

Description

Method of populating substrates with components

- 5 The invention relates to a method of populating substrates with components.

When substrates, in particular printed circuit boards, are being populated with components, the components are removed from feed units with the aid of pick-and-place heads and are positioned at a predefined position on the substrate by the pick-and-place head. For a high pick-and-place performance (populated substrates per unit time) the intention is for as many components as possible to be positioned on the substrates per unit time.

For this purpose, WO 98/37744 discloses an apparatus for producing electrical subassemblies which, in a central region, has two closely adjacent, parallel linear longitudinal guides, in which carriages can be moved appropriately. These carriages have transverse supports cantilevered outward away from each other for pick-and-place heads. In this case, the result is two separate processing stations, which can be operated independently of each other. This permits a high pick-and-place performance of the apparatus.

For a still higher pick-and-place performance, automatic pick-and-place devices are put together in a line. In this case, the different automatic pick-and-place devices have different supplies of component types, and can be designed specially for the respective component types. The different automatic pick-and-place devices in this case have a characteristic time response, which includes the time needed to pick up the components from the feed units, to transport them to the desired position on the substrate and to put the components down on the substrate. To a first

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approximation, this time response is viewed as the same for all the automatic pick-and-place devices of the same type. With the aid of this approximated time response, a

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pick-and-place program is prepared which optimizes the paths of the pick-and-place head in such a way that as many components as possible can be placed in the shortest possible time.

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However, this equipment optimization, as it is known, does not take into account the real time response of the automatic pick-and-place devices. The result is the wrong loading of the individual pick-and-place stations in the line. In addition, it is possible for interruptions which cannot be foreseen to occur in the pick-and-place line, such as a component which is not restocked in good time or a conveyor which has failed because of a defect, a failed pick-and-place head or an entire station. In these cases, the entire line comes to a standstill, although only one station is faulty. It is the object of the invention to increase the pick-and-place performance during the use of a plurality of pick-and-place stations.

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According to the invention, the object is achieved by a method having the features of claim 1.

By means of the method according to the invention, the pick-and-place program is monitored during operation and, if bottlenecks occur, an improved pick-and-place program is used. The continuous tuning of the pick-and-place program to the real time response of the pick-and-place heads both takes into account the real time response of the machine and, in the event of the occurrence of unforeseen faults, permits emergency operation of the line.

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In the embodiment of the method as claimed in claim 2, the pick-and-place program determined is checked again, in that the time actually needed for the pick-and-place process is measured. As a result, a check is made to see whether the initially only theoretically determined improvement in performance is also actually achieved.

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In the event of a large deviation of the theoretical from the real response of the pick-and-place heads, it is therefore possible to avoid the situation where the objective of shortening the time means that the latter
5 actually becomes longer and longer.

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In an advantageous way according to the method as claimed in claim 3, the real time response of the pick-and-place stations is compared with the theoretically predefined model. If the real time response deviates from the theoretical time response, then an improved program is determined, taking into account the real time response, and is used for the next pick-and-place processes.

10 The method may be employed both, according to claim 4, for automatic pick-and-place devices in which at least two pick-and-place stations are provided and also, as claimed in claim 5, in lines in which a plurality of automatic pick-and-place devices are erected one after another.

In order to check which components have been placed by which machine, provision is advantageously made, according to claim 6, for an item of information relating to the components placed at the respective pick-and-place stations to be stored on the substrate.

20 Displaying an item of information to an operator, according to claim 8, advantageously ensures that improvements in performance which arise from re-equipping feed units are also implemented.

The invention will be explained in more detail using the exemplary embodiments illustrated in the figures of the drawing, in which:

Figure 1 shows a schematic plan view of a line comprising three automatic pick-and-place devices each having two pick-and-place stations,

35 Figure 2 shows the control loops for the arrangement according to Figure 1 and

Figure 3 shows a structural diagram for the flow of the method.

