

The present invention relates to a method for processing workpieces in an automatic manufacturing system with digitally controlled processing devices 10, the workpieces being mounted on pallets, on which data relating to the workpieces and their processing are stored electronically.

Furthermore, the invention relates to an automatic manufacturing system with digitally controlled processing devices, with control units individually associated with the processing devices, with tools for the complete processing of workpieces, with magazines for the storage of the tools and the workpieces, with handling devices associated with the processing devices, for supplying the processing devices with workpieces and for the exchange of tools as well as with at least one measuring device, which is set up for the pre-adjustment and checking of the state of the workpieces or tools.

It is the aim of the invention, in conjunction with the monitoring and control of the production sequence of such a manufacturing system, to provide an efficient system for the flow of information between the various units of the system and the workpieces or tools, which in a relatively simple manner allows a flexible, in particular order-related manufacture with many different workpieces in small batch sizes. In particular the invention relates to an improved identification system. Furthermore, the information system should be suitable to transmit other information, for example controlling the manufacture, in the way of identification.

Patent Specification No. DE-A1-37 20 157 discloses a manufacturing system of a similar type, in which the processing data necessary for processing workpieces are to be made available to a processing tool in a simple manner. The workpieces to be processed are received individually or in groups by pallets, on each of which a memory module is located, in which the entire processing data required are stored. At the time of installing the pallets in a pallet store, these processing data are

transmitted by a RC-tape of a stationary tape storage device into the store module of the pallets. At the time of transfer of a pallet provided with workpieces to a processing device, the processing data from the respective storage module of the pallet are read and supplied to the control device of the respective processing device. The tools necessary for processing the workpieces are supplied to the processing device by another route; in this connection there is no mention of pallets and storage modules.

One essential drawback of this known manufacturing system consists in that for each workpiece pallet, an extensive data package with the entire pre-programmed processing data must be decoded several times until this data reaches the control device of a processing device. This situation endangers the transmission security. Furthermore, obviously no measures are taken, which in the case of a multiply equipped workpiece pallet, made it possible to monitor the individual workpieces individually as regards data, so that all the workpieces of a pallet are processed solely according to a uniform processing program, without taking into account random deviations of mass and position of the workpieces. In this way, extremely high processing accuracies cannot be achieved. A further drawback results from the fact that the storage modules located on the pallets, for receiving the entire processing data, require a relatively high storage capacity. Furthermore it is virtually indispensable that in a manufacturing system with several manufacturing stations, all these manufacturing stations operate with a uniform operating system, in order to facilitate friction-free operation, since respective decoding of the extensive data programs would be too complicated.

The aforementioned drawbacks can be avoided with the method according to the invention due to the fact that in a control unit 30 individually associated with each processing device, a plurality of processing programs is stored electronically, that before its introduction into a processing device 10, each

workpiece 35 is measured on the pallet, the position of the workpiece with regard to its pallet 36 or the displacement of the latter with respect to a reference system associated with the pallet being ascertained, that on the pallet 36 a designation for the workpiece 35, a designation for the processing program intended for this workpiece as well as the measuring data ascertained on this workpiece are stored electronically, and that the data stored on the pallet 36 of a workpiece called-up for processing, are read and supplied to the control unit of the processing device, whereby by means of the designation of the processing program, the processing program required for processing this workpiece is selected, corrected on the basis of the measuring data and then used for controlling the processing device.

An automatic manufacturing system of the aforementioned type is suitable for carrying out this method, which according to the invention is characterised by the fact that for introduction into the processing devices and at the measuring device, the workpieces and the tools are mounted individually or in groups on uniform pallets, which can be clamped in the correct position in the processing devices and on which the workpieces remain on their path through the manufacturing system until processing is completed, that the control units comprise a data store, in which a plurality of different processing programs can be stored, that the pallets for the workpieces and those for the tools are provided with electronic data stores, in which data for indentifying the workpieces or tools and data for controlling the automatic manufacturing sequence can be stored, that the handling devices and the measuring device are equipped with data-processing devices suitable for reading the stored data, and that the data-processing devices are connected to communicate with the respectively associated control units of the processing devices.

The use of workpiece or tool pallets, which comprise uniform mechanical positioning aids, forms a favourable prerequisite for the application of the identification system according to the

invention. In this case, in particular in the case of the workpiece pallets, the latter may be those for individual workpieces or those for a group of similar workpieces.

In contrast to previous identification systems, which with respect to the location of the workpieces and tools work with position coding, in the identification system according to the invention, the workpieces and tools themselves can be clearly identified. This circumstance increases not solely the security against confusion in the mutual allocation of data and of the respective workpieces or tools, but also allows disordered depositing of the workpieces and tools in the respective magazines.

