

TITLE OF THE INVENTION

PICK-AND-PLACE DEVICE HAVING FORCE MEASUREMENT CAPABILITY

TECHNICAL FIELD

The present invention relates to a pick-and-place device. More specifically the present invention relates to a pick-and-place device which has the capability to provide the pick-and-place process with force measurement in a single unit.

BACKGROUND OF THE INVENTION

Pick-and-place devices are of importance in automated product handling lines. This is because when combined with sensors such as weighing cells, photocells, cameras and the like, articles on a conveyor belt can for example be identified according to size, colour, shape etc. and picked-up and placed for example on an another conveyor, or into preformed packaging. Also, in the electronic manufacturing process, electronics components are being transferred from one station to another station for further processing. The pick-and-place operation generally requires vacuum to pick-up a work-piece and unloads it by either purging air or releasing vacuum pressure.

Generally, such pick-and-place apparatus produce rapid transfer operations, during pick-and-place operation, the force exerted on the components are unknown and damage to the components could happen if calibration is not done properly. It is the objective of the present invention to provide a force measuring capability by a feedback control system to set the force within desired range in order to prevent damage on the components or to apply a regulated force during pick-up and placement operation.

During the pick-and-place transfer operation, some applications desire to detect the presence of the work-piece rather than measuring the contact force. The present invention could also make use of the force measuring capability to detect the presence of the work-piece.

US Patent Publication No. 20150147141 discloses a pick-and-place head for transporting a plurality of work-pieces from at least one first location to at least one second location, the pick-and-place head comprising: a plurality of nozzles with each nozzle configured to engage one of the plurality of work-pieces; at least one independent vacuum supply configured to attach to one nozzle of the plurality of nozzles; and, at least

one shared vacuum supply configured to attach to at least two nozzles of the plurality of nozzles not attached to the at least one independent vacuum supply. The pick-and-place head further comprising a vacuum sensors configured to indicate whether or not a sufficient force is being applied to the plurality of work-pieces. The pick-and-place head
 5 does not provide a force measuring capability that can be used by a feedback control system.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a pick-and-place device for picking a work-piece from a first location to a second location and having force
 10 measurement capability, the pick-and-place device comprising:

(a) a positive pressure chamber forming from a pick-and-place holder (10), a force measuring membrane (20) and a cover (60), wherein a positive pressure is supplied to the positive pressure chamber (65) via a pressure supply inlet (80) provided on the pick and place holder (10), and thus the force measuring membrane (20) is being preloaded;

15 (b) a vacuum chamber forming from the pick-and-place holder (10), the force measuring membrane (20) and a pick-up membrane (40), wherein a negative pressure is provided via a vacuum supply inlet (70) provided on the pick-and-place holder (10), wherein the pick-and-place device provides a pressure difference between the work-piece and the pick-and-place device, enabling a pick-and-place capability.

20 Another object of the present invention is to provide a method for picking and placing a work-piece from a first location to a second location using a pick-and-place device having a force measurement capability, the method comprising the steps of:

a) positioning the pick-and-place device above a work-piece at a first location;

b) approaching the work-piece with the pick-and place device and observing feedback
 25 signal of the strain gauge;

c) detecting a desired feedback signal to turn-on a vacuum to pick up the work-piece;

d) positioning the pick-and-place device above a second location;

e) approaching a placing location and observing a feedback signal of the strain gauge;

- f) detecting a desired feedback signal to turn-off the vacuum supply to place the work-piece thereto; and
- g) returning back the pick-and-place device to the first location for the next cycle.

5 Yet still another object of the present invention is to provide a method of simulating a pressure contact onto a work-piece using a pick-and-place device, comprising the steps of:

- a) positioning the pick-and-place device above the work-piece;
- b) approaching the work-piece while observing a feedback signal indicated by the strain meter;
- 10 c) detecting a desired feedback signal from the strain meter, stop approaching the work-piece further;
- d) waiting for a specified time set by the user and move away from the work-piece, re-start the steps from step b);

15 A further object of pick-up membrane (40) of the present invention is to provide a pick-and-place capability and protect work-piece from impact force. Wherein the pick-up membrane (40) is a low stiffness membrane is used to reduce impact force during a rapid pick-and-place process.

