures thereof are incorporated herein by reference.

Claims

1. A vacuum gripper, comprising: a main body; a plurality of first vacuum pads attached directly or indirectly to the main body and configured to suction an uppermost workpiece among a plurality of stacked workpieces in a state in which the first vacuum pads make contact with positions on a surface of the uppermost workpiece; a slider configured to slide in an outward direction of the main body; a sensor attached to the slider and configured to detect an end portion of the uppermost workpiece when the slider slides to protrude in the outward direction of the main body while the first vacuum pads are suctioning the uppermost workpiece; and a second vacuum pad attached to the slider and configured to hold up the end portion of the uppermost workpiece by suctioning the uppermost workpiece in a state in which the second vacuum pad makes contact with a position outside the positions at which the first vacuum pads make contact on the surface of the uppermost workpiece while the sensor detects the end portion of the uppermost workpiece and the slider is stopped.
2. The vacuum gripper according to claim 1, further comprising an air nozzle configured to blow air to the end portion of the uppermost workpiece while the second vacuum pad is holding up the end portion of the uppermost workpiece.
3. A workpiece sucking and holding method, comprising: suctioning, by a plurality of first vacuum pads attached directly or indirectly to a main body, an uppermost workpiece among a plurality of stacked workpieces in a state in which the first vacuum pads make contact with positions on a surface of the uppermost workpiece; sliding a slider configured to slide in an outward direction of the main body so as to protrude in the outward direction of the main body; stopping the slider when a sensor attached to the slider and configured to detect an end portion of the uppermost workpiece detects an end portion of the uppermost workpiece; holding up, by a second vacuum pad attached to the slider, the end portion of the uppermost workpiece by suctioning the uppermost workpiece in a state in which the second vacuum pad makes contact with a position outside the positions at which the first vacuum pads make contact on the surface of the uppermost workpiece; and stopping suction of the workpiece by the second vacuum pad and suctioning and holding the uppermost workpiece with the first vacuum pads.

4. The workpiece sucking and holding method according to claim 3, further comprising blowing, by an air nozzle, air to the end portion of the uppermost workpiece while the second vacuum pad is holding up the end portion of the uppermost workpiece.