

Description

Method for controlling successive machine processes

5 The invention relates to a method for controlling successive machine processes, in which at least one first and a second control unit for the various machine processes are connected to one another and to a central control station.

10 Such successive machine processes play a part, for example, in automatically fitting components (for example SMD components, SMD = Surface Mounted Device, or Ball Grid Arrays = BGA) on substrates (for example printed circuit boards or ceramic substrates). In this
15 context, the individual components are taken from a magazine or a supply device by means of a fitting head and are then positioned on the substrate at a prescribed location.

 During this process cycle, a large number
20 (approximately 20 to 30 for each component) of successive machine processes are carried out, some of which must be carried out only when the previous machine process taking place has been finished successfully. Such process cycles also take place in
25 other automatic processing machines which are required in the fitting process, such as for applying bonding points on substrates. For the purpose of monitoring this imposed sequence of machine processes, the control units controlling and monitoring the individual machine
30 processes are connected to a central control station which monitors the entire process cycle. The individual control unit transmits the end of its associated machine process to the central control station, and the central control station then transmits a start
35 instruction to the control unit for the subsequent machine process. However, since the central control station controls a plurality of machine processes

taking place in parallel and handles additional tasks, such as communicating with an operator of the automatic component fitting machine, there are time delays between reception of the end signal from the first control unit and transmission of the start instruction to the second control unit. When there are a large number of successive machine processes, there are then considerable time losses and hence fewer components fitted. In addition, communication between the control units and the central control station requires time, which reduces the number of components fitted.

One possibility for reducing the time would be to provide different central control stations for different tasks, for example one central control station for control tasks and an additional central control station for communication between the operator and the machines and for data processing tasks. However, communication among the central control stations also takes up an undesirable amount of time.

The object of the invention is therefore to specify a method which minimizes the time required for carrying out successive machine processes.

The invention achieves the object by means of a method of the type mentioned initially, having the features of claim 1.

As a result of this implementation, the control units for successive machine processes are notified of the dependency on the state of the previous machine processes as a start condition. The control units inform each other of the fulfillment of these start conditions, without any diversion via the central control station. The central control station distributes its tasks - assuming that the cycle is undisturbed - early enough for them to be present in the respective control unit before the start conditions are fulfilled. The delay is determined only by the transmission between the individual control units, and is accordingly slight.

Concentrating various tasks (control and operation) in a central control station (and hence on a computer), which the invention makes possible without any time loss, saves cost both for the hardware and for the software. This is because only one central control station is used, for which only one standard operating system is used.

In the advantageous refinement according to claim 2, a plurality of start conditions are transmitted. This makes it possible for machine processes which, before they start, have to wait for the results of a plurality of machine processes taking place at an earlier time to be effectively taken into account as well.

In accordance with claim 3, the central control station advantageously stores a cycle plan for the machine processes, and the central control station records correct progress on the basis of acknowledgements from the control units. This makes it possible for the central control station to initiate a fault handling procedure in the event of faults arising in the process cycle.

The method has a particularly simple structure if the central control station and the control units are connected to one another by an intercommunicating bus, in accordance with claim 4. An intercommunicating bus has the property that all the peripheral units (control units) connected to it track the communication taking place on the bus and evaluate all the signals and instructions which are relevant to themselves. This means that the signals and instructions do not need to be transmitted a plurality of times, but just once.

The invention is explained in more detail below with the aid of the illustrative embodiment shown in the figures of the drawing, and with the aid of the prior art.

In the drawing

Figure 1 shows a diagram of the invention's connection of the control units and the central control station,

5 Figure 2 shows a schematic time sequence for the method according to the invention,

Figure 3a shows a schematic cycle for previous control without an operating unit,

Figure 3b shows a schematic cycle for previous control with an operating unit,

10 Figure 4 shows a schematic time sequence for previous control, and

Figure 5 shows a structogram of the method according to the invention.

Figure 3a shows the conventional cycle, and
15 Figure 4 the associated time sequence, for control of a plurality of successive machine processes. A central control station 1 is connected to a first control unit 2 and to a second control unit 3, which each handle machine processes locally. In this context, successive
20 machine processes in the component fitting process may be, by way of example, the fitting head moving toward a position, the suction pipette being lowered, the suction pipette being raised, the fitting head rotating, the component being recorded by a camera, the
25 prescribed position on the substrate being approached, the suction pipette being lowered, the vacuum being turned off and the suction pipette being raised. These examples should be understood as being merely illustrative. Any other machine processes (with which
30 the person skilled in the art is familiar) for fitting components or else for applying bonding points are likewise coupled to one another by the method according to the invention. The method according to the invention is also suitable for other automation methods familiar
35 to the person skilled in the art.