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Figure 1 illustrates, in schematic form, a plan view of
a line comprising three automatic pick-and-place
devices 1, 7, 8, the individual automatic pick-and-
place devices 1, 7, 8 each having two pick-and-place
5 stations 6, 17. The way in which the automatic pick-
and-place devices 1, 7, 8 function

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will in this case be illustrated by way of example using the first automatic pick-and-place device 1 on the extreme left. The way in which the further automatic pick-and-place devices function corresponds to this. With the aid of the first automatic pick-and-place device 1, a substrate 2, in particular a printed circuit board, is populated with components 3. For this purpose, a pick-and-place head 6 removes the components 3 from a feed unit 5, moves the components 3 into the placement position above the substrate 2 and puts down the components 3 in the predefined position on the substrate 2. The pick-and-place head 4 illustrated in Figure 1 by way of example is a turret head, as it is known, which has along its periphery a number of suction pipettes 15 which hold the components 3 on the pick-and-place head 4 by means of a vacuum.

In order to move the pick-and-place head 4 parallel to the surface of the substrate 2, in this case provision is made for a first rail 11, on which a first slide 12 moves, and a second rail 13 which is fixed to the first slide 12 and on which a second slide 14 moves. Connected to the second slide 14 is the pick-and-place head 4, which can therefore reach any position on the substrate 2 and the positions of the feed units 5. This region, which can be reached by the pick-and-place head 4, is referred to below as the first pick-and-place station 6.

The movement of the pick-and-place head 4 is controlled by a first control unit 16. Also provided on the first automatic pick-and-place device 1 is a second pick-and-place station 17 with exactly the same construction, in order that two substrates 2 can be processed in parallel. In this case, it is possible both for two substrates 2 to be populated identically, in order subsequently to be transported onward, but provision is also made for the substrates 2 to pass through both pick-and-place stations 6, 17 and, in the process, to

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be populated with components 3 which are generally different. After the first automatic pick-and-place device 1 has been used to place a certain range of components, for example in a first populated substrate
5 region 20, the substrate 2 is transported onward to the right by a transport device 10 to the second automatic

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pick-and-place device 7. Provided there is a further pick-and-place station, in which, for example, a second substrate region 21 is then populated. The second automatic pick-and-place device 7 is controlled by a
5 second control unit 22. In addition, a third automatic pick-and-place device 8 having a third control unit 23 is illustrated, functioning in a corresponding way. The first control unit 16, the second control unit 22 and the third control unit 23 are connected to a line
10 control unit 24. Of course, further automatic pick-and-place devices can be provided in the line. In addition, automatic pick-and-place devices can also be provided which, for example, comprise, instead of the turret head, other pick-and-place heads which, for example,
15 have only one suction pipette 15. In this case, Figure 1 illustrates automatic pick-and-place devices 1, 7, 8 which can operate simultaneously on two adjacently arranged transport devices 10, as a result of which as many substrates 2 as possible can be processed
20 simultaneously with the minimum space requirement.

In addition, the populating region 6 of the pick-and-place head 4 is extended as far as the substrate 2', which is located on the second transport device. As a
25 result, the pick-and-place head 4 is able to populate the substrate 2' located there with components from the feed device 5' while the further pick-and-place head 4' is picking up components from the further feed devices 5'. In this case, the method according to the
30 invention for determining the pick-and-place stations can be applied to the two pick-and-place stations of the pick-and-place head 4 and the further pick-and-place head 4'.

35 Figure 2 shows the control loops of the arrangement according to Figure 1. In this case, the first control unit 16, the second control unit 22 and the third control unit 23 each have a controller 30, 33, 36, a controlled section 31, 34, 37 and an observer 32, 35, 38.