The clear identification of the components (workpieces and/or tools) forms the basis for the fact that additional information can be imparted to the individual components, in particular target data for the transportation of the material and data for the calling-up of programs for the processing of the material. Workpiece or tool pallets, which carry corresponding data and can transmit the latter, if required, to the control device, first of all allow a fully automatic operation of a manufacturing system with a plurality of manufacturing stations operated in conjunction.

In this case it is of particular advantage that it is not necessary to store in the data stores of the workpiece pallets, the processing data in the form of a more or less complete control or processing program for the required processing devices. Solely data for the identification of the processing programs must be provided, in order to call up the respectively required processing program stored in the storage unit, as soon as a pallet is supplied to a processing device. The storage volume of the data store can be correspondingly smaller.

In addition to this, a preferred embodiment of the manufacturing system according to the invention consists in that the

manufacturing stations, the storage device, the conveying vehicles and the reloading station comprise uniform receiving locations for the pallet magazines, at these receiving locations, respectively one data-processing device being equipped with a reading head for reading the data stored in the data stores of the pallet magazines. This data includes in particular a travel plan for the pallet magazine with details of the manufacturing stations to be controlled in succession.

As soon as a pallet magazine is transferred to the conveying device, the next transportation target can be read from the data store of this pallet magazine. This information is now transmitted to the control means of the conveying device, which controls a vehicle loaded with the pallet magazine, as far as the given target, for example a manufacturing station. Since the conveying device is always informed about the next travel destination, it is no longer necessary to feed entire conveying programs into the conveying-control means. Due to this the control of the material flow is substantially simpler and more flexible.

The information flow system according to the invention furthermore makes it possible, in a simple manner, to take measures to vary the travel plan, for the case where for example a certain target station is occupied and therefore cannot be approached. Measures of this type can be restricted to a data exchange within the internal data network and require no change of program at the process control computer. A pallet magazine, which cannot reach its target according to the travel plan, can be diverted into the storage device, from where it can be called up again at a later time, for example upon a signal which announces the clearance of the previously occupied manufacturing station.

Data stores are preferably provided, which make it possible to vary the data stored during the manufacturing process, thus for example to adapt the data of a workpiece respectively to the

present state of processing. For this purpose, each data-processing device may comprise apart from a reading head, a writing head and a control and evaluation device controlling the reading cycle and the writing cycle.

The security of the data transmission is a prerequisite for a trouble-free operation. With reference to the frequently rough operation in the field of processing devices with the disturbing influences of oil, chips and coolant, it is an advantage for the data transmission to provide a system with contact-free data transmission, for which purpose a wireless carrier frequency system is particularly well suited.

As regards the energy supply to the data store, one advantageous solution results due to the fact that data stores with energy-free storage are used and devices are provided, by which the energy, which the data stores require for the data transmission, is transmitted by wireless from the data-processing device to the respectively controlled data store. Semi-conductor stores of this type are economical and in addition relatively small and overall are easy to assemble. An inductive alternating field is advantageously provided for the energy transmission.

One embodiment of the invention is illustrated diagrammatically in the drawings, in which:

Figure 1 is an overall plan of the automatic manufacturing system according to the invention; and

Figure 2 shows details of a manufacturing station and of a measuring device.

The manufacturing system illustrated in Figure 1 comprises for example a setting-up location for the equipping of the pallets, a reloading station 2 for loading and unloading transportable pallet magazines, a storage station 3 for pallet magazines, four manufacturing stations 4 and a traffic network 5, which connects the various stations 2, 3 and 4 to each other.

The setting-up location 1 contains a clamping location 6, at which the workpieces and tools are clamped on pallets, and a measuring device 7 for determining the geometric data of the workpieces or tools clamped on the pallets.

At the reloading station 2, which comprises two locations 8 for respectively one pallet magazine, on the one hand incoming pallet magazines with finished workpieces are unloaded and on the other hand empty pallet magazines with newly equipped pallets are loaded.

The storage station comprises a plurality of storage locations, in the present example five storage locations 9 for the temporary storage of empty or occupied pallet magazines.

In the present example, each manufacturing station 4 comprises a processing device 10, generally in the form of a digitally controlled machine tool, a location 11 for a pallet magazine and a handling device 12 for supplying the processing device 10 with workpieces and for the exchange of tools.

The traffic network 5 is part of an automatic conveying device, which comprises a central conveying control station 13, a remote control system 14 and a plurality of remotely controlled vehicles 15 which can be called up optionally. In detail the traffic network 5 consists of different, preferably rail-free paths, along which the vehicles 15 are guided, in which case a closed path 16 leads past the reloading station 2, the storage station 3 and all the manufacturing stations 4 and separate path loops 17 are laid to each magazine location 8, 9 or 11 of the various stations 2, 3 and 4, so that several vehicles are able to circulate simultaneously without mutual interference on the traffic network 5. Furthermore, siding tracks 18 are provided for unused vehicles 15.