Conventionally, the process now proceeds as follows (Figure 3a, Figure 4):

The central control station 1 transmits a start instruction 5 for the first machine process 11 to the first control unit 2, the first control unit 2 handles the first machine process 11,

the first control unit 2 transmits an end message 6 to the central control station 1 when the first machine process 11 has finished. Once the end message 6 has been received, the central control station 1 transmits
5 a start instruction 7 for the second machine process 12 to the second control unit 3, the second control unit 3 handles the second machine process 12 and, when handling is finished, transmits an end message 8 to the central control station 1. This method can be continued
10 as desired until the entire process cycle has been completed. The communication via the central control station results in an undesirable time delay 13 between the end of the first machine process and the start of the second machine process. The delay times for the
15 signals between the control units 2, 3 and the central control station 1 result in further undesirable time losses.

As Figure 3b shows, the central control station 1 frequently additionally communicates with other
20 peripheral units, such as an operating unit 4 which an operator can use to intervene in the process cycle, or which can be used to display process data for the operator. The start instructions 9 and end messages 10 for the operating process disturb the control of the
25 control units 2, 3. If the central control station 1 first needs to handle an operating process, there is a further undesirable time delay 13, as compared with the first example, between the end of the first machine process 11 and the start of the second machine process
30 12.

The method according to the invention is shown in Figures 1 and 2 and in the structogram in Figure 5. In this context, the central control station 1 and the control units 2, 3 are connected to one another by
35 means of an intercommunicating bus 20.

The central control station 1 transmits a preparation instruction 30 to the first control unit 2 at the start of the process cycle. The first machine

process 11 is then carried out. The start of the first machine process 11 is transmitted to the central control station 1 using a start signal 32. While the first machine process 11

is taking place, the central control station 1 transmits a preparation instruction 23, 33 to the second control unit 3. The received preparation instruction 24 does not now cause the second machine
5 process 12 to be carried out immediately, but rather contains a start condition. When the first machine process 11 has finished, the first control unit 2 transmits a completion signal 34 directly to the second control unit 3, which means that the start condition in
10 the latter has been fulfilled. The second control unit 3 then starts the second machine process 12.

This method can also be extended to a plurality of machine processes. Transmission of a plurality of start conditions to the second control unit 3 is also
15 envisaged. Before the start of the second machine process 12, the appropriate completion signals 34 then need to be received by other control units, which are not shown in Figure 2 and Figure 5.

The central control station 1 monitors the
20 process cycle, in which the start and end of the respective machine processes are transmitted to the central control station 1 by the control units 2, 3. The central control station 1 compares the process cycle with a stored cycle plan, and starts a fault
25 handling procedure as soon as a fault arises (for example an end message not having been transmitted over a prescribed period of time, or a completion signal not having been transmitted). By way of example, involves a fault handling procedure being a component rejected by
30 the suction pipette and a new component being taken.

The method according to the invention uses only one central control station 1 to carry out both control tasks and communication tasks without any time loss
35 arising between individual machine processes as a result. In addition, only one standard operating system is used for this one central control station 1, unlike

in individual computer solutions, which provide specific computers for control and communication tasks.

Patent claims



1. A method for controlling successive machine processes (11, 12), in particular in an automatic processing machine for fitting components on substrates, in which at least one first control unit (2) for a first machine process (11) and a second control unit (3) for a second machine process (12) are connected to one another and to a central control station (1), in which
- the central control station (1) transmits a start instruction (21) for the first machine process (11) to the first control unit (2),
- the first control unit (2) starts the first machine process (11) and transmits a start signal (32) to the central control station (1),
- the central control station (1) transmits, over the duration of the first machine process (11), a preparation instruction (23, 24, 33) and, at the same time, at least one start condition for the second machine process (12) to the second control unit (3),
- the first control unit (2) transmits, after the first machine process (11) has finished, a completion signal (34) as fulfillment of the start condition to the second control unit (3),
- the second control unit (3) starts the second machine process (12) after receiving the completion signal (34).
2. The method for controlling successive machine processes (11, 12) as claimed in claim 1, characterized
- in that the central control station (1) transmits a plurality of start conditions for the second machine process (12) to the second control unit (3) with the preparation instruction (23, 24, 33),
- in that the second control unit (3) checks that the start conditions have been fulfilled by communicating with other control units (for example 2), and



in that the second control unit (3) starts the second machine process (12) when all the start conditions have been fulfilled.



3. The method for controlling successive machine processes (11, 12) as claimed in one of claims 1 or 2, characterized

5 in that the central control station (1) stores a cycle plan for the machine processes (11, 12),

in that the central control station (1) monitors the completion signals (34) which the control units (2, 3) exchange with one another for the purposes of recording the machine processes (11, 12) which are currently

10 running, and

in that the central control station (1) initiates a fault handling procedure if there is a discrepancy between the stored cycle plan and the current machine process (11, 12).

15 4. The method for controlling successive machine processes (11, 12) as claimed in one of claims 1 to 3, characterized

in that the control units (2, 3) and the central control station (3) are connected to one another by an

20 intercommunicating bus (20).