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If, then, for example, the observer 32 of the first control unit determines that the two pick-and-place stations 6, 17 are loaded to different extents,

then the controller 30 of the first control unit will ensure that an appropriate signal is output to the controlled section 31. This signal comprises a changed pick-and-place program, which assigns the components to
5 be fitted and the pick-and-place stations to one another. For the entire line performance, an observer belonging to the line control unit 40 is provided, which forwards its information to a controller 39
10 belonging to the line control unit. The effect of this controller 39 is that an improved pick-and-place program is used, in that the information from the observer 40 belonging to the line control unit has been taken into account.

15 The method according to the invention will now be explained using the structural diagram of Figure 3. Firstly, by using the theoretical time response of the automatic pick-and-place devices 1, 7, 8, a theoretical model is prepared. If, then, a substrate is to be
20 populated with a specific quantity of components from a specific component range, then the individual components, the component types and the individual positions at which the components are to be placed on the substrate are processed, with the aid of the
25 theoretical model, to form a pick-and-place program which uses the different pick-and-place stations 6, 17 in as optimum a manner as possible in order to populate as many substrates 2 as possible in the shortest possible time. In this case, it is also predefined
30 which components 2 have to be kept in stock in the feed units 5 respectively assigned to the automatic pick-and-place devices 1, 7, 8.

While this program is being used, the pick-and-place
35 performance which is actually achieved is measured. In general, the real time response of the automatic pick-and-place devices 1, 7, 8 will deviate from the theoretical time response. The deviations are determined with the aid of the observers 32, 35, 38, 40

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and an adapted theoretical model of the line is produced. This adapted theoretical model will then generally also lead to an adapted pick-and-place program, in which the actual time response of the
5 individual automatic pick-and-place devices 1,

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be taken over by a different automatic pick-and-place device.

Claims

1. A method for equipping substrates with components, the method comprising the steps of:

providing at least two equipping locations, each including a plurality of components held in a delivery unit and an equipping head for taking the plurality of components from the delivery unit for placement onto a substrate;

creating a theoretical model for operating of the equipping heads;

determining an equipping program on the basis of the theoretical model;

controlling each of the equipping heads with the equipping program, whereby the program allocates equipping locations and components to be placed on a substrate at the respective equipping locations;

identifying an equipping time during an equipping process controlled by the equipping program;

measuring an actual equipping time of the equipping heads;

adapting the theoretical model on the basis of the measured actual equipping time;

comparing the actual equipping time to a time stored in the equipping program and calculating a time difference time between the stored time and the actual equipping time;

comparing the calculated time difference to a time span stored in the equipping program;

deriving an updated equipping program that allocates between the equipping locations and components to be placed at the respective equipping locations, wherein the

updated equipping program is modified compared to the equipping program according to the time difference; and

subsequently controlling the equipping process for further substrates according to the updated equipping program.

2. The method for equipping substrates according to claim 1, further comprising the steps of:

further updating the updated equipping program according to the adapted theoretical model.

3. The method for equipping substrates according to claim 1, further comprising the steps of:

creating a theoretical model for a duration of individual work steps of the equipping heads;

determining the predetermined equipping program on the basis of the theoretical model;

identifying a read duration of the individual work steps of the equipping heads during measurement of the equipping time;

adapting the theoretical model on the basis of the identified real duration; and

further updating the updated equipping program according to the adapted theoretical model.

4. The method for equipping substrates according to claim 1, wherein at least two equipping locations are provided in one automatic equipping unit.

5. The method for equipping substrates according to claim 1, wherein the at least two equipping locations are provided in different automatic equipping units arranged in a process line.

6. The method for equipping substrates according to claim 1, wherein information about the components actually placed at the respective equipping locations is stored on the substrate.

7. The method for equipping substrates according to claim 1, wherein each delivery unit is allocated to only one equipping location.

8. The method for equipping substrates according to claim 1, further comprising the steps of:

displaying information for an operator; and

refitting components from one equipping location onto another equipping location in order to enable the control by the updated equipping program when the displayed information indicates a problem with one equipping location.