The information flow system comprises two separate data networks, namely an external data network 19 and an internal data network

20. The external data network 19 connects the control devices of the processing devices 10 of all manufacturing stations 4 and the conveyance control station 13 to a central process control computer 21 and is provided for the exchange of process control data between the process control computer 21 and the control units of the processing devices 10 and for the exchange of conveyance control data between the process control computer 21 and the conveyance control station 13. The external data network 19 may be part of a data transmission system known by the name "Ethernet", to which there may be connected, apart from the process control computer, for example a process planning system.

In comparison therewith, the internal data network 20 connects the parts of the system (storage station 2, handling devices 12 and vehicles 15) associated with the material flow system to each other, and indeed all the magazine locations 8, 9 and 11 of the reloading station 2, storage station 3 and manufacturing stations 4 as well as the remote control system 14 for the circulation of the vehicles 15 are connected to each other by way of this internal data network 20. Provided for the data exchange between the magazine locations 11 and the handling devices 12 of the manufacturing stations 4 on the one hand and between the conveying control station 13 and the remote control system 14 on the other hand are data buses 22 or 23. Furthermore, in each manufacturing station 4, the handling device 12 is connected to the control unit of the processing device 10 by way of a uniform interface indicated by the bus 24, which interface contains means for transmitting the data program of the internal data network 20 to the data program of the control unit of the respective processing device 10 connected to the external data network 19.

Associated with the material to be transformed, i.e. the pallets equipped with tools or workpieces and the transportable pallet magazines are data for identifying the material, destination data for the conveyance of the material and data for the calling-up of programs for processing the material, the internal data network 20 being intended for the exchange of this data. For

this purpose, all the pallets and pallet magazines each comprise a data store, in which the respective data are stored, and provided at all types of residence of the pallet magazines and at all transfer points of the pallets are data-processing devices, which are equipped with a reading head for reading the stored data. Associated with the handling devices 12 and the measuring device 7 are data-processing devices, which additionally comprise a writing head, in order to write data in the data stores, for example data which indicate the state of the manufacture.

Details of a manufacturing station 4 (without magazine location 11) and of the measuring device 7 of the setting-up location 1 are illustrated in Figure 2, corresponding parts being provided with the same reference numerals as in Figure 1.

Associated with the processing device 10 is a control unit 30, which is connected by way of a data lead 31 to the external data network 19 and by way of the data lead 24 to the handling device 12 and which comprises a data store, in which a plurality of different processing programs are stored.

The measuring device 7 comprises a computer terminal 32, which is connected by way of the data lead 33 to the external data network 19 and to which a measuring device 34 for determining geometric data is connected.

The workpiece 35 is mounted on a pallet 36, which is uniform with respect to the positioning means, which pallet can be clamped in the correct position at each place where the workpiece 35 stops for storage, measurement and processing, for example on a support 37 of the measuring device 34 and on the chuck 38 of the processing device 10. The pallet 36 is provided with a data store 39, in which the data necessary for identifying and for the processing of the workpiece 35 are stored.

On the basis of a processing order, the workpiece 35 provided for

this is clamped on a pallet and supplied to the measuring device 7, where the data specified in the order (such as workpiece designation, NC-program designation, etc.) are transmitted. At the measuring device 7, the pre-setting of the workpiece 35 takes place. In this case, by means of the measuring device 34, the position of the workpiece 35 with respect to its pallet 36 or the displacement of the latter with respect to a reference system associated with the pallet 36 is ascertained. Together with the above-mentioned order data, the measuring data are stored in the data store 39 located on the pallet 36. Thus the measuring data are associated with a certain, identifiable workpiece, and confusion relating to this is therefore precluded. After this the equipped pallet is transferred to the reloading station 2 (Figure 1), where it is located in a pallet magazine. At this point, the data store of the pallet magazine is also loaded with the necessary data, which are necessary for identifying the pallet magazine and for the conveyance thereof. A vehicle 15 receives the loaded pallet magazine and supplies the latter either directly to a manufacturing station 4 or in the meantime to the storage device 3.

At the beginning of a manufacturing program, the pallet magazine loaded with equipped pallets is moved to the receiving location of a manufacturing station 4 provided for this, where it can be reached by the movable gripping arm 40 of the handling device 12. The handling device 12 is equipped with a data-processing device 41, whereof the reading head is connected for example to the movable gripping arm 40.