20 When pick-up membrane (40) is in contact with the work-piece, a reactive force will be created arising from the reaction on the pick-up membrane (40). The force will be transmitted through force transmission spacer (42) to the force measuring membrane (20). The amount of force will be proportional to the strain of the force measuring membrane (20). The strain could be observed by the strain gauge (72). After calibration, the value of strain will be known to be corresponding to a certain amount of force.

25 When the pick-and-place device (100) is attached on a stage (10) and strain gauge signal being connected to a general industrial-use strain meter, a controller can control the force within a specific range with feedback from the strain gauge signal being produced by a strain meter. When the controller realises that more force is needed to be applied to the work-piece, the controller will command the stage (10) to move closer to the work-piece.

The force measuring membrane (20) thus deforms more to provide more force and this phenomenon creates more strain on force measuring membrane. This strain could be realized by the strain gauge and strain meter.

5 These and other objects, advantages and features of the present invention will be better appreciated by those having ordinary skill in the art in view of the following detailed description of the invention in view of the drawings.

The capability of force measuring and feedback control system could also be used with others mechanisms to mimic the human finger contact force for instances.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The nature and mode of operation of the present invention will now be more fully described in the following detailed description of the invention taken with the accompanying drawing figures, in which:

FIG. 1A is a perspective view of a pick-and-place device with force measurement in accordance with the present invention;

15 FIG. 1B is a sectional view of the pick-and-place device with force measurement in accordance with the present invention;

FIG. 2 is an exploded perspective view showing a pick-and-place device with force measurement in accordance with the present invention; and

20 FIG.3 is a schematic perspective view of the pick-and-place device with force measurement capability being mounted to a pick-and-place assembly for transfer a work-piece from a first location to a second location.

FIG. 4 is a flowchart indication signal control of the pick-and-place device in accordance with the present invention.

DETAILED DESCRIPTION

25 At the outset, it should be appreciated that like drawing numbers on different drawing views identify identical, or functionally similar, structural elements of the invention. While the present invention is described with respect to what is presently considered to be the preferred aspects, it is to be understood that the invention as claimed is not limited to the disclosed aspect. Also, it is to be understood that the invention is not limited in its

application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is applicable to other embodiments or of being practiced or carried out in various ways and is intended to include various modifications and equivalent arrangements within the spirit and scope of the appended claims.

Furthermore, it is understood that this invention is not limited to the particular methodology, materials and modifications described and as such may, of course, vary. It is also understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to limit the scope of the present invention, which is limited only by the appended claims.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this invention belongs. Although any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the invention, the preferred methods, devices, and materials are now described.

As shown in the FIG. 1, there is shown a perspective view of a pick-and-place device (100) having a force measurement capability in accordance with the present invention. The pick-and-place device (100) of the present invention comprises a pick-and-place holder (10), a cover (60) mounted on the top of the pick and place holder (10), a force measuring membrane (20) positioned beneath the cover (60), forming into a positive pressure chamber (65) (as shown in FIG. 1B), and a pick-up membrane (40) located beneath the force measuring membrane (20). At one end of the pick-and-place holder (10), there is provided a pressure supply inlet (80) and a vacuum inlet (70), and a positive pressure is supplied to the positive pressure chamber (65) through a general pressure pump (not shown).

The positive pressure that is generated by the pressure pump in the positive pressure chamber (65) preloads the force measuring membrane (20) and therefore, an elastic deflection range of the force measuring membrane(20) is increased.

FIG. 1B is a section view of the pick-and-place device (100) as shown in FIG. 1A. A force transmission spacer (42) is positioned between the pick-up membrane (40) and the force measuring membrane (20) for the transmission of vacuum from the vacuum

chamber (25) to the pick-up membrane (40). On the pick-and-place holder (10), there is shown the sectional view of the pressure supply inlet (80) and the vacuum inlet (70).

In the preferred embodiment, the pick-and-place holder (10), the force measuring membrane (20) and the pick-up membrane (40) form into a vacuum chamber (25) as shown in FIG. 1B. The vacuum inlet (70) is connected to a vacuum supply pump (not shown) which supplies a vacuum to the vacuum chamber (25). The vacuum chamber (25) of the pick-and-place device (100) provides a pressure difference between a workpiece and the pick-and-place device (100) via a plurality of holes (41) (as shown in FIG. 2) on formed the pick-up membrane (40). The vacuum of the vacuum chamber (25) is used to lift up a work-piece (90) (as shown in FIG. 3) for placement onto another location in accordance with the present invention.

FIG. 2 is an exploded perspective view of the pick-and-place device in accordance with the present invention. As shown, the pick-and-place device (100) comprises a pick-and-place holder (10) which in this preferred embodiment is a ring like structure, a pick-up membrane (40) as the base of the device (100), a force measuring membrane (20) above the pick-up membrane (40), and a cover (60) positioned above the force measuring membrane (20). A pressure inlet (80) and a vacuum inlet (70) are provided on the pick-and-place holder (10) to provide a positive pressure to the pressure chamber (65) and the vacuum chamber (25). A force transmission spacer (42) is positioned in between the pick-up membrane (40) and the force measuring membrane (20) for the transmission of vacuum from the vacuum chamber (25) to the pick-up membrane (40). A strain gauge (72) is positioned on the surface of the force measuring membrane (20), which is used to give a signal or reading with respect to a force that has been applied. In the preferred embodiment, a wire is connecting the strain gauge (72) to a strain meter (not shown) and the strain meter converts the mechanical strain into electrical signal for controller so that a specific force is then provided to the pick-and-place device (100).

A plurality of holes on the pick-up membrane (40) allows the picking up of a workpiece (90) by the pick-up membrane (40) by having a vacuum suction from the vacuum chamber (25).

FIG. 3 is a perspective view showing the pick-and-place device (100) mounted onto a pick-and-place assembly to provide a picking and placing of a work-piece from one location to another location.

In the course of picking up a work-piece (90) and placing the work-piece, the work-piece touches an environment, for instance, a lead frame base. The reaction force due to the contact between the pick-up membrane (40) and the workpiece (90) is transmitted via the force transmission spacer (42). The reaction force between the pick-up membrane (40) and the work-piece (90) is proportion to the strain of the force measuring membrane (20). The strain in the force measuring membrane (20) is due to the reaction force formed in between the pick-up membrane (40) and the workpiece (90) will be measured by the strain gauge (72). The strain value of the strain gauge (72) will then be read by a strain meter (not shown) and then convert the strain value into a corresponding force value after calibration.

The pick-and-place device (100) is moveable in relation to a work-piece (90) to be transferred from one location to another location, and the pick-up membrane (40) which has a low stiffness, is used to reduce impact force during a rapid pick-and-place process by the pick-and-place device (100). The strain gauge (72) is mounted, in the present preferred embodiment, to the force measuring membrane (20) in the pick-and-place device (100).

In accordance with the preferred embodiment of the present invention, the pick-and-place device (100) uses a low stiffness pick-up membrane (40) to reduce the impact force during a rapid pick-and-place process. The pick-and-place device (100) integrated with force measurement capability into one unit, and therefore the overall mass of the device is reduced. The reduction of overall weight of the device enables a faster pick-and-place operation carried out by the pick-and-place assembly (200), as shown in FIG. 3.

In the preferred embodiment, a strain gauge (72) is used in the pick-and-place device (100) as a force measuring device which further reduces the overall weight of the device. The positive pressure of the device (100) provides a larger working range to the force measuring membrane (20) and changes the shape of the pick-up membrane (40) to provide a better contact between the workpiece (40) and the pick-and-place device (100).

FIG. 4 is a flowchart indication signal control of the pick-and-place device in accordance with the present invention. At the initial stage, a setpoint is first set, which is a desired force that the pick-and-place device (100) is to be exerted. A controller (300) controls the force exerted by the pick-and-place device (100) to proceed with the pick-and-place process (400). A strain meter or strain gauge (500) is used to indicate the force that is exerted by the device (100). The force that exerted by the pick-and-place device (100) can be readjusted at the setpoint if it is required.