In an initialisation run, the reading head approaches all the storage positions in the pallet magazine and reads the data stored in the data stores 39, in the working store of its data-processing unit 41. By way of the interface to the handling device 12, the control unit 30 of the processing device 10 may now directly call up the designation of the required workpiece 35, whereupon the handling device 12 fetches the respective workpiece from the pallet magazine and supplies it to the

processing device 10. The data-processing device 41 associated with the handling device 12 reads, with a reading head, during the transfer of the workpiece 35, the data stored in the data store 39 and transmits the latter to the control unit 30, in which case by means of the entrained NC-program designation, the NC-program required for processing the workpiece 35 is selected from the NC-program stored in the control unit 30 and is used for controlling the processing device 10.

Basically it is possible to proceed in the same way with the tools required for machining the workpieces.

The workpiece 35, which after it has been processed in the processing device 10, is to be supplied to one or more further processing devices, can be stored in a magazine in the meantime. However, first of all, the workpiece 35 may also be conveyed to the measuring device 7 or to another measuring device, where it is once more measured and the new measuring data are fed into the data store 39 on its pallet 36. In this phase also, additional data, relating for example to the further-processing of the workpiece 35, may be stored in the data store 39.



Claims

1. Method for processing workpieces in an automatic manufacturing system with digitally controlled processing devices (10), the workpieces being mounted on pallets, on which data relating to the workpieces and their processing are stored electronically, characterized in that in a control unit (30) individually associated with each processing device (10), a plurality of processing programs is stored electronically, that before its introduction into a processing device (10) on the pallet, each workpiece (35) is measured, the position of the workpiece with regard to its pallet (36) or the displacement of the latter with respect to a reference system associated with the pallet being ascertained, that on the pallet (36) a designation for the workpiece (35), a designation for the processing program intended for this workpiece as well as the measuring data ascertained on this workpiece are stored electronically, and that the data stored on the pallet (36) of a workpiece called-up for processing, are read and supplied to the control unit of the processing device, whereby by means of the designation of the processing program, the processing program required for processing this workpiece is selected, corrected on the basis of the measuring data and then used for controlling the processing device.

2. Automatic manufacturing system with digitally controlled processing devices (10), with control units (30) individually associated with the processing devices, with tools for the complete processing of workpieces (35), with magazines for the storage of the tool and the workpieces, with handling devices (12) associated with the processing devices (10), for supplying the processing devices with workpieces (35) and for the exchange of tools as well as with at least one measuring device (7), which is set up for the pre-adjustment and checking of the state of the workpieces (35) or tools, characterized in that for introduction into the processing devices (10) and at the measuring device (7), the workpieces (35) and the tools are mounted individually or in



groups on uniform pallets (36), which can be clamped in the correct position in the processing devices (10) and on which the workpieces (35) remain on their path through the manufacturing system until processing is completed, that the control units (30) comprise a data store, in which a plurality of different processing programs can be stored, that the pallets (36) for the workpieces (35) and those for the tools are provided with electronic data stores (39), in which data for identifying the workpieces or tools and data for controlling the automatic manufacturing sequence can be stored, that the handling devices (12) and the measuring device (7) are equipped with data-processing devices (32, 41) suitable for reading the stored data, and that the data-processing devices are connected to communicate with the respectively associated control units (30) of the processing devices (10).

3. Automatic manufacturing system according to Claim 2, characterized in that data stores (39) are provided, which make it possible to change the stored data during the manufacturing process.

4. Automatic manufacturing system according to Claim 2, characterized in that each data-processing device (32, 41) comprises a reading head, a writing head and a control and evaluation device controlling the reading cycle and the writing cycle.

5. Automatic manufacturing system according to one of Claims 2 to 4, characterized in that a wireless carrier frequency system is provided for the data transmission.

6. Automatic manufacturing system according to one of Claims 2 to 5, characterized in that data stores with energy-free storage are used and devices are provided by which the energy, which the data stores require for the data transmission, is transmitted by wireless from the data-processing device to the respectively controlled data store.



7. Automatic manufacturing system according to Claim 6, characterized in that an inductive alternating field is provided for the energy transmission.

8. Automatic manufacturing system according to Claim 2, characterized in that for determining geometric data of the workpieces (35) clamped on the pallets (36) or tools, the measuring device (7) is equipped with a data-processing device (32) having a reading head and writing head and cooperating with the data store (39) of the pallets (36).

9. Automatic manufacturing system according to Claim 2, characterized in that the data-processing device (41) associated with each handling device (12) is connected to a reading and writing device cooperating with the data stores (39) of the pallets (36) and at a uniform junction (24) contains means for transcribing the data program onto the data program of the control unit (30) of the respective processing device (10).