The present invention also relates to a method for picking and placing a work-piece from a first location to a second location using a pick-and-place device and having force measurement capability, the method comprising the steps of:

- a) positioning the pick-and-place device (100) above a work-piece (90) at the first location;
- b) approaching the work-piece with the pick-and-place device and observing feedback signal of the strain gauge;
- c) detecting a desired feedback signal to turn-on a vacuum to pick up the work-piece;
- d) positioning the pick-and-place device above a second location;
- e) approaching a placing location and observing a feedback signal of the strain gauge ;
- f) detecting a desired feedback signal to turn-off the vacuum supply to place the work-piece thereto; and
- g) returning back the pick-and-place device to the first location for the next cycle.

The present invention also relates to a method of simulating a pressure contact onto a work-piece (90) using a pick-and-place device (100) to pick and transfer the work-piece (90) from one location to another location, comprising the steps of:

- a) positioning the pick-and-place device above the work-piece at the first location;
- b) approaching the work-piece to pick up the work-piece while observing a feedback signal indicated by the strain gauge coupled to a controller;
- c) detecting a desired feedback signal from the strain gauge, stop further approaching to the work-piece;

d) waiting for a specified time set by user to re start the approaching step in step b) that is set by the user;

e) controlling the pick-and-place device to move away from the work-piece; and

f) moving the pick-and-place device to a second location of the work-piece to start another pick and place next cycle.

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In the method of simulating a pressure contact onto a work-piece (90), the pick-and-place device (100) is being controlled to exert an appropriate force by a controller (not shown). Similarly, in the method for picking and placing a work-piece (90) from a first location to a second location using a pick-and-place device (100), the device (100) is being controlled to exert an appropriate force by a controller.

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Though modifications and changes to the invention should be readily apparent to those having ordinary skill in the art, which modifications are intended to be within the spirit and scope of the invention as claimed, it is understood that the foregoing description is illustrative of the present invention and should not be considered as limiting. Therefore, other embodiments of the present invention are possible without departing from the spirit and scope of the present invention as claimed.

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CLAIMS:

1. A pick-and-place device for picking a work-piece from a first location to a second location and having force measurement capability, the pick-and-place device comprising:

- 5 (a) a positive pressure chamber (65) formed among a pick-and-place holder (10), a force measuring membrane (20) and a cover (60), wherein a positive pressure is supplied to the positive pressure chamber (60) via a pressure supply inlet (80) provided on the pick-and-place holder (10), and thus the force measuring membrane (20) is being preloaded;
- 10 (b) a vacuum chamber formed among the pick-and-place holder (10), the force measuring membrane (20) and a pick-up membrane (40), wherein a negative pressure is provided via a vacuum supply inlet (70) provided on the pick-and-place holder (10), wherein the pick-and-place device provides a pressure difference between the work-piece and the pick-and-place device, enabling a
- 15 pick-and-place capability.

2. The pick-and-place device for picking a work-piece from a first location to a second location as set forth in Claim 1, further comprising a force transmission spacer (42) which is located in between the force measuring membrane (20) and the pick-up membrane (40).

- 20 3. The pick-and-place device as set forth in Claim 2, wherein the force transmission spacer (42) is used to transmit the force that is received from the pick-up membrane (40) to the force measuring membrane (20).

4. The pick-and-place device as set forth in Claim 1, wherein vacuum is supplied in between the force measuring membrane (20) and the pick-up membrane (40).

- 25 5. The pick-and-place device as set forth in Claim 3, wherein the force transmission spacer (42) is used to transmit the force that is received from the pick-up membrane (42) to the force measuring membrane (20).

6. The pick-and-place device as set forth in Claim 2, wherein the pick-and-place device is moveable relative to the work-piece to be transferred from a first location to a
- 30 second location.

7. The pick-and-place device as set forth in Claim 2, wherein the pick-up membrane (40) is used to reduce impact force during a rapid pick-and-place process.

8. The pick-and-place device as set forth in Claim 1, further comprising a strain gauge (72) mounted onto the top surface of the force measuring membrane (20) is used
5 to measure the strain of the force measuring membrane (20) in the course of a pick-and-place process.